CLAIMS

1. A method of determining a respiratory parameter of a patient during expiration when receiving respiratory support comprising:

providing an apparatus gas flow with a flow rate and a gas proportion, to a patient,

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

determining a proportion of apparatus gas flow through the mouth and/or nose,

determining an exhaled gas flow rate using all of:

apparatus gas flow gas proportion,

apparatus gas flow flow rate,

composite gas outflow gas parameter, and

exhaled gas flow parameter,

wherein the exhaled gas flow parameter is determined using the measured parameter of the gas present in the composite gas outflow and a time-varying flow rate or gas proportion of the apparatus gas flow, and

from the exhaled gas flow rate, determining one or more respiratory parameters.

2. A method according to claim 1, wherein the one or more respiratory parameters includes any one or more of:

tidal volume,

minute ventilation,

respiratory rate,

apnoea,

airway patency, and/or

peak flow rate.

3. A method according to any one of claims 1 to 2, wherein the composite gas outflow parameter is a gas proportion measured with a sensor at the mouth.

4. A method according to any one of claims 1 to 3, wherein the gas is one or more of O_2, CO_2, N_2 or a tracer gas.

5. A method according to any one of claims 1 to 4, wherein the method comprises determining the exhaled gas flow rate further using the proportion of apparatus gas flow through the mouth and/or nose.

6. A method according to any one of claims 1 to 5, wherein one of the flow rate and gas proportion is time-varying.

7. A method according to any one of the preceding claims, wherein the apparatus gas flow flow rate oscillates at a frequency greater than breathing frequency.

8. A method according to any one of claims 1 to 7, wherein the exhaled gas flow parameter is an exhaled gas flow gas proportion.

9. A method according to any one of claims 1 to 8, wherein determining a proportion of apparatus gas flow through the mouth and/or nose comprises determining a proportion of apparatus gas flow through the mouth.

10. A method according to any one of claims 1 to 9, wherein the exhaled gas flow rate Q_E of the patient is determined based on:

$$Q_E(t) = k(t)Q_o(t)\frac{F_o(t) - F_m(t)}{F_m(t) - F_E(t)}$$

wherein
Q_E is the exhaled gas flow rate,
Q_o is the apparatus gas flow flow rate,
k is the proportion of the apparatus gas flow exiting through the mouth, wherein k=0 represents the patient's mouth being closed,
F_o is the apparatus gas flow gas proportion,
F_m is the composite gas outflow gas parameter, and
F_E is the exhaled gas flow parameter.

11. A method according claim 10, wherein the exhaled gas flow parameter is determined using a time-varying flow rate of the apparatus gas flow, and the composite gas outflow gas parameter (F_m) is a volume fraction of O_2, and wherein the exhaled gas flow parameter (F_E) is determined based on:

$$F_E(t) \approx \frac{Q_o(t)F_m(t+\Delta t)\big(F_o(t) - F_m(t)\big) - Q_o(t+\Delta t)F_m\big(t\big)(F_o(t+\Delta t) - F_m(t+\Delta t)\big)}{Q_o(t)\big(F_o(t) - F_m(t)\big) - Q_o(t+\Delta t)\big((F_o(t+\Delta t) - F_m(t+\Delta t)\big)}$$

12. A method according to claim 10, wherein the exhaled gas flow parameter is determined using a time-varying flow rate of the apparatus gas flow, and the composite

gas outflow gas parameter (F_m) is a volume fraction of CO_2, and wherein the exhaled gas flow parameter (F_E) is determined based on:

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

13. A method according to claim 10, wherein the exhaled gas flow parameter is determined using a time-varying oxygen fraction of the apparatus gas flow, and the composite gas outflow gas parameter (F_m) is a volume fraction of O_2, and wherein the exhaled gas flow parameter (F_E) is determined based on:

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

14. A method according to any one of claims 11 to 13, wherein the one or more respiratory parameters includes tidal volume (V_{Tidal}), and tidal volume can be determined based on

$$V_{Tidal}(t) = \int Q_E(t)dt$$

15. A method according to any one of claims 1 to 14, wherein the exhaled gas flow parameter is determined using the measured parameter of the gas present in the composite gas outflow, a time-varying flow rate or gas proportion, and the proportion of apparatus gas flow through the mouth and/or nose.

16. An apparatus for providing respiratory support and determining a respiratory parameter of a patient when receiving the respiratory support, the apparatus comprising:

a flow generator for providing an apparatus gas flow with a flow rate and a gas proportion to the patient,

one or more sensors or inputs for one or more sensors placed at a mouth and/or nose of the patient for measuring a parameter of the gas present in a composite gas outflow from the patient,

a controller being configured to

determine a proportion of apparatus gas flow through the mouth and/or nose,

determine an exhaled gas flow rate using all of:

apparatus gas flow gas proportion,

apparatus gas flow flow rate,
composite gas outflow gas parameter, and
exhaled gas flow parameter,

wherein the exhaled gas flow parameter is determined using the measured parameter of the gas present in the composite gas outflow and a time-varying flow rate or gas proportion of the apparatus gas flow, and

from the exhaled gas flow rate, determining one or more respiratory parameters.

17. The apparatus according to claim 16, wherein the one or more respiratory parameters includes any one or more of:

tidal volume,
minute ventilation,
respiratory rate,
apnoea,
airway patency, and/or
peak flow rate.

18. The apparatus according to claim 16 or 17, wherein the composite gas outflow parameter is a gas proportion measured with the one or more sensors placed at the mouth.

19. The apparatus according to any one of claims 16 to 18, wherein the gas is one or more of O_2, CO_2, N_2 or a tracer gas.

20. The apparatus according to any one of claims 16 to 19, wherein the controller is configured to determine the exhaled gas flow rate further using the proportion of the apparatus gas flow.

21. The apparatus according to any one of claims 16 to 20, wherein one of the flow rate and gas proportion is time-varying.

22. The apparatus according to any one of claims 16 to 21, wherein the apparatus gas flow flow rate oscillates at a frequency greater than breathing frequency.

23. The apparatus according to any one of claims 16 to 22, wherein the exhaled gas flow parameter is an exhaled gas flow gas proportion.

24. The apparatus according to any one of claims 16 to 23, wherein the controller is configured to determine a proportion of apparatus gas flow through the mouth and/or nose by determining a proportion of apparatus gas flow through the mouth based on input from the one or more sensors.

25. The apparatus according to any one of claims 16 to 24, wherein the controller is configured to determine the exhaled gas flow rate Q_E of the patient based on:

$$Q_E(t) = k(t)Q_o(t)\frac{F_o(t) - F_m(t)}{F_m(t) - F_E(t)}$$

wherein
Q_E is the exhaled gas flow rate,
Q_o is the apparatus gas flow flow rate,
k is the proportion of the apparatus gas flow exiting through the mouth, wherein k=0 represents the patient's mouth being closed,
F_o is the apparatus gas flow gas proportion,
F_m is the composite gas outflow gas parameter, and
F_E is the exhaled gas flow parameter.

26. The apparatus according to claim 25, wherein the controller is configured to determine the exhaled gas flow parameter using a time-varying flow rate of the apparatus gas flow, and the composite gas outflow gas parameter (F_m) is a volume fraction of O_2, and wherein the controller determines the exhaled gas flow parameter (F_E) based on:

$$F_E(t) \approx \frac{Q_o(t)F_m(t+\Delta t)\big(F_o(t) - F_m(t)\big) - Q_o(t+\Delta t)F_m\big(t\big)(F_o(t+\Delta t) - F_m(t+\Delta t)\big)}{Q_o(t)\big(F_o(t) - F_m(t)\big) - Q_o(t+\Delta t)\big((F_o(t+\Delta t) - F_m(t+\Delta t)\big)}$$

27. The apparatus according to claim 25, wherein the controller is configured to determine exhaled gas flow parameter using a time-varying flow rate of the apparatus gas flow, and the composite gas outflow gas parameter (F_m) is a volume fraction of CO_2, and wherein the controller determines the exhaled gas flow parameter (F_E) based on:

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

28. The apparatus according to claim 25, wherein the controller is configured to determine exhaled gas flow parameter using a time-varying oxygen fraction of the

apparatus gas flow, and the composite gas outflow gas parameter (F_m) is a volume fraction of O_2, and wherein the controller determines the exhaled gas flow parameter (F_E) based on:

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

29. The apparatus according to any one of claims 25 to 28, wherein the one or more respiratory parameters includes tidal volume (V_{Tidal}), and the controller is configured to determine tidal volume based on

$$V_{Tidal}(t) = \int Q_E(t)dt$$

30. The apparatus according to any one of claims 16 to 29, wherein the controller is configured to determine the exhaled gas flow parameter using the measured parameter of the gas present in the composite gas outflow, a time-varying flow rate or gas proportion, and the proportion of apparatus gas flow through the mouth and/or nose.

31. The apparatus according to any one of claims 16 to 30, further comprising a humidifier

32. The apparatus according to any one of claims 16 to 31, wherein the apparatus has or connects to a non-sealing interface.

33. A method of determining a respiratory parameter of a patient during expiration when receiving respiratory support comprising:

providing an apparatus gas flow with a flow rate and a gas proportion, to a patient,

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

determining a proportion of apparatus gas flow through the mouth and/or nose,

determining an exhaled gas flow rate using one or more of:

apparatus gas flow gas proportion,

apparatus gas flow flow rate,

composite gas outflow gas parameter,

proportion of the apparatus gas flow,

exhaled gas flow parameter, wherein the exhaled gas flow parameter is determined using the measured parameter of the gas present in the composite gas

outflow, a time-varying flow rate or gas proportion of the apparatus gas flow, and the proportion of apparatus gas flow through the mouth and/or nose, and

from the exhaled gas flow rate, determining one or more respiratory parameters.

34. A method according to claim 33, wherein the one or more respiratory parameters includes any one or more of:

tidal volume,
minute ventilation,
respiratory rate,
apnoea,
airway patency, and/or
peak flow rate.

35. A method according claim 33 or 34, wherein the composite gas outflow parameter is a gas proportion measured with a sensor at the mouth.

36. A method according to any one of claims 33 to 35, wherein the gas is one or more of O_2, CO_2, N_2 or a tracer gas.

37. A method according to any one of claims 33 to 36, wherein the method comprises determining the exhaled gas flow rate using all of: apparatus gas flow gas proportion, apparatus gas flow flow rate, composite gas outflow gas proportion, exhaled gas flow parameter.

38. A method according to any one of claims 33 to 37, wherein one of the flow rate and gas proportion is time-varying.

39. A method according to any one of claims 33 to 38, wherein the apparatus gas flow flow rate oscillates at a frequency greater than breathing frequency.

40. A method according to any one of claims 33 to 39, wherein the exhaled gas flow parameter is an exhaled gas flow gas proportion.

41. A method according to any one of claims 33 to 40, wherein determining a proportion of apparatus gas flow through the mouth and/or nose comprises determining a proportion of apparatus gas flow through the mouth.

42. A method according to any one of claims 33 to 41, wherein the exhaled gas flow rate Q_E of the patient is determined based on:

$$Q_E(t) = k(t)Q_o(t)\frac{F_o(t) - F_m(t)}{F_m(t) - F_E(t)}$$

wherein
Q_E is the exhaled gas flow rate,
Q_o is the apparatus gas flow flow rate,
k is the proportion of the apparatus gas flow exiting through the mouth, wherein k=0 represents the patient's mouth being closed,
F_o is the apparatus gas flow gas proportion,
F_m is the composite gas outflow gas parameter, and
F_E is the exhaled gas flow parameter.

43. A method according claim 42, wherein the exhaled gas flow parameter is determined using a time-varying flow rate of the apparatus gas flow, and the composite gas outflow gas parameter (F_m) is a volume fraction of O_2, and wherein the exhaled gas flow parameter (F_E) is determined based on:

$$F_E(t) \approx \frac{Q_o(t)F_m(t+\Delta t)\big(F_o(t) - F_m(t)\big) - Q_o(t+\Delta t)F_m\big(t\big)(F_o(t+\Delta t) - F_m(t+\Delta t)\big)}{Q_o(t)\big(F_o(t) - F_m(t)\big) - Q_o(t+\Delta t)\big((F_o(t+\Delta t) - F_m(t+\Delta t)\big)}$$

44. A method according to claim 42, wherein the exhaled gas flow parameter is determined using a time-varying flow rate of the apparatus gas flow, and the composite gas outflow gas parameter (F_m) is a volume fraction of CO_2, and wherein the exhaled gas flow parameter (F_E) is determined based on:

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

45. A method according to claim 42, wherein the exhaled gas flow parameter is determined using a time-varying oxygen fraction of the apparatus gas flow, and the composite gas outflow gas parameter (F_m) is a volume fraction of O_2, and wherein the exhaled gas flow parameter (F_E) is determined based on:

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

46. A method according to any one of claims 43 to 45, wherein the one or more respiratory parameters includes tidal volume (V_{Tidal}), and tidal volume can be determined based on

$$V_{Tidal}(t) = \int Q_E(t)dt$$

47. An apparatus for providing respiratory support and determining a respiratory parameter of a patient when receiving the respiratory support, the apparatus comprising:

a flow generator for providing an apparatus gas flow with a flow rate and a gas proportion to the patient,

one or more sensors or inputs for one or more sensors placed at a mouth and/or nose of the patient for measuring a parameter of the gas present in a composite gas outflow from the patient,

a controller being configured to

determine a proportion of apparatus gas flow through the mouth and/or nose,

determine an exhaled gas flow rate using one or more of:

apparatus gas flow gas proportion,

apparatus gas flow flow rate,

composite gas outflow gas parameter,

proportion of the apparatus gas flow,

exhaled gas flow parameter, wherein the exhaled gas flow parameter is determined using the measured parameter of the gas present in the composite gas outflow, a time-varying flow rate or gas proportion of the apparatus gas flow, and the proportion of apparatus gas flow through the mouth and/or nose, and

from the exhaled gas flow rate, determining one or more respiratory parameters.

48. The apparatus according to claim 47, wherein the one or more respiratory parameters includes any one or more of:

tidal volume,

minute ventilation,

respiratory rate,

apnoea,

airway patency, and/or

peak flow rate.

49. The apparatus according to claim 47 or 48, wherein the composite gas outflow parameter is a gas proportion measured with the one or more sensors placed at the mouth.

50. The apparatus according to any one of claims 47 to 49, wherein the gas is one or more of O_2, CO_2, N_2 or a tracer gas.

51. The apparatus according to any one of claims 47 to 50, wherein the controller is configured to determine the exhaled gas flow rate using all of: apparatus gas flow gas proportion, apparatus gas flow flow rate, composite gas outflow gas proportion, exhaled gas flow parameter.

52. The apparatus according to any one of claims 47 to 51, wherein one of the flow rate and gas proportion is time-varying.

53. The apparatus according to any one of claims 47 to 52, wherein the apparatus gas flow flow rate oscillates at a frequency greater than breathing frequency.

54. The apparatus according to any one of claims 47 to 53, wherein the exhaled gas flow parameter is an exhaled gas flow gas proportion.

55. The apparatus according to any one of claims 47 to 54, wherein the controller is configured to determine a proportion of apparatus gas flow through the mouth and/or nose by determining a proportion of apparatus gas flow through the mouth based on input from the one or more sensors.

56. The apparatus according to any one of claims 47 to 55, wherein the controller is configured to determine the exhaled gas flow rate Q_E of the patient based on:

$$Q_E(t) = k(t)Q_o(t)\frac{F_o(t) - F_m(t)}{F_m(t) - F_E(t)}$$

wherein
Q_E is the exhaled gas flow rate,
Q_o is the apparatus gas flow flow rate,
k is the proportion of the apparatus gas flow exiting through the mouth, wherein k=0 represents the patient's mouth being closed,
F_o is the apparatus gas flow gas proportion,

F_m is the composite gas outflow gas parameter, and
F_E is the exhaled gas flow parameter.

57. The apparatus according to claim 56, wherein the controller is configured to determine the exhaled gas flow parameter using a time-varying flow rate of the apparatus gas flow, and the composite gas outflow gas parameter (F_m) is a volume fraction of O_2, and wherein the controller determines the exhaled gas flow parameter (F_E) based on:

$$F_E(t) \approx \frac{Q_o(t)F_m(t+\Delta t)\big(F_o(t)-F_m(t)\big)-Q_o(t+\Delta t)F_m\big(t\big)(F_o(t+\Delta t)-F_m(t+\Delta t)\big)}{Q_o(t)\big(F_o(t)-F_m(t)\big)-Q_o(t+\Delta t)\big((F_o(t+\Delta t)-F_m(t+\Delta t)\big)}$$

58. The apparatus according to claim 56, wherein the controller is configured to determine exhaled gas flow parameter using a time-varying flow rate of the apparatus gas flow, and the composite gas outflow gas parameter (F_m) is a volume fraction of CO_2, and wherein the controller determines the exhaled gas flow parameter (F_E) based on:

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

59. The apparatus according to claim 56, wherein the controller is configured to determine exhaled gas flow parameter using a time-varying oxygen fraction of the apparatus gas flow, and the composite gas outflow gas parameter (F_m) is a volume fraction of O_2, and wherein the controller determines the exhaled gas flow parameter (F_E) based on:

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

60. The apparatus according to any one of claims 56 to 59, wherein the one or more respiratory parameters includes tidal volume (V_{Tidal}), and the controller is configured to determine tidal volume based on

$$V_{Tidal}(t) = \int Q_E(t)dt$$

61. The apparatus according to any one of claims 47 to 60, further comprising a humidifier

62. The apparatus according to any one of claims 47 to 61, wherein the apparatus has or connects to a non-sealing interface.