WHAT IS CLAIMED IS:

1. A gases measurement apparatus comprising:

a gases measuring chamber comprising a gases flow path from a first end of the gases measuring chamber to a second end of the gases measuring chamber, wherein a downstream direction is defined along the gases flow path from the first end to the second end and an upstream direction is defined along the gases flow path from the second end to the first end;

a controller;

a first ultrasonic sensor positioned at the first end of the gases measuring chamber, the first ultrasonic sensor configured to transmit a downstream acoustic pulse train in a first measurement phase, to detect an upstream acoustic pulse train in a second measurement phase, and to send a signal to the controller; and

a second ultrasonic sensor positioned at the second end of the gases measuring chamber, the second ultrasonic sensor configured to transmit the upstream acoustic pulse train in the second measurement phase, to detect the downstream acoustic pulse train in the first measurement phase, and to send a signal to the controller;

wherein the controller is configured to determine a characteristic of the gases based at least in part on a signal received from the first ultrasonic sensor and a signal received from the second ultrasonic sensor.

2. The apparatus of Claim 1, wherein the gases comprise two gases.

3. The apparatus of Claim 2, wherein the two gases comprise oxygen and air.

4. The apparatus of Claim 1, wherein the downstream acoustic pulse train or the upstream acoustic pulse train comprises a plurality of acoustic pulses.

5. The apparatus of Claim 1, wherein the downstream acoustic pulse train or the upstream acoustic pulse train comprises a single acoustic pulse.

6. The apparatus of Claim 1, wherein the characteristic of the gases comprises at least one of gases concentration, flow rate, or velocity.

7. The apparatus of Claim 1, wherein the first and second ultrasonic sensors are configured to be excited at a natural resonant frequency.

8. The apparatus of Claim 1, wherein the controller is configured to determine a downstream time of flight for the downstream acoustic pulse train, the controller is

configured to determine an upstream time of flight for the upstream acoustic pulse train, and the controller is configured to determine the characteristic of the gases based at least in part on the downstream time of flight and the upstream time of flight.

9. A method for determining a characteristic of gases flowing through an apparatus along a gases flow path from a first end of the apparatus to a second end of the apparatus, the apparatus comprising a first ultrasonic sensor positioned at the first end and a second ultrasonic sensor positioned at the second end, a downstream direction defined along the gases flow path from the first end to the second end and an upstream direction defined along the gases flow path from the second end to the first end, the method comprising:

transmitting a downstream acoustic pulse train from the first ultrasonic sensor and detecting the downstream acoustic pulse train at the second ultrasonic sensor;

determining a downstream time of flight based at least in part on the downstream acoustic pulse train;

transmitting an upstream acoustic pulse train from the second ultrasonic sensor and detecting the upstream acoustic pulse train at the first ultrasonic sensor;

determining an upstream time of flight based at least in part on the upstream acoustic pulse train; and

determining the characteristic of the gases based at least in part on the downstream time of flight and the upstream time of flight.

10. The method of Claim 9, wherein the downstream acoustic pulse train or the upstream acoustic pulse train comprises a plurality of acoustic pulses.

11. The method of Claim 9, wherein the downstream acoustic pulse train or the upstream acoustic pulse train comprises a single acoustic pulse.

12. The method of Claim 9, comprising:

transmitting a second downstream acoustic pulse train from the first ultrasonic sensor and detecting the second downstream acoustic pulse train at the second ultrasonic sensor;

determining the downstream time of flight based at least in part on an average of the downstream acoustic pulse train and the second downstream acoustic pulse train;

transmitting a second upstream acoustic pulse train from the second ultrasonic sensor and detecting the second upstream acoustic pulse train at the first ultrasonic sensor; and

determining the upstream time of flight based at least in part on an average of the upstream acoustic pulse train and the second upstream acoustic pulse train.

13. The method of Claim 9, wherein the characteristic of the gases comprises at least one of gases concentration, flow rate, or velocity.

14. The method of Claim 9, wherein transmitting a downstream acoustic pulse train from the first ultrasonic sensor comprises exciting the first ultrasonic sensor at a natural resonant frequency and transmitting an upstream acoustic pulse train from the second ultrasonic sensor comprises exciting the second ultrasonic sensor at the natural resonant frequency.

15. The method of Claim 9, wherein the gases comprise oxygen and air.

16. The method of Claim 15, wherein determining the characteristic of the gases comprises determining an oxygen concentration as a volume percentage using the equation:

$$OC(vol.) = \frac{(100-20.9)(G_{avg} - A_{avg})}{(O_{avg} - A_{avg})} + 20.9$$

where G_{avg} represents an average of the downstream time of flight and the upstream time of flight, A_{avg} represents an average downstream and upstream time of flight for air, and O_{avg} represents an average downstream and upstream time of flight for oxygen.

17. The method of Claim 16, wherein determining the characteristic of the gases comprises determining a flow rate in liters per minute for a given oxygen concentration using the equation:

$$F(l/m) = k \times [(G_u - G_d) - f_G]$$

where k represents a constant factor for geometric aspects of the apparatus, G_u represents the upstream time of flight, G_d represents the downstream time of flight, and f_G represents a calibrated correction determined using the equation:

$$f_G = f_A + \frac{(f_O - f_A)(x-20.9)}{(100-20.9)}$$

where f_A represents a calibrated correction for air, f_O represents a calibrated correction for oxygen, and x represents an oxygen concentration as a volume percentage.

18. A gases delivery apparatus comprising:

a gases mixing chamber configured to receive gases from a gases source, the gases mixing chamber comprising a gases flow path from a first end of the gases mixing chamber to a second end of the gases mixing chamber and at least one mixing element situated within the gases flow path; and

a gases measuring chamber configured to receive gases from the gases mixing chamber, the gases measuring chamber comprising a gases flow path from a first end of the gases measuring chamber to a second end of the gases measuring chamber, the gases measuring chamber situated coaxially within the gases mixing chamber;

wherein the at least one mixing element is configured to mix gases in the gases flow path of the gases mixing chamber before the gases enter the gases flow path of the gases measuring chamber.

19. The apparatus of Claim 18, wherein the at least one mixing element comprises a vane that is configured to reduce turbulence in gases that flow from the gases flow path of the gases mixing chamber to the gases flow path of the gases measuring chamber.

20. The apparatus of Claim 18, wherein the at least one mixing element comprises a baffle that is configured to increase the length of the gases flow path of the gases mixing chamber.

21. The apparatus of Claim 18, wherein the gases mixing chamber is configured to receive two or more gases.

22. The apparatus of Claim 18, wherein the gases mixing chamber is configured to mix the received gases.

23. The apparatus of Claim 18 comprising a first ultrasonic sensor positioned at the first end of the gases measuring chamber and a second ultrasonic sensor positioned at the second end of the gases measuring chamber.

CLAIMS:

1. A gases measurement apparatus comprising:

a gases measuring chamber comprising a gases flow path from a first end of the gases measuring chamber to a second end of the gases measuring chamber, wherein a downstream direction is defined along the gases flow path from the first end to the second end and an upstream direction is defined along the gases flow path from the second end to the first end;

an upstream gases flow path configured to connect a gases source to the gases measuring chamber, the upstream gases flow path comprising a gases mixing chamber coaxial with the gases measuring chamber, and further comprising a gases flow guide configured to improve laminar flow of the gases prior to entering the gases flow path of the gases measuring chamber, the gases flow guide located downstream of the gases source;

a controller;

the gases measuring chamber further comprising:

a first ultrasonic sensor positioned at the first end of the gases measuring chamber, the first ultrasonic sensor configured to transmit a downstream acoustic pulse train in a first measurement phase, to detect an upstream acoustic pulse train in a second measurement phase, and to send a signal to the controller;

a second ultrasonic sensor positioned at the second end of the gases measuring chamber, the second ultrasonic sensor configured to transmit the upstream acoustic pulse train in the second measurement phase, to detect the downstream acoustic pulse train in the first measurement phase, and to send a signal to the controller;

a first temperature sensor at an inlet of the gases measuring chamber, the first temperature sensor configured to measure temperature of the gases flowing in the gases flow path at the inlet;

a second temperature sensor at an outlet of the gases measuring chamber, the second temperature sensor configured to measure temperature of the gases flowing in the gases flow path at the outlet; and

at least one pressure sensor configured to measure a pressure of the gases flowing in the gases flow path; and

wherein the controller is configured to determine a characteristic of the gases based at least in part on the signal received from the first ultrasonic sensor, the signal received from the second ultrasonic sensor, and signals received from the first and second temperature sensors.

2. The apparatus of Claim 1, wherein the gases comprise gases from two sources of gases.

3. The apparatus of Claim 2, wherein the two sources of gases comprise a concentrated source of oxygen and room air.

4. The apparatus of any of Claims 1 to 3, wherein the downstream acoustic pulse train or the upstream acoustic pulse train comprises a plurality of acoustic pulses.

5. The apparatus of any of Claims 1 to 3, wherein the downstream acoustic pulse train or the upstream acoustic pulse train comprises a single acoustic pulse.

6. The apparatus of any of Claims 1 to 5, wherein the characteristic of the gases comprises at least one of gases concentration, flow rate, or velocity.

7. The apparatus of any of Claims 1 to 6, wherein the first and second ultrasonic sensors are configured to be excited at a natural resonant frequency.

8. The apparatus of any of Claims 1 to 7, wherein the controller is configured to determine a downstream time of flight for the downstream acoustic pulse train, the controller is configured to determine an upstream time of flight for the upstream acoustic pulse train, and the controller is configured to determine the characteristic of the gases based at least in part on the downstream time of flight and the upstream time of flight.

9. A method for determining a characteristic of gases flowing through an apparatus along a gases flow path from a first end of the apparatus to a second end of the apparatus, the apparatus comprising a first ultrasonic sensor positioned at the first end and a second ultrasonic sensor positioned at the second end, a downstream direction defined along the gases flow path from the first end to the second end and an upstream direction defined along the gases flow path from the second end to the first end, the method comprising:

transmitting a downstream acoustic pulse train from the first ultrasonic sensor and detecting the downstream acoustic pulse train at the second ultrasonic sensor;

determining a downstream time of flight based at least in part on the downstream acoustic pulse train;

transmitting an upstream acoustic pulse train from the second ultrasonic sensor and detecting the upstream acoustic pulse train at the first ultrasonic sensor;

determining an upstream time of flight based at least in part on the upstream acoustic pulse train;

determining a temperature of the gases flowing along the gases flow path at an inlet of the apparatus using a first temperature sensor;

determining a temperature of the gases flowing along the gases flow path at an outlet of the apparatus using a second temperature sensor;

determining the characteristic of the gases based at least in part on the downstream time of flight, the upstream time of flight, and the temperature of gases flowing along the gases flow path at the inlet and outlet of the apparatus; and

determining a pressure of the gases flowing in the flow path using a pressure sensor,

wherein the gases are configured to flow from a portion of the gases flow path upstream of the apparatus, the portion of the gases flow path comprising a gases flow guide configured to improve laminar flow of the gases prior to entering the apparatus, the gases flow guide located downstream of a gases source,

wherein the apparatus comprises a single gases measuring chamber defined by a housing of the apparatus, wherein the first and second ultrasonic sensors, the first and second temperature sensors, and the pressure sensor are located at the single gases measuring chamber, and wherein the single gases measuring chamber is coaxial with a gases mixing chamber.

10. A gases delivery apparatus comprising:

a gases mixing chamber configured to receive gases from a gases source, the gases mixing chamber comprising a gases flow path from a first end of the gases mixing chamber to a second end of the gases mixing chamber and at least one mixing element situated within the gases flow path;

a humidification system; and

a gases measurement apparatus comprising:

a gases measuring chamber configured to receive the gases from the gases mixing chamber, wherein the gases measuring chamber and the gases mixing chamber are coaxial the gases measuring chamber comprising a gases flow path from a first end of the gases measuring chamber to a second end of the gases measuring chamber, wherein a downstream direction is defined along the gases flow path from the first end to the second end and an upstream direction is defined along the gases flow path from the second end to the first end;

a controller; and

the gases measuring chamber further comprising:

a first ultrasonic sensor positioned at the first end of the gases measuring chamber, the first ultrasonic sensor configured to transmit a downstream acoustic pulse train in a first measurement phase, to detect an upstream acoustic pulse train in a second measurement phase, and to send a signal to the controller;

a second ultrasonic sensor positioned at the second end of the gases measuring chamber, the second ultrasonic sensor configured to transmit the upstream acoustic pulse train in the second measurement phase, to detect the downstream acoustic pulse train in the first measurement phase, and to send a signal to the controller;

a first temperature sensor at an inlet of the gases measuring chamber, the first temperature sensor configured to measure temperature of the gases flowing in the gases flow path at the inlet;

a second temperature sensor at an outlet of the gases measuring chamber, the second temperature sensor configured to measure temperature of the gases flowing in the gases flow path at the outlet; and

at least one pressure sensor configured to measure a pressure of the gases flowing in the gases flow path;

wherein the controller is configured to determine a characteristic of the gases based at least in part on a signal received from the first ultrasonic sensor, a signal received from the second ultrasonic sensor, a signal from the first temperature sensor, and a signal from the second temperature sensor,

wherein the at least one mixing element is configured to mix gases in the gases flow path of the gases mixing chamber and to improve laminar flow of the gases before the gases enter the gases flow path of the gases measuring chamber, the at least one mixing element located downstream of the gases source.

11. The apparatus of Claim 10, wherein the gases measurement apparatus is a separate component that is selectively removable from the gases delivery apparatus and is configured to be located between the gases source and the humidification system.

12. The apparatus of Claim 10 or Claim 11, further comprising a blower assembly that includes a blower, wherein the blower is the gases source and the gases measurement apparatus is a part of the blower assembly.

13. The apparatus of any of Claims 10 to 12, further comprising a valve to regulate the contribution of at least one of the gases to the gases mixture.

14. The apparatus of any of Claims 10 to 13, wherein the controller is adapted to control a blower or a valve in response to the determined characteristic.

15. The apparatus of any of Claims 1 to 8, further comprising heat transfer features that increase heat transfer from the gases flowing through the measurement apparatus to a housing of the measurement apparatus and reduce heat transfer from the gases to an environment.

16. The apparatus of Claim 15, wherein the heat transfer features are tracks formed on a surface of a printed circuit board or a moulded component, or a conductive path assembled into the measurement apparatus.

17. The apparatus of any of Claims 1 to 8, wherein the gases measuring chamber is a part of a blower assembly of a gases delivery apparatus, the blower assembly comprising a blower, wherein the blower is the gases source.

18. The apparatus of any of Claims 1 to 8, wherein the gases flow guide comprises a vane.

19. The apparatus of Claim 12, further comprising a humidity sensor is at an intake of the blower.

20. The apparatus of any of Claims 1 to 8 and 10 to 19, further comprising a first humidity sensor located upstream of the gases source.

21. The apparatus of Claim 20, wherein the gases measuring chamber further comprises a second humidity sensor configured to measure humidity of gases flowing in the gases flow path.

22. The apparatus of Claim 21, wherein the controller is further configured to determine the characteristic of the gases based at least in part on signals received from the first and second humidity sensors.

23. The apparatus of any of Claims 1 to 8 and 10 to 19, wherein the inlet of the gases measuring chamber comprises an oxygen inlet and an air inlet, the at least one pressure sensor comprising a first pressure sensor at the oxygen inlet and a second pressure sensor at the air inlet.

24. The apparatus of Claim 23, wherein the at least one pressure sensor further comprises a third pressure sensor at the outlet.

25. The apparatus of Claim 24, wherein the controller is further configured to determine the characteristic of the gases based at least in part on signals received from the first, second, and third pressure sensors.