

HUMIDIFIER

[0001] This application claims priority from United States Provisional Application No. 63/505,008 filed on 30 May 2023, and entitled 'Humidifier', the entire contents of which are hereby incorporated by reference.

TECHNICAL FIELD

[0002] The present disclosure generally relates to humidified gases therapy. More particularly, the present disclosure relates to humidifiers and humidification systems for use in humidified gases therapy.

BACKGROUND

[0003] A patient dealing with respiratory illness, for example chronic obstructive pulmonary disease (COPD), can have difficulty engaging in effective respiration. This difficulty may be the result of a variety of causes, including a breakdown of lung tissue, dysfunctions of the small airways, excessive accumulation of sputum, infection, genetic disorders, or cardiac insufficiency. With some respiratory illnesses, it is useful to provide a therapy that can improve the ventilation of the patient. In some situations, the patient can be provided with a respiratory therapy system that includes a gases source, an interface that may be used to transmit gases to an airway of a patient, and a conduit extending between the gases source and the interface. Gases delivered to the airway of the patient from the gases source can help to promote adequate ventilation. The gases source may include, for example, a container of air and/or another gas suitable for inspiration, e.g., oxygen or nitric oxide, a mechanical blower capable of propelling gases through the conduit to the interface, or some combination of both. The respiratory therapy system can include a gases humidifier that can humidify and heat gases passing through the respiratory therapy system to improve patient comfort and/or improve the prognosis of the patient's respiratory illness. The gases humidifier can include a water reservoir and a heating element for heating the water in the reservoir. As the water heats up, water vapor is formed that can join the stream of gases passing through the gases humidifier.

[0004] The gases humidifier is used to provide humidified respiratory gases to a patient. Gases are delivered to the patient via a patient interface. Examples of a patient interface include an oral mask, a nasal mask, a nasal cannula, a combination of oral and nasal mask, and the like.

[0005] Conventional gases humidifiers are useful in ameliorating the discomfort of cold and dry gases therapies, but are typically configured in such a way that all of the water in the reservoir, or an excess of water, must be heated before the generation of vapor rises to an acceptable level for providing adequately humidified gases. In some

cases, it can take up to half an hour from turning the humidifier on to begin generating sufficient water vapor. Additionally, when settings change and the humidity is reduced, and the water is allowed to cool, the large thermal mass and consequent inertia of cooling make the rate of change slow. Therefore, conventional gases humidifiers may not be able to respond appropriately to changing input conditions, or may have an impaired response in part due to the high thermal inertia of the water in the reservoir.

[0006] In a conventional gases humidifier, there usually will be features within the chamber to encourage the air to take a flow path that puts it in contact with the heated water before it exits through the outlet. When the air passes over the water in the chamber, the gas layers in the immediate vicinity of the water increase in humidity greatly, the layers further away are humidified by a far lesser amount. The humidity of the gas stream received by the patient is a mixture of the few high humidity layers, and the many relatively "dry" layers above. Consequently, a therapy device using such a style of gases humidifier must operate the heater plate at a high temperature to evaporate enough water to sufficiently humidify the close layers and penetrate the "dry" air further away. Therefore, the humidifier may be required to "over humidify" proximal layers in order to penetrate to the distal layers, and / or in order that, when the proximal layers subsequently merge with the "dry" layers, a required overall humidity of the merged gases is achieved.

[0007] The gases that pass closest to the humidifying surface have the greatest fluid or water vapour uptake and have the highest humidity compared to the gases that pass more distant from the humidifying surface. The region of high humidity close to the humidifying surface may be referred to as a "high humidity band" or "high humidity boundary layer".

[0008] In "tub" humidifiers that use a reservoir of fluid as the humidifying surface, as the water level decreases throughout a therapy session, the high humidity band may reduce as the reservoir level and thus surface of the water moves further away from the flow of gases. At the start of a therapy session the "tub" style humidifiers perform best with the water level at the maximum fill line. Therefore, the gas flows through the humidifier as close as possible to the water as the design allows. As time passes and the water level drops, the gap between the flow and the water surface widens causing a decrease in gases flowing close to the water and thus a reduced uptake of water vapour.

[0009] In a vaporization humidifier, the fluid level issue is addressed by using a heated wicking surface element of humidification. However, various aspects may compromise the flow path of the air. In some designs, apertures or baffles protrude from the sides of the humidification chamber to provide and direct gases. These may occupy space in the path of the humidifying gases flow, causing turbulent flow and influencing the transfer of liquid molecules to the gases. Therefore, part of a gases flow may be directed out of the high humidity band.

[0010] US 10688272 B2, the contents of which are incorporated by reference, discloses the delivery of water in controlled quantities to a heated surface to control the humidification of the air stream. The heated surface is coated in a hydrophilic material that wicks water evenly across the area. This uses a smaller volume of water in residence than in the conventional humidification chambers. The vaporization humidifier eliminates the water level issue by switching to a heated wicking surface method of humidification.

[0011] It is an aim of the present disclosure to provide improvements in the flow path of the gases for humidification.

SUMMARY

[0012] The present disclosure provides a water vaporization / humidification system that in some configurations does not require a reservoir of water, or in some configurations does not require an excess of water, to be heated. Disclosed are embodiments which allow a desired amount of water to be quickly vaporized, whilst being in close vicinity of the humidification surface thus improving response time to system or environmental changes, reducing energy requirements and greatly reducing warm-up periods. Some embodiments relate to humidification chambers which may form part of the water vaporization / humidification systems.

[0013] In accordance with certain features, aspects and advantages of at least one of the embodiments disclosed herein, a humidification chamber for a respiratory humidification system is disclosed, the humidification chamber comprising: a humidifying section having an inlet and an outlet; a humidifying element in the humidifying section; and a flow channel for gases to flow from the inlet to the outlet proximal to the humidifying element, the humidifying element configured to humidify a flow of gases passing through the flow channel, wherein a transverse dimension of the flow channel is determined by a target humidity for at least a portion of the gases to achieve at the outlet, said transverse dimension being a function of at least one of: the length of the flow channel; a flow rate of the gases; a temperature of the humidifying element; and a relative gases concentration.

[0014] In accordance with certain features, aspects and advantages of at least one of the embodiments disclosed herein, a humidification chamber for a respiratory humidification system is disclosed, the humidification chamber comprising: a humidifying section having an inlet and an outlet; a humidifying element in the humidifying section; and a flow channel for gases to flow from the inlet to the outlet proximal to the humidifying element, the humidifying element configured to humidify a flow of gases passing through the flow channel, wherein a target humidity for a portion of the gases to achieve at the outlet is determined by a transverse dimension of the flow channel normal to a direction of flow of the gases, the transverse dimension being a function of at least

one of: the length of the flow channel; a flow rate of the gases; a temperature of the humidifying element; and a relative gases concentration.

[0015] Reference to "a function of" made herein is also to mean "related to" or "determined by" and each of the terms are interchangeable where context allows.

[0016] In accordance with certain features, aspects and advantages of at least one of the embodiments disclosed herein, a humidification chamber for a respiratory humidification system is disclosed, the humidification chamber comprising: a humidifying section having an inlet and an outlet; a humidifying element in the humidifying section; and a flow channel for gases to flow from the inlet to the outlet proximal to the humidifying element, the humidifying element configured to humidify a flow of gases passing through the flow channel, wherein a transverse dimension of the flow channel normal to a direction of flow of the gases is such that said gases have a relative humidity of at least about 80% upon reaching the outlet.

[0017] In accordance with certain features, aspects and advantages of at least one of the embodiments disclosed herein, a humidification chamber for a respiratory humidification system is disclosed, the humidification chamber comprising: a humidifying section having an inlet and an outlet, said humidifying section defining a flow channel for the flow of gases between said inlet and outlet, wherein the humidifying section is elongate; wherein said flow channel has a maximum transverse dimension normal to a direction of flow of the gases of about 10 mm; and wherein said transverse dimension is selected such that gases passing through said at least one flow channel achieves at least 80% relative humidity upon reaching the outlet.

[0018] In some configurations, where not previously present, the humidification chamber comprises a humidifying element in the humidifying section.

[0019] In some configurations, the transverse dimension is at most about 10% of a length of the humidifying section measured between the inlet and the outlet.

[0020] In some configurations, the transverse dimension is between a minimum of about 0 mm and a maximum about 22 mm, optionally the transverse dimension is between about 1 mm and about 5 mm.

[0021] In some configurations, a high humidity boundary layer is formed within the humidifying section for humidifying the flow of gases.

[0022] In some configurations, the high humidity boundary layer is formed proximal to the humidifying element.

[0023] In some configurations, the high humidity boundary layer fully develops to a dimension from the humidifying element.

[0024] In some configurations, the transverse dimension of the flow channel is equal to or less than the fully developed high humidity boundary layer dimension to fill at least part of the flow channel with the high humidity boundary layer.

[0025] In some configurations, the fully developed high humidity boundary layer dimension is less than the transverse dimension of the flow channel.

[0026] In some configurations, the transverse dimension of the flow channel normal to the direction of flow of the gases is determined by or a function of at least a flow rate of the flow of gases through humidifying section, wherein an average volumetric flow rate through the humidifying section is between about 0.5 L/min and about 200 L/min, optionally wherein the average volumetric flow rate through the humidifying section is between about 10 L/min and about 100 L/min, optionally, wherein the average volumetric flow rate through the humidifying section is at most about 70 L/min.

[0027] In some configurations, the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a temperature of the humidifying element, wherein an average temperature of the humidifying element is between about 0°C and 100°C, optionally wherein an average temperature of the humidifying element is between about 30°C and about 80°C, optionally wherein an average temperature of the humidifying element is between about 60°C and about 80°C.

[0028] In some configurations, the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a flow rate of the flow of gases through humidification chamber, wherein a mass flow rate of gases is less than about 300 g/min.

[0029] In some configurations, either the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least the volumetric flow rate of liquid supplied to the humidifying element, or wherein there is a volumetric flow rate of liquid supplied to the humidifying element, wherein the volumetric flow rate of liquid being at least about 10 µl/min.

[0030] In some configurations, the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least an oxygen fraction of the gases through the flow channel, and wherein the oxygen fraction of the gases is between about 21% to about 100%, optionally wherein oxygen fraction of the gases is between about 30% to about 50%.

[0031] In some configurations, the length of the flow channel and/or humidifying section is between about 5 mm to about 300 mm, optionally wherein the length of the flow channel is between about 50 mm to about 200 mm, optionally wherein the length of the flow channel is between about 90 mm to about 200 mm.

[0032] In some configurations, the width of the flow channel is between about 0.1 mm to about 500 mm, optionally wherein the width of the flow channel is between about 5 mm to about 20 mm.

[0033] In some configurations, the surface area of the humidifying element is about 10 mm² to about 10,000 mm², optionally wherein the surface area of the humidifying element is between about 40 mm² to about 3,000 mm².

[0034] In some configurations, either the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a liquid flow rate to the humidifying element, or wherein there is a liquid flow rate to the humidifying element, wherein the liquid flow rate is between about 0.1 mL/min and about 50 mL/min, optionally wherein the liquid flow rate is between about 1 mL/min and about 5 mL/min.

[0035] In some configurations, either the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least an inlet gases temperature to the humidifying section, or wherein there is an inlet gases temperature to the humidifying section, wherein the inlet gases temperature is between about 0°C and about 50°C, optionally wherein the inlet gases temperature is between about 15°C and about 35°C.

[0036] In some configurations, either the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least an outlet gases temperature from the humidifying section, or wherein there is an outlet gases temperature from the humidifying section, wherein the outlet gases temperature is between about 18°C and about 70°C, optionally wherein the outlet gases temperature is between about 30°C and about 40°C.

[0037] In some configurations, the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a humidity of the outlet gases from the humidifying section, wherein the humidity of the outlet gases is between about 12 mg/L and about 62 mg/L, optionally wherein the humidity of the outlet gases is between about 40 mg/L and about 50 mg/L.

[0038] In some configurations, the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a humidity of the inlet gases to the humidifying section, wherein the humidity of the inlet gases is between about 0 mg/L and about 50 mg/L, optionally wherein the humidity of the inlet gases is between about 0.1 mg/L and about 5 mg/L.

[0039] In some configurations, the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a flow velocity of gases through the flow channel, wherein the flow velocity of the gases is between about 0.003 m/s and about 330 m/s, optionally wherein the flow velocity of the gases is between about 0.1 m/s and about 30 m/s.

[0040] In some configurations, either the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a ratio of the cross-sectional area of humidifying section inlet to the cross-sectional area of the flow channel, or wherein there is a ratio of the cross-sectional area of humidifying section inlet to the cross-sectional area of the flow channel, wherein the ratio is between about 1:10 and about 12:1.

[0041] In some configurations, the transverse dimension of the flow channel normal to the direction of flow of the gases is determined by a function comprising all of: the length of the flow channel; the flow rate of the gases; the temperature of the humidifying element; and the relative gases concentration.

[0042] In some configurations, the transverse dimension of the flow channel is such that at least about 90% of the flow of gases of the flow channel passes proximal to the humidifying element.

[0043] In some configurations, the humidification chamber comprises an inlet antechamber at, upstream or in fluid communication with the inlet of the humidifying section, the inlet antechamber for delivering the flow of gases to the humidifying section.

[0044] In some configurations, the humidification chamber comprises an outlet antechamber at, downstream or in fluid communication with the outlet of the humidifying section, the outlet antechamber for delivering the flow of gases from the humidifying section.

[0045] In some configurations, the humidifying section comprises at least one wall or wall portion extending between the inlet and the outlet, the flow channel defined as a gases flow area between the humidifying element and the at least one wall or wall portion.

[0046] In some configurations, the transverse dimension of the flow channel is limited by a distance between the humidifying element and the at least one wall or wall portion for the flow channel.

[0047] In some configurations, a cross-sectional gases flow area at any location in the humidifying section is less than a cross-sectional gases flow area at any location in the outlet antechamber.

[0048] In some configurations, the inlet antechamber is shaped to direct the flow of gases substantially parallel to the humidifying element.

[0049] In some configurations, the portion of the gases is substantially all of the gases in the flow channel.

[0050] In some configurations, the humidifying element is centrally positioned in the humidifying section.

[0051] In some configurations, the flow channel is split into a plurality of flow channels.

[0052] In some configurations, the flow channel is a plurality of flow channels.

[0053] In some configurations, the transverse dimension of each of the at least one flow channels is as hereinbefore described.

[0054] In some configurations, the humidifying element splits the at least one flow channel into the plurality of flow channels.

[0055] In some configurations, the plurality of flow channels are separated by the humidifying element.

[0056] In some configurations, the outlet antechamber has a tapered configuration, wherein the gases flow area of the flow channel is increased from a portion of the outlet antechamber adjacent to the humidifying section to a downstream portion of the outlet antechamber.

[0057] In some configurations, a distance between an upper wall or upper wall portion and a lower wall or lower wall portion of the humidifying section is smaller than the distance between an upper wall or upper wall portion and a lower wall or lower wall portion of the outlet antechamber when viewed from the side to increase the flow area of the gases flow path from the humidifying section to the outlet antechamber.

[0058] In some configurations, the inlet antechamber has at least one angled surface extending to and adjacent one of the at least one wall or wall portion of the humidifying section for directing the flow of gases through the humidifying section.

[0059] In some configurations, the at least one angled surface directs the flow of gases onto at least one surface of the humidifying element.

[0060] In some configurations, the flow of gases are directed substantially parallel along the at least one surface of the humidifying element, optionally, this may be following being directed onto the at least one surface of the humidifying element.

[0061] In some configurations, an internal angle inside the humidification chamber between the angled surface and the adjacent wall or wall portion is a reflex angle.

[0062] In some configurations, an internal angle between the angled surface and the adjacent wall or wall portion of the humidifying section is between about 200° and 260°.

[0063] In some configurations, an internal angle between the angled surface and the adjacent wall or wall portion of the humidifying section is between about 220° and 240°.

[0064] In some configurations, the inlet antechamber comprises two symmetrically opposed angled surfaces.

[0065] In some configurations, the inlet antechamber is nozzle shaped.

[0066] In some configurations, the outlet antechamber is diffuser shaped.

[0067] In some configurations, the humidifying element has a substantially rounded or tapered leading edge at or adjacent to the inlet.

[0068] In some configurations, a thickness of the humidifying element is increased from the inlet through a portion of the humidifying section when viewed from the side to reduce the transverse dimension of the or each at least one flow channel.

[0069] In some configurations, the flow area of the gases flow path is reduced from the inlet antechamber to the humidifying section.

[0070] In some configurations, a distance between an upper wall or upper wall portion and a lower wall or lower wall portion of the inlet antechamber is greater than a

distance between an upper wall or upper wall portion and a lower wall or lower wall portion of the humidifying section.

[0071] In some configurations, the inlet antechamber is a mirrored shape of the outlet antechamber.

[0072] In some configurations, the outlet antechamber has at least one angled surface extending from and adjacent one of the at least one wall or wall portion of the humidifying section at the downstream outlet.

[0073] In some configurations, an internal angle of the angled surface of the outlet antechamber adjacent the wall or wall portion is less than that of the internal angle of the angled surface of the inlet antechamber adjacent the wall or wall portion.

[0074] In some configurations, a slope from the horizontal plane of the angled surface of the outlet antechamber adjacent the wall or wall portion is less than that of a slope from the horizontal plane of the angled surface of the inlet antechamber adjacent the wall or wall portion.

[0075] In some configurations, at least one of the humidifying section and / or humidifying element is substantially rectangular in cross-section.

[0076] In some configurations, at least one of the humidifying section and / or humidifying element is substantially circular in cross-section.

[0077] In some configurations, the transverse dimension of the flow channel is greater at the inlet end of the humidifying element compared to the outlet end of the humidifying element.

[0078] In some configurations, the transverse dimension of the flow channel is smallest at a position along the humidifying element between the inlet and the outlet.

[0079] In some configurations, an inner surface of the at least one wall or wall portion of the humidifying section facing the humidifying element has ridges or bumps.

[0080] In some configurations, the ridges or bumps are positioned along substantially the length of the humidifying section.

[0081] In some configurations, the ridges or bumps extend substantially perpendicular to the length of the humidifying section.

[0082] In some configurations, the humidifying element comprises at least one first humidifying plate connected to and extending from one of the walls or wall portion of the humidifying section toward the opposite wall or wall portion, the at least one first humidifying plate with a gap provided between the opposite wall or wall portion.

[0083] In some configurations, the humidifying element comprises at least one second humidifying plate positioned next to the at least one first humidifying plate, the at least one second humidifying plate separated from the first humidifying plate and extending from and connected to the opposite wall or wall portion of the humidifying section, the at least one second humidifying plate with a gap provided between the wall or wall portion to which the first humidifying plate is connected.

[0084] In some configurations, the at least one first humidifying plate and at least one second humidifying plate are angled when viewed from a side direction.

[0085] In some configurations, the humidification chamber comprises at least one first baffle, wherein the at least one first baffle is connected to and extends from one of the wall or wall portion toward the humidifying element, wherein a gap is provided between the at least one first baffle and the humidifying element.

[0086] In some configurations, the humidification chamber comprises at least one second baffle, wherein the at least one second baffle is connected to and extends from the wall or wall portion opposite the at least one first baffle, the at least one second baffle extending toward the humidifying element, wherein a gap is provided between the at least one second baffle and the humidifying element.

[0087] In some configurations, the at least one first baffle and / or the at least one second baffle is angled when viewed from a side direction.

[0088] In some configurations, the at least one first baffle and / or the at least one second baffle is angled toward the downstream end when viewed from a side direction such that the connected end is closer to the upstream end than an opposite end of the or each baffle.

[0089] In some configurations, the humidification chamber comprises a plurality of the first baffles and / or the second baffles, the baffles being substantially equally distanced apart in a length direction when viewed from the side.

[0090] In some configurations, the humidifying element is provided on an inner surface (e.g. at least one wall or wall portion) of the humidifying section.

[0091] In some configurations, the humidifying element comprises a liquid reservoir.

[0092] In some configurations, the humidification chamber comprises a heating plate in or under the liquid reservoir to heat liquid in the liquid reservoir.

[0093] In some configurations, the humidification chamber comprises a gases inlet in fluid communication to the inlet antechamber and/or humidifying section inlet, the gases inlet for providing the gases for humidification, and a gases outlet in fluid communication to the outlet antechamber and/or humidifying section outlet, the gases outlet for delivering humidified gases to a patient interface.

[0094] In some configurations, the cross-sectional flow area of the gases flow path of the flow channel normal to the direction of flow of the gases is at most about 25% of the cross-sectional flow area of the gases flow path normal to the direction of flow of the gases at the gases inlet. Optionally, the gases inlet is upstream of the inlet antechamber.

[0095] In some configurations, the inlet antechamber and outlet antechamber are substantially coaxially aligned along an axis extending between the inlet and outlet of the humidifying section.

[0096] In some configurations, the humidification chamber comprises a liquid inlet, the liquid inlet configured to deliver liquid to the humidifying element.

[0097] In accordance with certain features, aspects and advantages of at least one of the embodiments disclosed herein, a respiratory humidification system for providing humidification to gases before being provided to an airway of a patient is disclosed, the respiratory humidification system comprising a humidification chamber as described above in any aspect optionally combined with any number of configurations.

[0098] In accordance with certain features, aspects and advantages of at least one of the embodiments disclosed herein, a respiratory humidification system is disclosed, wherein the respiratory humidification system is for providing humidification to gases before being provided to an airway of a patient, the respiratory humidification system comprising a humidification chamber comprising: a humidifying section having an inlet and an outlet; a humidifying element in the humidifying section; and a flow channel for gases to flow from the inlet to the outlet proximal to the humidifying element, the humidifying element configured to humidify a flow of gases passing through the flow channel, wherein a transverse dimension of the flow channel is determined by a target humidity for at least a portion of the gases to achieve at the outlet, said transverse dimension being a function of at least one of: the length of the flow channel; a flow rate of the gases; a temperature of the humidifying element; and a relative gases concentration.

[0099] In some configurations, the respiratory humidification system further comprises a flow generator to deliver gases to the humidification chamber.

[00100] In some configurations, the respiratory humidification system further comprises a patient interface to deliver humidified gases from the humidification chamber to a patient.

[00101] In accordance with certain features, aspects and advantages of at least one of the embodiments disclosed herein, a humidification chamber for a respiratory humidification system is disclosed, the humidification chamber defining a gases flow path, the humidification chamber comprising: an elongate humidifying section having an upstream end and a downstream end; an inlet antechamber at the upstream end of the humidifying section; and an outlet antechamber at the downstream end of the humidifying section, wherein a flow area of the gases flow path is reduced from the inlet antechamber to the humidifying section.

[00102] In some configurations, the inlet antechamber and outlet antechamber are substantially coaxially aligned along an axis.

[00103] In some configurations, the axis substantially extends in a direction between the upstream end and the downstream end of the humidifying section.

[00104] In some configurations, a resultant flow of gases through the inlet antechamber is substantially in a same flow direction as a resultant flow of gases through the outlet antechamber.

- [00105]** In some configurations, a resultant flow of gases through the humidifying section is substantially in a same flow direction as a gases flow through the inlet antechamber and through the outlet antechamber.
- [00106]** In some configurations, the humidification chamber comprises a gases inlet in fluid communication with the inlet antechamber and/or humidifying section inlet, the gases inlet for providing the gases for humidification, and a gases outlet in fluid communication with the outlet antechamber and/or humidifying section outlet, the gases outlet for delivering humidified gases to a patent interface.
- [00107]** In some configurations, the gases inlet and gases outlet are substantially coaxially aligned along an axis.
- [00108]** In some configurations, a gases flow between the inlet antechamber and the humidifying section is substantially laminar.
- [00109]** In some configurations, a gases flow between the inlet antechamber and the outlet antechamber is substantially laminar.
- [00110]** In some configurations, the humidifying section comprises a humidifying element configured to humidify the gases in the gases flow path passing through the humidifying section.
- [00111]** In some configurations, the gases flow proximate to the humidifying element through the humidifying section.
- [00112]** In some configurations, the humidifying section comprises at least one wall or wall portion extending between the upstream end and the downstream end, the humidifying element and at least one wall or wall portion defining a flow channel for the gases flow path from the upstream end to the downstream end.
- [00113]** In some configurations, the flow channel has a transverse dimension normal to the direction of flow of the gases through the flow channel.
- [00114]** In some configurations, the maximum transverse dimension of the flow channel is configured to enable a target fraction of the gases to reach a target humidity at the outlet antechamber.
- [00115]** In some configurations, the direction of the flow of the gases through the flow channel is the resultant flow at a given point in the flow channel.
- [00116]** In some configurations, the target fraction of the gases is substantially all of the gases in the gases flow path.
- [00117]** In some configurations, the transverse dimension of the flow channel is a function of at least one of: a flow velocity of the gases; a temperature of the humidifying element; a length of the channel between the upstream end and the downstream end, and a relative gases concentration.
- [00118]** In some configurations, the transverse dimension is at most about 10% of a length of the humidifying section measured between the upstream end and the downstream end.

[00119] In some configurations, the transverse dimension is between about 0 mm and about 22 mm, optionally the transverse dimension is between about 1 mm and about 5 mm.

[00120] In some configurations, a high humidity boundary layer is formed within the humidifying section for humidifying the flow of gases.

[00121] In some configurations, the high humidity boundary layer is formed proximal to the humidifying element.

[00122] In some configurations, the high humidity boundary layer fully develops to a dimension from the humidifying element.

[00123] In some configurations, the transverse dimension of the flow channel is equal to or less than the fully developed high humidity boundary layer dimension to fill at least part of the flow channel with the high humidity boundary layer.

[00124] In some configurations, the fully developed high humidity boundary layer dimension is less than the transverse dimension of the flow channel.

[00125] In some configurations, the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a flow rate of the flow of gases through humidifying section, wherein an average volumetric flow rate through the humidifying section is between about 0.5 L/min and about 200 L/min, optionally wherein the average volumetric flow rate through the humidifying section is between about 10 L/min and about 100 L/min, optionally, wherein the average volumetric flow rate through the humidifying section is at most about 70 L/min.

[00126] In some configurations, the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a temperature of the humidifying element, wherein an average temperature of the humidifying element is between about 0°C and 100°C, optionally wherein an average temperature of the humidifying element is between about 30°C and about 80°C, optionally wherein an average temperature of the humidifying element is between about 60°C and about 80°C.

[00127] In some configurations, the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a flow rate of the flow of gases through the humidifying section or humidification chamber, wherein a mass flow rate of gases is less than about 300g/min.

[00128] In some configurations, either the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least the volumetric flow rate of liquid supplied to the humidifying element, or wherein there is a volumetric flow rate of liquid supplied to the humidifying element, wherein the volumetric flow rate of liquid being at least about 10 µl/min.

[00129] In some configurations, the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least an oxygen fraction of the gases through the flow channel, wherein the gases comprise oxygen, and wherein

the oxygen fraction of the gases is between about 21% to about 100%, optionally wherein oxygen fraction of the gases is between about 30% to about 50%.

[00130] In some configurations, the length of flow channel and/or humidifying section is between about 5 mm to about 300 mm, optionally wherein the length of flow channel is between about 50 mm to about 200 mm, optionally wherein the length of the flow channel is between about 90 mm to about 200 mm.

[00131] In some configurations, the width of flow channel is between about 0.1 mm to about 500 mm, optionally wherein the width of flow channel is between about 5 mm to about 20 mm.

[00132] In some configurations, the surface area of humidifying element is about 10 mm² to about 10,000 mm², optionally wherein the surface area of humidifying element is between about 40 mm² to about 3,000 mm².

[00133] In some configurations, either the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a liquid flow rate to the humidifying element, or wherein there is a liquid flow rate to the humidifying element, wherein the liquid flow rate is between about 0.1 mL/min and about 50 mL/min, optionally wherein the liquid flow rate is between about 1 mL/min and about 5 mL/min.

[00134] In some configurations, either the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least an inlet gases temperature to the humidifying section, or wherein there is an inlet gases temperature to the humidifying section, wherein the inlet gases temperature is between about 0°C and about 50°C, optionally wherein the inlet gases temperature is between about 15°C and about 35°C.

[00135] In some configurations, either the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least an outlet gases temperature from the humidifying section, or wherein there is an outlet gases temperature from the humidifying section, wherein the outlet gases temperature is between about 18°C and about 70°C, optionally wherein the outlet gases temperature is between about 30°C and about 40°C.

[00136] In some configurations, the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a humidity of the outlet gases from the humidifying section, wherein the humidity of the outlet gases is between about 12 mg/L and about 62 mg/L, optionally wherein the humidity of the outlet gases is between about 40 mg/L and about 50 mg/L.

[00137] In some configurations, the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a humidity of the inlet gases to the humidifying section, wherein the humidity of the inlet gases is between about 0 mg/L and about 50 mg/L, optionally wherein the humidity of the inlet gases is between about 0.1 mg/L and about 5 mg/L.

[00138] In some configurations, the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a flow velocity of gases through the flow channel, wherein the flow velocity of the gases is between about 0.003 m/s and about 330 m/s, optionally wherein the flow velocity of the gases is between about 0.1 m/s and about 30 m/s.

[00139] In some configurations, either the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a ratio of the cross-sectional area of humidifying section inlet to the cross-sectional area of the flow channel, or wherein there is a ratio of the cross-sectional area of humidifying section inlet to the cross-sectional area of the flow channel, wherein the ratio is between about 1:10 and about 12:1.

[00140] In some configurations, the humidification chamber is configured for use in an ambulance.

[00141] In some configurations, the humidification chamber is suitable for use with no water or a limited volume of water.

[00142] In some configurations, the humidification chamber is dimensioned in a compact manner.

[00143] In some configurations, the transverse dimension of the flow channel normal to the direction of flow of the gases is determined by a function comprising: the length of the flow channel; the flow rate of the gases; the temperature of the humidifying element; and the relative gases concentration.

[00144] In some configurations, the humidifying element extends in a direction between the upstream end and the downstream end.

[00145] In some configurations, the humidifying element is centrally positioned in the humidification section.

[00146] In some configurations, the gases flow path is a plurality of flow channels.

[00147] In some configurations, the gases flow path is split into a plurality of flow channels.

[00148] In some configurations, the humidifying element splits the gases flow path into a plurality of the flow channels.

[00149] In some configurations, the plurality of flow channels are separated by the humidifying element.

[00150] In some configurations, the transverse dimension of each of the at least one flow channels is as hereinbefore described.

[00151] In some configurations, the inlet antechamber is shaped to direct gases through the humidifying section.

[00152] In some configurations, the inlet antechamber has at least one angled surface extending to and adjacent one of the at least one wall or wall portion of the humidifying section for directing the flow of gases through the humidifying section.

[00153] In some configurations, the at least one angled surface directs the flow of gases onto at least one surface of the humidifying element.

[00154] In some configurations, the flow of gases are directed substantially parallel along the at least one surface of the humidifying element, optionally, this may be following being directed onto the at least one surface of the humidifying element.

[00155] In some configurations, an internal angle inside the humidification chamber between the angled surface and the adjacent wall or wall portion is a reflex angle.

[00156] In some configurations, an internal angle between the angled surface and the adjacent wall or wall portion of the humidifying section is between about 200° and 260°.

[00157] In some configurations, an internal angle between the angled surface and the adjacent wall or wall portion of the humidifying section is between about 220° and 240°.

[00158] In some configurations, the inlet antechamber comprises two symmetrically opposed angled surfaces.

[00159] In some configurations, the humidifying element has a substantially rounded or tapered leading edge at or adjacent to the upstream end.

[00160] In some configurations, a thickness of the humidifying element is increased from the upstream end through a portion of the humidifying section when viewed from the side to reduce the transverse dimension of the or each at least one flow channel.

[00161] In some configurations, the flow area of the gases flow path is reduced from the inlet antechamber to the humidifying section.

[00162] In some configurations, a distance between an upper wall or upper wall portion and a lower wall or lower wall portion of the inlet antechamber is greater than a distance between an upper wall or upper wall portion and a lower wall or lower wall portion of the humidifying section.

[00163] In some configurations, the inlet antechamber is a mirrored shape of the outlet antechamber.

[00164] In some configurations, the outlet antechamber has at least one angled surface extending from and adjacent one of the at least one wall or wall portion of the humidifying section at the downstream end.

[00165] In some configurations, an internal angle of the angled surface of the outlet antechamber adjacent the wall or wall portion is less than that of the internal angle of the angled surface of the inlet antechamber adjacent the wall or wall portion.

[00166] In some configurations, a slope from the horizontal plane of the angled surface of the outlet antechamber adjacent the wall or wall portion is less than that of a slope from the horizontal plane of the angled surface of the inlet antechamber adjacent the wall or wall portion.

- [00167]** In some configurations, at least one of the humidifying section and / or humidifying element is substantially rectangular in cross-section.
- [00168]** In some configurations, at least one of the humidifying section and / or humidifying element is substantially circular in cross-section.
- [00169]** In some configurations, at least one of the humidifying section and / or humidifying element is substantially elliptical in cross-section.
- [00170]** In some configurations, the transverse dimension of the or each at least one flow channel is greater at the upstream inlet end of the humidifying element compared to the downstream end of the humidifying element.
- [00171]** In some configurations, the transverse dimension of the or each at least one flow channel is smallest at a position along the humidifying element between the upstream end and the downstream end.
- [00172]** In some configurations, an inner surface of the at least one wall or wall portion of the humidifying section facing the humidifying element has ridges or bumps.
- [00173]** In some configurations, the ridges or bumps are positioned along substantially the length of the humidifying section.
- [00174]** In some configurations, the ridges or bumps extend substantially perpendicular to the length of the humidifying section.
- [00175]** In some configurations, the humidifying element comprises at least one first humidifying plate connected to and extending from one of the walls or wall portion of the humidifying section toward the opposite wall or wall portion, the at least one first humidifying plate with a gap provided between the opposite wall or wall portion.
- [00176]** In some configurations, the humidifying element comprises at least one second humidifying plate positioned next to the at least one first humidifying plate, the at least one second humidifying plate separated from the first humidifying plate and extending from and connected to the opposite wall or wall portion of the humidifying section, the at least one second humidifying plate with a gap provided between the wall or wall portion to which the first humidifying plate is connected.
- [00177]** In some configurations, the at least one first humidifying plate and at least one second humidifying plate are angled when viewed from a side direction.
- [00178]** In some configurations, the humidification chamber comprises at least one first baffle, wherein the at least one first baffle is connected to and extends from one of the wall or wall portion toward the humidifying element, wherein a gap is provided between the at least one first baffle and the humidifying element.
- [00179]** In some configurations, the humidification chamber comprises at least one second baffle, wherein the at least one second baffle is connected to and extends from the wall or wall portion opposite the at least one first baffle, the at least one second baffle extending toward the humidifying element, wherein a gap is provided between the at least one second baffle and the humidifying element.

[00180] In some configurations, the at least one first baffle and / or the at least one second baffle is angled when viewed from a side direction.

[00181] In some configurations, the at least one first baffle and / or the at least one second baffle is angled toward the downstream end when viewed from a side direction such that the connected end is closer to the upstream end than an opposite end of the or each baffle.

[00182] In some configurations, the humidification chamber comprises a plurality of the first baffles and / or the second baffles, the baffles being substantially equally distanced apart in a length direction when viewed from the side.

[00183] In some configurations, the humidifying element is provided on an inner surface (e.g. at least one wall or wall portion) of the humidifying section.

[00184] In some configurations, the humidifying element comprises a liquid reservoir.

[00185] In some configurations, the humidification chamber comprises a heating plate in or under the liquid reservoir to heat liquid in the liquid reservoir.

[00186] In some configurations, the humidification chamber comprises a gases inlet in fluid communication to the inlet antechamber and/or humidifying section inlet, the gases inlet for providing the gases for humidification, and a gases outlet in fluid communication to the outlet antechamber and/or humidifying section outlet, the gases outlet for delivering humidified gases to a patient interface.

[00187] In some configurations, the cross-sectional flow area of the gases flow path of the or each at least one flow channel normal to the direction of flow of the gases is at most about 25% of the cross-sectional flow area of the gases flow path normal to the direction of flow of the gases at the gases inlet, or the gases inlet end of the inlet antechamber or the gases inlet end of the humidifying section inlet.

[00188] In some configurations, the inlet antechamber and outlet antechamber are substantially coaxially aligned along an axis extending between the upstream end and downstream end of the humidifying section.

[00189] In some configurations, the humidification chamber comprises a liquid inlet, the liquid inlet configured to deliver liquid to the humidifying element.

[00190] In accordance with certain features, aspects and advantages of at least one of the embodiments disclosed herein, a respiratory humidification system for providing humidification to gases before being provided to an airway of a patient is disclosed, the respiratory humidification system comprising a humidification chamber as described above optionally combined with any number of configurations.

[00191] In some configurations, the respiratory humidification system further comprises a flow generator to deliver gases to the humidification chamber.

[00192] In some configurations, the respiratory humidification system further comprises a patient interface to deliver humidified gases from the humidification chamber to a patient.

[00193] In accordance with certain features, aspects and advantages of at least one of the embodiments disclosed herein, a humidification chamber for a respiratory humidification system is disclosed, the humidification chamber comprising: a gases inlet and a gases outlet defining a flow path therebetween for a flow of gases; a humidifying section having an upstream end and a downstream end, and having a flow channel for the flow of gases; an inlet antechamber positioned between the gases inlet and the upstream end of the humidifying section and comprising a wall or wall portion extending between the gases inlet and the upstream end and having a flow channel for the flow of gases therebetween; and a humidifying element positioned in the humidifying section, configured to allow the flow of gases over at least one surface or surface portion of the humidifying element to humidify the flow of gases in the flow path, wherein, the flow channel through the humidifying section is smaller in size than the flow channel through the inlet antechamber, wherein the size of the flow channel of the humidifying section is measured as a dimension in a transverse direction of said flow channel extending from the at least one surface or surface portion of the humidifying element to an opposing surface or opposing part of the surface portion, and the size of the flow channel of the inlet antechamber is measured as a dimension in a transverse direction of said flow channel extending from the at least one wall or wall portion of the inlet antechamber to an opposing at least one wall or opposing part of the wall portion.

[00194] In some configurations, the transverse direction is normal to the resultant direction of the flow of gases through the flow channel of the humidifying section.

[00195] In some configurations, a high humidity boundary layer is formed within the humidifying section for humidifying the flow of gases.

[00196] In some configurations, the high humidity boundary layer is formed proximal to the humidifying element.

[00197] In some configurations, the high humidity boundary layer fully develops to a dimension from the humidifying element.

[00198] In some configurations, the transverse dimension of the flow channel is equal to or less than the fully developed high humidity boundary layer dimension to fill at least part of the flow channel with the high humidity boundary layer.

[00199] In some configurations, the fully developed high humidity boundary layer dimension is less than the transverse dimension of the flow channel.

[00200] In some configurations, the transverse direction is measured to the dimension of the respective flow channel that contains at least about 90% of the flow of gases.

[00201] In some configurations, the transverse direction of the flow channel through the inlet antechamber is measured to the dimension of an opposing at least one wall or opposing part of the wall portion.

[00202] In some configurations, the transverse direction of the flow channel through the humidifying section is measured to the dimension of an opposing surface or the opposing part of the surface portion.

[00203] In some configurations, the transverse direction of the flow channel through the inlet antechamber is measured normal to the at least one wall or part of the wall portion.

[00204] In some configurations, the transverse direction of the flow channel through the humidifying section is measured normal to the surface or surface portion.

[00205] In some configurations, the gases inlet and the gases outlet are substantially coaxially aligned along an axis.

[00206] In some configurations, a resultant flow of gases through the gases inlet is substantially in a same flow direction as a resultant flow of gases through the gases outlet.

[00207] In some configurations, a resultant flow of gases through the humidifying section is substantially in a same flow direction as the flow through gases inlet and through the gases outlet.

[00208] In some configurations, a gases flow between the inlet antechamber and the humidifying section is substantially laminar.

[00209] In some configurations, a gases flow between the gases inlet and the gases outlet is substantially laminar.

[00210] In some configurations, the humidification chamber comprises an outlet antechamber positioned between the gases outlet and the downstream end of the humidifying section and comprising a wall or wall portion extending between the downstream end and the gases outlet and having a flow channel for the flow of gases therebetween.

[00211] In some configurations, the inlet antechamber and outlet antechamber are substantially coaxially aligned along an axis.

[00212] In some configurations, the axis substantially extends in a direction between the upstream end and the downstream end of the humidifying section

[00213] In some configurations, a resultant flow of gases through the inlet antechamber is substantially in a same flow direction as a resultant flow of gases through the outlet antechamber.

[00214] In some configurations, a resultant flow of gases through the humidifying section is substantially in a same flow direction as a gases flow through the inlet antechamber and through the outlet antechamber.

[00215] In some configurations, the gases flow proximate to the humidifying element through the humidifying section.

[00216] In some configurations, the humidifying section comprises at least one wall or wall portion extending between the upstream end and the downstream end, the at least one surface or surface portion of the humidifying element and at least one wall or wall portion of the humidifying section defining the flow channel through the humidifying section for the gases flow path from the upstream end to the downstream end.

[00217] In some configurations, the maximum size of the flow channel through the humidifying section is configured to enable a target fraction of the gases to reach a target humidity at the outlet antechamber.

[00218] The size of the flow channel through the humidifying section measured as a dimension in a transverse direction of said flow channel may be referred to as a transverse dimension.

[00219] In some configurations, the direction of the flow of the gases through the flow channel is the resultant flow at a given point in the flow channel through the humidifying section.

[00220] In some configurations, the target fraction of the gases is substantially all of the gases in the gases flow path.

[00221] In some configurations, the transverse dimension of the flow channel is a function of at least one of: a flow velocity of the gases; a temperature of the humidifying element; a length of the flow channel through the humidifying section between the upstream end and the downstream end, and a relative gases concentration.

[00222] In some configurations, the transverse dimension is at most about 10% of a length of the humidifying section measured between the upstream end and the downstream end.

[00223] In some configurations, the transverse dimension is between about 0 mm and about 22 mm, optionally the transverse dimension is between about 1 mm and about 5 mm.

[00224] In some configurations, the transverse dimension of the flow channel through the humidifying section is a function of at least a flow rate of the flow of gases through humidifying section, wherein an average volumetric flow rate through the humidifying section is between about 0.5 L/min and about 200 L/min, optionally wherein the average volumetric flow rate through the humidifying section is between about 10 L/min and about 100/L/min, optionally, wherein the average volumetric flow rate through the humidifying section is at most about 70 L/min.

[00225] In some configurations, the transverse dimension of the flow channel through the humidifying section is a function of at least a temperature of the humidifying element, wherein an average temperature of the humidifying element is between about 0°C and 100°C, optionally wherein an average temperature of the humidifying element is

between about 30°C and about 80°C, optionally wherein an average temperature of the humidifying element is between about 60°C and about 80°C.

[00226] In some configurations, the transverse dimension of the flow channel through the humidifying section is a function of at least a flow rate of the flow of gases through the humidifying section or the humidification chamber, wherein a mass flow rate of gases is less than about 300g/min.

[00227] In some configurations, either the transverse dimension of the flow channel through the humidifying section is a function of at least the volumetric flow rate of liquid supplied to the humidifying element, or wherein there is a volumetric flow rate of liquid supplied to the humidifying element, wherein the volumetric flow rate of liquid being at least about 10 µl/min.

[00228] In some configurations, the transverse dimension of the flow channel through the humidifying section is a function of at least an oxygen fraction of the gases through the flow channel, wherein the gases comprise oxygen, and wherein the oxygen fraction of the gases is between about 21% to about 100%, optionally wherein oxygen fraction of the gases is between about 30% to about 50%.

[00229] In some configurations, the length of flow channel through the humidifying section is between about 5 mm to about 300 mm, optionally wherein the length of flow channel is between about 50 mm to about 200 mm, optionally wherein the length of the flow channel is between about 90 mm to about 200 mm.

[00230] In some configurations, the width of flow channel through the humidifying section is between about 0.1 mm to about 500 mm, optionally wherein the width of flow channel is between about 5 mm to about 20 mm.

[00231] In some configurations, the surface area of humidifying element is about 10 mm² to about 10,000 mm², optionally wherein the surface area of humidifying element is between about 40 mm² to about 3,000 mm².

[00232] In some configurations, either the transverse dimension of the flow channel through the humidifying section is a function of at least a liquid flow rate to the humidifying element, or wherein there is a liquid flow rate to the humidifying element, wherein the liquid flow rate is between about 0.1 mL/min and about 50 mL/min, optionally wherein the liquid flow rate is between about 1 mL/min and about 5 mL/min.

[00233] In some configurations, either the transverse dimension of the flow channel through the humidifying section is a function of at least an inlet gases temperature to the humidifying section, or wherein there is an inlet gases temperature to the humidifying section, wherein the inlet gases temperature is between about 0°C and about 50°C, optionally wherein the inlet gases temperature is between about 15°C and about 35°C.

[00234] In some configurations, either the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least an outlet

gases temperature from the humidifying section, or wherein there is an outlet gases temperature from the humidifying section, wherein the outlet gases temperature is between about 18°C and about 70°C, optionally wherein the outlet gases temperature is between about 30°C and about 40°C.

[00235] In some configurations, the transverse dimension of the flow channel through the humidifying section is a function of at least a humidity of the outlet gases from the humidifying section, wherein the humidity of the outlet gases is between about 12 mg/L and about 62 mg/L, optionally wherein the humidity of the outlet gases is between about 40 mg/L and about 50 mg/L.

[00236] In some configurations, the transverse dimension of the flow channel through the humidifying section is a function of at least a humidity of the inlet gases to the humidifying section, wherein the humidity of the inlet gases is between about 0 mg/L and about 50 mg/L, optionally wherein the humidity of the inlet gases is between about 0.1 mg/L and about 5 mg/L.

[00237] In some configurations, the transverse dimension of the flow channel through the humidifying section is a function of at least a flow velocity of gases through the flow channel, wherein the flow velocity of the gases is between about 0.003 m/s and about 330 m/s, optionally wherein the flow velocity of the gases is between about 0.1 m/s and about 30 m/s.

[00238] In some configurations, either the transverse dimension of the flow channel through the humidifying section is a function of at least a ratio of the cross-sectional area of humidifying section inlet to the cross-sectional area of the flow channel, or wherein there is a ratio of the cross-sectional area of humidifying section inlet to the cross-sectional area of the flow channel, wherein the ratio is between about 1:10 and about 12:1.

[00239] In some configurations, the humidification chamber is configured for use in an ambulance.

[00240] In some configurations, the humidification chamber is suitable for use with no water or a limited volume of water.

[00241] In some configurations, the humidification chamber is dimensioned in a compact manner.

[00242] In some configurations, the transverse dimension of the flow channel through the humidifying section is determined by a function comprising: the length of the flow channel; the flow rate of the gases; the temperature of the humidifying element; and the relative gases concentration.

[00243] In some configurations, the humidifying element extends in a direction between the upstream end and the downstream end.

[00244] In some configurations, the humidifying element is centrally positioned in the humidifying section.

[00245] In some configurations, the flow channel through the humidifying section is split into a plurality of flow channels.

[00246] In some configurations, the gases flow path is a plurality of flow channels.

[00247] In some configurations, the humidifying element splits the flow channel through the humidifying section into a plurality of the flow channels.

[00248] In some configurations, the transverse dimension of each of the at least one flow channels is as hereinbefore described.

[00249] In some configurations, the inlet antechamber is shaped to direct gases through the humidifying section.

[00250] In some configurations, the inlet antechamber has at least one angled surface extending to and adjacent one of the at least one wall or wall portion of the humidifying section for directing the flow of gases through the humidifying section.

[00251] In some configurations, the at least one angled surface directs the flow of gases onto at least one surface of the humidifying element.

[00252] In some configurations, the flow of gases are directed substantially parallel along the at least one surface of the humidifying element, optionally, this may be following being directed onto the at least one surface of the humidifying element.

[00253] In some configurations, an internal angle inside the humidification chamber between the angled surface and the adjacent wall or wall portion is a reflex angle.

[00254] In some configurations, an internal angle between the angled surface and the adjacent wall or wall portion of the humidifying section is between about 200° and 260°.

[00255] In some configurations, an internal angle between the angled surface and the adjacent wall or wall portion of the humidifying section is between about 220° and 240°.

[00256] In some configurations, the inlet antechamber comprises two symmetrically opposed angled surfaces.

[00257] In some configurations, the humidifying element has a substantially rounded or tapered leading edge at or adjacent to the upstream end.

[00258] In some configurations, a thickness of the humidifying element is increased from the upstream end through a portion of the humidifying section when viewed from the side to reduce the transverse dimension of the or each at least one flow channel through the humidifying section.

[00259] In some configurations, the flow area of the flow channel through the inlet antechamber is smaller than the flow area of the flow channel through the humidifying section.

[00260] In some configurations, a distance between an upper wall or upper wall portion and a lower wall or lower wall portion of the inlet antechamber is greater than a

distance between an upper wall or upper wall portion and a lower wall or lower wall portion of the humidifying section.

[00261] In some configurations, the inlet antechamber is a mirrored shape of the outlet antechamber.

[00262] In some configurations, the outlet antechamber has at least one angled surface extending from and adjacent one of the at least one wall or wall portion of the humidifying section at the downstream end.

[00263] In some configurations, an internal angle of the angled surface of the outlet antechamber adjacent the wall or wall portion is less than that of the internal angle of the angled surface of the inlet antechamber adjacent the wall or wall portion.

[00264] In some configurations, a slope from the horizontal plane of the angled surface of the outlet antechamber adjacent the wall or wall portion is less than that of a slope from the horizontal plane of the angled surface of the inlet antechamber adjacent the wall or wall portion.

[00265] In some configurations, at least one of the humidifying section and / or humidifying element is substantially rectangular in cross-section.

[00266] In some configurations, at least one of the humidifying section and / or humidifying element is substantially circular in cross-section.

[00267] In some configurations, at least one of the humidifying section and / or humidifying element is substantially elliptical in cross-section.

[00268] In some configurations, the transverse dimension of the or each at least one flow channel through the humidifying section is greater at the upstream end of the humidifying element compared to the downstream end of the humidifying element.

[00269] In some configurations, the transverse dimension of the or each at least one flow channel through the inlet antechamber, outlet antechamber and humidifying section is smallest at a position along the flow channel through the humidifying section between the upstream end and the downstream end.

[00270] In some configurations, an inner surface of the at least one wall or wall portion of the humidifying section facing the humidifying element has ridges or bumps.

[00271] In some configurations, the ridges or bumps are positioned along substantially the length of the humidifying section.

[00272] In some configurations, the ridges or bumps extend substantially perpendicular to the length of the humidifying section.

[00273] In some configurations, the humidifying element comprises at least one first humidifying plate connected to and extending from one of the walls or wall portion of the humidifying section toward the opposite wall or wall portion, the at least one first humidifying plate with a gap provided between the opposite wall or wall portion.

[00274] In some configurations, the humidifying element comprises at least one second humidifying plate positioned next to the at least one first humidifying plate, the at

least one second humidifying plate separated from the first humidifying plate and extending from and connected to the opposite wall or wall portion of the humidifying section, the at least one second humidifying plate with a gap provided between the wall or wall portion to which the first humidifying plate is connected.

[00275] In some configurations, the at least one first humidifying plate and at least one second humidifying plate are angled when viewed from a side direction.

[00276] In some configurations, the humidification chamber comprises at least one first baffle, wherein the at least one first baffle is connected to and extends from one of the wall or wall portion toward the humidifying element, wherein a gap is provided between the at least one first baffle and the humidifying element.

[00277] In some configurations, the humidification chamber comprises at least one second baffle, wherein the at least one second baffle is connected to and extends from the wall or wall portion opposite the at least one first baffle, the at least one second baffle extending toward the humidifying element, wherein a gap is provided between the at least one second baffle and the humidifying element.

[00278] In some configurations, the at least one first baffle and / or the at least one second baffle is angled when viewed from a side direction.

[00279] In some configurations, the at least one first baffle and / or the at least one second baffle is angled toward the downstream end when viewed from a side direction such that the connected end is closer to the upstream end than an opposite end of the or each baffle.

[00280] In some configurations, the humidification chamber comprises a plurality of the first baffles and / or the second baffles, the baffles being substantially equally distanced apart in a length direction when viewed from the side.

[00281] In some configurations, the humidifying element is provided on an inner surface (e.g. at least one wall or wall portion) of the humidifying section.

[00282] In some configurations, the humidifying element comprises a liquid reservoir.

[00283] In some configurations, the humidification chamber comprises a heating plate in or under the liquid reservoir to heat liquid in the liquid reservoir.

[00284] In some configurations, the gases inlet is in fluid communication to the inlet antechamber and/or humidifying section inlet, the gases inlet for providing the gases for humidification, and the gases outlet in fluid communication to the outlet antechamber and/or humidifying section outlet, the gases outlet for delivering humidified gases to a patient interface.

[00285] In some configurations, the cross-sectional flow area of the gases flow path of the or each at least one flow channel through the humidifying section is at most about 25% of the cross-sectional flow area of the gases flow path of the flow channel

through the gases inlet, or gases inlet end of the inlet antechamber or the gases inlet end of the humidifying section inlet.

[00286] In some configurations, the inlet antechamber and outlet antechamber are substantially coaxially aligned along an axis extending between the upstream end and downstream end of the humidifying section.

[00287] In some configurations, the humidification chamber comprises a liquid inlet, the liquid inlet configured to deliver liquid to the humidifying element.

[00288] In some configurations, the liquid is delivered via gravity.

[00289] In some configurations, the liquid is provided from a reservoir.

[00290] In some configurations, the liquid is provided through the inlet or outlet of the humidification chamber.

[00291] In some configurations, the humidification chamber is orientated such that the flow of gases through the humidification chamber is opposed to the direction of the supply of the liquid to the humidifying element.

[00292] In accordance with certain features, aspects and advantages of at least one of the embodiments disclosed herein, a respiratory humidification system for providing humidification to gases before being provided to an airway of a patient is disclosed, the respiratory humidification system comprising a humidification chamber as described above optionally combined with any number of configurations.

[00293] In some configurations, the respiratory humidification system comprises a heated breathing tube and a patient interface.

[00294] In some configurations, the patient interface is a non-sealed patient interface.

[00295] In some configurations, the respiratory humidification system further comprises a flow generator to deliver gases to the humidification chamber.

[00296] In some configurations, the respiratory humidification system further comprises a patient interface to deliver humidified gases from the humidification chamber to a patient.

[00297] Features from one or more embodiments or configurations may be combined with features of one or more other embodiments or configurations. Additionally, more than one embodiment or configuration may be used together in a respiratory support system during a process of respiratory support of a patient.

[00298] As used herein the term "(s)" following a noun means the plural and/or singular form of that noun.

[00299] As used herein the term "and/or" means "and" or "or", or where the context allows both.

[00300] As used herein the term referring to "a" feature is not to be construed as limiting to a singular of said feature, nor should it be construed as being a plurality of a feature, but may refer to a singular or plurality where the context allows.

[00301] The term “comprising” as used in this specification means “consisting at least in part of”. When interpreting each statement in this specification that includes the term “comprising”, features other than that or those prefaced by the term may also be present. Related terms such as “comprise” and “comprises” are to be interpreted in the same manner.

[00302] It is intended that reference to a range of numbers disclosed herein (for example, 1 to 10) also incorporates reference to all rational numbers within that range (for example, 1, 1.1, 2, 3, 3.9, 4, 5, 6, 6.5, 7, 8, 9 and 10) and also any range of rational numbers within that range (for example, 2 to 8, 1.5 to 5.5 and 3.1 to 4.7) and, therefore, all sub-ranges of all ranges expressly disclosed herein are hereby expressly disclosed. These are only examples of what is specifically intended and all possible combinations of numerical values between the lowest value and the highest value enumerated are to be considered to be expressly stated in this application in a similar manner.

[00303] This disclosure may also be said broadly to consist in the parts, elements and features referred to or indicated in the specification of the application, individually or collectively, and any or all combinations of any two or more said parts, elements or features, and where specific integers are mentioned herein which have known equivalents in the art to which this disclosure relates, such known equivalents are deemed to be incorporated herein as if individually set forth.

[00304] The disclosure consists in the foregoing and also envisages constructions of which the following gives examples only.

BRIEF DESCRIPTION OF THE DRAWINGS

[00305] Specific embodiments and modifications thereof will become apparent to those skilled in the art from the detailed description herein having reference to the figures that follow, of which:

[00306] Figure 1 is a schematic of an exemplary configuration of a respiratory therapy system of the present disclosure comprising a humidification chamber.

[00307] Figure 2 is a side sectional view of an exemplary configuration of the humidification chamber according to the present disclosure.

[00308] Figure 3 is a side sectional view of a configuration of the humidification chamber of Figure 2 including a humidifying element.

[00309] Figure 4 is a plan view of the humidification chamber of Figure 3.

[00310] Figure 5 is a partial side sectional view of the humidification chamber of Figure 3.

[00311] Figure 6 is a partial side sectional view of a configuration of the humidification chamber of Figure 3.

[00312] Figure 7 is a side sectional view of a simulation of humidity of the humidification chamber of Figure 3.

[00313] Figure 8 is a partial side sectional view of a simulation of air flow velocity of the humidification chamber of Figure 3.

[00314] Figure 9 is a schematic side view of the boundary layer formation in a humidification chamber according to the present disclosure.

[00315] Figure 10 is a schematic side view of an alternative boundary layer formation to that of Figure 9.

[00316] Figure 11 is a schematic side view of an alternative boundary layer formation to that of Figures 9 and 10.

[00317] Figure 12 is a schematic side view of an alternative boundary layer formation to that of Figures 9, 10 and 11.

[00318] Figure 13 is a schematic side view of a humidification chamber similar to that of Figures 9 to 12 with a different configuration of humidifying elements.

[00319] Figure 14 is a schematic side view of the boundary layer formation of Figure 13.

[00320] Figure 15 is a schematic side view of an alternative the boundary layer formation of Figure 14.

[00321] Figure 16 is a partial side sectional view of a configuration of the humidification chamber according to the present disclosure with a single flow channel.

[00322] Figure 17 is a partial side sectional view of a configuration of the humidification chamber according to Figure 9 with a reservoir.

[00323] Figure 18 is a partial side sectional view of a CFD analysis of a configuration of the humidification chamber according to the present disclosure including baffles.

[00324] Figure 19 is a partial side sectional view of a configuration of the humidification chamber according to the present disclosure including dimples.

[00325] Figure 20 is a partial side sectional view of a configuration of the humidification chamber according to the present disclosure including humidifying plates.

[00326] Figure 21 is a side sectional view of a configuration of the humidification chamber according to the present disclosure having tubular geometry.

[00327] Figure 22 is a side sectional view and end view of a configuration of the humidification chamber according to the present disclosure having constant external tubular geometry.

[00328] Figure 23 is a perspective view of the humidification chamber according to Figure 22.

[00329] Figure 24 is a partial side sectional view of a configuration of the humidification chamber according to the present disclosure with a tubular humidifying element.

[00330] Figure 25 is a partial side sectional view of a configuration of humidification chamber according to the present disclosure showing an alternative orientation.

[00331] Figure 26 is a schematic of a configuration of the or an alternative respiratory therapy system of the present disclosure.

DETAILED DESCRIPTION

[00332] Certain features, aspects, and advantages of the present disclosure include the realization of an on-demand humidifier, where water (or other humidification fluid) is metered onto a humidifying surface such as a heated element or provided in heated reservoir, evaporated and mixed with a gases source that passes over the humidifying surface to produce a desired humidity level. The gases that pass closest to the humidifying surface have the greatest fluid or water vapour uptake and have the highest humidity compared to the gases that pass more distant to the humidifying surface. The region of high humidity close to the humidifying surface may be referred to as a "high humidity band" or "high humidity boundary layer". Advantageously, disclosed is a system to humidify a source of gases to maximise the gases in the high humidity band and the humidification of the gases.

[00333] With reference to Figure 1, a non-limiting exemplary configuration of a respiratory therapy system 100 is shown in schematic form and not to scale. The respiratory therapy system 100 includes a flow generator 120. The flow generator 120 may comprise a blower to propel gases through the respiratory therapy system 100. The gases propelled by the flow generator 120 may include air received from the environment outside of the respiratory therapy system 100 (for example, "ambient air" or "ambient gases") and/or gases from a gases container in communication with the respiratory therapy system 100. Gases from the flow generator 120 are directed to and/or through a respiratory humidification chamber 110 adapted to add moisture to the gases. The humidification chamber 110 may be fluid connection with the flow generator 120 by a breathing tube or inspiratory tube adapted to receive gases from the flow generator 120 and/or another gases source. The humidification chamber 110 is also in fluid communication with an outlet, such as a patient interface 122 and channels the gases to the patient interface 122.

[00334] As indicated by the arrow in the Figure 1, in use, gases generally move from the flow generator 120 through the humidification chamber 110 and to the outlet or patient interface 122 in a downstream direction.

[00335] Schematically shown within the humidification chamber 110 of Figure 1, the humidification chamber 110 comprises a humidifying element 114 or heating element 114. As described herein, the humidifying element 114 may have a heated surface or be a heated reservoir to provide a humidifying surface to distribute a fluid such that it becomes entrained in a gases flow in use by the respiratory therapy system 100 as the gases pass through the humidification chamber 110. In some configurations, the humidifying element 114 may be in the form of a heated surface or wick, such as a vapour permeable membrane.

[00336] In some configurations, the respiratory therapy system 100 may include a controller 118 that can control the operation of components of the respiratory therapy system 100, including but not limited to the flow generator 120, the flow of gases, temperature of the humidifying element 114, delivery of fluid to the humidifying element 114. In other configurations, the controller 118 is manually operable.

[00337] The respiratory therapy system 100 as herein described may also be a respiration humidification system 100 and the references made are applicable to one another. In some non-limiting examples, a respiratory humidification system 100 provides humidified gases to a patient. Alternatively, the respiratory therapy system 100 may provide humidified gases where flow rate, humidity level and supplementary gases concentration may be adjusted/controlled.

[00338] With reference to Figure 2, a non-limiting exemplary configuration of a humidification chamber 110 of a respiratory therapy system 100 such as described with reference to Figure 1 is shown. The humidifying element 114 is not shown in Figure 2 for purpose of explanation of the other features.

[00339] The humidification chamber 110 comprises an inlet 111 (gases inlet 111) and an outlet 112 (gases outlet 112) for a flow of gases therethrough. When the humidification chamber 110 is part of a respiratory therapy system 100 of Figure 1, the inlet 111 is downstream of the flow generator 120, the outlet 112 is downstream of the inlet 111 and the patient interface 122 is downstream of the outlet 112 (and the inlet 111 and flow generator 120) and all in fluid communication with one another.

[00340] In the configuration shown, the inlet 111 and outlet 112 are formed as conduits. However, in some configurations, the inlet 111 and outlet 112 are ports directly into the humidification chamber 110 without a conduit. The port or conduit of the inlet 111 and/or the outlet 112 may be connectable to a tube to place the humidification chamber 110 in fluid communication with further components.

[00341] A flow path 60 or flow channel 60 is defined between the inlet 111 and outlet 112 for gases to flow therethrough and its overall direction is shown schematically by an arrow extending from the inlet 111 to the outlet 112.

[00342] In some configurations, the inlet 111 and outlet 112 are coaxial.

[00343] In the configuration shown, the humidification chamber 110 comprises a humidifying section 130. The humidifying section 130 has an inlet 131 (humidifying section inlet 131) and an outlet 132 (humidifying section outlet 132). The inlet 131 is upstream to the outlet 132 and both being downstream to the gases inlet 111 and upstream to the gases outlet 112. Therefore, the humidifying section 130 also has an upstream end 133 and a downstream end 134. The upstream end 133 is at or proximal to the inlet 131. The downstream end 134 is at or proximal to the outlet 132. Therefore, when the humidification chamber 110 is part of a respiratory therapy system 100 of Figure 1, the inlet 131 is

proximal to the flow generator 120 and the outlet is proximal to the patient interface 122 from a fluid communication aspect.

[00344] For the purposes of description, reference to one of the upstream end 133 or inlet 131 is also a reference to the other where context allows. Likewise, reference to one of the downstream end 134 or outlet 132 is also a reference to the other where context allows.

[00345] The inlet 131 and outlet 132 of the humidifying section 130 define a flow channel 30 therebetween, as schematically shown by an arrow in the figure. Likewise, the upstream end 133 and downstream end 134 of the humidifying section 130 define the same flow channel 30. The flow channel 30 enables a flow of gases through the humidifying section 130. The flow of gases may originate from the flow generator 120 and have a destination at the patient interface 122 and pass through the humidification chamber 110 to be humidified for the purposes as described elsewhere in this disclosure.

[00346] The flow channel 30 may also be referred to as a flow path 30. In some configurations the flow channel 30 or flow path 30 is the resultant flow of the flow of gases therethrough. This likewise applies to any flow channel or flow path discussed herein.

[00347] The inlet 131 and outlet 132 may be coaxial or could be a different configuration. In some configurations, the inlet 131 is coaxial with the gases inlet 111, and/or the outlet 132 is coaxial with the gases outlet 112.

[00348] Extending from the inlet 131 or upstream end 133 is a wall 135 defining a perimeter of the flow channel 30. The wall 135 extends to the outlet 132 or downstream end 134 thus forming a flow channel 30. In Figure 2, the flow channel 30 is shown as an arrow defining an overall direction of flow of a gases flow path, i.e. downstream. However, the flow channel 30 is the entirety of the area defined by the inlet 131, outlet 132 and the wall 135.

[00349] The humidifying section 130 is enclosed by the wall 135. However, the wall 135 may refer to a whole surrounding wall 135, or a portion of a wall 135 at one side of the humidifying section 130. Therefore, the wall 135 is also a top / upper wall 135 or top / upper portion of a wall 135. Likewise, there is an opposing bottom / lower wall 136 or bottom / lower portion of a wall 136. However, the upper wall 135 and lower wall 136 may be the same wall 135, 136 formed as a continuous wall 135, 136, such as a curved or tubular conduit. Conversely, in some configurations, the upper wall 135 is separate to the lower wall 136 and is joined by further side walls (not shown). Whilst the terms "upper" and "lower" are used, these are stated with reference to the figures, such as Figure 2 and are not limiting on the orientation of the humidification chamber 110 in use.

[00350] The humidification chamber 110 comprises an inlet antechamber 140 in fluid communication with the humidifying section 130. The inlet antechamber 140 is positioned between the gases inlet 111 and the inlet 131 (or upstream end 133) of the humidifying section 130. The inlet antechamber 140 provides a channel or conduit for a

gases flow to pass through before entering the humidifying section 130. Therefore, when part of a respiratory therapy system 100, the inlet antechamber 140 is in fluid communication with the flow generator 120 upstream of the humidifying section 130.

[00351] The inlet antechamber 140 has an upstream end 141 and a downstream end 142 defining the openings throughout which a flow of gases may pass. The inlet antechamber 140 defines a flow channel 40 or flow path 40 between the upstream end 141 and downstream end 142 as schematically shown by an arrow in the figure. In some configurations, the inlet antechamber 140 is directly connected (at its downstream end 142) to the inlet 131 of the humidifying section 130. In some configurations, the inlet antechamber 140 is directly connected (at its upstream end 141) to the gases inlet 111.

[00352] In Figure 2, the inlet antechamber 140 is shown positioned extending between the dot-dashed lines of the upstream end 141 and the downstream end 142.

[00353] In the configuration shown, the inlet antechamber 140 comprises a wall 145 or wall portion 145 extending from the upstream end 141 in a downstream direction. The wall 145 is formed parallel to an axis between at least one of the upstream end 141 and downstream end 142, or the inlet 131 and outlet 132, or the gases inlet 111 and gases outlet 112. The central axis line (Ax) is shown in Figure 3 as a dot-dashed line.

[00354] The inlet antechamber 140 further comprises an angled wall 147 connected and extending from the straight wall 145 and adjoining to the downstream end 142 and humidifying section inlet 131. The angled wall 147 allows for a distance, size, dimension, radius, diameter, width or height of the flow channel 40 of the inlet antechamber 140 defined by the wall 145 to be larger or smaller than a distance, size, dimension, radius, diameter, width or height of the flow channel 30 of the humidifying section 130. Therefore, the angled wall 147 narrows or expands the flow channel 40 to that of the inlet 131 or the humidifying section 130.

[00355] It is to be understood that unless specifically stated or as context allows, reference to one of the distance, size, dimension, radius, diameter, width or height throughout the disclosure may be reference to any other of said dimensions.

[00356] The inlet antechamber 140 is enclosed by the wall 145 and angled wall 147. However, the walls 145, 147 may refer to surrounding walls 145, 147 or a portion of walls 145, 147 at one side of the inlet antechamber 140. Therefore, the wall 145 may also be referred to as a top / upper wall 145 or top / upper portion of a wall 145. Likewise, the angled wall 147 may also be referred to as a top / upper angled wall 147 or top / upper portion of an angled wall 147. There is also an opposing bottom / lower wall 146 or bottom / lower portion of a wall 146 to the upper wall 145 or upper wall portion 146. Likewise, there is also an opposing bottom / lower angled wall 148 or bottom / lower portion of a lower wall 148 to the upper angled wall 146 or angled wall portion 146. However, the upper wall 145 and lower wall 146 may be the same wall 145, 146 formed as a continuous wall 145, 146, such as a curved or tubular conduit. Conversely, in some configurations, the

upper wall 145 is separate to the lower wall 146 and is joined by further side walls (not shown). Likewise, the upper angled wall 147 and lower angled wall 148 may be the same angled wall 147, 148 formed as a continuous angled wall 147, 148, such as a curved or tubular conduit. Conversely, in some configurations, the upper angled wall 147 is separate to the lower angled wall 148 and is joined by further side walls (not shown). Whilst the terms "upper" and "lower" are used, these are stated with reference to the figures, such as Figure 2 and are not limiting on the orientation of the humidification chamber 110 in use.

[00357] The humidification chamber 110 comprises an outlet antechamber 160 in fluid communication with the humidifying section 130. The outlet antechamber 160 is positioned between the outlet 132 (or downstream end 134) and the gases outlet 112. The outlet antechamber 160 provides a channel or conduit for a gases flow to pass through after entering the humidifying section 130. Therefore, when part of a respiratory therapy system 100, the outlet antechamber 160 is in fluid communication with the patient interface 122 downstream of the humidifying section 130.

[00358] The outlet antechamber 160 has an upstream end 161 and a downstream end 162 defining the openings throughout which a flow of gases may pass. The outlet antechamber 160 defines a flow channel 50 or flow path 50 between the upstream end 161 and downstream end 162 as schematically shown by an arrow in the figure. In some configurations, the outlet antechamber 160 is directly connected (at its upstream end 161) to the outlet 132 of the humidifying section 130. In some configurations, the outlet antechamber 160 is directly connected (at its downstream end 162) to the gases outlet 112.

[00359] In Figure 2, the outlet antechamber 160 is shown positioned extending between the dot-dashed lines of the upstream end 161 and the downstream end 162.

[00360] In the configuration shown, the outlet antechamber 160 comprises a wall 165 or wall portion 165 extending from the downstream end 162 in an upstream direction. The wall 165 is formed parallel to the central axis (Ax – Figure 3) between at least one of the upstream end 161 and downstream end 162, or the inlet 131 and outlet 132, or the gases inlet 111 and gases outlet 112.

[00361] The outlet antechamber 160 further comprises an angled wall 167 connected and extending from the straight wall 165 in the upstream direction and adjoining to the upstream end 161 and humidifying section outlet 132. The angled wall 167 allows for a distance, size, dimension, radius, diameter, width or height of the flow channel 50 of the outlet antechamber 160 defined by the wall 165 to be larger or smaller than a distance, size, dimension, radius, diameter, width or height of the flow channel 30 of the humidifying section 130. Therefore, the angled wall 167 narrows or expands the flow channel 40 from that of the outlet 132 or the humidifying section 130.

[00362] The outlet antechamber 160 is enclosed by the wall 165 and angled wall 167. However, the walls 165, 167 may refer to surrounding walls 145, 147 or a portion of walls 165, 167 at one side of the outlet antechamber 160. Therefore, the wall 165 may also be referred to as a top / upper wall 165 or top / upper portion of a wall 165. Likewise, the angled wall 167 may also be referred to as a top / upper angled wall 167 or top / upper portion of an angled wall 167. There is also an opposing bottom / lower wall 166 or bottom / lower portion of a wall 166 to the upper wall 165 or upper wall portion 166. Likewise, there is also an opposing bottom / lower angled wall 168 or bottom / lower portion of a lower wall 168 to the upper angled wall 166 or angled wall portion 166. However, the upper wall 165 and lower wall 166 may be the same wall 165, 166 formed as a continuous wall 165, 166, such as a curved or tubular conduit. Conversely, in some configurations, the upper wall 165 is separate to the lower wall 166 and is joined by further side walls (not shown). Likewise, the upper angled wall 167 and lower angled wall 168 may be the same angled wall 167, 168 formed as a continuous angled wall 167, 168, such as a curved or tubular conduit. Conversely, in some configurations, the upper angled wall 167 is separate to the lower angled wall 168 and is joined by further side walls (not shown). Whilst the terms "upper" and "lower" are used, these are stated with reference to the figures, such as Figure 2 and are not limiting on the orientation of the humidification chamber 110 in use.

[00363] In some configurations, the wall 145, 165, upper wall 145, 165, angled wall 147, 167, upper angled wall 147, 167, lower wall 146, 166, and lower angled wall 148, 168, may be referred to as "surfaces" or "surface portions", such as surface 145, 165, upper surface 145, 165, angled surface 147, 167, upper angled surface 147, 167, lower surface 146, 166, and lower angled surface 148, 168. Likewise, any other "wall" or "wall portion" referred to herein may be referred to as a "surface", "surface portion", "wall" or "wall portion", and any other "surface" or "surface portion" herein may be referred to as a "wall", "wall portion", "surface", or "surface portion" as context allows.

[00364] The inlet antechamber 140 may be a mirrored shape to that of the outlet antechamber 160. The two-dimensional lines of symmetry passing through the inlet antechamber downstream end 142 and outlet antechamber upstream end 161 for the inlet antechamber 140 and outlet antechamber 160 respectively. The three-dimensional planes of symmetry pass through the same lines and are perpendicular to the axis line (Ax – Figure 3) between at least one of the upstream end 141 and downstream end 142 of the inlet antechamber 140, upstream end 161 and downstream end 162 of the outlet antechamber 160, or the inlet 131 and outlet 132, or the gases inlet 111 and gases outlet 112.

[00365] In Figure 2, the gases inlet 111 and gases outlet 112 have been shown as a channel having a length, e.g. a conduit or tube. However, in some configurations, the gases inlet 111 and gases outlet 112 may refer to the port of the humidification chamber

110, such as a port formed in the upstream end 141 of the inlet antechamber 140 or the downstream end 162 of the outlet antechamber 160, or a port formed in the conduit of the gases inlet 111 and gases outlet 112 itself. The gases inlet 111 or gases outlet 112 may connect to a further tube, conduit or other gases conveying channel such as described with reference to Figure 1.

[00366] The gases flow at the gases inlet 111 and the gases flow at the gases outlet 112 have the generally same flow direction. Therefore the (resultant) flow of gases into the humidification chamber 110 is generally the same direction as the (resultant) flow of gases out of the humidification chamber 110.

[00367] The humidification chamber 110 is formed as being generally elongate.

[00368] The humidifying section 130 is formed as being generally elongate.

[00369] An elongate shape has a dimension, e.g. length, that is longer than its corresponding width. In the case of a 3D shape, the length of the shape is greater than the planar cross-section. An elongate shape is not required to be straight. However, in some configurations, the elongate shapes described herein may be straight with gases having flow in the same resultant direction. However, not all configurations are limited in this manner.

[00370] In the illustrated figure, the humidifying section 130 is shaped such that the flow of gases passes from the inlet 131 to the outlet 132 in generally the same (resultant) direction. Therefore, in some configurations, the inlet 131 to the outlet 132 are formed on the same central axis with the generally elongate humidifying section 130 extending therebetween. In view of this, the flow path 30 or flow channel 30 is likewise generally elongate. However, in some configurations, the shape of the flow channel 30 may be varied within a generally elongate humidifying section 130.

[00371] Whilst elongate humidification chambers 110 and humidifying section 130 are herein generally described for the configurations discussed, in some configurations, other arrangements may be provided, where the humidification chamber and / or humidification section are not necessarily straight, and / or where the gases inlet 111 and gases outlet 112 are not necessarily arranged on opposing ends of a body.

[00372] The humidification chambers 110 herein described, allow for more efficient humidification. There is no need for a large volume of water in the described humidification chambers 110. The reduction in water volume results in more efficient humidification as there is less thermal mass to heat.

[00373] The humidification chambers 110 described herein, also allow for a smaller humidifier as there is no need for a large volume of water.

[00374] Due to the advantages discussed above, the humidification chamber 110 provides faster humidification which allows on demand humidification or use of the humidifier in other environments where a large volume of water is not ideal e.g., ambulance or emergency departments of hospitals. In particular, the humidification

chamber 110 is useful for ambulance use as it can be relatively small and does not require a large volume of water within it. This also reduces chances of water splashing back into flow generator space or electronics. Referring to Figure 3, a humidification chamber 110 is shown with a schematically similar view to that of Figure 2. The humidification chamber 110 comprises the same features as Figure 2 and the description of which applies to the configuration of Figure 3. However, reference signs are omitted for some features for purpose of explanation.

[00375] Figure 3 additionally includes the humidifying element 114 positioned in the generally elongate humidifying section 130. In the configuration of Figure 3, the humidifying element 114 is positioned away from the upper wall 135 and lower wall 136 of the humidifying section 130.

[00376] The flow path / channel 30, i.e. between the inlet 131 and outlet 132 of the humidifying section 130 is illustrated by arrows extending between the inlet 131 and outlet 132 (or upstream 133 and downstream 134 ends). As the humidifying element 114 is positioned within the humidifying section 130 and thus in the path of the flow channel 30 as shown in Figure 2, the flow channel 30 extends around the humidifying element 114. Therefore, the flow channel 30 passes through a gap or channel formed between the upper wall 135 and lower wall 136 and humidifying element 114. This effectively splits the flow channel 30 into two flow channels 30, 31, 32 or an upper flow channel 31 and a lower flow channel 32 (as shown in Figure 5).

[00377] The humidifying element 114 comprises an upper or top surface 1143. The upper surface 1143 faces the upper wall 135 of the humidifying section 130 and the gap is formed therebetween. The humidifying element 114 also comprises a lower or bottom surface 1144. The lower surface 1144 faces the lower wall 136 of the humidifying section 130 and the gap is formed therebetween.

[00378] The humidifying element 114 comprises a leading edge or upstream end 1141. The upstream end 1141 of the humidifying element 114 faces the inlet antechamber 140. The humidifying element 114 also comprises a trailing edge or downstream end 1142. The downstream end 1142 of the humidifying element 114 faces the outlet antechamber 160. In some configurations, the humidifying element 114 may be in the form of a heated surface or wick, such as a vapour permeable membrane with the upper surface 1143 and lower surface 1144 being a surface of the wick.

[00379] In the configuration of Figure 3, there is a space provided between the inlet 131 or upstream end 133 of the humidifying section 130 and the upstream end 1141 of the humidifying element 114. The same is shown with respect to the outlet 132 or downstream end 134 of the humidifying section 130 and the downstream end 1142 of the humidifying element 114 where a gap is formed. Therefore, the humidifying section has a length 139 that extends between the inlet 131 or upstream end 133 and the outlet 132 or downstream end 134. Likewise, the humidifying element 114 has a length 38 that extends

between the upstream end 1141 and downstream end 1142. The humidifying section length 139 is greater than the humidifying element length 38.

[00380] However, in some configurations, the humidifying element 114 extends fully along the length of the humidifying section 130 or the humidifying section 130 is defined as extending between upstream end 1141 and downstream end 1142 of the humidifying element 114. Therefore, the humidifying section length 139 is the same as the humidifying element length 38.

[00381] Figure 3 is schematically shown as a side view, in some configurations, the flow channel 30 may also pass through a gap formed between side walls of the humidifying section 130 and the humidifying element 114. In other configurations, there is no gap formed at these positions and the flow channel 30 is formed only between upper and lower walls 135, 136. In some configurations, the humidifying element length 38 refers to the length of the flow channel 30. However, in other configurations, the flow channel 30 may have a separate channel length or may be determined by the humidifying section length 139.

[00382] Referring to Figure 4, a top or plan view of the humidification chamber 110 as described herein is illustrated. As with Figure 3, the humidifying element 114 is shown within the humidifying section 130 and the description of which applies to the configuration of Figure 4. However, reference signs are omitted for some features for purpose of explanation. In Figure 4, the humidifying element 114 is shown in dashed lines to indicate that it is internal to the humidification chamber 110.

[00383] In the configuration of Figure 4, the gases inlet 111 and gases outlet 112 are shown as tubular conduits extending from the upstream end 141 of the inlet antechamber 140 and extending from the downstream end 162 of the outlet antechamber 160 respectively. The gases inlet 111 has a gases inlet diameter 113, the gases outlet 112 also has a gases outlet diameter 114. The gases inlet diameter 113 is the external diameter of the conduit forming the gases inlet 111. The gases outlet diameter 114 is the external diameter of the conduit forming the outlet 112.

[00384] The gases inlet diameter 113 is relatively smaller in width than an inlet antechamber width 150, where the width of the inlet antechamber 140 is the distance between the sides, i.e. perpendicular to the distance between the upper wall 145 and lower wall 146. Therefore, the width of the flow channel of the humidification chamber 60 expands (widens) to the width of the flow channel 40 of the inlet antechamber 140 at its transition at the upstream end 141 of the inlet antechamber 140.

[00385] The gases outlet diameter 114 is relatively smaller in width than an outlet antechamber width 169, where the width of the outlet antechamber 160 is the distance between the sides, i.e. perpendicular to the distance between the upper wall 165 and lower wall 166. Therefore, the width of the flow channel of the outlet antechamber 50 reduces (narrows) to the width of the flow channel 60 (that is, the width corresponding to the outlet

gases diameter 114) at its transition at the downstream end 162 of the outlet antechamber 160.

[00386] In the configuration of Figure 4, the inlet diameter 113 and outlet diameter 114 are the same diameter. The inlet antechamber width 150 is also the same width as the outlet antechamber width 169. The generally elongate humidifying section 130 has a humidifying section width 39, where the width of the humidifying section 130 is the distance between the sides, i.e. perpendicular to the distance between the upper wall 135 and lower wall 136. The humidifying section width 39 is equal to the inlet antechamber width 150 and the outlet antechamber width 169. Therefore, there is no change in width of the flow channels between the inlet antechamber flow channel 40, the humidifying section flow channel 30 and the outlet antechamber flow channel 50.

[00387] In some configurations, the inlet diameter 113 and outlet diameter 114 are different sizes. In some configurations, the inlet antechamber width 150 is a different width to the outlet antechamber width 169. In some configurations, the humidifying section width 39 is different to at least one of the inlet antechamber width 150 and the outlet antechamber width 169.

[00388] Referring to Figure 5, the humidification chamber 110 as described herein is shown, the description of which applies to the configuration of Figure 5. However, reference signs are omitted for some features for purpose of explanation. Figure 5 shows a partial view of the inlet antechamber 140 and the humidifying section 130 of Figure 3.

[00389] The distance between the straight upper wall 145 and the straight lower wall 146 of the inlet antechamber 140 defines an inlet antechamber height 151. This may also be the height of the inlet antechamber flow channel 40.

[00390] The distance between the upper wall 135 and the lower wall 136 of the humidifying section 130 defines a humidifying section height 137. Unlike the inlet antechamber flow channel 40, the presence of the humidifying element 114 in the humidifying section 130 results in a height of the humidifying section flow channel 30 being less than the humidifying section height 137. However, in some configurations, the heights may be the same.

[00391] The inlet antechamber height 151 is greater than the humidifying section height 137.

[00392] As described with reference to Figure 2, the upper and low angled walls 147, 148 transition the relatively larger inlet antechamber height 151 to the relatively smaller humidifying section height 137.

[00393] As the gas enters the humidification chamber 110, the gases inlet 111 transitions to the inlet antechamber 140. Therefore, the gases of the humidification flow channel 60 transitions to follow the contours of the walls 145, 146 of the inlet antechamber 140 through the inlet antechamber flow channel 40. As gases in the inlet antechamber 140 progress through flow channel Band past the narrowing angled walls 147, 148, the gases

are funnelled into the shorter / narrower humidification section 130 having a relatively smaller humidifying section height 137 than the inlet antechamber height 151.

[00394] An angle is formed between the narrowing angled walls 147, 148 and the adjoining upper 135 and lower 136 walls of the humidifying section 130. For the purposes of explanation, the angle has been shown on the lower walls 148, 136 of the inlet antechamber 140 and humidifying section 130 in Figures 5 and 6. However, the explanation can also apply to the respective upper walls 147, 135. This humidifying section transition angle 143 is the internal angle 143 between the narrowing angled wall 148 and the lower wall 136 of the humidifying section 130. An internal angle refers to an angle formed within the humidification chamber 10, e.g. internal to the walls that form the chambers, inlet / outlet antechambers 140, 160, humidifying section 130, or within at least one of the flow paths 30, 40, 50, 60. The internal angle 143 influence how much shear layer separation, "unsticking", occurs between the gases flow and the sides of the internal walls 135, 136 of the humidifying section 130. The optimal internal angle 143 is where the angular difference between the narrow angled wall 147, 148 and the humidifying section walls 135, 136 is large enough that the gases flow detaches from the sides and continues along the humidifying element 114.

[00395] An insufficiently large internal angle 143 value increases the distance to transition to the humidifying section height 137 and may lead to streamlined flow without separation from the walls 135, 136 in the humidifying section 130, as the path deviation at the vertex is not sharp enough. On the other hand, if the internal angle 143 is too large, the gases flow may collide too abruptly with the humidifying element 114 and excessive turbulent gases flow will form at the surface of the humidifying element 114 where the gases flow is directed, which may impede humidification of the gases. Accordingly, the angle of the humidifying section transition angle 143 (internal angle 143) is preferably optimized so as to be neither excessively small nor excessively large.

[00396] The humidifying section transition angle 143 (internal angle 143) may be between about 200° and about 260°, or between about 220° and 240°. More particularly still, the humidifying section transition angle 143 is about 240°.

[00397] The humidifying section transition angle 143 is a reflex angle and provides a relatively sharp transition into the humidifying section 130. This is advantageous as a sharp transition detaches the gases from the walls of the inlet antechamber 140 and humidifying section 130 and "ejects" the gases flow stream towards the humidifying element 114. The proximity of the gases flow to the humidifying element 114 increases humidification, such as due to being in the aforementioned high humidity band (or spending more time in the high humidity band), or generally through improved proximity to the humidifying element 114. Otherwise, if there was an excessively gradual change in humidifying section transition angle 143, the gases may cling to the walls 135, 136 of the humidifying section and remain distanced from the humidifying element 114.

[00398] Likewise, the value for the humidifying section transition angle 143 is chosen to prevent the gases flow causing excessive turbulent flow or other disrupted flow upon contact with or toward the humidifying element 114. In this regard, the transition angle 143 is chosen so as not to be too large (i.e. so the transition is not too steep), which would tend to cause the gases to "collide" overly abruptly with the humidifying element 114, resulting in excessive turbulence. Therefore, the humidifying section transition angle 143 and resultant direction of the flow of gases is such to prevent the flow clinging to the walls, while causing the gases to flow proximate to the humidifying element 114 in the downstream direction. Whilst a laminar flow of gases may be preferred, it is noted that in some configurations, a level of turbulence may help with mixing of the flows, therefore, a balance must be drawn. In some configurations, the humidifying section transition angle 143 directs the gases flow into a substantially parallel flow with the humidifying element 114. For instance, the gases flow is directed toward the surface of humidifying element 114 and flows along or near the surface of the humidifying element 114 in a substantially parallel direction.

[00399] Whilst not shown in Figure 5, the outlet antechamber 160 may, in some configurations, have the same humidifying section transition angle 143 as shown with respect to the inlet antechamber 140. This may assist with manufacturing or in installation as the humidification chamber 110 may be effectively symmetrical along a centre line. Alternatively, as the separation of flow and shearing from surfaces is not required for flow exiting the humidifying section 130, the outlet antechamber 160 may have a different arrangement such as no angled surfaces. The upper narrowing angled wall 147 may be symmetrical to the lower narrowing angled wall 148 and share the same humidifying section transition angle 143. Alternatively, different humidifying section transition angles 143 may be provided on different walls or no directing of flow for one of the walls 147, 148.

[00400] To assist in the transition of a gases flow through the inlet antechamber into the humidifying section 130, a further angle may be formed between walls of the inlet antechamber 140 to the angled walls 147, 148. In the illustrated configuration of Figures 5 and 6, the inlet antechamber has straight wall 145, 146. However, in other configurations, different arrangements between walls may be provided.

[00401] Referring to Figures 5 and 6, the straight walls 145, 146 and the angled wall 147, 148 form a wall transition angle 144, i.e. an internal angle between the two walls 146, 148. Therefore, the wall transition angle 144 would be at or between about 90° if the straight wall 146 and angled wall 148 were perpendicular to one another and at 180° if the angled wall 148 was straight (flush) with the straight wall 146. More particularly, as shown in Figure 5, the wall transition angle 144 is between about 110° and 160°. More particularly still, the transition angle 144 is about 120°. When present, the wall transition angle 144 influences (or is influenced by) the humidifying section transition angle 143. Therefore, the

wall transition angle 144 and the humidifying section transition angle 143 are complementary angles in this configuration. The value for the wall transition angle 144 may assist in the shear layer separation discussed above by varying the velocity or direction of the gases flow before the angled wall 147, 148. For instance, laminar flow may be encouraged at the wall surfaces before reaching the angled walls 147, 148.

[00402] In some explanations, a humidifying section transition ray angle 149 is the angle between a ray line extending from the angled wall 148 and the lower wall 136 of the humidifying section 130.

[00403] An excessive wall transition angle 144 value (e.g. around 180°, such as about 165° to 195°) would have substantially no influence on the gases flow through the angled walls 147, 148 and the humidifying section transition angle 143 would direct the flow as described above. Conversely, too small of wall transition angle 144 value (e.g. around 90°, such as about 75° to 105°) would cause a stagnation point to form on the face of the angled walls 147, 148, therefore, impeding the function of the humidifying section transition angle 143. The wall transition angle 144 is accordingly preferably optimized, so as to urge the gases flow to flow substantially laterally along the angled walls 147, 148 prior to encountering the humidifying section transition angle 143.

[00404] The wall transition angle 144, when optimized in this fashion, may assist with the humidifying section transition angle 143 that provides the relatively sharp transition into the humidifying section 130 as described above. This is advantageous as a sharp transition detaches the gases from the walls of the inlet antechamber 140 and humidifying section 130 and "ejects" the gases flow stream towards the humidifying element 114. The proximity of the gases flow to the humidifying element 114 increases humidification, such as due to being in the aforementioned high humidity band.

[00405] Whilst not shown in Figures 5 and 6, the outlet antechamber 160 may, in some configurations, have the same wall transition angle 144 as shown with respect to the inlet antechamber 140.

[00406] The humidifying element 114 splits or directs the flow channel 30 of the humidifying section 130 as described above. Therefore, the resultant flow channels 31, 32 have a height that is reduced relative to the humidifying section height 137. The height 34 of the upper flow channel 31 corresponds to the height between the upper surface 1143 and the upper wall 135 of the humidifying section 130. As the flow of gases is from the humidifying section inlet 131 to the humidifying section outlet 132 parallel to the upper surface 1143 of the humidifying element 114, i.e. in the direction shown by flow channel 30, the height 34 of the flow channel 31 may also be referred to as a transverse dimension of the flow channel normal to the direction of flow of the gases 31.

[00407] The lower flow channel 32 formed by the gap between the lower surface 1144 of the humidifying element 114 and the lower wall 136 of the humidifying section 130 also has a height 35. Likewise, as described with the height 34 of the upper flow

channel 31, the flow of gases is from the humidifying section inlet 131 to the humidifying section outlet 132 parallel to the lower surface 1144 of the humidifying element 114, i.e. in the direction shown by flow channel 30. Therefore, the height 35 of the flow channel 32 may also be referred to as a transverse dimension of the flow channel normal to the direction of flow of the gases 32.

[00408] The term flow channel height or transverse dimension of the flow channel normal to the direction of flow of the gases may refer to height of an upper channel 34, lower channel 35, both or a combined height.

[00409] It will be understood that an objective of the present disclosure is to, generally speaking, ensure that most of the gases passing through the device are within the high-humidity "boundary layer" that arises adjacent the humidifying element(s) and thus that the "target humidity" is achieved. This is achieved at least in part by limiting the height (and / or transverse dimension) of the flow channel(s), and in particular by ensuring the height of the flow channel(s) is substantially equal to (or not greater than, or not significantly greater than) a height of the expected boundary layer within the flow channel(s).

[00410] If there are a plurality of substantially equally-sized and substantially parallel flow channels in the device, it can be assumed that substantially an equal portion of the overall incoming flow will pass through each of the flow channels. As such, each of the flow channels should be so dimensioned and configured as to humidify *the corresponding portion* of the overall gases flow to the target humidity. The other flow channels should each do the same. This way, the humidity of the overall gases flow (once recombined upon leaving the individual flow channels) will also be at the target humidity.

[00411] Similar would apply in the case of unequally-sized flow channels, wherein each flow channel receives a portion of the overall flow that is commensurate with its size. Each channel will ideally be configured to achieve the target humidity *of the portion of gases flowing through that channel*.

[00412] In any embodiment comprising a plurality of flow channels, if one of the channels humidifies a lower portion / percentage of gases flowing therethrough than the other channels, that is to say, if one of the channels achieves a humidification rate below the target humidity of the target portion of gases passing therethrough, then one (or more than one) of the other channel(s) may need to achieve a correspondingly higher humidification portion / percentage, such that, when the gases flows recombine, the gases overall have been humidified in accordance with a prescribed target humidity.

[00413] An alternative way of conceptualising the configurations disclosed herein is by considering not the individual flow channels, but rather the flow channels collectively (and considering the overall gases flow as well). If the *overall* incoming gases flow is considered, then it may be said that an *overall* (collective) height (and / or transverse dimension) of *all* of the plurality of flow channels must be such as to ensure that the target

humidity of the *overall* gases flow is attained upon the gases reaching the downstream end of the humidifying section.

[00414] The humidifying element 114 splits the flow channel 30 of the humidifying section 130 as described above. Therefore, the resultant flow channels 31, 32 have a height that is reduced relative to the humidifying section height 137. The height 34 of the upper flow channel 31 is the distance between the upper surface 1143 and the upper wall 135 of the humidifying section 130. As the flow of gases is from the humidifying section inlet 131 to the humidifying section outlet 132 parallel to the upper surface 1143 of the humidifying element 114, i.e. in the direction shown by flow channel 30, the height 34 of the flow channel 31 may also be referred to as a transverse dimension of the flow channel normal to the direction of flow of the gases 31.

[00415] As illustrated in Figure 5, the upstream end 1141 of the humidifying element 114 is perpendicular to the inlet antechamber flow channel 40 as shown by the arrow. When viewed from the side, the humidifying element 114 of Figure 5 is effectively rectangular. A perpendicular upstream end 1141 of the humidifying element 114 may cause abrupt changes in gases flow profile, potentially impeding the profile of the downstream gases flow over the upper and lower surfaces 1143, 1144 of the humidifying element 114.

[00416] As described herein, the inlet antechamber 140 is generally shaped to direct a gases flow toward the humidifying section 130 and/or humidifying element 114.

[00417] Referring to Figure 6, the same view of the humidification chamber 110 of Figure 5 is shown. However, the upstream end 1141 of the humidifying element 114 is curved, rounded or tapered.

[00418] Therefore, the profile of the humidifying element 114 at the upstream end 1141 is rounded to redirect gases flow around the humidifying element 114. This adds to the flow along the upper and lower surfaces 1143, 1144 of the humidifying element 114 supplied from the sides of the inlet antechamber 140. Therefore, any gases flowing in the inlet antechamber 140 that does not follow the contours of the sides or walls and flows straight to the upstream end 1141 is redirected, but the rounded upstream end promotes this occurring in a gradual rather than abrupt manner, thus avoiding excessively turbulent or interrupted flow and rather promoting substantially laminar and orderly flow of the gases proximate the surfaces 1143, 1144 of the humidifying element 114. The rounded upstream surface 1141 may be fully rounded, have tapered edges or be chamfered. In some configurations, the downstream end 1142 of the humidifying element 114 may likewise be rounded or curved.

[00419] As described in addition or separately from above, the humidification element 114 may have a lead in section at the end adjacent the humidification section inlet 131. Likewise, in addition or alternatively, the humidification element 114 may have a lead out section at the humidification section outlet 132. The lead in and lead out reduces

turbulence or eddy currents or flow separation occurring at the ends of the humidification element.

[00420] The upstream end 1141 of the humidifying element 114 when curved or rounded may also be an angled section that terminates in a point at each end to define a ramped section i.e., a lead in or lead out to prevent turbulence.

[00421] As discussed herein and with reference to Figures 1 to 6, a flow of gases is humidified by being in close vicinity to the humidifying element 114. The closer the gases flow to the humidifying element 114, the greater the uptake of water by the gases and thus humidification. To assist the flow of gases to remain in the high humidity boundary layer region relative to the humidifying element 114, the gases firstly arrive into the inlet antechamber 140 wherein the diameter 113 of the gases inlet 111 transitions to the inlet antechamber having height 151. The humidifying section 130 is bisected by humidifying element 114 where the upper surface 1143 and lower surface 1144 both humidify a flow of gases thereover through the flow channels 31, 32. The effective reduction in height of the flow channels 31, 32 compared to the humidifying section height 137 brings a flow of gases into a closer contact with the humidifying element 114.

[00422] More particularly, the height 34, 35 of the flow channels 31 and 32 may be selected so as to be substantially equal to, or not greater than or not substantially greater than, an expected boundary layer height (being a height above (i.e. substantially normal to) the humidifying element of the high-humidity region when the boundary layer reaches its "mature" state). As such, all or most of the gases flowing through the flow channels 31, 32 will flow within the high-humidity boundary layer region.

[00423] The humidifying element 114 is parallel with the upper and lower walls 135, 136 of the humidifying section 130 such that the humidifying element 114 upper surface 1143 and lower surface 1144 maintains a constant gap for gases to flow through the flow channels 31, 32.

[00424] Following the humidifying section 130, the humidified gases pass into the outlet antechamber 160 preceding the gases outlet 112. The outlet antechamber 160 is the same as the inlet antechamber 140 but mirrored. The humidified gases flow through the outlet 112 and into the breathing tube towards the patient.

[00425] As described in more detail below, the gap between the humidifying element 114 and the humidifying section walls 135, 136 is small to keep the flow close to the humidifying element 114 to increase humidification. When the gap is increased, the effectiveness of the humidification is diminished. If the gap is too wide, there will be space for flow layers outside of the "high humidity band" to form.

[00426] The humidifying element 114 may be positioned in the humidification section 130 by mounts or mounting structures (not shown). Alternatively, the humidifying element 114 may be directly mounted on the walls. Such mounting structures may be in

the form of arms or pillars. Mounting structures may extend along the length of the humidifying element 114 or may be positioned at distanced locations.

[00427] Referring to Figure 7, a schematic of a simplified humidification chamber 110 as described herein is shown. Some reference signs are omitted for some features for purpose of explanation. Figure 7 shows a humidification of a gases flow in an example where a gas having 0% humidity is shown by non-humidified shading 211 and a gas having 100% humidity is shown by humidified shading 212. There is a transition area between the two shadings 211, 212 in the vicinity of the humidifying element 114 where the humidity of a flow of gases is between 0% and 100%. This transition area is due to the profile of the "high humidity boundary layer" as it forms at a normal to the humidification element and along its length. The "boundary layer" will take the form of a generally arc-shaped profile, with a small height closer to the upstream end of the humidifying element and a progressively greater height further downstream.

[00428] A downstream portion 180 is indicated where the high humidity boundary layer fills the height of the flow channel 30, 31, 32. This is discussed below with reference to Figures 9 to 15.

[00429] In the simplified arrangement, the humidification chamber 110 is modelled with the upstream end 1141 of the humidifying element 114 at the upstream end 133 of the generally elongate humidifying section 130 and the upstream end 1141 of the humidifying element 114 having a flat surface facing the direction of flow, e.g. humidifying section inlet 131.

[00430] The gases inlet 111 has gases with 0% humidity shown by the non-humidified shading 211. Likewise, as the gases flow into the inlet antechamber 140, the gases of flow channel 40 are shown to have 0% humidity by non-humidified shading 211. The flow channel 40 is shown as a region, i.e. within the inlet antechamber 140.

[00431] Where the gases flow reaches the humidifying section 130, the gases begin to humidify by contact with the humidifying element 114. This is shown by humidified shading 212 on the upper and lower surfaces 1143, 1144 of the humidifying element 114 near its upstream end 1141. However, the gases closer to the upper wall and lower wall 135, 136 of the humidifying section 130 (and thus further from the humidifying element 114) remain at 0% humidity near the upstream end 1141, as shown by the non-humidified shading 211.

[00432] As the gases pass through the humidifying section flow channel 30, as shown as the region between the humidifying element 114 and the walls of the humidifying section 130, the gases become more humidified as they pass to the downstream end 134 of the humidifying element 130. This is shown as the non-humidified shading 211 turning to the humidified shading 212.

[00433] Before the downstream end 134 of the humidifying section 134, the flow of gases is fully humidified as indicated by the complete shading to the humidified shading

212. The gases that pass into the outlet antechamber 112 and then into the gases outlet 112 remain at 100% humidification. This is achieved by selecting the height (34, 35) of the flow channels 31, 32 to correspond to, or to not be greater than or substantially greater than, (or indeed to be lesser than), an expected height of the high-humidity boundary layer (particularly when "mature" or substantially fully-developed) in each of the channels 31, 32 (determination of said expected height being discussed further below). This way, all or most of the gases flowing through the humidifying section 134 will be within the high humidity boundary layer.

[00434] Therefore, the gases that pass proximal to the humidifying element surfaces 1143, 1144 proximal to the upstream end 1141, increases in humidity quickly.

[00435] As the gases progress through the humidifying section 130, the boundary layer of high humidity gas expands, until the full height of the humidification chamber is encompassed as shown by the humidified shading 212.

[00436] Except in configurations where specifically described otherwise, the flow through the humidification chamber 110 from the gases inlet 111 to the gases outlet 112 is substantially laminar flow to ensure that the gases flow is directed proximate the humidifying element surfaces 1143, 1144, as this may be most effective in humidifying the gases. However, in some configurations, it is beneficial to have a controlled amount of turbulent flow or mixing of flow to mix a humidified flow with less humidified flow (such as to draw a portion of the flow that is farther from the humidifying element surfaces 1143, 1144 closer to them).

[00437] Referring to Figure 8, a partial view of FEA analysis of velocity magnitude of a flow through the humidification chamber 110 is illustrated. The humidification chamber 110 is modelled on a simplified humidification chamber 110 as described herein. Therefore, the features are as described elsewhere. However, reference numerals are omitted in part to assist with explanation.

[00438] The flow through the inlet antechamber 140 is shown by flow path 40; and is represented by the arrows in this section showing flow direction. As described above with reference to Figure 7, the gases flow in a substantially uniform direction along the general central axis (Ax – Figure 3) of the humidification chamber 110. At the walls of the inlet antechamber 140, the flow is generally directed along the walls.

[00439] Upon reaching the humidifying section 130 and in particular at the flow channel 30, 31, 32, as shown by the upstream end 1141 of the humidifying element 114 having a line extending normal to the general central axis, the gases flow is directed into either of the upper channel 31 or lower channel 32. The flow path through the humidifying section 130 is shown by the arrows showing the direction of flow labelled by 30, 31 and 30, 32. Therefore, in the flow channels 30, 31, 32, the overall flow is in the general axial direction, e.g. from the upstream end 1141 to the downstream end 1142 of the humidifying element 114.

[00440] The upper flow channel 31 and lower flow channel 32 have the respective channel heights 34, 35 as described with reference to Figure 5. Furthermore, the transverse direction of the flow channel normal (including substantially normal) to the direction of flow (including the general direction of flow) 36, 37 is shown as the direction that extends normal to the direction of flow (from the side view of Figure 7) and, in the present configuration, also extends normal from the relevant surface 1143, 1144 of the humidifying element 114. Therefore, an upper transverse direction of the flow channel normal to the direction of flow 36 extends from the upper surface 1143 of the humidifying element 114. A lower transverse direction of the flow channel normal to the direction of flow 37 extends from the lower surface 1144 of the humidifying element 114.

[00441] Any flow channel described herein may be referred to as having a transverse direction or dimension, being normal to the direction of flow. For instance, for the inlet antechamber 140, the dimension between the upper and lower walls 145, 146 may be referred to as the transverse dimension or direction of the flow channel 40 normal to the direction of flow.

[00442] Referring back to Figure 5, the transverse direction(s) of the flow channel(s) normal to the direction of flow 36, 37 are shown with reference to the resultant flow path / channel 30, 31, 32 represented by an arrow.

[00443] In the configuration shown in Figures 3 to 8, the humidifying section flow channel height 34, 35 is less than the height of the inlet antechamber 140. As discussed elsewhere, the height is transverse to the respective flow channels 30, 40 and is normal to the direction of flow 30, 40. Due to the humidifying element 114 splitting the flow channel 30 into upper and lower flow channels 31, 32, the inlet flow channel height 151 at the upstream end 141 of the inlet antechamber 140, and the humidifying section height 137 at the downstream end 142 of the inlet antechamber 140 are both greater than upper and lower humidifying section flow channel heights 34, 35. The reduction in height brings the flow of gases into close proximity with the humidifying element 114 within the upper and lower flow channels 31, 32. The close proximity is within the high humidity band / boundary layer. This is discussed in more detail elsewhere in the present document. The reduction between the inlet antechamber 140 and the humidifying section flow channels 30, 31, 32 also allows for the gases flow to be directed toward the surfaces of the humidifying element 114, where the humidifying of gases is greatest. Due to the sloped walls 147, 148 of the inlet antechamber 140 the height varies along the direction of flow. In the present configuration, the (transverse) height of the inlet antechamber 140 at any point is greater than that of the upper or lower flow channels 31, 32. However, in some configurations, the height of the inlet antechamber 140 or the height of the flow channels 31, 32 may be determined as an average value across their lengths.

[00444] As discussed with reference to Figure 4, the width of the humidifying section 39 and the width of the inlet antechamber 150 are the same. Therefore, the upper

and lower flow channels 31, 32 have the same width as the width of the humidifying section 39. In some configurations, the widths may vary or even be a diameter or circumference in the case of tubular humidifying sections 130. In some configurations the cross-sectional area of the inlet antechamber 140 is greater than the cross-sectional area of the humidifying section flow channel 30, 31, 32. The cross-sectional area may be taken as a cross-sectional line extending normal to the central axis (Ax – Figure 3) when viewed from the side, i.e. the area of the height and width. In some configurations the cross-sectional area of the inlet antechamber 140 is greater than the cross-sectional area of the humidifying section flow channel 30, 31, 32. The cross-sectional area of the inlet antechamber 140 or the humidifying section flow channel 30, 31, 32 may change along its length. Therefore, the cross-sectional area may be an average value in some configurations.

[00445] In some configurations, the outlet antechamber 160 has a greater height and/or cross-sectional area than the humidifying section flow channel 30, 31, 32 as described with reference to the inlet antechamber 140.

[00446] The inlet antechamber 140 may be configured to increase the velocity of the gas flow passing therethrough. The increase in the velocity may be due to the shape of the inlet antechamber 140. The inlet antechamber 140 may be a nozzle or be nozzle shaped. This may be as a result of the shape as herein described or independently.

[00447] The outlet antechamber 160 may be configured to decrease the velocity of the gas flow passing therethrough. The decrease in the velocity may be due to the shape of the outlet antechamber 160. The outlet antechamber 160 may be a diffuser or diffuser shaped. This may be as a result of the shape as herein described or independently.

[00448] To obtain the required humidity for the flow of gases, the boundary conditions must be considered. The boundary layer of a flow can be considered with reference to the boundary layer thickness, δ , that is a distance normal to a plate to a distance where the flow velocity is constant, that is to say that the velocity asymptotes to a constant velocity from the plate. The asymptotic velocity is denoted by u_e . The boundary layer thickness may be approximated to the high humidity band as discussed herein.

[00449] As the asymptotic velocity u_e is an asymptote, in practice, the 99% boundary layer thickness is used to define the point where the flow velocity has essentially reached asymptotic velocity u_e . The 99% boundary layer thickness is denoted as δ_{99} .

[00450] The Blasius boundary layer equation describes laminar flow for a boundary layer where flow is parallel to the plate. Given the discussion above, a laminar parallel flow is appropriate to approximate the present arrangement, wherein:

[00451]
$$\delta_{99}(x) \approx 5.0 \sqrt{\frac{\nu x}{u_0}} = 5.0 \sqrt{\frac{x}{\sqrt{Re_x}}} \quad \dots(1)$$

[00452] Wherein, Re_x is the Reynolds number, u_0 is the freestream velocity, x is the distance downstream from the start of the boundary layer, and ν is the kinematic viscosity. And wherein $u_e \approx u_0$ is constant.

[00453] As the 99% boundary layer thickness is generally unsuitable for bounded flow, the momentum thickness, δ_2 is considered which is the normal distance to a reference plane representing the lower edge of a fluid of uniform velocity u_e .

[00454] Therefore, following the Blasius equation conditions, the momentum thickness is:

$$\delta_2(x) \approx 0.664 \sqrt{\frac{\nu x}{u_0}} \quad \dots(2)$$

[00456] Wherein $u_e \approx u_0$ is constant.

[00457] Where a thermal boundary layer thickness is considered, the ratio between this and the velocity boundary layer can be given by the Prandtl number, Pr . For air at standard conditions, the thermal boundary layer is thicker than the velocity boundary layer. For a Prandtl number greater than 0.6:

$$\frac{\delta}{\delta_T} = Pr^{1/3} \quad \dots(3)$$

[00459] Where δ_T is a region where the temperature, T , is less than 99% of its far field value.

[00460] These values can be applied to the Schmidt number, Sc , in certain conditions. Therefore:

$$\frac{\delta_2}{\delta_c} = Sc^{1/3} \quad \dots(4)$$

[00462] Applying the Schmidt number to the equation (2) above:

$$\delta_c \approx \frac{0.664 \sqrt{\frac{\nu x}{u}}}{Sc^{1/3}} \quad \dots(5)$$

[00464] This can be further derived using the Schmidt equation, wherein:

$$Sc = \frac{\nu}{D} \quad \dots(6)$$

[00466] Where ν is the kinematic viscosity, D is the mass diffusivity and δ_c is the concentration boundary thickness. The mass diffusivity, D , may be approximated to the mass transfer coefficient, which is affected by the temperature, T of the plate.

[00467] Whilst the equation may require certain conditions or approximations, such as the momentum thickness, δ_2 also not specifically for a bounded flow, albeit more accurate than boundary layer thickness, δ_{99} , the factors can be considered relevant for determining a concentration boundary thickness. Therefore, the momentum thickness, δ_2 is used to determine the thickness or height of the humidity boundary layer (high-humidity boundary layer).

[00468] In view of the above and with reference to Figures 1 to 6, the channel height 34, 35 can be determined to achieve the required humidity of the gases passing through the flow channel 30, 31, 32. Referring to the Blasius boundary layer equation (1), the boundary layer distance is determined as a distance from a plate. Therefore, it is the

distance or channel height 34, 35 from the relevant surface 1143, 1144 of the humidifying element 114 that is used to determine the humidity boundary layer. The Blasius equations assume a two-dimensional model. Therefore, the distance is also taken being normal or perpendicular to the direction of flow over the plate. Referring to Figure 5 or Figure 7, the direction of flow through the channel is defined by flow path 30, 31, 32. Therefore, the direction is the transverse direction of the flow channel normal to the direction of flow 36, 37, this may also be referred to as a transverse dimension of the flow channel normal to the direction of flow 36, 37 having a determined dimension. Whilst this is generally normal / perpendicular to the relevant surface 1143, 1144 of the humidifying element 114, this is generally determined as perpendicular to the direction of flow 30, 31, 32 for the purposes of determining the channel height 34, 35.

[00469] Referring to Figures 9 to 15, the determined humidity boundary layer 200 is schematically shown in the flow channel 30, 31, 32 of a humidifying section 130. As discussed above, the humidity boundary layer 200 asymptotes from the surface, i.e. the humidifying element 114, to the distance where the boundary layer 200 is the mature boundary layer 220 (fully developed boundary layer). The boundary layer 200 refers to the whole of the boundary layer including the mature boundary layer 220. For purposes of explanation, reference to any one of the flow channels 30, 31, 32 may be reference to the other flow channels 30, 31, 32.

[00470] It is highlighted that the transverse dimension of the flow channel normal to the direction of flow 36, 37 may not be the same dimension as the height of the flow channel 34, 35 from the surface of the humidifying element 114 to the wall of the humidifying section 130. Instead, in some configurations, the transverse dimension of the flow channel normal to the direction of flow 36, 37 is the part of the flow channel 30, 31, 32 in which the gases flow. This is schematically illustrated in the Figures by the transverse dimension of the flow channel normal to the direction of flow 36, 37 being a directional arrow showing the transverse direction of the flow for the relevant the flow channel 30, 31, 32. However, in some configurations, transverse dimension of the flow channel normal to the direction of flow 36, 37 is equal to the flow channel height 34, 35 as discussed below.

[00471] As noted before, the present disclosure aims to ensure that a target humidity of the gases is achieved by the time the gases exit the humidifying section; with the transverse dimension 36, 37 of the flow channel(s) 30, 31, 32 being selected so as to achieve said target humidity. Therefore, referring to Figure 9, if the target humidity is 100%, then the transverse dimension of the flow channel(s) will be equal to (or lesser than) the determined boundary layer 200, such that all of the gases flowing through the transverse dimension 36, 37 of the flow channel(s) are within the high-humidity boundary layer 200 and thus become humidified. This is exemplified by Figure 7, where prior to the end of the humidifying section the entirety of the flow channels becomes taken up by the high-humidity boundary layer. However, referring to Figure 10, if the target humidity is

around 80%, then the transverse dimension 36, 37 of the flow channel may accordingly be different; for instance, in such a case the transverse dimension 36, 37 of the flow channel may be somewhat greater than the determined boundary layer 200, such that a portion of the gases may flow outside of the high-humidity boundary layer (proximal to the walls and distal from the humidifying element 114), since only 80% humidification of the gases is required.

[00472] Referring to Figure 11, it will be understood that where 100% humidification is required, the transverse dimension 36, 37 of the flow channel may be equal to *or lesser than* the determined (expected) height of the boundary layer 200 (when substantially fully developed), since, if the transverse dimension 36, 37 is less than the boundary layer 200, then the boundary layer 200 (when substantially fully developed) will occupy the entire transverse dimension 36, 37 of the flow channel and thus substantially all of the gases flow will be within the boundary layer 200.

[00473] Furthermore, referring to Figure 12, it will also be understood that a "mature" or fully-developed (or substantially-developed) boundary layer 220 may be achieved prior to the end of the humidifying section 130, i.e. upstream of its downstream end 134, in the indicated downstream portion 180; with the downstream portion 180 of the humidifying section 130 therefore accommodating the fully-developed (or substantially-developed) boundary layer 220. This can be seen in Figure 7; downstream portion 180 accommodates the substantially fully-developed boundary layer as schematically shown with reference to Figure 11 or 12. In some configurations, the "mature" or fully developed or substantially fully developed boundary layer 220 may be achieved substantially midway along the humidifying section 130; this may advantageously allow the gases flowing through the second half of the humidifying section 130 to be fully "immersed" in the boundary layer 200, and thus further improve humidification.

[00474] Referring to Figures 13 to 15, a humidifying section 130 having multiple humidifying elements 115, 116 and thus flows / flow channels 31, 32, 33, is shown. The figures assume the same characteristics and thus same boundary layer formation. In Figure 13, the humidifying section 130 is split by first and second humidifying element 115, 116. They are arranged parallel in the humidifying section 130 such that the first flow channel 31 is formed between the first humidifying element 115 and the humidifying section 130, the second flow channel 32 is formed between the first humidifying element 115 and the second humidifying element 116. The third flow channel 33 is formed between the second humidifying element 116 and the humidifying section 130.

[00475] As shown in Figure 14, the boundary layer 202 formed in the first channel 31 between the first humidifying element 115 and the wall of the humidifying section 130 is similar to that of Figure 9. Therefore, the mature boundary layer 220 is formed and the transverse dimension of the flow channel 31 will be equal to (or lesser than) the determined boundary layer 202. The boundary layer 206 formed in the third flow channel 33 between

the second humidifying element 116 and the wall of the humidifying section 130 is similar to that of the first flow channel 31. Therefore, the mature boundary layer 226 is formed and the transverse dimension of the flow channel 33 will be equal to (or lesser than) the determined boundary layer 206.

[00476] For the second flow channel 32, there are two boundary layers 208, 209 formed from each humidifying element 115, 116 that are facing one another. As illustrated in Figure 14, the "mature" or fully-developed height of boundary layer 208, 224 from the first humidifying element 115 meets the "mature" or fully-developed boundary layer 209, 224 from the second humidifying element 116. Therefore, the transverse dimension of the flow channel 32 is selected to be equal to twice the height of the "mature" or fully-developed boundary layer 222, 224, 226.

[00477] As shown in Figure 15, the transverse dimension of the flow channel 32 may also be selected to be smaller than twice the height of the "mature" or fully-developed boundary layer 222, 224, 226. Therefore, the boundary layer 210 converges at a distance between the first and second humidifying element 115, 116. However, as the transverse dimension of the flow channel 32 contains an effective high humidity boundary layer, the channel 32 is fully "immersed".

[00478] A "mature", fully-developed or substantially fully-developed boundary layer 220 will be understood to refer to a boundary layer 200 whose height is no longer significantly changing with distance along the x-axis (i.e. along the direction of flow), i.e. a boundary layer 200 that has reached a substantially stable height.

[00479] As discussed herein, the derivation of the "high humidity boundary layer" equations is related to the derivation of the "flow velocity boundary layer" and "momentum boundary layer" equations. Thus, the latter equation(s) and resultant boundary layer profile(s) may provide a convenient "proxy", in practical terms, for approximating the high-humidity boundary layer. The two may not have an identical profile, but may often be approximately similar for a given set of operating conditions.

[00480] The derivation of the Blasius equation (1) describes that in some configurations the distance, size, dimension, radius, diameter, or height 34, 35 of the flow channel 30, 31, 32 through the humidifying section 130 for a required humidity or target humidity or relative humidity of at least 80% of the gases or portion of gases that pass through the humidification chamber 110 is a function of at least one of the length of the flow channel 38, the flow rate of the gases (in particular, the flow velocity), the temperature of the humidifying element 114 or a relative gases concentration.

[00481] In some configurations, the transverse dimension of the flow channel 30, 31, 32 normal to the direction of flow 36, 37 is a function of at least one of the length of the flow channel 38, the flow rate of the gases, the temperature of the humidifying element 114 or a relative gases concentration.

[00482] Therefore, the transverse dimension may be a function of:

- a) the length of the flow channel 38;
- b) the flow rate of the gases;
- c) the temperature of the humidifying element 114;
- d) the relative gases concentration;
- e) the length of the flow channel 38, the flow rate of the gases, the temperature of the humidifying element 114 and relative gases concentration;
- f) the length of the flow channel 38, the flow rate of the gases, and the temperature of the humidifying element 114;
- g) the length of the flow channel 38, the flow rate of the gases, and the relative gases concentration;
- h) the length of the flow channel 38, the temperature of the humidifying element 114, and the relative gases concentration;
- i) the flow rate of the gases, the temperature of the humidifying element 114 or a relative gases concentration;
- j) the length of the flow channel 38 and the flow rate of the gases,
- k) the length of the flow channel 38 and the temperature of the humidifying element 114;
- l) the length of the flow channel 38 and the relative gases concentration;
- m) the flow rate of the gases and the temperature of the humidifying element 114;
- n) the flow rate of the gases and the relative gases concentration
- o) the temperature of the humidifying element 114 and the relative gases concentration
- p) or any other combination thereof.

[00483] Other factors or parameters may also be relevant in the construction of the humidification chamber 110. At least some of these factors or parameters may be directly or indirectly influential in the distance, size, dimension, radius, diameter or height of the flow channel 34, 35 or the transverse dimension of the flow channel 30, 31, 32 normal to the direction of flow 36, 37. The table below (Table 1) provides a non-exhaustive list with the range of values. All values are substantially as listed and the expected range or value may be based on design preference rather than physical limits.

[00484]

Table 1

Parameter / Factor	First Lower Limit	Second Lower Limit	First Upper Limit	Second Upper Limit	Expected range or value
Gases Flow Rate	0.5 L/min	10 L/min	200 L/min	100 L/min	70 L/min
Oxygen Fraction of gases	21%	30%	100%	50%	40%
Liquid Flow Rate	0.1 mL/min	1 mL/min	50 mL/min	5 mL/min	3 ml/min

Humidifying Element Surface Temperature	0°C	30°C	200°C	80°C	60°C – 80°C
Inlet Gases Temperature	0°C	15°C	50°C	35°C	20°C
Outlet Gases Temperature	18°C	30°C	70°C	40°C	38°C
Outlet Humidity	12 mg/L	40 mg/L	62 mg/L	50 mg/L	44 mg/L (BTPS)
Inlet Humidity	0 mg/L	0.1 mg/L	50 mg/L	5 mg/L	3 mg/L
Height of flow channel of humidifying section (34, 35)	0 mm	1 mm	22 mm	5mm	2 mm
Length of flow channel of humidifying section (38)	1 mm	5 mm	2 m	300 mm	90 mm – 200 mm
Width or circumference of flow channel of humidifying section	0.1 mm	5 mm	500 mm	50 mm	20 mm
Cross-sectional Area flow channel of humidifying section	10 mm ²	40 mm ²	10,000 mm ²	3,000 mm ²	50 mm ²
Flow velocity of the gases	0.003 m/s	0.1 m/s	330 m/s	50 m/s	30 m/s
Ratio of cross-sectional area of inlet antechamber to cross-sectional area of humidifying section	1:10	2:5	22 ² :0.1 ²	20:1	12:1

[00485] Any value shown in Table 1 may be combined with another value to form a range. All values within the range are considered as viable values by themselves or for forming sub ranges thereof. For instance, for the inlet gases temperature, may be between about 0°C and about 50°C, or between about 0°C and about 35°C, or between about 15°C and about 50°C, or between about 15°C and about 35°C, or between about 15°C and about 20°C. The inlet gases temperature may be any value of the ranges, for instance, about: 1°C, 2°C, 3°C, 4°C, 5°C, 6°C, 7°C, 8°C, 9°C, 10°C, 11°C, 12°C, 13°C, 14°C, 15°C, 16°C, 17°C, 18°C, 19°C, 20°C, 21°C, 22°C, 23°C, 24°C, 25°C, 26°C, 27°C, 28°C, 29°C, 30°C, 31°C, 32°C, 33°C, 34°C, 35°C, 36°C, 37°C, 38°C, 39°C, 40°C, 41°C, 42°C, 43°C, 44°C, 45°C, 46°C, 47°C, 48°C, 49°C, or 50°C. This is not limited to whole number integers but also values between whole numbers. The values in the tables may be exact values or may be approximate values (e.g. “12 mg/L” may be interpreted as “about 12 mg/L”).

[00486] It is clarified that whilst specific examples are given, these can apply to any such parameter, value or range discussed herein.

[00487] The gases flow rate is the flow of gases provided to the humidification chamber 110 from, for example, the blower or flow generator 120. Therefore, the flow of gases is determined as the gases that enter the humidification chamber 110 through the gases inlet 111 (and subsequently exit via the gases outlet 112). The limits of the range may, in some configurations, be determined by the limitation of the flow generator 120, or by the suitable therapy limits for treatment of a user. The gases itself may be gas or aerosolised fluids, the gases may be air, or may be a mix of gases (including fluids) mixed with other gases. As discussed above, the flow velocity is a direct variable in the equations determining the humidity boundary layer 200. The gases flow rate is determined by the flow velocity (and the flow size). Therefore, the gases flow rate is used in the determination of the height of the boundary layer 200 and thus the required transverse height 36, 37 of the flow channels.

[00488] The oxygen fraction is the percentage of oxygen included in the gases for the gases flow through the humidification chamber 110. The limits are based on standard air and the maximum saturation of oxygen in a gas. The kinematic viscosity is required to determine the humidity boundary layer 200. As the composition of the gases affect the kinematic viscosity, the oxygen fraction will affect the height of the boundary layer 200 and thus the required transverse height 36, 37 of the flow channels. However, in practice, the oxygen fraction may not be one of the principal parameters that is varied when seeking to regulate boundary layer 200 and associated flow channel height in use.

[00489] The liquid flow rate is the flow rate of the liquid provided to the humidifying element 114 for the purposes of humidifying a gases flow. The humidifying element 114 may be in the form of a heated surface or wick, such as a vapour permeable membrane with the upper surface 1143 and lower surface 1144 being a surface of the wick. Therefore, a liquid supply is provided to the humidifying element 114 for the purposes of humidification.

[00490] The humidifying element 114 temperature is a temperature of the surface, heating plate, wick etc for humidifying a liquid into a gases flow through the flow channel 30 to humidify the gases flow at the gases outlet 112. The temperature provides the humidification to the flow of gases and, therefore, affects the humidification boundary layer 200.

[00491] The inlet gases temperature is the temperature of air supplied to the humidification chamber 110, such as from the flow generator 120. This may be determined by the ambient temperature of air. However, pre-heating (or cooling) of gases may be adopted. Some limits may be determined by the suitable therapy limits for a user or the safe environment for use. Whilst this is influential on the kinematic viscosity that is required to determine the humidity boundary layer 200, in practice, the temperature of inlet gases

may not be one of the principal parameters that is varied when seeking to regulate boundary layer 200 and associated flow channel height in use.

[00492] The outlet gases temperature is the temperature of gases exiting the humidification chamber 110, i.e. through the gases outlet 112. The gases may then be provided to a user through the patient interface as described with reference to Figure 1. The outlet gases temperature may be related to the ambient temperature of air. However, in practice, the humidifying element temperature may be a presiding factor in determining and controlling the outlet gases temperature. The limits of the range may be determined by the suitable therapy limits for a user, and the most effective values.

[00493] The outlet humidity is the humidity of the gases at the gases outlet 112 of the humidification chamber 110, i.e. after humidifying occurs in the humidification chamber 110 and, in some configurations, the humidified gas is then provided to a user through the patient interface 122 as described with reference to Figure 1. The range for the outlet humidity may be determined by the therapy requirement for the user and also regulatory limits for suitable therapy.

[00494] The inlet humidity is the humidity of gases supplied to the humidification chamber 110, such as gases provided from a flow generator 120. The ranges may be determined by physical limits on gases and also by limits placed on an environment in which a humidification chamber 110 operates. The humidity boundary layer 200 will be varied by the inlet humidity of the gases. Namely, if the inlet conditions are less humid, the boundary layer 200 will have a larger / taller profile. Therefore, there will be a greater difference between inlet humidity and humidifying element humidity (i.e. atmosphere is less humid). If the inlet gases have a higher humidity, the profile of the boundary layer 200 will be flatter. This has an effective "sponge" effect. However, this does not have a great effect on the requirements as a humid atmosphere, whilst having a flatter boundary layer 200, will not require much active humidification anyway. However, in use the inlet humidity is much lower than surface humidity at the humidifying element 114. Therefore, in practice, the inlet humidity might not be one of the principal parameters that is varied when seeking to regulate boundary layer height in use.

[00495] The height of the flow channel 34, 35 is the height as described elsewhere as the transverse dimension of the flow channel normal to the direction of flow 36, 37. Whilst it has been shown that the height may be determined from the calculation of the high humidity boundary layer, the range of values for the dimension may also be based on physical limits. Furthermore, in some configurations, the required outlet humidity of the flow of gases determines the dimension. It is also noted that a capillary effect may be utilized, such as in infant devices, where the channel height is effectively 0 mm. In some configurations the transverse dimension of the flow channel may exceed the size of the "mature" or fully-developed (or substantially developed) boundary layer 220 and thus

a portion of the flow of gases remains outside of the humidifying boundary layer and is not humidified such as shown with reference to Figure 10.

[00496] The length of the flow channel 38 (or 139 in some configurations), is the length as described elsewhere where the gases pass through the flow channel 30 and are humidified, i.e. the gases pass over the humidifying element 114. The range of values are determined by physical limits where the device is too small or large to utilise (and / or compatibility requirements with other breathing assistance apparatus components), and / or also on limits based on the humidifying of the flow of gases such that the required formation of the boundary layer 200, such as a mature boundary layer 220 is achieved or the target humidity of outlet gases is achieved. Therefore, as discussed above, length of the flow channel is used in determining the humidity boundary layer 200. In some configuration, the height of the flow channel 30, 31, 32 may be referred to as a ratio or percentage of the length of the flow channel 38, for instance, the ratio of height to length may preferably not exceed 1:10 in some configurations. A width of the flow channel 30 may be the width of the humidifying section 39. In some configurations, the width of the humidifying element may be the same as the width of the flow channel 30, 31, 32, in other words, the humidifying element 114 takes up the entire width of the flow channel 30, 31, 32. In other configurations (see for example Figure 21), the width of the flow channel 30, 31, 32 may be greater than the width of the humidifying element 114 disposed therein. The range of values for width of the flow channel are determined by physical limits where the device is too small or large to utilise (and / or compatibility requirements with other breathing assistance apparatus components). Under the conditions of the equations above, the width of the flow channel 30, 31, 32 will not vary the boundary layer 200 where other conditions are kept the same, such as length of the channel, gases flow rate, element temperature and gases concentration. Therefore, the boundary layer 200 will be formed across the width of the humidifying section 130. However, as discussed, the flow velocity of the gases is used in the equations. Therefore, for the same volume of gas delivered across a greater width, then the flow velocity will be varied. Therefore, the height of the boundary layer 200 may be affected by the width if it is influential on other factors, such as the cross-section and thus flow rate.

[00497] A flow channel width may also be a diameter, such as configurations where the humidifying section 130 is tubular. Therefore, the parameter may also refer to an internal diameter of the flow channel 30.

[00498] The humidifying section flow channel height 34, 35, channel length 38, and channel width 39 (or diameter) also provide a surface area or volume for the flow channel 30, 31, 32. A cross-section area through the flow channel 30, such as determined from the humidifying section flow channel height 34, 35, and channel width 39 (or diameter) may be determined. The range limits may be based on similar factors as the height, length, and width described elsewhere. As discussed above, where the flow velocity

would be varied for the change in cross-section, such as where a set volume of gas is delivered, then the cross-section will vary the height of the boundary layer 200. However, this is determinate on the flow velocity rather than directly by the cross-section.

[00499] As will be understood, throughout the specification, channel height 34, 35 is not limited to or dependent on a specified orientation but is in reference to the distance between the points defined herein. Likewise, channel width 39 is not determined by orientation nor is it limited in such a manner, but is in reference to the distance between the points defined herein.

[00500] The gases flow velocity is the velocity of gases through the humidification chamber 110. Due to changes in the velocity due to varying dimensions and geometry, such as the flow area, the flow velocity of the gases through the flow channel 30 may be vary along the flow path, and also vary in comparison to the flow velocity through the inlet antechamber flow channel 40 or outlet antechamber flow channel 50, for instance. The range of values may be limited by physical limitations. However, as discussed above, the flow velocity is a direct variable in the equations determining the humidity boundary layer 200 and, therefore, in practice, may be a principal parameter in the determination of the height of the boundary layer 200 and thus the required transverse height 36, 37 of the flow channels.

[00501] The ratio of the cross-section area of the inlet antechamber 140 to the cross-sectional area of the humidifying section flow channel 30, 31, 32 is a dimensionless value determined by the cross-sectional area of the two parts. Whilst, generally, as shown in at least Figures 1 to 8, the cross-sectional area of the inlet antechamber 140 is larger than the (at least one) flow channel 30, 31, 32 to urge the flow of gases to flow proximate to the humidifying element 114, in some configurations the cross-sectional area of the inlet antechamber 140 may be relatively smaller. Therefore, the range of limits account for this. The cross-sectional area of the inlet antechamber 140 or the humidifying section flow channel 30, 31, 32 may change along its length. Therefore, the cross-sectional area may be an average value in some configurations.

[00502] As described above, a flow of gases through the humidifying chamber 110 is humidified to a target value. This may be a relative humidity value, although in some configurations it may alternatively or additionally be expressed as an absolute humidity value, such as the range given in Table 1, or another target value as determined by operational or therapy requirements. A fraction or portion of the gases flowing through the humidifying chamber 110 may be required to reach the target humidity. For instance, some percentage of the gases flow may not be required to be humidified, may not pass through the humidifying section 130 or may not be required to be fully humidified to the target humidity. In view of this the channel height 34, 35, i.e. transverse dimension of the flow channel normal to the direction of flow 36, 37, may be such that a portion of the gases flow reaches the target humidity. In some configurations, the fraction or portion of the

gases may be substantially all of the gases passing through the flow channel 30, 31, 32. In some configurations, the portion of gases may be 60% of the gases that pass from the gases inlet 111 to the gases outlet 112. In some configurations, the portion of gases may be 80% of the gases that pass from the gases inlet 111 to the gases outlet 112.

[00503] Additionally, or alternatively to the portion of gases flowing through the humidification chamber 110, the channel height 34, 35, i.e. transverse dimension of the flow channel normal to the direction of flow 36, 37 may be such that 60% of a flow of gases (or portion thereof) reaches the target humidity at the gases outlet 112. In some configurations 80% of a flow of gases (or portion thereof) reaches the target humidity. Wherein the target humidity may be any value as described above with reference to Table 1. Additionally, or alternatively, in some configurations the flow of gases (or portion thereof) has a relative humidity of 60% at the gases outlet 112. In some configurations, the flow of gases (or portion thereof) has a relative humidity of 80% at the gases outlet 112.

[00504] Referring to Figures 16 and 17, an alternative configuration of the humidification chamber 110 as described with reference to Figures 1 to 8 and the boundary layers of Figure 9 to 15 is shown. Except for the differences described below, the description of the humidification chamber 110 of Figures 16 and 17 is as described with reference to Figures 1 to 8 and some reference signs are omitted for some features for purpose of explanation.

[00505] Referring to Figure 16, a partial section view of the inlet antechamber 140, generally elongate humidifying section 130 and outlet antechamber 160 is shown. A single flow channel 30, 31 is formed by the humidifying element 114 in the humidifying section 130. Therefore, a single surface 1143 of the humidifying element 114 is in contact with or faces the flow of gases through humidifying section 130.

[00506] There is no equivalent of the lower flow channel 32 of the configurations of Figs 2-8.

[00507] In the present configuration, the humidifying element 114 is formed in the lower wall 136 of the humidifying section 130. Therefore, the height of the channel 34 is the same as the height of the humidifying section 137 as they both extend between the top wall 135 and the respective upper surface 1143 or lower wall 136.

[00508] In some configurations, the flow path 40 through the inlet antechamber 140 may only be required to be directed to one surface 1143 of the humidifying element 114. Therefore, at least one of the upper angled wall 147 or lower angled wall 148 of the configurations of Figs 2-8 are absent, e.g. the angled wall 147, 148 connecting to the wall 135, 136 having the humidifying element 114 is omitted as the flow of gases do not need to be directed away from the angled wall 147, 148 of the inlet antechamber 140.

[00509] In the configuration of Figure 16, the lower (straight) wall 146 of the inlet antechamber 140 is directly connected to the lower wall 136 and humidifying element

114. Therefore, the lower wall 146 of the inlet antechamber 140 is parallel to the lower wall 136 and humidifying element 114. The upper wall 145 of the inlet antechamber 140 is connected to the angled wall 147. The angled wall 147 reduces the height of the inlet antechamber 151 to the height of the flow channel 34 at the upstream end 1141 of the humidifying element 114. The angled wall 147 is connected to the upper wall 135 of the humidifying section 130. Therefore, the flow of gases is directed from the angled wall 147 toward the surface 1143 of the humidifying element 114 due to the angle at the transition, as described with reference to Figure 5.

[00510] The flow path 40, 30, 50 through the flow channels 40, 30, 50 of the inlet antechamber 140, 40, humidifying section 130, 30, and outlet antechamber 160, 50 is represented by an arrow. This is an approximation of the gases flow at the top wall 145 of the inlet antechamber 140. The transverse dimension of the flow channel normal to the direction of flow 36 is perpendicular to the humidifying element 114 also.

[00511] In the present configuration, as a single channel 30, 31 is used, to achieve the target humidity for the gases, the flow channel 30, 31 may have different characteristics as determined above in comparison to the configurations with multiple flow channels 30, 31, 32 to provide the mature humidity boundary layer 220. For instance, the flow channel 30, 31, 32 may be longer in length. Therefore, the period or area over which the flow of gases are in the high humidity band 200 of the humidifying element 114 is effectively compensated.

[00512] As discussed, in some configurations, the outlet antechamber 160 has a different (mirrored) geometry to the inlet antechamber 140. In Figure 16, an example configuration is shown where the upper angled wall 167 of the outlet antechamber 160 has a lower gradient than that of the upper angled wall 147 of the inlet antechamber 140. Therefore, the flow of gases out of the humidifying section 130 is smoother. In the configuration of Figure 16, the lower (straight) wall 166 is connected directly to the lower wall 136 and humidifying element 114. Therefore, no lower angled wall 168 for the outlet antechamber 160 is provided.

[00513] Whilst the configuration is described with reference to the single upper angled wall 167 of the outlet antechamber 160 by virtue of the single flow channel 30, 31, in some configurations the lower angled wall 168 of the outlet antechamber 160 with relatively smaller gradient than that of the lower angled wall 148 of the inlet antechamber 140 is provided.

[00514] The smoother transition to the outlet antechamber 160 is to minimize turbulence and, therefore, pressure drop, which is important for effective high flow therapy. The flow of gases becomes humidified when passing through the humidifying section 130, and, therefore, the directing of the gases flow is not required in the same manner in the outlet antechamber 160 as in the inlet antechamber 140. In some configurations, where the outlet antechamber 160 connects a substantially rectangular

cross-section of a humidifying section 130 to the gases outlet, the transition between the two shapes may be gradual to assist in the laminar flow of humidified gases. In some configurations, the smoother transition may be achieved by having an angle of the upper and/or lower angled wall 167, 168 of between approximately 185 and 250 degrees. In some configurations, this angle may be between 190 and 200 degrees.

[00515] The smoother transition of the outlet antechamber 160 may be applied to any humidification chamber 110 as described herein. The configuration may be taken separate or in combination with the single flow channel 30, 31 as herein described.

[00516] Referring to Figure 17, the same configuration as Figure 16 is shown, with an alternative configuration for the humidifying element 114. The humidifying element 114 comprises a heating plate 117 positioned at a base of a fluid reservoir 119. (This may be provided by a known passover humidifier setup, such as for example a setup that includes the MR290 humidification chamber manufactured by Fisher & Paykel Healthcare. The humidification chamber may be appropriately modified (or combined with additional elements) to form the height-regulated flow channel 34 depicted in Figure 17 and described herein.) The heating plate 117 is formed in an indentation in the bottom wall 136 of the humidifying section 130, the indentation forming the reservoir 119. The height of a fluid in the reservoir 119 forms the effective humidifying element upper (fluid) surface 1143. Therefore, the gases flow through the flow channel 30, 31 between the humidifying element upper fluid surface 1143 and the upper wall 135 of the humidifying section 130. The height of the flow channel 34 is likewise determined as the distance between the humidifying element upper fluid surface 1143 and the upper wall 135. Furthermore, the transverse dimension of the flow channel normal to the direction of flow 36 also extends from the humidifying element upper fluid surface 1143 towards the upper wall 135.

[00517] As the humidifying element 114 with the heating plate 117 and fluid reservoir 119 requires an orientation where the fluid will be contained in the reservoir, a single channel 30, 31 such as described with reference to Figure 16 is used. Likewise, the shapes of the inlet antechamber 140 and outlet antechamber 160 may optionally be adopted here to direct the flow accordingly. However, in some configurations, the humidifying element 114 with the heating plate 117 and fluid reservoir 119 may be used with other configurations of humidification chambers 110 including those described herein.

[00518] The humidifying element upper fluid surface 1143 of the humidifying element 114 with the heating plate 117 and fluid reservoir 119 may move over time as a gases flow is humidified and the fluid in the reservoir 119 is evaporated. Therefore, the high humidity band may move toward the heating plate 117 and away from the upper wall 135. Where the transverse dimension of the flow channel normal to the direction of flow 36 is determined by a target or percentage humidity of the gases flow through the channel or by the high humidity band, the transverse dimension of the flow channel normal to the direction of flow 36 will tend to generally move toward the heating plate 117 and away

from the upper wall 135 as the fluid level in the reservoir drops and the flow of gases follows the humidifying element upper fluid surface 1143.

[00519] The use of a fluid reservoir 119 allows for a smaller volume of water.

[00520] In an alternative configuration of the humidifying element 114 with the heating plate 117 and fluid reservoir 119, the humidifying element upper fluid surface 1143 is maintained at a substantially constant level to ensure an optimal flow path for the gases. This may be via precise flow control, or a vapour permeable membrane or other means to maintain the level.

[00521] In some configurations, rather than forming the lower wall 136 of the humidifying section 130, the heating plate 117 and fluid reservoir 119 may be arranged in any location within the humidifying section 130 whilst ensuring a flow path for the humidification of gases over the surface of the fluid.

[00522] Referring to Figure 18, an alternative configuration of the humidification chamber 110 as described with reference to Figures 1 to 8 and with reference to the boundary layer of Figures 9 to 15 is shown. Other than the differences described below, the description of the humidification chamber 110 of Figure 18 is as described with reference to Figures 1 to 8 and where some reference signs are omitted for some features for purpose of explanation. Figure 18 is a CFD view of the gases flow through the humidification chamber 110.

[00523] In the configuration of Figure 18, the humidifying element 114 is positioned in the generally elongate humidifying section 130 splitting or directing the humidifying section flow channel 30 into the upper 31 and the lower 32 flow channels similar to the configuration of Figures 3 to 8. Additionally, in this configuration, the humidification chamber 110 comprises a first baffle 171 extending between the upper wall 135 of the humidifying section 130 and the humidifying element 114. The baffle 171 is a plate or wall that extends substantially across the flow path 30 of the humidifying section 130, i.e. the baffle extends along the width of the humidifying section 39 (Figure 4) from the humidifying section internal upper wall 135.

[00524] At the base of the wall or plate of the first baffle 171 there is a first baffle base 173. The first baffle base 173 extends to a first baffle tip 175 at the end of the plate or wall forming the first baffle 171.

[00525] The first baffle 171 is connected or directly connected to the upper wall 135 of the humidifying section 130 at the first baffle base 173. The first baffle tip 175 is not connected to any further structure and is positioned in the humidifying section 130 within the flow channel 30. Therefore, there is a gap formed between the first baffle tip 175 and the upper surface 1143 of the humidifying element 114.

[00526] As described with reference to other configurations, the humidifying section upper channel height 34 is the distance between the upper wall 135 of the humidifying section 130 and the upper surface 1143 of the humidifying element 114.

Therefore, the channel height 34 extends transverse to the flow channel 30 and is perpendicular to the humidifying element 114. The first baffle 171 directs the flow of gases through the humidifying section 135 through the gap between the first baffle tip 175 and the upper surface 1143. Therefore, the flow of gases is directed to be proximal to the humidifying element 114.

[00527] As shown in Figure 18 by the CFD shading of the gases flow through the humidification chamber 110, in the shading denoted by reference 215, the flow velocity of the gases is relatively high. Therefore, this is the high velocity shading 215. In the shading denoted by reference 216, the flow velocity of the gases is relatively low. Therefore, this is the low velocity shading 216. Where the flow of gases enters the humidification chamber 110 at the gases inlet 111, there is high velocity shading 215 as the gases flow rate from the flow generator 120, for instance, is high. This flow rate remains substantially high with predominant high velocity shading through the flow path 40 of the inlet antechamber 140. Upon entering the humidifying section 130 into the flow channel 30, 31, 32, there is a clear band of high velocity shading 215. This is close to the humidifying element 114 as directed by the first baffle 171 described above. In the region behind the first baffle 171 there is a region of low velocity shading 216 where the gases flow is blocked from the high flow from the inlet antechamber flow path 40.

[00528] When considering the high-humidity boundary layer 200 as discussed with reference to Figures 9 to 12, the mature boundary layer 220 may be one of the arrangements schematically shown. However, the flow of gases is directed into the boundary layer 200 by the first baffle 171. Therefore, the height 34 of the flow channel 31 may not be the determining height and instead it is the distance between the first baffle tip 175 and the upper surface 1143 of the humidifying element 114 that is the relevant height. Therefore, the transverse dimension of the flow channel normal to the direction of flow 36 may be determined as the dimension that extends perpendicular from the upper surface 1143 of the humidifying element 114 to at or near the first baffle tip 175. This is shown by the high velocity shading 215 near the humidifying element 114 that the majority of flow is in this region.

[00529] Therefore, the first baffle 171 effectively reduces the active part of the flow channel 30 (or at least the portion of the flow channel 30 that is proximate the first baffle 171) to the transverse dimension of the flow channel normal to the direction of flow 36 by altering the flow path of the gases through the humidifying section 130.

[00530] In some configurations, the lower flow channel 32 comprises an equivalent second baffle 172 extending between the lower wall 136 of the humidifying section 130 and the humidifying element 114. The second baffle 172 is a plate or wall that extends across the flow path 30 of the humidifying chamber 110, i.e. the baffle extends along the width of the humidifying section (39 - Figure 4) from the internal humidifying section lower wall 136. The second baffle 172 comprises a second baffle base 174 and a

second baffle tip 176 at its ends. The second baffle 172 is connected or directly connected to the lower wall 136 of the humidifying section 130 at the second baffle base 174. The second baffle tip 176 is not connected to any further structure and is positioned in the humidifying section 130 within the flow channel 30, 32. Therefore, there is a gap formed between the second baffle tip 176 and the lower surface 1144 of the humidifying element 114.

[00531] The second baffle 172, therefore, has the same function and effect on the flow of gases through the lower flow channel 32 as described for the first baffle 171 with respect to the upper flow channel 31. Likewise, whilst the lower channel height 35 extends between the lower surface 1144 of the humidifying element 114 and the lower wall 136, the active part is the transverse dimension of the flow channel normal to the direction of flow 37 by altering the flow path of the gases through the humidifying section 130 due to the second baffle 172.

[00532] In some configurations, the first baffle 171 and second baffle 172 may be horizontally symmetrical, i.e. the line of symmetry pass through the central axis (Ax – Figure 3) between the gases inlet 111 and gases outlet 112, or the plane of symmetry that extends along the central axis line and forms a plane in the width direction. Symmetry of the first and second baffles 171, 172 may encourage laminar flow when the upper and lower flow channels 31, 32 reconverge in the outlet antechamber 160 (if present) or the outlet 112. However, in some configurations, the first baffle 171 and second baffle 172 are positioned symmetrically staggered such that the flow converging from the upper and lower flow channels 31, 32 are encouraged to mix. However, given that the final pair of baffles, i.e., those at the downstream end 134, will be influential on the flow of gases entering the outlet antechamber 160 or outlet 112, then in some configurations, only the final pair of baffles are made symmetrical or symmetrically staggered as required.

[00533] In some configurations, there may be a plurality of at least one of the first baffles 171 and second baffles 172. The plurality of baffles 171, 172 are formed on the respective upper or lower walls 135, 136 of the humidifying section 130 separated by gaps between them along the humidifying section length 139. Therefore, a number of width extending baffles 171, 172 are provided. The plurality of first baffles 171 may have gaps (such as equal gaps) formed between them; and the plurality of second baffles 172 may have gaps (such as equal gaps) formed between them. This arrangement will form pockets of gases between each neighbouring or adjacent pair of first baffles 171, and between each neighbouring or adjacent pair of second baffles 172, to promote mixing of the most humid layer with other layers.

[00534] In some configurations, the first baffles 171 and/or second baffles 172 may be parallel to one another.

[00535] In some configurations, either in combination with the second baffles 172 and/or plurality of first and second baffles 171, 172 or as its own configuration, at least

one first or second baffle 171, 172 may be angled, such that the baffle base 173, 174 for a given baffle 171, 172 is proximal to the inlet antechamber 140 relative to the corresponding baffle tip 175, 176. By the baffle base 173, 174 for a given baffle 171, 172 being relatively proximal to the inlet antechamber 140 relative to the corresponding baffle tip 175, 176, a flow of gases may be directed to the surface of the humidifying element 114 by the angle of the plate. The choice of an angle for at least the first or second baffle 171, 172 may be determined in the same manner as discussed above with reference to Figures 5 and 6. The angle is chosen optimized to create a sharper separation point from baffle 171, 172. Furthermore, the angle is selected as not to cause excessive turbulent gases flow forming at the surface of the humidifying element 114 where the gases flow is directed. The angle formed by the baffle 171, 172 does not need to be chosen to influence how much shear layer separation occurs between the gases flow and the sides of the internal walls 135, 136 as the baffles 171, 172 already direct the flow away from the walls. Whilst a laminar flow of gases along the humidifying element 114 may be preferred, it is noted that in some configurations, a level of turbulence may help with mixing of the flows, therefore, a balance must be drawn.

[00536] In some configurations, such as a tubular humidification section 130, the first baffle 171 may extend around the inner circumference of the humidifying section inner wall.

[00537] The first and second baffles 171, 172 may be formed of rigid or semi-rigid material which increases the resilience of the humidification chamber 110 to drops and rough handling.

[00538] Referring to Figure 19, an alternative configuration of the humidification chamber 110 as described herein is shown. Other than the differences described below, the description of the humidification chamber 110 is as described elsewhere herein for like features. Where some reference signs are omitted for some features, these are for purposes of explanation.

[00539] In the configuration of Figure 19, the humidifying element 114 is positioned in the generally elongate humidifying section 130 splitting the humidifying section flow channel 30 into the upper 31 and the lower 32 flow channels similar to the configuration of Figures 3 to 8 and 18. Additionally, in this configuration, the humidification chamber 110 comprises first ridges or bumps 181 extending from the upper wall 135 of the humidifying section 130 and facing the humidifying element 114. The first ridges 181 may be a surface detail or pattern formed on the upper wall 135. In some configurations, the first ridges 181 are disposed at intervals along the length of the upper wall 135. In other configurations, the first ridges 181 end along the width of the upper wall 135. In some configurations, the first ridges extend along a width direction of the upper wall 135, i.e. extend substantially transversely to the direction of flow of the gases. The first ridges

181 may be arranged in a uniform pattern on the upper wall or may be a scattered or non-uniform pattern.

[00540] The first ridges 181 may be considered similar to the first baffle 171 of Figure 18. The first ridges 181 extend partially into the flow channel 30, 31. Therefore, for the channel height 34, the first ridges 181 may extend at most about 10% of the total channel height 34 from the upper wall 135 of the channel 30, 31. In some configurations, the first ridges 181 may extend at most 5% of the total channel height 34 from the upper wall 135 of the channel 30, 31.

[00541] The first ridges 181 extend into the flow channel 30, 31 from the wall 135 parallel with the humidifying element 1143. The addition of the ridges acts to slow or impede the flow rate of gases flowing proximate the upper wall 135. This is illustrated by the arrow of the first ridge flow path 71 in Figure 19. As the first ridge flow path 71 flows over the first ridges 181, the first ridge flow path is slower compared to the upper channel flow path 31 shown by the arrow in Figure 19. This means that a greater proportion of the gases flow passes close to the humidifying element 114. Therefore, it may be considered that the transverse dimension of the flow channel normal to the direction of flow 36 is moved away from the upper wall 135 by altering the flow path of the gases through the humidifying section 130 due to the first ridges 181. This increases the uptake of water vapour in the gases flow.

[00542] In some configurations, corresponding second ridges 182 are formed on the lower wall 136. These may have the same configurations and alternatives, and thus effect, to the first ridges 181 but instead for the lower channel 32. The schematic second ridge flow path 76 is shown by the indicated arrow on Figure 19, and is impeded or slowed down by the presence of the second ridges 182. Therefore, the transverse dimension of the flow channel 30, 32 normal to the direction of flow 37 is moved away from the lower wall 136 by altering the flow path of the gases through the humidifying section 130 due to the first ridges 182. This increases the uptake of water vapour in the gases flow in the lower channel 32.

[00543] Referring to Figure 20, there is shown an alternative configuration of the humidification chamber 110 as hereinbefore described. Other than the differences described below, the description of the humidification chamber 110 is as described elsewhere herein for like features. Where some reference signs are omitted for some features, this is for purposes of explanation.

[00544] The humidification chamber 110 of Figure 20 comprises the humidifying section 130 extending between the gases inlet 111 and gases outlet 112, and respectively between the inlet antechamber 140 and outlet antechamber 160 as hereinbefore described.

[00545] The humidifying element 114 is formed of at least one upper humidifying plate 153 and at least one lower humidifying plate 152. The upper and lower humidifying plates 153, 152 are formed as plates or walls extending in the width direction. The upper

humidifying plate 153 is connected at one end to the upper wall 135 of the humidifying section 130. The upper humidifying plate 153 extends toward the lower wall 136 of the humidifying section 130. The end of the upper humidifying plate 153 that faces the lower wall 136 is an upper open end 156 and forms a gap between the upper open end 156 and the lower wall 136. Therefore, the upper humidifying plate 153 and thus open end 156 of the plate are not connected to the lower wall 136 of the humidifying section 130.

[00546] The lower humidifying plate 152 is connected at one end to the lower wall 136 of the humidifying section 130. The lower humidifying plate 152 extends toward the upper wall 135 of the humidifying section 130. The end of the lower humidifying plate 152 that faces the upper wall 135 is a lower open end 155 and forms a gap between the lower open end 155 and the upper wall 135. Therefore, the lower humidifying plate 152 and thus open end 155 of the plate are not connected to the upper wall 135 of the humidifying section 130.

[00547] The upper humidifying plate 153 and lower humidifying plate 152 are arranged in a non-mirrored fashion. Therefore, they extend to the opposing respective wall 135, 136 past the opposing humidifying plate 153, 152. The upper humidifying plate 153 and lower humidifying plate 152 are each arranged extend at least over halfway of the humidifying chamber height 137. Therefore, part of the upper humidifying plate 153 and lower humidifying plate 152 overlap when viewed from the end view, i.e. in the upstream to downstream direction or from the inlet 111 toward the outlet 112. The upper humidifying plate 153 and lower humidifying plate 152 are arranged to have a channel gap between the surfaces of the upper humidifying plate 153 and the lower humidifying plate 152. The channel gap is the flow channel 30, 31 through the humidifying section 130. The flow channel 30, 31 therefore has a channel size, height or dimension 72 extending transverse between the upper humidifying plate 153 and lower humidifying plate 152 in the overlapping parts. This overlapping channel size 72 is similar to the humidifying section channel height 34 as described herein. However, the channel size 72 is not normal to the central axis (A_x – Figure 3) formed between in the inlet 111 and outlet 112, but is normal to at least one of the upper humidifying plate 153 and lower humidifying plate 152. In some configurations, the upper humidifying plate 153 and lower humidifying plate 152 are arranged to be parallel.

[00548] Therefore, the flow of gases from the inlet 111 passes through the flow channel 40 of the inlet antechamber 140 toward the humidifying section 130. The flow of gases then passes through the gap formed between the upper open end 156 and the lower wall 136 of the humidifying section 130 into the flow channel 30, 31 having a channel size 72 between the upper humidifying plate 153 and lower humidifying plate 152. The flow of gases is humidified by both the upper humidifying plate 153 and lower humidifying plate 152 surfaces facing the flow of gases. The flow of gases passes through the gap between

the lower open end 155 and the upper wall 135 and out of the humidifying section 130 into the outlet antechamber 160.

[00549] The start of the flow channel 30, 31 where the humidifying of gases occurs may be determined by the upstream end 1141 of the upper humidifying plate 153, this may also be the upper open end 156. Once the gases flow passes this point, or a line / plane perpendicular to the point extending transverse to the flow channel 30, 31, the flow channel 30, 31 commences.

[00550] Whilst upper and lower humidifying plates 153, 152 have been described with the first upper humidifying plates 153 closer to the inlet antechamber 140 than the first lower humidifying plates 152, in some configurations, these may be reversed such that the first upper humidifying plate 153 is more proximal to the outlet antechamber 160 than the first lower humidifying plate 152.

[00551] The boundary layer in the flow channel 31 between the upper and lower humidifying plates 153, 152 will be formed in the manner discussed with reference to Figures 14 and 15. Therefore, a boundary layer is formed by each of the upper and lower humidifying plates 153, 152 that face one another. The transverse dimension of the flow channel 30, 31 normal to the direction of flow 36 will extend between the upper humidifying plate 153 and the lower humidifying plate 152 and is selected to be twice the height or less than the height of the "mature" or fully-developed boundary layer. The transverse direction of the dimension 36 is normal to the direction of flow that is shown by the arrow in Figure 20.

[00552] In some configurations, a plurality of upper and lower humidifying plates 153, 152 may be provided. These are arranged in alternating pattern such that the gases flow 30, 31 is required to take a tortuous path therethrough to pass through the humidification chamber 110 as it passes through each section. At each upper open end 156 and lower open end 155 before entering a further flow channel 30, 31 with a size 72, the flow of gases pass through a U-turn as the flow changes direction. At this point there is a distance formed between the two adjacent upper humidifying plates 153 or lower humidifying plates 152 where the flow of gases turns about the upper or lower open end 156, 155 and changes flow directions. Therefore, the flow of gases turns and flows between in the next section of the flow channel between in the next pair of upper and lower humidifying plates 153, 152, i.e. a section of flow channel formed between the opposing side of one of the humidifying plates and the next downstream humidifying plate. Therefore, the effective size of the U-turn flow turning space 73 is approximately twice that of the size of the flow channel 72 between upper and lower humidifying plates 153, 152.

[00553] In the subsequent section of the flow channel 31, i.e. after the flow of gases has passed through one turning space 73 is, the flow of gases will have a higher humidity as they were already partly humidified in the preceding section of the flow channel

31. The respective humidifying plates 153, 152 will continue to humidify the flow, but the humidifying boundary layers may be slightly shallower as discussed above. In view of this, in each subsequent section of the flow channel 31 after each turning space 73, the opposing boundary layers may be shallower and the "mature" or fully-developed boundary layers may take longer to meet or may not meet. This can be visualised by the boundary layer 210 of Figure 15 compared to the boundary layers 208, 209 of Figure 14. In some configurations, this may be compensated by selecting a transverse dimension normal to the direction of flow 36 that is smaller than twice the boundary layer height for the whole channel 31, or by reducing the transverse dimension normal to the direction of flow 36 for each section of the flow channel 31. It is noted that as gases already have high humidity from preceding sections of the flow channel 31, that it may be acceptable to have "mature" boundary layers which do not converge.

[00554] The tortuous path provided by upper and lower humidifying plates 153, 152 results in a flow of gases being exposed to the humidifying element 114 for a longer period of time for a given space or length (as viewed from the side) of the humidifying section 130, compared to if the flow path of the gases is linearly straight through a humidifying section 130 of the same length. This means the residence time of the gases within the humidifying section 130, and proximate the humidifying element 114, will be relatively longer. As defined another way the residence time of gases in the humidification section 130 is increased so the gases are exposed to humidity longer as compared to a linear gases path.

[00555] The end of the flow channel 30, 31 may be determined as the downstream end 1142 of an upper humidifying plate 153, this may also be the lower open end 155. In some configurations, the lower open end 155 is formed by a lower humidifying plate 152.

[00556] In some configurations, the number of upper and lower humidifying plates 153, 152 are not equal. Therefore, for instance, the first and last humidifying plate 153, 152 in the humidifying section may both be upper or lower humidifying plates 153, 152.

[00557] In some configurations, either in combination with a plurality of upper and lower humidifying plates 153, 152 or with a single upper and lower humidifying plate 153, 152, at least one of the upper and lower humidifying plates 153, 152 may be angled, one end of each upper and lower humidifying plates 153, 152 is relatively more proximal to the inlet antechamber 140 than the opposing end. For instance, by the upper open end 156 for each upper humidifying plate 153, being relatively distal to the inlet antechamber 140 relative to the corresponding end, a flow of gases may be directed to the surface of the humidifying element 114 by the angle of the plates. Likewise, the corresponding neighbouring lower open end 155 for each lower humidifying plate 152 may be relatively

proximal to the inlet antechamber 140 relative to the corresponding end. Therefore, the upper and lower humidifying plates 153, 152 are orientated or angled in the same direction.

[00558] In some configurations, the angle of upper and/or lower humidifying plates 153, 152 are between about 15° and about 60° from the vertical plane (i.e. the plane perpendicular to the central axis (Ax - Figure 3)).

[00559] In Figure 20, the gases flow at the gases inlet 111 and the gases flow at the gases outlet 112 have the generally same flow direction therefore the (resultant) flow of gases into the humidification chamber 110 is generally the same direction as the (resultant) flow of gases out of the humidification chamber 110. Likewise, the flow of gases passes from the inlet 131 to the outlet 132 (Figure 3) in generally the same (resultant) direction. However, the flow of gases through the flow channel 30, 31 is such that the flow path is tortuous between the inlet 131 and outlet 132 within the humidifying section 130.

[00560] Referring to Figure 21, there is shown an alternative configuration of the humidification chamber 110 as hereinbefore described. Other than the differences described below, the description of the humidification chamber 110 is as described elsewhere herein for like features. Where some reference signs are omitted for some features, this is for purposes of explanation.

[00561] The humidification chamber 110 of Figure 21 comprises a tubular or cylindrical inlet antechamber 140, outlet antechamber 160 and generally elongate humidifying section 130; thus, all three sections have a substantially circular cross-section. Therefore, in such a configuration, the inlet antechamber wall 145 and angled wall 147 form the walls 145, 147 on all sides of the inlet antechamber, i.e. they extend around the circumference of the tubular inlet antechamber 140. Likewise, the outlet antechamber wall 165 and angled wall 167 form the walls 165, 167 on all sides of the outlet antechamber 160, i.e. they extend around the circumference of the tubular outlet antechamber 160.

[00562] In some configurations, the inlet antechamber 140, outlet antechamber 160 and generally elongate humidifying section 130 may all comprise elliptical cross-sections. In other configurations, some of the cross-sections may be elliptical. Likewise, the humidifying element 114 may have an elliptical cross-section.

[00563] The wall 135 of the humidifying section 130 extends around the circumference of the tubular humidifying section 130. Therefore, the humidifying section wall forms the substantially same wall 135 around the humidifying section 130. In some configurations, the present wall 135, or any cylindrical wall, may be referred to as having upper and lower portions analogous to, for instance, the upper wall 135 and lower wall 136 of the humidifying section 130.

[00564] The humidifying element 114 may likewise be cylindrical and positioned substantially in the centre of the humidifying section 130. In such an arrangement, the flow channel through the humidifying section 130, as shown by the arrows in Figure 21 has, in cross-section, a profile similar to the flow channel 30, 31, 32 of the earlier Figures,

but, viewed in three dimensions (as seen in Figure 21), it becomes clear that the flow channel is not completely split but instead has the humidifying element 114 positioned at a centre of it, such that the flow channel extends circumferentially around the humidifying element 114. In other words, the humidifying element does not completely separate the humidifying section 130 into two discrete portions. However, the principles of the present disclosure described above apply to this configuration also, and there can still effectively be said to be an upper and lower flow channel when the humidifying chamber is considered longitudinally in cross-section. Alternatively, in some configurations, the humidifying element 114 may still bisect the humidifying section 130 and split the flows into a discrete and separate upper flow channel 31, and a lower flow channel 32 (for example, if the humidifying element 114 has a substantially rectangular cross-section and reaches from wall to wall of the humidifying section 130).

[00565] In some configurations, arms may be provided to position the humidifying element 114 within the humidifying section 130 as described elsewhere in the present disclosure.

[00566] Any one or more parts of the configuration of Figure 21, such as the tubular or cylindrical inlet antechamber 140, tubular or cylindrical outlet antechamber 160, tubular or cylindrical humidifying section 130 or tubular or cylindrical humidifying element 114, may be applied to any configuration discussed herein with the part of the walls forming effective upper and lower sections.

[00567] The humidification chamber 110 having a circular cross-section from the gases inlet 111 to gases outlet 112 may be beneficial for reducing turbulent gases flow. Therefore, the gases flow between gases inlet 111 and gases outlet 112 is substantially laminar. The tubular shape may also assist with connection to a breathing circuit or tube which are generally tubular.

[00568] Referring to Figures 22 and 23, there is shown an alternative configuration of the humidification chamber 110 as hereinbefore described. Other than the differences described below, the description of the humidification chamber 110 is as described elsewhere herein for like features. Where some reference signs are omitted for some features, this is for purposes of explanation. A side section view and an end view of the humidification chamber 110 are shown in Figure 22. A perspective view of the humidification chamber 110 is shown in Figure 23.

[00569] The humidification chamber 110 of Figures 22 and 23 comprises a tubular or cylindrical inlet antechamber 140, outlet antechamber 160, humidifying section 130 and humidifying element 114 as described with reference to Figure 21. Therefore, there is provided a profile similar to the flow channel 30, 31, 32 of the earlier figures, but, viewed in three dimensions, it becomes clear that the flow channel is not completely split but instead has the humidifying element 114 positioned at a centre of it, such that the flow channel extends circumferentially around the humidifying element 114. In other words,

the humidifying element does not completely separate the humidifying section 130 into two discrete portions. However, the principles of the configurations described above apply to this configuration also, and there can still effectively be said to be an upper and lower flow channel when the humidifying chamber is considered longitudinally in cross-section.

[00570] The wall 145 of the inlet antechamber 140 and the wall 135 of the humidifying section 130 are continuous and parallel. Therefore, there is no angled wall 146 to reduce the cross-sectional area of the inlet antechamber 140. The inlet antechamber 140 and humidifying section 130 have the same diameter. In some configurations, the diameter of the inlet antechamber 140 and humidifying section 130 is the same as the gases inlet diameter.

[00571] The reduction in the flow channel 30, 31, 32 through the humidifying section 130 to bring the flow of gases into close proximity with the humidifying element 114 is provided by the geometry of the humidifying element 114. To ensure that the upstream end 1141 of the humidifying element 114 does not disrupt the flow of gases through the humidifying section 130 with a right-angled end or leading edge, the humidifying element 114 has an angled, tapered or rounded portion 1146 that begins at a point of the upstream end 1141 and expands to the full tubular or cylindrical body of the humidifying element 114.

[00572] The length of the angled portion 1146 in the direction between the upstream end 1141 and downstream end 1142 may be a maximum of 15% of the total length of the humidifying element 114 between the upstream end 1141 and downstream end 1142.

[00573] As a result of the tapering size of the humidifying element 114 due to the angled portion 1146, with reference to the upper flow channel 31, the flow channel height 75 (i.e. the distance from the humidifying element 114 and the inner surface of the wall 135 of the humidifying section 130) at the start of the humidifying section 130 is larger than the flow channel height 74 proximal to the centre of the humidifying section 130 past the angled portion 1146. Therefore, the flow channel height 75, 74 varies along the length 38 of the flow channel 30, 31, 32 / humidifying element 1145.

[00574] The position of the base of the humidification boundary layer formed in the humidifying section 130 will, therefore, be changed along the length of the humidifying section 130. Therefore, the transverse dimension of the flow channel 30, 31 normal to the direction of flow 36 will be selected to equal to or less than the boundary layer for the flow channel proximal to the centre of the humidifying section 130 past the angled portion 1146. The transverse dimension of the flow channel 30, 31 normal to the direction of flow 36 is therefore selected to be the flow channel height 74 in this section. The location past the angled portion 1146 of the humidifying element 114 may be the upper surface 1143 that is substantially parallel with the upper wall 135 of the humidifying section 130.

[00575] The above explanation likewise may apply for the lower flow channel 32.

[00576] In such a configuration, the humidifying element may be suspended at the substantial central area of the humidifying section 130 by arms 138. The arms 138 may be ergonomically shaped to reduce obstruction of flow, and may also have a small area or footprint relative to an overall cross-section of the flow channel 30, 31, 32, for the same reason. Fluid and heating may be contained or supplied through the arms 138, such as passages or conduits formed in the arms 138. The arms 138 may be combined with any humidifying element 114 disclosed herein.

[00577] In some configurations, the channel size (height) 74 is such that the distance between wall 135 and the humidifying element 114 is optimally sized to contain the high humidity boundary layer for the gases flow.

[00578] In some configurations, the outlet antechamber 160 may likewise have the same diameter as the humidifying section 130. Therefore, no angled walls 167 are present and the walls 135 of the humidifying section 130 are parallel and continuous with the walls 165 of the outlet antechamber 160. The humidifying element 114 may likewise have an angled portion 1147 at its end narrowing to the point of the downstream end 1142 of the humidifying element 114. In some configurations, the diameter of the outlet antechamber 160 and humidifying section 130 is the same as the gases outlet diameter.

[00579] In some configurations, the angled portion 1147 at the end of the humidifying element 114 narrowing to the point of the downstream end 1142 is a different shape or angle to the angled portion 1146 that begins at the point of the upstream end 1141 of the humidifying element 114. This is illustrated in Figure 23. The varying shapes may be arranged such that there is no angled portion 1146, 1147 at one end of the humidifying element 114 in some configurations. Additionally or alternatively, in some configurations, the downstream end 1142 of the humidifying element 114 is a different shape or diameter than the upstream end 1141. This is illustrated in Figure 23.

[00580] Having an outer diameter that constant for the whole length of humidification chamber 110 may assist with space saving or installation inline in a system.

[00581] Such a constant profile humidification chamber 110 may be combined with any configuration described herein whilst using the humidifying element 114 to provide a narrowing flow channel 30, 31, 32.

[00582] Referring to Figure 24, there is shown an alternative configuration of the humidification chamber 110 as hereinbefore described. Other than the differences described below, the description of the humidification chamber 110 is as described elsewhere herein for like features. Where some reference signs are omitted for some features, this is for purposes of explanation.

[00583] The humidification chamber 110 of Figure 24 comprises a tubular or cylindrical inlet antechamber 140, outlet antechamber 160 and humidifying section 130 as described with reference to Figure 21. However, as discussed below, in this case the heating element is not centrally disposed such that the humidifying section is split into

multiple channels. Therefore, there is a single flow channel 30, 31 through the humidifying section 130.

[00584] The wall 135 of the humidifying section 130 is also the humidifying element 114 (or the humidifying element 114 is disposed / provided on the wall 135). Therefore, the flow channel 30, 31 is formed through the humidifying element 114. And the humidifying element 114 is tubular.

[00585] The humidifying element being disposed circumferentially around the humidifying section may affect the appropriate dimensions of the humidifying chamber. For instance, in a first example, assuming a requirement of humidification of 100% the flow of gases, the flow channel diameter 34 may be sized such that it can be effectively twice the size of a single flow channel 30, 31 with the humidifying element 114 on one side; and the transverse dimension of the flow channel normal to the direction of flow 36 may also be the diameter, such that all of the gases pass through the high-humidity boundary layers. This is similar to the opposing and converging boundary layers 208, 209 described with reference to Figure 14.

[00586] Alternatively, some overlap between (or merging of) the high-humidity boundary layers (associated with each of the upper and lower (in cross-section) portions of the circumferential humidifying element) may be acceptable, in which case the flow channel size (height) may be less than in the previous example. This is similar to the opposing and converging boundary layer 210 described with reference to Figure 15. Still alternatively, if for instance only 80% or 90% of the gases flow must be humidified, the flow channel size / height may be greater than in the first example, such that the respective high-humidity boundary layers associated with the upper and lower portions of the heater element 114 approach each other but do not touch or overlap, and there is a gap between them through which a portion of the gases can flow (this being the portion of the gases that is not humidified, or not as effectively or highly humidified, on passing through the humidifying section).

[00587] For completeness, it is also noted that an alternative configuration is also possible wherein the humidifying element 114 is again disposed or provided on the wall 135 of the humidifying section 130, but not around the entire circumference; for instance, there may be only an upper or lower humidifying element portion 114 (generally similar to the configuration illustrated at Figure 16 or the plates of first and second humidifying elements 115, 116 of Figures 13 to 15), or a non-circumferential upper and lower humidifying element portion 114. The principles discussed elsewhere in this disclosure apply likewise to such a configuration.

[00588] Furthermore, as discussed, Figures 13 to 15 are related to the present configuration (and also that of Figure 20). In configurations of the present disclosure having multiple parallel humidifying elements 114, 115, 116, 153, 152 and thus multiple adjacent flow channels 30, 31, 32, 33, the arrangement of the humidifying elements may

affect the required dimensions of the various channels, in a manner similar to that described above with reference to the Figure 24 boundary layers. Considering Figures 13, 14 and 15, assuming a situation with two parallel humidifying elements (and thus three flow channels 31, 32, 33), each humidifying element 115, 116 projecting an equal amount of heat on either side, and further assuming that the overall incoming flow 30 is diverted to the respective flow channels in proportion to their respective cross-sectional size, and further assuming that 100% of the incoming gases flow is required to be humidified (such that within each of the flow channels the height of the boundary layer(s) therein must equal or exceed the height of that flow channel).

[00589] In the Figure 14 embodiment, the middle or second flow channel 32 will have a high-humidity boundary layer 208, 209 extending from each of the two humidifying elements 115, 116 that bound 32 on either side. Thus, the height of the second flow channel 32 can be twice that of the upper or first flow channel 31 and the lower or third flow channel 33. In the first flow channel 31 and the third flow channel 33, the height of the flow channels is such that the (mature) boundary layer 222, 226 fills the entire height of the flow channel 31, 33, such that all of the gases flow through the high-humidity boundary layer. In the second flow channel 32, two such (opposing) boundary layers 208, 209 will be formed, and the height of the flow channel is equal to the cumulative height of the two (mature) boundary layers 224, thus the boundary layers will meet in the middle of the flow channel and again all gases flowing through the second flow channel 32 will flow through the high humidity boundary layer(s).

[00590] Alternatively, the system could also be configured as schematically shown in Figure 15. Here, the three flow channels 31, 32, 33 are substantially of the same height. First and third flow channels 31, 33 are again sized such that the (mature) high-humidity boundary layer 222, 226 fills them entirely, such that all of the gases flowing through the first and third flow channels 31, 33 flow through the high-humidity boundary layer and thus humidification of substantially 100% of the gases in those flow channels is achieved. The second flow channel 32 has approximately the same or similar size/height as the first and third flow channels 31, 33, but again has two high-humidity boundary layers 208, 209 forming therein, one from the upper and lower humidifying element 115, 116 respectively. In this configuration, the boundary layers within the second flow channel 32 overlap or intersect with each other, because the height of the second flow channel 32 is less than the cumulative height of two of the (mature) boundary layers. However, the effect is still that all of the gases flowing through the second flow channel 32 pass through the high-humidity boundary layer(s), thus 100% of the gases flowing through the second flow channel 32 become humidified. These are schematics only, and are intended to illustrate principles of operation and configurations; the exact dimensions, boundary layer profiles, *et cetera* may vary.

[00591] Returning to Figure 24, because the humidifying element 114 is disposed circumferentially on the wall 135 of the humidifying section 130, it is not necessary to direct flow away from the walls as described in other configurations herein. However, narrowing from the antechamber to the humidifying section may still be beneficial.

[00592] The positioning of the humidifying elements 114 in the walls 135 may be combined with any configuration disclosed herein. In some configurations, the humidifying element 114 may be formed as walls of a cuboid with a conduit throughout as the flow channels.

[00593] The humidification chamber 110 as herein described may be used in a humidifier or a high flow system or a CPAP (continuous positive airway pressure) device or for use with a ventilator.

[00594] Referring to Figure 25, there is shown an alternative configuration of the humidification chamber 110 as hereinbefore described. Other than the differences described below, the description of the humidification chamber 110 is as described elsewhere herein for like features. Where some reference signs are omitted for some features, this is for purposes of explanation.

[00595] The humidification chamber 110 of Figure 25 comprises a gases inlet 111, a gases outlet 112 and a generally elongate humidifying section 130 therebetween, the humidifying section 130 comprising a humidifier element 114. Therefore, such a configuration has been described herein in various arrangements. In the configuration of Figure 25, the humidification chamber 110 is orientated such that the inlet 111 and outlet 112 are substantially vertically opposed. Therefore, the gases flow in a substantially vertical direction.

[00596] It is submitted that the orientation shown in Figure 25 is not limiting on orientations of the humidification chambers 110 in other arrangements shown herein. Namely, the humidification chambers 110 may be orientated at any direction or angle. Referring to Figure 17, the reservoir 119, may be arranged or positioned such that fluid is maintained therein for different required humidification chamber 110 orientations.

[00597] Referring back to Figure 25, a remote fluid reservoir 1119 is provided. The remote reservoir 1119 is for providing fluid to the wick or the humidifying element 114. The positioning of the remote reservoir 1119 is such that the fluid is provided to the humidifying element 114 under gravity. The fluid is provided through the gases outlet 112 such that the flow of gases 30 through the humidifying section 130 is opposed to the direction of flow of the fluid 1120 from the remote reservoir 1119 to the humidifying element 114. This allows the fluid to permeate downwardly through the humidifying section 130 as the flow of gas 30 is upwardly, thus encouraging humidification of the gases. The fluid may be provided to an edge of the humidifying element 114, such as a leading or trailing edge.

[00598] Whilst an arrangement is described and shown where the remote reservoir 1119 is positioned such that the flow of fluid 1120 is provided in the gases outlet 112 direction under gravity, other arrangements are available. In some configurations, the orientation of the humidification chamber 110 is reversed such that the flow of fluid 1120 is provided to the humidifying element 114 under gravity through the inlet 111. Therefore, the flow of gases 30 is in the same direction as the flow of fluid 1120. In other configurations, there is provided an opening into the humidifying section 130 that allows the fluid to flow from the remote reservoir 1119 to the humidifying element 114 from any required direction under gravity. Likewise, in some configurations, orientation is such that the remote fluid reservoir 1119 may be provided in any required position. Whilst fluid is described as being provided by gravity, other arrangements are available for delivering fluids that are known in the art.

[00599] A schematic representation (not to scale) of the or an alternative respiratory therapy system 100 or respiration humidification system 100 (as described with reference to Figure 1) is provided in Figure 26. The respiratory therapy system 100 includes a respiratory apparatus (generally shown in the dashed box 123) having the flow generator 120 and the controller 118 which may be as previously described. The respiratory apparatus 123 further includes the humidification chamber 110. The humidification chamber 110 may be referred to as a humidifier 110 and may have any of the features as hereinbefore described. In the example respiratory therapy system 100 of Figure 26, the humidifier 110 may be optional. The respiratory apparatus 123 may include the integrated flow generator 120 and humidifier 110 (e.g., the flow generator 120 and the humidifier 110 may be arranged in the same housing of the respiratory apparatus 123) as illustrated in Figure 26, or the humidifier 110 may be in a separate housing (as schematically illustrated in Figure 1). A delivery conduit 106 and the patient interface 122 may be provided, as part of the respiratory therapy system 100, to fluidly couple to the respiratory apparatus 123.

[00600] The controller 118 may include one or more control systems and/or may have controller function.

[00601] The respiratory therapy system 100 comprises a flow source 101 for providing a high flow gas 105 such as air, oxygen, air blended with oxygen, or a mix of air and/or oxygen and one or more other gases. The breathing assistance apparatus 123 may have a connection for coupling to a flow source. As such, the flow source might be considered to form part of the apparatus 123 or be separate to it, depending on context, or even part of the flow source forms part of the apparatus 123, and part of the flow source falls outside of the apparatus 123. In short, depending on the configuration (some components may be optional), the system 100 may include a combination of components selected from the following:

- a flow source,

- humidifier for humidifying the gas-flow,
- conduit (e.g., dry line or heated breathing tube),
- patient interface,
- non-return valve,
- filter.

[00602] The system 100, including the apparatus 123, will now be described in more detail.

[00603] The flow source may be an in-wall supply of oxygen, a tank of oxygen 102, a tank of other gas and/or a high flow apparatus with a flow generator 120. Figure 26 shows a flow source 101 with a flow generator 120, with an optional air inlet 104 and optional connection to an oxygen (O₂) source (such as tank or O₂ generator) 102 via a shut off valve and/or regulator and/or other gas flow control 103, but this is just one option. The flow generator 120 may control flows delivered to the user or patient 121 using one or more valves, or optionally the flow generator 120 comprises a blower. The flow source 101 could be one or a combination of a flow generator 120, O₂ source 102, and/or air source 104 as described. The flow source 101 is shown as part of the apparatus 123, although in the case of an external oxygen tank or in-wall source, it may be considered a separate component, in which case the apparatus 123 has a connection port to connect to such flow source. The flow source 101 provides a (preferably high) flow of gas that can be delivered to a patient 121 via a delivery conduit 106, and a patient interface 122.

[00604] The patient interface 122 may be an unsealed (non-sealing) interface (for example, when used in high flow therapy) such as a non-sealing nasal cannula.

[00605] In some embodiments, the patient interface 122 is a non-sealing patient interface which would, for example, help to prevent barotrauma (e.g., tissue damage to the lungs or other organs of the respiratory system due to difference in pressure relative to the atmosphere).

[00606] The patient interface 122 may be a nasal cannula with a manifold and nasal prongs, or any other suitable types of non-sealing patient interface.

[00607] In some configurations, the flow source 101 provides a base gas flow rate of between, e.g., 0.5 litres/min and 375 litres/min, or any range within that range, or even ranges with higher or lower limits. Details of the ranges and nature of flow rates have been described with reference to Table 1.

[00608] The humidifier 110 may optionally be provided between the flow source 101 and the patient 121 to provide humidification of the delivered gas. One or more sensors 126, 127, 128, 129 such as flow, oxygen fraction, pressure, humidity, temperature or other sensors are placeable throughout the system 100 and/or at, on or near the patient 121. Alternatively, or additionally, sensors from which such parameters are derived may be used. In addition, or alternatively, the sensors 126-129 may be one or more physiological sensors for sensing patient physiological parameters such as, heart rate, oxygen

saturation, partial pressure of oxygen in the blood, respiratory rate, partial pressure of carbon dioxide (CO₂) in the blood. Alternatively, or additionally, sensors from which such parameters are derived may be used. Other patient sensors could comprise EEG sensors, torso bands to detect breathing, and any other suitable sensors. In some configurations the humidifier 110 may be optional, or it may be preferred due to the advantages of humidified gases helping to maintain the condition of the airways. One or more of the sensors 126-129 might form part of the apparatus 123, or be external thereto, with the apparatus 123 having inputs for any external sensors. The sensors (e.g., 126-129) may be coupled to or send their output to a controller 118.

[00609] In some configurations, the respiratory system 100 includes a sensor 85 for measuring the oxygen fraction of air the patient 121 inspires. In some examples, the sensor 85 is placed on the patient interface 122, to measure or otherwise determine the fraction of oxygen proximate (at/near/close to) the patient's mouth and/or nose. In some configurations, the output from the sensor 85 is sent to the controller 118 to assist control of the respiratory apparatus 123 to alter operation accordingly. The controller 118 is coupled to the flow source 101, humidifier 110 and sensor 85. In some configurations, the controller 118 controls these and other aspects of the respiratory apparatus 123 and the respiratory system 100 as described herein. In some examples, the controller 118 operates the flow source 101 to provide the delivered flow of gas 105 at a desired flow rate high enough to meet or exceed a user's (i.e., patient's) inspiratory demand. The flow rate provided is sufficient that ambient gases are not entrained as the user (i.e., patient) 121 inspires. In some configurations, the sensor 85 can convey measurements of oxygen fraction at the patient mouth and/or nose to a user, who inputs the information to the respiratory apparatus 123 / controller 118.

[00610] An optional non-return valve 124 may be provided in the breathing conduit 106. A filter or filters may be provided at the air inlet 104 and/or inlets to the flow generator 120 to filter the incoming gases before they are pressurized into a high flow gas 105 by the flow generator 120.

[00611] The breathing assistance system 100 may be an integrated or a separate component-based arrangement. In some configurations, the system 100 and/or the apparatus 123 is a modular arrangement of components. Furthermore, the system 100 and/or the apparatus 123 may just comprise some of the components shown, not necessarily all are essential. The conduit 106 and patient interface 122 are separate from the respiratory apparatus 123. Breathing assistance apparatus will be broadly considered herein to comprise anything that provides a flow rate of gas to a patient. The breathing assistance apparatus can be part of a respiratory system. Some such apparatus and systems may include a detection system that can be used to determine if the flow rate of gas meets inspiratory demand.

[00612] The respiratory apparatus 123 may include a main device housing (not shown). The housing may contain the flow generator 120 that can be in the form of a motor/impeller arrangement, an optional humidifier or humidification chamber 110, a controller 118, and an input/output (I/O) user interface 107. The user interface 107 can include a display and input device(s) such as button(s), a touch screen (e.g., an LCD touch screen), a combination of a touch screen and button(s), or the like. The controller 118 may include one or more hardware and/or software processors and can be configured or programmed to control the components of the respiratory apparatus 123, including but not limited to operating the flow generator 120 to create a flow of gases 105 for delivery to a patient 121, operating the humidifier or humidification chamber 110 (if present) to humidify and/or heat the gases flow 105, receiving user input from the user interface 107 for reconfiguration and/or user-defined operation of the respiratory apparatus 123, and outputting information (for example on the display) to the user. The user can be a patient, healthcare professional, or others.

[00613] In one configuration, the user interface 107 of the respiratory apparatus 123 may comprise a removable display screen or touch screen.

[00614] With continued reference to Figure 26, a patient breathing conduit 106 may be coupled to a gases flow outlet (gases outlet or patient outlet port) 125 in the main device housing of the respiratory apparatus 123, and be coupled to a patient interface 122, such as a non-sealing interface like a nasal cannula with a manifold and nasal prongs. In some configurations, the respiratory apparatus gases flow outlet 125 may be the humidifier gases outlet 112. The patient breathing conduit 106 can also be a tracheostomy interface, or other unsealed interfaces.

[00615] The gases flow 105 may be generated by the flow generator 120, and may be humidified, before being delivered to the patient 121 via the patient breathing conduit 106 through the patient interface 122. The controller 118 can control the flow generator 120 to generate a gases flow 105 of a desired flow rate, and/or one or more valves to control mixing of air and oxygen or other breathable gas. The controller 118 can control a heating element in or associated with the humidification chamber 120, if present, to heat the gases to a desired temperature that achieves a desired level of temperature and/or humidity for delivery to the patient 121. The patient breathing conduit 106 can have a heating element, such as a heater wire, to heat gases flow 105 passing through to the patient 121. The heating element can also be under the control of the controller 118.

[00616] The system 100, including the apparatus 123, may use ultrasonic transducer(s), flow sensor(s) such as a thermistor flow sensor, pressure sensor(s), temperature sensor(s), humidity sensor(s), or other sensors, in communication with the controller 118, to monitor characteristics of the gases flow 105 and/or operate the apparatus 123 in a manner that provides suitable therapy. The gases flow characteristics may include gases concentration, flow rate, pressure, temperature, humidity, or others.

The sensors 126, 127, 128, 129, 85, such as pressure, temperature, humidity, and/or flow sensors, may be placed in various locations in the main device housing, the patient conduit 106, and/or the patient interface 122. The controller 118 can receive output from the sensors 126, 127, 128, 129, 85 to assist it in operating the respiratory apparatus 123 in a manner that provides suitable therapy, such as to determine a suitable target temperature, flow rate, and/or pressure of the gases flow. Providing suitable therapy can include meeting or exceeding a patient's inspiratory demand. In the illustrated embodiment, sensors 126, 127, and 128 are positioned in the housing of the apparatus 123, sensor 129 in the patient conduit 106, and sensor 85 in the patient interface 122.

[00617] The respiratory system 100 may include a sensor arrangement or a sensor module. The sensor arrangement or module may include a plurality of sensor types. The respiratory system 100 may include one or more of a flow (or flow rate) sensor, a pressure sensor, a temperature sensor, a humidity sensor and an oxygen (O₂) sensor. The O₂ sensor may be an ultrasonic sensor. An ultrasonic sensor may be positioned in line with the flow and hence can be used as a flow sensor in addition to the O₂ sensor. One non-limiting example of a flow rate sensor is a thermistor flow rate sensor as described in PCT Application Publication No. WO2018/052320, filed 3 September 2017, which is incorporated by reference herein in its entirety. Another non-limiting example of a flow rate sensor is an acoustic flow rate sensor as described in PCT Application Publication No. WO2017/095241, filed 2 December 2016, which is incorporated by reference herein in its entirety.

[00618] In some configurations, the gases flow rate may be measured using at least two different types of sensors. For example, a first type of sensor may include a thermistor flow rate sensor, and a second type of sensor may include an acoustic flow rate sensor. Readings from both the first and second types of sensors can be combined to determine a more accurate flow measurement. For example, a previously determined flow rate and one or more outputs from one of the types of sensor can be used to determine a predicted current flow rate. The predicted current flow rate can then be updated using one or more outputs from the other one of the first and second types of sensor, in order to calculate a final flow rate.

[00619] The apparatus 123 can include one or more communication modules to enable data communication or connection with one or more external devices or servers over a data or communication link or data network, whether wired, wireless or a combination thereof. In one configuration, for example, the apparatus 123 can include a wireless data transmitter and/or receiver, or a transceiver 108 to enable the controller 118 to receive data signals in a wireless manner from the operation sensors and/or to control the various components of the apparatus 123. The transceiver 108 or data transmitter and/or receiver module may have an antenna 109 as shown. In one example, the transceiver 108 may comprise a Wi-Fi modem. Additionally, or alternatively, the data

transmitter and/or receiver 108 can deliver data to a remote patient management system (i.e., a remote server) or enable remote control of the apparatus 123. The apparatus 123 can include a wired connection, for example, using cables or wires, to enable the controller 118 to receive data signals from the operation sensors and/or to control the various components of the apparatus 123. The apparatus 123 may comprise one or more wireless communication modules. For example, the apparatus 123 may comprise a cellular communication module such as for example a 3G, 4G or 5G module. The module 108 may be or may comprise a modem that enables the apparatus 123 to communicate with a remote patient management system (not illustrated in the figures) using an appropriate communication network. The remote management system may comprise a single server or multiple servers or multiple computing devices implemented in a cloud computing network. The communication may be two-way communication between the apparatus 123 and a patient management system (e.g., a server) or other remote system. The apparatus 123 may also comprise other wireless communication modules such as, for example, a Bluetooth module and/or a Wi-Fi module. The Bluetooth and/or WiFi module allow the apparatus 123 to wirelessly send information to another device such as, for example, a smartphone or tablet or operate over a LAN (local area network) or Wireless LAN (WLAN). The apparatus 123 may additionally, or alternatively, comprise a Near Field Communication (NFC) module to allow for data transfer and/or data communication.

[00620] For example, data representing determined or calculated work of breathing (WoB) indicators may be communicated to a remote patient management system (i.e., a remote server). The remote patient management system may be a single server or a network of servers or a cloud computing system or other suitable architecture for operating a remote patient management system. The remote patient management system (i.e., a remote server) further includes memory for storing received data and various software applications or services that are executed to perform multiple functions. Then, for example, the remote patient management system (i.e., remote server) may communicate information or instructions to the apparatus 123, as part of the system 100, at least in part dependent on the data received. For example, the nature of the data received may trigger the remote server (or a software application running on the remote server) to communicate an alert, alarm, or notification to the apparatus 123. The remote patient management system may further store the received data for access by an authorised party such as a clinician or the patient or another authorized party. The remote patient management system may further be configured to generate reports in response to a request from an authorized party, and the work of breathing data may be included into the generated reports. The reports may further comprise other data or patient breathing parameters, e.g., respiratory rate or SpO₂ and/or device parameters, e.g., flow rate, humidity level.

[00621] The respiratory apparatus 123 may comprise a high flow therapy apparatus. High flow therapy as discussed herein is intended to be given its typical ordinary meaning, as understood by a person of skill in the art, which generally refers to a respiratory system, having a high flow therapy apparatus, delivering a targeted flow of humidified respiratory gases via an intentionally unsealed patient interface with flow rates generally intended to meet or exceed inspiratory flow of a user. Typical patient interfaces include, but are not limited to, a nasal or tracheal patient interface. Typical flow rates for adults often range from, but are not limited to, about fifteen litres per minute (15 litres/min) to about sixty litres per minute (60 litres/min) or greater. Typical flow rates for paediatric users (such as neonates, infants and children) often range from, but are not limited to, about one litre per minute per kilogram of user weight to about three litres per minute per kilogram of user weight or greater.

[00622] High flow therapy can also optionally include gas mixture compositions including supplemental oxygen and/or administration of therapeutic medicaments.

[00623] High flow therapy is often referred to as nasal high flow (NHF), humidified high flow nasal cannula (HHFNC), high flow nasal oxygen (HFNO), high flow therapy (HFT), or tracheal high flow (THF), among other common names. For example, in some configurations, for an adult patient, 'high flow therapy' may refer to the delivery of gases to a patient at a flow rate of greater than or equal to about 10 litres per minute (10 LPM), such as between about 10 LPM and about 100 LPM, or between about 15 LPM and about 95 LPM, or between about 20 LPM and about 90 LPM, or between about 25 LPM and about 85 LPM, or between about 30 LPM and about 80 LPM, or between about 35 LPM and about 75 LPM, or between about 40 LPM and about 70 LPM, or between about 45 LPM and about 65 LPM, or between about 50 LPM and about 60 LPM. In some configurations, for a neonatal, infant, or child patient, 'high flow therapy' may refer to the delivery of gases to a patient at a flow rate of greater than 1 LPM, such as between about 1 LPM and about 25 LPM, or between about 2 LPM and about 25 LPM, or between about 2 LPM and about 5 LPM, or between about 5 LPM and about 25 LPM, or between about 5 LPM and about 10 LPM, or between about 10 LPM and about 25 LPM, or between about 10 LPM and about 20 LPM, or between about 10 LPM and 15 LPM, or between about 20 LPM and 25 LPM. A high flow therapy apparatus with an adult patient, a neonatal, infant, or child patient, may deliver gases to the patient at a flow rate of between about 1 LPM and about 100 LPM, or at a flow rate in any of the sub-ranges outlined above.

[00624] High flow therapy can be effective in meeting or exceeding the patient's inspiratory demand, increasing oxygenation of the patient and/or reducing the work of breathing. Additionally, high flow therapy may generate a flushing effect in the nasopharynx such that the anatomical dead space of the upper airways is flushed by the high incoming gases flow. The flushing effect can create a reservoir of fresh gas available for each and every breath, while minimizing re-breathing of carbon dioxide, nitrogen, etc.

High flow therapy can also increase expiratory time of the patient due to pressure during expiration. This in turn reduces the respiratory rate of the patient.

[00625] The flow rate may be set by a clinician to achieve flushing of the patient's upper airways and/or meet or exceed a patient's inspiratory demand and/or provide at least some of the advantages of high flow therapy (HFT) described herein.

[00626] The patient interface for use in a high flow therapy can be a non-sealing interface to prevent barotrauma, which can include tissue damage to the lungs or other organs of the patient's respiratory system due to difference in pressure relative to the atmosphere. The patient interface can be a nasal cannula with a manifold and nasal prongs, and/or an unsealed tracheostomy interface, or any other suitable types of non-sealing patient interface.

[00627] The respiratory apparatus or device 123 can have air and oxygen (or alternative auxiliary gas) inlets in fluid communication with a motor of the respiratory apparatus 123 to enable the motor to deliver air, oxygen (or alternative auxiliary gas), or a mixture thereof to the humidification chamber and thereby to the patient.

[00628] The respiratory apparatus 123 may include a connector arrangement with one or more connectors, for example, USB or other suitable connectors, for coupling of an alarm, a pulse oximetry port, and/or other suitable accessories.

[00629] The respiratory apparatus 123 may include an electrical connector through which mains electricity or battery power may be provided to power the respiratory apparatus 123. The respiratory apparatus 123 may further include a battery or an internal power source that can power the apparatus 123 for a set period of time if the mains are disconnected.

[00630] For purposes of clarity, in the present disclosure the same reference numbers are used in the drawings to identify similar elements. However, for the sake of convenience, certain features present or annotated with reference numerals in some figures of the present disclosure are not shown or annotated with reference numerals in other figures of the present disclosure. Unless the context clearly requires otherwise, these omissions should not be interpreted to mean that features omitted from the drawings of one figure could not be equally incorporated or implemented in the configurations of the disclosed methods, apparatus and systems related to or embodied in other figures. Conversely, unless the context clearly requires otherwise, it should not be assumed that the presence of certain features in some figures of the present disclosure means that the disclosed methods, apparatus and systems related to or embodied in such figures must necessarily include these features.

[00631] Although the present disclosure has been described in terms of certain embodiments, other embodiments apparent to those of ordinary skill in the art also are within the scope of this disclosure. Thus, various changes and modifications may be made without departing from the spirit and scope of the disclosure. For instance, various

components may be repositioned as desired. Features from any of the described embodiments may be combined with each other and/or an apparatus may comprise one, more, or all of the features of the above described embodiments. Moreover, not all of the features, aspects and advantages are necessarily required to practice the present disclosure. Accordingly, the scope of the present disclosure is intended to be defined only by the claims that follow.

CLAIMS

1. A humidification chamber for a respiratory humidification system, the humidification chamber comprising:
 - a humidifying section having an inlet and an outlet;
 - a humidifying element in the humidifying section; anda flow channel for gases to flow from the inlet to the outlet proximal to the humidifying element, the humidifying element configured to humidify a flow of gases passing through the flow channel,
wherein a transverse dimension of the flow channel is determined by a target humidity for at least a portion of the gases to achieve at the outlet, said transverse dimension being a function of at least one of: the length of the flow channel; a flow rate of the gases; a temperature of the humidifying element; and a relative gases concentration.
2. A humidification chamber for a respiratory humidification system, the humidification chamber comprising:
 - a humidifying section having an inlet and an outlet;
 - a humidifying element in the humidifying section; anda flow channel for gases to flow from the inlet to the outlet proximal to the humidifying element, the humidifying element configured to humidify a flow of gases passing through the flow channel,
wherein a transverse dimension of the flow channel normal to a direction of flow of the gases is such that said gases have a relative humidity of at least about 80% upon reaching the outlet.
3. A humidification chamber for a respiratory humidification system, the humidification chamber comprising:
 - a humidifying section having an inlet and an outlet, said humidifying section defining a flow channel for the flow of gases between said inlet and outlet, wherein the humidifying section is elongate;wherein said flow channel has a maximum transverse dimension normal to a direction of flow of the gases of about 10 mm; and
wherein said transverse dimension is selected such that gases passing through said at least one flow channel achieve at least 80% relative humidity upon reaching the outlet.
4. The humidification chamber according to claim 3, wherein the humidification chamber comprises a humidifying element in the humidifying section.

5. The humidification chamber of any one of claims 1 to 4, wherein the transverse dimension is at most about 10% of a length of the humidifying section measured between the inlet and the outlet.
6. The humidification chamber of any one of claims 1 to 5, wherein the transverse dimension is between a minimum of about 0 mm and a maximum about 22 mm, optionally the transverse dimension is between about 1 mm and about 5 mm.
7. The humidification chamber of any one of claims 1 to 6, wherein a high humidity boundary layer is formed within the humidifying section for humidifying the flow of gases.
8. The humidification chamber of claim 7, wherein the high humidity boundary layer is formed proximal to the humidifying element.
9. The humidification chamber of claim 6 or claim 7, wherein the high humidity boundary layer fully develops to a dimension from the humidifying element.
10. The humidification chamber of claim 9, wherein the transverse dimension of the flow channel is equal to or less than the fully developed high humidity boundary layer dimension to fill at least part of the flow channel with the high humidity boundary layer.
11. The humidification chamber of claim 9, wherein the fully developed high humidity boundary layer dimension is less than the transverse dimension of the flow channel.
12. The humidification chamber of any one of claims 1 to 11, wherein the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a flow rate of the flow of gases through humidifying section, wherein an average volumetric flow rate through the humidifying section is between about 0.5 L/min and about 200 L/min, optionally wherein the average volumetric flow rate through the humidifying section is between about 10 L/min and about 100 L/min, optionally, wherein the average volumetric flow rate through the humidifying section is at most about 70 L/min.
13. The humidification chamber of any one of claims 1 to 12, wherein the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a temperature of the humidifying element, wherein an average temperature of the humidifying element is between about 0°C and 100°C, optionally

wherein an average temperature of the humidifying element is between about 30°C and about 80°C, optionally wherein an average temperature of the humidifying element is between about 60°C and about 80°C.

14. The humidification chamber of any one of claims 1 to 13, wherein the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a flow rate of the flow of gases through the humidifying section, wherein a mass flow rate of gases is less than about 300 g/min.
15. The humidification chamber of any one of claims 1 to 14, wherein the volumetric flow rate of liquid supplied to the humidifying element is at least about 10 µl/min.
16. The humidification chamber of any one of claims 1 to 15, wherein the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least an oxygen fraction of the gases through the flow channel, and wherein the oxygen fraction of the gases is between about 21% to about 100%, optionally wherein oxygen fraction of the gases is between about 30% to about 50%.
17. The humidification chamber of any one of claims 1 to 16, wherein the length of the flow channel is between about 5 mm to about 300 mm, optionally wherein the length of the flow channel is between about 50 mm to about 200 mm, optionally wherein the length of the flow channel is between about 90 mm to about 200 mm.
18. The humidification chamber of any one of claims 1 to 17, wherein the width of the flow channel is between about 0.1 mm to about 500 mm, optionally wherein the width of the flow channel is between about 5 mm to about 20 mm.
19. The humidification chamber of any one of claims 1 to 18, wherein the surface area of the humidifying element is about 10 mm² to about 10,000 mm², optionally wherein the surface area of the humidifying element is between about 40 mm² to about 3,000 mm².
20. The humidification chamber of any one of claims 1 to 19, wherein a liquid flow rate to the humidifying element is between about 0.1 mL/min and about 50 mL/min, optionally wherein the liquid flow rate is between about 1 mL/min and about 5 mL/min.

21. The humidification chamber of any one of claims 1 to 20, wherein an inlet gases temperature to the humidifying section is between about 0°C and about 50°C, optionally wherein the inlet gases temperature is between about 15°C and about 35°C.
22. The humidification chamber of any one of claims 1 to 21, wherein an outlet gases temperature from the humidifying section is between about 18°C and about 70°C, optionally wherein the outlet gases temperature is between about 30°C and about 40°C.
23. The humidification chamber of any one of claims 1 to 22, wherein the transverse dimension of the flow channel normal to the direction of flow of the gases is determined by at least the humidity of the outlet gases from the humidifying section, wherein the humidity of the outlet gases is between about 12 mg/L and about 62 mg/L, optionally wherein the humidity of the outlet gases is between about 40 mg/L and about 50 mg/L.
24. The humidification chamber of any one of claims 1 to 23, wherein the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a humidity of the inlet gases to the humidifying section, wherein the humidity of the inlet gases is between about 0 mg/L and about 50 mg/L, optionally wherein the humidity of the inlet gases is between about 0.1 mg/L and about 5 mg/L.
25. The humidification chamber of any one of claims 1 to 24, wherein the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a flow velocity of gases through the flow channel, wherein the flow velocity of the gases is between about 0.003 m/s and about 330 m/s, optionally wherein the flow velocity of the gases is between about 0.1 m/s and about 30 m/s.
26. The humidification chamber of any one of claims 1 to 25, wherein a ratio of the cross-sectional area of humidifying section inlet to the cross-sectional area of the flow channel is between about 1:10 and about 12:1.
27. The humidification chamber of any one of claims 1 to 26, wherein the transverse dimension of the flow channel normal to the direction of flow of the gases is determined by a function comprising all of: the length of the flow channel; the flow rate of the gases; the temperature of the humidifying element; and the relative gases concentration.

28. The humidification chamber of any one of claims 1 to 27, wherein the transverse dimension of the flow channel is such that at least about 80% of the flow of gases to be humidified in the flow channel passes proximal to the humidifying element.
29. The humidification chamber of any one of claims 1 to 28, wherein the humidification chamber comprises an inlet antechamber upstream of the inlet of the humidifying section, the inlet antechamber for delivering the flow of gases to the humidifying section.
30. The humidification chamber of any one of claims 1 to 29, wherein the humidification chamber comprises an outlet antechamber downstream of the outlet of the humidifying section, the outlet antechamber for delivering the flow of gases from the humidifying section.
31. The humidification chamber of any one of claims 1 to 30, wherein the humidifying section comprises at least one wall or wall portion extending between the inlet and the outlet, the flow channel defined as a gases flow area between the humidifying element and the at least one wall or wall portion.
32. The humidification chamber of claim 31, wherein the transverse dimension of the flow channel is limited by a distance between the humidifying element and the at least one wall or wall portion of the flow channel.
33. The humidification chamber of any one of claims 1 to 32 when dependent on claim 30, wherein a cross-sectional gases flow area at any location in the humidifying section is less than a cross-sectional gases flow area at any location in the outlet antechamber.
34. The humidification chamber of any one of claims 1 to 33 when dependent on claim 29, wherein the inlet antechamber is shaped to direct the flow of gases substantially parallel to the humidifying element.
35. The humidification chamber of any one of claims 5 to 34 when dependent on claim 1, wherein the portion of the gases is substantially all of the gases in the flow channel.
36. The humidification chamber of any one of claims 1 to 35, wherein the humidifying element is centrally positioned in the humidifying section.

37. The humidification chamber of any one of claims 1 to 36, wherein the flow channel is a plurality of flow channels.
38. The humidification chamber of claim 37, wherein the humidifying element separates the at least one flow channel into the plurality of flow channels.
39. The humidification chamber of any one of claims 1 to 38 when dependent on at least claim 30, wherein the outlet antechamber has a tapered configuration, wherein the gases flow area of the flow channel is increased from a portion of the outlet antechamber adjacent to the humidifying section to a downstream portion of the outlet antechamber.
40. The humidification chamber of any one of claims 1 to 39 when dependent on at least claim 30 or claim 31, wherein a distance between an upper wall or upper wall portion and a lower wall or lower wall portion of the humidifying section is smaller than the distance between an upper wall or upper wall portion and a lower wall or lower wall portion of the outlet antechamber when viewed from the side to increase the flow area of the gases flow path from the humidifying section to the outlet antechamber.
41. The humidification chamber of any one of claims 1 to 40 when dependent on at least claim 29, 30, or 31, wherein the inlet antechamber has at least one angled surface extending to and adjacent one of the at least one wall or wall portion of the humidifying section for directing the flow of gases through the humidifying section.
42. The humidification chamber of claim 41, wherein the at least one angled surface directs the flow of gases onto at least one surface of the humidifying element.
43. The humidification chamber of claim 41 or 42, wherein an internal angle inside the humidification chamber between the angled surface and the adjacent wall or wall portion is a reflex angle.
44. The humidification chamber of claim 43, wherein an internal angle between the angled surface and the adjacent wall or wall portion of the humidifying section is between about 200° and 260°.

45. The humidification chamber of claim 43, wherein an internal angle between the angled surface and the adjacent wall or wall portion of the humidifying section is between about 220° and 240°.
46. The humidification chamber of any one of claims 41 to 45, wherein the inlet antechamber comprises two symmetrically opposed angled surfaces.
47. The humidification chamber of any one of claims 1 to 46, wherein the humidifying element has a substantially rounded or tapered leading edge at or adjacent to the inlet.
48. The humidification chamber of any one of claims 1 to 47, wherein a thickness of the humidifying element is increased from the inlet through a portion of the humidifying section when viewed from the side to reduce the transverse dimension of the or each at least one flow channel.
49. The humidification chamber of any one of claims 1 to 48 when dependent on at least claim 29, wherein the flow area of the gases flow path is reduced from the inlet antechamber to the humidifying section.
50. The humidification chamber of any one of claims 1 to 49, when dependent on at least claim 29 or 31, wherein a distance between an upper wall or upper wall portion and a lower wall or lower wall portion of the inlet antechamber is greater than a distance between an upper wall or upper wall portion and a lower wall or lower wall portion of the humidifying section.
51. The humidification chamber of any one of claims 1 to 50 when dependent on at least claim 29 or 30, wherein the inlet antechamber is a mirrored shape of the outlet antechamber.
52. The humidification chamber of any one of claims 1 to 51 when dependent on at least claim 30 or 31, wherein the outlet antechamber has at least one angled surface extending from and adjacent one of the at least one wall or wall portion of the humidifying section at the downstream outlet.
53. The humidification chamber of claim 52 when dependent on claim 41, wherein an internal angle of the angled surface of the outlet antechamber adjacent the wall or wall portion is less than that of the internal angle of the angled surface of the inlet antechamber adjacent the wall or wall portion.

54. The humidification chamber of claim 52 when dependent on claim 36, wherein a slope from the horizontal plane of the angled surface of the outlet antechamber adjacent the wall or wall portion is less than that of a slope from the horizontal plane of the angled surface of the inlet antechamber adjacent the wall or wall portion.
55. The humidification chamber of any one of claims 1 to 54, wherein at least one of the humidifying section and / or humidifying element is substantially rectangular in cross-section.
56. The humidification chamber of any one of claims 1 to 54, wherein at least one of the humidifying section and / or humidifying element is substantially circular in cross-section.
57. The humidification chamber of any one of claims 1 to 56, wherein the transverse dimension of the flow channel is greater at the inlet end of the humidifying section compared to the outlet end of the humidifying section.
58. The humidification chamber of any one of claims 1 to 57, wherein the transverse dimension of the flow channel is smallest at a position along the humidifying element between the inlet and the outlet.
59. The humidification chamber of any one of claims 1 to 58 when dependent on at least claim 31, wherein an inner surface of the at least one wall or wall portion of the humidifying section facing the humidifying element has ridges or bumps.
60. The humidification chamber of claim 59, wherein the ridges or bumps are positioned along substantially the length of the humidifying section.
61. The humidification chamber of claim 58 or 59, wherein the ridges or bumps extend substantially perpendicular to the length of the humidifying section.
62. The humidification chamber of any one of claims 1 to 61 when dependent on at least claim 31, wherein the humidifying element comprises at least one first humidifying plate connected to and extending from one of the walls or wall portion of the humidifying section toward the opposite wall or wall portion, the at least one first humidifying plate with a gap provided between the opposite wall or wall portion.

63. The humidification chamber of claim 62, wherein the humidifying element comprises at least one second humidifying plate positioned next to the at least one first humidifying plate, the at least one second humidifying plate separated from the first humidifying plate and extending from and connected to the opposite wall or wall portion of the humidifying section, the at least one second humidifying plate with a gap provided between the wall or wall portion to which the first humidifying plate is connected.
64. The humidification chamber of claim 63, wherein the at least one first humidifying plate and at least one second humidifying plate are angled when viewed from a side direction.
65. The humidification chamber of any one of claims 1 to 64 when dependent on at least claim 31, comprising at least one first baffle, wherein the at least one first baffle is connected to and extends from one of the wall or wall portion toward the humidifying element, wherein a gap is provided between the at least one first baffle and the humidifying element.
66. The humidification chamber of claim 65, comprising at least one second baffle, wherein the at least one second baffle is connected to and extends from the wall or wall portion opposite the at least one first baffle, the at least one second baffle extending toward the humidifying element, wherein a gap is provided between the at least one second baffle and the humidifying element.
67. The humidification chamber of claim 66, wherein the at least one first baffle and / or the at least one second baffle is angled when viewed from a side direction.
68. The humidification chamber of claim 67, wherein the at least one first baffle and / or the at least one second baffle is angled toward the downstream end when viewed from a side direction such that the connected end is closer to the upstream end than an opposite end of the or each baffle.
69. The humidification chamber of any one of claims 65 to 67, comprising a plurality of the first baffles and / or the second baffles, the baffles being substantially equally distanced apart in a length direction when viewed from the side.
70. The humidification chamber of any one of claims 1 to 69, wherein the humidifying element is provided on an inner surface of the humidifying section.

71. The humidification chamber of any one of claims 1 to 70, wherein the humidifying element comprises a liquid reservoir.
72. The humidification chamber of claim 71, comprising a heating plate in or under the liquid reservoir to heat liquid in the liquid reservoir.
73. The humidification chamber of any one of claims 1 to 72, comprising a gases inlet in fluid communication to the inlet of the humidifying section, the gases inlet for providing the gases for humidification, and a gases outlet in fluid communication to the outlet of the humidifying section, the gases outlet for delivering humidified gases to a patient interface.
74. The humidification chamber of claim 73, wherein the cross-sectional flow area of the gases flow path of the flow channel normal to the direction of flow of the gases is at most about 25% of the cross-sectional flow area of the gases flow path normal to the direction of flow of the gases at the gases inlet.
75. The humidification chamber of any one of claims 1 to 74 when dependent on at least claims 29 and 30, wherein the inlet antechamber and outlet antechamber are substantially coaxially aligned along an axis extending between the inlet and outlet of the humidifying section.
76. The humidification chamber of any one of claims 1 to 76, comprising a liquid inlet, the liquid inlet configured to deliver liquid to the humidifying element.
77. A respiratory humidification system for providing humidification to gases before being provided to an airway of a patient, the respiratory humidification system comprising a humidification chamber in accordance with any one of claims 1 to 77.
78. A respiratory humidification system of claim 77, wherein the respiratory humidification system further comprises a flow generator to deliver gases to the humidification chamber.
79. A respiratory humidification system of claim 76 or claim 77, wherein the respiratory humidification system further comprises a patient interface to deliver humidified gases from the humidification chamber to a patient.
80. A humidification chamber for a respiratory humidification system, the humidification chamber defining a gases flow path, the humidification chamber comprising:

an elongate humidifying section having an upstream end and a downstream end;
an inlet antechamber at the upstream end of the humidifying section; and
an outlet antechamber at the downstream end of the humidifying section,
wherein a flow area of the gases flow path is reduced from the inlet antechamber
to the humidifying section.

81. The humidification chamber of claim 80, wherein the inlet antechamber and outlet antechamber are substantially coaxially aligned along an axis.
82. The humidification chamber of claim 81, wherein the axis substantially extends in a direction between the upstream end and the downstream end of the humidifying section
83. The humidification chamber of any one of claims 80 to 82, wherein a resultant flow of gases through the inlet antechamber is substantially in a same flow direction as a resultant flow of gases through the outlet antechamber.
84. The humidification chamber of any one of claims 80 to 83, wherein a resultant flow of gases through the humidifying section is substantially in a same flow direction as a gases flow through the inlet antechamber and through the outlet antechamber.
85. The humidification chamber of any one of claims 80 to 84, comprising a gases inlet in fluid communication with the inlet antechamber, the gases inlet for providing the gases for humidification, and a gases outlet in fluid communication with the outlet antechamber, the gases outlet for delivering humidified gases to a patient interface.
86. The humidification chamber of claim 85, wherein the gases inlet and gases outlet are substantially coaxially aligned along an axis.
87. The humidification chamber of any one of claims 80 to 86, wherein a gases flow between the inlet antechamber and the humidifying section is substantially laminar.
88. The humidification chamber of any one of claims 80 to 87, wherein a gases flow between the inlet antechamber and the outlet antechamber is substantially laminar.
89. The humidification chamber of any one of claims 80 to 88, wherein the humidifying section comprises a humidifying element configured to humidify the gases in the gases flow path passing through the humidifying section.

90. The humidification chamber of claim 89, wherein the gases flow proximate to the humidifying element through the humidifying section.
91. The humidification chamber of claim 89 or claim 90, wherein the humidifying section comprises at least one wall or wall portion extending between the upstream end and the downstream end, the humidifying element and at least one wall or wall portion defining a flow channel for the gases flow path from the upstream end to the downstream end.
92. The humidification chamber of any one of claims 80 to 91, wherein the flow channel has a transverse dimension normal to the direction of flow of the gases through the flow channel.
93. The humidification chamber of claim 93, wherein the maximum transverse dimension of the flow channel is configured to enable a target fraction of the gases to reach a target humidity at the outlet antechamber.
94. The humidification chamber of claim 93, wherein a high humidity boundary layer is formed within the humidifying section for humidifying the flow of gases.
95. The humidification chamber of claim 94, wherein the high humidity boundary layer is formed proximal to the humidifying element.
96. The humidification chamber of claim 94 or claim 95 when dependent on at least claim 89, wherein the high humidity boundary layer fully develops to a dimension from the humidifying element.
97. The humidification chamber of claim 96, wherein the transverse dimension of the flow channel is equal to or less than the fully developed high humidity boundary layer dimension to fill at least part of the flow channel with the high humidity boundary layer.
98. The humidification chamber of claim 96, wherein the fully developed high humidity boundary layer dimension is less than the transverse dimension of the flow channel.
99. The humidification chamber of any one of claims 93 to 98, wherein the direction of the flow of the gases through the flow channel is the resultant flow at a given point in the flow channel.

100. The humidification chamber of any one of claims 93 to 99, wherein the target fraction of the gases is substantially all of the gases in the gases flow path.
101. The humidification chamber of any one of claims 93 to 99, wherein the transverse dimension of the flow channel is a function of at least one of: a flow velocity of the gases; a temperature of the humidifying element; a length of the channel between the upstream end and the downstream end, and a relative gases concentration.
102. The humidification chamber of claim 99, wherein the transverse dimension is at most about 10% of a length of the humidifying section measured between the upstream end and the downstream end.
103. The humidification chamber of claim 101 or claim 102, wherein the transverse dimension is between about 0 mm and about 22 mm, optionally the transverse dimension is between about 1 mm and about 5 mm.
104. The humidification chamber of any one of claims 101 to 103, wherein the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a flow rate of the flow of gases through humidifying section, wherein an average volumetric flow rate through the humidifying section is between about 0.5 L/min and about 200 L/min, optionally wherein the average volumetric flow rate through the humidifying section is between about 10 L/min and about 100 L/min, optionally, wherein the average volumetric flow rate through the humidifying section is at most about 70 L/min.
105. The humidification chamber of any one of claims 101 to 104, wherein the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a temperature of the humidifying element, wherein an average temperature of the humidifying element is between about 0°C and 100°C, optionally wherein an average temperature of the humidifying element is between about 30°C and about 80°C, optionally wherein an average temperature of the humidifying element is between about 60°C and about 80°C.
106. The humidification chamber of any one of claims 101 to 105, wherein the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a flow rate of the flow of gases through the humidifying section, wherein a mass flow rate of gases is less than about 300g/min.

107. The humidification chamber of any one of claims 101 to 106, wherein the volumetric flow rate of liquid supplied to the humidifying element is at least about 10 $\mu\text{l}/\text{min}$.
108. The humidification chamber of any one of claims 101 to 107, wherein the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least an oxygen fraction of the gases through the flow channel, wherein the gases comprise oxygen, and wherein the oxygen fraction of the gases is between about 21% to about 100%, optionally wherein oxygen fraction of the gases is between about 30% to about 50%.
109. The humidification chamber of any one of claims 101 to 108, wherein the length of the flow channel is between about 5 mm to about 300 mm, optionally wherein the length of the flow channel is between about 50 mm to about 200 mm, optionally wherein the length of the flow channel is between about 90 mm to about 200 mm.
110. The humidification chamber of any one of claims 101 to 109, wherein the width of flow channel is between about 0.1 mm to about 500 mm, optionally wherein the width of flow channel is between about 5 mm to about 20 mm.
111. The humidification chamber of any one of claims 101 to 110, wherein the surface area of humidifying element is about 10 mm^2 to about 10,000 mm^2 , optionally wherein the surface area of humidifying element is between about 40 mm^2 to about 3,000 mm^2 .
112. The humidification chamber of any one of claims 101 to 111, wherein a liquid flow rate to the humidifying element is between about 0.1 mL/min and about 50 mL/min , optionally wherein the liquid flow rate is between about 1 mL/min and about 5 mL/min .
113. The humidification chamber of any one of claims 101 to 112, wherein an inlet gases temperature to the humidifying section is between about 0°C and about 50°C , optionally wherein the inlet gases temperature is between about 15°C and about 35°C .
114. The humidification chamber of any one of claims 101 to 113, wherein an outlet gases temperature from the humidifying section is between about 18°C and about 70°C , optionally wherein the outlet gases temperature is between about 30°C and about 40°C .

115. The humidification chamber of any one of claims 101 to 114, wherein the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least the humidity of the outlet gases from the humidifying section, wherein the humidity of the outlet gases is between about 12 mg/L and about 62 mg/L, optionally wherein the humidity of the outlet gases is between about 40 mg/L and about 50 mg/L.
116. The humidification chamber of any one of claims 101 to 115, wherein the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a humidity of the inlet gases to the humidifying section, wherein the humidity of the inlet gases is between about 0 mg/L and about 50 mg/L, optionally wherein the humidity of the inlet gases is between about 0.1 mg/L and about 5 mg/L.
117. The humidification chamber of any one of claims 101 to 117, wherein the transverse dimension of the flow channel normal to the direction of flow of the gases is a function of at least a flow velocity of gases through the flow channel, wherein the flow velocity of the gases is between about 0.003 m/s and about 330 m/s, optionally wherein the flow velocity of the gases is between about 0.1 m/s and about 30 m/s.
118. The humidification chamber of any one of claims 101 to 117, wherein a ratio of the cross-sectional area of humidifying section inlet to the cross-sectional area of the flow channel is between about 1:10 and about 12:1.
119. The humidification chamber of any one of claims 101 to 118, wherein the transverse dimension of the flow channel normal to the direction of flow of the gases is determined by a function comprising: the length of the flow channel; the flow rate of the gases; the temperature of the humidifying element; and the relative gases concentration.
120. The humidification chamber of any one of claims 80 to 119 when dependent on at least claim 89, wherein the humidifying element extends in a direction between the upstream end and the downstream end.
121. The humidification chamber of any one of claims 80 to 120 when dependent on at least claim 89, wherein the humidifying element is centrally positioned in the humidification section.

122. The humidification chamber of any one of claims 80 to 121 when dependent on at least claim 89, wherein the gases flow path is a plurality of flow channels.
123. The humidification chamber of claims 122, wherein the humidifying element splits the gases flow path into a plurality of the flow channels.
124. The humidification chamber of any one of claims 80 to 123, wherein the inlet antechamber is shaped to direct gases through the humidifying section.
125. The humidification chamber of any one of claims 80 to 124 when dependent on at least claim 91, wherein the inlet antechamber has at least one angled surface extending to and adjacent one of the at least one wall or wall portion of the humidifying section for directing the flow of gases through the humidifying section.
126. The humidification chamber of claim 125, wherein the at least one angled surface directs the flow of gases onto at least one surface of the humidifying element.
127. The humidification chamber of claim 125 or claim 126, wherein an internal angle inside the humidification chamber between the angled surface and the adjacent wall or wall portion is a reflex angle.
128. The humidification chamber of claim 126, wherein an internal angle between the angled surface and the adjacent wall or wall portion of the humidifying section is between about 200° and 260°.
129. The humidification chamber of claim 126, wherein an internal angle between the angled surface and the adjacent wall or wall portion of the humidifying section is between about 220° and 240°.
130. The humidification chamber of any one of claims 125 to 129, wherein the inlet antechamber comprises two symmetrically opposed angled surfaces.
131. The humidification chamber of any one of claims 80 to 130 when dependent on at least claim 89, wherein the humidifying element has a substantially rounded or tapered leading edge at or adjacent to the upstream end.
132. The humidification chamber of any one of claims 80 to 131 when dependent on at least claim 89, wherein a thickness of the humidifying element is increased from

the upstream end through a portion of the humidifying section when viewed from the side to reduce the transverse dimension of the or each at least one flow channel.

133. The humidification chamber of any one of claims 80 to 132, wherein the flow area of the gases flow path is reduced from the inlet antechamber to the humidifying section.
134. The humidification chamber of any one of claims 80 to 133 when dependent on at least claim 91, wherein a distance between an upper wall or upper wall portion and a lower wall or lower wall portion of the inlet antechamber is greater than a distance between an upper wall or upper wall portion and a lower wall or lower wall portion of the humidifying section.
135. The humidification chamber of any one of claims 80 to 134, wherein the inlet antechamber is a mirrored shape of the outlet antechamber.
136. The humidification chamber of any one of claims 80 to 135 when dependent on at least claim 91, wherein the outlet antechamber has at least one angled surface extending from and adjacent one of the at least one wall or wall portion of the humidifying section at the downstream end.
137. The humidification chamber of claim 136 when dependent on claim 125, wherein an internal angle of the angled surface of the outlet antechamber adjacent the wall or wall portion is less than that of the internal angle of the angled surface of the inlet antechamber adjacent the wall or wall portion.
138. The humidification chamber of claim 136 when dependent on claim 125, wherein a slope from the horizontal plane of the angled surface of the outlet antechamber adjacent the wall or wall portion is less than that of a slope from the horizontal plane of the angled surface of the inlet antechamber adjacent the wall or wall portion.
139. The humidification chamber of any one of claims 80 to 138 when dependent on at least claim 89, wherein at least one of the humidifying section and / or humidifying element is substantially rectangular in cross-section.
140. The humidification chamber of any one of claims 80 to 138 when dependent on at least claim 89, wherein at least one of the humidifying section and / or humidifying element is substantially circular in cross-section.

141. The humidification chamber of any one of claims 80 to 140 when dependent on at least claim 89, wherein the transverse dimension of the or each at least one flow channel is greater at the upstream inlet end of the humidifying element compared to the downstream end of the humidifying element.
142. The humidification chamber of any one of claims 80 to 140 when dependent on at least claim 89, wherein the transverse dimension of the or each at least one flow channel is smallest at a position along the humidifying element between the upstream end and the downstream end.
143. The humidification chamber of any one of claims 80 to 142 when dependent on at least claim 89, wherein an inner surface of the at least one wall or wall portion of the humidifying section facing the humidifying element has ridges or bumps.
144. The humidification chamber of claim 143, wherein the ridges or bumps are positioned along substantially the length of the humidifying section.
145. The humidification chamber of claim 143 or 144, wherein the ridges or bumps extend substantially perpendicular to the length of the humidifying section.
146. The humidification chamber of any one of claims 80 to 145 when dependent on at least claim 91, wherein the humidifying element comprises at least one first humidifying plate connected to and extending from one of the walls or wall portion of the humidifying section toward the opposite wall or wall portion, the at least one first humidifying plate with a gap provided between the opposite wall or wall portion.
147. The humidification chamber of claim 146, wherein the humidifying element comprises at least one second humidifying plate positioned next to the at least one first humidifying plate, the at least one second humidifying plate separated from the first humidifying plate and extending from and connected to the opposite wall or wall portion of the humidifying section, the at least one second humidifying plate with a gap provided between the wall or wall portion to which the first humidifying plate is connected.
148. The humidification chamber of claim 147, wherein the at least one first humidifying plate and at least one second humidifying plate are angled when viewed from a side direction.

149. The humidification chamber of any one of claims 80 to 148 when dependent on at least claim 91, comprising at least one first baffle, wherein the at least one first baffle is connected to and extends from one of the wall or wall portion toward the humidifying element, wherein a gap is provided between the at least one first baffle and the humidifying element.
150. The humidification chamber of claim 149, comprising at least one second baffle, wherein the at least one second baffle is connected to and extends from the wall or wall portion opposite the at least one first baffle, the at least one second baffle extending toward the humidifying element, wherein a gap is provided between the at least one second baffle and the humidifying element.
151. The humidification chamber of claim 150, wherein the at least one first baffle and / or the at least one second baffle is angled when viewed from a side direction.
152. The humidification chamber of claim 151, wherein the at least one first baffle and / or the at least one second baffle is angled toward the downstream end when viewed from a side direction such that the connected end is closer to the upstream end than an opposite end of the or each baffle.
153. The humidification chamber of any one of claims 150 to 152, comprising a plurality of the first baffles and / or the second baffles, the baffles being substantially equally distanced apart in a length direction when viewed from the side.
154. The humidification chamber of any one of claims 80 to 153 when dependent on at least claim 89, wherein the humidifying element is provided on an inner surface of the humidifying section.
155. The humidification chamber of any one of claims 80 to 154 when dependent on at least claim 89, wherein the humidifying element comprises a liquid reservoir.
156. The humidification chamber of claim 155, comprising a heating plate in or under the liquid reservoir to heat liquid in the liquid reservoir.
157. The humidification chamber of any one of claims 80 to 156, wherein the cross-sectional flow area of the gases flow path of the or each at least one flow channel normal to the direction of flow of the gases is at most about 25% of the cross-

sectional flow area of the gases flow path normal to the direction of flow of the gases at the gases inlet end of the inlet antechamber.

158. The humidification chamber of any one of claims 80 to 157, wherein the inlet antechamber and outlet antechamber are substantially coaxially aligned along an axis extending between the upstream end and downstream end of the humidifying section.
159. The humidification chamber of any one of claims 80 to 158 when dependent on at least claim 89, comprising a liquid inlet, the liquid inlet configured to deliver liquid to the humidifying element.
160. A respiratory humidification system for providing humidification to gases before being provided to an airway of a patient, the respiratory humidification system comprising a humidification chamber in accordance with any one of claims 80 to 159.
161. A respiratory humidification system of claim 160, wherein the respiratory humidification system further comprises a flow generator to deliver gases to the humidification chamber.
162. A respiratory humidification system of claim 160 or claim 161, wherein the respiratory humidification system further comprises a patient interface to deliver humidified gases from the humidification chamber to a patient.
163. A humidification chamber for a respiratory humidification system, the humidification chamber comprising:
 - a gases inlet and a gases outlet defining a flow path therebetween for a flow of gases;
 - a humidifying section having an upstream end and a downstream end, and having a flow channel for the flow of gases;
 - an inlet antechamber positioned between the gases inlet and the upstream end of the humidifying section and comprising a wall or wall portion extending between the gases inlet and the upstream end and having a flow channel for the flow of gases therebetween; and
 - a humidifying element positioned in the humidifying section, configured to allow the flow of gases over at least one surface or surface portion of the humidifying element to humidify the flow of gases in the flow path,

wherein, the flow channel through the humidifying section is smaller in size than the flow channel through the inlet antechamber, wherein the size of the flow channel of the humidifying section is measured as a dimension in a transverse direction of said flow channel extending from the at least one surface or surface portion of the humidifying element to an opposing surface or opposing part of the surface portion, and the size of the flow channel of the inlet antechamber is measured as a dimension in a transverse direction of said flow channel extending from the at least one wall or wall portion of the inlet antechamber to an opposing at least one wall or opposing part of the wall portion.

164. The humidification chamber of claim 163, wherein the transverse direction is normal to the resultant direction of the flow of gases through the flow channel of the humidifying section.
165. The humidification chamber of claim 163 or claim 164, wherein the transverse direction of the flow channel through the inlet antechamber is measured normal to the at least one wall or part of the wall portion.
166. The humidification chamber of any one of claims 163 to 165, wherein the transverse direction of the flow channel through the humidifying section is measured normal to the surface or surface portion.
167. The humidification chamber of any one of claims 163 to 166, wherein the gases inlet and the gases outlet are substantially coaxially aligned along an axis.
168. The humidification chamber of any one of claims 163 to 167, wherein a resultant flow of gases through the gases inlet is substantially in a same flow direction as a resultant flow of gases through the gases outlet.
169. The humidification chamber of any one of claims 163 to 168, wherein a resultant flow of gases through the humidifying section is substantially in a same flow direction as the flow through gases inlet and through the gases outlet.
170. The humidification chamber of any one of claims 163 to 169, wherein a gases flow between the inlet antechamber and the humidifying section is substantially laminar.
171. The humidification chamber of any one of claims 163 to 170, wherein a gases flow between the gases inlet and the gases outlet is substantially laminar.

172. The humidification chamber of any one of claims 163 to 171, further comprising an outlet antechamber positioned between the gases outlet and the downstream end of the humidifying section and comprising a wall or wall portion extending between the downstream end and the gases outlet and having a flow channel for the flow of gases therebetween.
173. A humidification chamber for a respiratory humidification system, the humidification chamber comprising:
- a humidifying section having an inlet and an outlet;
 - a humidifying element in the humidifying section; and
 - a flow channel for gases to flow from the inlet to the outlet proximal to the humidifying element, the humidifying element configured to humidify a flow of gases passing through the flow channel,
- wherein a target humidity for a portion of the gases to achieve at the outlet is determined by a transverse dimension of the flow channel normal to a direction of flow of the gases, the transverse dimension being a function of at least one of: the length of the flow channel; a flow rate of the gases; a temperature of the humidifying element; and a relative gases concentration.