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(54) **Title:** REBREATHER APPARATUS

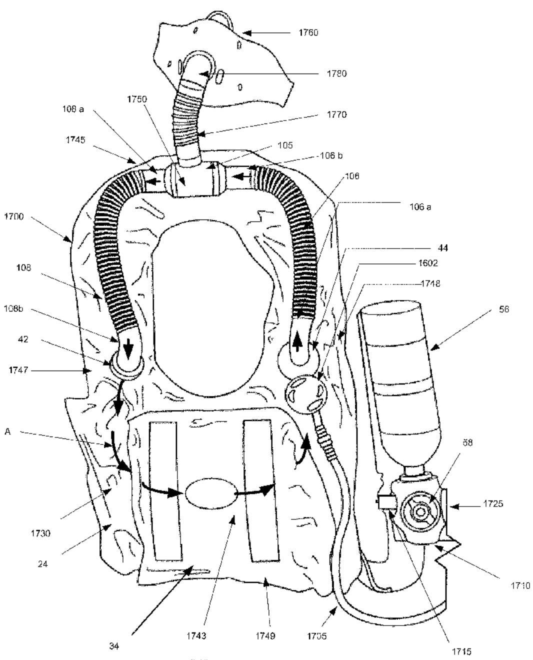

Figure 17

(57) **Abstract:** Disclosed are apparatuses and methods for a self-contained rebreather device in the form of a vest or a horse collar that scrubs carbon dioxide from exhaled air and cools the scrubbed air to an appropriate temperature for human inhalation. A heat sink material is positioned within a mouthpiece apparatus to transfer heat energy from the scrubbed air to an ambient environment, where the heat is dissipated, causing the scrubbed air to be cooled before inhalation. In some embodiments, a phase change material is included within the vest to absorb heat from the scrubbed air, further cooling the scrubbed air to a point that is appropriate and in some cases comfortable for inhalation.

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REBREATHER APPARATUS

CROSS REFERENCE TO RELATED APPLIATIONS

[0001] This Application claims priority to U.S. Provisional Application No. 62/401,778, filed September 29, 2016, entitled "Rebreather Apparatus" which is incorporated herein in its entirety by reference.

FIELD OF THE INVENTION

[0002] This disclosure generally relates to a closed-circuit wherein resulting heat from a chemical reaction to remove carbon dioxide from the rebreathing system is dissipated before inhalation by a user.

BACKGROUND

[0003] Rebreather devices are used in a wide variety of applications including military settings, especially underwater teams that desire to remain stealth and not have air bubbles surface as would be the case if using open circuit breathing apparatus. Other applications include mine rescue or other industries where poisonous gas may be present or oxygen absent, manned space vehicles and space suits where a person is effectively in a vacuum, hospital anesthesia breathing systems that supply appropriately proportioned gas mixtures to a patient without letting the gas escape to be breathed by hospital personnel, submarines, and oxygen hyperbaric chambers, among other applications.

[0004] The rebreather works by recirculating exhaled air from the user's breath based on the fact that a person only absorbs about 25 percent of the available oxygen with each breath. The exhaled air passes through a scrubbing material, such as soda lime, wherein the carbon dioxide is removed. Additional oxygen and/or a diluent is added to the circuit either manually or via an electronic system that senses for the oxygen concentration using appropriate sensors such as oxygen sensitive electro-galvanic fuels cells that calculate the oxygen concentration in the breathing loop. The scrubbing material is held within a canister that is worn about the body of the person. The breathing air within the loop moves into and out of the canister through the small pressure changes generated through respiration by the user.

The chemical reaction between the exhaled breath and the scrubbing material introduces a significant amount of energy in the form of heat that makes the scrubbed air too hot for human inhalation. What is needed is a mouthpiece heat regulator and/or phase change material that is used to dissipate enough heat from the scrubbed air to cool the air to a breathable temperature prior to inhalation by the user.

SUMMARY OF INVENTION

[0005] The following presents a summary of certain embodiments of the present invention. This summary is not intended to be a comprehensive overview of all contemplated embodiments, and is not intended to identify key or critical elements of all embodiments nor delineate the scope of any or all embodiments. Its sole purpose is to present certain concepts and elements of one or more embodiments in a summary form as a prelude to the more detailed description that follows.

[0006] Embodiments of the present invention address the above needs and/or achieve other advantages by removing heat from air in a rebreathing system. Some embodiments of the invention comprises a horse-collar-shaped rebreathing apparatus for removing carbon dioxide from air exhaled from a user resulting in heated air and cooling the heated air, the apparatus comprising a first portion and a second portion opposite the first portion and operatively coupled with the first portion by a third portion; an outer layer configured to be exposed to the atmosphere and an inner layer configured to be in contact with a user, the outer layer and the inner layer together defining an internal channel extending through the third portion and operatively coupling the first portion and the second portion, wherein the internal channel comprises an exhalation chamber, a carbon dioxide scrubbing material and an inhalation chamber; an outlet port disposed on the first portion; an inlet port disposed on the second portion; an inlet hose comprising a first end and a second end, wherein the first end of the inlet hose is configured for operatively coupling to the inlet port; an outlet hose comprising a first end and a second end, wherein the second end of the outlet hose is configured for operatively coupling to the outlet port; a mouthpiece valve assembly configured for operatively coupling to the second end of the inlet hose and configured for operatively coupling to the first end of the outlet hose; a mouthpiece interface configured for operatively coupling to the mouthpiece valve assembly and further configured for veiling the face of the user; wherein the apparatus is configured to receive air at a first temperature exhaled from the user, the air enters the outlet hose which delivers the air through the exhalation chamber to the scrubbing material and to the inhalation chamber, the scrubbing material is configured for chemically reacting with the air to remove carbon dioxide, thereby raising the temperature of the air to a second temperature, the apparatus is configured to cool the air to a third temperature by dissipating heat from the scrubbed air through the outer layer to the atmosphere, the apparatus is configured to deliver the cooled air from the inhalation chamber to the mouthpiece interface by the inlet hose, and the mouthpiece interface is configured for delivering the cooled air to the user for inhalation.

[0007] In some embodiments, the mouthpiece interface is configured for operatively coupling to the mouthpiece valve assembly by an elbow to T-bit hose and an oral-nasal elbow.

[0008] In some embodiments, the apparatus is configured so that the exhaled air enters the mouthpiece interface and is transferred to the mouthpiece valve assembly, the mouthpiece valve assembly configured to function as a heat sink by the oral nasal elbow and the elbow to T-bit hose, wherein the air passes through the mouthpiece valve assembly and enters the outlet hose.

[0009] In some embodiments, the outer layer and the inner layer are made from same material.

[0010] In some embodiments, wherein the outer layer and the inner layer are made from different material.

[0011] The scrubbing material is disposed in the internal channel enclosed in a casing, wherein the casing comprises aluminum.

[0012] In some embodiments, the mouthpiece interface comprises an oral nasal cup, wherein the oral nasal cup is configured to be secured to the user's head with an oral nasal head harness.

[0013] In some embodiments, the oral nasal head harness further comprises an adjustable strap.

[0014] In some embodiments, a second layer is present inside the inner layer to prevent the heat from dissipating through the inner layer.

[0015] In some embodiments, a second layer is present outside the inner layer to prevent the heat from dissipating through the inner layer.

[0016] In some embodiments, the horse collar rebreathing apparatus further comprises a demand regulator and a low pressure oxygen hose configured to attach a canister to the rebreather device.

[0017] In some embodiments, the low pressure oxygen hose injects oxygen into the inhalation chamber of the internal channel at a rate proportional to an amount of oxygen that leaves the apparatus through absorption in lungs of the user. In some embodiments, the apparatus further comprises a waist strap holding the canister to secure the rebreather device to the user's body.

[0018] In some embodiments, the heat from the scrubbed air is dissipated into the atmosphere through the inlet hose, the outlet hose and the outer layer.

[0019] In some embodiments, the third temperature is cooler than the first temperature by two (2) to three (3) degrees.

[0020] Some embodiments of the invention are directed to an apparatus for cooling air prior to inhalation by a user, the apparatus comprising an outer layer configured to be exposed to the environment; an inlet hose configured to connect an inlet port and a mouthpiece valve assembly; an outlet hose configured to connect an outlet port and the mouthpiece valve assembly; a heat sink material located within the mouthpiece valve assembly; wherein the air at a first temperature exhaled into the mouthpiece interface by a user enters the mouthpiece valve assembly, the exhaled air enters the outlet hose which delivers the exhaled air through an exhalation chamber to the scrubbing material and to the inhalation chamber at a second temperature lower than the first temperature, the scrubbing material is configured for chemically reacting with the air to remove carbon dioxide from the exhaled air thereby raising the temperature of the scrubbed air to a third temperature higher than the first and the second temperature, the scrubbed air enters the inlet hose at a fourth temperature lower than the third temperature which delivers the cool scrubbed air at a fifth temperature lower than the fourth and the first temperature to the mouthpiece valve assembly.

[0021] In some embodiments, the inlet hose comprises a first end and a second end, wherein the first end of the inlet hose is operatively coupled to the outlet port.

[0022] In some embodiments, the outlet hose comprises a first end and a second end, wherein the second end of the outlet hose is operatively coupled to the inlet port.

[0023] In some embodiments, wherein the mouthpiece valve assembly further comprises an inlet valve and an outlet valve.

[0024] Some embodiments of the invention are directed to a mouthpiece interface apparatus for exhaling and inhaling air using a rebreathing apparatus, the apparatus comprising an oral nasal cup; an oral nasal elbow; an elbow to T-bit hose configured to be coupled to the oral nasal elbow and a mouthpiece valve assembly; wherein the mouthpiece valve assembly further comprises an inlet valve, an outlet valve and a heat sink material; wherein the air exhaled by a user into the oral nasal cup is delivered to the outlet valve via the oral nasal elbow and the elbow to T-bit hose; and wherein the air for inhalation by the user is delivered into the oral nasal cup from the inlet valve via the oral nasal elbow and the elbow to T-bit hose.

[0025] Some embodiments of the invention are directed to horse-collar-shaped rebreather apparatus comprising an outer closure edge defining an outer circumference of the apparatus; an inner closure edge defining an inner circumference of the apparatus; at least one internal channel configured to support air flow; wherein the inner closure edge defines a neck receiving opening; wherein the outer closure edge and inner closure edge define a front portion and a back portion of the apparatus; wherein the at least one internal channel is present in the front portion of the apparatus.

[0026] In some embodiments, the front portion of the apparatus is larger than the back portion and comprises at least one internal channel.

[0027] In some embodiments, the back portion is configured to support the apparatus hanging from the user's neck.

[0028] In some embodiments, the back portion is configured to not support air flow.

[0029] To the accomplishment of the foregoing and related objectives, the embodiments of the present invention comprise the function and features hereinafter described. The following description and the referenced figures set forth a detailed description of the present invention, including certain illustrative examples of the one or more embodiments. The functions and features described herein are indicative, however, of but a few of the various ways in which the principles of the present invention may be implemented and used and, thus, this description is intended to include all such embodiments and their equivalents.

[0030] The features, functions, and advantages that have been discussed may be achieved independently in various embodiments of the invention or may be combined with yet other embodiments, further details of which can be seen with reference to the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] Having thus described embodiments of the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

[0032] **FIG. 1A** is a frontal view of the rebreather vest of the present invention in a single layer demand and/or constant flow gas injection configuration, in accordance with an embodiment of the invention;

[0033] **FIG. 1B** is a rear view of the rebreather vest FIG. 1A, in accordance with an embodiment of the invention;

[0034] **FIG. 2A** is a frontal view of the rebreather vest of the present invention with unidirectional air flow channels, in accordance with an embodiment of the invention;

[0035] **FIG. 2B** is a rear view of the rebreather vest of FIG. 2A, in accordance with an embodiment of the invention;

[0036] **FIG. 3** is a frontal view of the rebreather vest in a double layer demand and electronic control gas injection configuration, in accordance with embodiments of the present invention;

[0037] **FIG. 4** is a rear view of the rebreather vest of FIG. 3, in accordance with an embodiment of the invention;

[0038] **FIG. 5** is a perspective view of the rebreather vest of FIG. 3, in accordance with an embodiment of the invention;

[0039] **FIG. 6** is a partial cross-section view of the rebreather vest of FIG. 3 comprising carbon dioxide scrubbing material, in accordance with an embodiment of the invention;

[0040] **FIG. 7** is a partial cross-section view of the rebreather vest of FIG. 3 comprising heat absorbing phase change material, in accordance with an embodiment of the invention;

[0041] **FIG. 8** is a perspective sectioned view of a portion of the internal channels within the rebreather vest of FIG. 3, in accordance with an embodiment of the invention;

[0042] **FIG. 9** is an end view of the rebreather vest of FIG. 6, in accordance with an embodiment of the invention;

[0043] **FIG. 10A** is a perspective view of an alternate shape possible for extruded carbon-dioxide absorbent material for use within the internal cavity of the rebreather vest, in accordance with an embodiment of the invention;

[0044] **FIG. 10B** is a perspective view of an alternate shape possible for extruded carbon-dioxide absorbent material for use within the internal cavity of the rebreather vest, in accordance with an embodiment of the invention;

[0045] **FIG. 11A** is an expanded view of a rebreather vest including a cutaway to show the internal cavity of the rebreather vest, in accordance with embodiments of the present invention;

[0046] **FIG. 11B** is a frontal view of a rebreather vest including a cutaway to show the internal cavity of the rebreather vest, in accordance with embodiments of the present invention;

[0047] **FIG. 11C** is a rear view of a rebreather vest including a cutaway to show the internal cavity of the rebreather vest, in accordance with embodiments of the present invention;

[0048] **FIG. 11D** is an expanded view of a rebreather vest including a cutaway to show the internal cavity of the rebreather vest, in accordance with embodiments of the present invention;

[0049] **FIG. 12A** is a perspective exploded-out view of a mouthpiece apparatus including a heat sink material for use with the rebreather vest, in accordance with an embodiment of the invention;

[0050] **FIG. 12B** is a frontal view of a mouthpiece apparatus for use with the rebreather vest, in accordance with an embodiment of the invention;

[0051] **FIG. 13A** is a top view of a mouthpiece apparatus without a mouthpiece interface, in accordance with an embodiment of the invention;

[0052] **FIG. 13B** is a top view of a mouthpiece apparatus with a mouthpiece interface in place, in accordance with an embodiment of the invention;

[0053] **FIG. 13C** is a top view of a mouthpiece apparatus with a mouthpiece plug blocking air flow through the mouthpiece interface, in accordance with an embodiment of the invention;

[0054] **FIG. 14** is a perspective cross-sectional view of a portion of the mouthpiece interface showing the internal configuration of the mouthpiece body and the heat sink material, in accordance with an embodiment of the invention;

[0055] **FIG. 15A** is a frontal view of a rebreather vest, in accordance with an embodiment of the invention;

[0056] **FIG. 15B** is a perspective view of the rebreather vest of FIG. 15A, in accordance with an embodiment of the invention;

[0057] **FIG. 16A** is an exploded view of a regulator, in accordance with an embodiment of the invention; and

[0058] **FIG. 16B** is a perspective view of the regulator of FIG. 16A, in accordance with an embodiment of the invention.

[0059] **FIG. 17** is a frontal view of the rebreather apparatus of the present invention with a mouthpiece comprising an oral nasal cup, in accordance with an embodiment of the invention.

[0060] **FIG. 18** is a frontal view of the rebreather apparatus of the present invention with an alternate mouthpiece comprising a hood and an oral nasal cup, in accordance with an embodiment of the invention.

[0061] **FIG. 19** is a frontal view of the rebreather apparatus of the present invention with an alternate mouthpiece without an oral nasal cup, in accordance with an embodiment of the invention.

[0062] **FIG. 20** is a rear view of the rebreather apparatus of the present invention with a mouthpiece comprising an oral nasal cup, in accordance with an embodiment of the invention.

[0063] **FIG. 21** is an exploded side view of the mouthpiece comprising an oral nasal cup, in accordance with an embodiment of the present invention.

[0064] **FIG. 22** is exploded top view of the mouthpiece comprising an oral nasal cup and oral nasal head harness, in accordance with an embodiment of the present invention.

[0065] **FIG. 23** is an exploded rear view of the oral nasal cup, in accordance with an embodiment of the present invention.

[0066] **FIG. 24** is a frontal view of the mouthpiece apparatus donned by a user, in accordance with an embodiment of the present invention.

[0067] **FIG. 25** is a right side view of the mouthpiece comprising an oral nasal cup covered with adjustable oral nasal head harness, in accordance with an embodiment of the present invention.

[0068] **FIG. 26** is a left side view of the mouthpiece comprising an oral nasal cup covered with adjustable oral nasal head harness, in accordance with an embodiment of the present invention.

[0069] **FIG. 27** is an exploded view of the assembly of the rebreather apparatus, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0070] Embodiments of the present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all, embodiments of the invention are shown. Indeed, the invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Like numbers refer to like elements throughout. Where possible, any terms expressed in the singular form herein are meant to also include the plural form and vice versa, unless explicitly stated otherwise. Also, as used herein, the term “a” and/or “an” shall mean “one or more,” even though the phrase “one or more” is also used herein.

[0071] Various embodiments or features will be presented in terms of systems that may include a number of devices, components, modules, and the like. It is to be understood and appreciated that the various systems may include additional devices, components, modules, and the like, and/or may not include all of the devices, components, modules, and the like, discussed in connection with the figures. A combination of these approaches may also be used.

[0072] As will be appreciated by one of ordinary skill in the art, the present invention may be embodied as an apparatus (including, for example, a system, a machine, a device, and/or the like), as a method, or as any combination of the foregoing.

[0073] Referring now to the drawings, it is seen that embodiments of a rebreather device of the present invention, generally denoted by reference numeral 10, is comprised of a vest 12 of typical human torso configured vest configuration having a front left portion 14 that serves as a first counter-lung, a front right portion 16 that serves as a second counter-lung joined by a back portion 18. Webbing 20 may be used to join the back portion 18 with the ends of the front portions 14 and 16 or the back portion 18 may be full. Appropriate closure mechanisms (zipper, snap, latches, etc., none illustrated) can be used to close the front of the vest 12 in the usual way.

[0074] In the embodiment illustrated in FIG. 1A, the rebreather device 10 has a first front closure edge, right closure edge or right closure segment extending substantially parallel to, and adjacent to, the zipper at opening 38. Likewise, the rebreather device 10 has a second front closure edge, left closure edge or left closure segment shown, in FIG. 1A, opposite of such right closure segment. As illustrated in FIG. 1A, the rebreather device 10 has a perimeter edge extending along the perimeter of the vest. The perimeter edge includes the right closure segment, left closure segment and bottom segment. The perimeter edge defines the neck receiving opening when the right closure segment is in contact with the left closure segment. The vest 12 has a right arm receiving edge which, in the embodiment illustrated in FIG. 5, is located to the right of the inlet port 44. The vest 12 has a left arm receiving edge which, in the embodiment illustrated in FIG. 5, is located to the left of the outlet port 42.

[0075] FIGS. 8-10B illustrate in more detail how the vest 12 is formed from an inner layer 22 that contacts the user's body and an outer layer 24 joined together in order to provide an air tight internal cavity 26 within the vest 12. In some embodiments, a plurality of seals join the layers 22 and 24 together. A first seal extends along the perimeter edge described above. A second seal extends along the right arm receiving edge described above. A third seal extends along the left arm receiving edge described above.

[0076] The inner layer 22 is made from an appropriate material for body contact which material allows for body hugging as well as stretching. Thin neoprene and Lycra are two suitable materials, although other candidates are also possible. The outer layer 24 may be the same as the inner layer and may have an additional layer 28 thereon that provides additional functionality to the vest 12 such as a ballistic material (KEVLAR etc.,) or may have pockets (not illustrated) into which appropriate body armor may be disposed. If a breathable material is used for either layer 22 and 24, an appropriate layer will be added in order to achieve the air tight internal cavity 26.

[0077] The internal cavity 26 is segregated into a series of channels 30 by a series of walls 32, made from an appropriate sturdy material such as flexible plastic that is attached to the inner layer 22 and the outer layer 24. In some embodiments, as illustrated in FIGS. 1A and 1B, the channels 30 form a single overall continuous channel. In other embodiments, as illustrated in FIGS. 2A and 2B, the channels 30 form a plurality of continuous, substantially unidirectional channels. Removably attached to the inner layer 22 or outer layer 24 or both layers 22 and 24 is an appropriate carbon dioxide scrubbing material 34 such as soda lime, etc. As shown in FIG. 6, the scrubbing material 34 is to be disposed on a separate backing material 36 (a so-called scrubbing material belt) so as to allow the scrubbing material 34 to be able to be quickly and easily removed and replaced when fully spent. In some embodiments, the scrubbing material is held in place by a compression sleeve 33, as shown in FIG. 11D, where the compression sleeve is operatively coupled to the inner layer 22, the outer layer, 24, and/or the separate backing material 36. The scrubbing material 34 removes carbon dioxide from air through a chemical process that produces a byproduct of energy in the form of heat. The chemical process of the activated scrubbing material causes the scrubbed, or treated, air to heat up to a temperature that is above a level that is safe for human inhalation. In some instances, the scrubbed air can be at or above 130 degrees Fahrenheit.

[0078] In some embodiments, a heat absorbing phase change material 35 may be positioned within at least a portion of the internal cavity 26. As used herein, a phase change material 35 is a substance with a high heat of fusion which, melting at a certain temperature, is capable of storing large amounts of energy. The phase change material 35 may be in a solid state when near normal temperatures of an internal human body, but changes to a liquid state when the temperature around the phase change material 35 exceeds a certain threshold. By changing its state from solid to liquid, the phase change material 35 absorbs a larger amount of energy (and therefore heat) from its surrounding environment than the material would absorb if it remained in a single state (e.g., solid). In this manner, the phase change material 35 can be used to at least partially cool down the scrubbed air to a lower temperature. In some cases, the phase change material 35 can reduce the temperature of the scrubbed air to levels that are acceptable for human inhalation. However, in other embodiments, scrubbed air that is cooled by phase change material 35 is still too hot for human inhalation and other or additional techniques are required to cool the scrubbed air to an appropriate temperature. The phase change material 35 may be contained within one or more pouches, bags, pockets, sacks, or other containers that hold the phase change material 35 substantially in a certain position while allowing the phase change material 53 to change its phase from solid to liquid and liquid to solid.

[0079] As shown in FIG. 7, the phase change material 35 may be positioned, attached, etc., in the internal cavity 26 in a similar manner to the scrubbing material 34. Since the phase change material 35 is used to reduce the temperature of scrubbed air, the phase change material 35 is positioned alongside and/or further down the internal cavity 26 from the scrubbing material 34. For example, as the vest 12 is configured such that air flows from the outlet port

42, through the channel(s) 30 of the vest, and leaves the vest at the inlet port 44, the scrubbing material 34 may be positioned in the channel(s) at one or more points that are closer to the outlet port 42. The phase change material 35 may therefore be positioned between the scrubbing material 34 and the inlet port 44. In this embodiment, air that is exhaled by a user will enter the internal cavity of the vest 12 the outlet port 42, travel along a channel 30, be scrubbed of carbon dioxide by the scrubbing material 34, gain energy in the form of heat as a result of the scrubbing, then interact with phase change material 35 at a point further down the channel 30 from the scrubbing material 34, transfer at least a portion of the energy to the phase change material 35 (causing the phase change material 35 to melt), and continue through the channel 30 until the air reaches the inlet port 44.

[0080] Similarly, the phase change material 35 may be placed in the same area as the scrubbing material 34 within the internal cavity 26. For example, the scrubbing material 34 may be positioned along the outer layer 24 while the phase change material 35 is positioned opposite the scrubbing material 34 on the inner layer 22. In this embodiment, the phase change material 35 is positioned on the side of the vest 12 that is closest to the wearer's torso, providing insulation between the wearer and the hot scrubbing material 34. Of course, the phase change material 35 could be positioned on the outer layer 24 while the scrubbing material is positioned on the inner layer 22, or the phase change material 35 and the scrubbing material 34 could alternate which sides (e.g., inner layer 22 and outer layer 24) they are respectively attached to at different points along the channel 30.

[0081] An opening 38, such as the illustrated zipper (other candidates include cooperating hook and loop material, snaps, etc.,) is provided in order to have service access to the internal cavity 26—the opening 38 can be located at any appropriate location about the vest 12. An appropriate seal (not illustrated) is located beyond the opening 38 in order to maintain the air tightness of the internal cavity 26. Also disposed within the internal cavity 26 is a pair of oxygen compatible anti-collapse coils 40 that help maintain the internal cavity 26 in an "open" configuration when the rebreather device 10 is being used.

[0082] As seen a first or outlet port 42 is attached to the left portion 14 of the vest 12 and air flow communicates with the channel 30 at the channel 30's commencement point. A second or inlet port 44 is attached to the right portion 16 of the vest 12 and air flow communicates with the channel 30 at its termination point. An inlet hose 106 has a first end

106a operatively coupled to the inlet port 44 and a second end 106b operatively coupled to the mouthpiece 48. An outlet hose 108 has a first end 108a operatively coupled to the mouthpiece 48 and a second end 108b operatively coupled to the outlet port 42. In some embodiments, an inlet valve 52 is located between the second end 106b of the inlet hose 106 and the mouthpiece 48. Additionally, an outlet valve 50 may be located between the mouthpiece 48 and the first end 108a of the outlet hose 108. Is some embodiments, the inlet valve 52 is located within the inlet hose 106 or the mouthpiece 48. Similarly, in some embodiments, the outlet valve 50 is located within the outlet hose 108 or the mouthpiece 48.

[0083] A canister port 54 is provided and is fluid flow connected to a first canister 56 having a first valve 58 system thereon, via a first air hose 60. The first canister 56 may comprise oxygen or diluent therein.

[0084] As best seen in FIGS. 3-5, the first canister 56 may also be connected via a second air hose 62 to a control valve 64, advantageously located on the back portion 18, the control valve 64 fluid flow connecting the second hose 62 with the internal cavity 26. One or more oxygen sensors 66 are located on the back portion 18 within a pocket of the vest 12 and sense oxygen levels within the channel 30. The oxygen sensors 66 are electronically connected to a processing module 68 which module 68 is also connected to the control valve 64 for controlling operation of the control valve 64 based on the readings of the sensors 66. An appropriate display device 70 is connected to the processing module 68 in order to allow the user to monitor the status of the processing module 68. As also seen, a second canister port 72 may be provided and be fluid flow connected to a second canister 74 having a second valve 76 thereon, via a third air hose 78, the second canister 74 having oxygen or diluent therein. In a two canister configuration, typically the first canister 56 has oxygen therein while the second canister 74 has diluent therein.

[0085] As seen, the internal cavity 26 may be separated into two sections via a semi-rigid (sufficiently rigid to hold its shape, yet sufficiently flexible for vest 12 donning and doffing) divider 80 that extends essentially throughout the internal cavity 26 so that one section of the internal cavity 26 is located between the divider 80 and the inner layer 22 of the vest 12 and the other section is located between the divider 80 and the outer layer 24 of the vest 12. The scrubbing material 34 is disposed on both sides of the divider 80. In this configuration, the channel 30 is still a single continuous channel with its commencement point at the first outlet port 42 and its termination point at the inlet port 44, but now passes through both sections of the internal cavity 26. In this configuration, the air A passes across substantially more scrubbing material 34 allowing for longer dwell times with the scrubbing material 34 allowing more effective scrubbing of the air A as well as a longer life span between scrubbing material 34 change out.

[0086] Similarly to the single sectioned internal cavity 26 embodiment, the phase change material 35 may be disposed on both sides of the divider 80 at points of the channel that are between the scrubbing material 34 and the inlet port 44. Additionally and/or alternatively, the phase change material 35 may be placed in the same area as the scrubbing material 34 within the bi-sectioned internal cavity 26. For example, the scrubbing material 34 may be positioned in the center of the internal cavity 26, separators 82 may be placed between the scrubbing material 34 and the inner layer 22 and the outer layer 24 of the internal cavity 26, and phase change material 35 may be positioned alongside the inner layer 22 and/or the outer layer 24. In such embodiments, the phase change material 35 may quickly begin to absorb the heat byproduct of the chemical reaction from the scrubbing material 34 interacting with the exhaled air. As with the non-sectioned internal cavity 26 embodiments, the scrubbing material 34 and the phase change material 35 may be positioned along any combination of the inner layer 22, the outer layer 24, and either side of the divider 80.

[0087] In this dual section configuration, the vest 12 is maintained in the "open" position by a series of separators 82 that are attached to the inner layer 22 of the vest 12 as well as the outer layer 24 of the vest 12. The separators 82 are made from an appropriate resilient material such as a flexible non-reactive plastic. When the rebreather device 10 is not being used, the vest 12 may be held flat, that is the outer layer 24 and the inner layer 22 are pressed tight together which causes the separators 82 to flatten out thereby maintaining the vest 12 is a very flat and compact configuration that is easily stored and transported. The vest 12 may be held in this very flat configuration via an appropriate mechanical means or may be stored under at least partial vacuum to so maintain the vest 12. When the vest 12 is ready for use, either release of the vest 12 from its mechanical or vacuum hold allows the separators 82 to resiliently spring back to their original V-shape or introduction of air A into the internal cavity 26 achieves the result, thereby filling the vest 12 out. In this configuration, the separators 82 act as valves or flow restrictors for the air A passing thereby. This creates turbulence within the channel 30 which increases the interaction time between the air A and the scrubbing material 34 so as to achieve greater efficiency in air scrubbing. As also seen, a series of mounting ribs 84 may be provided and have mounting studs 86 thereon to hold auxiliary equipment E as desired.

[0088] As seen in FIGS. 9-10B, an alternate method of separating the layers of the internal cavity 26 uses a divider 80′ that has a series of spacer ribs 88 of any appropriate configuration (see FIGS. 10A and 10B) on either side, either formed as part of the divider 80′ or attached thereto. In this configuration, once a belt of scrubbing material 34 is attached to or positioned upon the spacer ribs 88, a spacer 90 may be placed on the scrubbing material 34, such spacer 90 being a fiber air filter type of material, with a second belt of scrubbing material 34 placed onto the spacer 90 in order to further increase the amount of scrubbing material 34 within the internal cavity 26.

[0089] If water should enter the internal cavity 26 in any fashion, then either a desiccant (not illustrated) can be disposed within the internal cavity 26 or one or more dump/over-pressure valves 92 can be located on the vest 12 at substantially the lowest point on the vest 12 in order to dispel any water entrained within the internal cavity 26.

[0090] In order to use the rebreather device 10 of the present invention, the channel 30 is populated with the scrubbing material 34 while a fresh first canister 56 is attached to the first hose 60 and second hose 62 if so configured, and a fresh second canister 74 is attached to the third hose 78. In some embodiments, the channel 30 is also populated with the phase change material 35. The user dons the vest 12 is the typical way and places the mouthpiece 48 into his or her mouth. The user breathes in normal fashion in the same manner as with other rebreathers. As the person exhales, the exhaled air A is passed through the mouthpiece 48 and enters the outlet port 42 via the hose 46, the second inlet valve 52 preventing the air A from flowing toward the inlet port 44. The air enters the channel 30 within the vest 12 and travels the length of the channel 30 through the front left portion 14, through the back portion 18, and into the front right portion 16. While within the channel 30, the air A is scrubbed of carbon dioxide via the scrubbing material 34 in the usual way. As described above, the process of scrubbing the air A of carbon dioxide creates a byproduct of energy in the form of heat. In embodiments of the vest 12 that include phase change material 35, the air A continues down the channel 30 and interacts with the phase change material 35, whereby the phase change material 35 absorbs at least a portion of the heat energy from the scrubbed air A. Once the air A has reached the end of the channel 30, the air A enters the inlet hose 106, scrubbed of carbon dioxide, via the inlet port 44, and is breathed in by the user. During breath intake in, the user cannot draw air A from the outlet port 42 due to the first outlet valve 50. By having the relatively heavy scrubbing material 34, and possibly phase change material 35, distributed about the vest 12, both front and back, the overall weight distribution of the rebreather device 10 for the wearer is relatively well distributed and helps the user maintain balance as humans work exceedingly well whenever a load is essentially evenly placed on the user's torso. Additionally, both counter-lungs are at torso level making breathing more natural and less labored so as to reduce user fatigue during device 10 usage. Variations employ constant flow oxygen or gas mixture injection as in a semi-closed set plus conventional demand regulator gas delivery during high work output. The constant flow plus demand regulation system allows for positive pressure masks on the wearer. Land based use in contaminated atmospheres is greatly enhanced by this feature. When needed, oxygen, either pure or via a diluent, can be manually replenished into the channel 30 via the first canister 56 simply by opening the valve 58 thereon and letting the oxygen or diluent flow into the channel 30 via the canister port 54 or via the second canister 74 by opening the second valve 76 and letting the oxygen or diluent flow into the channel via the second canister port 72. Alternately, if the rebreather device 10 is electronically equipped, then oxygen or diluent is introduced into the channel 30 automatically via the control valve 64 via the readings of the oxygen sensors 66 and under the control of the processing module 68. Of course the automatic replenishment system can be manually overridden if the user so desires. When the scrubbing material 34 is fully spent, the scrubbing material 34 may be removed and replenished via the opening 38 provided.

[0091] Referring to FIGS. 11A through 11D, cutout views of the rebreather vest 12 are provided, in accordance with embodiments of the invention. FIG. 11A illustrates an unwrapped view of the rear of the vest 12, with a cutout to illustrate one embodiment of the internal cavity 26 that comprises scrubbing material 34 and phase change material 35. As shown, the air A, after being exhaled by the user, may enter the vest 12 from the outlet hose 108 then travel from the left front portion 14 through the back portion 18 and then the front right portion 16 before exiting the vest 12 through the inlet hose 106. The air A will then enter the internal cavity 26 of the vest 12. In some embodiments, one or more channels 30 are included to guide the flow of air A through the internal cavity 26. The air A may interact with the scrubbing material 34, initiating the chemical reaction that scrubs the air A of carbon dioxide and releases energy as heat into the air A. As the air continues through the internal cavity 26, packets of phase change material 35 absorb a portion of the heat from the air A as they change state from a solid to a liquid. As described above, the phase change material 35 absorbs more heat energy from the air A in the process of changing from a solid to a liquid than simply remaining in its same state. The air A then progresses out of the vest 12 through the inlet hose 106, on the way to the mouthpiece 48 where the heat sink material 105 can absorb additional heat from the air A before a user inhales the air A. In some embodiments, additional oxygen or diluent can be added to the air A through the canister port 54.

[0092] FIG. 11B illustrates a frontal view of the rebreathing device 10 with cutout sections that show the internal cavity 26 of the vest 12. Likewise, FIG, 11c illustrates a rear view of the vest 12 with a cutout section across the back portion 18 that shows one possible placement of scrubbing material 34 and pouches of phase change material 35 in the internal cavity 26 of the vest 12.

[0093] FIG. 11D illustrates an unwrapped view of the rear of the vest 12, with a cutout to illustrate one embodiment of the internal cavity 26 that comprises scrubbing material 34 and phase change material 35. A cross-section B-B is also provided, illustrating one configuration of the scrubbing material 34, wherein the scrubbing material is held within a compression sleeve 33 that is operatively coupled to the inner layer 22, the outer layer, 24, and/or the separate backing material 36. FIG. 11D also shows one possible configuration of the scrubbing material 34 and the phase change material 35 within the internal channel, where the air A flows across alternating sections of phase change material 35 and scrubbing material 34. The canister 56 is also included in FIG. 11D to illustrate how additional oxygen or diluent may be introduced to the internal cavity 26 of the vest 12 to maintain a desired level of oxygen or other gas in the air A. The canister port 54 is shown to be providing oxygen or diluent to the vest 12 after the air A has been scrubbed, but the canister port 54 could be positioned at any point of the vest 12 that permits access to the internal cavity 26.

[0094] Referring to FIGS. 12-14, illustrations of some embodiments of a mouthpiece apparatus 100 for use in conjunction with the rebreather vest are provided. FIG. 12A illustrates an exploded view of the mouthpiece apparatus 100. The core of the mouthpiece apparatus 100 includes a mouthpiece body 102, a mouthpiece connector 103, and a mouthpiece interface 104. The mouthpiece interface 104 can be any type of device that can be engaged by the mouth of a user such that the user may breathe air in and out of the device. The mouthpiece interface 104 may be made out of a soft plastic, a hard plastic, a soft rubber, a hard rubber, aluminum, another metallic material, or any combination of the foregoing. The mouthpiece interface 104 may comprise bite tabs 104a that allow a user to clench the mouthpiece interface 104 in place, and a bite flange 104b that may press up against the lips and face of the user to block external air from entering the user's mouth or the rebreathing system. As such, the user may secure the mouthpiece interface 104 to the user's mouth and only breathe air in from, and exhale air through, the mouthpiece interface 104.

[0095] The mouthpiece interface 104 is connected to the mouthpiece body 102 via the mouthpiece connector 103. The mouthpiece connector may be comprised of a soft plastic, a hard plastic, a soft rubber, a hard rubber, aluminum, another metallic material, or any combination of the foregoing. In some embodiments, the mouthpiece connector 103 and the mouthpiece interface 104 comprise a single piece. Similarly, in some embodiments, the mouthpiece body 102, the mouthpiece connector 103, and the mouthpiece interface 104 comprise a single piece.

[0096] The mouthpiece body 102 is a junction point in the mouthpiece apparatus 100 in that air from the inlet hose 106 enters the mouthpiece body 102, can travel up to the mouthpiece interface 104, return to the mouthpiece body 102 from the mouthpiece interface 104, and exit back into the vest system through the outlet hose 108. The mouthpiece body 102 may be made out of aluminum, a hard plastic, a different metallic material, or a combination of the foregoing.

[0097] The heat sink material 105 shown in FIG. 12A is positioned within the mouthpiece body 102 in the non-exploded configuration of the mouthpiece apparatus 100. The heat sink material 105 may be an aluminum mesh, a copper mesh, another metallic mesh, a metallic wool, metallic filaments, or other metallic material configured in such a way that air may pass through the heat sink material 105 and interact with a relatively large surface area of the heat sink material 105.

[0098] An inlet connector 110 is operatively coupled to the mouthpiece body 102 and the second end 106b of the inlet hose 106. Likewise, an outlet connector 112 is operatively coupled to the mouthpiece body 102 and the first end 108a of the outlet hose 108. The inlet and outlet connectors 110, 112 securely fasten the mouthpiece apparatus 100 to the inlet hose 106 and outlet hose 108 of the rebreathing vest 12, thereby completing the loop of the self-contained rebreather device 10. In some embodiments, the inlet connector 110, the outlet connector 112, and the mouthpiece body 102 may be a single piece. In such embodiments, the heat sink material 105 may be inserted within the mouthpiece body 102 at the time of manufacture, may be inserted through the opening where the mouthpiece connector 103 is secured to the mouthpiece body 102, or may be inserted through the inlet connector 110 or the outlet connector 112.

[0099] The outlet valve 50 may be positioned within the mouthpiece body 102, between the mouthpiece body 102 and the outlet connector 112, within the outlet connector 112, or within the outlet hose 108. The outlet valve 50 is configured such that the air pressure changes of either side of the outlet valve 50, caused by the inhalation and exhalation of air by the user, substantially prevents air from passing through the outlet valve 50 as the user inhales but allows air to pass through the outlet valve 50 and enter the outlet hose 108 when the user exhales. Likewise, the inlet valve 52 may be positioned within the mouthpiece body 102, between the mouthpiece body 102 and the inlet connector 110, within the inlet connector 110, or within the inlet hose 106. The inlet valve 52 is configured such that the air pressure changes of either side of the inlet valve 52, caused by the inhalation and exhalation of air by the user, substantially prevents air from passing through the inlet valve 52 as the user exhales but allows air to pass through the inlet valve 52 and enter the mouthpiece body 102 as the user inhales.

[00100] A nose clamp device 114 may be included in the mouthpiece apparatus 100. In some embodiments, the nose clamp device 114 is attached to the rest of the mouthpiece apparatus 100 via a nose clamp cable 118. In such embodiments, the nose clamp device 114 may remain tied to the rest of the mouthpiece apparatus 100 when not in use, or when a user removes the nose clamp device 114. The nose clamp device 114 may also be a separate device that is not connected to the rest of the mouthpiece apparatus 100. The user may secure the nose clamp device on the external sides of the user's nose, such that air cannot enter or leave the user's nose. As such, the user will only breathe in air from the mouthpiece apparatus 100 and exhale air only into the mouthpiece apparatus 100.

[0100] A mouthpiece plug 116 may also be provided with the mouthpiece apparatus 100. The mouthpiece plug 116 may comprise a mouthpiece plug end 116a and a mouthpiece plug handle 116b. The mouthpiece plug end 116a may be inserted within the air opening in the mouthpiece interface 104 such that the mouthpiece plug prevents air from entering or exiting the mouthpiece apparatus 100 when the mouthpiece apparatus 100 is not in use. The user may remove the mouthpiece plug 116 by pulling on the mouthpiece plug handle 116b before engaging the mouthpiece interface 104 to use the mouthpiece apparatus 100. A mouthpiece plug cable 120 may be operatively coupled to the mouthpiece plug 116 and a portion of the mouthpiece apparatus 100 such that the mouthpiece plug can be suspended from the mouthpiece apparatus 100 while the mouthpiece apparatus 100 is in use, while being easily accessible in the event the user wishes to re-plug the mouthpiece interface 104.

[0101] FIG. 12B is a side view of one embodiment of the mouthpiece apparatus 100 in its closed, operational configuration. Again, the heat sink material 105 (not shown) is positioned within the mouthpiece body 102, such that air coming in from the inlet hose 106 passes through the heat sink material 105 on the way to the mouthpiece interface 104 and the user.

[0102] FIGS. 13A through 13C illustrate top views of the mouthpiece apparatus 100. FIG. 13A illustrates a top view of the mouthpiece apparatus 100 where the mouthpiece interface 104 and the mouthpiece connector 103 are removed. The heat sink material 105 is visible through the aperture in the mouthpiece body. FIG. 13B illustrates a top view of the mouthpiece apparatus 100 that includes the mouthpiece interface 104. The heat sink material 105 is visible through the aperture in the mouthpiece body. Finally, FIG. 13C illustrates a top view of the mouthpiece apparatus 100 that includes the mouthpiece interface 104 and the mouthpiece plug 116 inserted within the aperture of the mouthpiece interface 104, thus blocking air from entering or exiting the mouthpiece apparatus 100.

[0103] In some embodiments, a separator (not shown) or the mouthpiece connector 103 separate the mouthpiece interface 104 from the mouthpiece body 102. The separator or mouthpiece connector 103 may be made from a different material than the mouthpiece body 102 and/or the mouthpiece interface 104. This different material may have very low heat transfer properties, such that the mouthpiece body 102 does not transfer a large amount of heat through the mouthpiece connector 103 or separator, and ultimately to the mouthpiece interface

104. The heat blocking properties of the mouthpiece connector 103 or the separator are especially beneficial in embodiments where the heat sink material 105 transfers a large amount of heat to the walls 102a of the mouthpiece body 102 because this heat will be transferred to the ambient environment from the mouthpiece body 102 instead of to the mouthpiece interface 104 which could burn the user.

[0104] FIG. 14 is a cross-sectional view of a portion of the mouthpiece apparatus 100 showing the heat sink material 105 positioned within the mouthpiece body 102. As described above, the heat sink material 105 may be an aluminum mesh, a copper mesh, another metallic mesh, a metallic wool, metallic filaments, or other highly conductive metallic material configured in such a way that air may pass through the heat sink material 105 and interact with a relatively large surface area of the heat sink material 105. In some embodiments, the heat sink material 105 is in a cylindrical configuration and abuts and/or is operatively coupled to at least a portion of the inner wall 102a of the mouthpiece body 102.

[0105] The high conductivity of the heat sink material 105 allows the heat sink material 105 to absorb heat from the scrubbed air as it enters the mouthpiece body 102 on the way to the mouthpiece interface 104. As described above, the chemical process of scrubbing the air causes the air to be heated up significantly to a temperature that is too high for human inhalation. As such, the scrubbed air must be cooled to a manageable temperature. As the hot, scrubbed air enters the mouthpiece body, at least a portion of the heat is transferred to the (initially cooler) heat sink material 105. As the heat sink material is in contact with the inner wall 102a of the mouthpiece body 102, the heat absorbed by the heat sink material 105 is transferred to the wall of the mouthpiece body 102, and further transferred to a cooler ambient (external) environment. Because the heat energy of the scrubbed air is transferred to the heat sink material 105 and ultimately the ambient environment, the temperature of the scrubbed air is reduced to a manageable temperature for human inhalation by the time the scrubbed air reaches the mouthpiece interface 104.

[0106] Increasing conductive ability of the heat sink material 105 and/or the material makeup of the mouthpiece body 102 (e.g., by changing the material to a more conductive material) increases the amount of heat energy that the heat sink material 105 is able to absorb from the scrubbed air, thereby making the scrubbed air more comfortable for inhalation by the user. Similarly, increasing the contact surface area between the heat sink material 105 and the mouthpiece body 102, increases the amount of heat energy absorbed from the scrubbed air that can be transferred out of the mouthpiece apparatus, thereby making the scrubbed air more comfortable for inhalation by the user.

[0107] In some embodiments, the mouthpiece body 102 and the heat sink material 105 comprise the same material (e.g., aluminum, copper, and other conductive metallic materials). In some embodiments, at least a portion of the heat sink material 105 is integrated with the mouthpiece body 102 such that the heat sink material 105 remains in contact with the wall 102a if the mouthpiece body 102, thus aiding the transfer of heat energy from the heat sink material 105 to the mouthpiece body 102 and ultimately to the ambient environment. In some embodiments, the heat sink material 105 and the mouthpiece body 102 comprise a single piece of a conductive metal. For example, the mouthpiece body 102 may comprise an outer channel for the passage of air and for connecting with the inlet connector 110, the outlet connector 112, and the mouthpiece connector 103, while including a metallic mesh throughout the center of the mouthpiece body 102 that the scrubbed air must pass through to reach the mouthpiece interface 104.

[0108] The overall rebreathing device 10 operates in a cyclical manner, one embodiment of which will now be summarized. Once the user has engaged the mouthpiece interface 104, the user may exhale air that contains carbon dioxide into the mouthpiece interface 104. The exhaled air travels through the mouthpiece body 102, is blocked by the inlet valve 52, and therefore passes through the outlet valve 50 and into the outlet hose 108. The outlet hose 108 carries the exhaled air to the outlet port 42 of the vest 12, where the exhaled air enters a channel 30 comprising an internal cavity 26. As the air travels along the channel 30, it interacts with scrubbing material 34 attached to the channel 30 that scrubs carbon dioxide from the exhaled air, but produces a significant amount of energy in the form of heat as a byproduct of the scrubbing chemical reaction. Therefore the scrubbed air is too hot to inhale by a human. During and/or after the air is scrubbed, the air may interact with heat absorbing phase change material 35 which absorbs at least a portion of the heat from the scrubbed air as the phase change material 35 melts. The scrubbed air then continues along the channel towards the inlet port 44. Prior to reaching the inlet port 44, additional oxygen or a diluent may be added to the air via a canister port to maintain a desired air composition within the rebreathing device 10. Once the scrubbed air reaches the inlet port 44, the scrubbed air enters the inlet hose 106 as a result of directional air pressure caused by inhalation by the user. The scrubbed air, still being too hot for human inhalation, then passes through the inlet valve 52, and interacts with the heat sink material 105 inside the mouthpiece body 102. Heat energy from the scrubbed air transfers to the heat sink material 105, is transferred to the internal wall 102b of the mouthpiece body 102, and dissipates into the ambient environment, thereby cooling the scrubbed air to a manageable temperature for human inhalation. As the outlet valve is closed during inhalation, the cooled, scrubbed air is directed upwards through the mouthpiece interface 104 and is inhaled by the user. This air then interacts with the lungs of the user, where oxygen enters the user's blood stream and carbon dioxide is pushed into the air system. The user then exhales this carbon dioxide-containing air back through the mouthpiece interface 104 and the cycle of the rebreathing device 10 continues.

[0109] Without scrubbing the carbon dioxide out of the exhaled air, the user would, over time, begin to breathe in air with higher concentrations of carbon dioxide, which can be harmful and deadly to a human. However, simply scrubbing the air of carbon dioxide is not enough to provide a safe rebreathing system for the user because the scrubbed air is so hot that it would burn the user upon inhalation. Therefore, the heat sink material 105, and/or, in some embodiments, the phase change material 35 are important features for absorbing the heat from the scrubbed air in the rebreathing device 10.

[0110] When the phase change material 35 and the heat sink material 105 are used in conjunction, the rebreather device 10 can provide a desired air composition to a user for a sustained period of time at a temperature that is more comfortable for inhalation than using either the heat sink material 105 or the phase change material 35 alone.

[0111] FIGS. 15A and 15B illustrate embodiments of the breathing device 10 in a configuration of being worn by a user. The canister 56 may be held in place by a canister pouch 61 operatively coupled to the side of the vest 12 such that the canister 56 does not hang from the canister port 54 by the first air hose 60. Additionally, the use of the canister pouch 61 does not require the user to hold and/or carry the canister. The first air hose 60 connects the first valve 58 of the air canister 56 to a regulator 1602 operatively coupled to the canister port 54 of the vest 12. The regulator 1602 may be manually utilized to provide oxygen or diluent to the internal cavity 26 of the vest 12. In some embodiments, the regulator 1602 has one or more automatic components and sensors such that the sensors may determine when an air pressure or air composition level is below a certain threshold and the automatic component automatically releases oxygen or diluent into the internal cavity without user intervention.

[0112] In some embodiments of the invention, a strap 107 is included on the vest. The strap 107 may be operatively coupled to the back portion 18, and the shoulder areas of the left portion 14 and the right portion 16 of the vest 12. The strap 107 covers the inlet hose 106, the outlet hose 108, and the mouthpiece 48 when the rebreather device 10 is not in use, protecting these components from damage and contamination. As shown in FIGS. 15A and 15B, the mouthpiece 48 may be positioned at the back portion 18 of the vest 12 when not engaged, such that the inlet hose 106 and the outlet hose 108 rest over the shoulder areas of the vest. To engage the mouthpiece 48, the user may release the strap 107 at the shoulder areas of the left portion 14 and right portion 16 of the vest 12, allowing the strap 107 to hang downwards from the back portion 18 of the vest, and revealing the inlet hose 106, the outlet hose 108, and the mouthpiece 48. The user may then lift the inlet hose 106, the outlet hose 108, and the mouthpiece 48 over the user's head, bringing the mouthpiece to the front of the user's body to where the mouthpiece interface 104 can be engaged by the user's mouth.

[0113] FIG. 16A illustrates an exploded view of a regulator 1602 to show the internal components. The regulator 1602 comprises a regulator body 1604, a diaphragm 1606, a retaining ring 1608, a thrust washer 1610, and a purge cover 1612. In some embodiments, the purge cover 1612 may be depressed by a user to cause the regulator 1602 to transfer oxygen or a diluent from the first air hose 60, through the regulator 1602, and to the internal cavity of the vest 12 via the canister port 54. The regulator 1602 also comprises an inlet fitting 1614, an adjustable orifice 1616, a first O-ring 1618, a second O-ring 1620 that is larger than the first O-ring 1618, a poppet 1622, a seat 1624, and a spring 1626. The inlet fitting 1614 may be operatively coupled to the first air hose, creating an air-tight seal that allows air to be transferred from the first air hose 60, through the regulator 1602, and subsequently into the internal cavity 26 of the vest 12. Finally, the regulator 1602 may also comprise a lever support 1628, a lever 1630, a spacer 1632, and a locknut 1634.

[0114] FIG. 16B illustrates an embodiment of the regulator 1602 in its combined, operational configuration. The regulator body 1604 can be attached to the canister port 54 if the vest 12. The retaining ring 1608 secures the purge cover 1612 to the regulator body 1604, allowing the purge cover 1612 to be depressed and released by a user without losing its general orientation. The inlet fitting 1614 is operatively coupled to the regulator body 1604, and the first air hose 60, such that oxygen, either pure or via a diluent may flow through the first air hose 60, enter the regulator 1602 via the inlet fitting 1614, and pass through the bottom of the regulator body 1604 to enter the internal cavity 26 of the vest 12 at the canister port 54. In some embodiments, the regulator 1602 passes the oxygen into the internal cavity 26 in response to the user depressing the purge cover 1612. The regulator 1602 can be used to supplement and/or increase the amount of oxygen concentration of the air A in the internal cavity 26 of the vest 12, such that the user can breathe in a constant or near constant mixture of air A.

[0115] FIG. 17 and FIG. 20 illustrate another embodiment of the rebreather device 10 that comprises an upper torso wearing device similar to the structure of a horse collar, the device defining at least one internal channel for the air flow. FIG. 17 illustrates a frontal view of the rebreather device 1700 and FIG. 20 illustrates a rear view of the rebreather device 1700. The rebreather device 1700 as shown in FIG. 17 has an outer closure edge and an inner closure edge. As illustrated in FIG.17, the rebreather device 1700 has a perimeter edge extending along the perimeter of the device, wherein the perimeter edge includes the outer closure edge and inner closure edge. The perimeter edge includes the front portion 1743 and back portion 1745. The front portion 1743 may be sub classified into a first portion 1747, a second portion 1748 and a third portion 1749. The second portion 1748 is opposite to the first portion 1747 and operatively coupled with the first portion 1747 by the third portion 1749. The outer closure edge defines the outer circumference of the device. The inner closure edge defines the neck receiving opening and the inner circumference of the device.

[0116] The rebreather device 1700 has an outlet port 42 in the first portion 1747 and an inlet port 44 in the second portion 1748 for receiving the air exhaled and transferring the air for inhalation respectively. A mouthpiece 1760 is present to inhale and exhale the air. Mouthpiece 1760 comprises an interface with an oral nasal cup 2130 (as shown in FIG. 23) coupled to a mouthpiece valve assembly 1750 with an elbow to T-bit hose 1770 and oral nasal elbow 1780. The mouthpiece valve assembly 1750 controls the process of inhalation and exhalation and also reduces dead space. Attached to the outlet port 42 there is an outlet hose 108 connecting the mouthpiece valve assembly 1750 and outlet port 42. An inlet hose 106 is attached to the inlet port 44 connecting the mouthpiece valve assembly 1750 and the inlet port 44. The outlet hose 108 has a first end 108a operatively coupled to the mouthpiece valve assembly 1750 and a second end 108b operatively coupled to the outlet port 42. The inlet hose 106 has first end 106a operatively coupled to the inlet port 44 and a second end 106b operatively coupled to the mouthpiece valve assembly 1750. In some embodiments, the mouthpiece valve assembly 1750 may include an inlet valve 52. In some other embodiments, an additional inlet valve 52 may be present between the second end 106b of the inlet hose 106 and the mouthpiece valve assembly 1750. Additionally, the mouthpiece valve assembly 1750 may include an outlet valve 50. In some other embodiments, an additional outlet valve 50 may be located between the mouthpiece valve assembly 1750 and the first end 108a of the outlet hose 108. In some embodiments, the inlet valve 52 is located within the inlet hose 106 or the mouthpiece valve assembly 1750. Similarly, in some embodiments, the outlet valve 50 is located within the outlet hose 108 or the mouthpiece valve assembly 1750.

[0117] The rebreather device 1700 has an inner layer 22 in contact with the body of the user and an outer layer 24 exposed to the surrounding atmosphere. The inner layer 22 may be made from synthetic polymers such as thermoplastics or thermosets or elastomers or synthetic fibers or the like. In one embodiment, the inner layer 22 may be made from Nylon. In another embodiment, the inner layer 22 may be made from Neoprene. The outer layer 24 may be made from synthetic polymers such as thermoplastics or thermosets or elastomers or synthetic fibers or the like. In one embodiment, the outer layer may be made from Nylon. In another embodiment, the outer layer 24 may be made from Neoprene. In yet another embodiment, the outer layer 24 may be made from heat-sealable polyurethane. The internal cavity 26 or internal channel present through the third portion 1749 located between the inner layer 22 and outer layer 24 provides a passage for the air flowing from the outlet port 42 to the inlet port 44. An appropriate carbon dioxide scrubbing material 34 such as soda lime and the like is placed in the internal cavity 26 (as illustrated in FIG. 20) attached to the inner layer 22 and outer layer 24. The scrubbing material 34 removes carbon dioxide from air exhaled into the outlet port through a chemical process that produces water and energy in the form of heat as by-products of the chemical reaction. The chemical process of the activated scrubbing material causes the scrubbed, or treated, air to heat up to a temperature that is above a level that is safe for human inhalation. The heat from the scrubbed air is exchanged with the atmosphere through the outer layer material, outlet hose 108 and inlet hose 106. Water produced as a by-product of the chemical reaction may support heat dissipation. The outer layer material, inlet hose, outlet hose, and water support heat exchange with the atmosphere cooling down the scrubbed air and making it suitable for human inhalation. In some embodiments, the water produced as a by-product of chemical reaction may convert into steam as a result of heat. In some embodiments, a desiccant (not illustrated) or one or more valves (not illustrated) may be present to dispel any water trapped within the internal cavity 26. In some embodiments, another layer of material (not illustrated) may be present outside or inside the inner layer to prevent heat from escaping into the atmosphere through the inner layer. In some embodiments, the rebreather device 1700 may include passages for the air flow.

[0118] The rebreather device 1700 also has a canister 56 present at the inlet port 44 comprising a demand regulator 1602, a pressure gauge 1710, an ON/OFF valve 58, a fill port 1715, a frangible disc 1720, and a pressure regulator 1725. A low pressure oxygen hose 1705 connects the canister 56 and the demand regulator 1602 (e.g., a regulator valve) to supply oxygen from the canister 56 to the device 1700. The canister 56 may comprise oxygen either in a pure form or via a diluent. In some embodiments, the canister may be a composite over wrapped pressure vessel containing one hundred and one (101) liters of medical grade oxygen weighing one-point-four (1.4) pounds. In some other embodiments, the canister may contain more or less than one-hundred and one (101) liters of oxygen and may weigh more or less than one-point-four (1.4) pounds. The canister 56 is provided with a pressure gauge 1710 to indicate pressure. In some embodiments, the pressure gauge 1710 may read three thousand (3000) PSI when charged. In some other embodiments, the pressure gauge may read more or less than three thousand (3000) PSI when charged. In some embodiments, the pressure gauge is visible during use. An ON/OFF valve 58 is present to activate the system and to turn on and off the flow of oxygen from the canister 56 to the device 1700. In some embodiments, the ON/OFF valve may be used to deactivate the system and may permit oxygen conservation. A fill port 1715 may be present to refill the oxygen or diluent in the canister 56. The canister may also be provided with a frangible disc 1720 for safety relief. In some embodiments, the frangible disc 1720 may relieve the pressure of the canister at five thousand (5000) P.S.I. In some other embodiments, the frangible disc 1720 may relieve the pressure of the canister at more or less than five thousand (5000) P.S.I. The frangible disc 1720 may prevent the pressure from rising above a predetermined maximum, preventing the rupture of a charged canister. The canister 56 is provided with a pressure regulator 1725 to regulate the pressure of the canister 56 and to match the flow of oxygen or diluent through the pressure regulator 1725 to the demand of oxygen or diluent placed on the canister 56. In some embodiments, the pressure regulator 1725 may reduce the pressure of the canister 56 to forty plus or minus five (40 +/- 5) P.S.I. A low pressure oxygen hose 1705, delivers the oxygen or diluent released with the help of pressure regulator 1725 to the device 1700 when the ON/OFF valve is in ON position. In some embodiments, the low pressure oxygen hose may allow a maximum pressure of two hundred and fifty (250) P.S.I through it.

[0119] In some embodiments, the rebreather device 1700 has one or more oxygen sensors 66 to automatically release the oxygen or diluent form the canister 56. The one or more sensors 66 are electronically connected to a processing module 68 and a control valve 64. The processing module 68 controls the operation of the control valve 64 based on the readings of the sensors 66. An appropriate display device 70 is connected to the processing module 68 in order to allow the user to monitor the status of the processing module 68.

[0120] The configuration of rebreather device 1700 has a front left portion also referred to as an exhalation chamber 1730, acts as a first counter-lung and a front right portion also referred to as an inhalation chamber 1740, acts as a second counter-lung to make breathing more natural and less labored so as to reduce user fatigue during the usage of the device 1700. During the process of exhalation, the first and second counter lungs inflate and during the process of inhalation, the first and second counter-lungs inflate. Typically, a normal human breathes zero-point-four (0.4) liters to five and a half ($5\frac{1}{2}$) liters. The first and second counter lung are provided to support the lung volume of a normal human to support breathing. In some embodiments, the total volume of the device 1700 is six and a half ($6\frac{1}{2}$) liters. For example, the device 1700 is configured to receive six and a half ($6\frac{1}{2}$) liters of air which is higher than the value of air exhaled and inhaled by a normal human. In some other embodiments, the total volume of the device may be less than or greater than six and a half ($6\frac{1}{2}$) liters.

[0121] The air A flows from the mouthpiece 1760 during the process of exhalation, through the outlet valve 50 into the outlet hose 108. The warm air exhaled by the human is cooled by the outlet hose 108 to an extent and is delivered into the device 1700 through the outlet port 42. The air A enters the first counter-lung or the exhalation chamber 1730 and then flows through the internal cavity 26 containing the scrubbing material 34. The carbon dioxide from the air A is removed through a chemical process by the scrubbing material 34 releasing heat as a by-product. The outer layer allows the exchange of heat with the atmosphere allowing the hot scrubbed air to cool down. Second counter-lung or the inhalation chamber 1740 receives the scrubbed air allowing it to flow into the inlet hose 106 through inlet port 44. The process of cooling the air by exchanging the heat into the atmosphere continues until the air reaches the mouthpiece 1760 for inhalation. By having only the scrubbing material 34, the weight of the rebreather device is greatly reduced making the breathing more natural and less labored so as to reduce user fatigue during the usage of the rebreather device 1700. When needed, oxygen, either pure or via a diluent, may be manually replenished into the inhalation chamber 1740 through the low pressure oxygen hose 1705 and demand regulator 1602 by opening the ON/OFF valve 58. Alternately, if the rebreather device 1700 is electronically equipped, the oxygen or diluent is introduced into the inhalation chamber 1740 automatically via the control valve 64 via the readings of the oxygen sensors 66 and under the control of the processing module 68. Of course the automatic replenishment system can be manually overridden if the user so desires. In some embodiments, the rebreather device 1700 may include one or more canisters.

[0122] In some embodiments, when a normal human exhales air, the exhalation chamber receives the exhaled air and may push half the volume of exhaled air into the internal cavity 26 containing the scrubbing material 34. For example, if the human exhales 6 liters of air, the exhalation chamber acting as a first counter lung accumulates 3 liters of the exhaled air and pushes the other 3 liters of the exhaled air into the internal cavity 26. In alternate embodiments, when a normal human exhales air, the exhalation chamber receives the exhaled air and may push more or less than half the volume of exhaled air into the internal cavity 26 containing the scrubbing material 34.

[0123] The rebreather device 1700, exchanges the heat with the atmosphere through the outer layer, inlet hose 106, and outlet hose 108 and does not include any phase change material for heat exchange thereby reducing the weight of the rebreather device. In some embodiments, the weight of the rebreather device may be thirteen (13) lbs. In alternate embodiments, the weight of the rebreather device may be more or less than thirteen (13) lbs. In some embodiments, the rebreather device 1700, is a one-time use device as the rebreather device may not support replacing the scrubbing material 34 and/or replenishing oxygen in the canister

56. In some other embodiments, the rebreather device 1700, is not a one-time use device as the rebreather device may support replacement of the scrubbing material 34 and/or replenishing oxygen in the canister 56. In some embodiments, the rebreather device 1700 lasts for one fifty (150) minutes. In some other embodiments, the rebreather device 1700 may be used for more or less than one fifty (150) minutes. The rebreather device 1700 may be primarily used for escape from hazardous atmosphere and may act as a respirator.

[0124] FIG. 18 illustrates another embodiment of the rebreather device 10 that comprises a human-upper-torso-searing configured device similar to the structure of a horse collar as disclosed in FIG. 17 and a mouthpiece 1810. The mouthpiece 1810 illustrated in this embodiment may comprise a hood 1820 to cover the head of the user and may be made of plastic or any other see through material. In some embodiments, the hood 1820, covers the head and face of the user. In some other embodiments, the hood 1820, covers the head and face of the user excluding eyes. In such an embodiment, the user may wear safety glasses and the hood 1820 can be made of any material such as rubber or the like, which may not be a see through material. In some embodiments, the mouthpiece 1810 may also include a heat sink material 105. The mouthpiece 1810 may comprise all the features of the mouthpiece 1760 illustrated in another embodiment of the present invention. The mouthpiece 1810 may also include all the features of the mouthpiece 48 or all the features of the mouthpiece interface or a combination of features of all mouthpieces described in the present invention.

[0125] FIG. 19 illustrates another embodiment of the rebreather device 10 that comprises a human-upper-torso-searing configured device similar to the structure of a horse collar as disclosed in FIG. 17 and a mouthpiece interface. In this embodiment, the mouthpiece interface may comprise a mouthpiece interface 104 connected to the mouthpiece body 102 via the mouthpiece connector 103 as illustrated in FIG. 12A. The mouthpiece connector may be comprised of a soft plastic, a hard plastic, a soft rubber, a hard rubber, aluminum, another metallic material, or any combination of the foregoing. In some embodiments, the mouthpiece connector 103 and the mouthpiece interface 104 comprise a single piece. Similarly, in some embodiments, the mouthpiece body 102, the mouthpiece connector 103, and the mouthpiece interface 104 comprise a single piece. The mouthpiece body 102 is a junction point in the mouthpiece apparatus 100 in that air from the inlet hose 106 enters the mouthpiece body 102, can travel up to the mouthpiece interface 104, return to the mouthpiece body 102 from the mouthpiece interface 104, and exit back into the device system through the outlet hose 108. The mouthpiece body 102 may be made out of aluminum, a hard plastic, a different metallic material, or a combination of the foregoing. The mouthpiece interface may include a heat sink material 105.

[0126] FIG. 21 through 26 illustrate different views of the mouthpiece 1760 shown in FIG. 17. FIG. 21 illustrates side view of the mouthpiece donned by the user 2110. FIG. 22 illustrates a top view of the mouthpiece with the oral nasal head harness 2120 positioned above the mouthpiece 1760 for ease of viewing the mouthpiece 1760. The mouthpiece 1760 may comprise an oral nasal cup 2130, and a oral nasal head harness 2120. The oral nasal cup 2130 receives the exhaled air by the human and also the scrubbed air for inhalation from the inlet hose 106. FIG. 23 illustrates the exploded rear view of the oral nasal cup 2130. The oral nasal cup 2130 may be made of soft plastic, hard plastic, hard rubber, soft rubber, or the like. In some embodiments, the oral nasal cup 2130 may be made with a combination of the materials. FIG. 24 illustrates the mouthpiece 1760 donned by the user 2110 by fastening a oral nasal head harness 2120 around the head. The oral nasal head harness 2120 secures the oral nasal cup by creating a seal. FIG. 25 and FIG. 26 illustrate the side views of the mouthpiece 1760 comprising the oral nasal cup 2130 and oral nasal head harness 2120. The oral nasal head harness 2120 may include an adjustor 2510 as shown in FIG. 25 and FIG.26 making the mouthpiece 1760 adaptable to fit all sizes. The adjustor 2510 may be a slide adjustor or the like. In some embodiments, the adjustor 2510 may include a strap. In some embodiments, a heat sink material 105 may be present within the mouthpiece 1760.

[0127] FIG. 27 illustrates an exploded view of assembly of the rebreather device 1700. The exploded view of assembly illustrates exploded view of canister assembly, hose and valve assembly, and scrubber material assembly. As illustrated of the scrubber material assembly, the scrubbing material 34 may be placed into casings 2710. In some embodiments, the casings may be made of aluminum or any metallic material or plastic or rubber or the like. In some embodiments, the casing 2710 may serve as a means for heat dissipation. In some embodiments, the rebreather device 1700 may include a waist strap 2720 operatively coupled to the inner layer 22 to prevent the rebreather device 1700 from dangling. In some embodiments, the waist strap 2720 may hold the canister 56.

[0128] In some embodiments, the rebreather device 1700 may be used in mines or escape from hazardous environments or the like. The rebreather device 1700, may allow communication during escape from hazardous environments or the like. In some embodiments, the rebreather device 1700 may have an operational duration of two-point-five (2.5) hours. In some other embodiments, the rebreather device 1700 may have an operational duration of more than or less than two-point-five (2.5) hours. In some embodiments, the rebreather device 1700 may have seven-point-five (7.5) hours of at-rest duration. In some other embodiments, the rebreather device 1700 may have more than or less than seven-point-five (7.5) hours of at-rest duration. In some embodiments, the rebreather device 1700 may take less than thirty (30) seconds to operate. In some embodiments, the rebreather device 1700 may have ten (10) years of shelf life. In alternate embodiments, the rebreather device 1700 may have more than or less than ten (10) years of shelf life. In some embodiments, the rebreather device 1700 may be stored at a temperature from minus thirty (-30) to one forty (140) degrees Fahrenheit. In alternate embodiments, the storage temperature of the rebreather device 1700 may be more than or less than minus thirty (-30) to one forty (140) degrees Fahrenheit.

[0129] While certain exemplary embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative of and not restrictive on the broad invention, and that this invention not be limited to the specific constructions and arrangements shown and described, since various other changes, combinations, omissions, modifications and substitutions, in addition to those set forth in the above paragraphs, are possible. Those skilled in the art will appreciate that various adaptations and modifications of the just described embodiments can be configured without departing from the scope and spirit of the invention. Therefore, it is to be understood that, within the scope of the appended claims, the invention may be practiced other than as specifically described herein.

WHAT IS CLAIMED IS:

1. A horse-collar-shaped rebreathing apparatus for removing carbon dioxide from air exhaled from a user resulting in heated air and cooling the heated air, the apparatus comprising:

a first portion and a second portion opposite the first portion and operatively coupled with the first portion by a third portion;

an outer layer configured to be exposed to atmosphere and an inner layer configured to be in contact with a user, the outer layer and the inner layer together defining an internal channel extending through the third portion and operatively coupling the first portion and the second portion,

wherein the internal channel comprises an exhalation chamber, a carbon dioxide scrubbing material and an inhalation chamber;

an outlet port disposed on the first portion;

an inlet port disposed on the second portion;

an inlet hose comprising a first end and a second end, wherein the first end of the inlet hose is configured for operatively coupling to the inlet port;

an outlet hose comprising a first end and a second end, wherein the second end of the outlet hose is configured for operatively coupling to the outlet port;

a mouthpiece valve assembly configured for operatively coupling to the second end of the inlet hose and configured for operatively coupling to the first end of the outlet hose; and

a mouthpiece interface configured for operatively coupling to the mouthpiece valve assembly and further configured for veiling a face of the user;

wherein:

the apparatus is configured to receive air at a first temperature exhaled from the user,

the air enters the outlet hose which delivers the air through the exhalation chamber to the scrubbing material and to the inhalation chamber,

the scrubbing material is configured for chemically reacting with the air to remove carbon dioxide, creating scrubbed air and thereby raising a temperature of the air from the first temperature to a second temperature, the apparatus is configured to cool the air to a third temperature by dissipating heat from the scrubbed air through the outer layer to the atmosphere,

the apparatus is configured to deliver the cooled air from the inhalation chamber to the mouthpiece interface by the inlet hose, and

the mouthpiece interface is configured for delivering the cooled air to the user for inhalation.

2. The apparatus of claim 1, wherein the mouthpiece interface configured for operatively coupling to the mouthpiece valve assembly by an elbow to T-bit hose and an oral-nasal elbow.

3. The apparatus of claim 1, wherein the apparatus is configured so that the air exhaled from the user enters the mouthpiece interface and is transferred to the mouthpiece valve assembly, the mouthpiece valve assembly configured to function as a heat sink by the oral nasal elbow and the elbow to T-bit hose, wherein the air passes through the mouthpiece valve assembly and enters the outlet hose.

4. The apparatus of claim 1, wherein the outer layer and the inner layer are made from a same material.

5. The apparatus of claim 4, wherein the outer layer and the inner layer comprise aluminum.

6. The apparatus of claim 1, wherein the outer layer and the inner layer are made from different material.

7. The apparatus of claim 1, wherein the scrubbing material is disposed in the internal channel enclosed in a casing.

8. The apparatus of claim 1, wherein the mouthpiece interface comprises an oral nasal cup.

9. The apparatus of claim 8, wherein the oral nasal cup is configured to be secured to a head of the user with an oral nasal head harness.

10. The apparatus of claim 9, wherein the oral nasal head harness further comprises an adjustable strap.

11. The apparatus of claim 1, wherein a second layer is present inside the inner layer to prevent the heat from dissipating through the inner layer.

12. The apparatus of claim 1, wherein a second layer is present outside the inner layer to prevent the heat from dissipating through the inner layer.

13. The apparatus of claim 1, wherein the apparatus further comprises a demand regulator and a low pressure oxygen hose configured to attach a canister to the apparatus.

14. The apparatus of claim 13, wherein the low pressure oxygen hose injects oxygen into the inhalation chamber of the internal channel at a rate proportional to an amount of oxygen that leaves the apparatus through absorption in lungs of the user.

15. The apparatus of claim 13 further comprises a waist strap holding the canister to secure the apparatus to a body of the user.

16. The apparatus of claim 1, wherein the heat from the scrubbed air is dissipated into the atmosphere through the inlet hose, the outlet hose and the outer layer.

17. The apparatus of claim 1, wherein the third temperature is cooler than the first temperature by two (2) to three (3) degrees.

18. An apparatus for cooling air prior to inhalation by a user, the apparatus comprising:
an outer layer configured to be exposed to an ambient environment;
an inlet hose configured to connect an inlet port and a mouthpiece valve assembly;
an outlet hose configured to connect an outlet port and the mouthpiece valve assembly;
a heat sink material located within the mouthpiece valve assembly;

wherein:

the air at a first temperature exhaled into a mouthpiece interface by a user enters the mouthpiece valve assembly,

the air exhaled by the user enters the outlet hose which delivers the exhaled air through an exhalation chamber to scrubbing material and to an inhalation chamber at a second temperature lower than the first temperature,

the scrubbing material is configured for chemically reacting with the air to remove carbon dioxide from the exhaled air thereby creating scrubbed air and raising the temperature of the scrubbed air to a third temperature higher than the first temperature and the second temperature,

the scrubbed air enters the inlet hose at a fourth temperature lower than the third temperature which delivers the cool scrubbed air at a fifth temperature lower than the fourth and the first temperature to the mouthpiece valve assembly.

19. The apparatus of claim 18, wherein the inlet hose comprises a first end and a second end, wherein the first end of the inlet hose is operatively coupled to the outlet port.

20. The apparatus of claim 19, wherein the mouthpiece valve assembly further comprises an inlet valve and an outlet valve.

21. The apparatus of claim 18, wherein the outlet hose comprises a first end and a second end, wherein the second end of the outlet hose is operatively coupled to the inlet port.

22. A mouthpiece interface apparatus for exhaling and inhaling air using a rebreathing apparatus, the apparatus comprising:

an oral nasal cup;

an oral nasal elbow;

an elbow to T-bit hose configured to be coupled to the oral nasal elbow and a mouthpiece valve assembly;

wherein the mouthpiece valve assembly further comprises an inlet valve, an outlet valve and a heat sink material;

wherein air exhaled by a user into the oral nasal cup is delivered to the outlet valve via the oral nasal elbow and the elbow to T-bit hose; and

wherein air for inhalation by the user is delivered into the oral nasal cup from the inlet valve via the oral nasal elbow and the elbow to T-bit hose.

23. The apparatus of claim 22, wherein the mouthpiece interface apparatus further comprises an oral nasal head harness configured to secure the oral nasal cup to a head of the user.

24. The apparatus of claim 23, wherein the oral nasal head harness is configured to seal the oral nasal cup to the user preventing external air from entering into the oral nasal cup.

25. The apparatus of claim 23, wherein the oral nasal head harness further comprises an adjustable strap.

26. A horse-collar-shaped rebreather apparatus comprising:

an outer closure edge defining an outer circumference of the apparatus;

an inner closure edge defining an inner circumference of the apparatus;

at least one internal channel configured to support air flow;

wherein the inner closure edge defines a neck receiving opening; wherein the outer closure edge and the inner closure edge define a front portion and a back portion of the apparatus; wherein the at least one internal channel is present in the front portion of the apparatus.

27. The apparatus of claim 26, wherein the front portion of the apparatus is larger than the back portion and comprises the at least one internal channel.

28. The apparatus of claim 26, wherein the back portion is configured to support the apparatus hanging from a neck of a user.

29. The apparatus of claim 26, wherein the back portion is configured to not support the air flow.

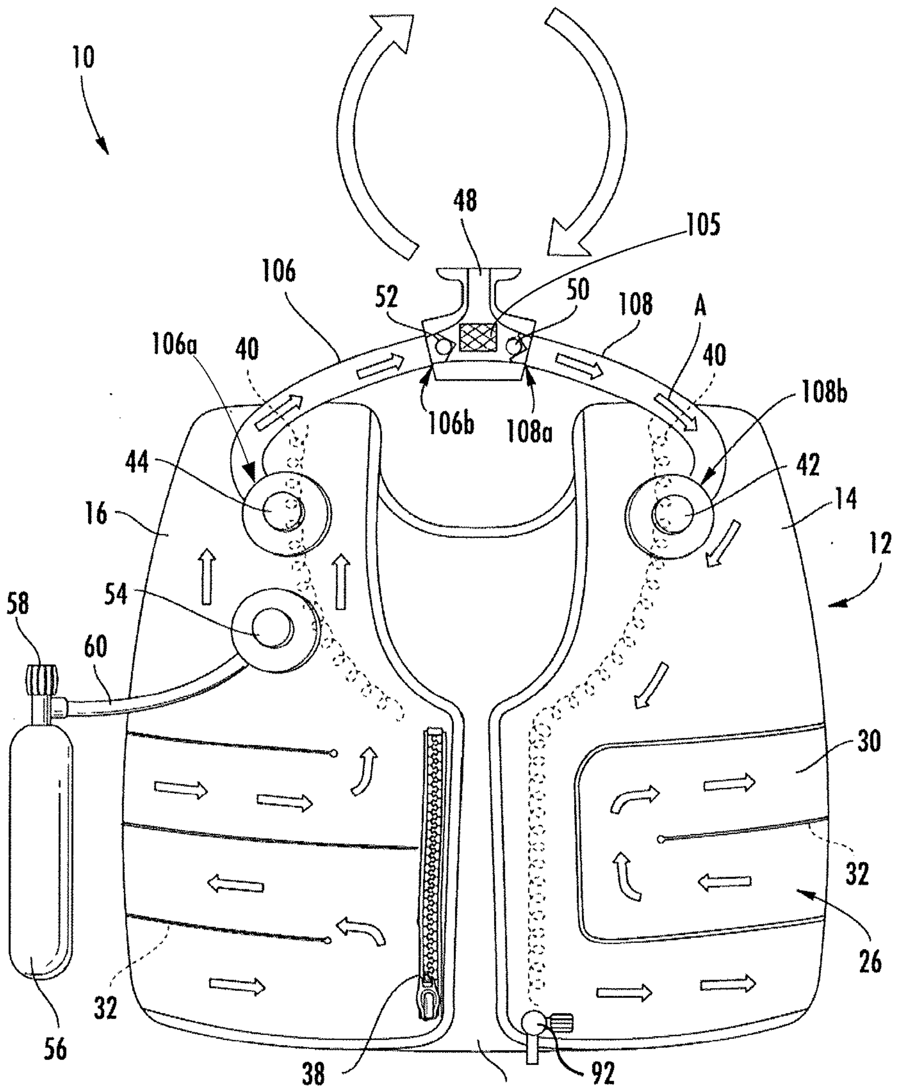
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Figure 1A

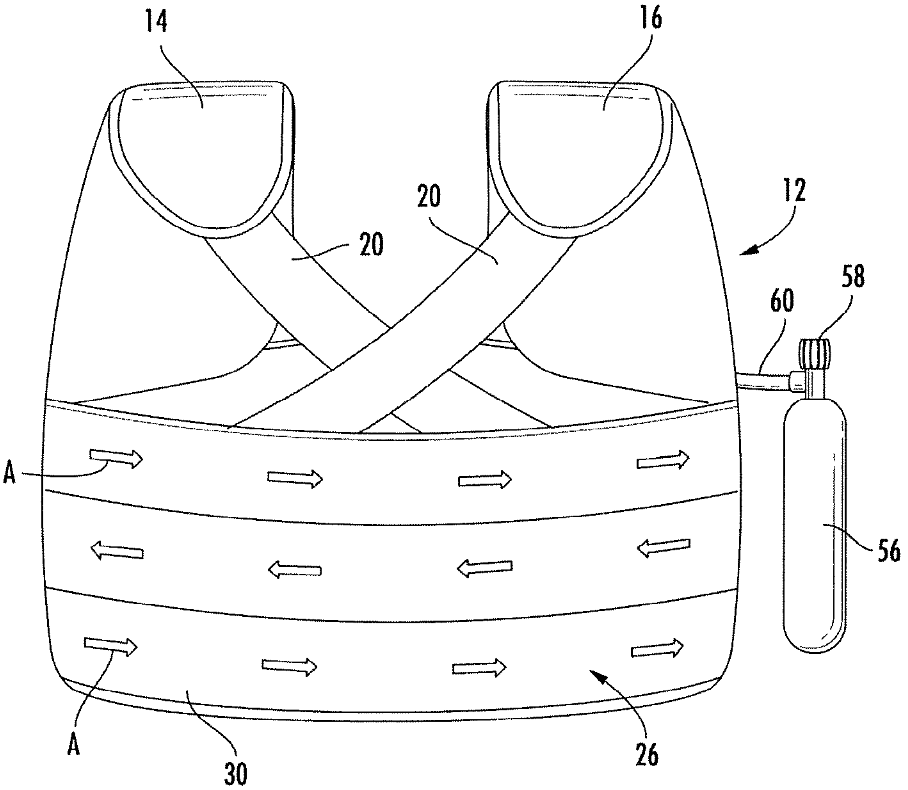

Figure 1B

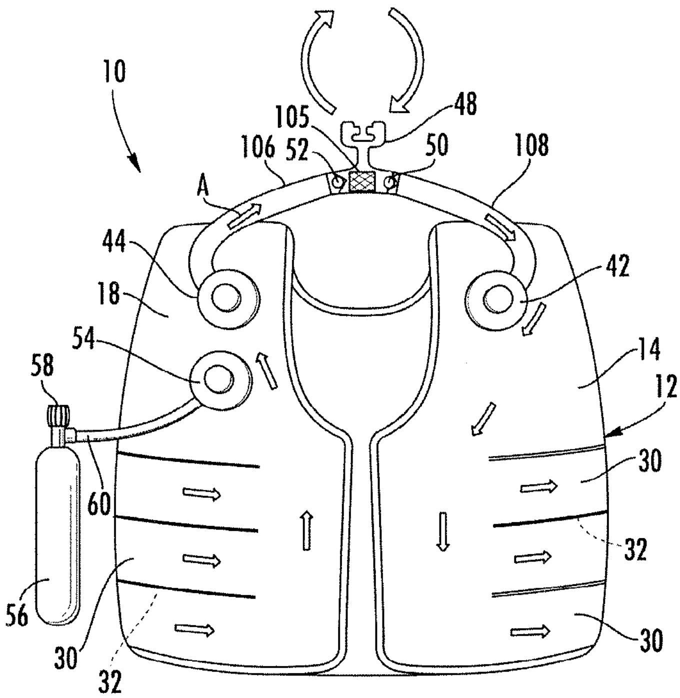

Figure 2A

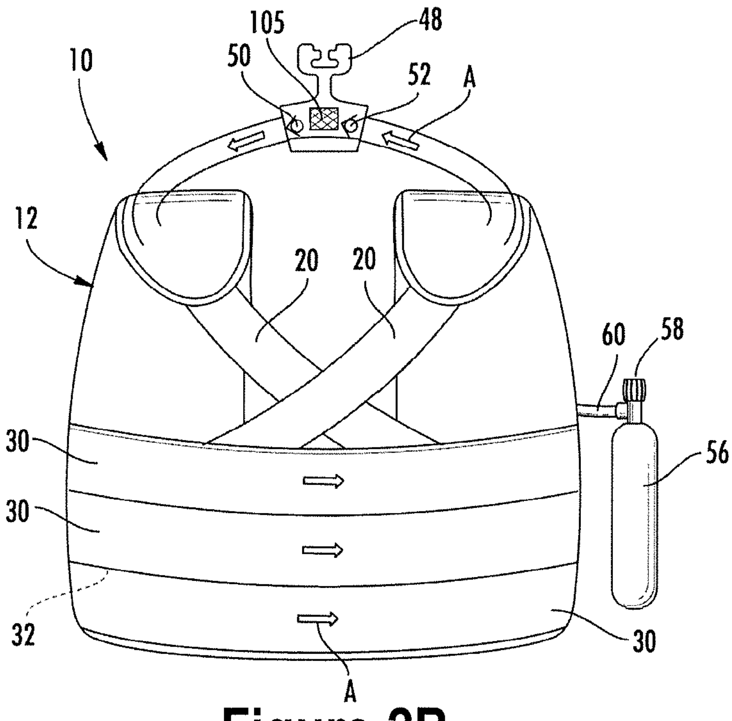

Figure 2B

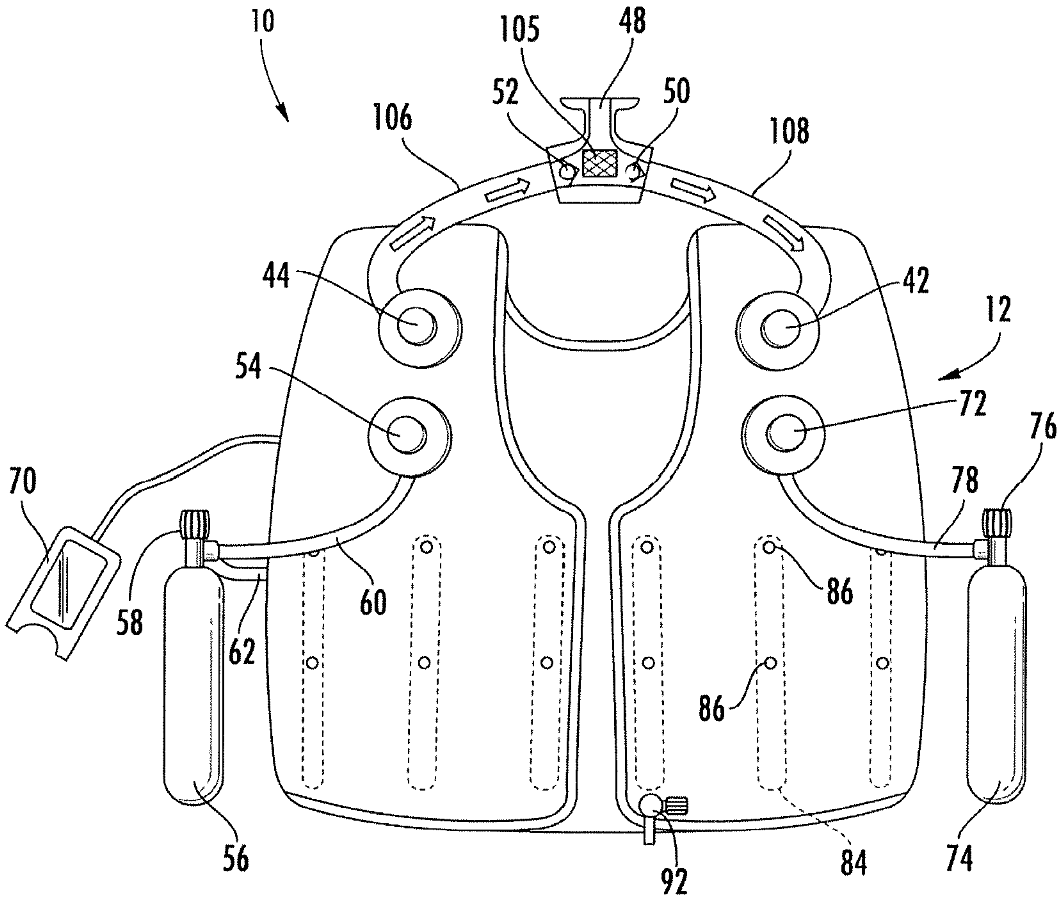
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Figure 3

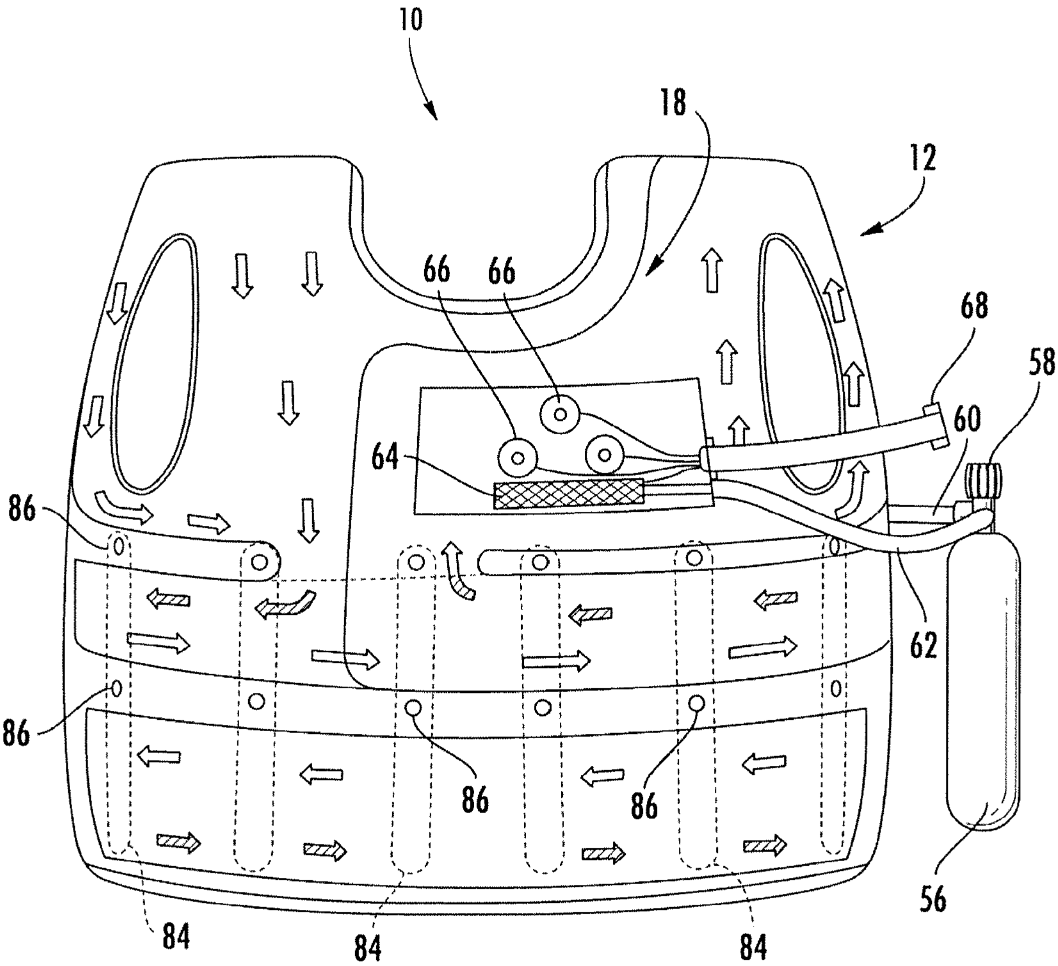

Figure 4

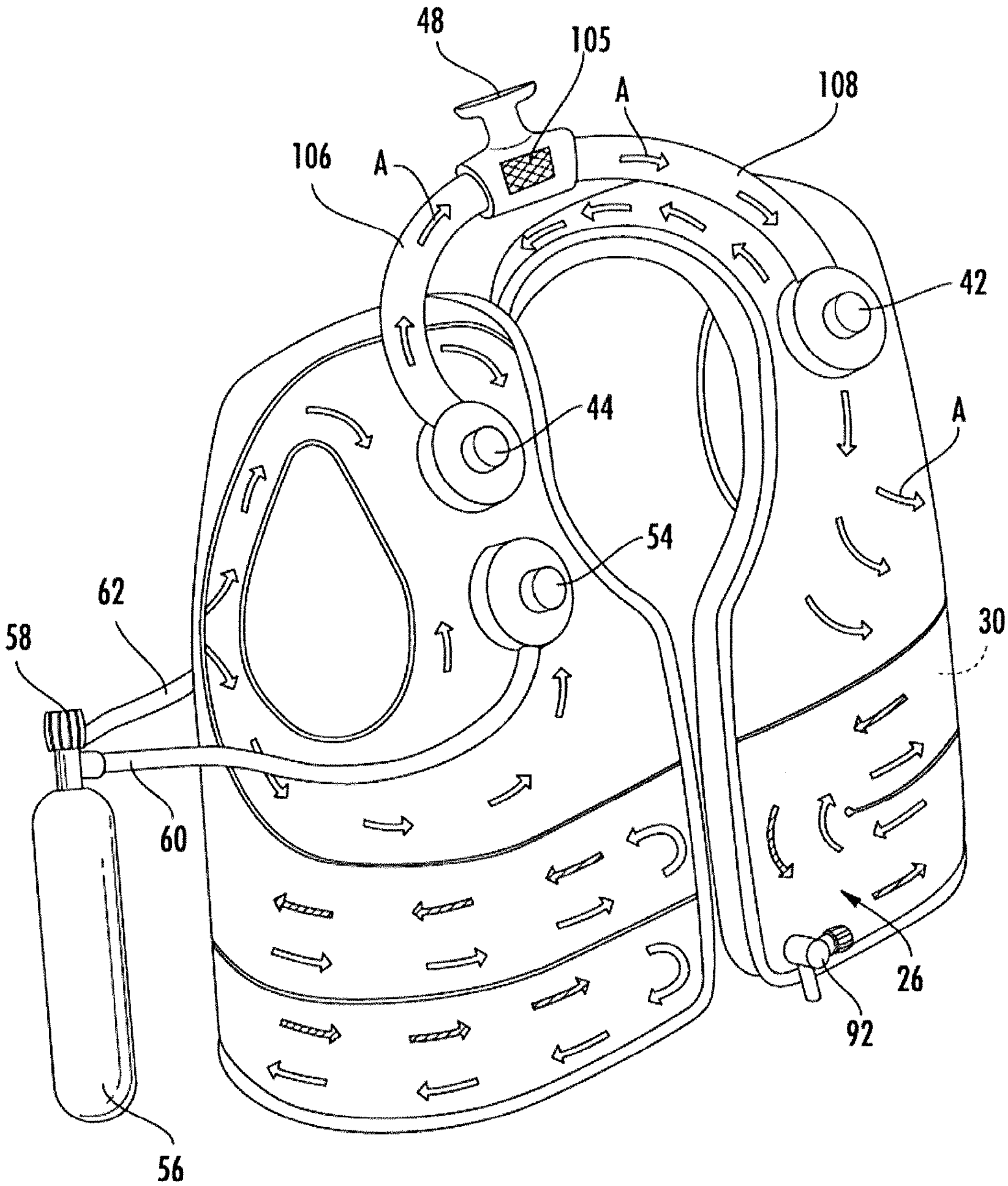

Figure 5

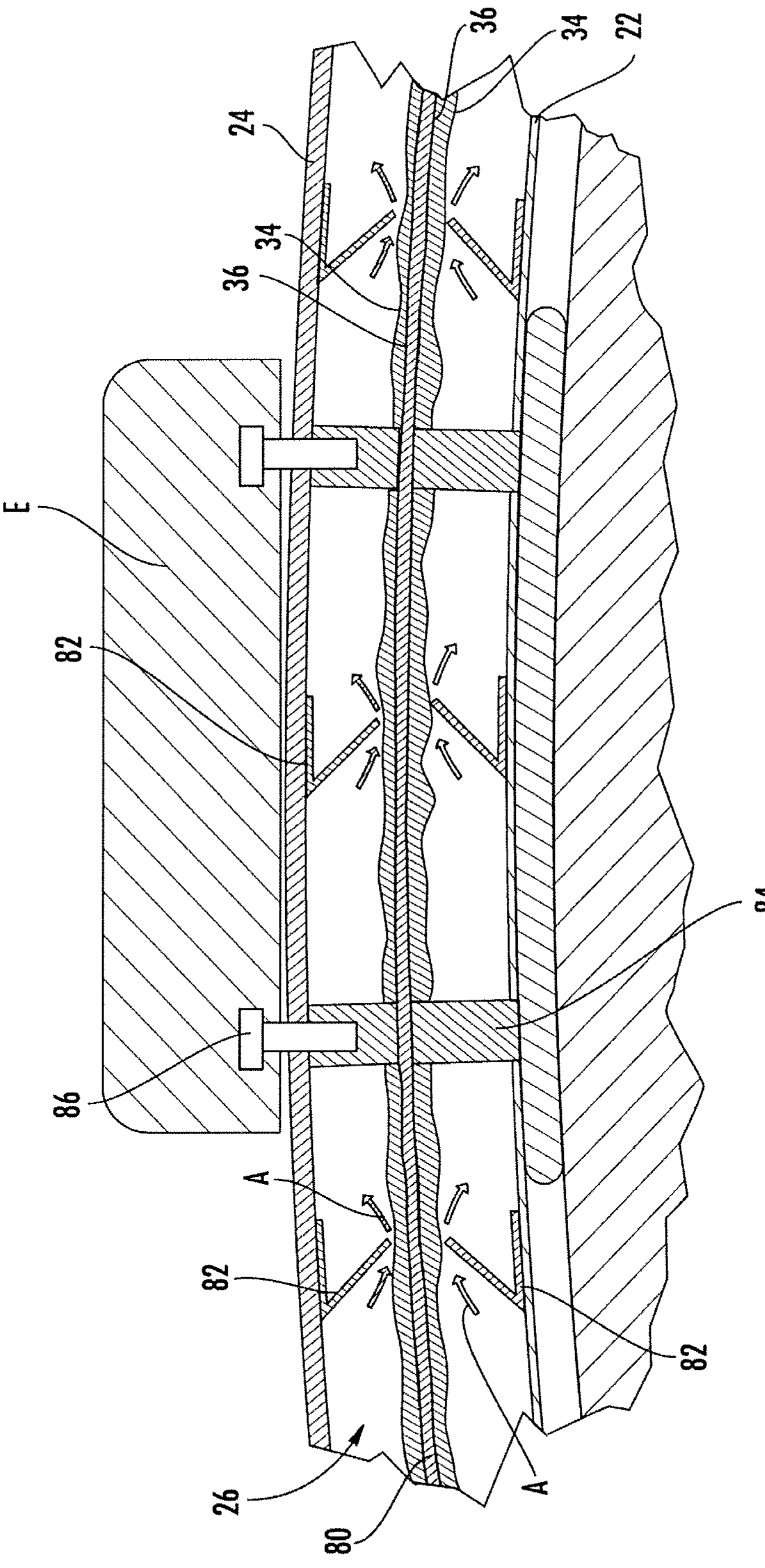

Figure 6

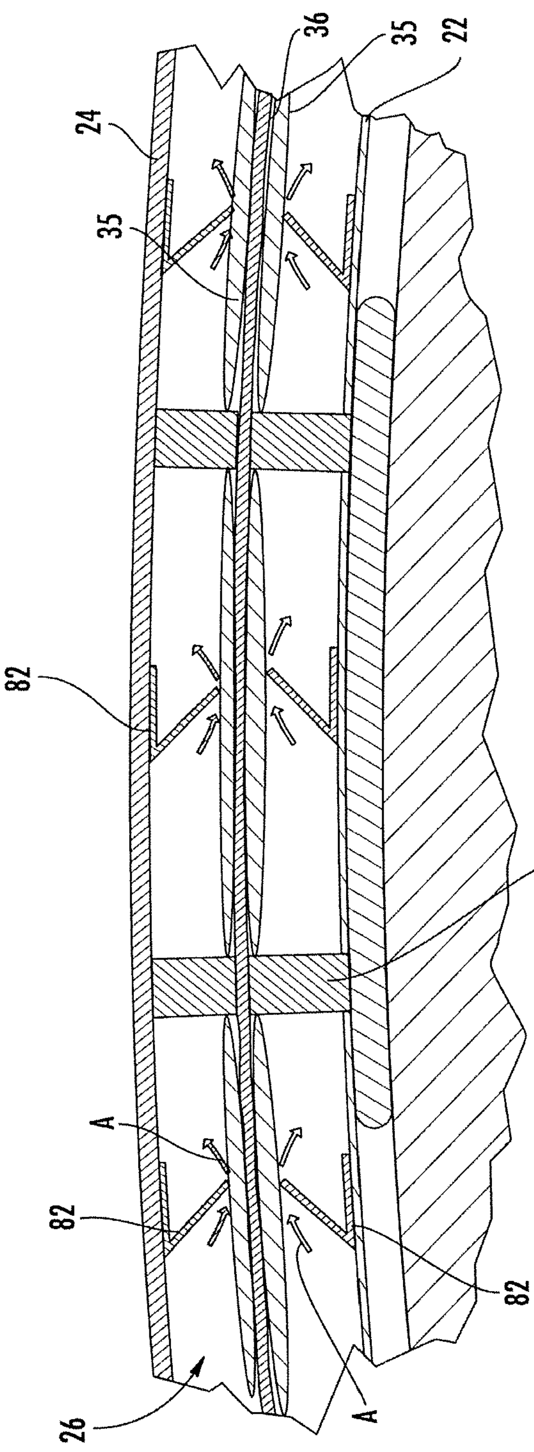

Figure 7

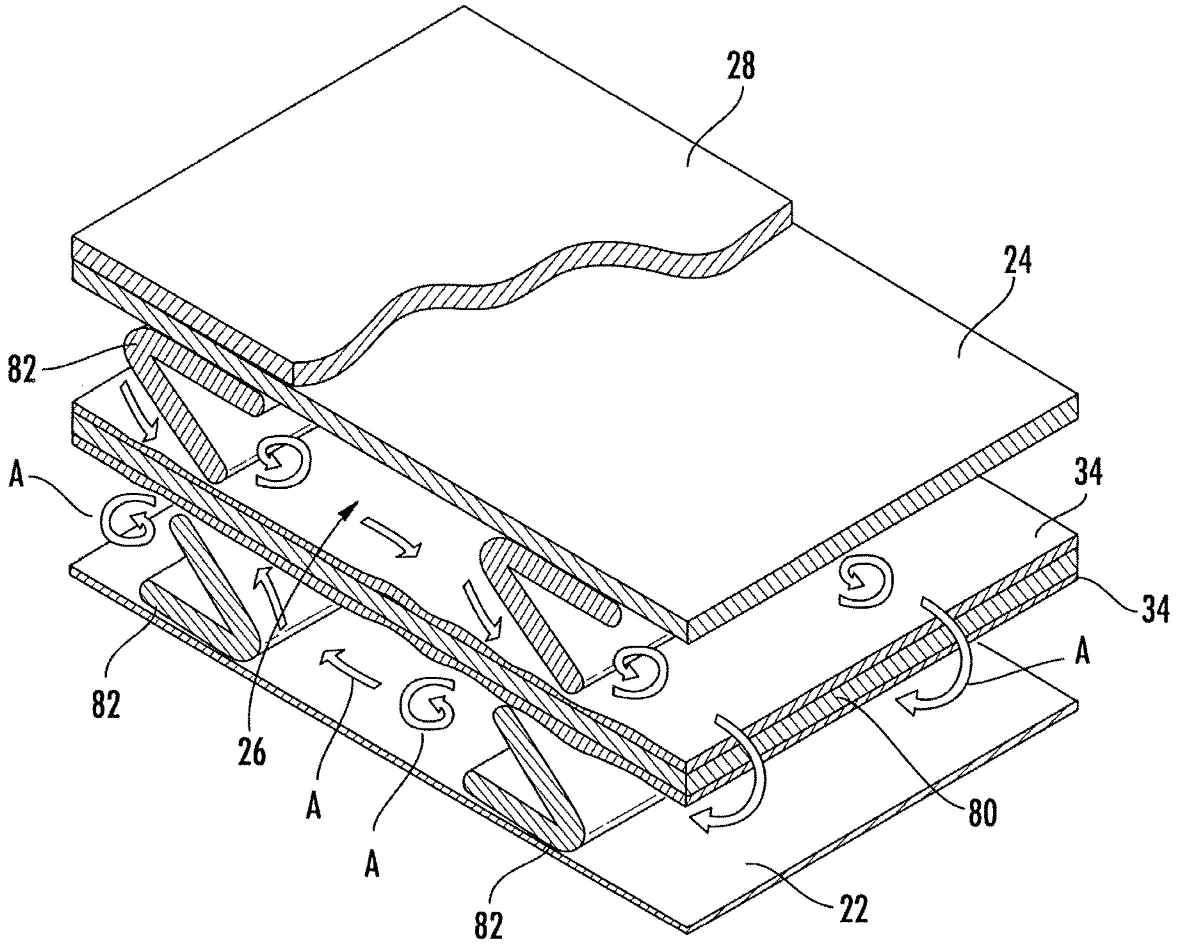

Figure 8

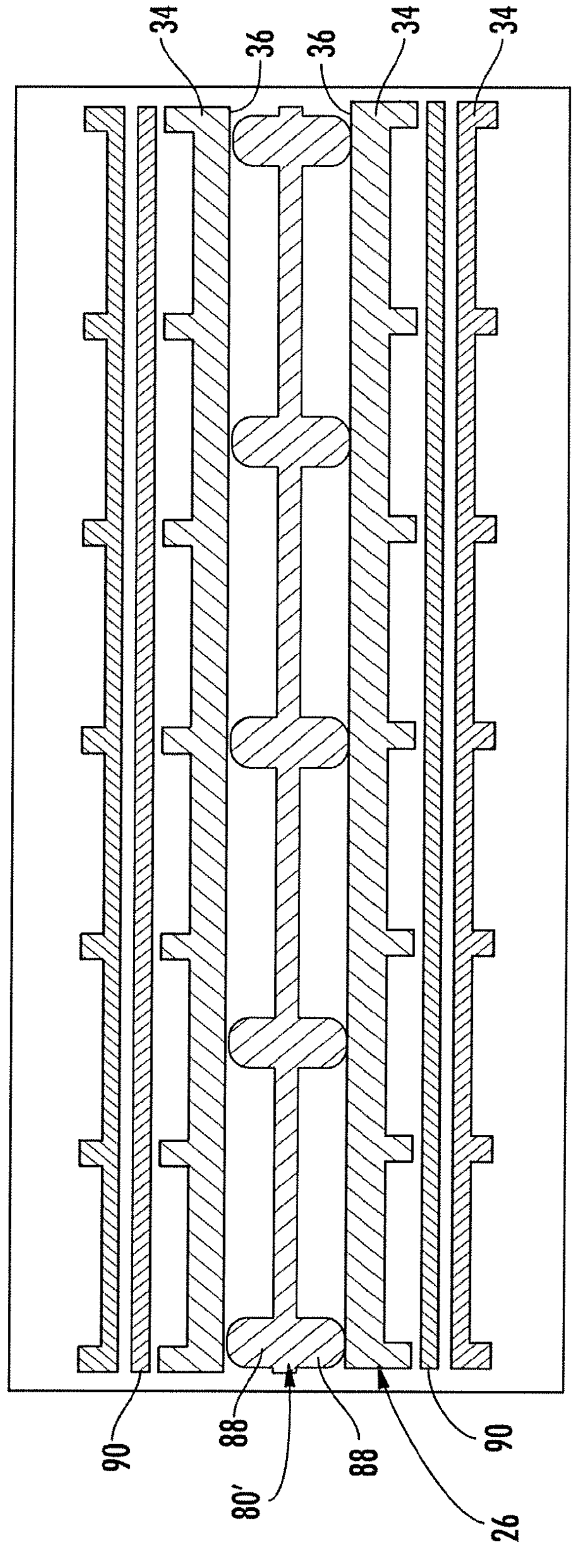

Figure 9

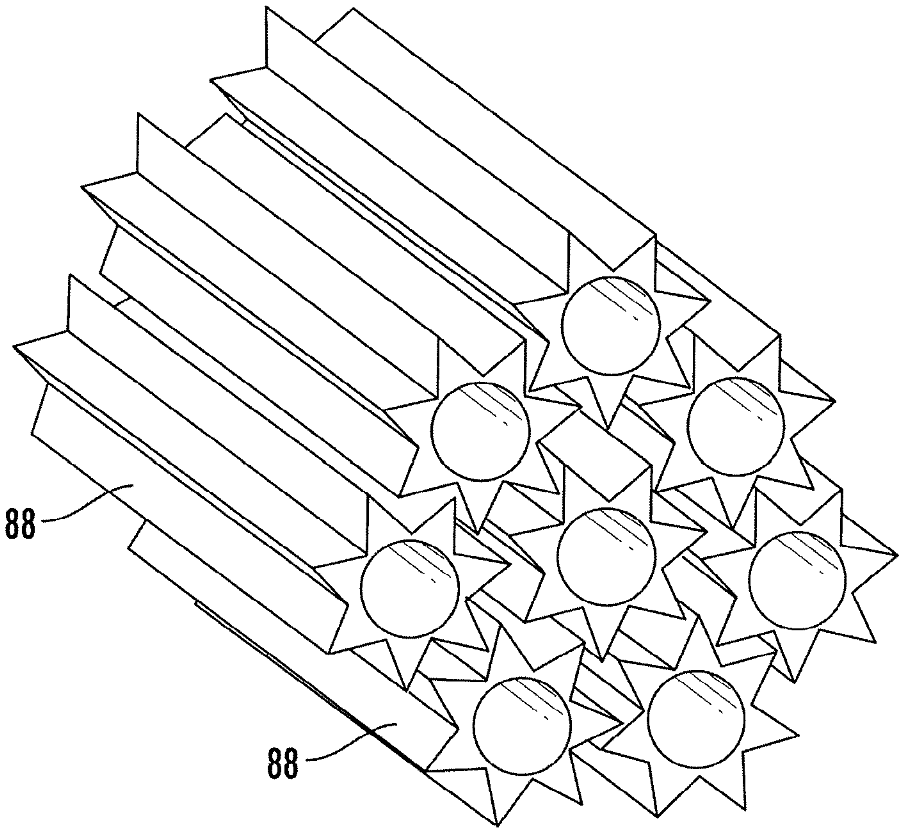

Figure 10A

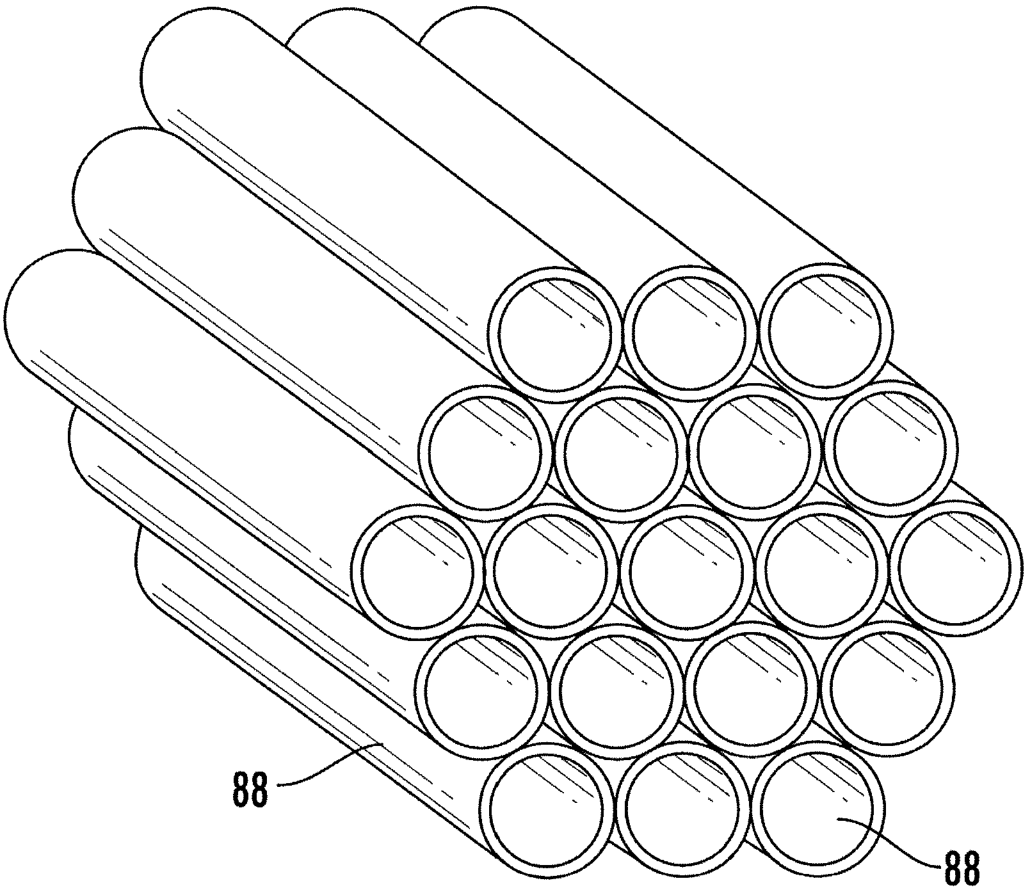

Figure 10B

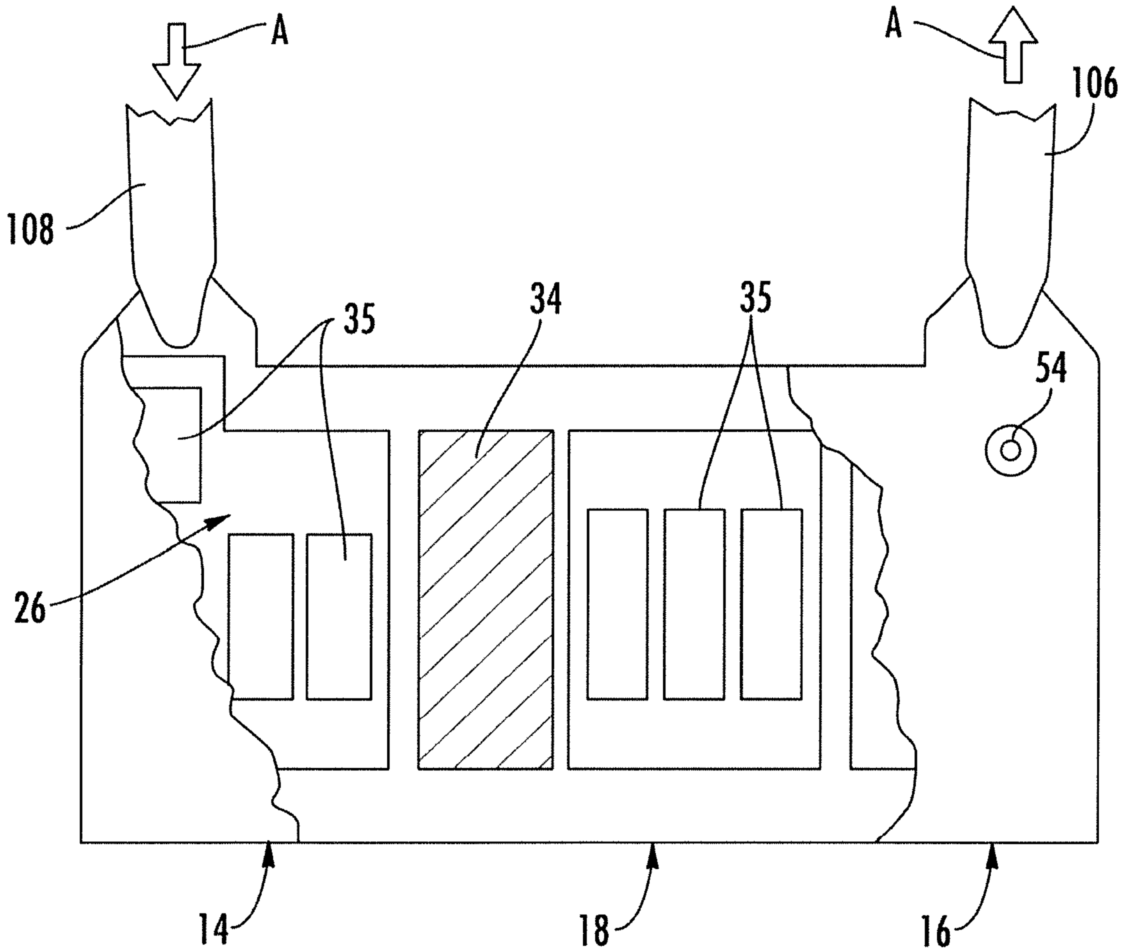

Figure 11A

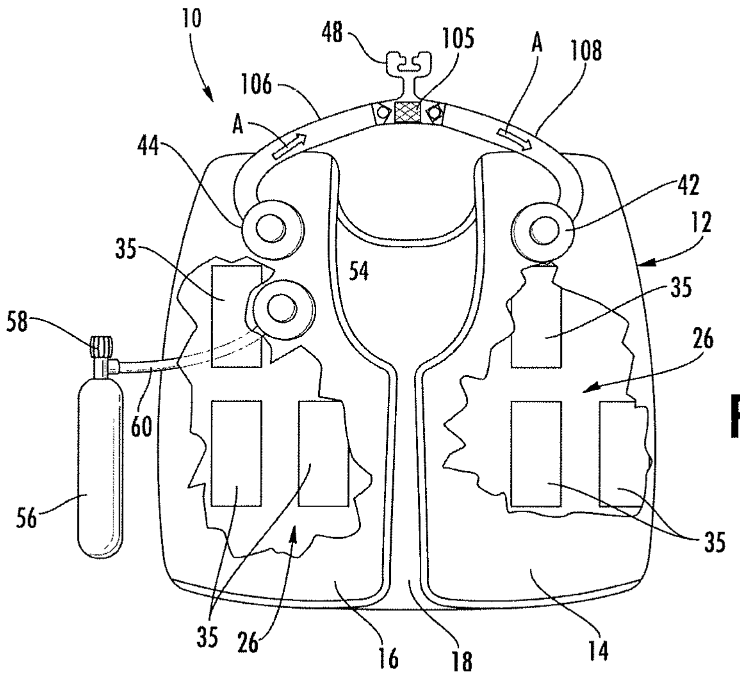

Figure 11B

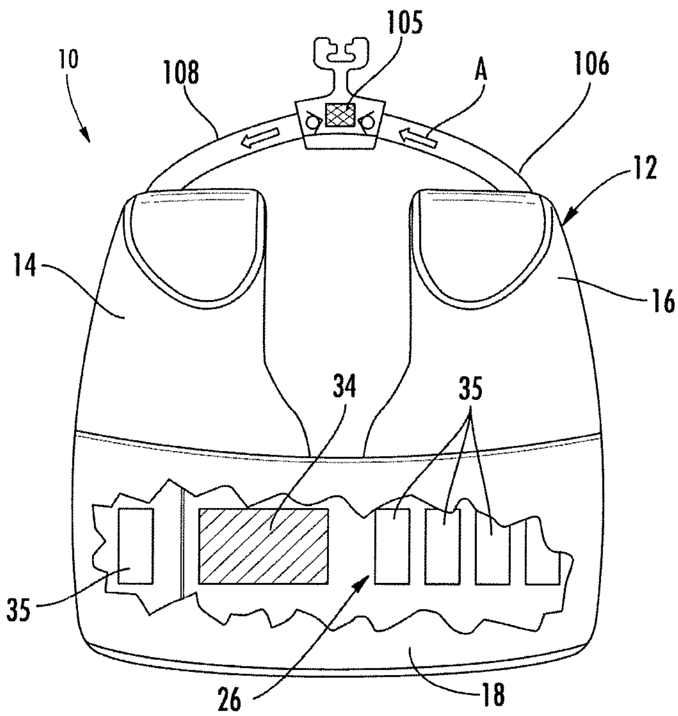

Figure 11C

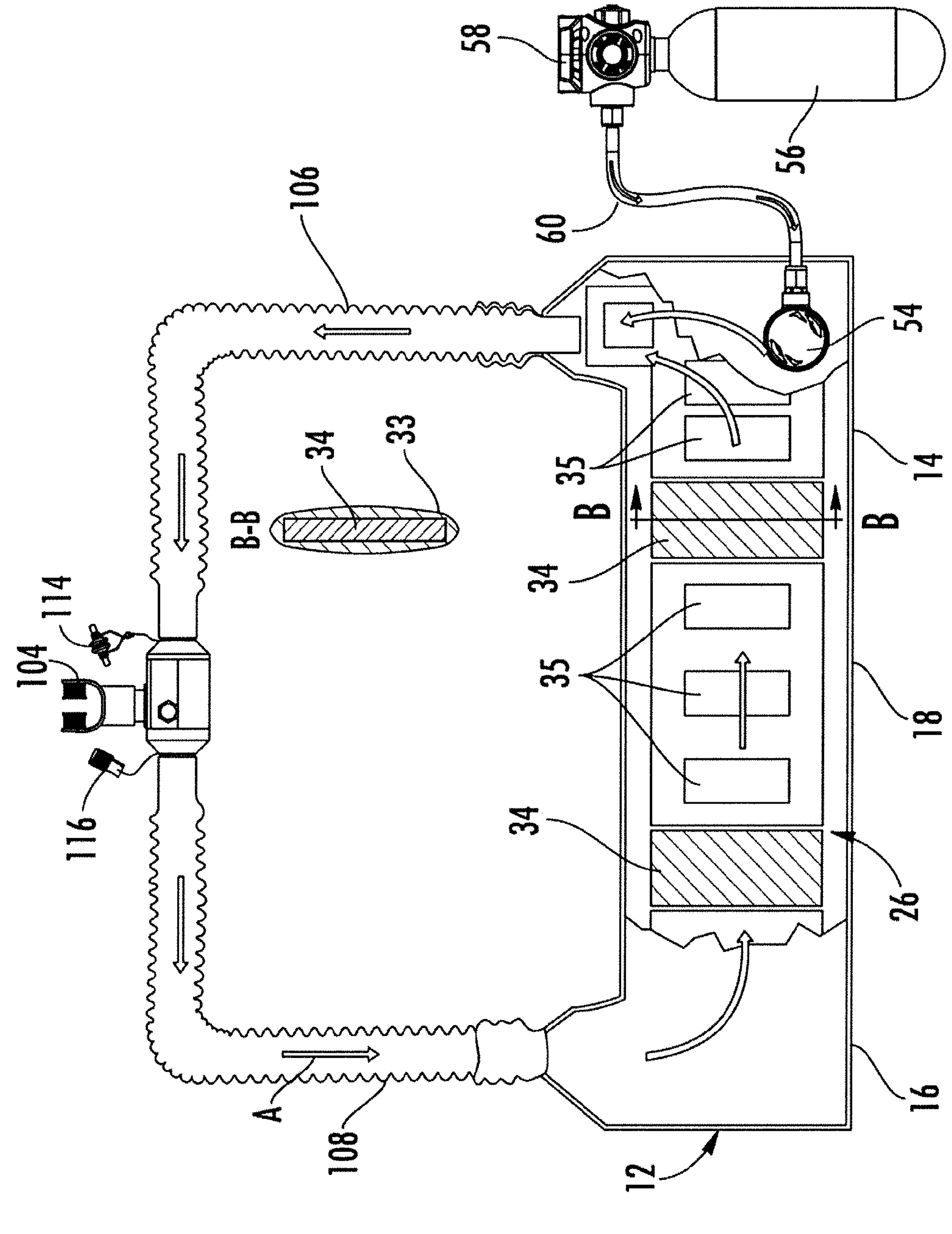
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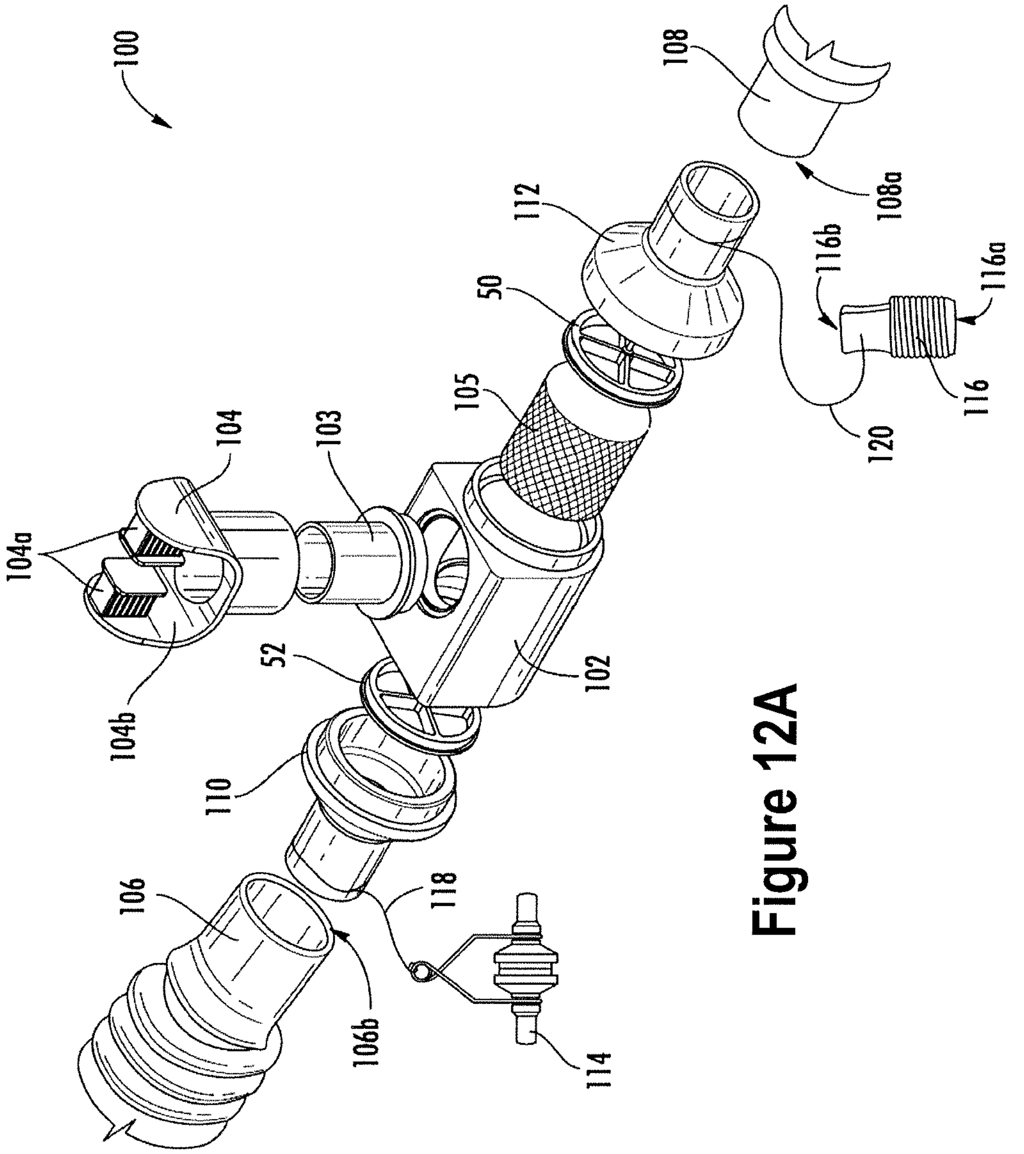
Figure 11D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106b
114

Figure 12A

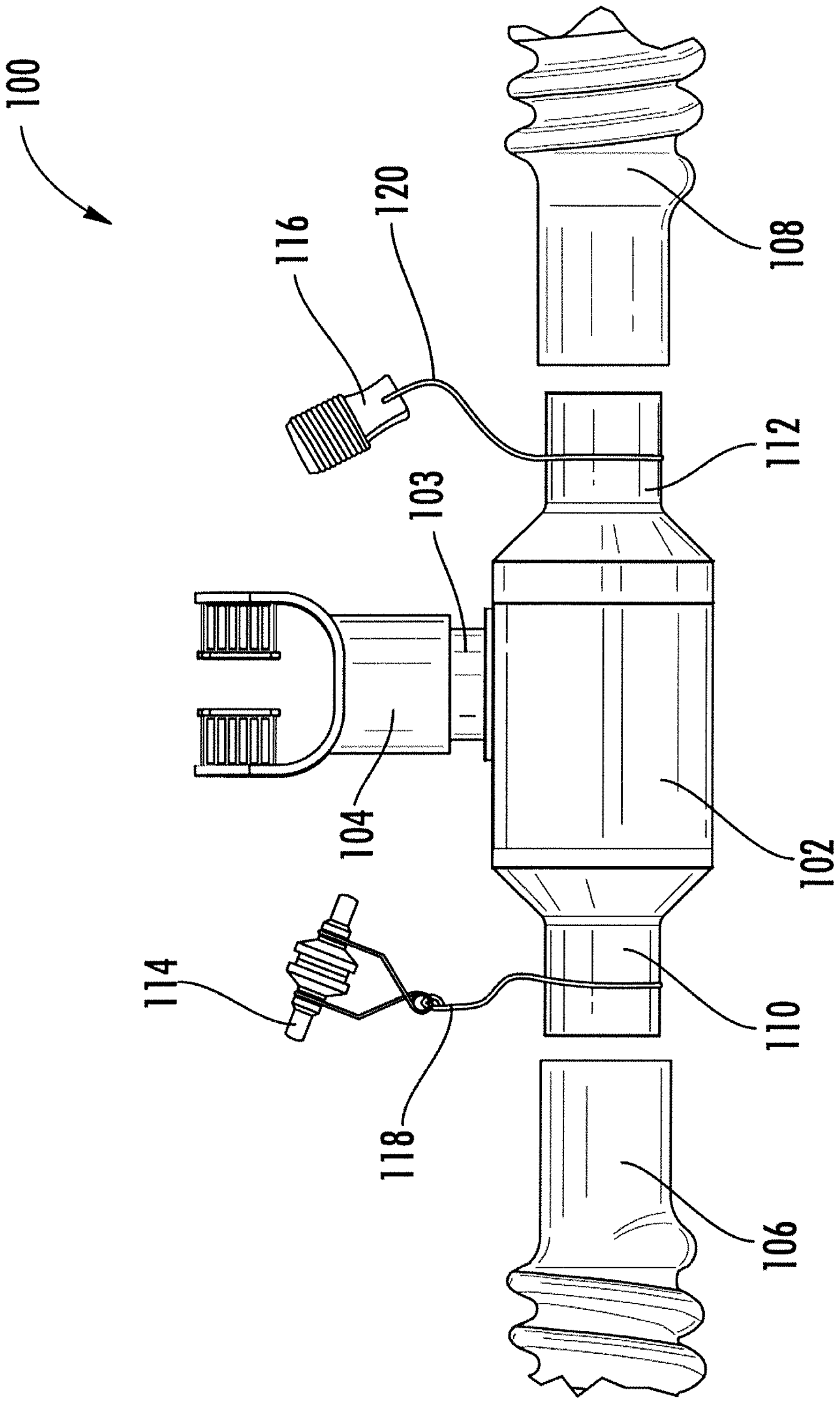


Figure 12B

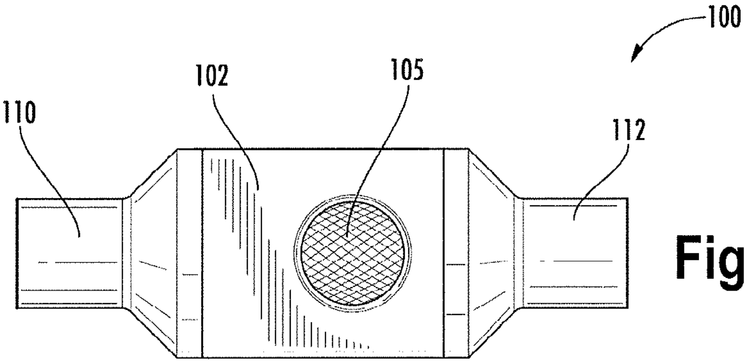
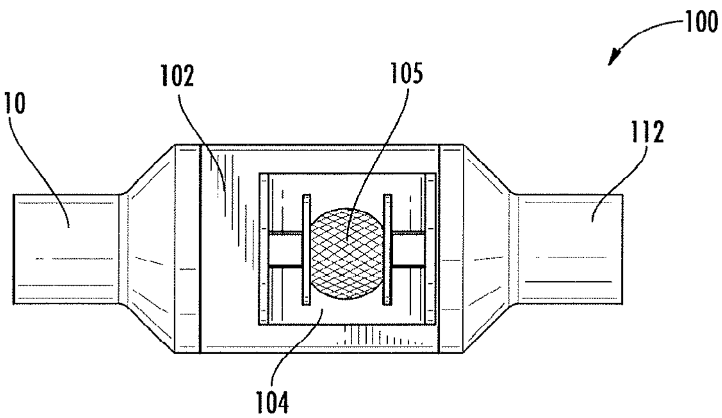


Figure 13A

Figure 13B



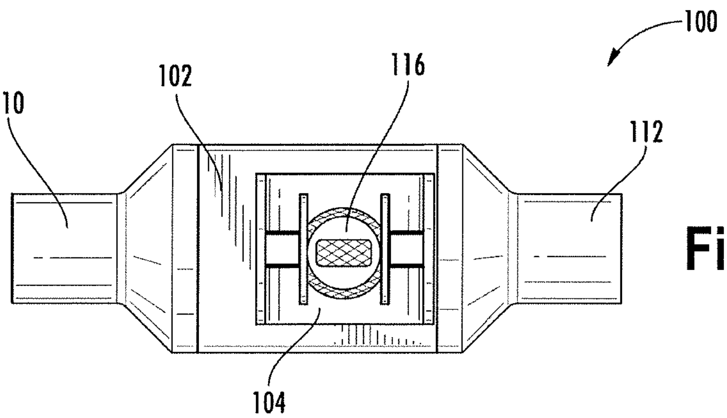


Figure 13C

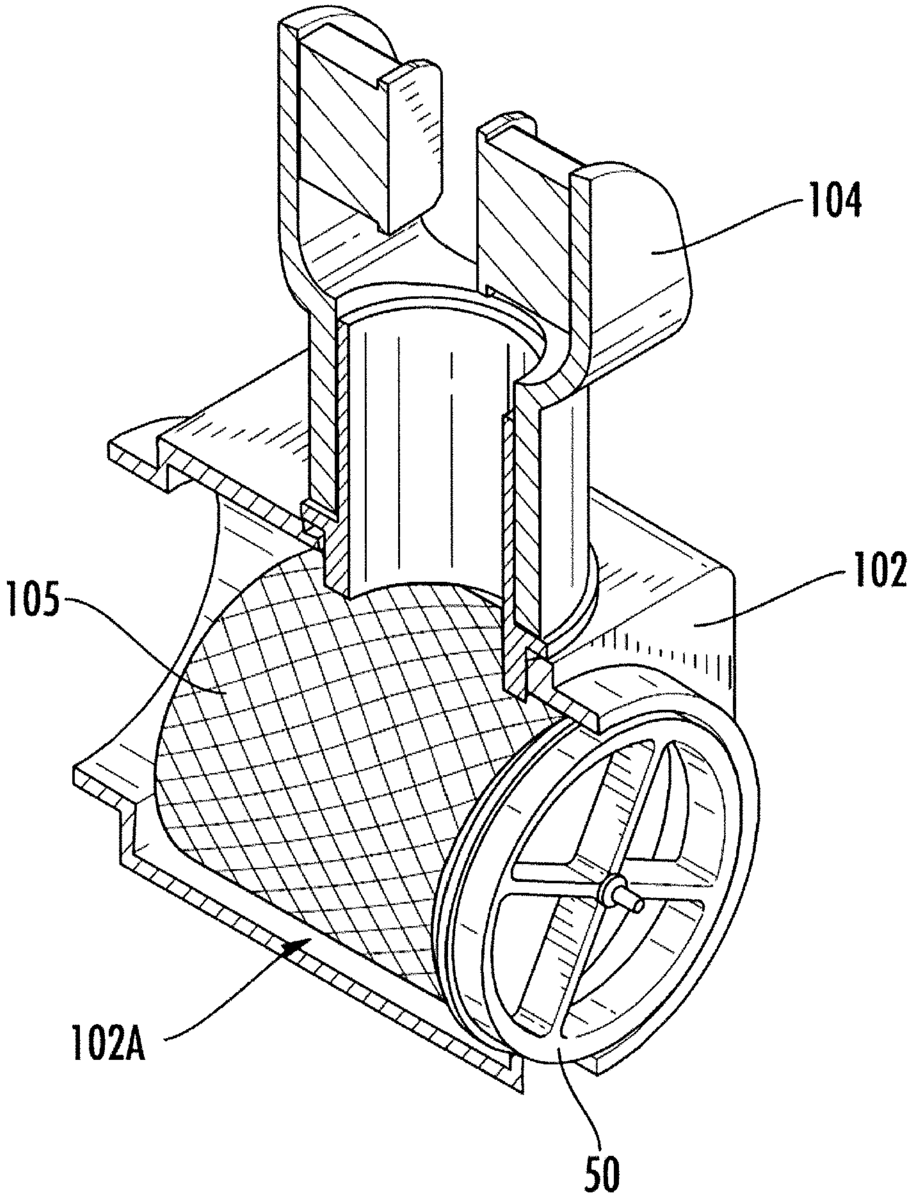


Figure 14

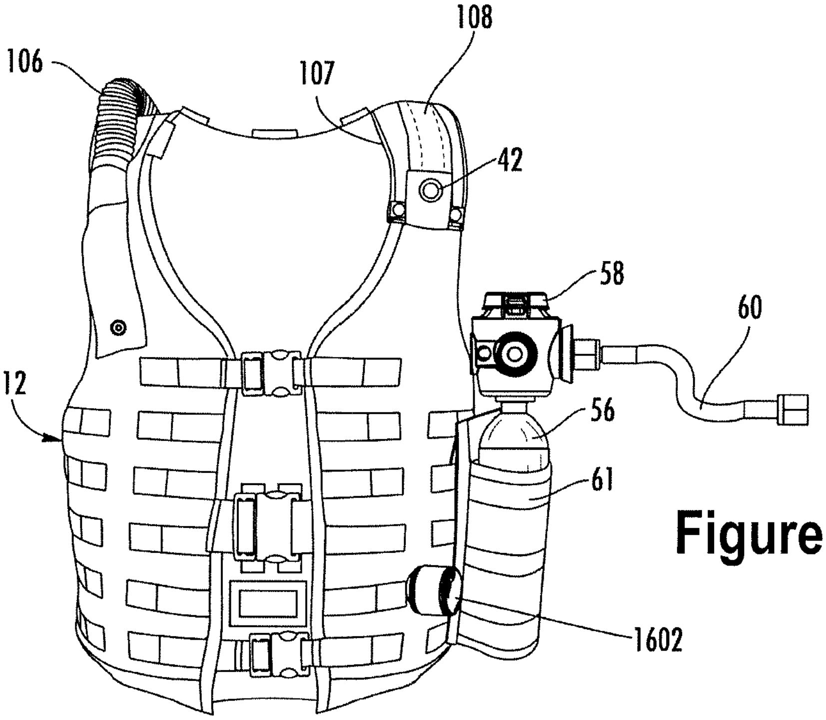


Figure 15A

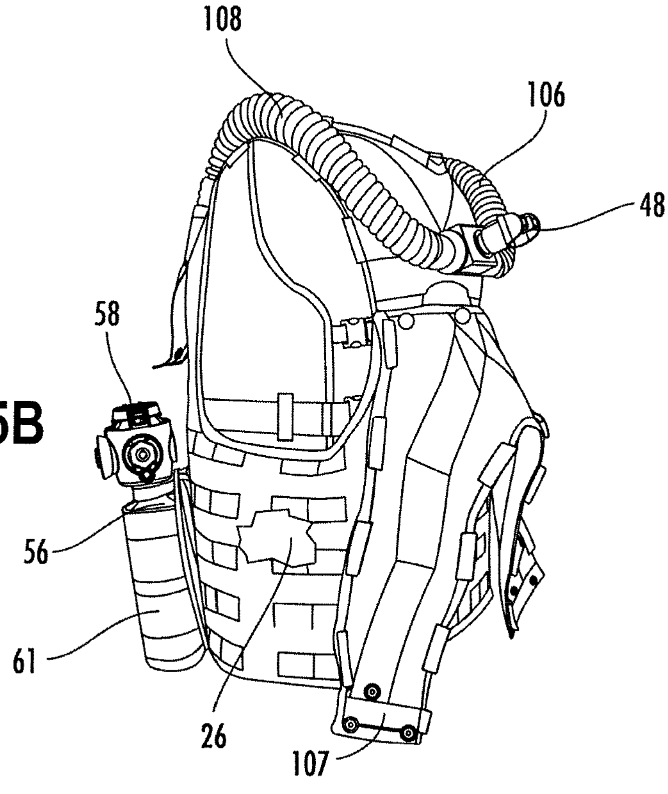


Figure 15B

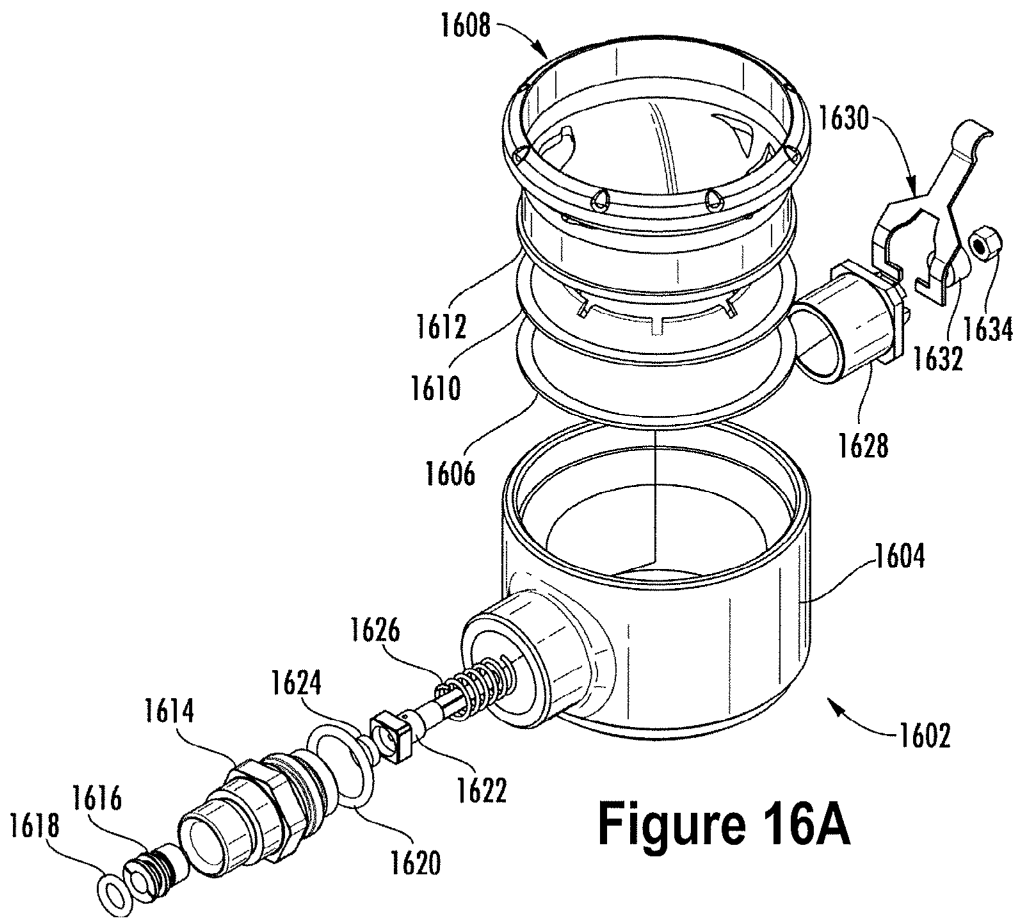


Figure 16A

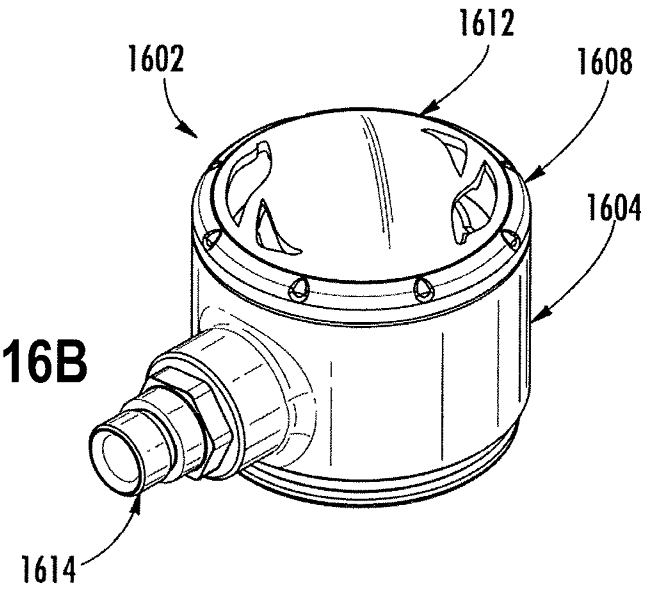
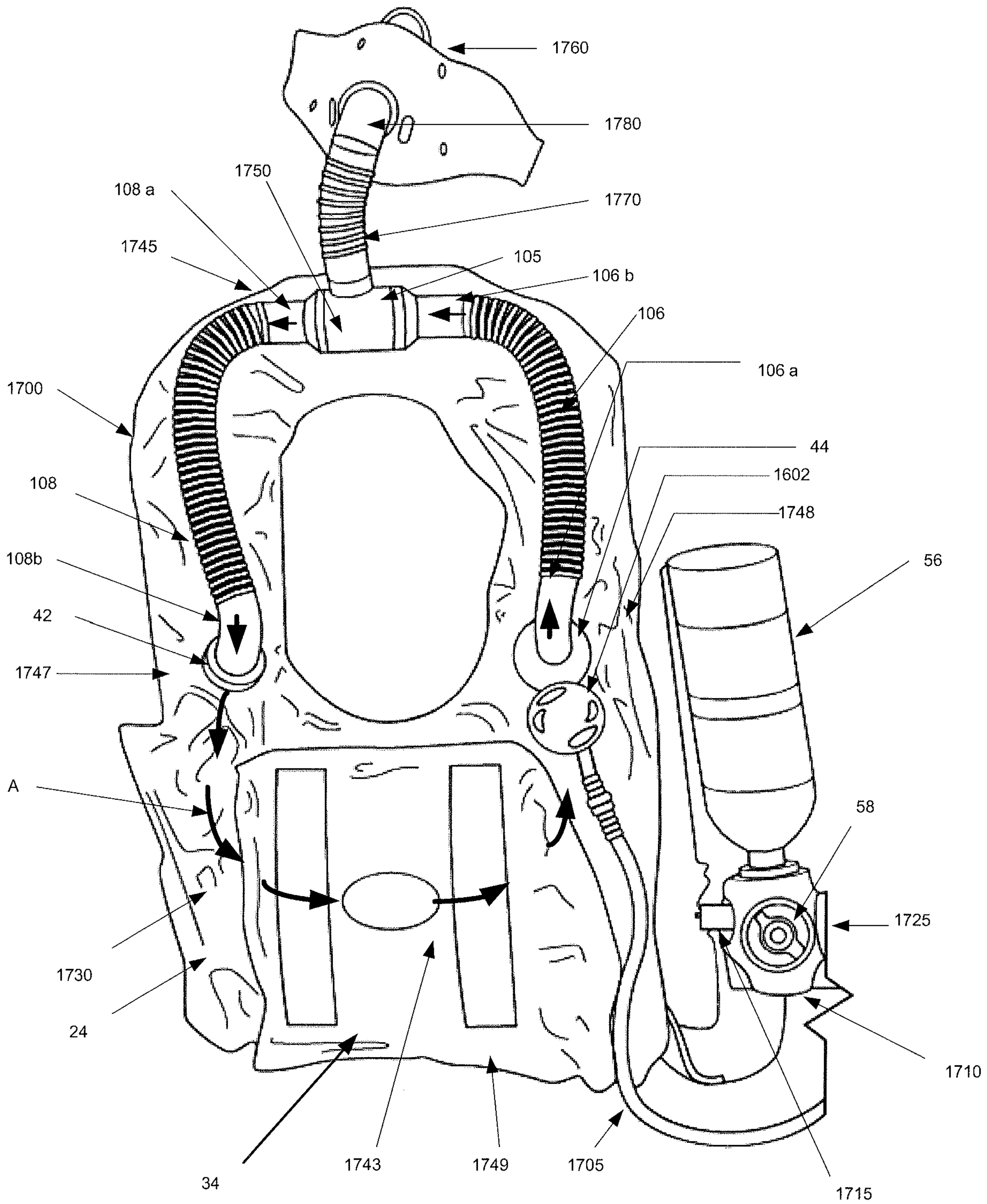


Figure 16B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A
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1705
1715

Figure 17

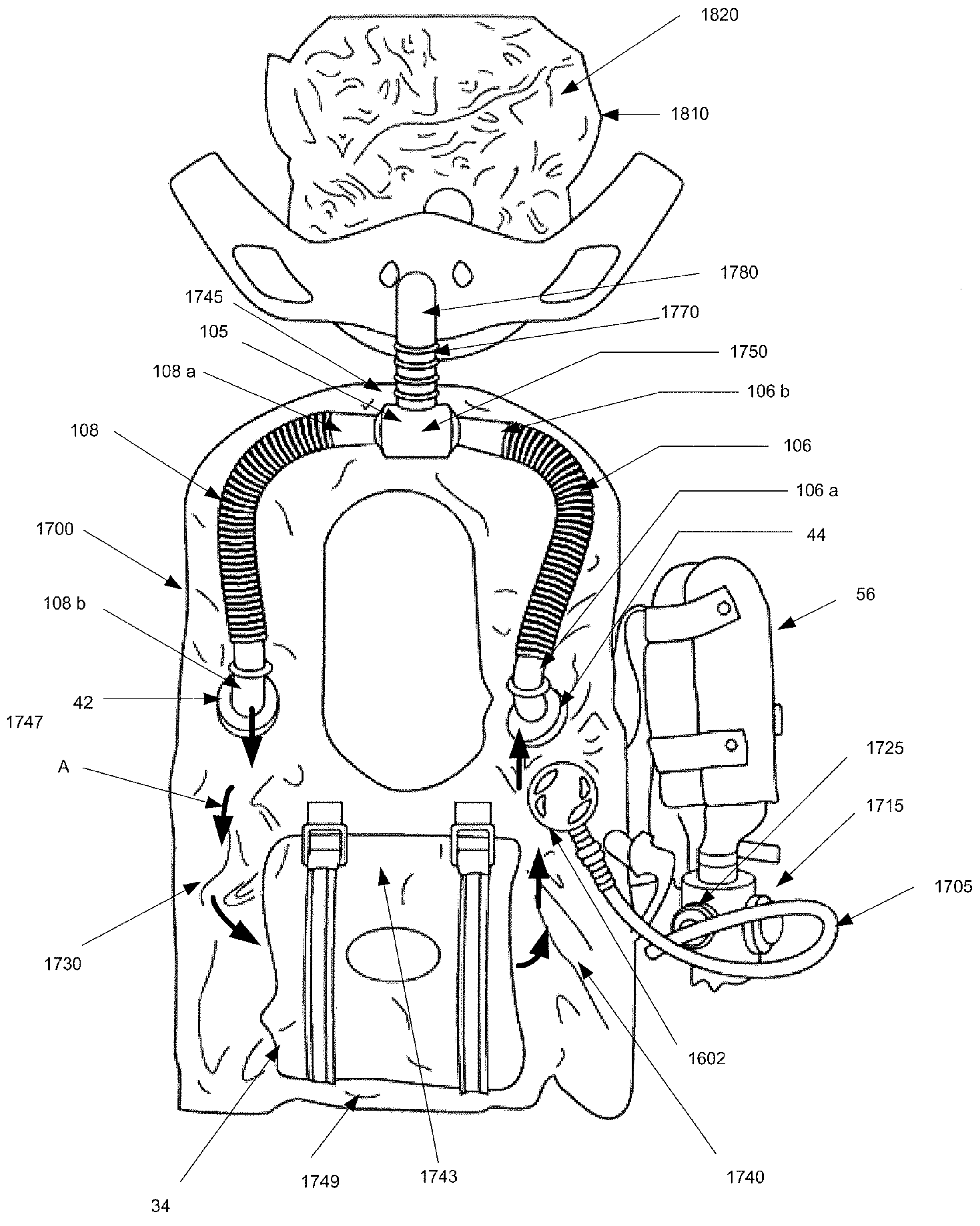
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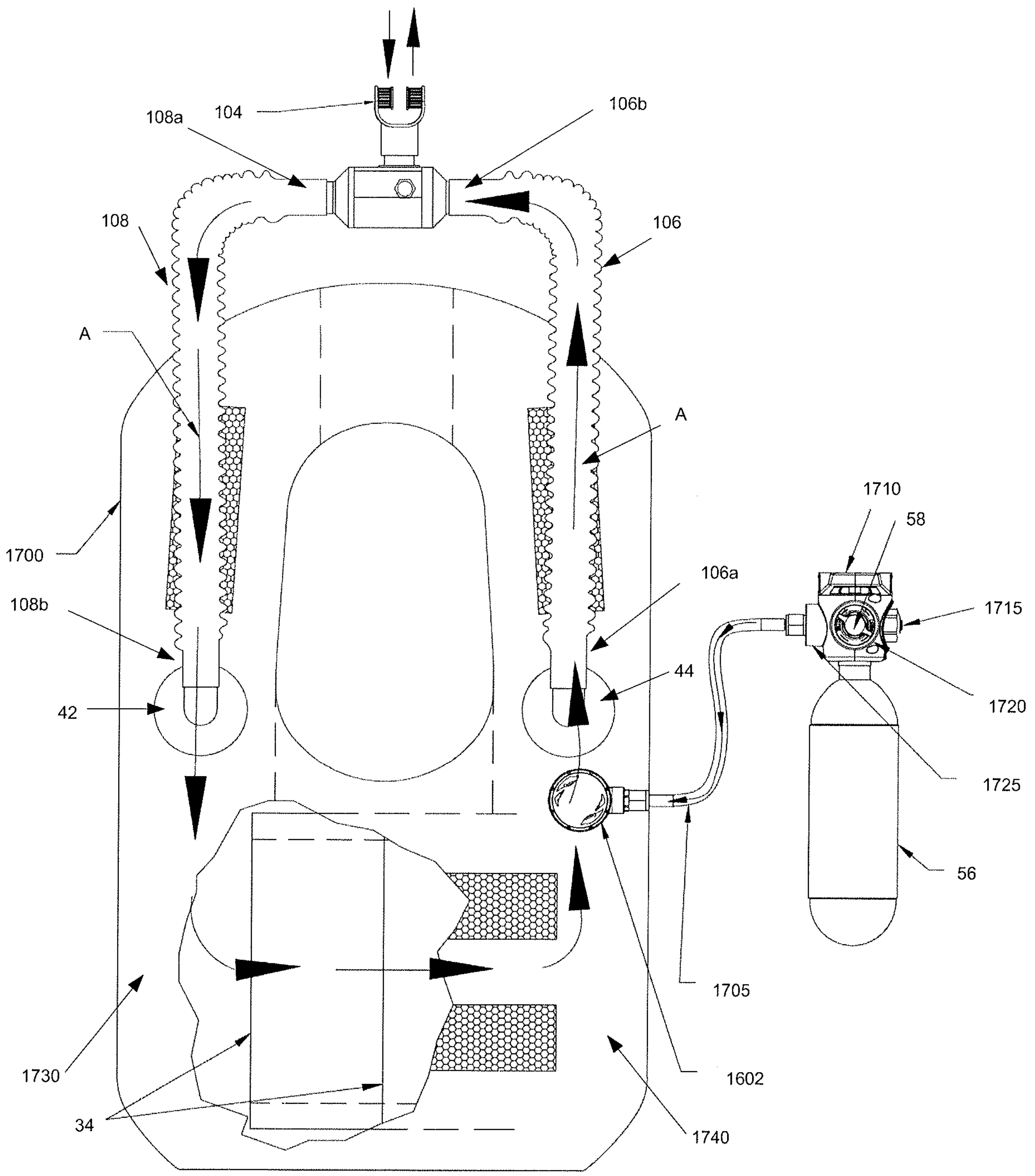
Figure 18



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A
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1710
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1705
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1602
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1740

Figure 19

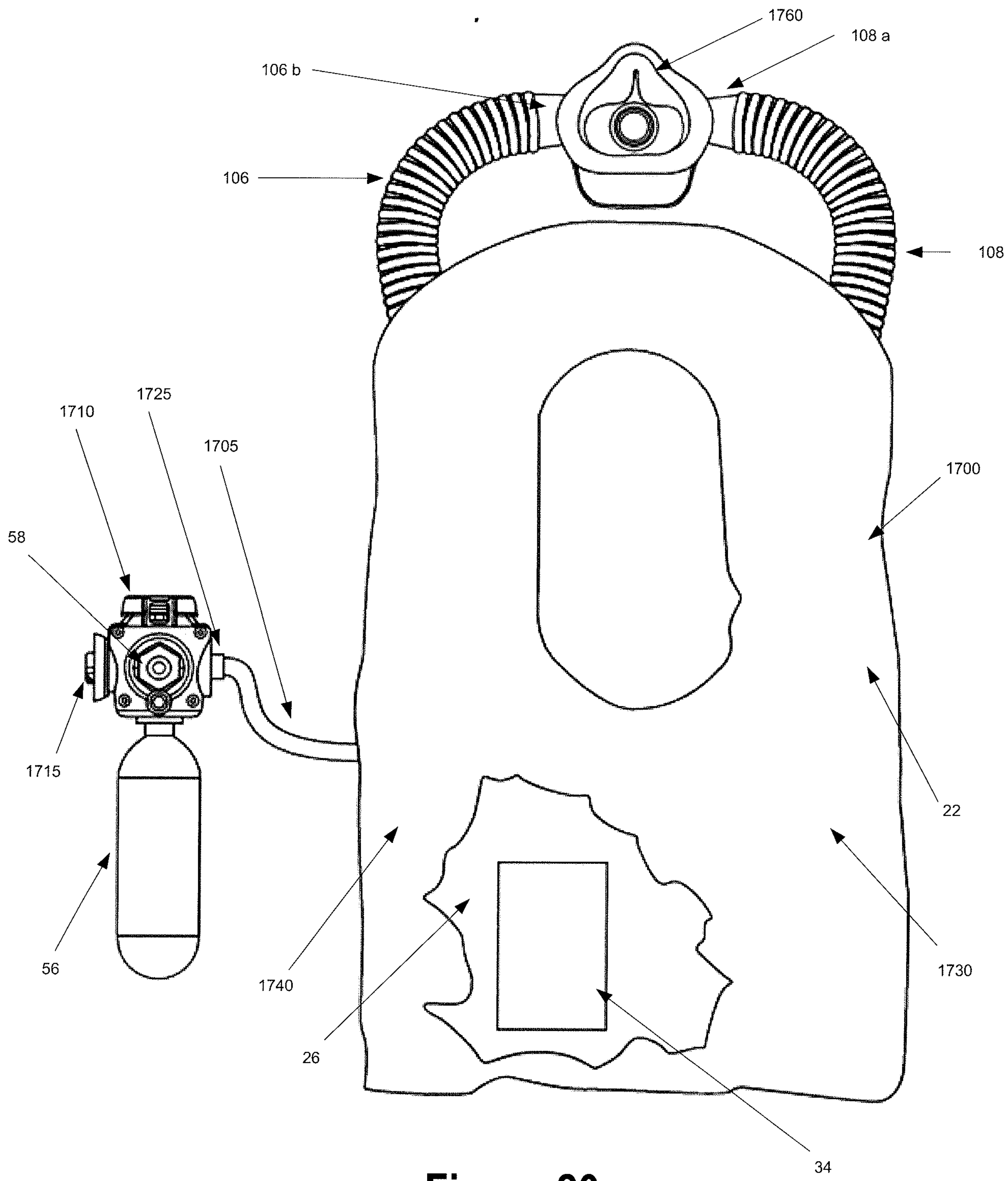
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Figure 20

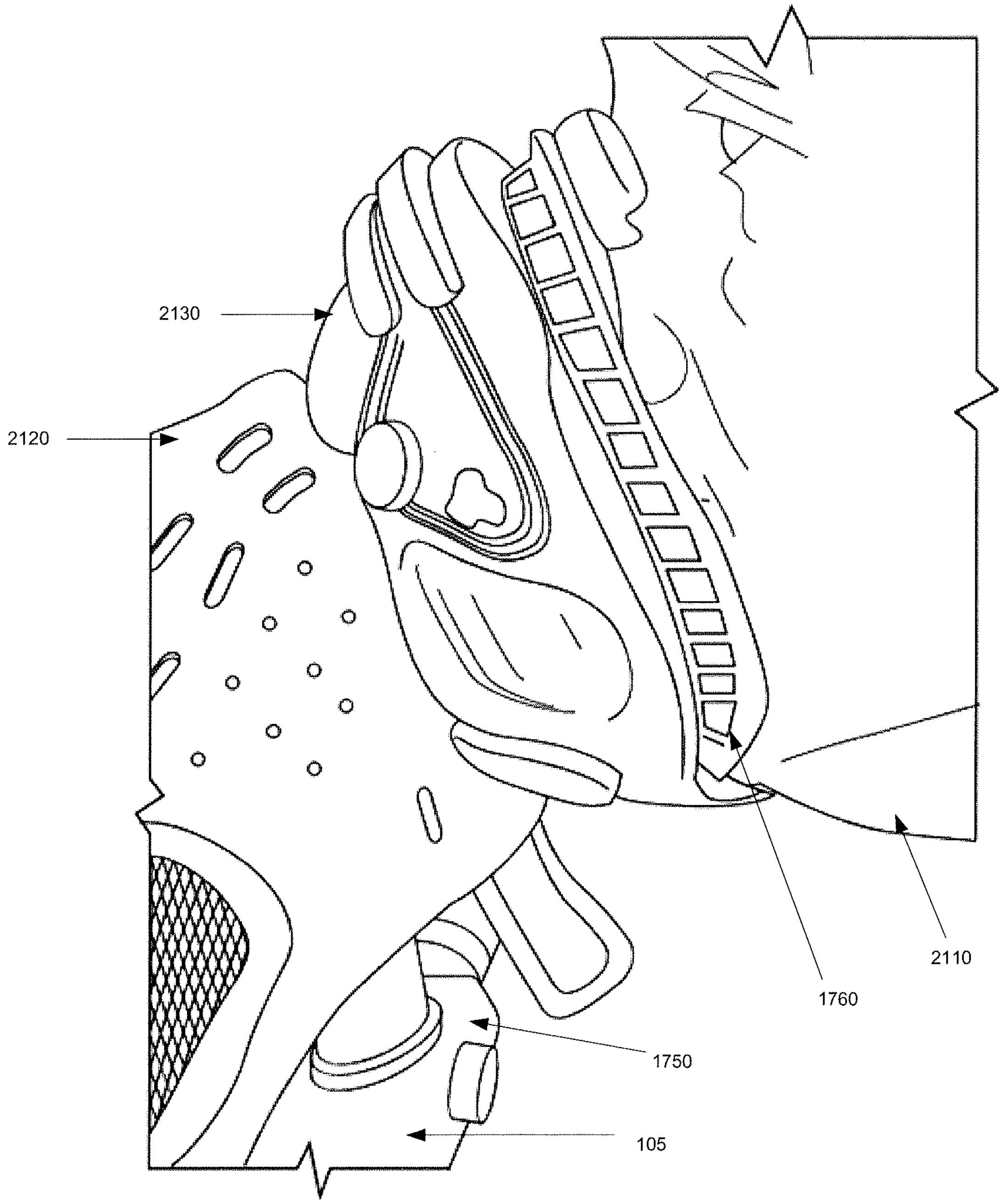


Figure 21

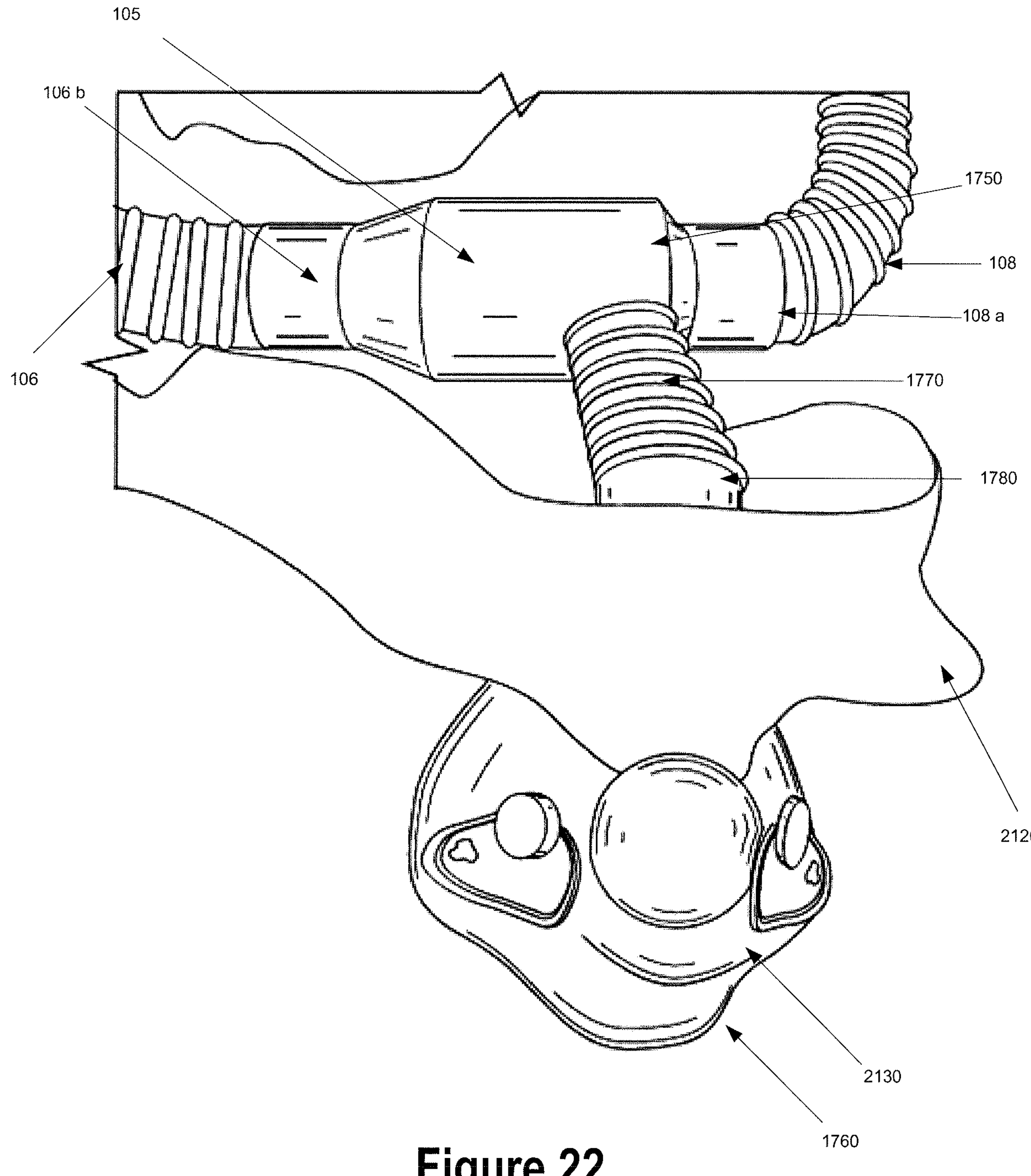


Figure 22

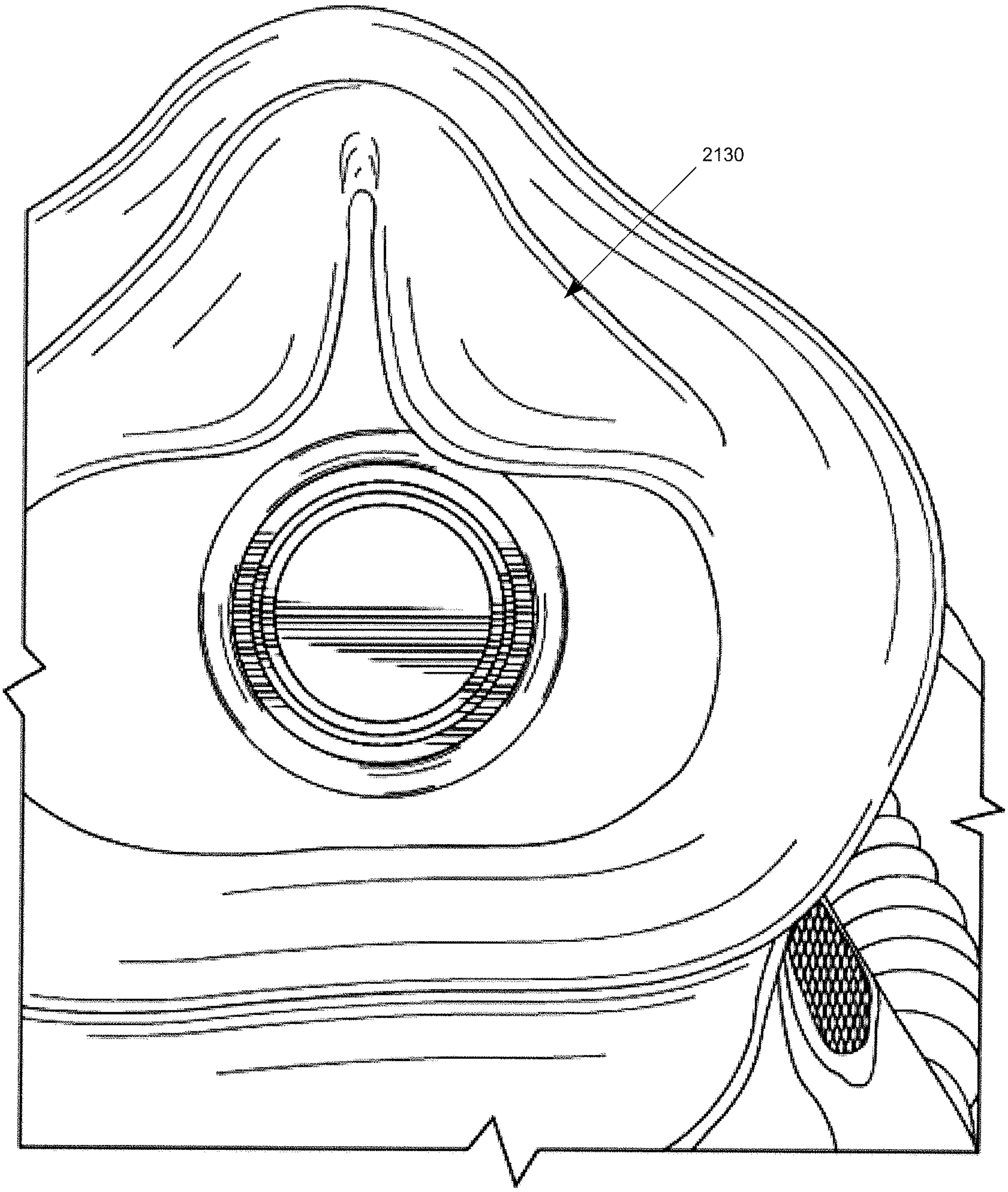


Figure 23

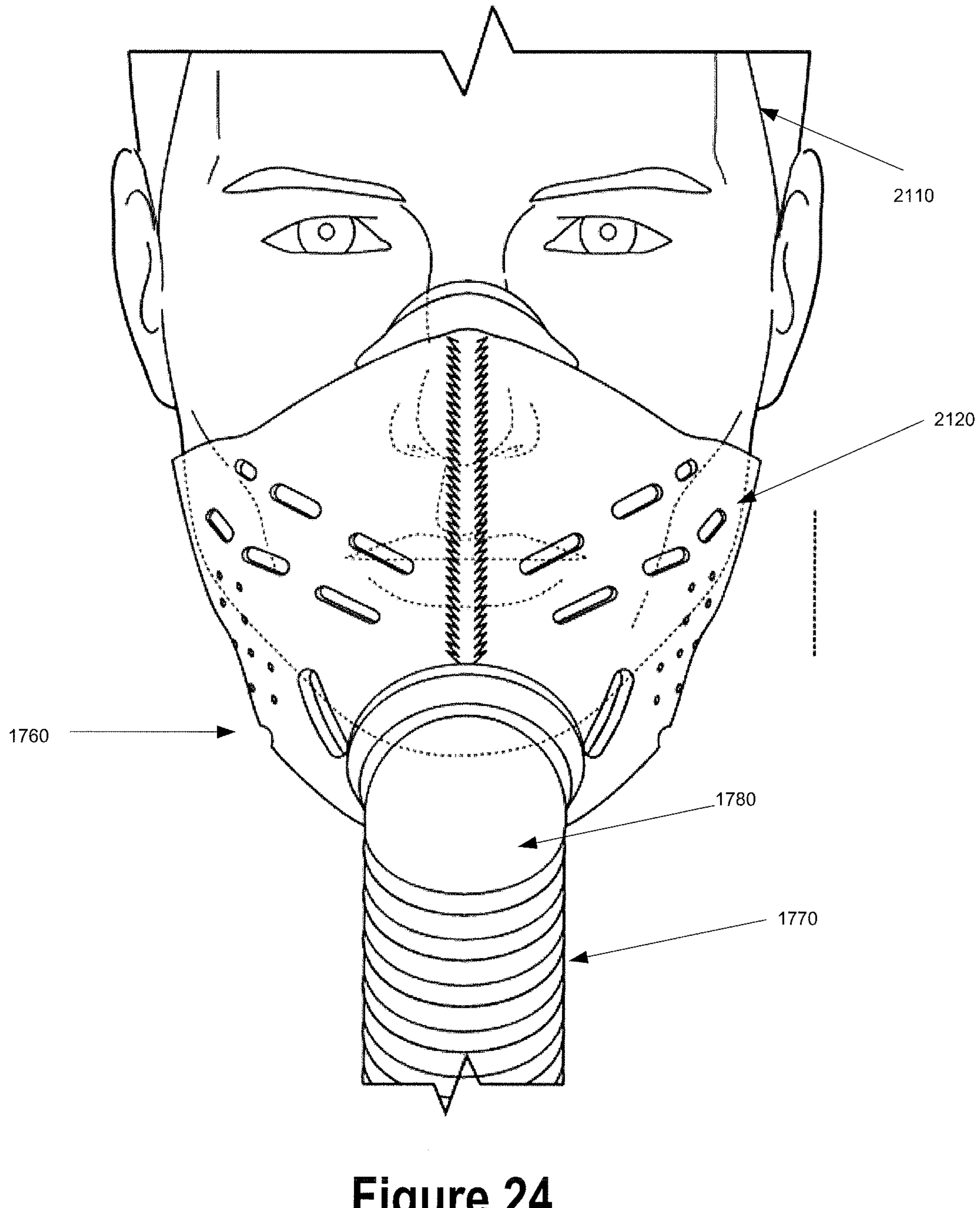


Figure 24

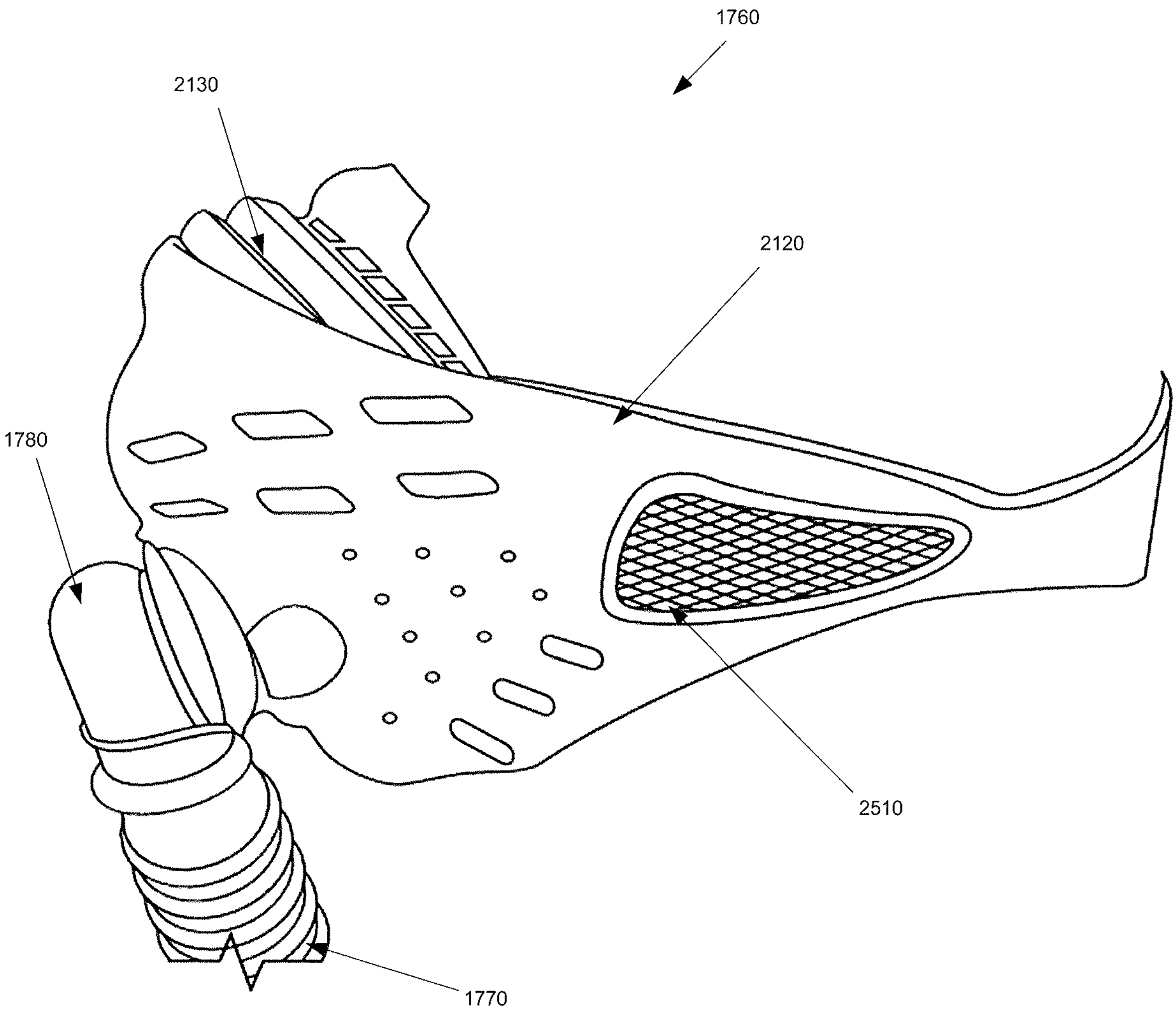


Figure 25

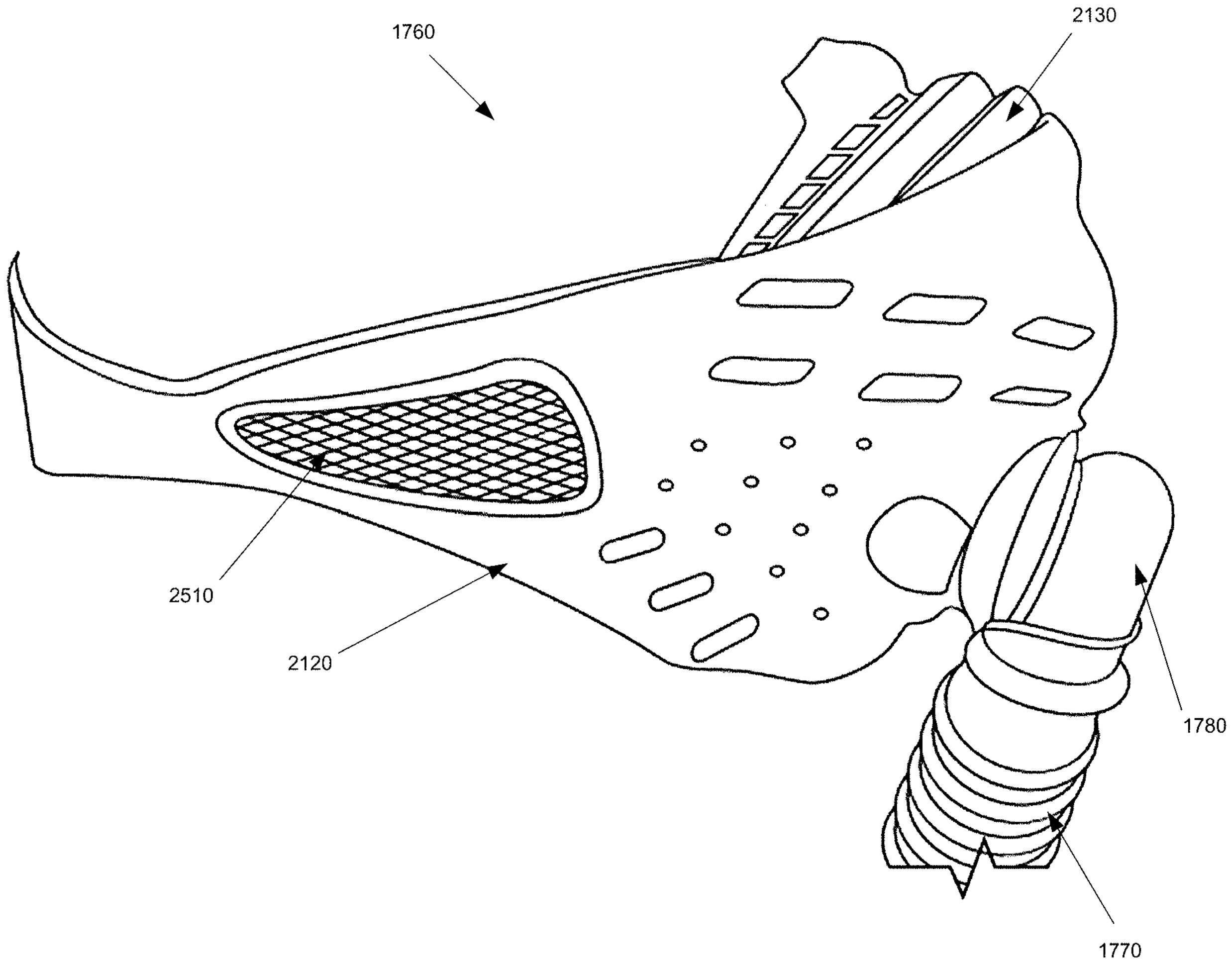
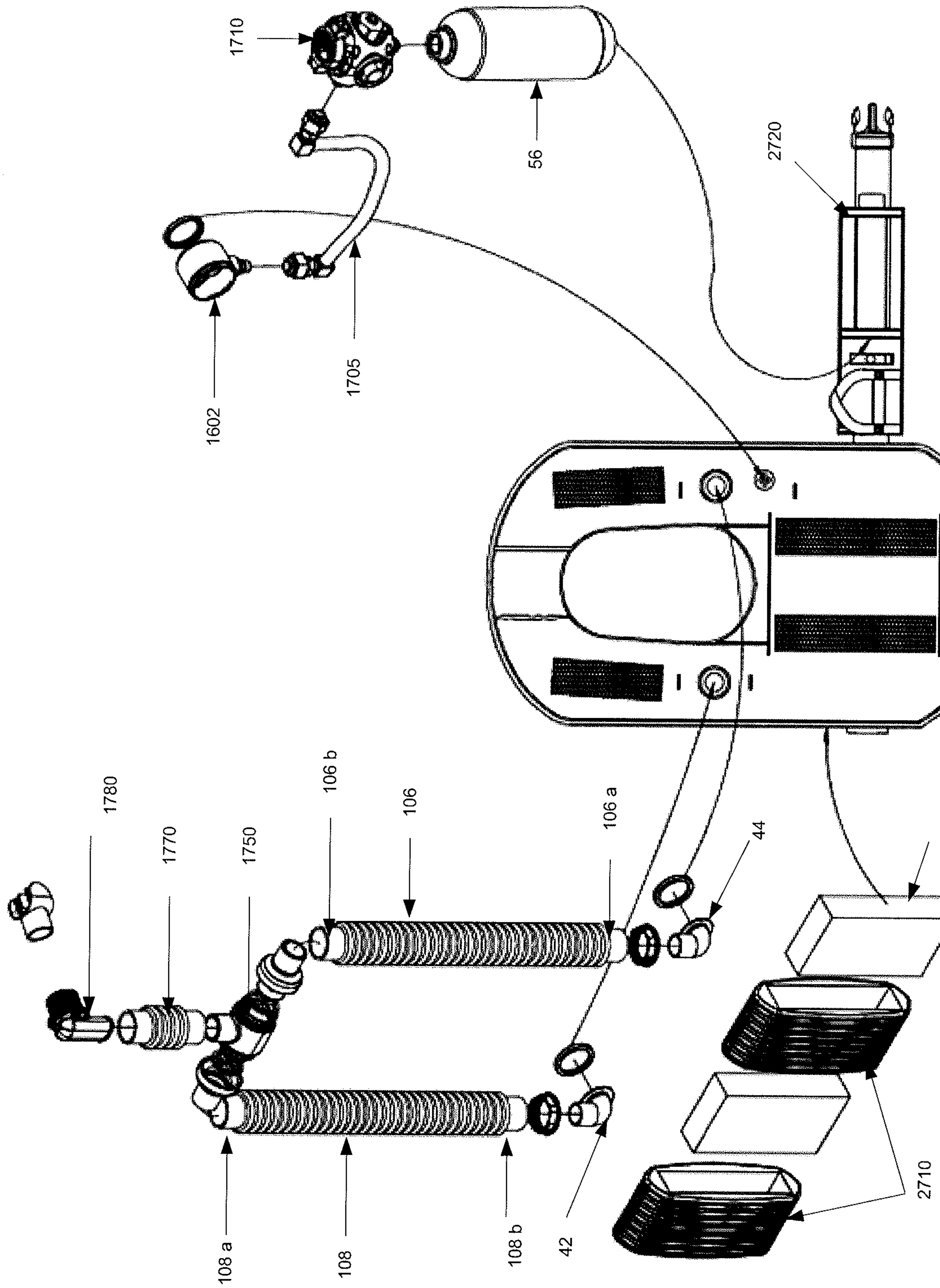


Figure 26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106 b
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106 a
44
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108 a
108
108 b
42
2710

Figure 27

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 17/53928

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - A61M 16/22, A61M 16/06, A62B 7/10 (2017.01)
CPC - A61M 16/22, A61M 16/0045, A61M 2205/3606, A61M 2202/0225, A61M 16/1075, A62B 9/003, A62B 7/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History Document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History Document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 2016/0213879 A1 (The Arizona Board of Regents on Behlaf of the University of Arizona), 28 July 2016 (28.07.2016), entire document, especially Fig. 2; para [0010], [0028]-[0039], [0044], [0050]-[0052], [0084]-[0096]	18-24 --------- 25
X -- A	US 2007/0084463 A1 (Niemann et al.), 19 April 2007 (19.04.2007), entire document, especially Fig. 1-2; para [0008]-[0033]	26-29 --------- 1-17
Y	US 4,294,242 A (Cowans), 13 October 1981 (13.10.1981), entire document, especially Fig. 5; col 4, ln 48-56	25
A	US 5,111,809 A (Gamble et al.), 12 May 1992 (12.05.1992), entire document	1-29
A	US 8,302,603 B1 (Weber), 06 November 2012 (06.11.2012), entire document	1-29
A	US 6,591,630 B2 (Smith et al.), 15 July 2003 (15.07.2003), entire document	1-29
A	US 2014/0360500 A1 (TDA Research, Inc.), 11 December 2014 (11.12.2014), entire document	1-29
A	US 3,575,167 A (Michielsen), 20 April 1971 (20.04.1971), entire document	1-29
A	US 2,390,233 A (Akerman et al.), 04 December 1945 (04.12.1945), entire document	1-29

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 November 2017	14 DEC 2017

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774