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(54) **DEVICE FOR MEASURING A PERSON'S VENTILATION INCLUDING OXYGEN-CONSUMPTION, AND A DEHUMIDIFICATION CARTRIDGE THEREFOR**

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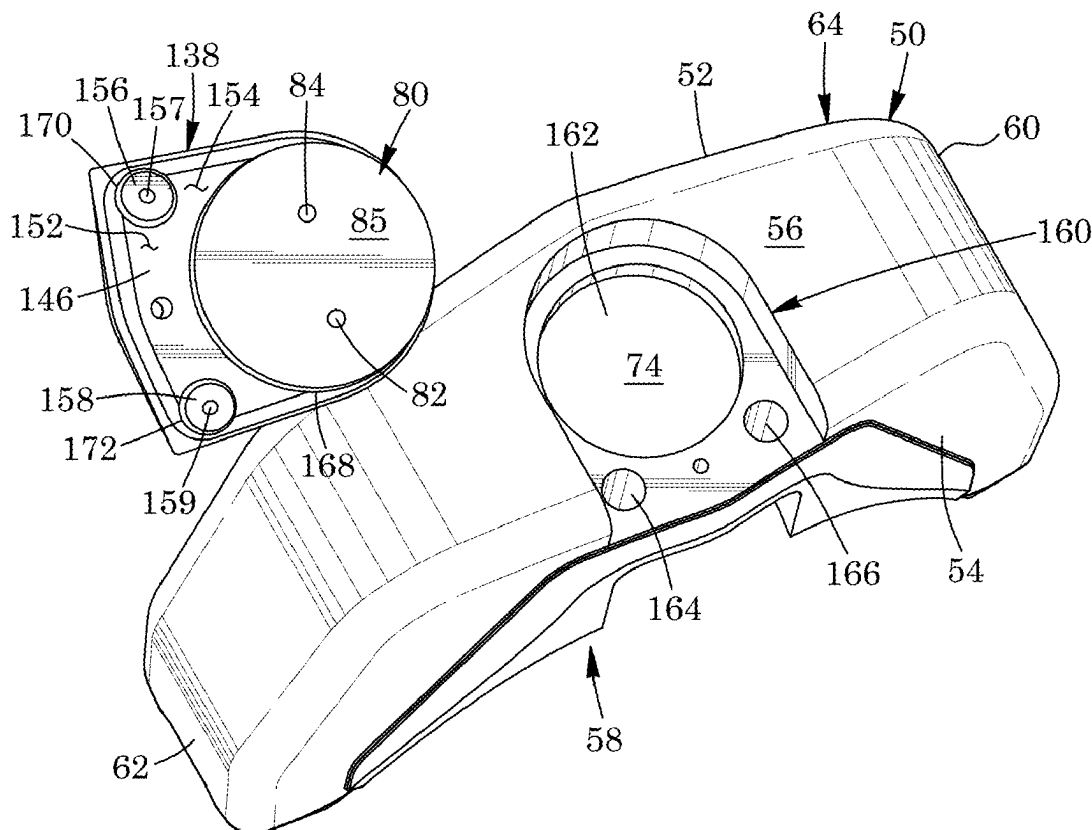
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CPC ..... *A61B 5/097* (2013.01); *A61B 5/0833* (2013.01); *B01D 53/268* (2013.01); *A61B 5/6803* (2013.01)

(57) **ABSTRACT**

There is provided a device for measuring a person's ventilation including oxygen consumption. The device includes a sensor assembly. The device includes a breathing conduit through which at least one exhalation is received. The device includes a dehumidification cartridge configured to receive a sample amount of said exhalation from the breathing conduit, dehumidify the sample amount of said exhalation, and direct the sample amount of said exhalation so dehumidified to the sensor assembly. The dehumidification cartridge includes a dehumidification conduit having a proximal end at said sensor sampling port and which extends from the sensor sampling port towards the sensor assembly. The dehumidification cartridge includes a dehumidification chamber enclosing the dehumidification conduit. The dehumidification chamber is shaped to promote a flow of air therethrough. The dehumidification cartridge is shaped to facilitate for sanitary purposes, periodic replacement of either or both of the replaceable dehumidification cartridge and the dehumidification conduit thereof.



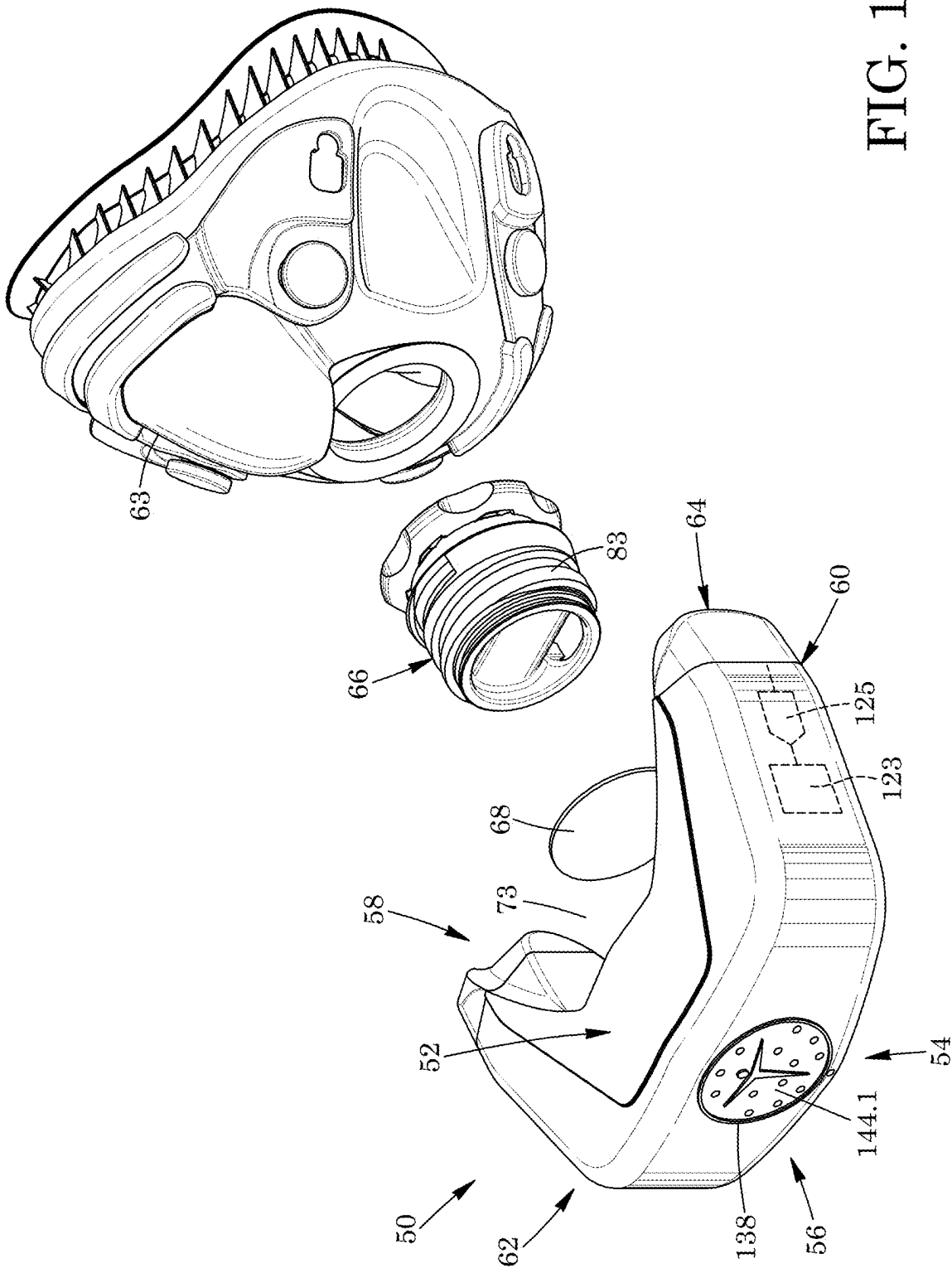


FIG. 1

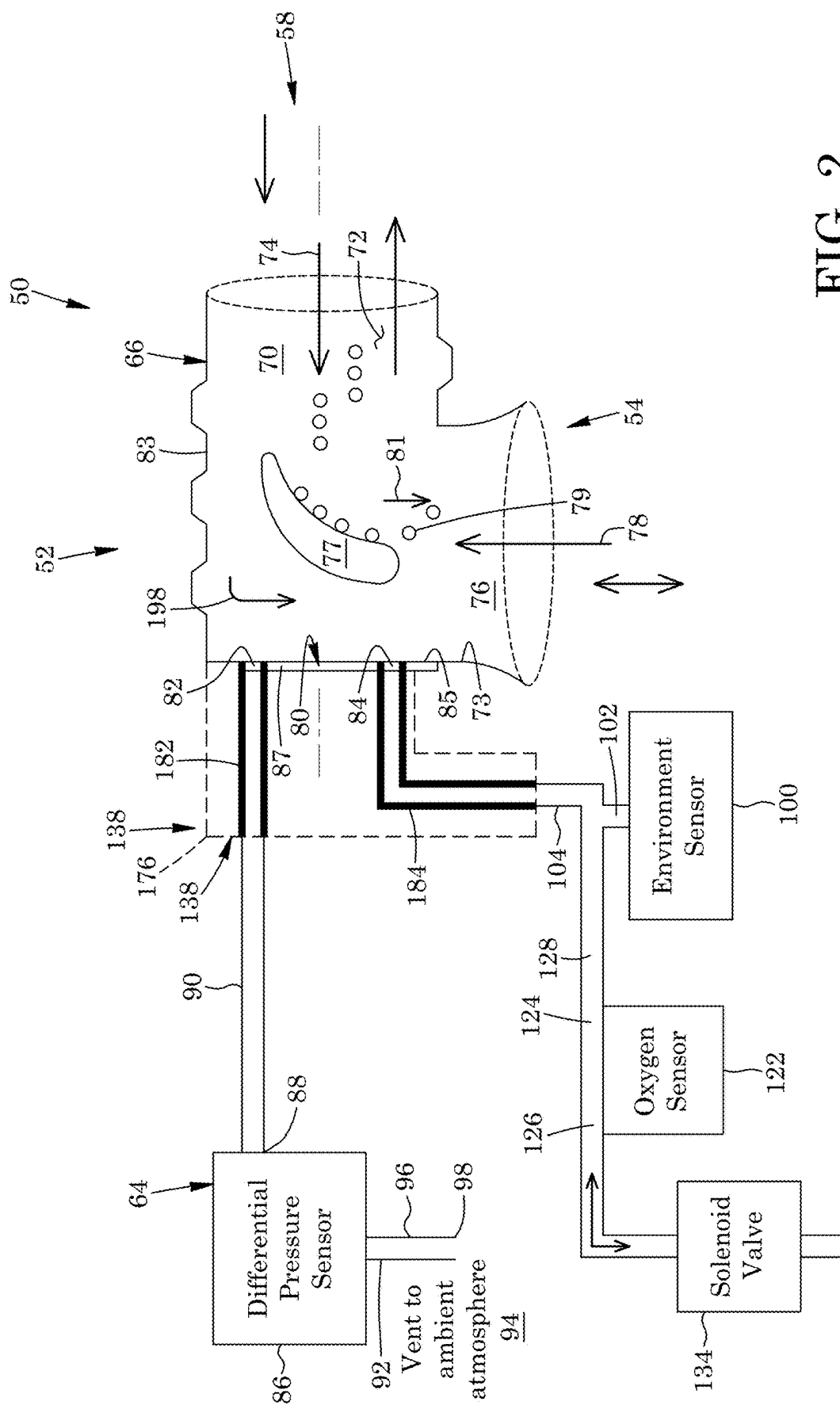


FIG. 2

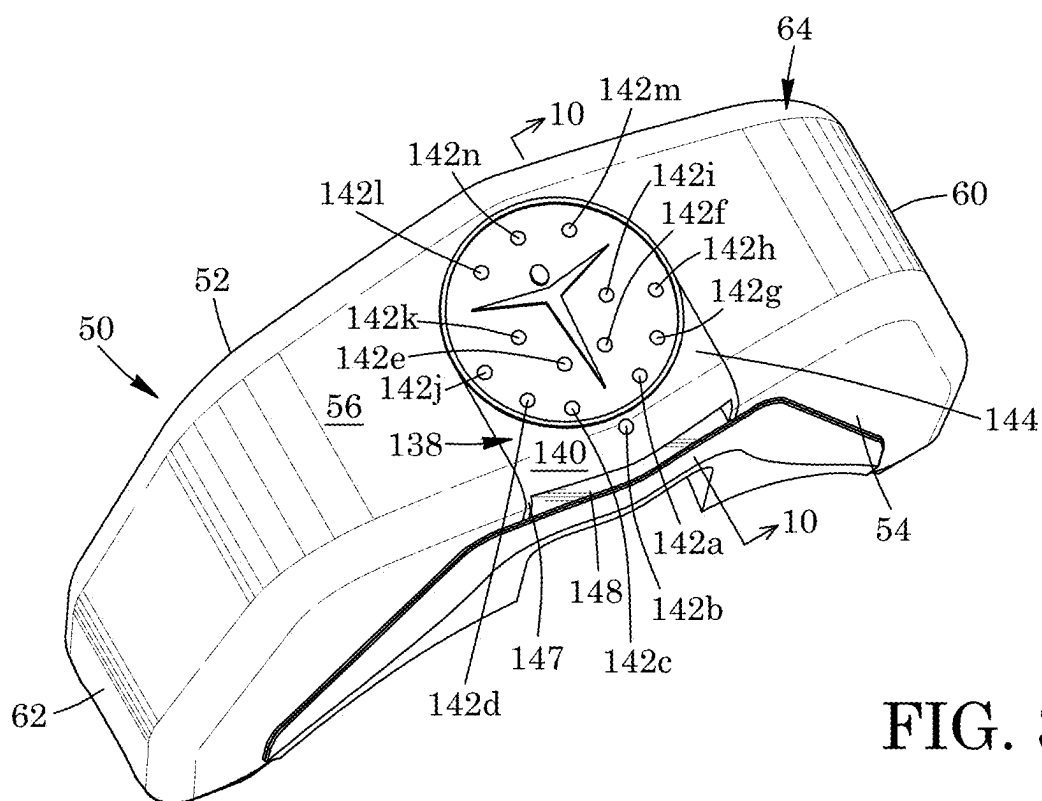


FIG. 3

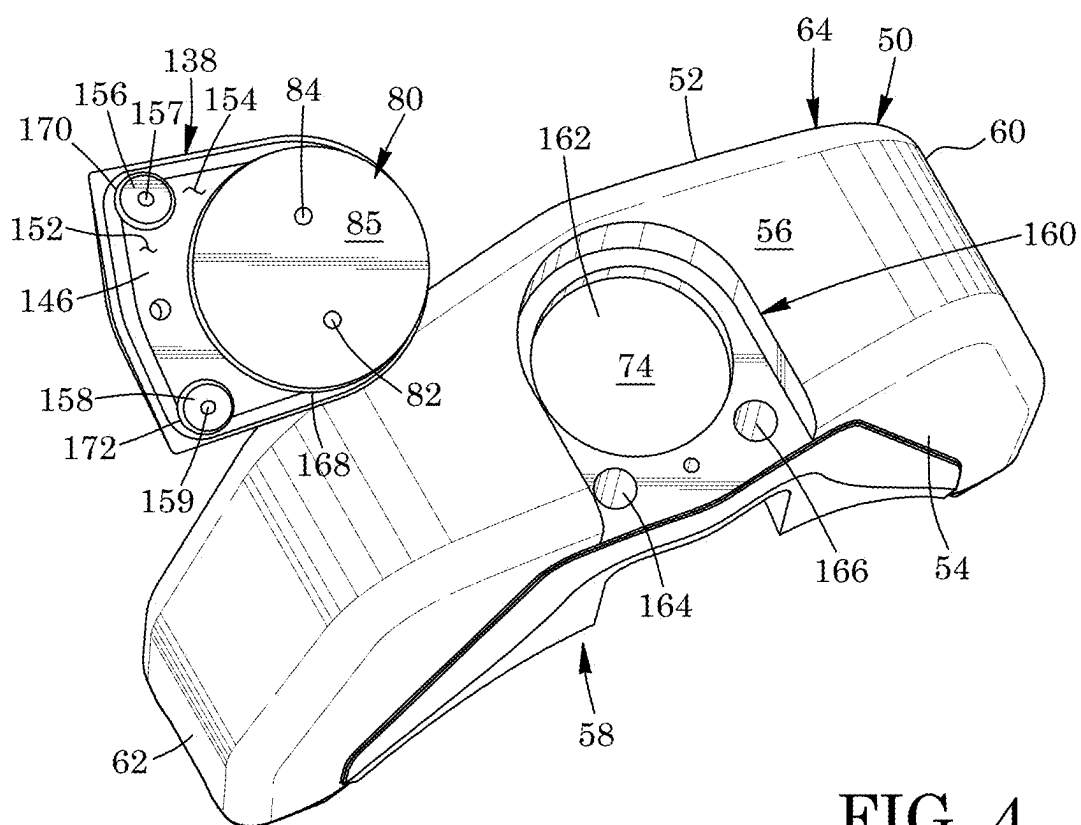


FIG. 4

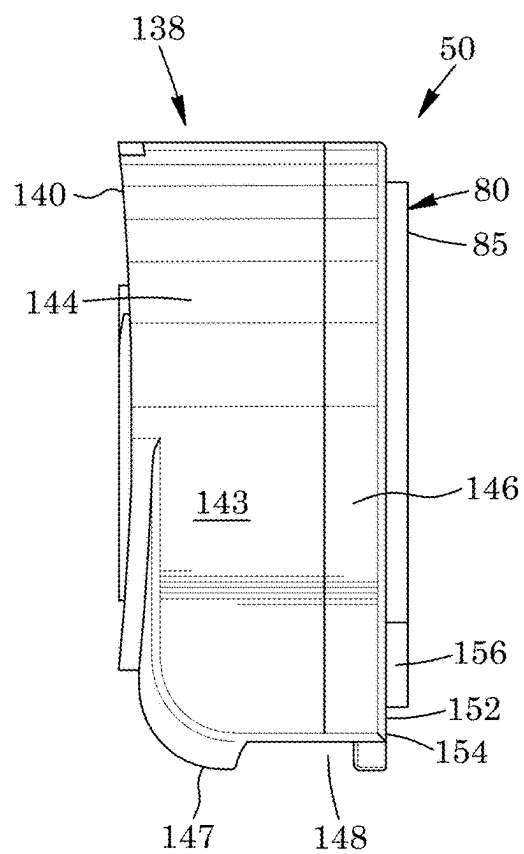


FIG. 5

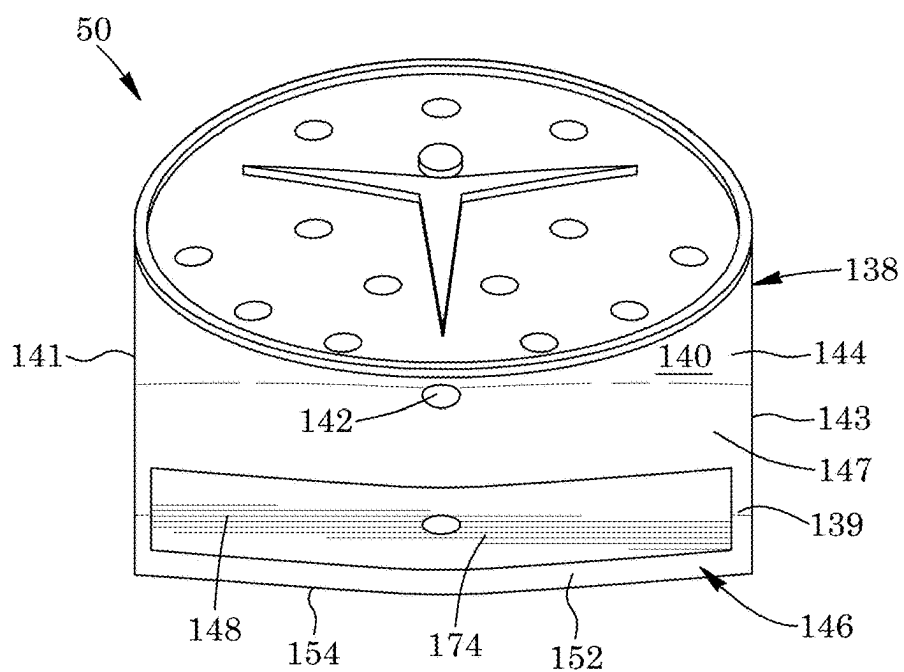


FIG. 6

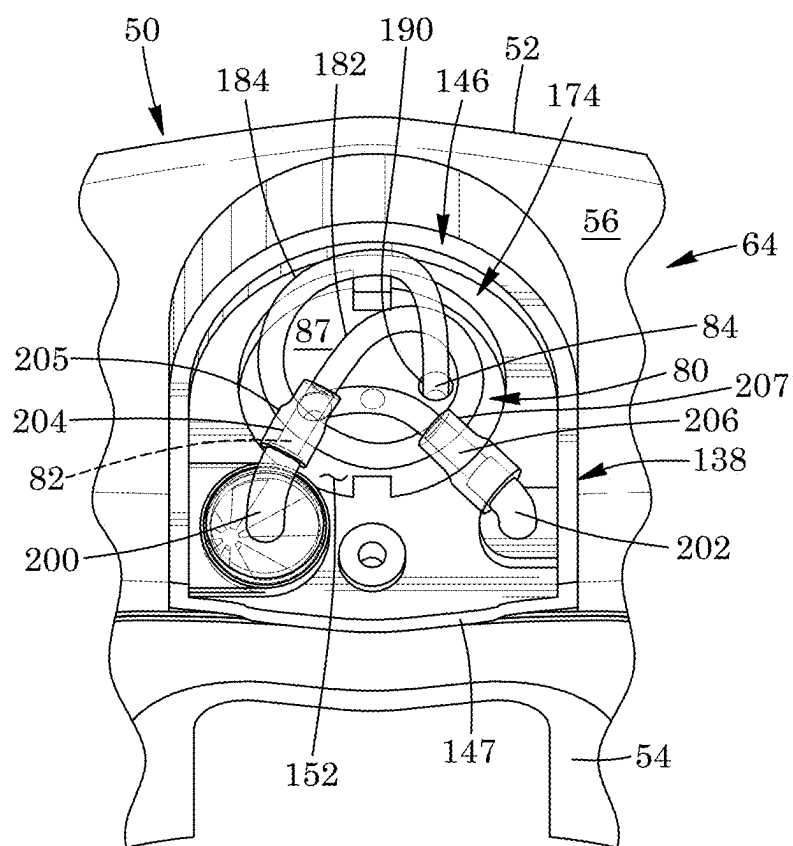


FIG. 7

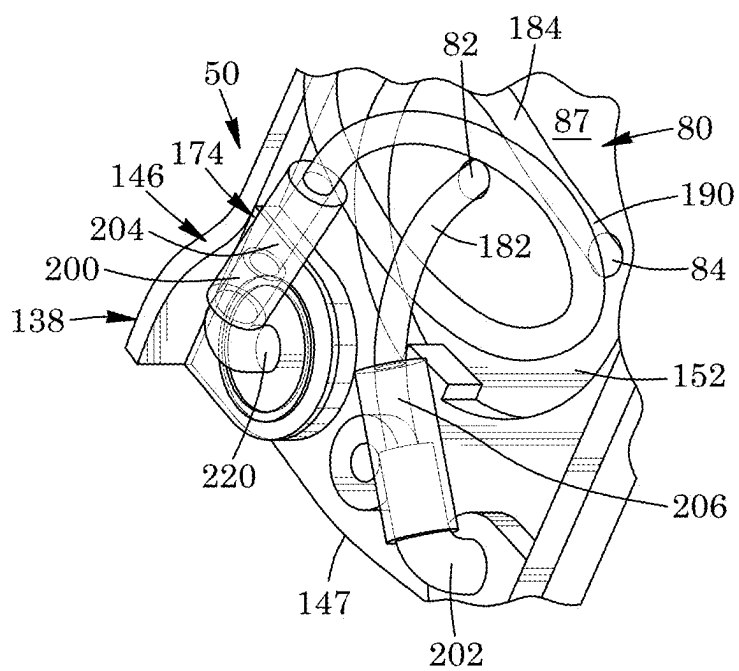


FIG. 8

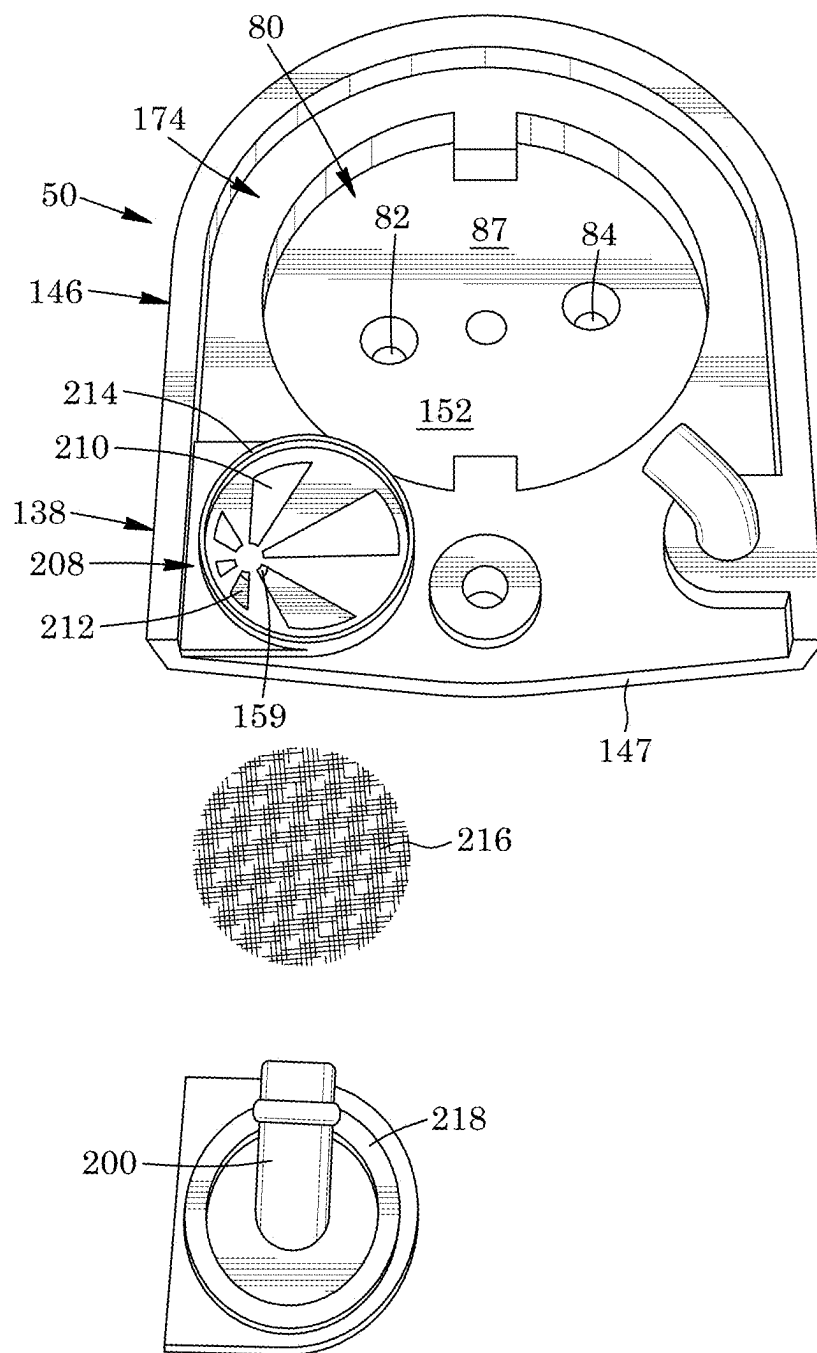


FIG. 9

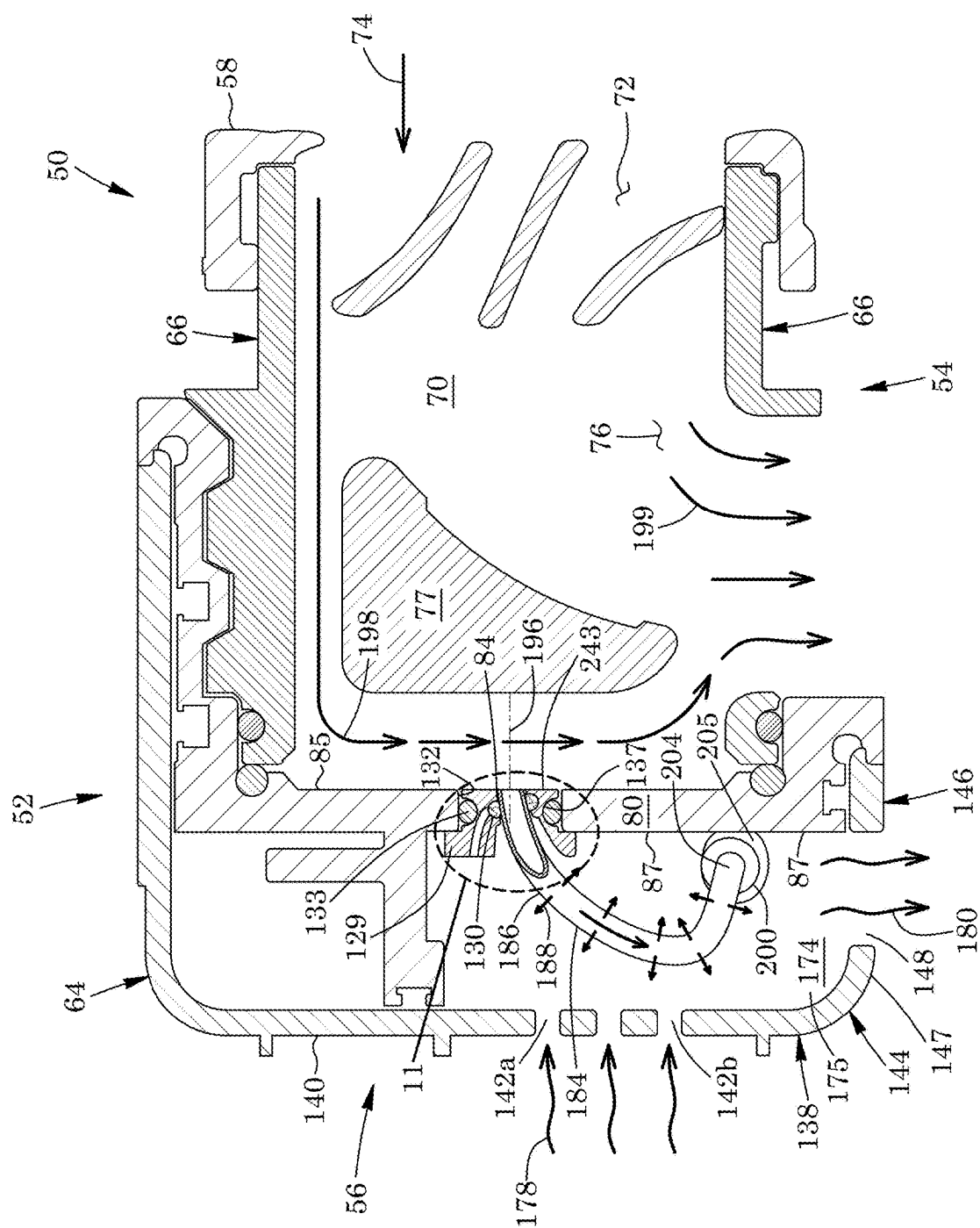


FIG. 10

176



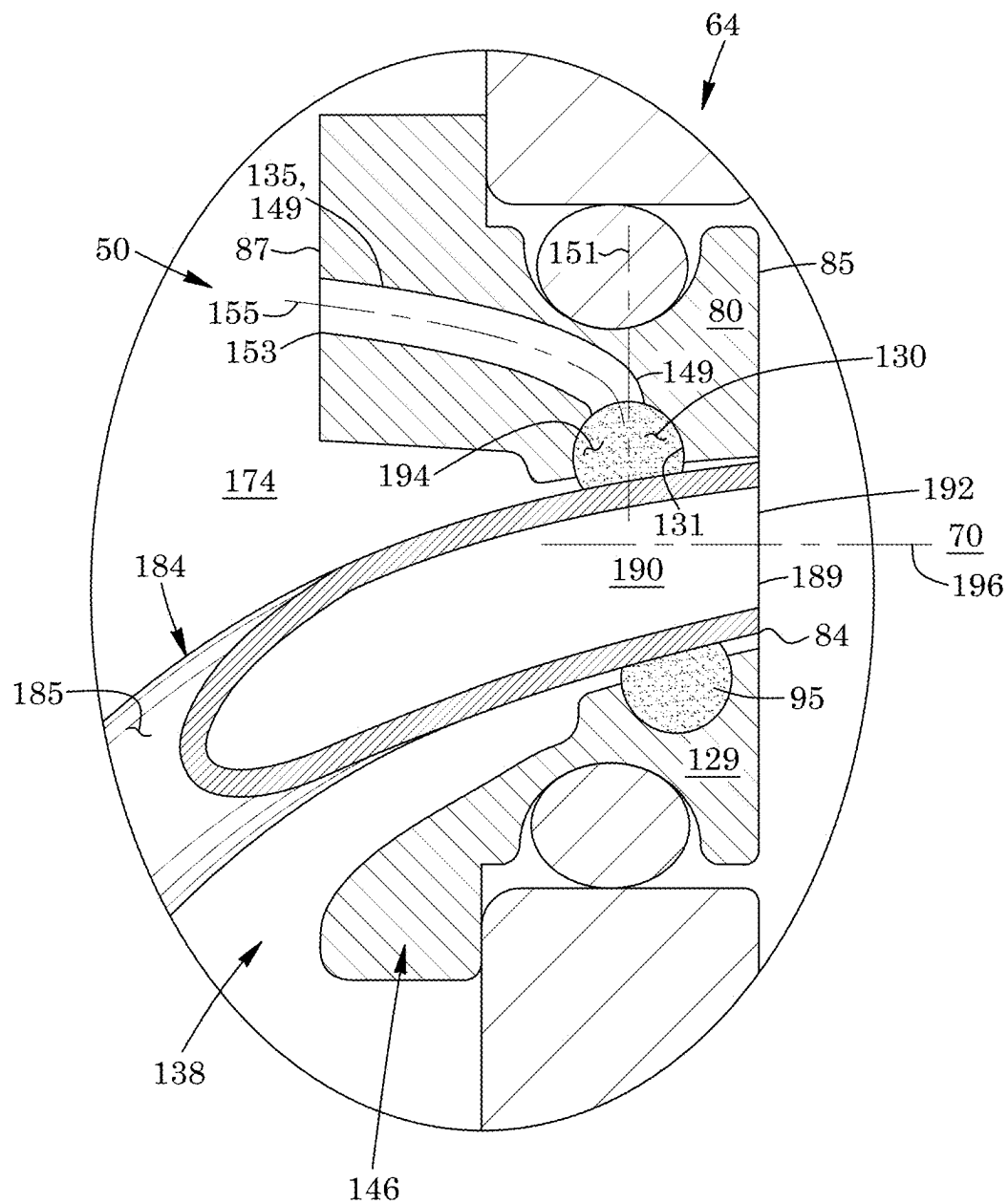
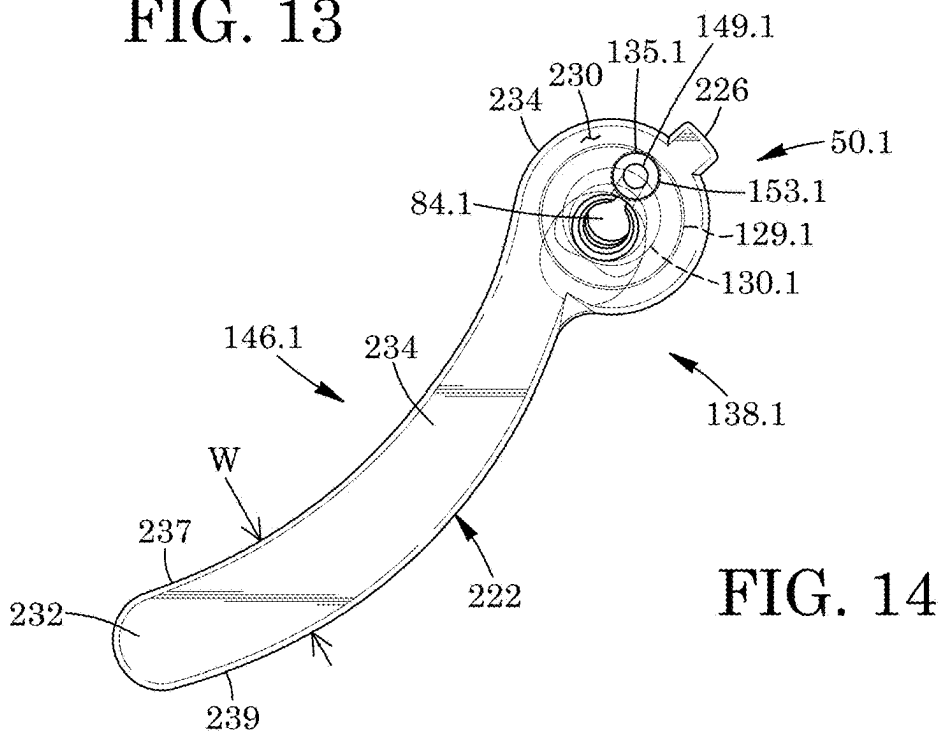
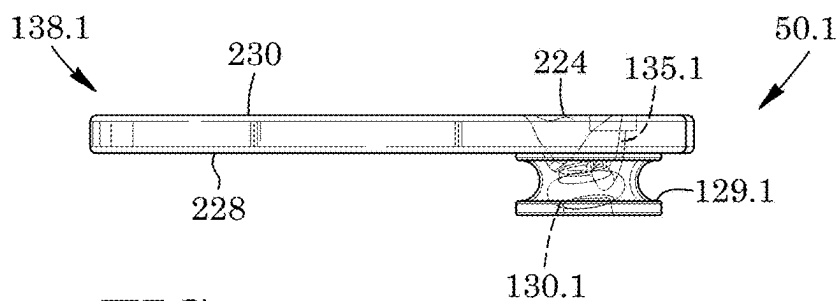
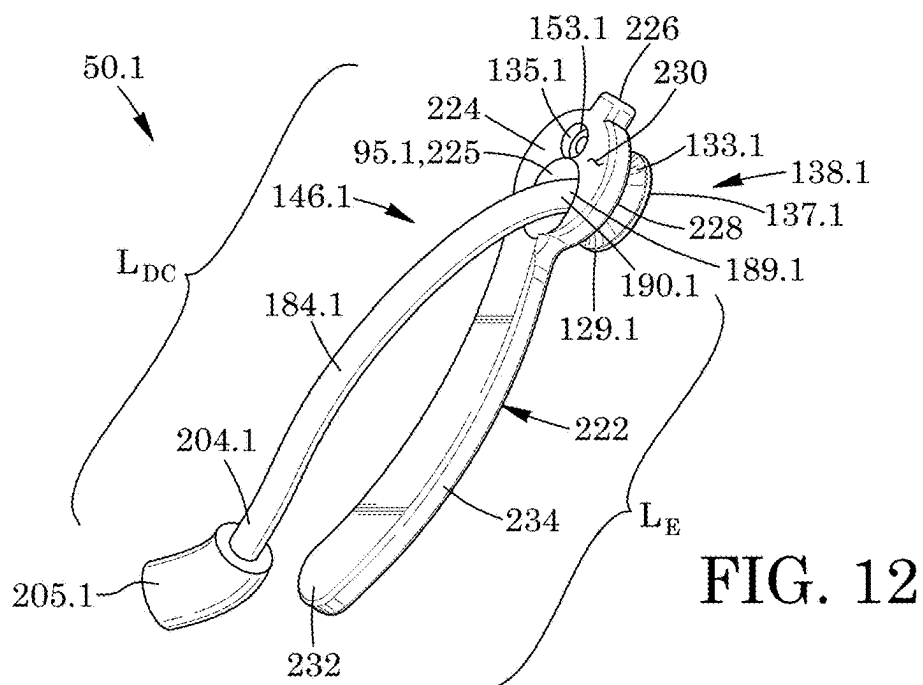


FIG. 11



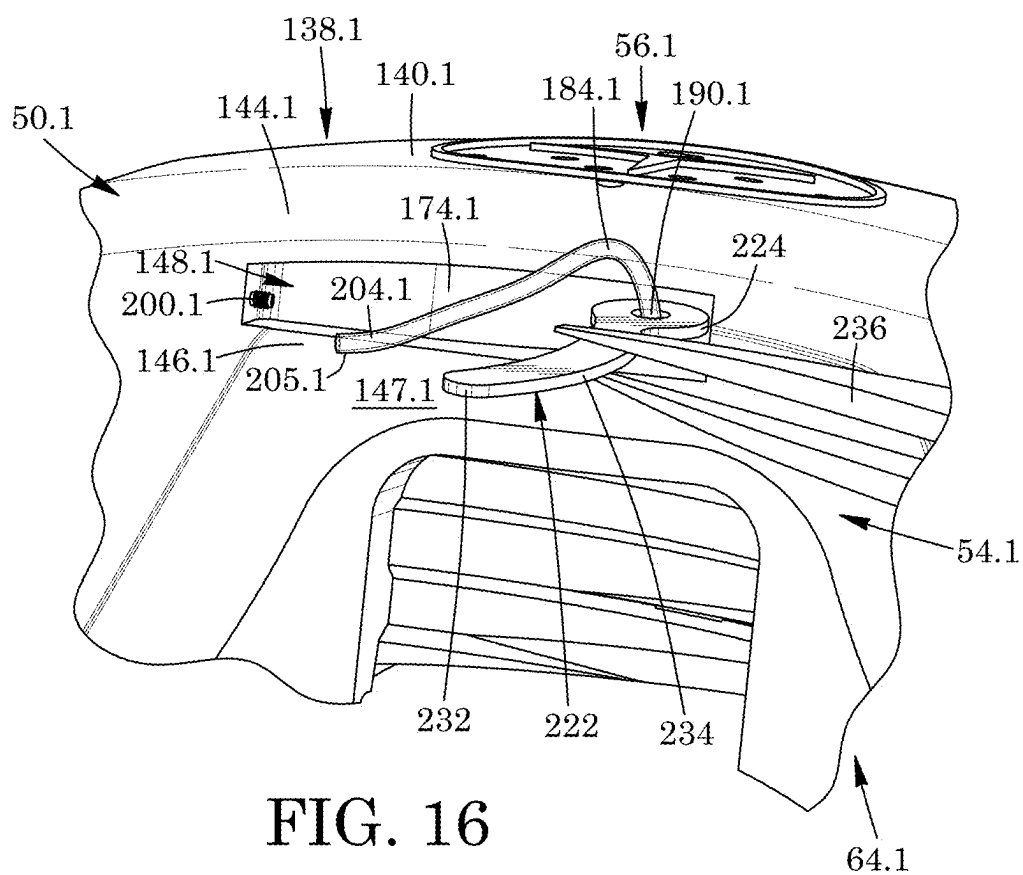
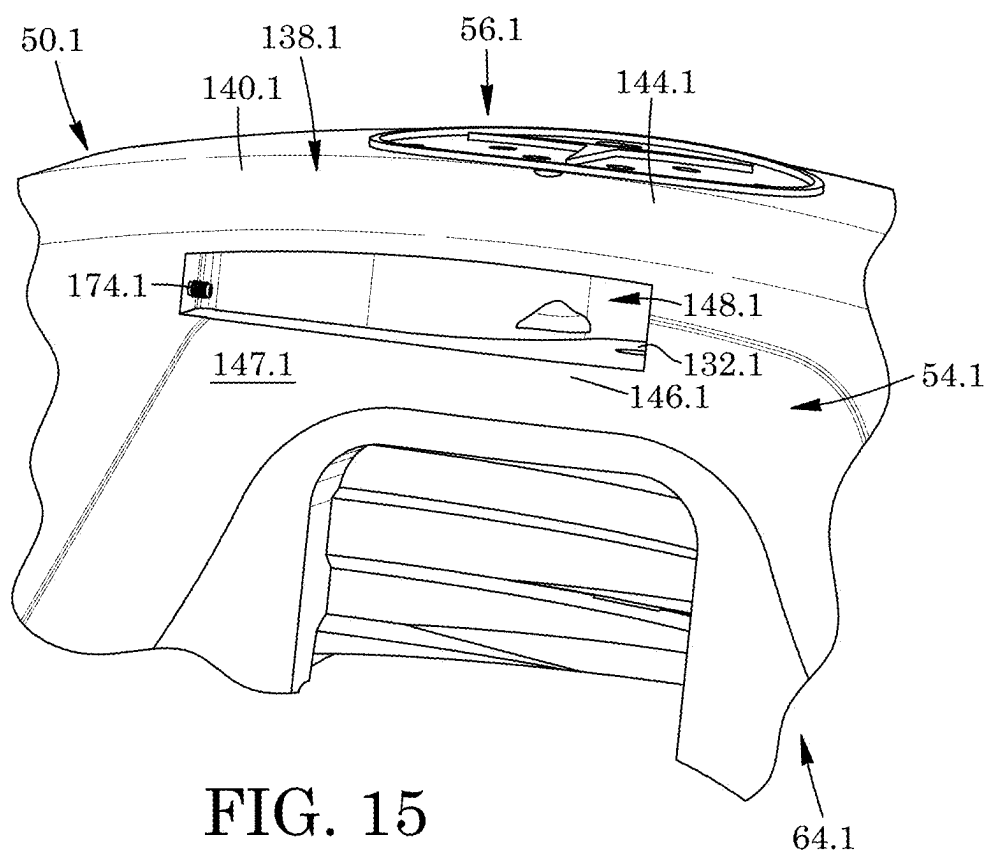
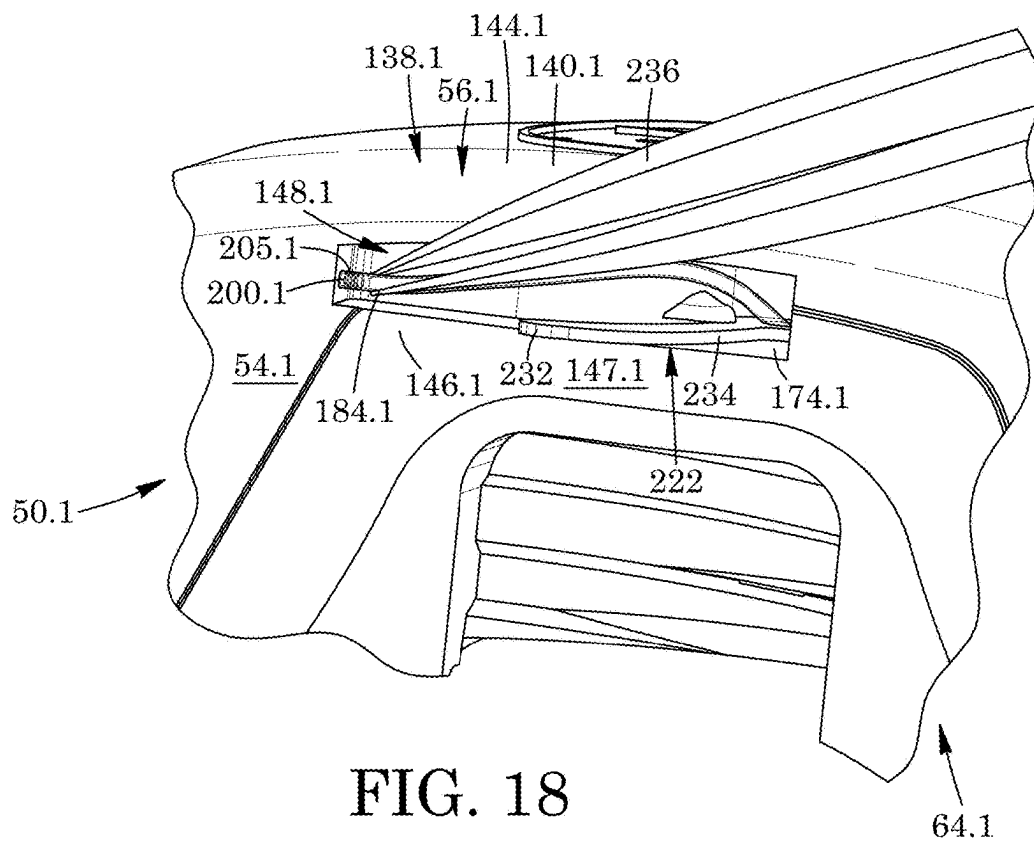
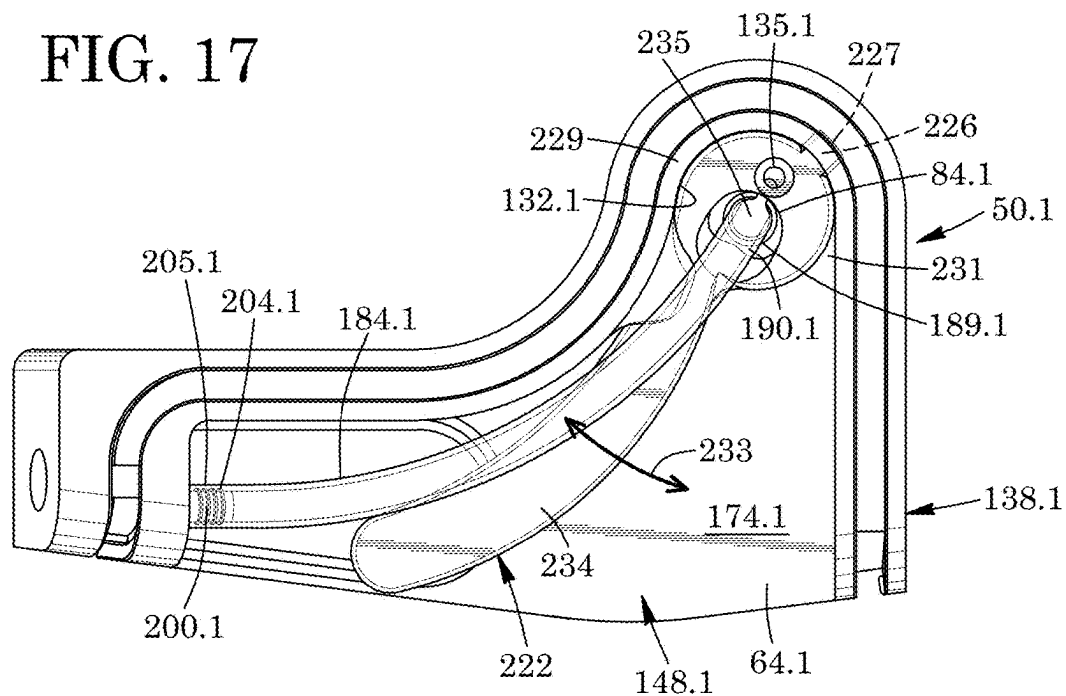
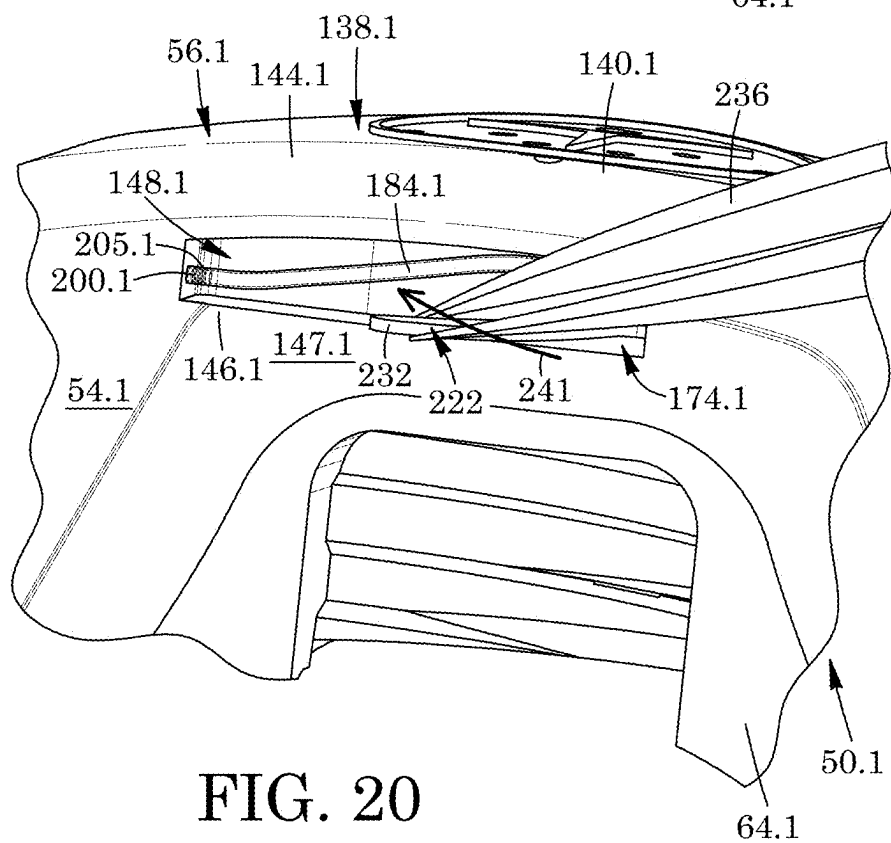
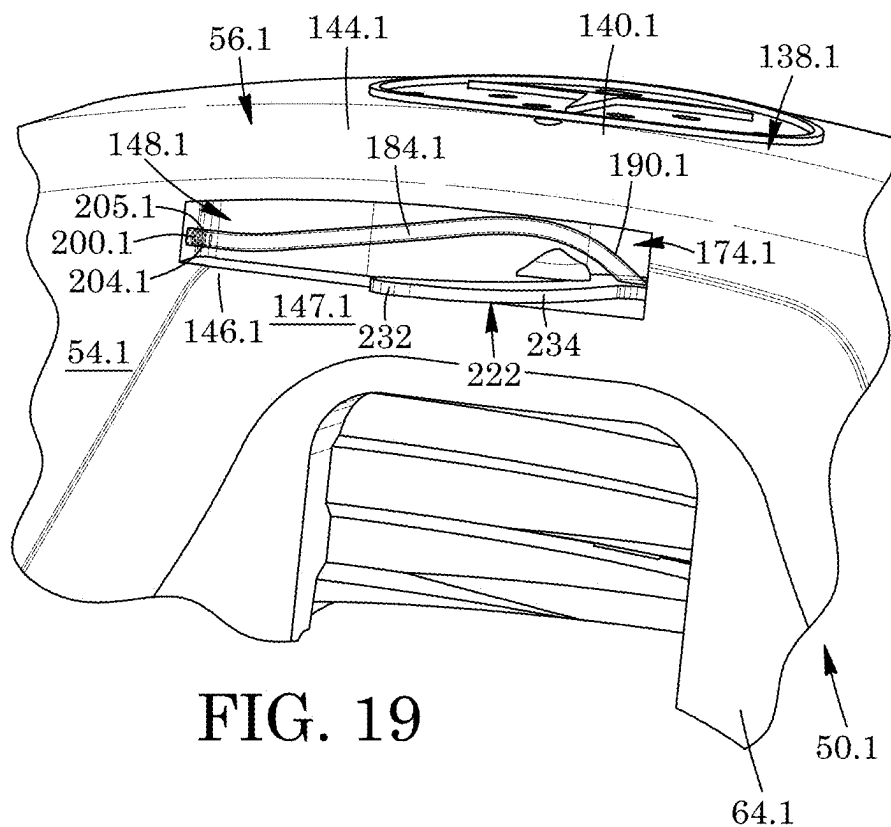


FIG. 17





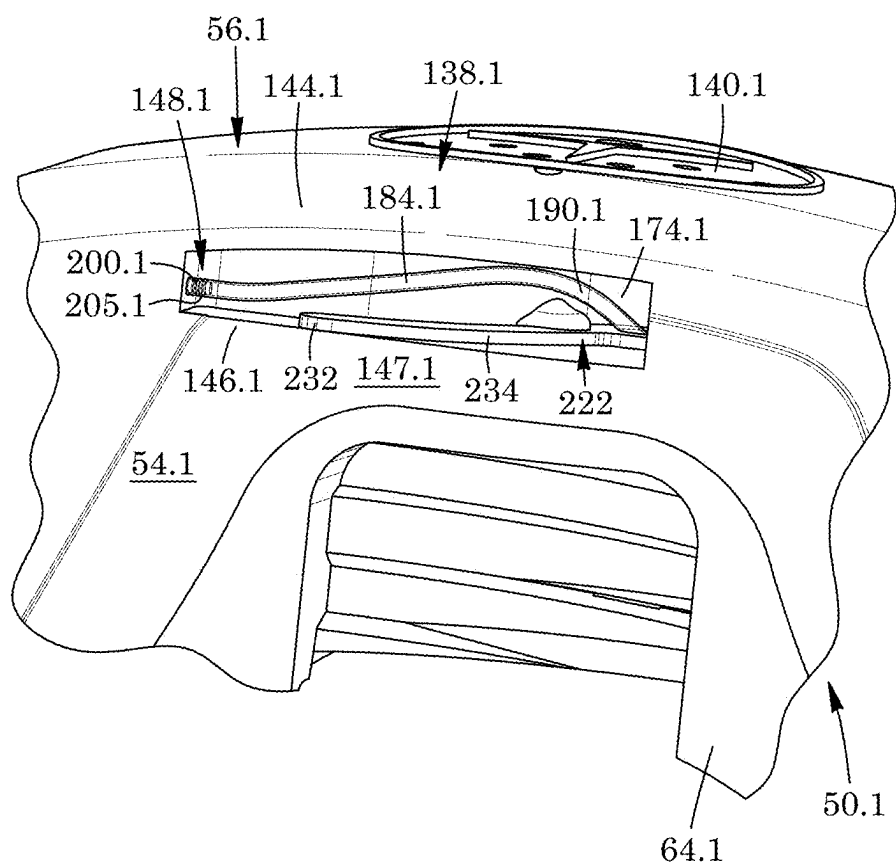


FIG. 21

**DEVICE FOR MEASURING A PERSON'S  
VENTILATION INCLUDING  
OXYGEN-CONSUMPTION, AND A  
DEHUMIDIFICATION CARTRIDGE  
THEREFOR**

**BACKGROUND OF THE INVENTION**

Field of the Invention

[0001] There is provided a device for measuring a person's ventilation. In particular, there is provided a device for measuring a person's ventilation including oxygen consumption, and a dehumidification cartridge therefor.

Description of the Related Art

[0002] International Patent Application Publication No. WO 2019/173894 A1 to O'Brien et al. discloses relates to a device for measuring a person's ventilation. The device includes a conduit with an exhaled-air receiving portion and an inhaled-air receiving portion. The device includes pressure and oxygen sensor sampling ports. The sampling ports are in fluid communication with the conduit. The device includes a deflector disposed within the conduit. The deflector is configured to deflect air exhaled into the exhaled-air receiving portion of the conduit away from the sensor ports.

[0003] U.S. Pat. No. 4,705,543 to Kertzman discloses a fluid dryer. The fluid dryer includes a section of tubing covered by a braided netting. The tubing is formed of a material that has selective and reversible water-absorption properties. The braided netting may be composed of electrical resistance wire, metallic wire, plastic monofilament, etc. Several dryers using the braided tubing employ a desiccant bed and multiple sections of braided tubing.

[0004] United States Patent Application Publication No. 2015/0083121 to Fisher discloses a portable respiratory support apparatus adapted to be easily mounted to a stretcher is disclosed. Prior devices that attach onto a stretcher are heavy and cumbersome and obstruct access to the patient. Accordingly, there is a great need for a portable emergency support device that overcomes the weight, size, positioning, and other portability disadvantages. One aspect relates to a portable life support device including at least one ambient gas inlet; a conditioned gas outlet; an oxygen concentrator fluidly connected between the at least one gas inlet and the gas outlet, and a ventilator fluidly connected downstream from the oxygen concentrator. A further aspect is directed to a portable life support apparatus in the form of a portable respiratory support apparatus capable of exploiting both ambient air and expired gas as oxygen sources, wherein the oxygen generator and ventilator are arranged end to end to provide a longitudinal profile that can thus be compactly secured to a stretcher or other similar emergency transport vehicle.

BRIEF SUMMARY OF INVENTION

[0005] There is provided, and it is an object to provide, an improved ventilation measuring device disclosed herein.

[0006] There is accordingly provided a device for measuring a person's ventilation including oxygen consumption according to one aspect. The device includes a sensor assembly. The device includes a breathing conduit through which at least one exhalation is received. The device includes a replaceable dehumidification cartridge configured

to receive a sample amount of said exhalation from the breathing conduit, dehumidify the sample amount of said exhalation, and direct the sample amount of said exhalation so dehumidified to the sensor assembly.

[0007] There is further provided a device for measuring a person's ventilation including oxygen consumption according to another aspect. The device includes a sensor assembly. The device includes a breathing conduit through which at least one exhalation is received. The breathing conduit has a sensor sampling port. The device includes a dehumidification cartridge. The dehumidification cartridge includes a dehumidification conduit having a proximal end at said sensor sampling port. The dehumidification conduit extends from the sensor sampling portion towards the sensor assembly. The dehumidification cartridge includes a dehumidification chamber enclosing the dehumidification conduit. The dehumidification chamber is shaped to promote a flow of air therethrough. The dehumidification cartridge is shaped to facilitate for sanitary purposes, periodic replacement of either or both of the replaceable dehumidification cartridge and the dehumidification conduit thereof.

[0008] There is additionally provided a device for measuring a person's ventilation including oxygen consumption according to yet another aspect. The device has a front, a rear and a pair of sides extending between the front and rear thereof. The device includes a sensor assembly with a recessed portion centrally positioned between said sides of the device. The recessed portion of the sensor assembly extends inwards from the front towards the rear of the device. The device includes a breathing conduit through which at least one exhalation is received. The device includes a dehumidification cartridge operatively connecting to and interposed between the breathing conduit and the sensor assembly so as to inhibit water damage to the sensor assembly. The dehumidification cartridge selectively couples to and is removable from the recessed portion of the sensor assembly.

BRIEF DESCRIPTION OF DRAWINGS

[0009] The invention will be more readily understood from the following description of preferred embodiments thereof given, by way of example only, with reference to the accompanying drawings, in which:

[0010] FIG. 1 is an exploded front, top, left side perspective view of a ventilation measuring device according to a first embodiment and a face mask therefor, the device including a sensor assembly, a filter, and a breathing conduit shaped to selectively couple to the sensor assembly;

[0011] FIG. 2 is a schematic diagram of the ventilation measuring device of FIG. 1;

[0012] FIG. 3 is a front perspective view of the sensor assembly of FIG. 1, with the sensor assembly including a dehumidification cartridge shown coupled thereto;

[0013] FIG. 4 is a front perspective view of the sensor assembly of FIG. 3, with the dehumidification cartridge shown removed therefrom and positioned in a rear perspective view;

[0014] FIG. 5 is a left side elevation view of the dehumidification cartridge of FIG. 4, the dehumidification cartridge including an outer shell and an inner subassembly;

[0015] FIG. 6 is a front, bottom perspective view of the dehumidification cartridge of FIG. 5;

[0016] FIG. 7 is a front, bottom perspective view of the inner subassembly of the dehumidification cartridge coupled

to the sensor assembly, with the outer shell of the dehumidification cartridge being removed and not shown;

[0017] FIG. 8 is a front perspective view of the inner subassembly of the dehumidification cartridge shown in fragment, with a water contact indicator thereof shown shaded or colored to indicate the presence of water;

[0018] FIG. 9 is an exploded front perspective view of the inner subassembly of the dehumidification cartridge, showing a moisture trap in the form of a hydrophobic membrane;

[0019] FIG. 10 is a sectional view taken along lines 10-10 of the ventilation measuring device of FIG. 3;

[0020] FIG. 11 is a fragmented, enlarged sectional view similar to FIG. 10 of a proximal end portion of a dehumidification conduit of the dehumidification cartridge of FIG. 10 shown coupled to an end wall of a breathing conduit of the ventilation measuring device of FIG. 10;

[0021] FIG. 12 is a front, top perspective view of a dehumidification conduit and lever of a ventilation measuring device according to a second aspect;

[0022] FIG. 13 is a top plan view of the lever of FIG. 12, with the dehumidification conduit being removed and not shown;

[0023] FIG. 14 is a front elevation view of the lever of FIG. 12, with the dehumidification conduit being removed and not shown;

[0024] FIG. 15 is a bottom perspective view of the ventilation measuring device of FIG. 12, with a breathing conduit thereof being removed and not shown;

[0025] FIG. 16 is a bottom perspective view of the ventilation measuring device of FIG. 15, with the dehumidification conduit and lever thereof shown in the process of being inserted within a dehumidification chamber of the device via a slot thereof and shown in the process of coupling to a dehumidification cartridge of the device;

[0026] FIG. 17 is a sectional view of the dehumidification chamber of the ventilation measuring device of FIG. 16, with the proximal end portion of the dehumidification conduit shown coupled to a sensor sampling port of the ventilation measuring device and with the lever positioned within the dehumidification chamber in a stowed position;

[0027] FIG. 18 is a bottom perspective view of the ventilation measuring device of FIG. 17, with the distal end portion of the dehumidification conduit shown in the process of being coupled to a hose barb;

[0028] FIG. 19 is a bottom perspective view of the ventilation measuring device of FIG. 18 with the distal end portion of the dehumidification conduit shown coupled to the hose barb, and with the distal end portion of the lever shown extending outwards from the dehumidification chamber in a deployed position;

[0029] FIG. 20 is a bottom perspective view of the ventilation measuring device of FIG. 19, with the lever thereof being shown in the process of being moved from the deployed position to the stowed position; and

[0030] FIG. 21 is a bottom perspective view of the ventilation measuring device of FIG. 19, with the dehumidification conduit and lever thereof shown fully positioned with the dehumidification chamber thereof, with the lever thus being in the stowed position.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0031] Referring to the drawings and first to FIG. 1, there is provided a device for measuring a person's ventilation

including oxygen-consumption, namely a ventilation measuring device 50. The device measures various ventilation-related data obtained from the person's exhalations and/or inhalations including but not necessarily limited to oxygen-consumption. The device 50 may thus also be referred to as an oxygen-consumption measuring device. The device has a top 52, a bottom 54, a front 56, a rear 58 and a pair of opposite sides 60 and 62. The sides of the device 50 extend between the top and bottom of the device, and between the front and rear of the device. The front 56 and rear 58 of the device extend between the top 52 and bottom 54 of the device.

[0032] The sides 60 and 62 and rear 58 of the device 50 are connectable to a breath-receiving member, in this example a face mask 63 shaped to cover a person's mouth and nose (not shown). In this example, the face mask is an off-the-shelf component of a 7450 V 2-type which may be purchased at Hans Rudolf, Inc., having an address of 8325 Cole Parkway Shawnee, Kansas, 66227, United States of America. However, this type of face mask is not strictly required and other types face masks or mouth and/or nose engagement mechanisms may be used in other embodiments, such as a swimming snorkel mouthpiece with a nose clamp, for example.

[0033] Still referring to FIG. 1, the device 50 includes a sensor assembly 64, a breathing conduit 66 threadably connectable to the sensor assembly, and a filter 68 interposable between the sensor assembly and breathing conduit thereof. The filter is circular in this example. The filter 68 is an off-the-shelf component that may be purchased at Superior Felt & Filter, having an address of 1150 Ridgeview Drive, McHenry, Illinois, 60050, United States of America, for instance. However, this is not strictly required and other types of filters may be used.

[0034] The sensor assembly 64 is u-shaped in top and bottom profile in this example. As seen in FIG. 4, the sensor assembly has a centrally-positioned recessed portion 73 extending from the rear 58 towards the front 56 of the device 50 in this example.

[0035] As seen in FIG. 2, the breathing conduit 66 has an interior 70. The breathing conduit includes an exhaled-air receiving portion 72 within the interior thereof and which receives exhalations in an airflow direction arrow 74. The breathing conduit 66 includes an inhaled-air receiving portion 76 within the interior 70 thereof and which receives inhalations in an airflow direction arrow 78. The exhaled-air receiving portion 72 of the breathing conduit is in fluid communication with the inhaled-air receiving portion 76 of the breathing conduit.

[0036] The breathing conduit 66 includes a divider or deflector 77 positioned within the interior 70 thereof. The deflector is positioned between exhaled air receiving portion 72 of the breathing conduit and inhaled-air receiving portion 76 of the breathing conduit. The deflector 77 is configured to deflect external liquid, such as saliva or water droplets 79 downwards relative to FIG. 2 and as shown by arrow 81.

[0037] The breathing conduit 66 has a first wall, in this example an annular wall 83 which in this example threadably couples to the sensor assembly 64 seen in FIG. 1. As seen in FIG. 2, the device 50 includes a second wall, in this example an end wall 80. The device has a plurality of sensor sampling ports extending through the end wall of the breathing conduit, in this example first and second sampling ports, in this case pressure sensor sampling port 82, and oxygen



and environmental sensor sampling port **84**. The end wall **80** may be part of the sensor assembly **64** in some embodiments, may be part of a removable cartridge in some embodiments, and/or may be integrally formed with the breathing conduit **66** in some embodiments.

**[0038]** Still referring to FIG. 2, the device **50** includes a flow sensing mechanism or flow sensor, in this example a pressure sensor, in this case a differential pressure sensor **86**. The differential pressure sensor in this example is an off-the-shelf component, in this case an A M S5915-type pressure sensor that may be purchased at Analog Microelectronics GmbH, having an address of An der Fahrt 13, 55124 Mainz, Germany. However, this type of sensor is not strictly required and other types of pressure sensors may be used in other embodiments. The pressure sensor **86** has a first pressure sensor inlet **88** connected to and in fluid communication with pressure sensor sampling port **82** via conduit **90**. The pressure sensor has a second pressure sensor inlet **92**. The device **50** includes an ambient or open air port **98** and a conduit **96** which extends between the second pressure sensor inlet of the pressure sensor **86** and the open air port. The second pressure sensor inlet **92** of the pressure sensor is thus connected to and in fluid communication with the ambient air/atmosphere **94** via conduit **96** in this embodiment.

**[0039]** The device **50** includes an environmental sensor **100**. The environmental sensor is in this example an off-the-shelf component, in this case a BM E280-type environmental sensor which may be purchased at Bosch Sensortec GmbH, having an address of Gerhard-Kindler-Straße 9, 72770 Reutlingen/Kusterdingen, Germany. However, this type of sensor is not strictly required and other types of environmental sensors may be used in other embodiments. The environmental sensor **100** has a port **102** connected to and in fluid communication with oxygen and environmental sensor sampling port **84** via a passage, in this example conduit **104**.

**[0040]** The device **50** includes an oxygen sensor **122**. The oxygen sensor is a passive sensor and is an off-the-shelf component of the galvanic fuel cell type in this example. The oxygen sensor **122** may be purchased at Analytical Industries Inc., having an address of 2855 Metropolitan Place, Pomona, California, 91767, United States of America. However, this type of sensor is not strictly required and other types of oxygen sensors may be used in other embodiments. The oxygen sensor **122** has a pair of oxygen sensor ports **124** and **126** that are in fluid communication with sampling port **84** via conduits **104** and **128**. Conduits **90**, **104** and **128** are relatively small in volume and relatively short in length to reduce the amount of gas that is not useful, namely, gas in the sample line before the sensors that is left in the sample line between breaths. The conduits so shaped minimize the time it takes for the new gas to reach the sensors. The conduits **90**, **104** and **128** so shaped also function to inhibit resistance to flow. The oxygen sensor **122** emits an oxygen sensor signal.

**[0041]** As seen in FIG. 1, the device **50** includes a microprocessor **123** positioned within sensor assembly **64**. The microprocessor is in communication with and receives data from the oxygen sensor **122** seen in FIG. 2 via an analog-to-digital converter **125** seen in FIG. 1 in this example.

**[0042]** As seen in FIG. 2, the device **50** in this example includes an electromechanically operated valve, in this case a solenoid valve **134**. The solenoid valve is an off-the-shelf

component, in this example Parker™ 915-000001-005-type solenoid valve which may be purchased at Parker Hannifin Corp, having an address of 26 Clinton Drive, Hollis, New Hampshire, 03049, United States of America. However, this type of valve is not strictly required and other types of electromechanically operated valve and/or solenoid valves may be used in other embodiments. The solenoid valve **134** selectively opens and closes for optimal use of oxygen sensor **100** and environmental sensor **122** and calibration of the device **50**. However, this is not strictly required and the device may omit the solenoid valve in other embodiments. Also, the oxygen sensor **122** is between the environmental sensor **100** and solenoid valve **134** in FIG. 2 but this too is not strictly required: for example, the oxygen sensor may be positioned closer to the sensor sampling port **84** than the environmental sensor in other embodiments.

**[0043]** Still referring to FIG. 2, when a person using the device **50** inhales, as seen by arrow of numeral **78**, the differential pressure sensor **86** is subject to turbulence that is absent in the environmental sensor's pressure output. The device **50** is thus configured to use the change in the environmental sensor's pressure output, in the form of signals or data sent to microprocessor **123** seen in FIG. 1, to determine the inhale flow rate. This circumvents signal noise which may otherwise occur in the differential pressure sensor signal during inhales. The environmental sensor **100** also outputs temperature and relative humidity data to the microprocessor **123** seen in FIG. 1 for flow calculations and oxygen sensor signal correction. Differential pressure is used by the microprocessor to calculate both inhale and exhale flow rates. In another embodiment, absolute pressure inhale flow sensing may optionally be used.

**[0044]** The pressure sensor output is used for breath state detection and exhale flow rate calculations performed by the microprocessor **123** seen in FIG. 1. The pressure sensor **86** seen in FIG. 2 is used to detect breath state by means of a zero-crossing check of the differential pressure sensor output with consideration to the sensor's signal noise threshold. If the breath state is in an exhale direction as shown by arrow **74**, the differential pressure sensor output is used to compute the instantaneous flow rate between data samples. If the breath state is in an inhale direction as shown by arrow **78**, the difference between the environmental sensor pressure output and ambient pressure is used to compute an instantaneous flow rate between data samples. Ambient pressure is considered to be the last environmental sensor pressure output where no breathing has occurred. The instantaneous flow volume between data samples is calculated using each gap's instantaneous flow rate. When the breath state returns to no breathing, all of the instantaneous flow volumes for the completed breath segment are summed. This sum is known by those skilled in the art as tidal volume ( $Tv(L)$ ). Breath segment frequency is then calculated using the following formula:  $(\text{segment } Rf) = 30 \text{ s} / (\text{breath segment time(s)})$ . The ventilation ( $Ve$ ) of the breath segment is calculated using the following formula:  $Ve(L/min) = (\text{breath segment frequency}) \times (\text{breath segment tidal volume } (L))$ . For each pair of inhale and exhale segments, average breath segment frequency ( $Rf$ ),  $Tv$ , and  $Ve$  are determined as the final flow metrics for the whole breath.

**[0045]** The sensors **86**, **100** and **122** and solenoid valve **134** together with microprocessor **123** seen in FIG. 1 function in unison to selectively acquire ventilation data and determine ventilation metrics, such as oxygen-consumption,

based on the flow of exhalations passing through breathing conduit 66, as well as based on inhalations in some embodiments and/or for some aspects thereof. The device 50 as disclosed to this stage is known and is described in more detail in U.S. patent application Ser. No. 16/093,853 having a filing date of 13 Apr. 2017 and U.S. patent application Ser. No. 16/970,325 having a filing date of 18 Oct. 2018, the disclosures of which are incorporated herein by reference and priority to which is hereby claimed.

[0046] Referring to FIG. 10, the end wall 80 may be considered a wall of the breathing conduit 66 as seen in FIG. 2. As seen in FIG. 11, the end wall 80 has an inner side 85 in fluid communication with the interior 70 of the breathing conduit and an outer side 87 spaced-apart from the inner side thereof. As seen in FIG. 10, the end wall 80 includes a wall portion extending about each sensor sampling port, as seen by wall portion 129 extending about sensor sampling port 84. Each wall portion is planar and circular in profile in this example. Each wall portion 129 has a distal end 243 facing the interior 70 of the breathing conduit 66.

[0047] As seen in FIG. 11, each wall portion 129 includes a reservoir, in this example an inner groove or annular recess 130 spaced from the inner side 85 of the wall 80 and spaced from distal end 243 of the wall portion. The annular recess is centrally positioned relative to, is in fluid communication with and extends radially outwards from bore 95 in this example. The annular recess 130 is toroidal in shape at least in part in this example. The annular recess 130 is annular in profile and semi-circular in lateral profile in this example. As seen in FIG. 11, each annular recess 130 extends radially outwards from its corresponding sensor sampling port 84. Each annular recess is positioned between the inner side 85 of the wall 80 and the outer side 87 of the wall. Each annular recess 130 has an inward facing annular surface 131 that is outwardly concave in lateral and longitudinal section in this example.

[0048] Referring to FIG. 11, the end wall 80 includes a passageway 135 that extends from one of the sides of the end wall, in this example from the outer side 87 of the wall 80 to the annular recess 130. The passageway is in fluid communication with its respective annular recess via a first end portion 149 thereof. The first or distal end portion 149 of the passageway 135 extends about a first longitudinal axis 151 that extends radially outwards from the annular recess 130 in this example; however this is not strictly required. The passageway includes a second end portion 153 that extends along a second longitudinal axis 155 that is perpendicular to the first longitudinal axis thereof; however, this is not strictly required. The passageway 135 includes an elongate portion 161 extending between the end portions 149 and 153 thereof. The elongate portion of the passageway is arc-shaped in this example.

[0049] As seen in FIG. 10, each wall portion 129 of the wall 80 in this example is selectively removable and press-fit into a corresponding aperture 132 of the wall and coupled thereto via a seal, in this case an O-ring 133. The portion 129 of the wall through each sensor sampling port 84 extends thus sealably couples to and is selectively removable from a corresponding aperture in the wall 80. The O-ring fits within an outer annular groove 137 of the wall portion 129.

[0050] As seen in FIG. 3, the device 50 includes a dehumidification assembly 138, which may be considered part of the sensor assembly 64. The dehumidification assembly has a first or front wall 140 that may be aligned with the front

56 of the device 50. However, this is not strictly required and the front wall may not be aligned with the front of the device in other embodiments. Through the front wall extends at least one and in this example a plurality of apertures 142a, 142b, 142c, 142d, 142e, 142f, 142g, 142h, 142i, 142j, 142m and 142n. Apertures 142a, 142g, 142h, 142m, 142n, 142l, 142j, 142d and 142c are arranged in a generally circular arrangement in this example, and apertures 142e, 142f, 142i and 142k are positioned within this circular arrangement in this example.

[0051] As seen in FIG. 6, the dehumidification assembly 138 includes an outer shell 144. The front wall 140 is part of the outer shell, and the outer shell further includes side walls 141 and 143 coupled to the front wall thereof. The dehumidification assembly 138 includes an inner subassembly 146 to which the outer shell 144 selectively couples. In this example the inner subassembly couples to the outer shell via a press-fit connection 139 that is further coupled together via fasteners, in this example bolts (not shown). As seen in FIG. 10, the outer shell 144 and inner subassembly 146 form a bottom 147 which has at least one aperture, in this example in the form of a slot 148, extending there-through.

[0052] As seen in FIG. 4, end wall 80 is a part of the inner subassembly 146 of the dehumidification assembly 138 in this example. The inner subassembly includes a base member 152. The end wall is circular in this example and couples to and extends outwards from a first or inner side 154 of the base member. The end wall 80 is centrally positioned relative to the base member 152 in this example. The inner subassembly 146 includes a pair of lower protrusions 156 and 158 that couple to and extend outwards from the inner side 154 of the base member. Each of the protrusions includes respective apertures 157 and 159 extending there-through.

[0053] As seen in FIGS. 3 and 4, the dehumidification assembly 138 is selectively removable from the rest of the sensor assembly 64 for sanitary purposes. In this example and referring to FIG. 4, the sensor assembly includes a recessed portion 160 centrally positioned between the sides 60 and 62 of the device 50 and extending inwards from the front 56 of the device towards the rear 58 of the device.

[0054] The recessed portion of the sensor assembly includes a central aperture 162 and a pair of spaced-apart-lower apertures 164 and 166. Aperture 164 seen in FIG. 4 is in fluid communication with conduit 104, environmental sensor 100, oxygen sensor 122 and solenoid valve 134 seen in FIG. 2. Aperture 166 is in fluid communication with conduit 90 and pressure sensor 86 seen in FIG. 2.

[0055] Referring back to FIG. 4, the end wall 80 and protrusions 156 and 158 selectively extend through the apertures 162, 164 and 166, and couple to adjacent portions of the sensor assembly 64 via seals, in this example O-rings 168, 170 and 172 extending about the end wall and protrusions. The dehumidification assembly 138 is thus selectively removable and may be referred to as a removable dehumidification cartridge or cartridge assembly, which may be press-fit and/or fastened in place via fasteners such as bolts (not shown). The O-rings 168, 170 and 172 seal the airflow path from the rest of the device 50.

[0056] As seen in FIG. 10, the dehumidification assembly 138 includes a dehumidification chamber 174. The dehumidification chamber is formed in part by shell 144 comprising front wall 140, bottom 147 and end wall 80, and side

walls **141** and **143** seen in FIG. 6. Referring back to FIG. 10, the dehumidification chamber **174** has an interior **175** enclosed by the front wall, bottom, end wall and side walls. The interior of the dehumidification chamber is accessible via the slot **148** of the dehumidification chamber. The apertures **142b**, **142n** of the front wall expose the dehumidification chamber **174** to ambient air **176**. The slot **148** extending through the bottom **147** is shaped further expose the dehumidification chamber to ambient air. The dehumidification chamber **174** may thus be said to have a plurality of openings including apertures **142b**, **142n** and slot **148**. The dehumidification chamber is shaped to promote a flow of air therethrough, including airflow entering into the chamber via apertures **142b** and **142n**, as seen by arrows **178**, and airflow exiting the chamber via slot **148**, as seen by arrows **180**.

[0057] Referring to FIG. 2, the dehumidification assembly **138** includes at least one, and in this example a pair of conduits, in this case flexible, dehumidification conduits **182** and **184**. The dehumidification conduits are sub-portions of conduits **90** and **128** in this example. The dehumidification conduits **182** and **184** have hydrophobic properties and are made of hydrophobic material in this example. Each of the dehumidification conduits comprises Nafion™-type tubing in this example, which may be purchased at Perma Pure LLC, having an address of 1001 New Hampshire Ave., Lakewood, New Jersey, 08701, United States of America. However, this is not strictly required and the dehumidification conduits may be made of other types in other embodiments.

[0058] The dehumidification conduits **182** and **184** are positioned to receive sample portions of air from one or more of expirations, as shown by arrow **74**, passing through the breathing conduit **66**. The dehumidification conduits are also positioned to receive sample portions of air from inhalations, as shown by arrow **78**, passing through the breathing conduit. The dehumidification conduits **182** and **184** are disposed at least in part within the dehumidification chamber **174**.

[0059] As seen in FIG. 10, each dehumidification conduit **184** may include a plurality of circumferentially, longitudinally and axially spaced-apart apertures **186** via which water particles/droplets may diffuse outwards, as shown by arrows of number **188**. The device **50** utilizes passive diffusion of humidity, with the area surrounding the dehumidification conduits, namely, dehumidification chamber **174**, being purged by ambient shown moving in airflow direction arrows **178** and **180** flowing through apertures **142b** and **142n** and slot **148**. The dehumidification conduits **184** are semi-open to ambient air with a volume that promotes humidity normalization through air-exchange and diffusion to the ambient air, particularly with wind and head movement of the user (not shown).

[0060] As seen in FIG. 2, the dehumidification conduits **182** and **184** extend from their corresponding sensor sampling ports **82** and **84** towards sensor **86** and sensors **100** and **122**, respectively. As seen in FIG. 7, dehumidification conduit **184**, in fluid communication with the environmental sensor **100** and oxygen sensor **122** seen in FIG. 2, is longer than dehumidification conduit **182** in fluid communication with the differential pressure sensor **86** seen in FIG. 2. Referring back to FIG. 7, dehumidification conduit **184** spirals within dehumidification chamber **174** in this example.

[0061] As seen in FIG. 11, each dehumidification conduit **184** has a proximal end **189** with a proximal end portion **190** which is at least in part press-fit into its corresponding sensor sampling port **84** in this example. The sensor sampling port is part of a bore **95**. The proximal end portion of the dehumidification conduit is positioned such that the proximal end **192** of the dehumidification conduit is flush with its sensor sampling port **84** and flush with the inner side **85** of wall **80**.

[0062] Still referring to FIG. 11, the dehumidification assembly **138** includes adhesive **194** selectively positioned within and, in this example, injected via passageway **135** into each annular recess **130** of wall **80**. The passageway is thus shaped to direct adhesive into the annular recess. The adhesive **194** thus further couples each of the proximal end portions **190** of the dehumidification conduits **184** to their respective wall portion **129** of the wall **80** in this example. The adhesive **194** is spaced-apart from the inner side **85** of the wall **80** and is positioned between the inner side and outer side **87** of the wall in this example. Each dehumidifying conduit **184** thus couples to its corresponding wall portion **129** via a relatively small contact area of adhesive. As each wall portion **129** is selectively removable, so too is each dehumidification conduit thus selectively removable and replaceable. Each dehumidifying conduit thus couples to its corresponding wall portion in a manner which inhibits the extent to which the adhesive **194** covers the outer surface **185** thereof.

[0063] As seen in FIG. 11, each dehumidification conduit **184** has a longitudinal axis **196** about which the proximal end portion **190** thereof extends. As seen in FIG. 10, the breathing conduit **66** is shaped to promote a sample portion flow of air **198** adjacent the sensor sampling ports **84** in one or more directions perpendicular (upwards or downwards relative to FIG. 10) to the longitudinal axes of the dehumidification conduits. However, this is not strictly required for the pressure sensor sampling port **82** seen in FIG. 2. The hydrophobic nature of the dehumidification conduits **184** functions to promote repelling of water droplets **79** and functions to inhibit water droplets from entering within the sensor sampling ports **82** and **84**. The second longitudinal axis **155** of the passageway **135** extends parallel to longitudinal axis **196** of the dehumidification conduit in this example.

[0064] Still referring to FIG. 2, the humidification conduits **182** and **184** are in fluid communication with sample volumes and a sample portion flow of air **198** of the flow of breath **74** and **199** through the breathing conduit **66**, rather than the entire volume and flow of breath of the breathing conduit. The humidification conduits so positioned are the first point of contact for the sample line and are in fluid communication with the sample volumes and sample portion flow of air **198** of the flow of breath **74** and **199** through the breathing conduit.

[0065] Condensation may be more likely to occur at the location of contact between each dehumidification conduit (Nafion™) and plastic (except for the hydrophobic properties of Nafion™) due to the temperature difference between the plastic and sample volume. The dehumidification conduits **182** and **184** so positioned may minimize the area that: cannot efficiently desiccate; accumulates micro-droplets; and provides nucleation sites for condensation. The dehumidification conduits so positioned, coupled to the device **50** and herein configured, may maximize the effective desicca-

tion ability for a given length of conduit, thereby reducing the required dehumidification conduit length comprising the hydrophobic properties.

[0066] As seen in FIG. 7, the dehumidification assembly 138 includes a pair of connectors, in this example spaced-apart hose barbs 200 and 202 coupled to the base member 152 of the inner subassembly 146. The barbs are positioned within the dehumidification chamber 174 in this example. Distal ends 204 and 206 of the dehumidification conduits 182 and 184 couple to the hose barbs 200 and 202 via sleeves 205 and 207 that extend about and press fit to the respective hose barbs. The sleeves thus couple to the distal ends of the dehumidification conduits. The distal ends 204 and 206 of the dehumidification conduits 182 and 184 are in fluid communication with apertures 157 and 159 seen in FIG. 4 via the hose barbs 200 and 202 seen in FIG. 7.

[0067] Referring to FIG. 11, adhesive 194 is positioned in such a way that the dehumidification conduits 182 and 184 are in contact with a minimal area that is not air. Each dehumidification conduit is not contacting air for about 1 mm of length that contacts the adhesive and 0.5 mm of length where it contacts the plastic/barb just before it ends at the distal end thereof in this example; however, these dimensions are not strictly required and may be different in other embodiments. The spacing and geometry shown in FIG. 11 is configured to facilitate flow of the adhesive 194.

[0068] As seen in FIG. 9, the dehumidification assembly 138 includes a moisture trap 208 comprising a hollow enclosure 210 which is generally circular in this example; however, this is not strictly required. The moisture trap 208 includes a first barrier member, in this example filter material or hydrophobic membrane 216. The hydrophobic membrane facilitates passage of gas therethrough while inhibiting passage of moisture therethrough.

[0069] The enclosure 210 of the moisture trap 208 includes a second barrier member, in this example in the form of an intermediate wall 214. The intermediate wall is meshed in this example and has a series of openings, in this example wedge-shaped openings 212 extending there-through. The hydrophobic membrane 216 extends along, is coextensive with and couples to the intermediate wall 214 of the enclosure 210 in this example. The intermediate wall is circular in this example, though this is not strictly required.

[0070] The enclosure 210 of the moisture trap 208 includes an outer end or shell 218 which is circular in this example. The shell couples to and extends about wall 214, with the hydrophobic membrane 216 positioned therebetween. Hose barb 200 couples to and is integrally formed with the outer shell 218 in this example. The enclosure 210 of the moisture trap 208 is in fluid communication with aperture 159 and is thus in fluid communication with environmental sensor 100 and oxygen sensor 122 seen in FIG. 2. Referring back to FIG. 9, the moisture trap is configured to further inhibit damage to the environmental sensor and oxygen sensor.

[0071] As seen in FIG. 8, the dehumidification assembly 138 includes water contact indicator 220. The water indicator is positioned within the enclosure 210 and couples to the hydrophobic membrane 216. The water contact indicator 220 is configured to change color upon detecting or coming into contact with water ingress, and thereby indicates when a water ingress event has occurred.

[0072] The dehumidification assembly 138 seen in FIG. 4 and as herein described is shaped to facilitate periodic replacement thereof and/or the dehumidification conduits 182 and 184 seen in FIG. 7.

[0073] FIGS. 15 to 21 show ventilation measuring device 50.1 according to a second aspect. Like parts have like numbers and functions as the ventilation measuring device 50 shown in FIGS. 1 to 14 with the addition of decimal extension “.1”. Ventilation measuring device 50.1 is substantially the same as ventilation measuring device 50 shown in FIGS. 1 to 14 with at least the following exceptions.

[0074] As seen in FIG. 12, the inner subassembly 146.1 of dehumidification assembly 138.1 includes an elongate member, in this example a handle, in this case a lever arm 222. The lever arm 222 includes a first or proximal end portion, in this example an enlarged end portion 224 which is circular in profile in this example. The lever arm includes a protrusion, in this example a catch 226 coupled to and extending radially outwards from the enlarged end portion thereof. The catch is a rectangular prism in shape and rectangular in profile in this example. The catch 226 is shaped to fit within a corresponding opening or catch recess 227 of the dehumidification chamber 174.1 seen in FIG. 17. The dehumidification chamber has an arcuate shaped member, in this example an outwardly concave seat, in this case an arc-shaped wall portion 229. The catch recess 227 extends into the arc-shaped wall portion of the dehumidification chamber 174.1. The arc-shaped wall portion of the dehumidification chamber 174.1 is outwardly concave in this example and extends about an axis 235. The arc-shaped wall portion 229 is shaped to receive the enlarged end portion 224 of the lever arm 222 and enable the lever arm to pivot about the same and axis 235. The lever arm is thus pivotable relative to the enlarged end portion thereof and relative to the arc-shaped wall portion 229 of the dehumidification chamber 174.1. The arc-shaped wall portion of the dehumidification chamber extends about aperture 132.1.

[0075] As seen in FIG. 13, wall portion or protrusion 129.1 couples to, is integrally formed with and extends outwards from a first or lower side 228 of the enlarged end portion 224 of the lever arm 222 in this example. Alternatively, protrusion 129.1 may be considered part of end portion 224 of the lever arm. As seen in FIG. 12, seal in this example O-ring 133.1 fits within outer annular groove 137.1 and extends about the protrusion. As seen in FIG. 12, protrusion 129.1 is smaller than and radially inwardly spaced from end portion 224 of the lever arm 222. The protrusion and end portion 224 of the lever are coaxial in this example. Passageway 135.1 extends through a second or upper side 230 of the enlarged end portion of the lever arm through to annular recess 130.1.

[0076] Bore 95.1 extends through the enlarged end portion 224 of the lever arm 222 and is shaped to receive the proximal end 189.1 of the conduit. The second end portion 153.1 of the passageway is coaxial with the bore in this example; however, this is not strictly required. The second end portion of the passageway has a diameter Dse which is smaller than the diameter DB of the bore 95.1 in this example.

[0077] As seen in FIG. 12, dehumidification conduit 184.1 extends through a first or central aperture 225 of the enlarged end portion 224 of the lever arm. The central aperture aligns with the sensor sampling port 84.1. The dehumidification

conduit **184.1** couples to protrusion **129.1** in a manner as previously described above in FIGS. **1** to **11** via adhesive and optionally press fitting. The proximal end portion **190.1** of the dehumidification conduit thus couples to and aligns with the enlarged end portion **224** of the lever arm **222**. As seen in FIG. **17**, the lever arm thus couples to and extends outwards from proximal end **189.1** of the dehumidification conduit **184.1** in this example and towards distal end **204.1** of the dehumidification conduit.

[0078] Referring to FIG. **14**, the lever arm includes a second or distal end portion, in this example a gripping end portion **232** spaced-apart from the enlarged end portion thereof. The lever arm **222** includes an elongate portion **234** extending between the gripping end portion thereof and enlarged end portion **224** thereof. The gripping end portion and elongate portion of the lever arm are planar and have a constant width *W* in this example. As seen in FIG. **12**, elongate portion **234** of the lever arm has a length *LE* equal to or less than the length *Loc* of the dehumidification conduit **184.1**.

[0079] The gripping end portion **232** of the lever arm **222** is outwardly convex and semi-circular in planar profile in this example; however, this is not strictly required. The elongate portion **234** of the lever arm is arc-shaped in this example. The elongate portion of the lever arm **222** has a first peripheral edge portion **237** that extends outwards tangentially from the enlarged end portion **224** of the lever arm in this example. The elongate portion **234** of the lever arm has a second peripheral edge portion **239** which is spaced-apart from and which generally extends parallel to the first peripheral edge portion thereof; however, this is not strictly required.

[0080] Referring to FIG. **16**, the dehumidification conduit **184.1** is selectively insertable into the dehumidification chamber **174.1** and removable therefrom through slot **148.1** via lever arm **222**. The dehumidification conduit is thus selectively replaceable. The user may first hold the dehumidification conduit **184.1** via in the lever arm **222**, in this example by holding the elongate portion **234** of the lever arm via a gripping member, in this example tweezers **236**. The enlarged end portion **224** is next positioned within recess **231** formed by wall portion **229** seen in FIG. **17**, with protrusion **129.1** being shaped to selectively and sealably fit within aperture **132.1**, such that catch **226** is positioned within catch recess **227** of the device **50**. This functions to sealably couple protrusion **129.1** seen in FIG. **12** in place for receiving inspirations and exhalations, while enabling the lever arm to selectively rotate as shown by arrow of numeral **233**. The lever arm **222** is rigid and is thus shaped to facilitate coupling the proximal end **189.1** and proximal end portion **190.1** of the dehumidification conduit **184.1** to a distal location within the dehumidification chamber **174.1**, in this example aperture **132.1**. The dehumidification conduit is thus positionable within the dehumidification chamber via the lever arm. The lever arm **222** so configured in FIGS. **16** and **18** is in a deployed position in which at least a portion thereof extends outwards from the slot **148.1** of the dehumidification chamber **174.1**; in this example the gripping end portion **232** thereof extends past the slot **148.1** and outwards from the dehumidification chamber **174.1**.

[0081] Rotation of the distal end portion **232** of the lever **222** relative to the proximal end portion **190.1** of the lever promotes rotation of the dehumidification conduit **184.1**. Referring to FIG. **18**, sleeve **205.1**, or portions of the

dehumidification conduit **184.1** adjacent thereto, are next gripped by the tweezers **236** so as to couple the sleeve to the corresponding hose barb **200.1**, in this example by press-fitting the sleeve about the hose barb.

[0082] The gripping end portion **232** of the lever arm **222** is next pushed inwards via the tweezers **236**, as seen by arrow of numeral **241**, causing the lever arm **222** to rotate from the deployed position seen in FIG. **20**, to a stowed position seen in FIG. **21**. The lever arm in the stowed position thereof is positioned within the dehumidification chamber **174.1**. The gripping end portion **232** of the lever arm **222** is flush with or spaced inwards from the bottom **54.1** of the device **50.1** in the stowed position of the lever arm

[0083] The above-described steps followed in reverse enable the lever arm **222** to be selectively removed. The lever arm is moved from the stowed position to the deployed position via the tweezers **236**. The lever arm **222** is thereafter selectively removable from the dehumidification chamber **174.1** by pulling outwards on the now-exposed gripping end portion thereof. The lever arm thus facilitates selective insertion of the dehumidification conduit **184.1** into the dehumidification chamber **174.1** and removal therefrom.

[0084] It will be appreciated that many variations are possible within the scope of the invention described herein.

#### ADDITIONAL DESCRIPTION

[0085] Examples of devices for measuring a person's ventilation including oxygen consumption have been described. The following clauses are offered as further description.

[0086] (1) A device for measuring a person's ventilation including oxygen consumption, the device comprising: a breathing conduit including at least one sensor sampling port; and a dehumidification conduit including a proximal end portion coupled to and flush with the sensor sampling port, the dehumidification conduit having a longitudinal axis about which the proximal end portion extends, and the breathing conduit being shaped to promote a flow of air adjacent the sensor sampling port in one or more directions perpendicular to said axis.

[0087] (2) The device of clause 1 or any clause herein, wherein the breathing conduit has an interior and includes a wall with an inner side in fluid communication with the interior thereof, and wherein the dehumidification conduit has a proximal end flush with the inner side of the wall of the breathing conduit.

[0088] (3) A device for measuring a person's ventilation including oxygen consumption, the device comprising: a breathing conduit having an interior and including a wall through which extends a sensor sampling port; a dehumidification conduit extending from the sensor sampling port; and adhesive selectively coupling the dehumidification conduit to the wall at location spaced-apart from the interior of the breathing conduit.

[0089] (4) The device of clause 3 or any clause herein, wherein the dehumidification conduit has a proximal end portion flush with the sensor sampling port.

[0090] (5) The device of any one of clauses 3 to 4, or any clause herein, wherein the adhesive selectively couples the dehumidification conduit to the wall at a location spaced-apart from an inner side of the wall.

- [0091] (6) The device of any one of clauses 3 to 5, or any clause herein, further including a reservoir via which the adhesive is insertable to selectively couple the dehumidification conduit.
- [0092] (7) The device of clause 6 or any clause herein, wherein the reservoir is annular.
- [0093] (8) The device of clause 6 or any clause herein, wherein the reservoir is annular in profile and semi-circular in lateral profile.
- [0094] (9) The device of clause 6 or any clause herein, wherein the reservoir is toroidal in shape at least in part.
- [0095] (10) The device of any one of clauses 6 to 9 or any clause herein, further including a passageway via which the adhesive is injected into the reservoir.
- [0096] (11) The device of any one of clauses 6 to 7 or any clause herein, wherein the wall has an inner side in fluid communication with the interior of the breathing conduit, wherein the wall has an annular recess spaced from the inner side of the wall, the annular recess extending radially outwards from the sensor sampling port, and wherein the adhesive is selectively positioned within the annular recess of the wall.
- [0097] (12) The device of clause 11 or any clause herein, further including a passageway that extends from one of the sides of the wall to the annular recess, with the adhesive being applied to the annular recess of the wall via said passageway.
- [0098] (13) The device of any one of clauses 5 to 12 or any clause herein, wherein the adhesive is positioned between the inner side of the wall and an outer side of the wall.
- [0099] (14) The device of any one of clauses 4 to 13 or any clause herein, wherein a portion of the wall through the sensor sampling port extends sealably couples to and is selectively removable from a corresponding aperture in the wall.
- [0100] (15) The device of any one of clauses 1 to 14 or any clause herein, wherein the dehumidification conduit is replaceable.
- [0101] (16) The device of any one of clauses 1 to 15 or any clause herein, wherein the dehumidification conduit includes a plurality of circumferentially and longitudinally spaced-apart apertures extending there-through, the apertures of the dehumidification conduit being shaped to promote diffusion of water particles therethrough and outwards therefrom.
- [0102] (17) The device of any one of clauses 1 to 16 or any clause herein, further including a moisture trap to inhibit damage from water ingress.
- [0103] (18) The device of clause 17 or any clause herein, wherein the moisture trap is a filter material.
- [0104] (19) The device of clause 17 or any clause herein, wherein the moisture trap is a hydrophobic membrane.
- [0105] (20) The device of any one of clauses 17 to 19 or any clause herein, wherein the dehumidification conduit is in fluid communication with the moisture trap.
- [0106] (21) The device of any one of clauses 1 to 20 or any clause herein, further including a water contact indicator to indicate when a water ingress event has occurred.
- [0107] (22) The device of clause 21 or any clause herein, wherein the dehumidification conduit is in fluid communication with the water contact indicator.
- [0108] (23) The device of any one of clauses 1 to 22 or any clause herein, wherein a press-fit cartridge assembly is shaped to facilitate periodic replacement of the dehumidification conduit.
- [0109] (24) A removable dehumidification assembly for a device that measures a person's ventilation including oxygen consumption, the dehumidification assembly comprising the dehumidification conduit of any one of clauses 1 to 23 or any clause herein.
- [0110] (25) A device for measuring a person's ventilation including oxygen consumption, the device comprising: a sensor assembly; a breathing conduit through which at least one exhalation is received; and a replaceable dehumidification cartridge configured to receive a sample amount of said exhalation from the breathing conduit, dehumidify the sample amount of said exhalation, and direct the sample amount of said exhalation so dehumidified to the sensor assembly.
- [0111] (26) The device of clause 25 or any clause herein, wherein the replaceable dehumidification cartridge includes a dehumidification chamber and a dehumidification conduit disposed within the dehumidification chamber, the dehumidification conduit extending from a sensor sampling port in communication with the breathing conduit, towards a sensor of the sensor assembly.
- [0112] (27) The device of any one of clauses 25 to 26 or any clause herein, wherein the replaceable dehumidification cartridge selectively couples to and is removable from a recessed portion of the sensor assembly.
- [0113] (28) The device of any one of clauses 25 to 27 or any clause herein, wherein the replaceable dehumidification cartridge sealably couples to the breathing conduit.
- [0114] (29) The device of any one of clauses 25 to 27 or any clause herein, wherein the replaceable dehumidification cartridge sealably couples to the sensor assembly.
- [0115] (30) A dehumidification assembly comprising: a dehumidification conduit; a dehumidification chamber shaped to extend at least in part about the dehumidification conduit; and an elongate member shaped to facilitate selective insertion of the dehumidification conduit into the dehumidification chamber and removal therefrom.
- [0116] (31) The assembly of clause 30 or any clause herein, wherein the elongate member couples to and extends outwards from one end of the dehumidification conduit.
- [0117] (32) The assembly of any one of clauses 30 to 31 or any clause herein, wherein the elongate member is shaped to be received at least in part within and be pivotable relative to the dehumidification chamber.
- [0118] (33) The assembly of any one of clauses 30 to 32 or any clause herein, wherein the elongate member includes a first end portion to which the dehumidification conduit couples.
- [0119] (34) The assembly of clause 33 or any clause herein, wherein the first end portion of the elongate member is circular in profile.

- [0120] (35) The assembly of any one of clauses 33 to 34 or any clause herein, wherein the elongate member includes a catch coupled to and extending outwards from the first end portion thereof.
- [0121] (36) The assembly of clause 35 or any clause herein, wherein the catch is rectangular in profile.
- [0122] (37) The assembly of any one of clauses 35 to 36 or any clause herein, wherein the dehumidification chamber has a recess shaped to receive the catch.
- [0123] (38) The assembly of any one of clauses 33 to 37 or any clause herein, wherein the dehumidification chamber includes an arc-shaped wall portion shaped to selectively receive the first end portion of the elongate member and enable pivoting of the elongate member relative thereto.
- [0124] (39) The assembly of any one of clauses 33 to 38 or any clause herein, further including a protrusion coupled to and extending outwards from the first end portion of the elongate member, the dehumidification conduit coupling to and extending through the protrusion.
- [0125] (40) The assembly of clause 39 or any clause herein, further including a seal extending about the protrusion.
- [0126] (41) The assembly of any one of clauses 39 to 40 or any clause herein, wherein the protrusion is planar.
- [0127] (42) The assembly of any one of clauses 39 to 41 or any clause herein, wherein the protrusion is circular in profile.
- [0128] (43) The assembly of any one of clauses 39 to 42 or any clause herein, wherein the protrusion is smaller than and radially inwardly spaced from the first end portion of the elongate member.
- [0129] (44) The assembly of any one of clauses 39 to 43 or any clause herein, wherein the protrusion and the first end portion of the elongate member are coaxial.
- [0130] (45) The assembly of any one of clauses 39 to 44 or any clause herein, wherein the protrusion is shaped to fit within an aperture and selectively sealably couple with a breathing conduit.
- [0131] (46) The assembly of any one of clauses 39 to 45 or any clause herein, wherein the protrusion has a sensor sampling port extending therethrough and to which the dehumidification conduit couples.
- [0132] (47) The assembly of clause 46 or any clause herein, wherein the protrusion has an annular recess in fluid communication with and extending about the sensor sampling port.
- [0133] (48) The assembly of clause 47 or any clause herein, wherein the protrusion has a distal end spaced-apart from the first end portion of the elongate member, and wherein the annular recess is spaced from the distal end of the protrusion.
- [0134] (49) The assembly of any one of clauses 47 to 48 or any clause herein, further including a passageway in fluid communication with the annular recess and via which adhesive is selectively inserted into the annular recess to couple the dehumidification conduit to the protrusion.
- [0135] (50) The assembly of clause 49 or any clause herein, wherein the first end portion of the elongate member has a first aperture which aligns with the sensor sampling port
- [0136] (51) The assembly of clauses 47 to 50 or any clause herein, wherein the annular recess is toroidal in shape at least in part.
- [0137] (52) The assembly of any one of clauses 33 to 51 or any clause herein, wherein the first end portion of the elongate member is enlarged.
- [0138] (53) The assembly of any one of clauses 33 to 52 or any clause herein, wherein the elongate member includes a second end portion spaced-apart from the first end portion and wherein the elongate member include an elongate portion extending between the first end portion thereof and the second end portion thereof.
- [0139] (54) The assembly of clause 53 or any clause herein, wherein the elongate portion of the elongate member is arc-shaped in profile.
- [0140] (55) The assembly of any one of clauses 30 to 54 or any clause herein, wherein the elongate member has a length equal to or less than the length of the dehumidification conduit.
- [0141] (56) The assembly of any one of clauses 30 to 55, wherein the elongate member has a stowed position in which the elongate member is positioned within the dehumidification chamber, and wherein the elongate member is moveable from the stowed position to a deployed position in which at least a portion thereof extends outwards from the dehumidification chamber.
- [0142] (57) The assembly of clause 56 or any clause herein, wherein the dehumidification chamber has a slot and wherein the elongate member in the deployed position extends in part through the slot and outwards from the dehumidification chamber for selectively removing the elongate member and thus the dehumidification conduit therefrom.
- [0143] (58) The assembly of any one of clauses 30 to 57 or any clause herein, wherein the dehumidification conduit is positioned to further receive sample amounts of one or more of exhalations therethrough.
- [0144] (59) The assembly of any one of clauses 30 to 58 or any clause herein, wherein the dehumidification chamber has one or more apertures to facilitate passage of air therethrough.
- [0145] (60) The assembly of any one of clauses 30 to 59 or any clause herein, wherein the dehumidification conduit includes a plurality of circumferentially and longitudinally spaced-apart apertures extending therethrough, the apertures of the dehumidification conduit being shaped to promote diffusion of water particles therethrough and outwards therefrom.
- [0146] (61) The assembly of any one of clauses 30 to 60 or any clause herein, wherein the elongate member is a lever arm.
- [0147] (62) A device for measuring a person's ventilation including oxygen consumption, the device including the assembly of any one of clauses 30 to 61 or any clause herein, with the dehumidification conduit being positioned to receive sample amounts of one or more of expirations therethrough.
- [0148] (63) A conduit assembly comprising: a flexible conduit having a first end and a second end spaced-apart from the first end thereof; and a handle including a first end portion coupled to the first end of the flexible conduit, the handle extending from the first end portion thereof towards the second end of the flexible conduit.

- [0149] (64) The assembly of clause 63 or any clause herein, wherein the handle is arcuate shaped.
- [0150] (65) The assembly of any one of clauses 63 to 64 or any clause herein, wherein the first end portion of the handle is shaped to sealably fit within an aperture.
- [0151] (66) The assembly of any one of clauses 63 to 65 or any clause herein, wherein the handle includes a second end portion rotation of which relative to the first end portion thereof promotes rotation of the flexible conduit.
- [0152] (67) The assembly of any one of clauses 63 to 66 or any clause herein, wherein the first end portion of the handle has a bore extending therethrough, the bore being shaped to receive the first end of the conduit, and wherein the first end portion of the handle has a centrally positioned annular groove in fluid communication with and extending radially outwards from said bore, the annular groove being shaped to receive adhesive via which the conduit couples to the handle.
- [0153] (68) The assembly of clause 67 or any clause herein, wherein the first end portion of the handle has a passageway in fluid communication with the groove and via which the adhesive is injected into the annular groove.
- [0154] (69) The assembly of clause 67 or any clause herein, wherein the first end portion of the handle has a passageway, with the passageway including a first end portion in fluid communication with the annular groove, the passageway including a second end portion coaxial with the bore, and the passageway being shaped to direct adhesive into the annular groove.
- [0155] (70) The assembly of any one of clauses 63 to 66 or any clause herein, wherein the first end portion of the handle has a bore extending therethrough, the bore being shaped to receive the first end of the conduit, and wherein the first end portion of the handle has a passageway in fluid communication with the bore and shaped to direct into the bore adhesive via which the conduit couples to the handle.
- [0156] (71) The assembly of any one of clauses 63 to 70 or any clause herein, further including a sleeve coupled to the second end of the conduit.
- [0157] (72) The assembly of any one of clauses 63 to 71 or any clause herein, further including a catch coupled to and extending outwards from the first end portion of the handle.
- [0158] (73) In combination, the assembly of any one of clauses 63 to 72 or any clause herein, and a chamber into which the conduit is positionable via the handle.
- [0159] (74) In combination, the assembly of clause 65 or any clause herein, and a chamber into which the conduit is positionable via the handle, the chamber including an arc-shaped portion shaped to receive the first end portion of the handle.
- [0160] (75) The combination of clause 74 or any clause herein, wherein the handle is pivotable relative to the first end portion thereof and pivotable relative to the arc-shaped portion of the chamber.
- [0161] (76) The combination of any one of clauses 74 to 75 or any clause herein, wherein the handle includes a catch and wherein the arc-shaped portion of the chamber has a catch recess shaped to receive the catch when the first end portion of the handle is received by the arc-shaped portion of the chamber.

[0162] (77) The combination of any one of clauses 73 to 76 or any clause herein, wherein the chamber has a slot and an interior accessible via said slot.

[0163] (78) The combination of clause 77 or any clause herein, wherein the handle has a deployed position, in which the handle extends outwards from the slot of the chamber in part, and wherein the handle is rotatable from the deployed position to a stowed position in which the handle is positioned within the chamber.

[0164] (79) The combination of any one of clauses 73 to 78 or any clause herein, wherein the handle is rigid and shaped to facilitate coupling the first end of the conduit to a distal location within the chamber.

[0165] (80) Apparatus including any new and inventive feature, combination of features, or sub-combination of features as described herein.

[0166] (81) Methods including any new and inventive steps, acts, combination of steps and/or acts or sub-combination of steps and/or acts as described herein.

[0167] It is therefore intended that the following appended clauses and clauses hereafter introduced are interpreted to include all such modifications, permutations, additions, omissions, and sub-combinations as may reasonably be inferred. The scope of the clauses should not be limited by the preferred embodiments set forth in the examples, but should be given the broadest interpretation consistent with the description as a whole.

What is claimed is:

1. A device for measuring a person's ventilation including oxygen consumption, the device comprising:

a sensor assembly;

a breathing conduit through which at least one exhalation is received; and

a replaceable dehumidification cartridge configured to receive a sample amount of said exhalation from the breathing conduit, dehumidify the sample amount of said exhalation, and direct the sample amount of said exhalation so dehumidified to the sensor assembly.

2. The device as claimed in claim 1, wherein the replaceable dehumidification cartridge is positioned along a front and between sides of the device.

3. The device as claimed in claim 1, wherein the replaceable dehumidification cartridge includes a dehumidification chamber shaped to promote a flow of air therethrough.

4. The device as claimed in claim 3, wherein the replaceable dehumidification cartridge has a plurality of apertures extending through a front wall thereof, with the apertures exposing the dehumidification chamber to ambient air.

5. The device as claimed in claim 3, wherein the dehumidification chamber has a slot extending through a bottom thereof, with the slot exposing the dehumidification chamber to ambient air and with an interior of the dehumidification chamber being accessible via said slot.

6. The device as claimed in claim 3, including a dehumidification conduit positioned within the dehumidification chamber, the dehumidification conduit extending from a sensor sampling port in communication with the breathing conduit, towards a sensor of the sensor assembly.

7. The device as claimed in claim 6, wherein the dehumidification chamber has a slot extending through a bottom thereof, with the dehumidification conduit being accessible via the slot of the dehumidification chamber.

8. The device as claim in claim 6, wherein the dehumidification conduit has hydrophobic properties and is made of



hydrophobic material, with the hydrophobic nature of the dehumidification conduit functioning to promote repelling of water droplets and functioning to inhibit water droplets from entering within the sensor sampling port.

9. The device as claimed in claim 6, wherein the dehumidification conduit is Nafion™-type tubing.

10. The device as claimed in claim 6, wherein the dehumidification conduit has a plurality of circumferentially, longitudinally and axially spaced-apart apertures via which water particles diffuse outwards therefrom and into the dehumidification chamber.

11. The device as claimed in claim 6, wherein the dehumidification conduit spirals within the dehumidification chamber.

12. The device as claimed in claim 6, wherein the dehumidification conduits is semi-open to ambient air with a volume that promotes humidity normalization through air-exchange and diffusion to the ambient air via wind and head movement.

13. The device as claimed in claim 1, wherein the dehumidification assembly includes a moisture trap to comprising a hollow enclosure with a hydrophobic membrane which facilitates passage of gas therethrough while inhibiting passage of moisture therethrough.

14. The device as claimed in claim 6, wherein the dehumidification assembly includes a moisture trap operatively connected to a distal end of the dehumidification conduit, the moisture trap being upstream of the sensor assembly for further inhibiting damage thereto.

15. The device as claimed in claim 6, wherein the dehumidification assembly includes a moisture trap interposed between the dehumidification conduit and the sensor assembly, the moisture trap including an enclosure and a water indicator positioned within the enclosure thereof, with the water indicator changing color upon detecting or coming into contact with water ingress.

16. The device as claimed in claim 1, wherein the device includes an outer shell and wherein the replaceable dehumidification cartridge couples to the outer shell via a press-fit connection.

17. The device as claimed in claim 1, wherein the replaceable dehumidification cartridge sealably couples to the breathing conduit.

18. The device as claimed in claim 1, wherein the replaceable dehumidification cartridge sealably couples to the sensor assembly.

19. A device for measuring a person's ventilation including oxygen consumption, the device comprising:

- a sensor assembly;
- a breathing conduit through which at least one exhalation is received, the breathing conduit having a sensor sampling port; and
- a dehumidification cartridge including i) a dehumidification conduit having a proximal end at said sensor sampling port and extending towards the sensor assembly, and ii) a dehumidification chamber enclosing the dehumidification conduit and being shaped to promote a flow of air therethrough, wherein the dehumidification cartridge is shaped to facilitate for sanitary purposes, periodic replacement of either or both of the replaceable dehumidification cartridge and the dehumidification conduit thereof.

20. A device for measuring a person's ventilation including oxygen consumption, the device having a front, a rear and a pair of sides extending between the front and rear thereof, and the device comprising:

- a sensor assembly including a recessed portion centrally positioned between said sides and extending inwards from the front towards the rear of the device;
- a breathing conduit through which at least one exhalation is received; and
- a dehumidification cartridge operatively connecting to and being interposed between the breathing conduit and the sensor assembly so as to inhibit water damage to the sensor assembly, the dehumidification cartridge selectively coupling to and being removable from the recessed portion of the sensor assembly.

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