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(54) **HUMIDIFIER WITH STRUCTURE TO PREVENT BACKFLOW OF LIQUID THROUGH THE HUMIDIFIER INLET**

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(73) Assignee: **ResMed Limited**, Bella Vista (AU)

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**Related U.S. Patent Documents**

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**F23D 11/00** (2006.01)  
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**A61M 15/00** (2006.01)

(52) **U.S. Cl.**  
USPC ..... **128/203.27**; 128/204.14; 128/203.26

(58) **Field of Classification Search**

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128/203.17, 206.12, 205.17, 204.17, 204.18  
See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

1,974,843	A	9/1934	Blashfield
RE19,826	E	1/1936	Aisenstein
2,220,669	A	11/1940	Allen
2,945,619	A	7/1960	Ballard
3,171,353	A	3/1965	McMahan

(Continued)

**FOREIGN PATENT DOCUMENTS**

AU	200065475	B2	4/2001
DE	275612		1/1913

(Continued)

**OTHER PUBLICATIONS**

Fisher & Paykel Healthcare "SleepStyle™ 200 CPAP Series" Specification Sheet, 1998, 4 pages.

(Continued)

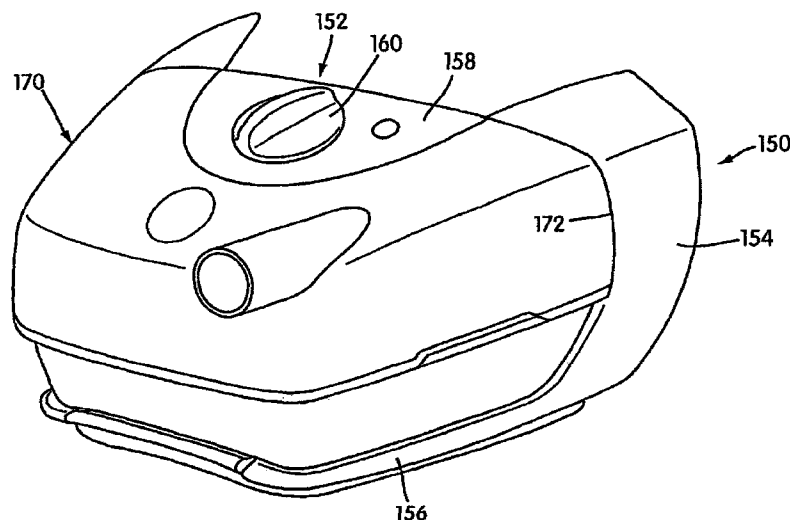
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(57) **ABSTRACT**

A humidifier includes a base configured to retain a body of liquid therein, a top cover, and a seal disposed between the top cover and the base. At least a portion of the base is constructed of a heat conducting material. The top cover defines both an inlet and an outlet communicated with an interior of the base. The inlet is configured to receive pressurized breathable gas and the outlet is configured to deliver the pressurized breathable gas with added humidity.

**98 Claims, 20 Drawing Sheets**



(56)

## References Cited

## U.S. PATENT DOCUMENTS

3,316,910 A	5/1967	Davis	5,943,473 A	8/1999	Levine
3,584,401 A	6/1971	Cryer et al.	5,951,300 A	9/1999	Brown
3,612,710 A	10/1971	Mount	5,956,501 A	9/1999	Brown
3,620,638 A	11/1971	Kaye et al.	5,960,403 A	9/1999	Brown
3,638,926 A	2/1972	Melville et al.	5,985,559 A	11/1999	Brown
3,659,604 A	5/1972	Melville et al.	5,997,476 A	12/1999	Brown
3,690,317 A	9/1972	Millman	D419,658 S	1/2000	Matchett et al.
3,806,102 A	4/1974	Valenta et al.	6,023,686 A	2/2000	Brown
3,864,440 A	2/1975	Giocoechea	6,032,119 A	2/2000	Brown et al.
3,954,920 A	5/1976	Heath	6,050,260 A	4/2000	Daniell et al.
4,037,994 A	7/1977	Bird	6,101,478 A	8/2000	Brown
4,051,205 A	9/1977	Grant	6,109,865 A	8/2000	Ishikawa
4,171,190 A	10/1979	Hudson	6,129,524 A	10/2000	Woollenweber et al.
4,222,971 A	9/1980	Eilert	6,131,571 A	10/2000	Lampotang et al.
4,229,142 A	10/1980	Le Dall et al.	6,135,432 A	10/2000	Hebblewhite et al.
4,237,080 A	12/1980	Elliott	6,144,837 A	11/2000	Quy
4,243,396 A	1/1981	Cronenberg	6,152,132 A	11/2000	Psaros
4,336,798 A	6/1982	Beran	6,158,978 A	12/2000	Norbury, Jr.
4,383,800 A	5/1983	Becker et al.	6,161,095 A	12/2000	Brown
4,523,896 A	6/1985	Lhenry et al.	6,189,870 B1	2/2001	Withall
4,532,088 A	7/1985	Miller	6,202,991 B1	3/2001	Coniglio et al.
4,576,616 A	3/1986	Mottram et al.	6,210,116 B1	4/2001	Kuczaj et al.
4,621,632 A	11/1986	Bartels et al.	6,213,119 B1	4/2001	Brydon et al.
4,657,713 A	4/1987	Miller	6,216,691 B1	4/2001	Kenyon et al.
4,686,354 A	8/1987	Makin	6,257,171 B1	7/2001	Rivard
4,753,758 A	6/1988	Miller	6,279,574 B1	8/2001	Richardson et al.
4,799,287 A	1/1989	Belanger	6,308,706 B1	10/2001	Lammers et al.
4,802,819 A	2/1989	Bevington	6,332,462 B1	12/2001	Krohn
4,807,616 A	2/1989	Adahan	6,340,288 B1	1/2002	Hulkkonen et al.
4,838,258 A	6/1989	Dryden et al.	6,349,724 B1	2/2002	Burton et al.
4,906,417 A	3/1990	Gentry	D454,393 S	3/2002	Lynch et al.
4,913,140 A	4/1990	Orec et al.	6,397,841 B1	6/2002	Kenyon et al.
4,921,642 A	5/1990	LaTorraca	6,398,197 B1	6/2002	Dickinson
4,926,856 A	5/1990	Cambio et al.	6,435,180 B1	8/2002	Hewson et al.
4,941,469 A	7/1990	Adahan	6,471,493 B2	10/2002	Choi et al.
4,946,348 A	8/1990	Yapp	D467,335 S	12/2002	Lithgow et al.
4,953,546 A	9/1990	Blackmer et al.	D468,011 S	12/2002	Lynch et al.
4,973,234 A	11/1990	Swenson	D468,017 S	12/2002	McCombs
4,993,411 A	2/1991	Callaway	6,514,053 B2	2/2003	Takura et al.
5,097,424 A	3/1992	Ginevri et al.	6,543,449 B1	4/2003	Woodring et al.
5,127,800 A	7/1992	Hyll et al.	6,554,260 B1	4/2003	Lipscombe et al.
5,199,009 A	3/1993	Svast	6,591,834 B1	7/2003	Colla et al.
5,231,979 A	8/1993	Rose et al.	6,604,390 B1	8/2003	Nooner
5,237,987 A	8/1993	Anderson et al.	6,615,444 B2	9/2003	McGilll et al.
5,271,391 A	12/1993	Graves	6,622,724 B1	9/2003	Truitt et al.
5,329,939 A	7/1994	Howe	6,672,300 B1	1/2004	Grant
5,391,063 A	2/1995	Hantle et al.	D487,311 S	3/2004	Lithgow et al.
5,443,061 A	8/1995	Champain et al.	6,718,974 B1	4/2004	Moberg
5,445,143 A	8/1995	Sims	D493,520 S	7/2004	Bertinetti et al.
5,474,112 A	12/1995	Carola	D493,884 S	8/2004	Virr et al.
5,482,031 A	1/1996	Lambert	6,772,999 B2	8/2004	Lipscombe et al.
5,537,997 A	7/1996	Mechlenburg et al.	6,775,882 B2	8/2004	Murphy et al.
5,558,084 A	9/1996	Daniell et al.	D498,527 S	11/2004	Virr et al.
5,564,415 A	10/1996	Dobson et al.	6,827,340 B2	12/2004	Austin et al.
5,577,496 A	11/1996	Blackwood et al.	6,837,260 B1	1/2005	Kuehn
5,588,423 A	12/1996	Smith	6,874,771 B2	4/2005	Birdsell et al.
5,598,837 A	2/1997	Sirianne, Jr. et al.	6,896,478 B2	5/2005	Botros et al.
5,651,775 A	7/1997	Walker et al.	6,910,483 B2	6/2005	Daly et al.
5,655,522 A	8/1997	Mechlenburg et al.	6,918,389 B2	7/2005	Seakins et al.
5,673,687 A	10/1997	Dobson et al.	6,935,337 B2	8/2005	Virr et al.
5,794,219 A	8/1998	Brown	7,096,864 B1	8/2006	Mayer et al.
5,822,715 A	10/1998	Worthington et al.	7,111,624 B2	9/2006	Thudor et al.
5,828,943 A	10/1998	Brown	7,137,388 B2	11/2006	Virr et al.
5,832,448 A	11/1998	Brown	7,225,809 B1	6/2007	Bowen et al.
5,848,592 A	12/1998	Sibley	7,413,173 B2	8/2008	DiMatteo et al.
5,879,163 A	3/1999	Brown et al.	7,616,871 B2	11/2009	Kramer
5,887,133 A	3/1999	Brown et al.	7,677,246 B2	3/2010	Kepler et al.
5,888,053 A	3/1999	Kobayashi et al.	2002/0020930 A1	2/2002	Austin et al.
5,897,493 A	4/1999	Brown	2002/0022973 A1	2/2002	Sun et al.
5,899,855 A	5/1999	Brown	2002/0056453 A1	5/2002	Klopp et al.
5,913,310 A	6/1999	Brown	2002/0159897 A1	10/2002	Kegg et al.
5,916,493 A	6/1999	Miller et al.	2003/0062045 A1	4/2003	Woodring et al.
5,918,603 A	7/1999	Brown	2003/0084900 A1	5/2003	LeClerc et al.
5,933,136 A	8/1999	Brown	2003/0115085 A1	6/2003	Satoh
5,940,801 A	8/1999	Brown	2003/0208465 A1	11/2003	Yurko et al.
			2003/0230308 A1	12/2003	Linden
			2004/0035422 A1	2/2004	Truitt et al.
			2004/0055597 A1	3/2004	Virr et al.
			2004/0060559 A1	4/2004	Virr et al.

2005/0005937 A1 1/2005 Farrugia et al.  
 2005/0103339 A1 5/2005 Daly et al.  
 2005/0217673 A1 10/2005 Daly et al.  
 2006/0191531 A1 8/2006 Mayer  
 2006/0237005 A1 10/2006 Virr et al.  
 2007/0036662 A1 2/2007 Pesola et al.  
 2007/0134085 A1 6/2007 Daly et al.  
 2009/0229606 A1 9/2009 Tang et al.  
 2010/0229867 A1 9/2010 Bertinetti et al.

## FOREIGN PATENT DOCUMENTS

DE 30 05 094 A1 8/1981  
 DE 3623162 A1 7/1986  
 DE 3823242 A1 2/1990  
 DE 9014848.7 3/1991  
 DE 4138098 C2 11/1991  
 DE 4244493 A1 7/1993  
 DE 93 17 450 6/1994  
 DE 3789221 T2 8/1994  
 DE 9409231.1 U1 12/1994  
 DE 195 15 739 A1 11/1996  
 DE 19630466 2/1998  
 DE 694 09 024 T2 10/1998  
 DE 29817685 U1 10/1998  
 DE 29909611 U1 10/1999  
 DE 10016005 A1 12/2001  
 DE 102005007773 A1 9/2005  
 EP 0 201 985 A1 11/1986  
 EP 0 274 996 A2 7/1988  
 EP 0 376 584 A2 7/1990  
 EP 0 589 429 A1 3/1994  
 EP 0 589 429 B1 3/1994  
 EP 0 845 277 A2 6/1998  
 EP 0 893 750 1/1999  
 EP 0 903 160 A1 3/1999  
 EP 1023912 A2 8/2000  
 EP 1 055 431 A2 11/2000  
 EP 1 087 322 A2 3/2001  
 EP 1318307 6/2003  
 EP 1 374 938 A1 1/2004  
 FR 2 323 436 4/1977  
 FR 2 714 985 7/1995  
 GB 1556492 A 11/1979  
 GB 2177006 A 1/1987  
 JP 7-145795 A 6/1995  
 JP 11-398 A 1/1999  
 JP 2000-337670 A 12/2000  
 JP 2001-160102 A 6/2001  
 JP 2002-206498 A 7/2002  
 JP 2002-253672 9/2002  
 JP 2002-306601 10/2002  
 WO WO 93/05451 A1 3/1993  
 WO WO 95/15778 A1 6/1995  
 WO WO 97/32619 A1 9/1997  
 WO WO 98/31937 A1 7/1998  
 WO WO 98/33433 8/1998  
 WO WO 98/57691 A1 12/1998  
 WO WO 99/13932 3/1999  
 WO WO 99/22794 A1 5/1999  
 WO WO 99/64747 12/1999  
 WO WO 00/27457 A1 5/2000  
 WO WO 00/32261 A1 6/2000  
 WO WO 01/10489 A2 2/2001  
 WO WO 01/32069 A2 5/2001  
 WO WO 01/73653 A1 10/2001  
 WO WO 02/02169 A1 1/2002  
 WO WO 02/066107 A1 8/2002  
 WO WO 2007/019628 A1 2/2007  
 WO WO 2009/059359 A1 5/2009  
 WO WO 2009/156921 A1 12/2009  
 WO WO 2010/092496 8/2010

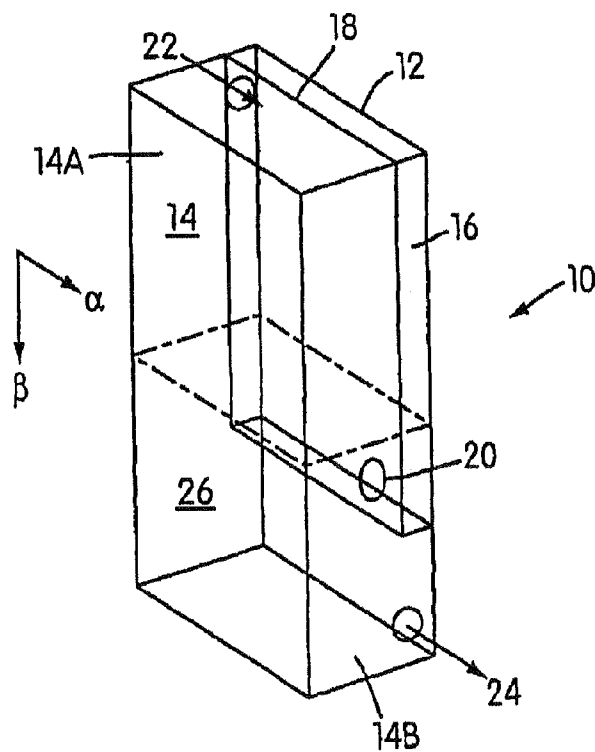
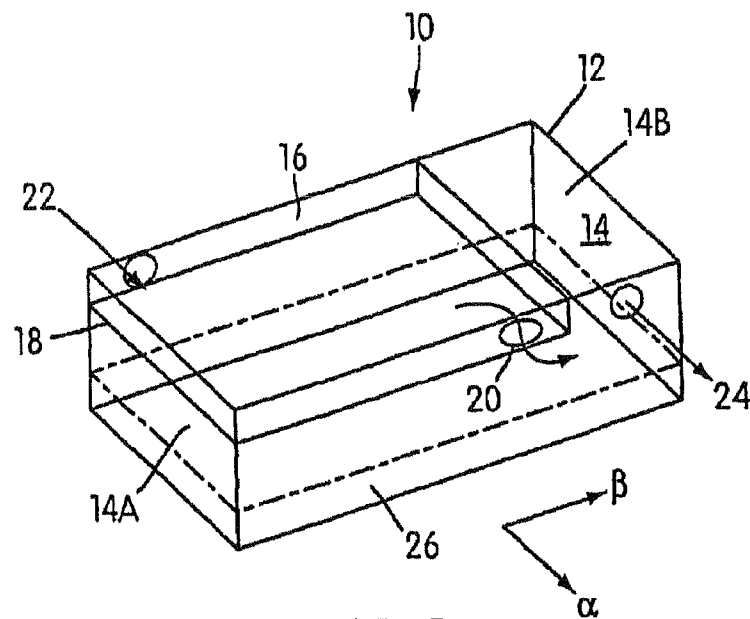
## OTHER PUBLICATIONS

J. H. Emerson Co., Cough Assist, "Non-Invasive Removal of Bronchial Secretions," 2 pages.  
 Madaus Schwarzer Medizintechnik, "New Approaches in Diagnosis and Therapy—Moritz biLevel User Manual", May 1994, 38 pages.  
 German Patient Manual for Hoffrichter/Sandmann CPAP Respira-

tor—Perfect CPAP Therapy, 30 pages plus Translation Verification Certificate, Mar. 1998.  
 Breas Medical AB "iSleep® 20" Brochure, Dec. 2007, 2 pages.  
 Fisher & Paykel Healthcare "SleepStyle™ 600 CPAP Series" Specification Sheet, 2005, 4 pages.  
 Fisher & Paykel Healthcare Two Easy Steps to Comfort, Humidification and Nasal CPAP Therapy, Aug. 1995, 4 pages.  
 Hoffrichter GmbH "Vector therapy in perfection" Brochure, 2002, 2 pages.  
 MAP Medizin-Technologie GmbH "minni Max nCPAP®, The respiratory therapy device without an integrated humidifier", Dec. 2003, 17 pages.  
 MAP Medizintechnik fuer Arzt und Patient "max II nCPAP moritz II biLevel—The gentle therapy for sleep-related breathing disorders" Brochure, 2000, 4 pages.  
 Resprionics "System One Heated Humidifier User Manual", May 2009, 20 pages.  
 ResMed, "The Sullivan® HumidAire™", 1997, 1 page.  
 De Vilbiss® Healthcare, "DeVilbiss IntelliPAP® Standard CPAP System," Nov. 2007, 2 pages.  
 Photos of HumidAire™, 11 pages.  
 Photos of tray system available before the critical date, with sample flow generator and humidifier, 5 pages.  
 Microfilm of Japanese Utility-Model Application No. S54-003858 (Japanese Utility-Model Application Publication No. S55-104925).  
 MAP Medizintechnik, "minni Max nCPAP®" brochure, 12 pages, Mar. 2005.  
 MAP Medizintechnik, "Moritz II biLEVEL®—The gentle therapy for sleep-related breathing disorders" brochure, 6 pages, Jan. 2001.  
 Photos of MAP Humidifier and Tub, 2 pages. And cover sheet, undated.  
 Madaus Schwarzer Medizintechnik, "New Approaches in Diagnosis and Therapy—Max nCPAP User Manual", Mar. 1994, 38 pages.  
 ResMed "Sullivan® HumidAire® User's Instructions", 8 pages, 1998.  
 MAP Medizin-Technologie GmbH, Moritz®S/Moritz®ST—Sailing toward therapeutic success . . . , Jul. 2004, 4 pages.  
 Hoffrichter "Vector CPAP—Therapy With Technical Mastery", 4 pages, Oct. 1998.  
 Fischer & Paykel, "Two Easy Steps to Comfort", 4 pages, Aug. 1995.  
 Notification of Second Office Action mailed Jan. 27, 2006 in Chinese Appln. No. 02804936.5, with English Translation (6 pages).  
 Notification of Reasons for Rejection mailed Feb. 19, 2008 in Japanese Appln. No. 2002-565664, with English translation (5 pages).  
 Final Notice of Reasons for Rejection delivered Sep. 24, 2008 in Japanese Appln. No. 2002-565664, with English translation (6 pages).  
 Notification of the First Office Action mailed Jul. 22, 2005 in Chinese Appln. No. 02804936.5, with English translation (8 pages).  
 Extended European Search Report mailed Apr. 28, 2011 in European Appln. No. 10189422.8 (5 pages).  
 International Search Report mailed Mar. 21, 2002 in International Appln. No. PCT/AU02/00155 (2 pages).  
 International Preliminary Examination Report completed Oct. 4, 2002 in International Appln. No. PCT/AU02/00155 (3 pages).  
 Office Action dated Jan. 22, 2008 in Japanese Patent Appln. No. 2002-565665 (w/English translation) (12 pages).  
 Examination Report mailed Oct. 10, 2003 in New Zealand Appln. No. 527088 (2 pages).  
 Supplementary European Search Report mailed Sep. 15, 2009 in European Appln. No. 02700014.0, (3 pages).  
 Communication mailed Jul. 1, 2010 in European Appln. No. 02 700 014.0 (5 pages).  
 Extended European Search Report mailed May 4, 2012 in European Appln. No. 12159042.6 (5 pages).  
 ITC Action related to Certain Sleep-Disordered Breathing Treatment Systems and Components Thereof, Inv. No. 337-TA-\_\_, CBI 13-185, filed on Mar. 28, 2013, 57 pages.  
 ResMed's First Amended Complaint for Patent Infringement, filed in the United States District Court Central District of California Southern Division, filed on Apr. 8, 2013, 342 pages.

“Complaint for Patent Infringement—Jury Trial Demanded” as filed in the United States District Court, Southern District of California, Case No. ’13CV1246 MMAWMC, dated May 29, 2013, 25 pages.

“Motion to Amend the Complaint and Notice of Investigation” as filed in the United States International Trade Commission, Investigation No. 337-TA-879, dated May 31, 2013, 18 pages.



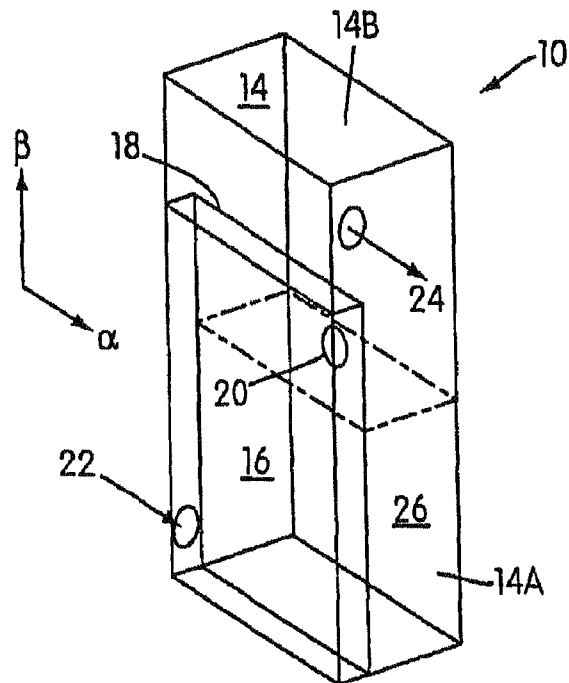


FIG. 3

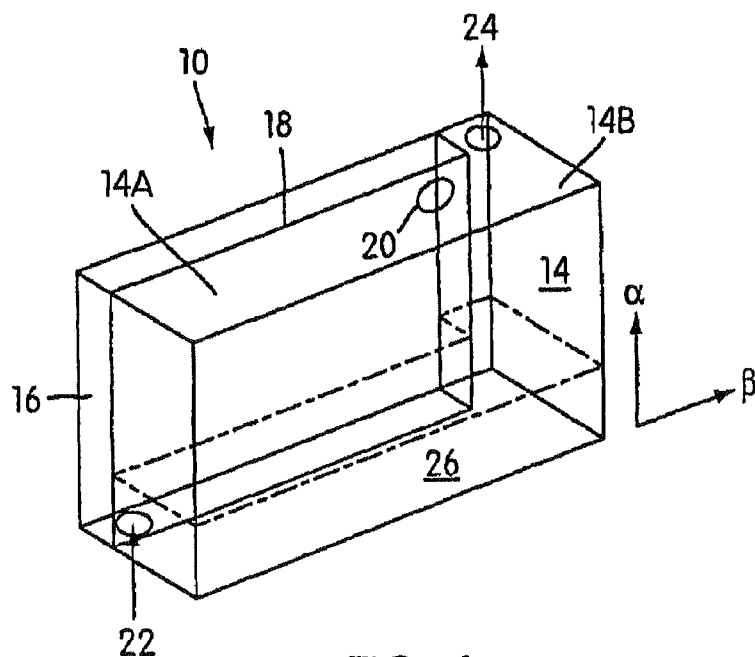


FIG. 4

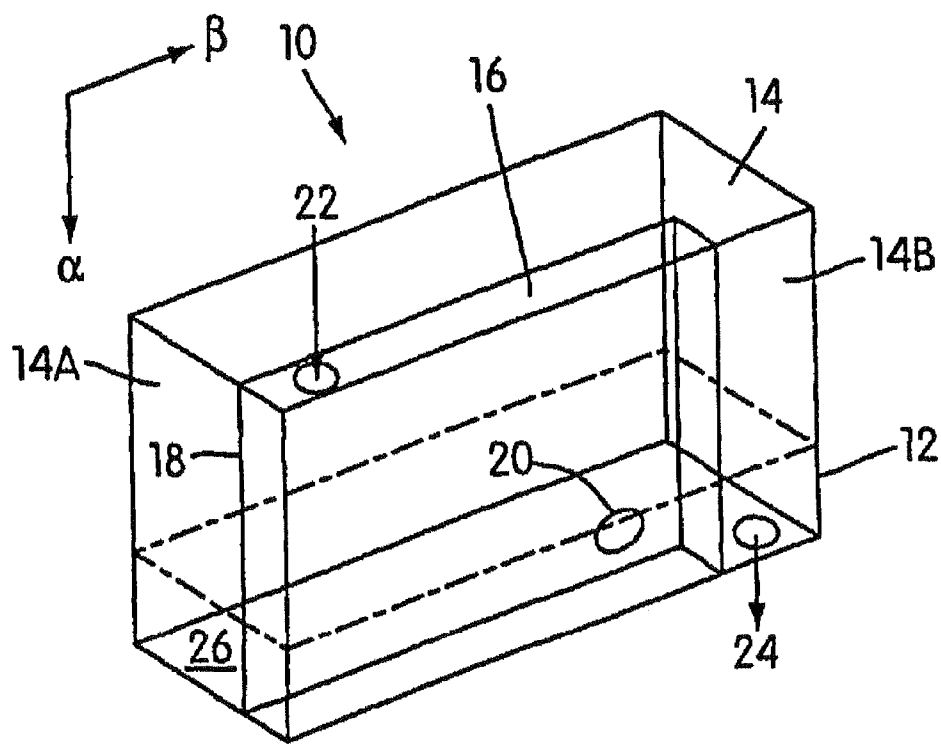


FIG. 5

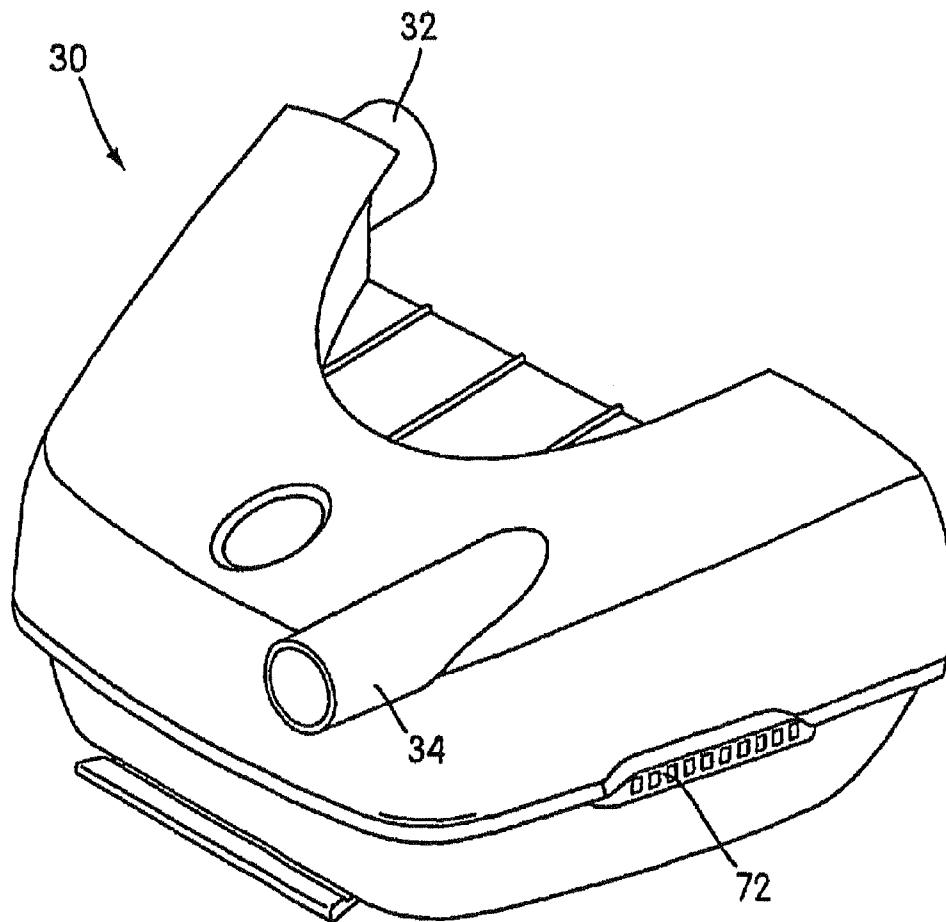


FIG. 6



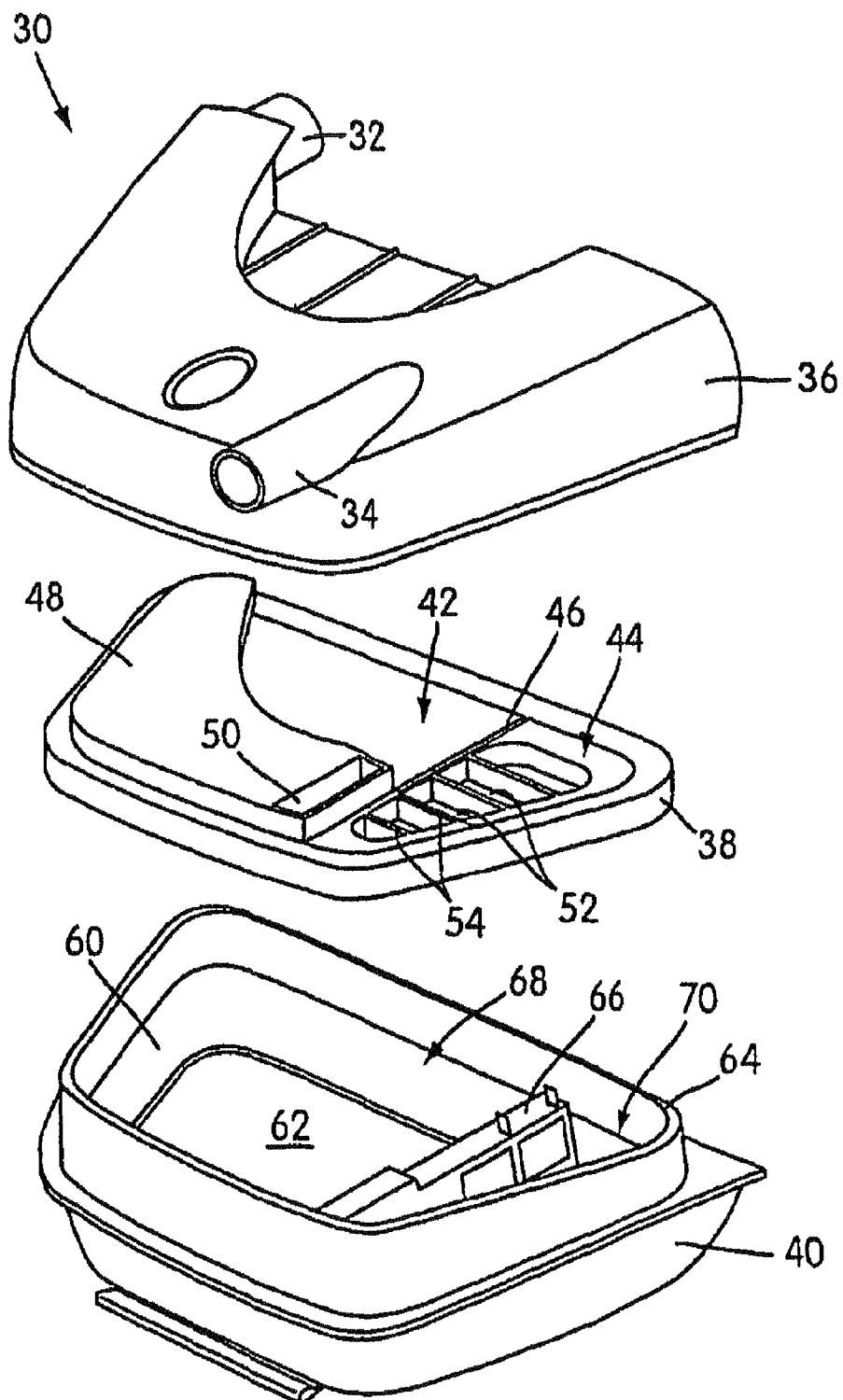


FIG. 7

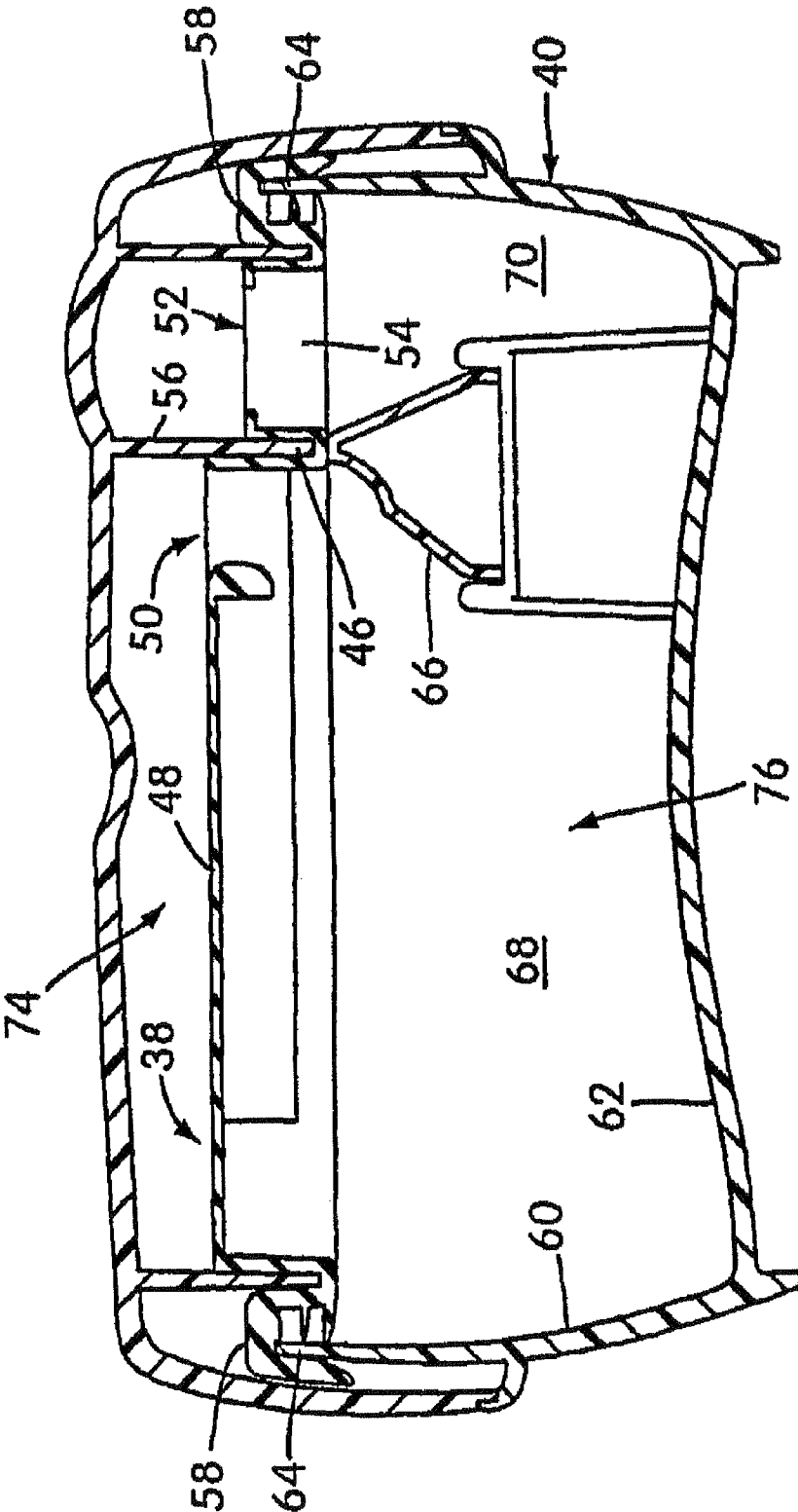


FIG. 8

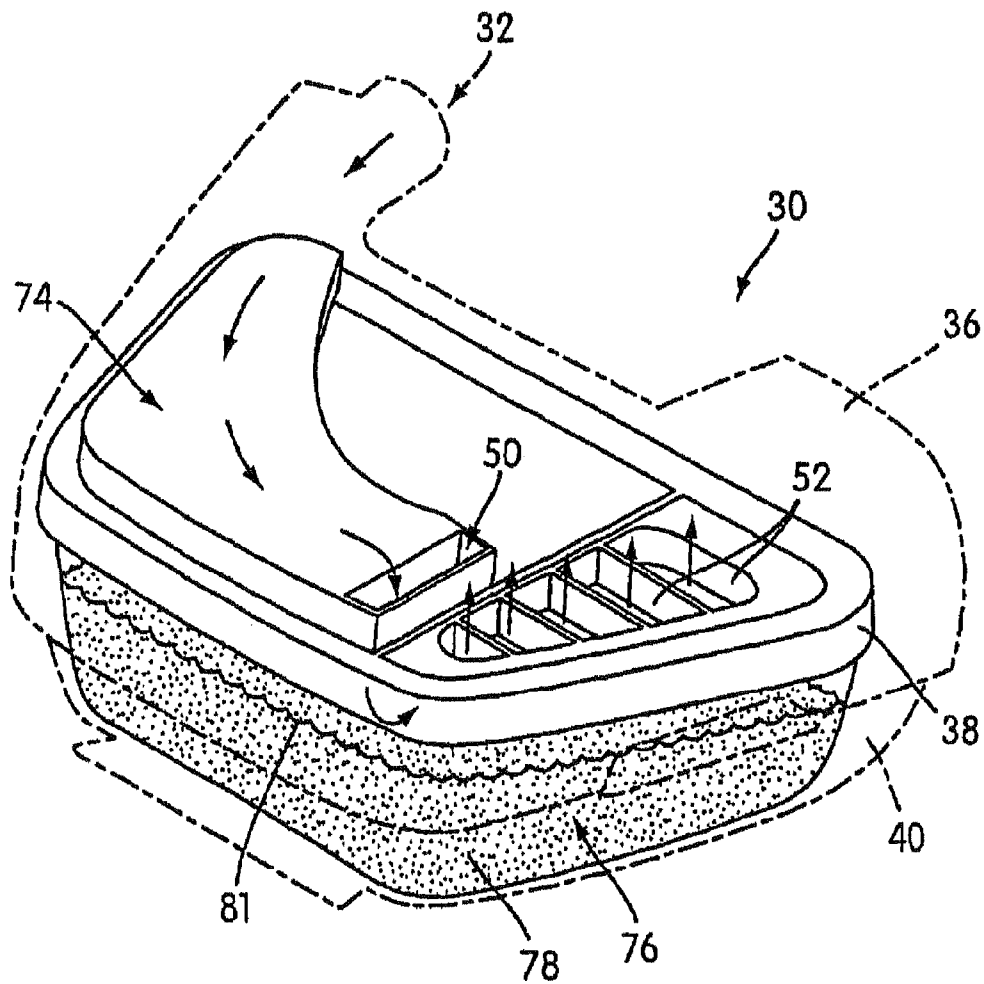


FIG. 9

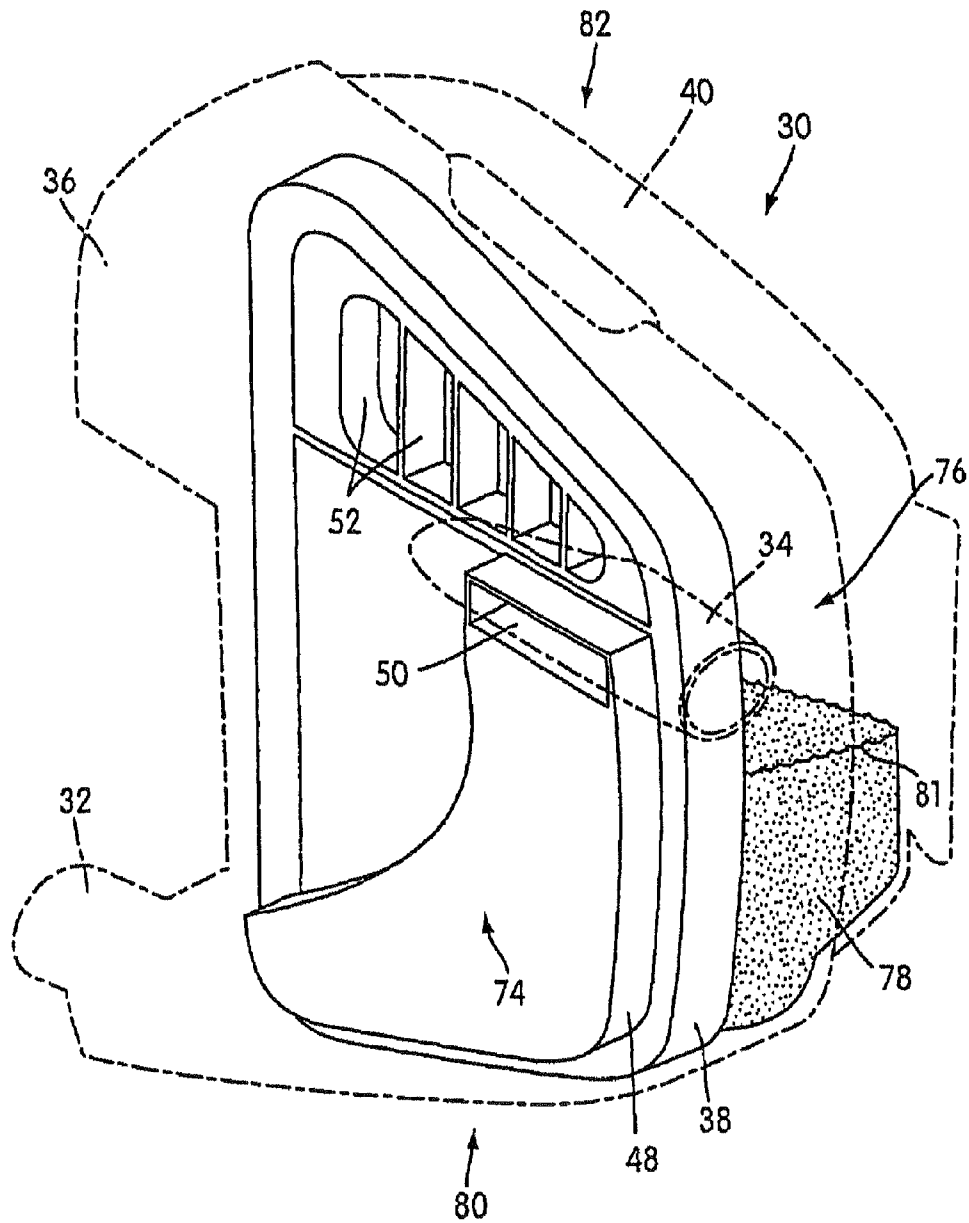


FIG. 10

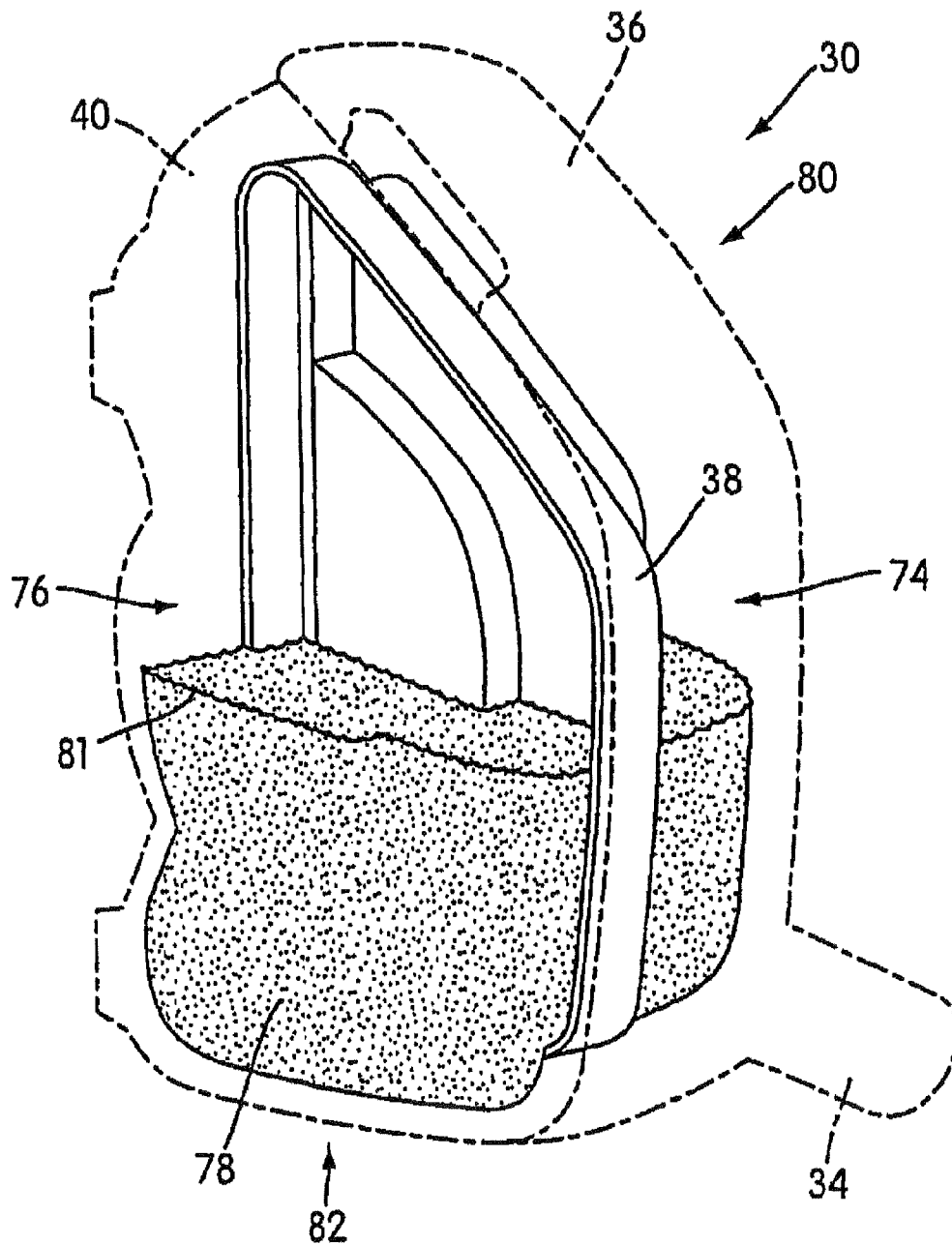
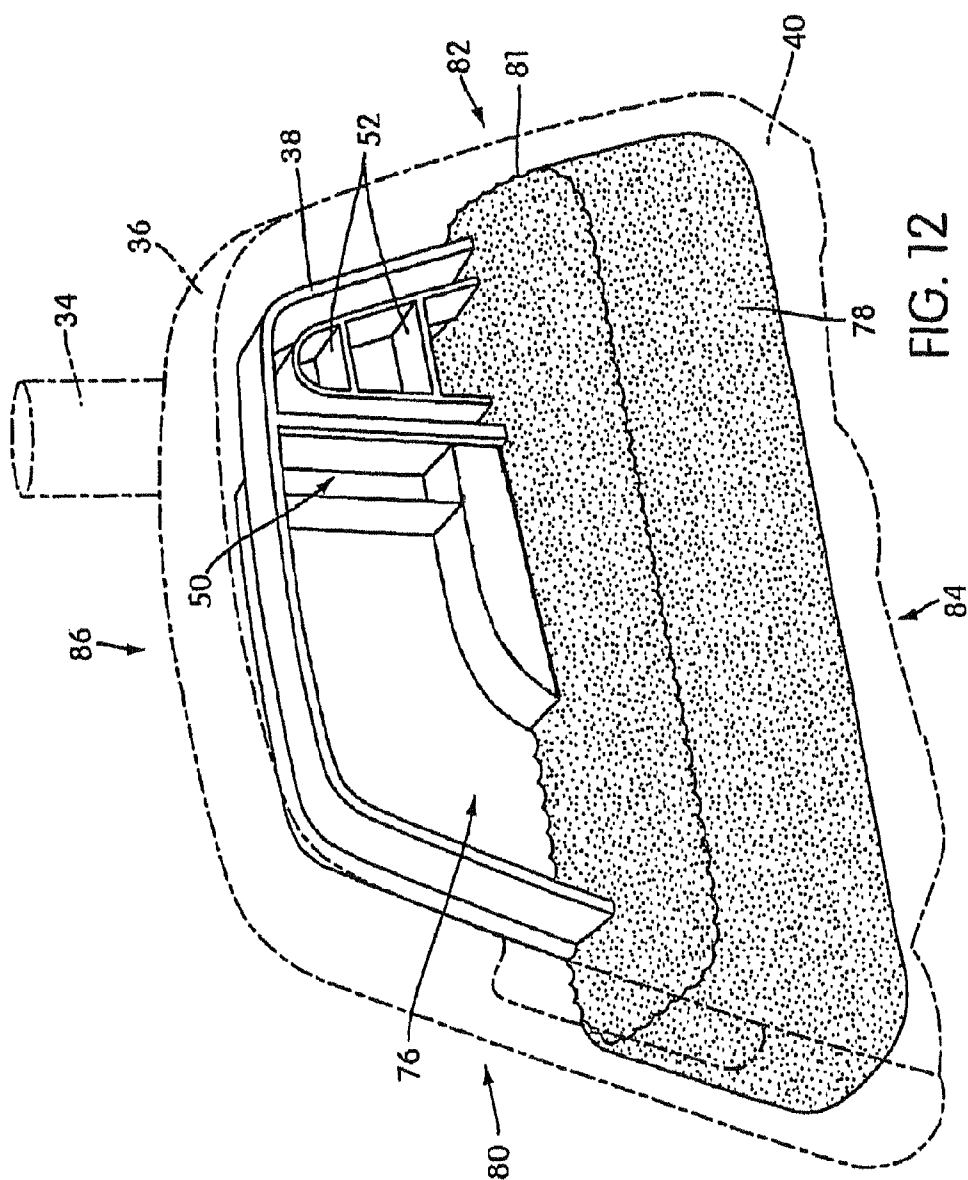
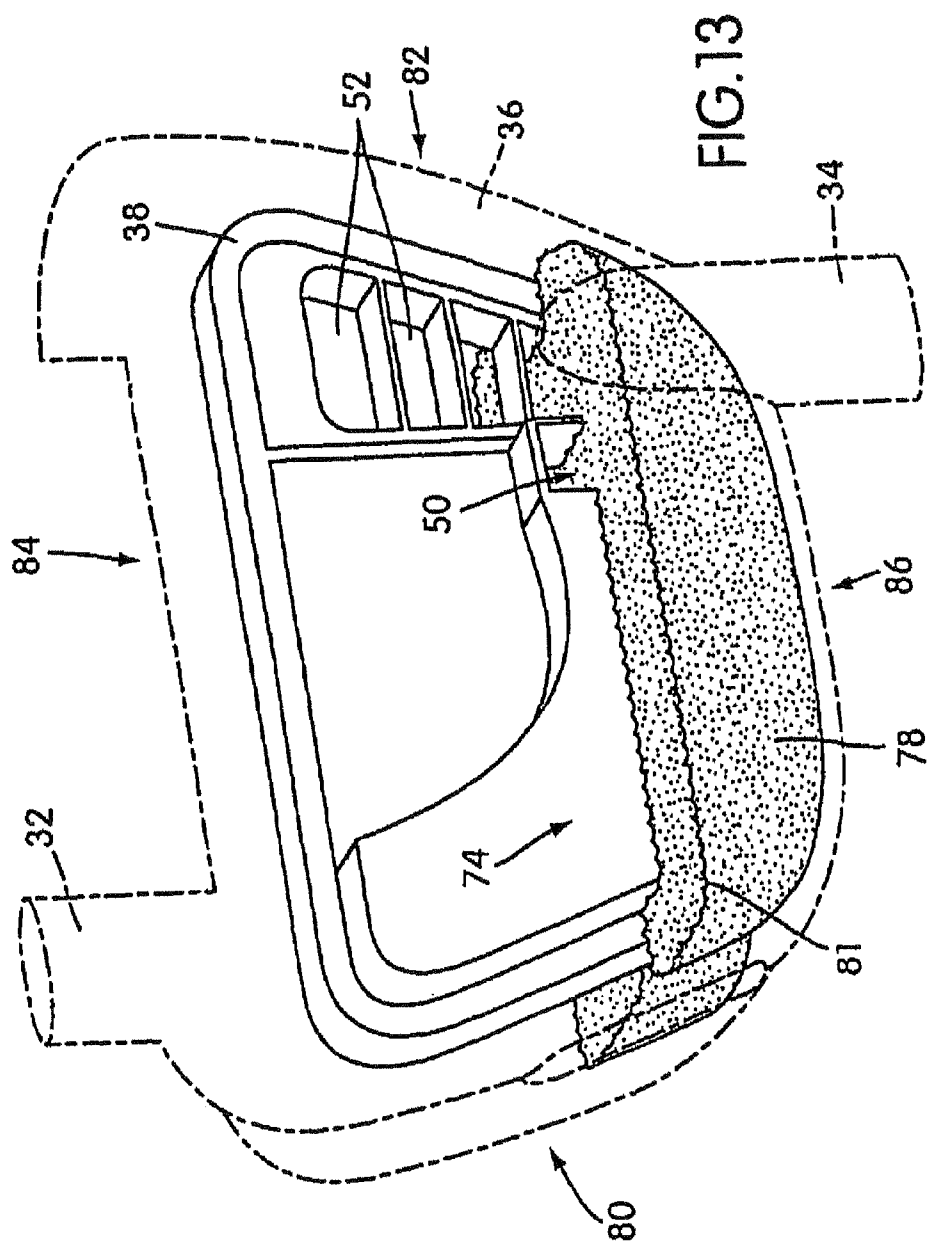
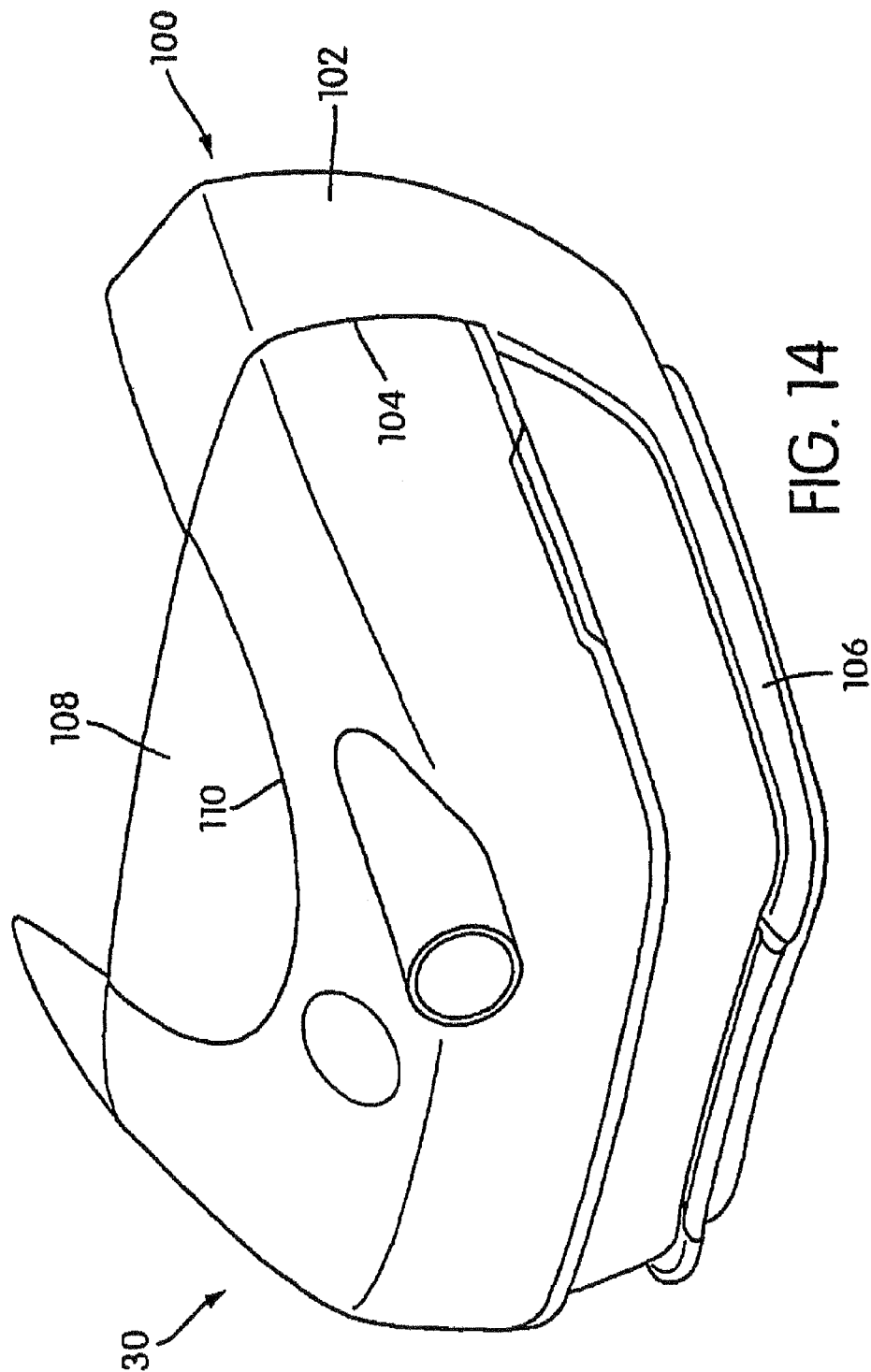


FIG. 11









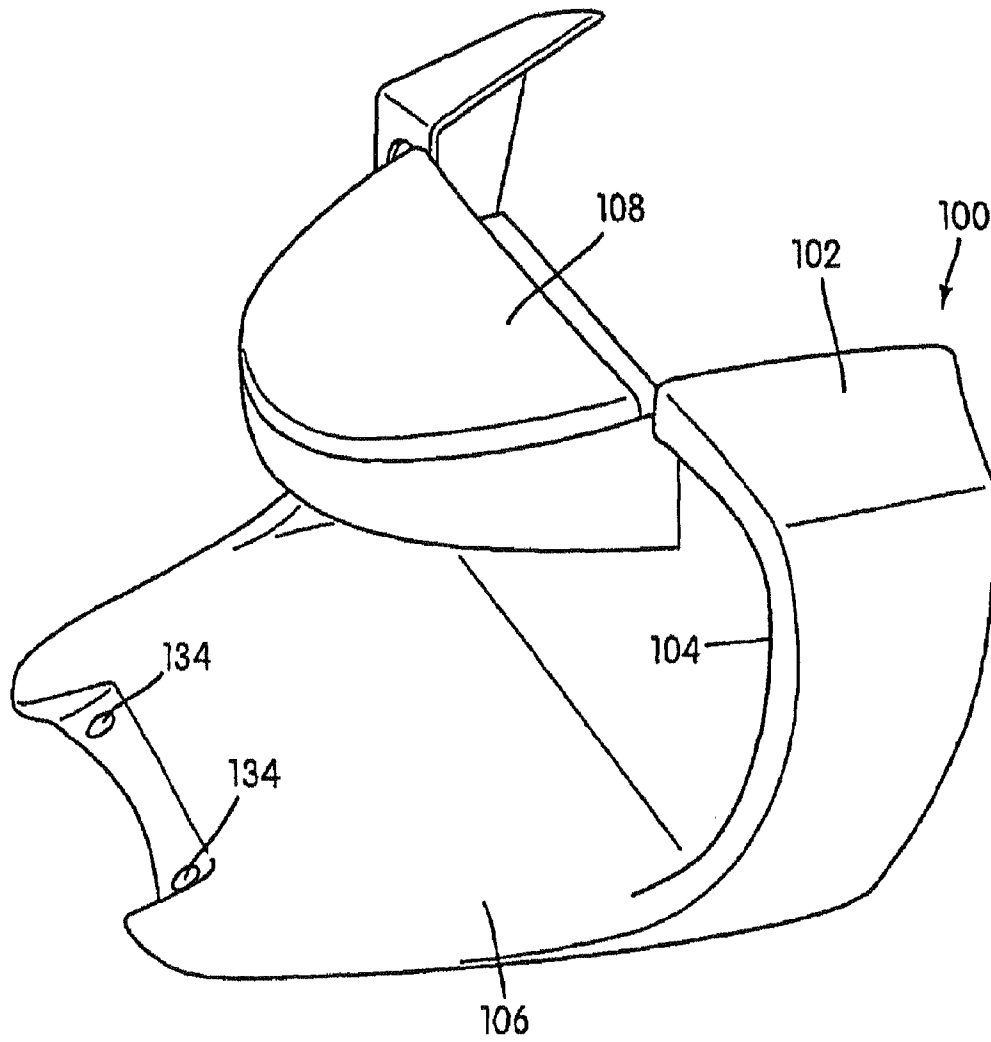


FIG. 15

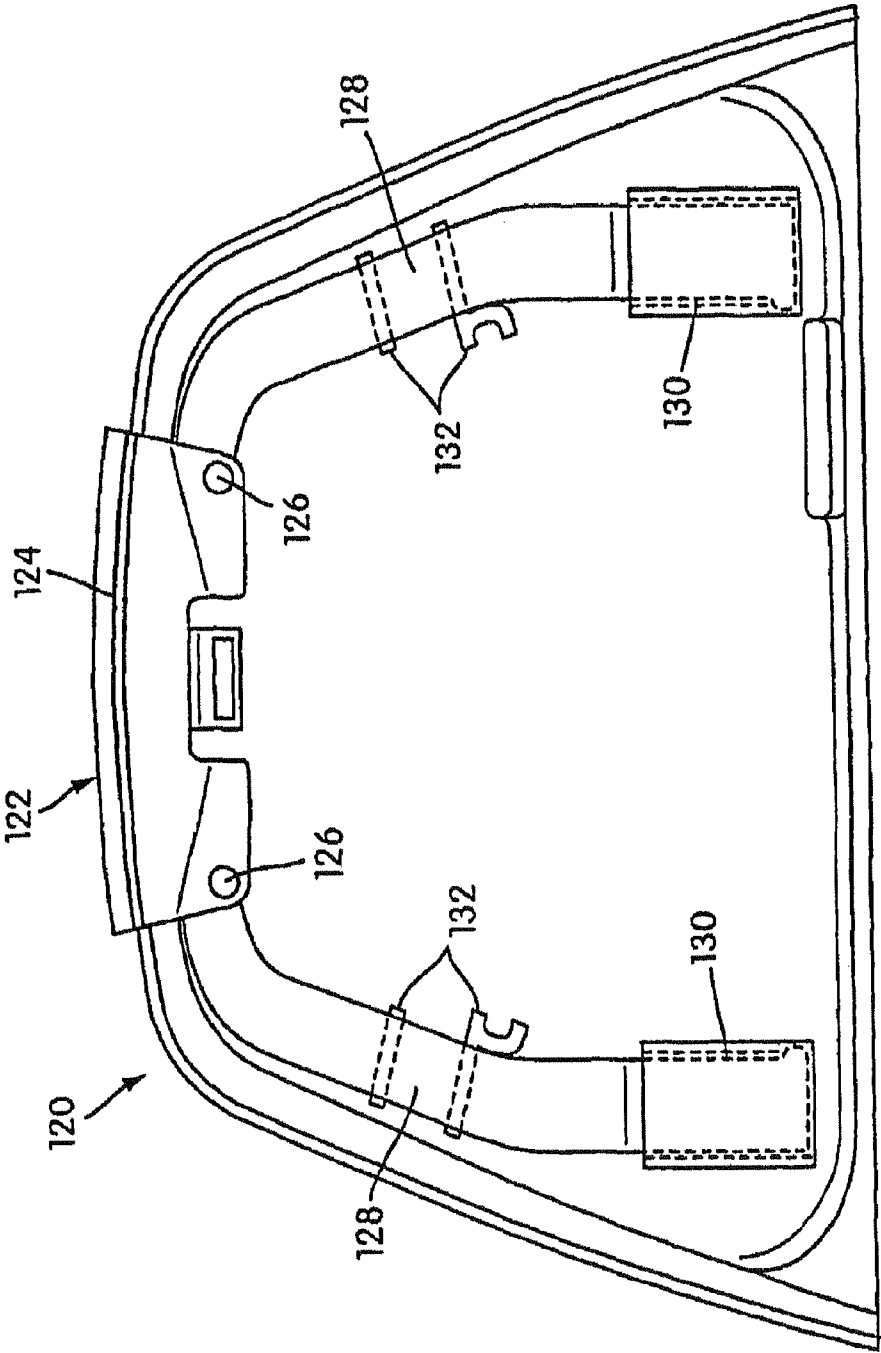


FIG. 16

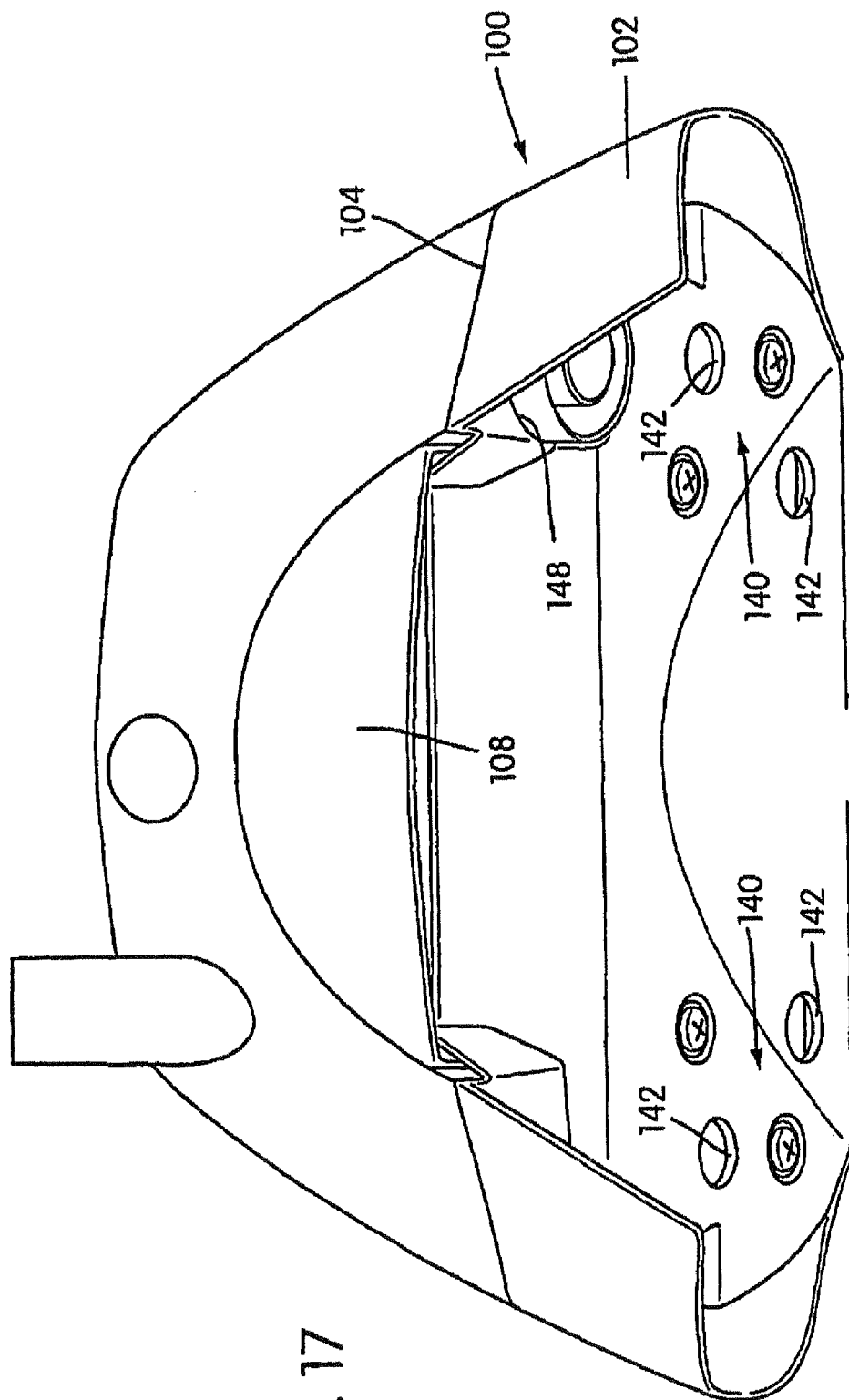


FIG. 17

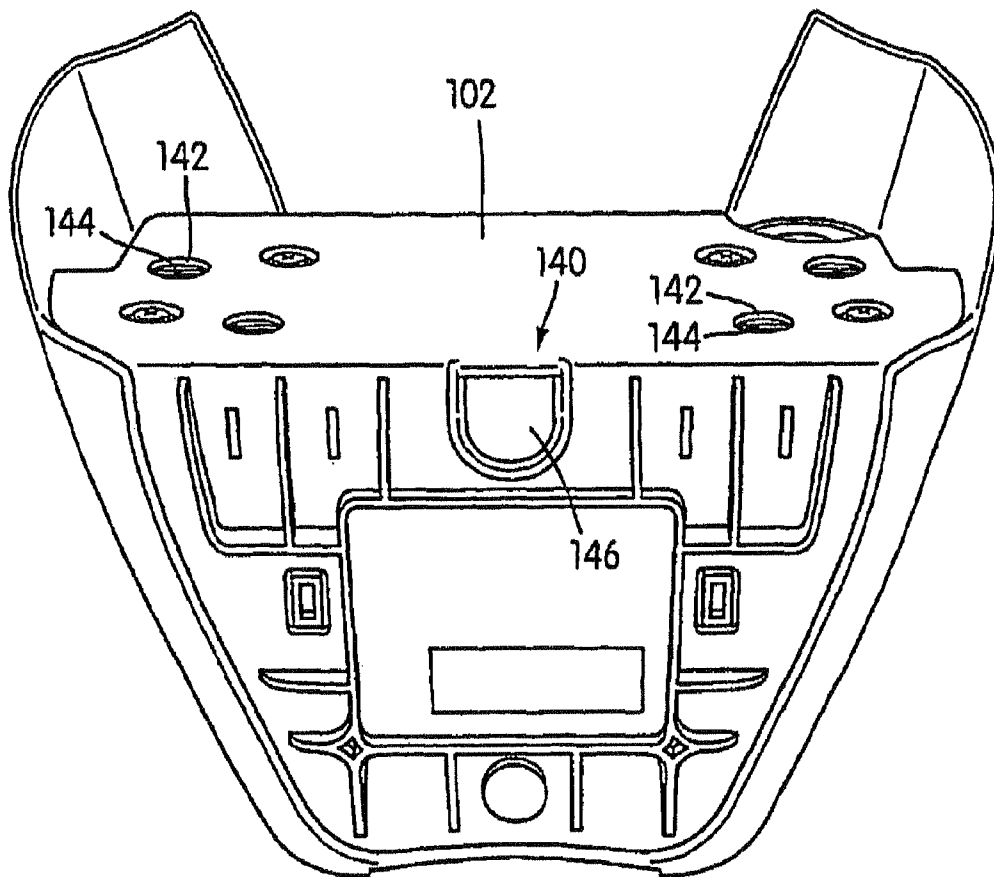
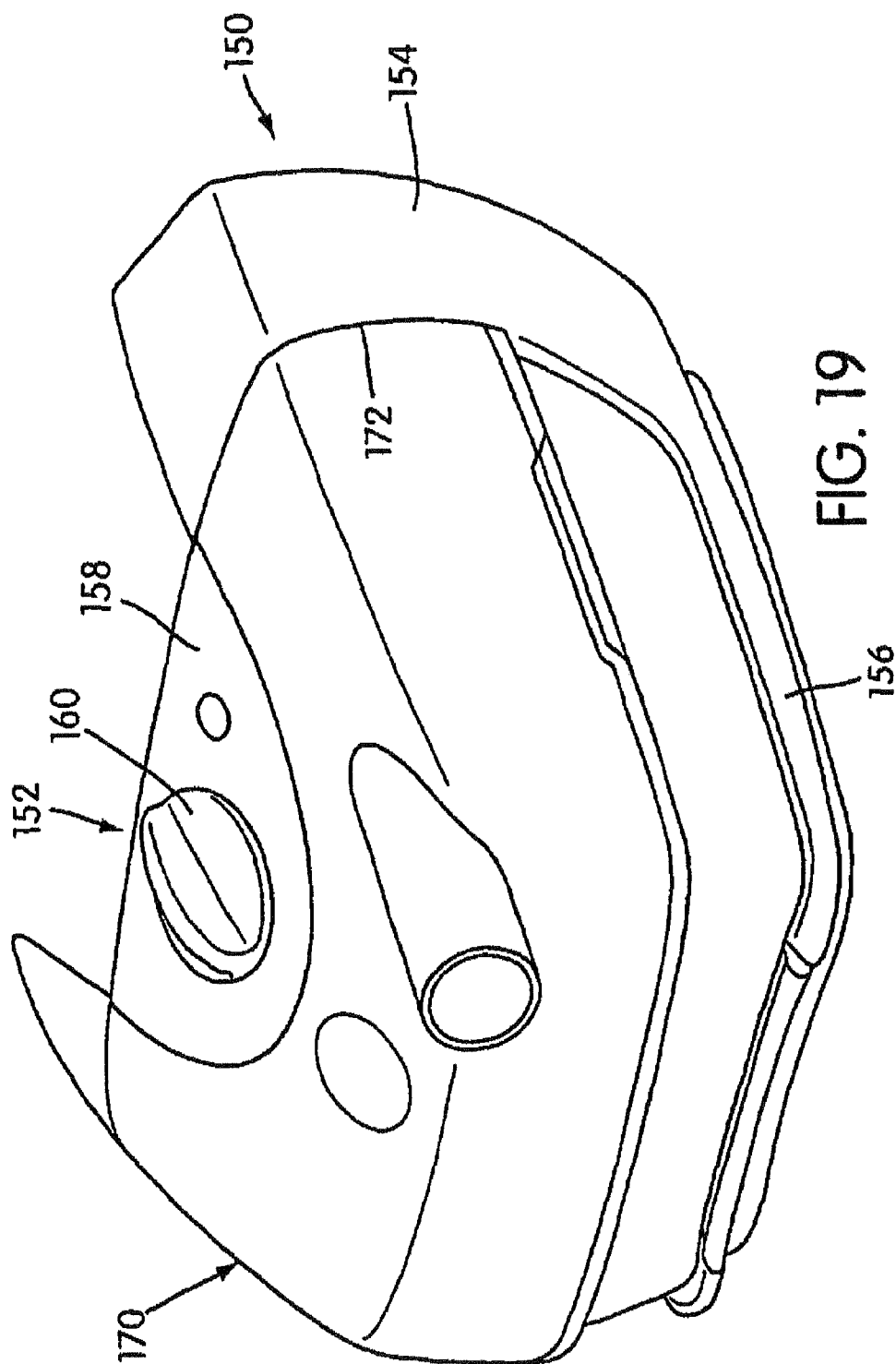


FIG. 18



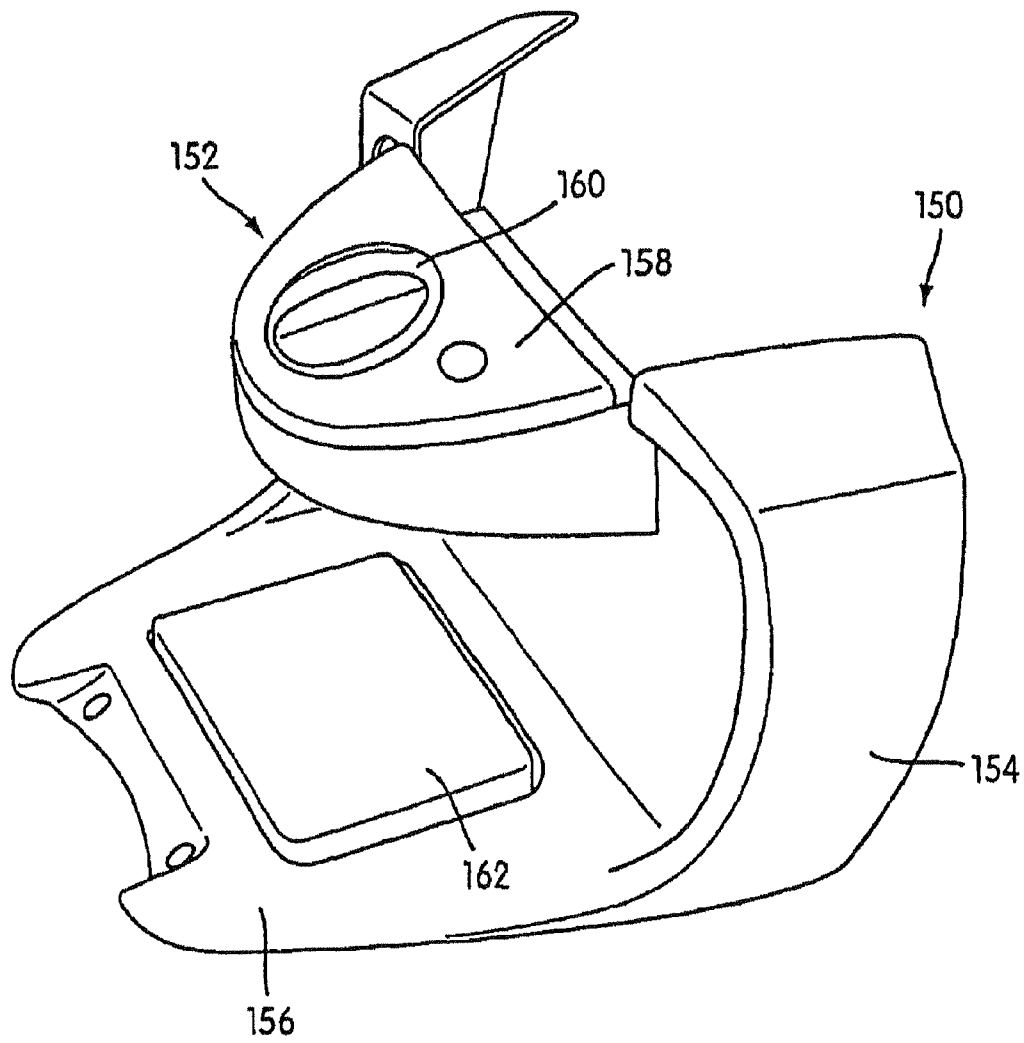


FIG. 20

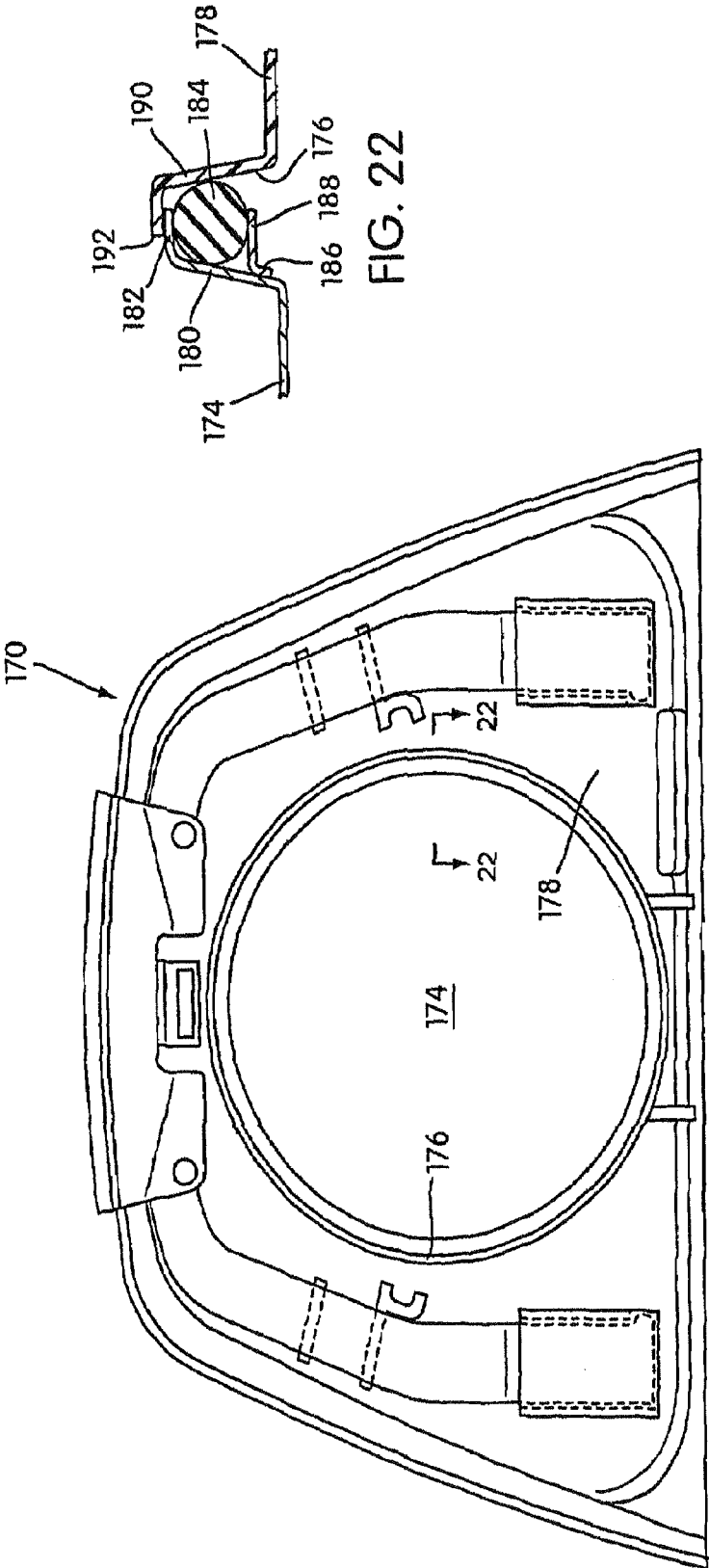


FIG. 21

FIG. 22

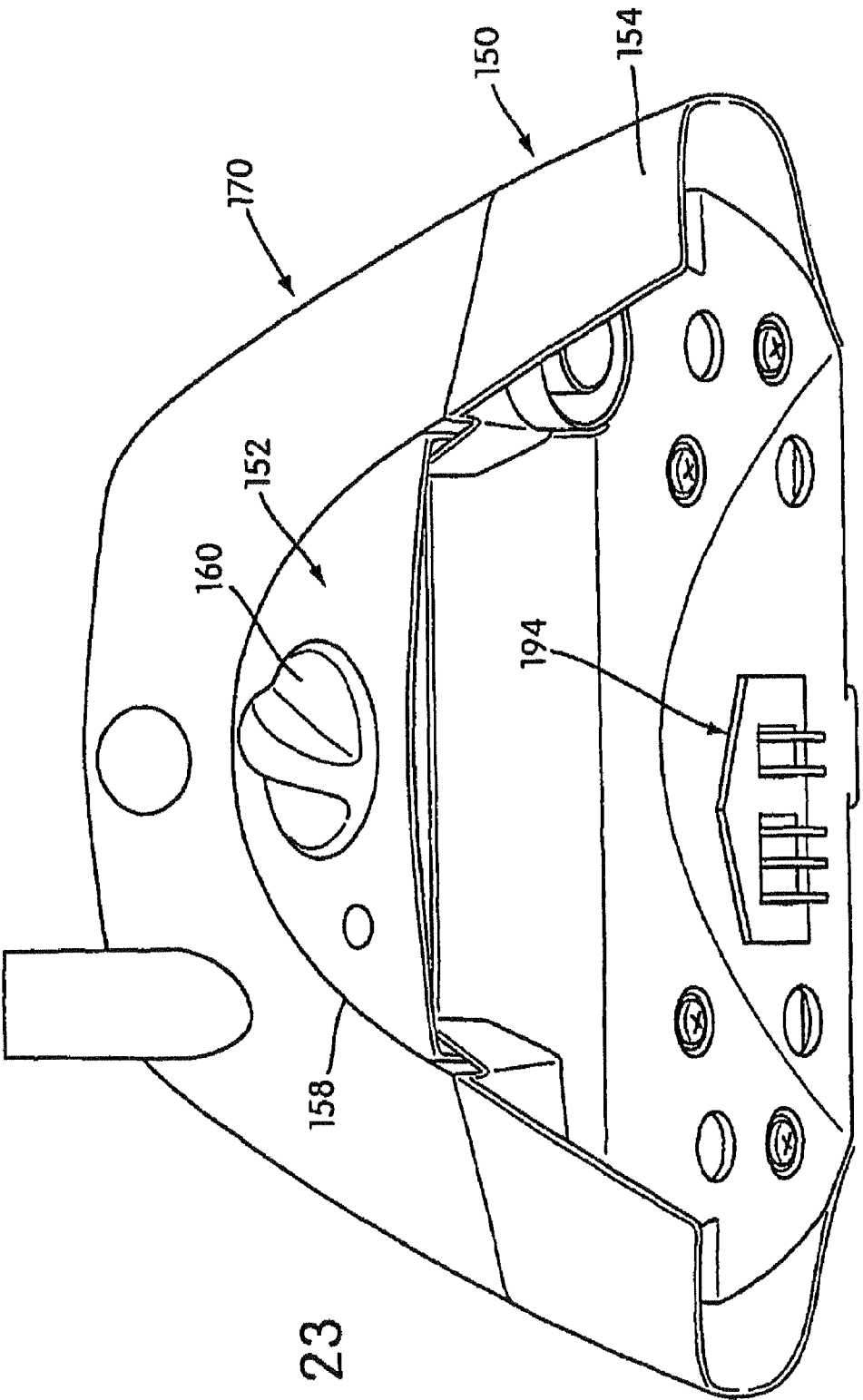


FIG. 23



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# HUMIDIFIER WITH STRUCTURE TO PREVENT BACKFLOW OF LIQUID THROUGH THE HUMIDIFIER INLET

**Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in *italics* indicates the additions made by reissue.**

## CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of Ser. No. 10/467,382, filed 7 Aug. 2003, now U.S. Pat. No. 6,935,337, which is the US national phase of international application PCT/AU02/00155 filed 14 Feb. 2002, which designated the United States, and claims the benefit of Australia Application Nos. PR3117, filed Feb. 16, 2001, and PR 7288, filed Aug. 27, 2001, each of which is incorporated herein by reference in its entirety.

The present application claims priority to Australian Provisional Applications PR3117, filed on Feb. 16, 2001 and PR7288, filed on Aug. 27, 2001, the specifications and drawings of which are incorporated by reference in their entirety.

The present invention relates to a humidifier for use with an apparatus for supplying breathable gas such as those used for Non-invasive Positive Pressure Ventilation (NIPPV) or Continuous Positive Airway Pressure (CPAP).

An apparatus for NIPPV or CPAP typically comprises a blower whose output is connected to a patient interface, such as a mask, via an air delivery conduit. Some patients find NIPPV or CPAP more comfortable when provided with humidified air. To this end, manufacturers often supply humidifiers which may be attached in the air circuit between the blower outlet and the patient interface. Humidifiers typically include a water reservoir and are configured such that ambient air from the blower entering the humidifier collects moisture through contact with the water, before continuing on to the patient interface.

Typically, the blower and humidifier are separate components connected via a flexible conduit. An air delivery conduit connects the humidifier outlet to a patient interface mask. Alternatively, the blower and humidifier may be rigidly-connected together. Air from the blower outlet passes into the humidifier inlet where it is humidified and then passes to the air delivery conduit. A potential problem with either arrangement is that if the humidifier is tilted relative to its normal orientation, water may run or spill from the humidifier into the blower outlet which may damage the electrical circuits of the blower and potentially cause infection control problems.

It is one aspect of the present invention to substantially overcome or at least ameliorate the prior art disadvantages.

It is another aspect to provide a humidifier for a CPAP apparatus that is adapted to substantially prevent liquid contained thereto from undesirably exiting an inlet of the humidifier.

It is another aspect to provide a humidifier that is capable of directly connecting to a CPAP apparatus.

It is another aspect to provide a humidifier that has an inlet that is directly connectable with a CPAP apparatus to effectively eliminate a supply tube.

It is another aspect to provide a humidifier that is capable of heating the liquid contained therein.

One embodiment of the present invention includes an apparatus for humidifying breathable gas including a humidifier body configured to retain a body of liquid therein, an inlet communicated with an interior of the humidifier body and

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connectable to a blower outlet, and an outlet communicated with the interior of the humidifier body and connectable to a patient supply conduit. The interior of the humidifier is arranged such that liquid from the body of liquid is prevented from exiting the humidifier body through the inlet thereof when the humidifier body is rotated from a working, upright orientation.

In this manner, the liquid is substantially prevented from entering the blower outlet and possibly damaging the blower.

It is contemplated that the apparatus may also include a first chamber having an inlet and an outlet, the first chamber inlet preferably being connectable to a blower outlet, a second chamber having an inlet preferably connected to the first chamber outlet, and an outlet preferably connectable to the patient supply conduit, the second chamber preferably having the carrying capacity for the body of liquid. The first chamber inlet and outlet and volumes of the first and second chambers may be adapted such that, when the humidifier is disposed in the working upright orientation, the body of liquid is contained in the second chamber and, in other relative positions of the humidifier, the body of liquid is retained in at least one of the second chamber and the first and second chambers at a level therewithin below a level of the first chamber inlet.

A volume of the second chamber may be larger than a volume of the first chamber.

The first chamber may be located substantially above the second chamber in the working upright orientation of the apparatus.

The first chamber inlet and outlet may be located adjacent opposing sections of the first chamber.

The second chamber outlet may be located closer to the first chamber outlet than the first chamber inlet.

At least a portion of a base of the second chamber may be made of a heat conducting material.

The heat conductive portion may be in the form of a metallic cap which covers an opening of the base.

The apparatus may also include a top cover, a base, and a divider disposed between the top cover and base, wherein the base defines a receptacle formed therewithin, which preferably retains the body of liquid in the working orientation of the apparatus.

The top cover and the divider together may define the first chamber and the receptacle and the divider together form the second chamber.

The first chamber inlet and the second chamber outlet may be formed in the top cover and is the first chamber outlet and the second chamber inlet may be formed in the divider, the first chamber outlet and the second chamber inlet may be defined by a single aperture in the divider which communicates the first and second chambers.

The divider may define first and second sections, the first section together with the top cover preferably defining the first chamber.

The divider may include a plurality of apertures, separated by ribs, which may provide fluid communication from the second chamber to the second chamber outlet formed in the top cover.

The top cover and the base may be formed from a relatively rigid polymer material and the divider may be formed from a relatively resilient material.

The first chamber inlet may be connected to a blower outlet, the first chamber outlet may be connected to the second chamber inlet, the second chamber outlet may be connected to the patient supply conduit, and a portion of the second chamber below and behind the second chamber inlet may define a volume thereof greater than a volume of the body of liquid.

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A portion of the second chamber between the first chamber inlet and the second chamber inlet and below the second chamber inlet may define a volume thereof greater than the volume of the body of liquid.

Portions of the first chamber and second chamber between the first chamber inlet and the second chamber outlet may define a volume thereof greater than the volume of the body of liquid.

Another embodiment of the present invention includes a CPAP apparatus including an apparatus for humidifying breathable gas as described above.

Another embodiment of the present invention includes a humidifier for a CPAP apparatus having a humidifier body defining a fluid reservoir and a fluid passage therein. The humidifier body has first and second chambers with a dividing member therebetween. The dividing member includes an orifice therethrough to communicate the first and second chambers with one another. Air from a blower (not shown) arrives in the first chamber via a first chamber inlet and departs from the second chamber via a second chamber outlet. The fluid passage includes the inlet, outlet, the orifice, and, at least, portions of the first and second chambers. The humidifier is designed to carry a body of liquid having a maximum volume,  $V_{max}$ . In a working orientation of the humidifier, the liquid body lies in a bottom portion of the second chamber. With respect to the working orientation of the humidifier the orifice lies forward of and to the side of the inlet. The first and second chambers are configured such that a volume of a first portion of the second chamber, which lies directly beneath the first chamber, is greater than  $V_{max}$ . Additionally, the volume of a second portion of the second chamber, which is disposed to the side of the first chamber, is greater than  $V_{max}$ . Furthermore, the volume of a portion of the second chamber forward of the inlet plus a portion of the first chamber forward of the inlet is greater than  $V_{max}$ . Additionally, the volume of a portion of the second chamber to the side of the inlet plus a portion of the first chamber to the side of the inlet is greater than  $V_{max}$ .

Yet another embodiment of the present invention includes a humidifier for a CPAP apparatus having first and second chambers, wherein an inlet to the humidifier is communicated with the first chamber, an outlet from the humidifier is communicated with the second chamber, and the first and second chambers are intercommunicated via an orifice extending therebetween. The inlet and orifice are arranged relative to one another such that a level of a volume of liquid present within the humidifier is below at least one of the inlet and orifice for any orientation of the humidifier.

Although certain embodiments of the invention are illustrated and described herein as having certain features, one skilled in the art would recognize that alternative embodiments of the invention could be provided based on at least one or more features, either individually or in combination, of the illustrated and described embodiments.

The benefits of the present invention will be readily appreciated and understood from consideration of the following detailed description of embodiments of this invention, when taken with the accompanying drawings, wherein:

FIG. 1 is a schematic view of a humidifier according to one embodiment of the present invention in a working, upright orientation;

FIGS. 2-5 are schematic views of the humidifier shown in FIG. 1 in corresponding non-working, upright orientations;

FIG. 6 is a perspective view of a humidifier according to another embodiment of the present invention in a working, upright orientation;

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FIG. 7 is an exploded perspective view of the humidifier shown in FIG. 6;

FIG. 8 is a partial sectional view of the humidifier shown in FIG. 6;

FIG. 9 is schematic view of the humidifier shown in FIG. 6 showing an air flow path through the humidifier;

FIGS. 10-13 are schematic views of the humidifier shown in FIG. 6 in corresponding non-working, upright orientations;

FIG. 14 is a perspective view of a humidifier and connecting structure according to another embodiment of the present invention;

FIG. 15 is a perspective view of the connecting structure shown in FIG. 14;

FIG. 16 is a bottom plan view of the humidifier shown in FIG. 14;

FIG. 17 is a rear perspective view of the humidifier and connecting structure shown in FIG. 14;

FIG. 18 is a bottom perspective view of the connecting structure shown in FIG. 14;

FIG. 19 is a perspective view of a humidifier and heater according to another embodiment of the present invention;

FIG. 20 is a perspective view of the heater shown in FIG. 19;

FIG. 21 is a bottom view of the humidifier shown in FIG. 19;

FIG. 22 is a cross-sectional view taken along line 22-22 in FIG. 21; and

FIG. 23 is a rear perspective view of the humidifier and heater shown in FIG. 19.

FIG. 1 schematically illustrates one embodiment of the humidifier of the present invention, indicated at 10. The humidifier 10 includes a humidifier body 12 defining a fluid reservoir and fluid passage therein. Additionally, there are two chambers 14, 16 defined by the humidifier body 12 and a dividing member 18. The dividing member 18 includes an orifice 20 therethrough to communicate the chambers 14, 16 to one another. Air from a blower (not shown) arrives in the first chamber 16 via a first chamber inlet 22. Air departs from the second chamber 14 via a second chamber outlet 24. The fluid passage includes the inlet 22, outlet 24, the orifice 20, and, at least, portions of the chambers 14, 16. The humidifier 10 is designed to carry a body of liquid 26 having a maximum volume,  $V_{max}$ .

In a working orientation represented in FIG. 1, the liquid body 26 lies in a bottom portion of the second chamber 14. With respect to the orientation of the humidifier 10 depicted in FIG. 1, e.g., the orifice 20 lies forward of and to the side of the first chamber inlet 22 (e.g., at a diagonally opposite end of the chamber 16). As shown, the volume of a first portion 14A of the second chamber 14, which lies directly beneath the first chamber 16, is greater than  $V_{max}$  due to its relatively increased height. Additionally, the volume of a second portion 14B of the second chamber 14, which is disposed to the side of the first chamber 16, is greater than  $V_{max}$ . Furthermore, the volume of a portion of the second chamber 14 forward of the inlet 22 plus a portion of the first chamber 16 forward of the inlet 22 is greater than  $V_{max}$ . Additionally, the volume of a portion of the second chamber 14 to the side of the inlet 22 plus a portion of the first chamber 16 to the side of the inlet 22 is greater than  $V_{max}$ . Hence, in order to minimize the volume of the humidifier 10, the first chamber inlet 22 is positioned as far to one side of the humidifier body 12 and as far rearward of the humidifier body 12 as possible.

The embodiment of the humidifier 10 shown in FIGS. 1-5 is configured to prevent liquid from the liquid body 26 from exiting through the inlet 22 thereof, such as when inadvertently rotated from an upright, normal working position (gen-

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erally illustrated in FIG. 1). For this reason, it is preferable for the humidifier 10 to be capable of being rotated from the upright, working position by about 120° without allowing liquid to exit from the inlet 22. It is more preferable for the humidifier 10 to be capable of being rotated from the upright, working position by about 80°-110° without allowing liquid to exit from the inlet 22. It is contemplated that for the embodiment of the humidifier 10 shown in FIG. 1, it may be especially preferable for the humidifier 10 to be capable of being rotated from the upright, working position by about 90° without allowing liquid to exit from the inlet 22, since the humidifier 10 is readily able to be placed on one side thereof due to the substantially fiat, normal sides thereof. However, of course, it may be desirable for the humidifier 10 to be capable of being rotated more or less than 90°, depending on the particular configuration of the humidifier 10. It is noted that while the humidifier 10 is designed to prevent liquid from exiting the inlet thereof when inadvertently oriented in other than the upright working position, it may be possible to purposefully enable liquid to exit from the inlet, such as by jostling or rapidly and/or repeatedly rotating the humidifier 10. In situations wherein it is highly undesirable for liquid to exit the inlet of the humidifier, the configuration (e.g., volume) of the chambers, size and placement of the inlet and outlet, and size and placement of the aperture intercommunicating the chambers may be altered from the illustrated embodiment to decrease the possibility of liquid exiting the inlet of the humidifier.

As shown in FIG. 2, the arrangement of the chambers 14, 16, inlet 22, and outlet 24 means that, if the humidifier 10 is rotated in a clockwise direction by up to 90° about axis  $\alpha$ , then the liquid body 26 will accumulate in the second portion 14B of the second chamber 14 and a portion of the first chamber 16 adjacent the outlet 24. In this situation, liquid of the liquid body 26 may run out of the outlet 24, but will not run out of the inlet 22 back into the blower.

Similarly, as shown in FIG. 3, if the humidifier 10 is rotated in a counter-clockwise direction (relative to the position illustrated in FIG. 1) by up to 90° about axis  $\alpha$ , then the liquid body 26 will accumulate in the first portion 14A of the second chamber 14, but will not spill over orifice 20 into the first chamber 16.

As shown in FIG. 4, if the humidifier 10 is rotated in a clockwise direction (relative to the position illustrated in FIG. 1) up to 90° about axis  $\beta$ , then the liquid body 26 will accumulate in a rearward portion of the second chamber 14 but will not spill over orifice 20 into the first chamber 16.

As shown in FIG. 5, if the humidifier 10 is rotated in a counter-clockwise direction (relative to the position illustrated in FIG. 1) up to 90° about axis  $\beta$ , then the liquid body 26 will accumulate in forward portions of the first and second chambers 14, 16 and will not spill back through first chamber inlet 22. Furthermore, liquid of the liquid body 26 will drain out of the humidifier 10 through second chamber outlet 24.

In the embodiment illustrated in FIGS. 1-5, the humidifier 10 has an exterior shape that is generally rectangular and the humidifier 10. As illustrated, the inlet 22 is positioned to correspond to a blower outlet being on the upper left-hand side when viewed from the front in an upright position. Therefore the humidifier inlet 22 is positioned at the back of the humidifier 10 on the upper left-hand side, when viewed from the front in an upright position. The humidifier outlet 24 lies on the front upper right-hand side, when viewed from the front in an upright position. However, it is, of course, possible for the inlet and outlet to be repositioned corresponding to the position of the blower outlet.

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For each of the orientations of the humidifier 10 shown in FIGS. 1-5, the level of the liquid body 26 is always below the level of at least one of the inlet 22 and orifice 20 intercommunicating the first and second chambers 16, 14. In this manner, in a case wherein the inlet 22 is disposed below the level of the liquid body 26 (such as in orientations illustrated in FIGS. 3 and 4), the orifice 20 is disposed above the level of the liquid body 26, which prevents liquid from flowing there-through and exiting the inlet 22. Conversely, in a case wherein the orifice 20 is disposed below the level of the liquid body 26 (such as in orientations illustrated in FIGS. 2 and 5), the inlet 22 is disposed above the level of the liquid body 26. Accordingly, liquid may flow through the orifice 20, but is prevented from exiting through the inlet 22.

FIG. 6 shows another embodiment of a humidifier 30 according to the present invention. The humidifier 30 includes an inlet 32 and an outlet 34, both of which are communicated with an interior of the humidifier 30. The interior of the humidifier 30 defines a reservoir for a body of liquid and a fluid passage. The fluid passage is communicated to each of the inlet 32 and outlet 34 and is configured such that fluid (e.g., breathable gas at an elevated pressure) flowing therethrough is exposed to the body of liquid. Additionally, the humidifier 30 is adapted for detachable connection to an NIPPV or CPAP apparatus (not shown) which includes a blower. When connected, the output of the blower is attached to the inlet 32. Air from the blower enters the inlet 32, flows through the fluid passage, and collects moisture through contact with the liquid body, before continuing onto the outlet 34 and then to the patient.

It is also contemplated that the humidifier 30 may include an additional internal passage to allow monitoring of the CPAP pressure without degrading signal strength or necessitating relatively large correction factors due to signal attenuation within the humidifier, such as described in co-pending Applications incorporated above, as well as co-pending Application No. WO 02/066107, entitled "Air Pressure Signal Monitoring in Apparatus for Treating Sleep Disordered Breathing", filed on even date herewith and hereby incorporated by reference in its entirety.

As shown in FIG. 7, the humidifier 30 includes a top cover 36, a gasket 38, and a base 40. The gasket 38 is disposed between the top cover 36 and base 40, which are secured together via sliding clips 72. (See FIG. 6.) Of course, other suitable fastening arrangements and constructions are possible. For example, the top cover 36 and base 40 may be formed with snap-fit or other cooperating constructions. Alternatively, other types of mechanical fasteners may be utilized. It is contemplated that the top cover 36 may be formed from a relatively rigid polymer material, such as polysulfone (for example, grade UDEL P1700, manufactured by BP Amoco Polymers), and includes the inlet 32 and the outlet 34. The gasket 38 may be formed from a relatively resilient material, such as silicone rubber (for example, SILASTIC 94595-IIC, manufactured by Dow Corning) and is divided into first and second sections 42 and 44 by a channel structure 46. The first section 42 includes a raised portion 48 having a first aperture 50 extending vertically therethrough. The second section 44 includes a plurality of second apertures 52 extending vertically therethrough and being separated from one another by ribs 54. The top cover 36 may also include a divider wall structure 56 (FIG. 8) which corresponds to and is received within the channel structure 46 of the gasket 38. The gasket 38 includes a sealing flange 58 formed about a periphery thereof. The base 40 may be formed from the same or similar rigid polymer material as the top cover 36 and may include a receptacle 60 formed therewithin,

a bottom portion 62, and side walls 64 extending upwardly from the bottom portion 62. The base 40 may also include a removable bridge structure 66, which divides the receptacle 60 into two sections 68 and 70, which correspond to the sections [22] 42 and [24] 44 of the gasket 38.

As shown in FIG. 8, to assemble the humidifier 30, the gasket 38 is attached to the base 40. The flange 58 of the gasket 38 forms a sealing engagement with an upper edge portion of the side walls 64 of the base 40. The top cover 36 is then attached to the base 40 via sliding clips 72 (FIG. 6) on opposite sides of the humidifier 30, such that the top cover 36 covers and seals with the gasket 38. The removable bridge structure 66 vertically supports an intermediate portion of the gasket 38. As shown, a downwardly facing surface of the channel structure 46 of the gasket 38 engages an upwardly facing surface of the bridge structure 66. When assembled, the gasket first section 42, the top cover 36, and the divider wall structure of the top cover 36 together form a first chamber 74. The receptacle 60 of the base 40 together with the gasket 38 form a second chamber 76. The first chamber 74 is thus located above the second chamber 76 and the volume of the second chamber 76 is larger than the volume of the first chamber 74. The first and second chambers 74, 76 are in communication with one another via the first aperture 50 within the gasket 38. The second chamber 76 is in communication with the outlet 34 via the second apertures 52 within the gasket 38.

In use, a predetermined maximum volume of liquid is poured into the receptacle 60 of the base 40 after removing the top cover 36 and the sealing gasket 38 from the base 40. The top cover 36 and the sealing gasket 38 are then reattached to the base 40. As shown in FIG. 9, a body of liquid 78 is held in the second chamber 76 when the humidifier 10 is in the upright working orientation of the humidifier 30. Breathable gas from the blower enters the inlet 32 and travels through the first chamber 74 and into the first aperture 50. The gas passes through the aperture 50 and enters the second chamber 76 where it is humidified by contact with the body of liquid 78, before exiting through apertures 52 in the gasket 38, and then out through outlet 34 (FIG. 6).

In the working upright orientation of the humidifier 30, as shown in FIG. 9, a liquid level, indicated at 81, of the body of liquid 78 is below the aperture 50. Thus, liquid from the body of liquid 78 cannot exit via the inlet 32 and there is no risk of damaging the electronic components of the NIPPV or CPAP apparatus. The body of liquid 78, however, will be displaced in the humidifier 30 according to the orientation of the humidifier 30. Accordingly, the humidifier 30 is configured to substantially prevent liquid of the body of liquid 78 from exiting through the inlet 32 in non-upright orientations to avoid damage to the NIPPV or CPAP apparatus connected to the humidifier 30.

Similarly as with the embodiment illustrated in FIGS. 1-5, the embodiment of the humidifier 30 shown in FIGS. 6-13 is configured to prevent liquid from the liquid body 78 from exiting through the inlet 32 thereof, such as when inadvertently rotated from an upright normal working position (generally illustrated in FIG. 6). For this reason, it is preferable for the humidifier 30 to be capable of being rotated from the upright, working position by about 120° without allowing liquid to exit from the inlet 32. It is more preferable for the humidifier 30 to be capable of being rotated from the upright, working position by about 80°-110° without allowing liquid to exit from the inlet 32. It may be especially preferable for the humidifier 30 to be capable of being rotated from the upright, working position by about 90° without allowing liquid to exit from the inlet 32. However, of course, it may be desirable for

the humidifier 30 to be capable of being rotated more or less than 90°. It is noted that while the humidifier 30 is designed to prevent liquid from exiting the inlet thereof when inadvertently oriented in other than the upright working position, it may be possible to purposefully enable liquid to exit from the inlet, such as by jostling or rapidly and/or repeatedly rotating the humidifier 30. In situations wherein it is highly undesirable for liquid to exit the inlet of the humidifier, the configuration (e.g., volume) of the chambers, size and placement of the inlet and outlet, and size and placement of the aperture intercommunicating the chambers may be altered from the illustrated embodiment to decrease the possibility of liquid exiting the inlet of the humidifier.

For each of the orientations of the humidifier 30 shown in FIGS. 10-13, the level of the liquid body 78 is always below the level of at least one of the inlet 32 and aperture 50 intercommunicating the first and second chambers 74, 76. In this manner, in a case wherein the inlet 32 is disposed below the level of the liquid body 78 (such as in orientations illustrated in FIGS. 10 and 12), the aperture 50 is disposed above the level of the liquid body 78, which prevents liquid from flowing therethrough and exiting the inlet 32. Conversely, in a case wherein the aperture 50 is disposed below the level of the liquid body 78 (such as in orientations illustrated in FIGS. 11 and 13), the inlet 32 is disposed above the level of the liquid body 78. Accordingly, liquid may flow through the aperture 50, but is prevented from exiting through the inlet 32.

In FIG. 10, the humidifier 30 is rotated to an angle about 90° from the working upright orientation, such that a side 80 thereof corresponding to the side of the humidifier 30 adjacent the inlet 32, is oriented below a side 82 thereof corresponding to the side of the humidifier 30 adjacent the outlet 34. Because the raised portion 48 of the gasket 38 increases the volume of the second chamber 76, the body of liquid 78 remains only in the second chamber 76 and the level 81 of the liquid body 78 remains below the first aperture 50. Thus, the liquid will not exit through the inlet 32.

In FIG. 11, the humidifier 30 is rotated to an angle about 90° from the working upright orientation, such that the side 82 is below the side 80 (i.e., flipped 180° from the orientation illustrated in FIG. 11). As the level 81 of the body of liquid 78 is above (at least initially) the apertures 52, liquid will pass therethrough and exit the outlet 34. However, since the level 81 of the liquid body 78 is below the inlet 32, liquid will not exit through the inlet 32. Liquid exiting through the outlet 34 is generally acceptable as there is not generally a risk in damaging the NIPPV or CPAP apparatus.

In FIG. 12, the humidifier 30 is rotated to an angle about 90° from the working upright orientation, such that a rear side thereof indicated at 84, corresponding to the side at which the inlet 32 is located, is below a forward side thereof indicated at 86, corresponding to the side at which the outlet 34 is located. As shown, the body of liquid 78 remains substantially in the second chamber 76 and the level 81 of the liquid body 78 remains below the first aperture 50. Thus, water cannot exit through the inlet 32.

FIG. 13 illustrates when the humidifier 30 is tilted to an angle about 90° from the working upright orientation, such that the forward side 86 is below the rear side 84. As shown, the body of liquid 78 is disposed within forward portions of the first and second chambers 74, 76. As the level 81 of the body of liquid 78 is at least initially above the level of the aperture 50, liquid will flow through the aperture 50 into the first chamber 74. However, since the inlet 32 is disposed above the level of the body of liquid 78 in this orientation, no liquid exits through the inlet 34.

The humidifier 30 thus ensures that the body of liquid 78 is disposed in one of (a) only the second chamber 76, or (b) portions of the first and second chambers 74, 76 at a level below the inlet 32, to prevent liquid from exiting through the inlet 32 at orientations of the humidifier 30 up to an angle of about 90° from the working upright orientation. In the illustrated embodiment, a number of features of the humidifier 30 contribute to ensuring this function. These include relative positions of the inlet 32 and first aperture 50. More particularly, the inlet 32 and first aperture 50 are located on opposing ends of the first chamber 74. Also, the volume of the second chamber 76 is larger than the volume of the first chamber 74, which is assisted by the raised portion 48 of the gasket 38 so that liquid displaced from the first chamber 74 may be accommodated within the second chamber 76 without overflow through aperture 50. Furthermore, the outlet 34 is located closer to the first aperture 50 than the inlet 32, which assists in ensuring that liquid will exit via the outlet 34, rather than through the inlet 32.

The humidifier 30 therefore substantially prevents or reduces the risk of water exiting through the inlet 32, which may damage the NIPPV or CPAP apparatus, when the humidifier 30 is in other orientations up to an angle of about 90° from its working upright orientation.

It is contemplated that the humidifier 30 may be used as a retrofit or add-on component for a CPAP apparatus. To facilitate this usage, it may be preferable to provide a connecting structure 100 that is configured to connect between the CPAP apparatus and humidifier 30. As shown in FIGS. 14 and 15, the connecting structure 100 includes a housing 102, which provides a generally horizontally extending receptacle 104 within which the humidifier 30 may be disposed. The housing 102 provides a base portion 106 that is configured to support the humidifier 30 thereon and a retaining portion 108 configured to secure the humidifier 30 in position. As shown in FIG. 16, the retaining portion 108 extends generally parallel to the base portion 106 and is spaced above the base portion 106. Referring back to FIG. 14, the humidifier 30 may be formed with a recess 110 that is open and of a complimentary shape to receive the retaining portion 108 therein.

To facilitate connection of the humidifier 30 to the connecting structure 100, it is contemplated that another embodiment of a humidifier, indicated at 120 in FIG. 16, may include a securing mechanism 122. As shown, the securing mechanism 122 includes a resiliently biased pull member 124 that includes one or more locking lugs 126 extending generally downwardly therefrom. The pull member 124 is disposed at a forward end (assuming the rearward end of the humidifier 120 is adjacent the connecting structure 100) of the humidifier 120 and is resiliently biased by a pair of resilient legs 128. Rearward portions of the legs 128 are relatively securely retained within corresponding pocket structures 130 provided on a bottom side of the humidifier 120. Ribs 132 extend downwardly from the bottom side of the humidifier 120 and engage an intermediary portion of the legs 128 to define a space between the resilient legs 128 and the bottom side of the humidifier 120. In this manner, the pull member 124 is biased generally downwardly by the resilient legs 128, but may be manually moved (e.g., pulled) upward against a resilient bias of the legs 128.

As shown in FIG. 15, a forward portion of the base portion 106 includes generally upwardly open lug receiving recesses 134 within which the lugs 126 may be disposed when the humidifier 120 is disposed within the receptacle 104. As the humidifier 120 is inserted within receptacle 104, the legs 128 resiliently bias the lugs 126 into recesses 134. The lugs 126 and recesses 134 thereby secure the humidifier 120 within the

receptacle 104. To remove the humidifier 120 from the receptacle 104, the pull member 124 is pulled upwardly to withdraw the lugs 126 from the recesses 134. The humidifier 120 may then be pulled generally horizontally out of the receptacle 104.

FIG. 17 shows a rearward side of the connecting structure 100. The rearward side of the connecting structure 100 provides a retaining mechanism 140 to secure the connecting structure 100 to the CPAP apparatus. It is contemplated that the retaining mechanism 140 may include a series of apertures 142 within the rearward portion of the housing 102. The apertures 142 may receive therein, for example, prongs or tabs (not shown) provided by the CPAP apparatus. As shown in FIG. 18, within each aperture 142, a locking member 144 may be provided that is resiliently biased toward a position that partially encloses the respective aperture 142. As also shown in FIG. 18, a button structure 146 may be coupled to the locking members 144, such that manual movement of the button structure 146 moves the locking members 144 out of their biased positions to substantially fully open the apertures 142. It is contemplated that the tabs or prongs on the CPAP apparatus are provided with a groove therein such that when positioned within the apertures 142, the locking members 144 engage within respective grooves to thereby securely and detachably retain the connecting structure 100 to the CPAP apparatus.

Referring back to FIG. 17, the housing 102 of the connecting structure 100 may be provided with an opening 148 that allows the inlet of the humidifier to extend therethrough so as to be connected to the CPAP apparatus.

In certain circumstances, it may be desirable to provide heated humid air to the respirator mask. Accordingly, another embodiment of the connecting structure, indicated at 150 in FIG. 19, may include a heater 152. The connecting structure 150 may include a housing 154, which provides a base portion 156 and retaining portion 158, similar to the housing 102 described above. As shown in FIG. 19, the retaining portion 158 may include a controller such as a knob or other selecting device 160 thereon to control a heat setting of the heater 152. It is also contemplated that the controller 160 may include a display device, such as an LCD screen.

As shown in FIG. 20, the base portion 156 may include a heating element 162 thereon. The heating element 162 may be in the form of a substantially flat plate-like resistance heater, which heat generated thereby may be directly controlled by the controller 160. As shown in FIG. 19, another embodiment of the humidifier is indicated at 170. The humidifier 170 is disposed within a receptacle 172 provided by the housing 154. It is contemplated that the humidifier 170 has the same basic construction as the humidifiers 10 and 120 described above. However, it is contemplated that the humidifier 170 may include a heating plate 174 (also referred to as a metallic cap) to facilitate heating of the liquid contained therein. In particular, an opening 176 is provided within a bottom wall 178 of the humidifier 170. The heating plate 174 is shaped to fit within the opening 176, as shown in FIG. 21. As shown in more detail in FIG. 22, the heating plate 174 includes an upstanding peripheral wall 180 which includes an outwardly extending peripheral lip 182. A resilient seal member 184 is disposed about an outer periphery of the peripheral wall 180 in contact with the peripheral lip 182. A ring-like retaining member 186 may be press-fit onto the peripheral wall 180 to retain the seal 184 in position on the peripheral wall 180. The retaining member 186 includes an outwardly extending flange structure 188. The seal 184 is disposed between the peripheral lip 182 and flange structure 188. It is contemplated that the retaining member 186 may be press fit

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onto the heating plate 174, as described above, or may be formed in one piece therewith. The bottom wall 178 of the humidifier 170 is formed with an annular upstanding flange 190 which receives the heating plate 174. It is contemplated that the flange 190 may be slightly tapered inwardly in the upward direction to ease insertion of the heating plate 174. As shown, the flange 190 may include a generally horizontally extending lip structure 192 that vertically retains the heating plate 174.

Referring to FIG. 19, with the humidifier 170 in position within the receptacle 172, a bottom surface of the heating plate 174 is in contact with an upper surface of the heating element 162. In this manner, a heat generated by the heating element 162 is conductively transferred to the heating plate 174. The liquid within the humidifier 170 is exposed to an upper surface of the heating plate 174 and conducts heat therefrom. It is contemplated that a temperature of the liquid within the humidifier 170 may be controlled by manipulation of the controller 160.

It is also contemplated that the heating element 162 may be upwardly resiliently biased to ensure adequate contact between the heating element 162 and the heating plate 174.

As shown in FIG. 23, a rearward portion of the connecting suture 150 may include a plurality of generally outwardly extending contact elements 194. It is contemplated that the contact element 194 may communicate with a power supply within the CPAP apparatus and/or a controller and/or sensors. In this manner, power may be delivered to the heater 152 directly from the CPAP apparatus. Additionally, a controller within the CPAP apparatus itself may control the heater 152. Furthermore, it is contemplated that sensors within the CPAP apparatus may monitor a heat output of the heater 152. Moreover, it may be possible for a CPAP apparatus to automatically adjust a heat output of the heater 152 based on a measured temperature thereof or of the water within the humidifier or of the breathable air exiting the humidifier.

The invention claimed is:

1. A humidifier assembly for a CPAP apparatus, comprising

a humidifier including

a base configured to retain a body of liquid therein, at least a portion of the base being constructed of a heat conducting material,

a top cover, and

a seal disposed between the top cover and the base; and a connecting structure configured to connect between the CPAP apparatus and humidifier and allow communication of an outlet of the CPAP apparatus with [the] an inlet of the humidifier, the connecting structure including a housing providing a base portion to support the humidifier thereon, and a retaining mechanism configured to secure the connecting structure to the CPAP apparatus,

wherein the base portion includes a heating element in contact with the heat conducting material of the base of the humidifier.

2. A humidifier assembly according to claim 1, wherein the top cover defines both an inlet and an outlet communicated with an interior of the base, the inlet configured to receive pressurized breathable gas and the outlet configured to deliver the pressurized breathable gas with added humidity.

3. A humidifier assembly according to claim 1, wherein the connecting structure includes a control knob to control a heat setting of the heating element.

4. A humidifier assembly according to claim 1, wherein the connecting structure includes contact elements that communicate with a power supply within the CPAP apparatus.

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5. A humidifier assembly according to claim 1, wherein the connecting structure is configured to allow removable attachment of the CPAP apparatus to the humidifier.

6. A humidifier assembly according to claim 1, wherein the heat conducting material is a metallic material.

7. A CPAP apparatus including a humidifier assembly according to claim 1.

8. A humidifier assembly according to claim 1, wherein the inlet of the humidifier is provided in the base and an outlet of the humidifier is provided in the top cover.

9. A humidifier for humidifying a flow of breathable gas to be delivered to a patient, the humidifier comprising:

a humidifier body configured to retain a body of liquid having a predetermined maximum volume, the humidifier body comprising:

a first chamber having a first chamber inlet configured to receive the flow of breathable gas, and

a second chamber in communication with the first chamber through a passage, the second chamber being structured to contain a predetermined maximum volume of liquid when the humidifier body is in a normal upright, operating position, the second chamber comprising a second chamber outlet configured to deliver the flow of breathable gas with added humidity,

wherein the first chamber, the second chamber, and the passage are arranged such that when liquid is contained in the second chamber in the upright, normal operating position, the possibility of liquid flowing from the second chamber through the passage is reduced or prevented, and liquid that flows from the second chamber and through the passage is collected in the first chamber such that liquid is discouraged or prevented from spilling back from the first chamber inlet when the humidifier body is inadvertently rotated from the upright, normal operating position to a non-upright position.

10. A humidifier according to claim 9, wherein the humidifier body has a longitudinal axis extending in a direction from a rear side of the humidifier body to a front side of the humidifier body, and a transverse axis extending in a direction from a left side of the humidifier body to a right side of the humidifier body, and no liquid will flow out of the first chamber inlet when the humidifier body is rotated about 80°-110° around the longitudinal axis and/or transverse axis from the upright, normal operating position.

11. A humidifier according to claim 10, wherein the second chamber outlet is higher than the first chamber inlet in the upright, normal operating position.

12. A humidifier according to claim 11, wherein the second chamber has a larger volume than the first chamber.

13. A humidifier according to claim 12, wherein the passage is forward of and to the side of the first chamber inlet.

14. A humidifier according to claim 13, wherein the first chamber inlet is positioned on a transverse side of the humidifier body.

15. A humidifier according to claim 14, wherein the first chamber inlet is positioned on a rearward end of the transverse side of the humidifier body.

16. A humidifier according to claim 14, wherein the first chamber inlet is positioned on the left side of the humidifier body.

17. A humidifier according to claim 14, wherein a portion of the second chamber extends forward of the first chamber.

18. A humidifier according to claim 9, wherein the second chamber outlet is disposed above the passage from the first chamber to the second chamber.

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19. A humidifier according to claim 9, wherein a level of the predetermined maximum volume of liquid is below the passage in the upright, normal operating position.

20. A humidifier according to claim 9, wherein the first chamber and the second chamber are releasably engagable with each other.

21. A humidifier according to claim 20, wherein when the first chamber and the second chamber are engaged with each other, mating portions of the first chamber and the second chamber provide a seal between the first chamber and the second chamber.

22. A humidifier according to claim 21, wherein the mating portions provide a releasable connection between the first chamber and the second chamber.

23. An apparatus for supplying breathable gas under pressure, comprising:

a blower to generate a flow of pressurized breathable gas; the humidifier according to claim 9 structured to reduce risk of or prevent spillback of liquid from the humidifier to the blower;

a connecting structure configured to connect between the blower and the humidifier and allow communication of an outlet of the blower with the first chamber inlet of the humidifier; and

an air delivery conduit in communication with output from the humidifier.

24. An apparatus according to claim 23, further comprising:

a patient interface connected to the air delivery conduit.

25. A humidifier assembly for a CPAP apparatus, comprising:

a humidifier that defines a reservoir for a body of liquid, and a fluid passage between an inlet provided at a rear side of the humidifier and an outlet of the humidifier for exposure of a flow of breathable gas from the CPAP apparatus to the body of liquid, the humidifier comprising

a base configured to retain the body of liquid therein and including a heat conducting material, and

a top cover that covers the base, the top cover including the outlet; and

a connecting structure configured to connect between the CPAP apparatus and humidifier and allow communication of an outlet of the CPAP apparatus with the inlet of the humidifier; the connecting structure comprising a housing, the housing providing a generally horizontal, open receptacle within which the humidifier may be removably disposed by generally horizontally inserting the humidifier within and pulling it out of the receptacle, the housing comprising a base portion forming a lower surface of the receptacle and configured to support the humidifier thereon, a heating element positioned on the lower surface and in thermal contact with the heat conducting material of the base when the humidifier is disposed in the receptacle, and a retaining portion positioned adjacent the top cover of the humidifier and being spaced above the base portion, the retaining portion being configured to assist in retaining the humidifier in the generally horizontal receptacle.

26. A humidifier assembly according to claim 25, wherein the base and the top cover are detachably connected to each other.

27. A humidifier assembly according to claim 26, wherein the housing comprises an opening that communicates with the inlet when the humidifier is fully inserted into the generally horizontal receptacle.

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28. A humidifier assembly according to claim 27, further comprising a retaining mechanism to secure the connecting structure to the CPAP apparatus.

29. A humidifier assembly according to claim 28, wherein the retaining mechanism comprises a resiliently biased locking member configured to releasably engage a projection of the CPAP apparatus.

30. A humidifier assembly according to claim 29, further comprising a release member coupled to the resiliently biased locking member to move the resiliently biased locking member out of engagement with the projection of the CPAP apparatus.

31. A humidifier assembly according to claim 30, wherein the release member is provided in the base portion of the housing.

32. A humidifier assembly according to claim 25, wherein the heat conducting material of the base of the humidifier is provided in an opening in a bottom wall of the base of the humidifier.

33. A humidifier assembly according to claim 31, wherein the heating element is upwardly biased into engagement with the heat conducting material.

34. A humidifier assembly according to claim 33, wherein the heating element is a resistance heater.

35. A humidifier assembly according to claim 34, further comprising a seal between the heat conducting material and the bottom wall.

36. A humidifier assembly according to claim 35, wherein the connecting structure includes contact elements that communicate with a power supply, a controller, and/or sensors within the CPAP apparatus.

37. The humidifier assembly according to claim 36, further comprising a resiliently biased member to facilitate connection and disconnection between the humidifier and the connecting structure, wherein the humidifier is removed from the connecting structure by upwardly moving the member to withdraw its lugs from recesses on the connecting structure and pulling the humidifier generally horizontally out of the receptacle.

38. A CPAP system, comprising:

a CPAP apparatus wherein the CPAP apparatus includes a controller to control the heating element of the humidifier assembly; and

a humidifier assembly according to claim 37.

39. The CPAP system according to claim 38, wherein the CPAP apparatus includes a controller to control the heating element of the humidifier assembly.

40. A humidifier, comprising:

a humidification chamber having a reservoir configured to store a body of liquid having a maximum value, the humidification chamber defining a portion of a fluid passage, the fluid passage configured to direct a flow of breathable gas into exposure with the body of liquid to humidify the flow of breathable gas, the humidification chamber also having an inlet for the flow of breathable gas and an outlet for the humidified flow of breathable gas; and

a backflow chamber forming another portion of the fluid passage and in fluid communication with the humidification chamber; the backflow chamber having an inlet to receive the flow of breathable gas and an outlet in fluid communication with the inlet of the humidification chamber,

wherein the maximum volume of the body of liquid is contained entirely in the humidification chamber when the humidifier is in a normal, upright operating position, and a level of the maximum volume of the body of liquid



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is below the humidification chamber inlet and/or the backflow chamber inlet when the humidifier is in a non-upright position in which a portion of the body of liquid is transferrable along the fluid passage from the humidification chamber to the backflow chamber.

41. A humidifier according to claim 40, wherein the humidification chamber and the backflow chamber are constructed and arranged to be releasably connected to each other, and when the humidification chamber and backflow chamber are connected to each other, the outlet of the backflow chamber engages and is in fluid communication with the inlet of the humidification chamber.

42. A humidifier according to claim 41, wherein the humidifier comprises a base, a top cover removably connected to the base, and a seal between the base and the top cover.

43. A humidifier according to claim 42, wherein the top cover includes the outlet of the humidification chamber.

44. A humidifier according to claim 43, wherein the base includes a receptacle that forms part of the humidification chamber.

45. A humidifier according to claim 44, wherein the base is formed of a transparent material.

46. A humidifier according to claim 45, wherein the top cover is formed of a transparent material.

47. A humidifier according to claim 46, wherein the base comprises a heat conducting plate provided in an opening in the base.

48. A humidifier according to claim 47, wherein the heat conducting plate is formed of metal.

49. A humidifier according to claim 48, wherein the heat conducting plate is circular.

50. A humidifier according to claim 49, further comprising a seal between the heat conducting plate and the base.

51. A humidifier assembly, comprising:  
the humidifier according to claim 50; and  
a connecting structure configured to connect between the humidifier and a CPAP apparatus and allow communication of an outlet of the blower with the backflow chamber inlet of the humidifier, the connecting structure comprising a housing defining a generally horizontally extending receptacle configured to receive the humidifier.

52. A humidifier assembly according to claim 51, wherein the housing comprises a base portion configured to support the humidifier and a retaining portion configured to retain the humidifier in the housing.

53. A humidifier assembly according to claim 52, wherein the retaining portion is spaced above the base portion and is generally parallel with the base portion when the humidifier is retained in the housing.

54. A humidifier assembly according to claim 53, wherein the base portion comprises a heating element configured to engage the heat conducting plate of the humidifier when the humidifier is retained in the housing.

55. A humidifier assembly according to claim 54, wherein the heating element is resiliently biased into engagement with the heat conducting plate.

56. A humidifier assembly according to claim 55, wherein the heating element is a flat plate-like resistance heater.

57. A humidifier assembly according to claim 56, wherein the housing comprises contact elements configured to receive power from the CPAP apparatus.

58. A humidifier assembly according to claim 57, wherein the housing comprises resiliently biased locking members on

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a side thereof that are configured to engage the CPAP apparatus to secure the connecting structure to the CPAP apparatus.

59. A humidifier assembly according to claim 58, further comprising a release member configured to move the resiliently biased locking members out of their biased position to release the connecting structure from the CPAP apparatus.

60. A humidifier assembly according to claim 59, wherein the release member is provided in the base portion of the housing.

61. An apparatus for humidifying breathable gas, comprising:

a CPAP apparatus configured to generate a flow of breathable gas; and

a humidifier assembly according to claim 60 releasably connected to the CPAP apparatus to humidify the flow of breathable gas.

62. An apparatus according to claim 61, wherein the flow of breathable gas from the CPAP apparatus enters the backflow chamber through the inlet of the backflow chamber, travels through the backflow chamber, and enters the humidification chamber through the inlet of the humidification chamber.

63. A humidifier, comprising:  
a humidification chamber having a reservoir configured to store a body of liquid having a maximum volume, the humidification chamber defining a portion of a fluid passage, the fluid passage configured to direct a flow of breathable gas into exposure with the body of liquid to humidify the flow of breathable gas, the humidification chamber also having an inlet for the flow of breathable gas and an outlet for the humidified flow of breathable gas; and

a backflow chamber forming another portion of the fluid passage and in fluid communication with the humidification chamber, the backflow chamber having an inlet to receive the flow of breathable gas and an outlet in fluid communication with the inlet of the humidification chamber,

wherein the maximum volume of the body of liquid is contained entirely in the humidification chamber when the humidifier is in a normal, upright operating position, and the maximum volume of the body of liquid is retained in the humidification chamber or in the humidification chamber and the backflow chamber below the inlet of the backflow chamber in a non-upright position in which a portion of the body of liquid is transferrable along the fluid passage from the humidification chamber to the backflow chamber.

64. A humidifier according to claim 63, wherein the humidification chamber and the backflow chamber are constructed and arranged to be releasably connected to each other, and when the humidification chamber and backflow chamber are connected to each other, the outlet of the backflow chamber engages and is in fluid communication with the inlet of the humidification chamber.

65. A humidifier according to claim 64, wherein the humidifier comprises a base, a top cover removably connected to the base, and a seal between the base and the top cover.

66. A humidifier according to claim 65, wherein the top cover includes the outlet of the humidification chamber.

67. A humidifier according to claim 66, wherein the base includes a receptacle that forms part of the humidification chamber.

68. A humidifier according to claim 67, wherein the base is formed of a transparent material.



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69. A humidifier according to claim 68, wherein the top cover is formed of a transparent material.

70. A humidifier according to claim 69, wherein the base comprises a heat conducting plate provided in an opening in the base.

71. A humidifier according to claim 70, wherein the heat conducting plate is formed of metal.

72. A humidifier according to claim 71, wherein the heat conducting plate is circular.

73. A humidifier according to claim 72, further comprising a seal between the heat conducting plate and the base.

74. A humidifier assembly, comprising:

the humidifier according to claim 73; and

a connecting structure configured to connect between the humidifier and a CPAP apparatus and allow communication of an outlet of the CPAP apparatus with the backflow chamber inlet of the humidifier, the connecting structure comprising a housing defining a generally horizontally extending receptacle configured to receive the humidifier.

75. A humidifier assembly according to claim 74, wherein the housing comprises a base portion configured to support the humidifier and a retaining portion configured to retain the humidifier in the housing.

76. A humidifier assembly according to claim 75, wherein the retaining portion is spaced above the base portion and is generally parallel with the base portion when the humidifier is retained in the housing.

77. A humidifier assembly according to claim 76, wherein the base portion comprises a heating element configured to engage the heat conducting plate of the humidifier when the humidifier is retained in the housing.

78. A humidifier assembly according to claim 77, wherein the heating element is resiliently biased into engagement with the heat conducting plate.

79. A humidifier assembly according to claim 78, wherein the heating element is a flat plate-like resistance heater.

80. A humidifier assembly according to claim 79, wherein the housing comprises contact elements configured to receive power from the CPAP apparatus.

81. A humidifier assembly according to claim 80, wherein the housing comprises resiliently biased locking members on a side thereof that are configured to engage the CPAP apparatus to secure the connecting structure to the CPAP apparatus.

82. A humidifier assembly according to claim 81, further comprising a release member configured to move the resiliently biased locking members out of their biased position to release the connecting structure from the CPAP apparatus.

83. A humidifier assembly according to claim 82, wherein the release member is provided in the base portion of the housing.

84. An apparatus for humidifying breathable gas, comprising:

a CPAP apparatus configured to generate a flow of breathable gas; and

a humidifier assembly according to claim 83 releasably connected to the CPAP apparatus to humidify the flow of breathable gas.

85. An apparatus according to claim 84, wherein the flow of breathable gas from the CPAP apparatus enters the backflow chamber through the inlet of the backflow chamber, travels through the backflow chamber, and enters the humidification chamber through the inlet of the humidification chamber.

86. A humidifier assembly for a CPAP apparatus, comprising:

a humidifier including:

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a base configured to hold a volume of liquid therein, at least a portion of the base being constructed of a heat conducting material,

a top cover, and

a seal disposed between the top cover and the base; and

a connecting structure configured to connect between the CPAP apparatus and the humidifier and allow communication of an outlet of the CPAP apparatus with an inlet of the humidifier, the connecting structure including:

a housing providing a base portion to support the humidifier thereon, the base portion includes a heating element in contact with the heat conducting material of the base of the humidifier,

wherein the humidifier assembly further comprises:

first and second internal passages;

the first passage extending from a first inlet, through the base of the humidifier configured to hold the volume of liquid, and to a common outlet;

the second passage extending from a second inlet to the common outlet;

the first passage being disposed so as to be exposed to a surface of said volume of liquid when held in the humidifier;

the second passage being configured to be able to communicate with a pressure and/or sound sensing device arranged to obtain measurement signals of the flow of breathable gas; and,

the second passage being isolated from a surface of a said volume of liquid when held in the humidifier so as to avoid degradation of the measurement signals.

87. A humidifier assembly according to claim 86, wherein the connecting structure includes a control knob to control a heat setting of the heating element.

88. A humidifier assembly according to claim 87, wherein the connecting structure includes contact elements to communicate with a controller within the CPAP apparatus.

89. A humidifier assembly according to claim 87, wherein the connecting structure includes contact elements to communicate with sensors within the CPAP apparatus.

90. A humidifier assembly according to claim 86, wherein the connecting structure is configured to allow removable attachment of the CPAP apparatus to the humidifier.

91. A humidifier assembly according to claim 90, wherein the first and second inlets are coaxial.

92. A humidifier assembly according to claim 91, wherein the second internal passage is communicated with the common outlet via at least one aperture formed in the common outlet.

93. A humidifier assembly according to claim 92, wherein the top cover and the base of the humidifier are held together by a retaining clip.

94. A humidifier assembly according to claim 93, wherein the top cover includes an internal wall structure to guide gas, the internal wall structure extending downwardly from a top wall of the top cover towards the base.

95. A humidifier assembly according to claim 94, wherein the housing of the connecting structure provides a generally horizontally extending receptacle within which the humidifier may be disposed.

96. A humidifier assembly according to claim 95, wherein the connecting structure includes a retaining portion configured to secure the humidifier in position.

97. A CPAP apparatus including a humidifier assembly according to claim 96.

98. A CPAP apparatus according to claim 97, further comprising a power supply to provide power to both the CPAP apparatus and the humidifier assembly when the CPAP apparatus is connected to the humidifier assembly.

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