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Virr et al.

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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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Reissue of:

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Filed: **Jul. 15, 2005**

U.S. Applications:

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See application file for complete search history.

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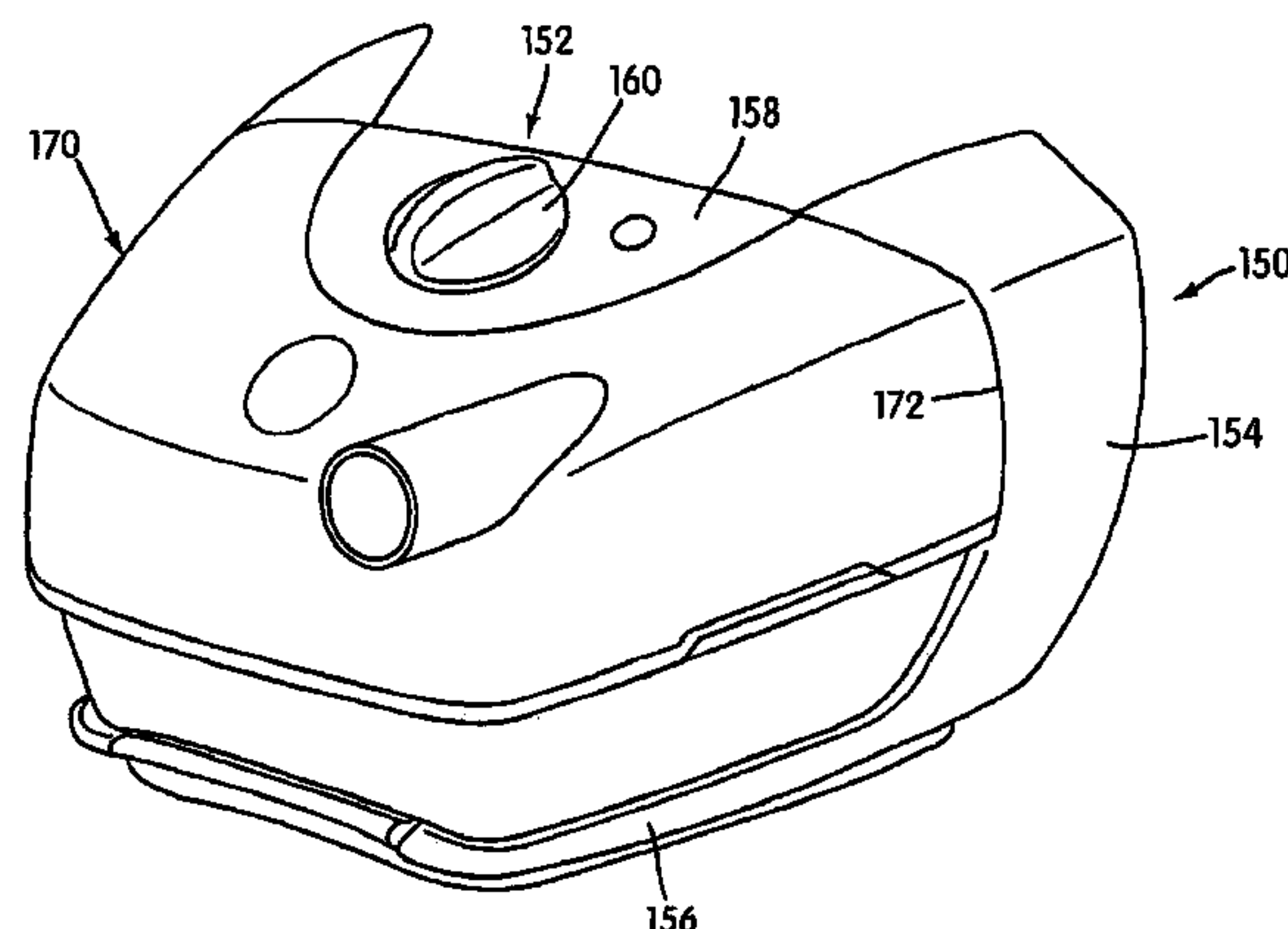
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(57) **ABSTRACT**

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.

150 Claims, 20 Drawing Sheets



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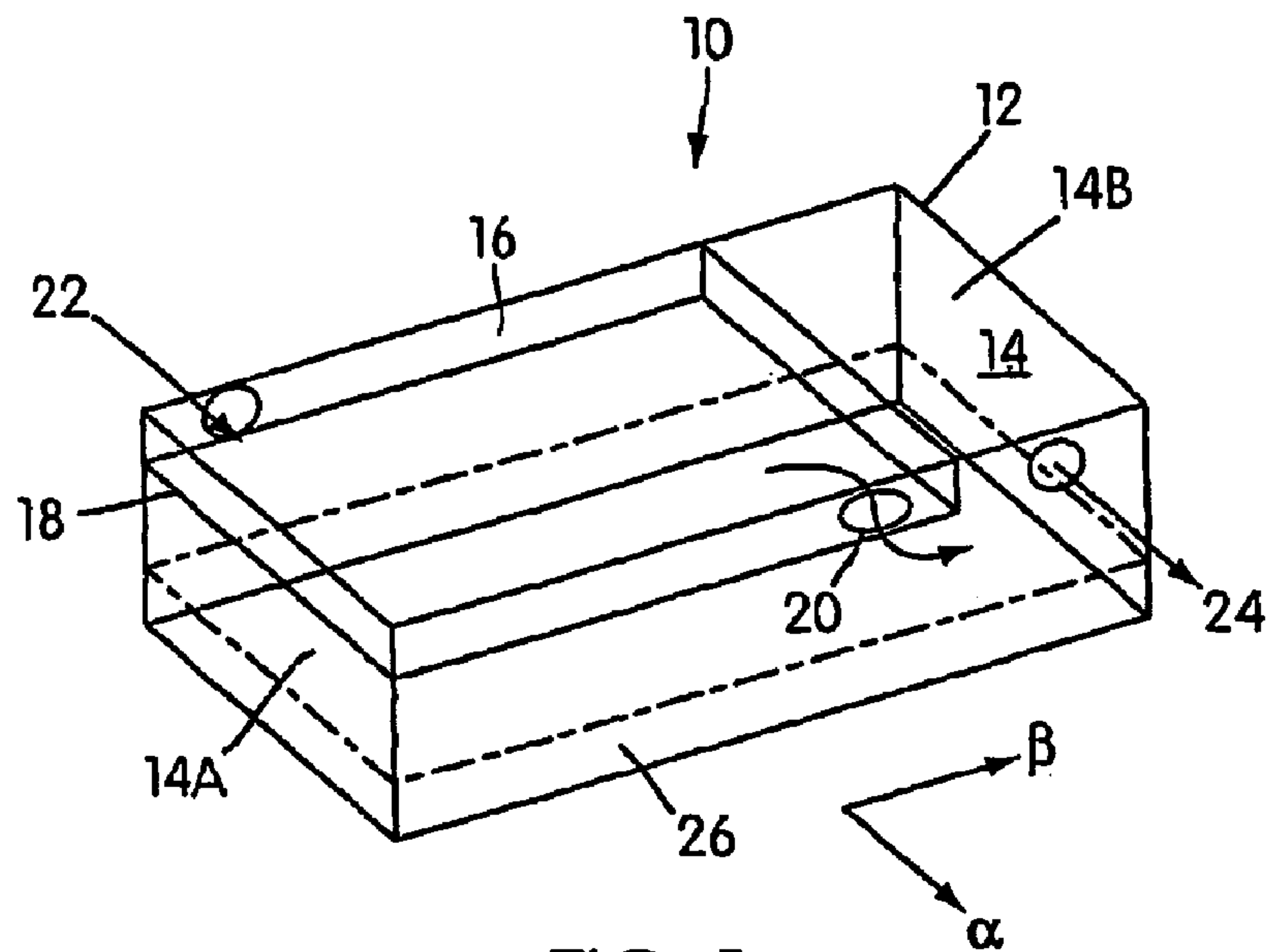


FIG. 1

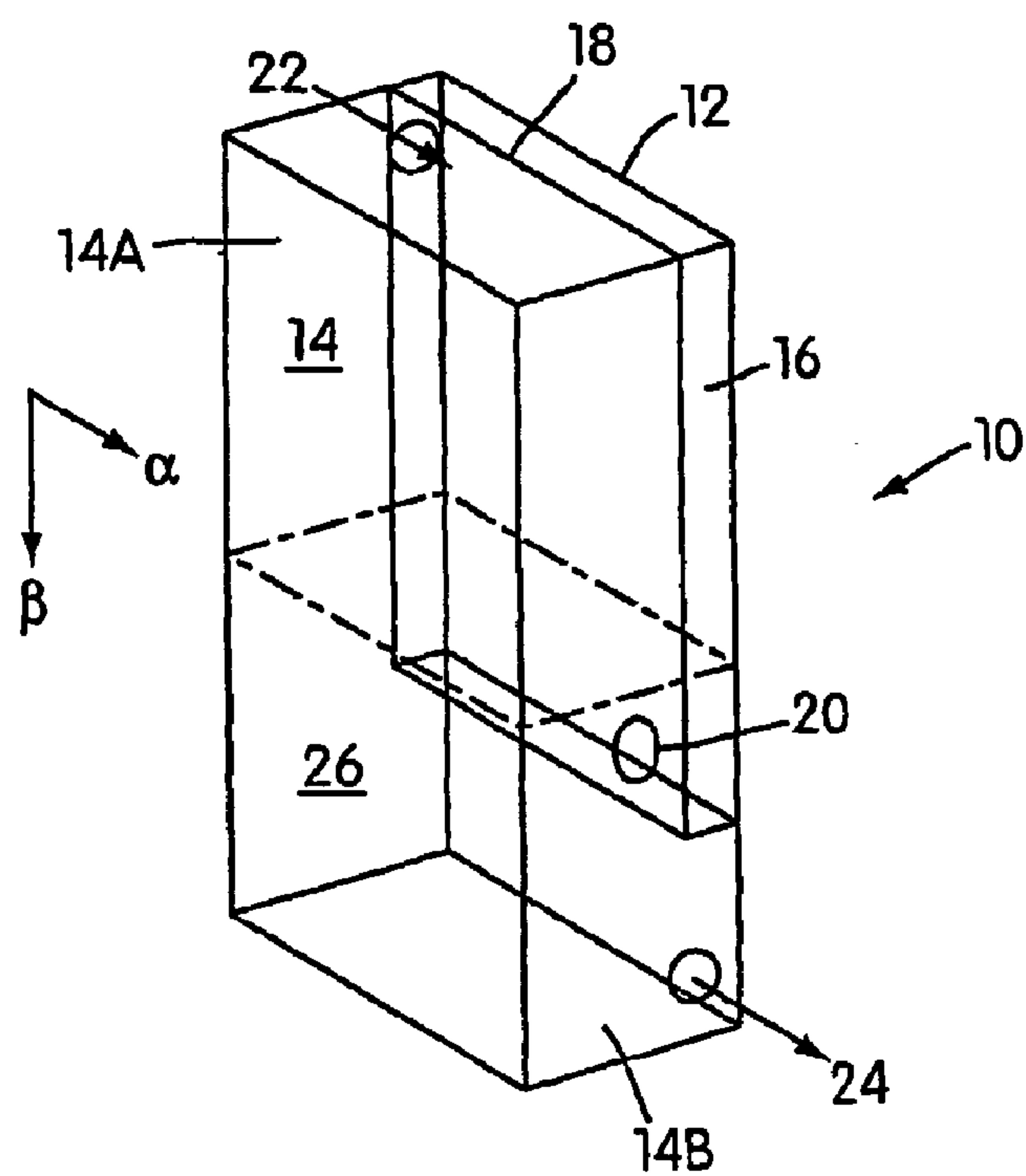


FIG. 2

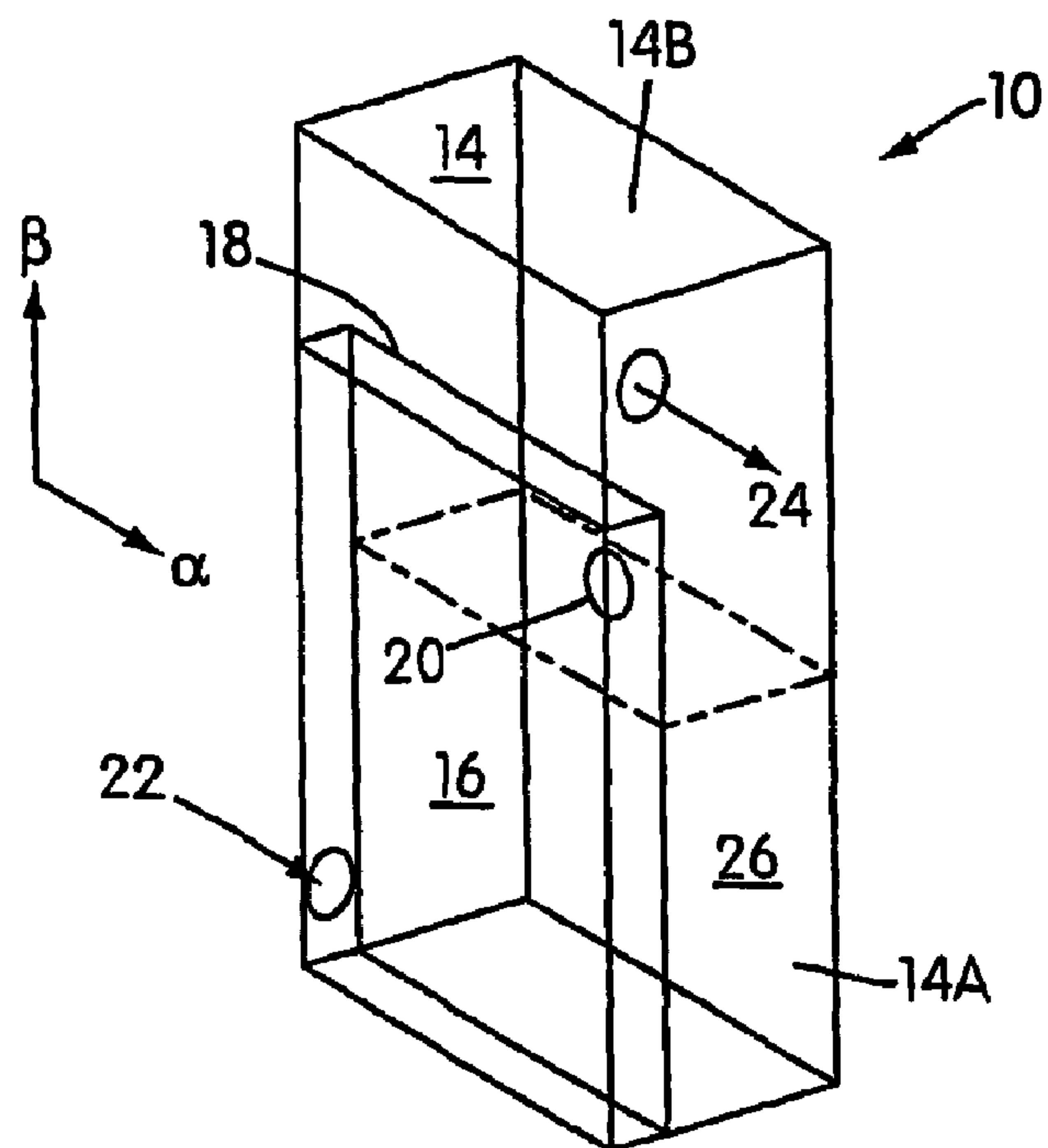


FIG. 3

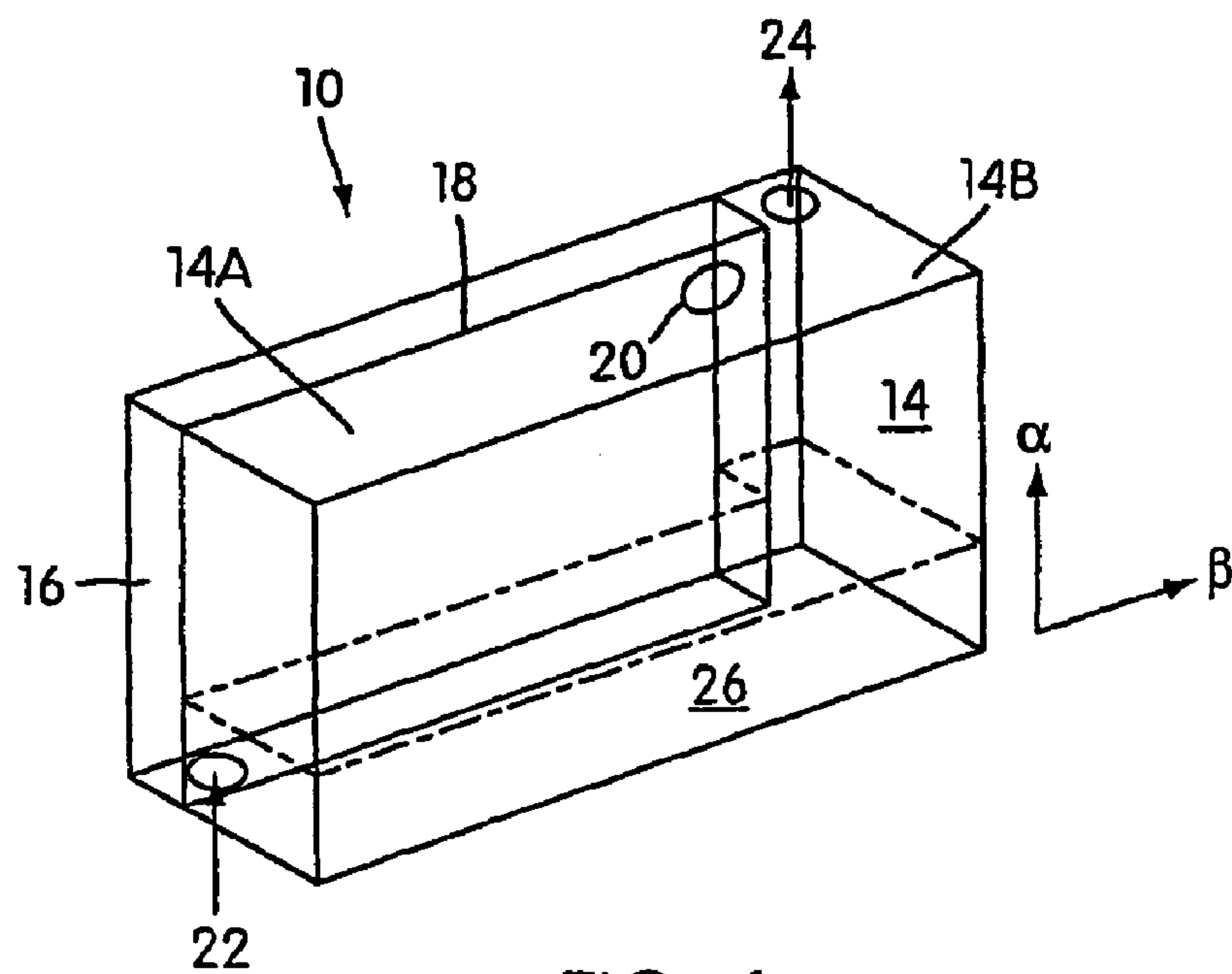


FIG. 4

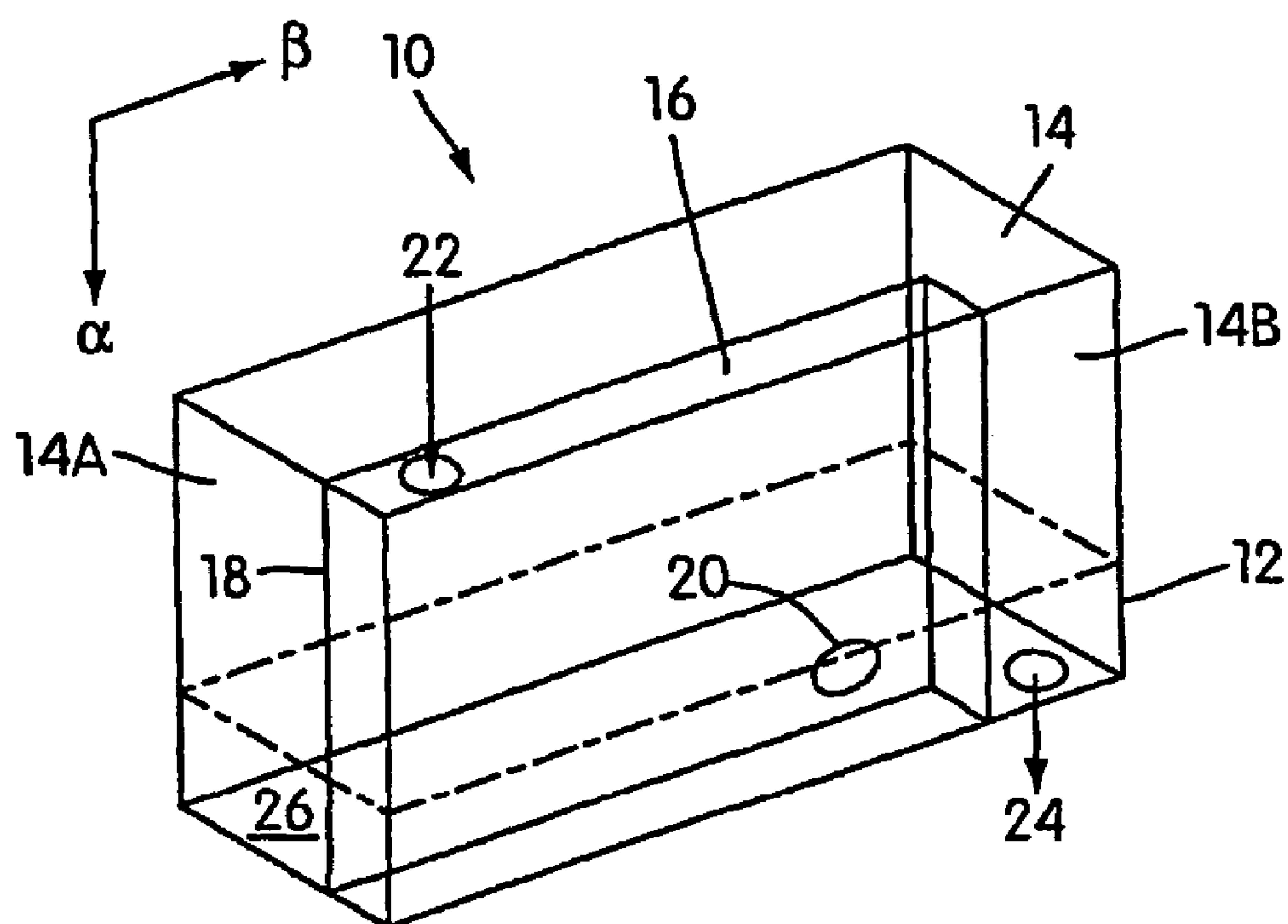


FIG. 5

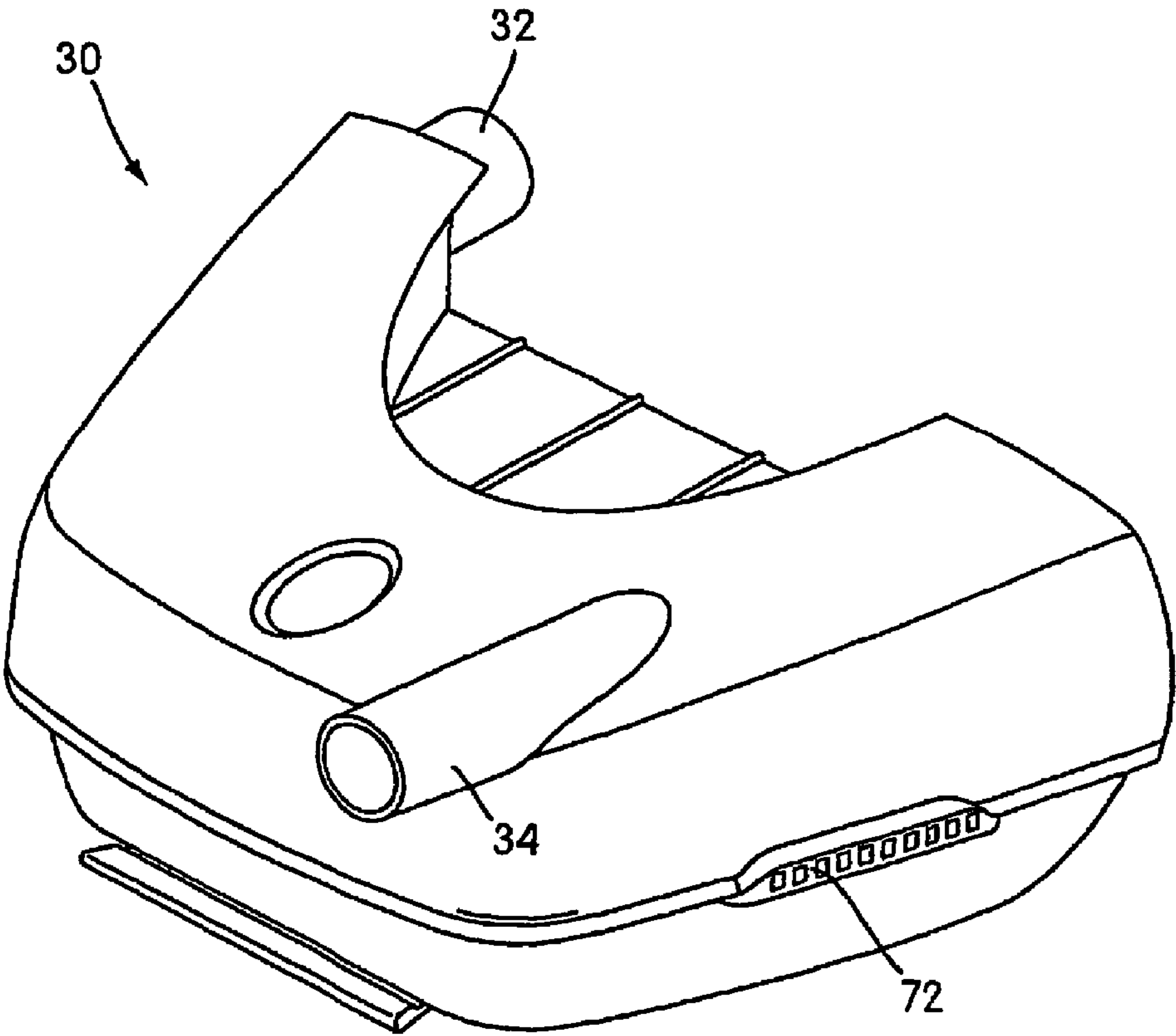


FIG. 6

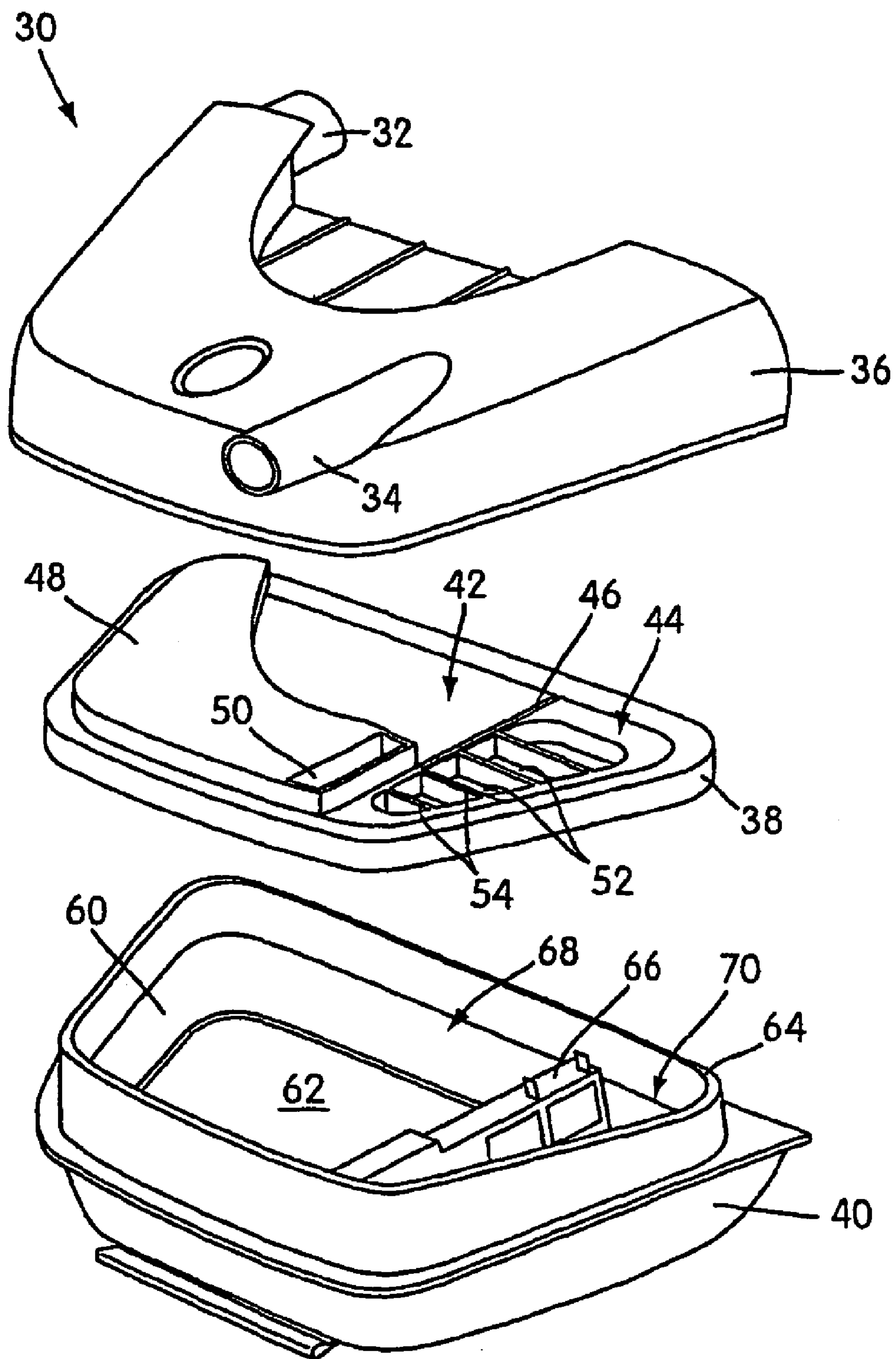


FIG. 7

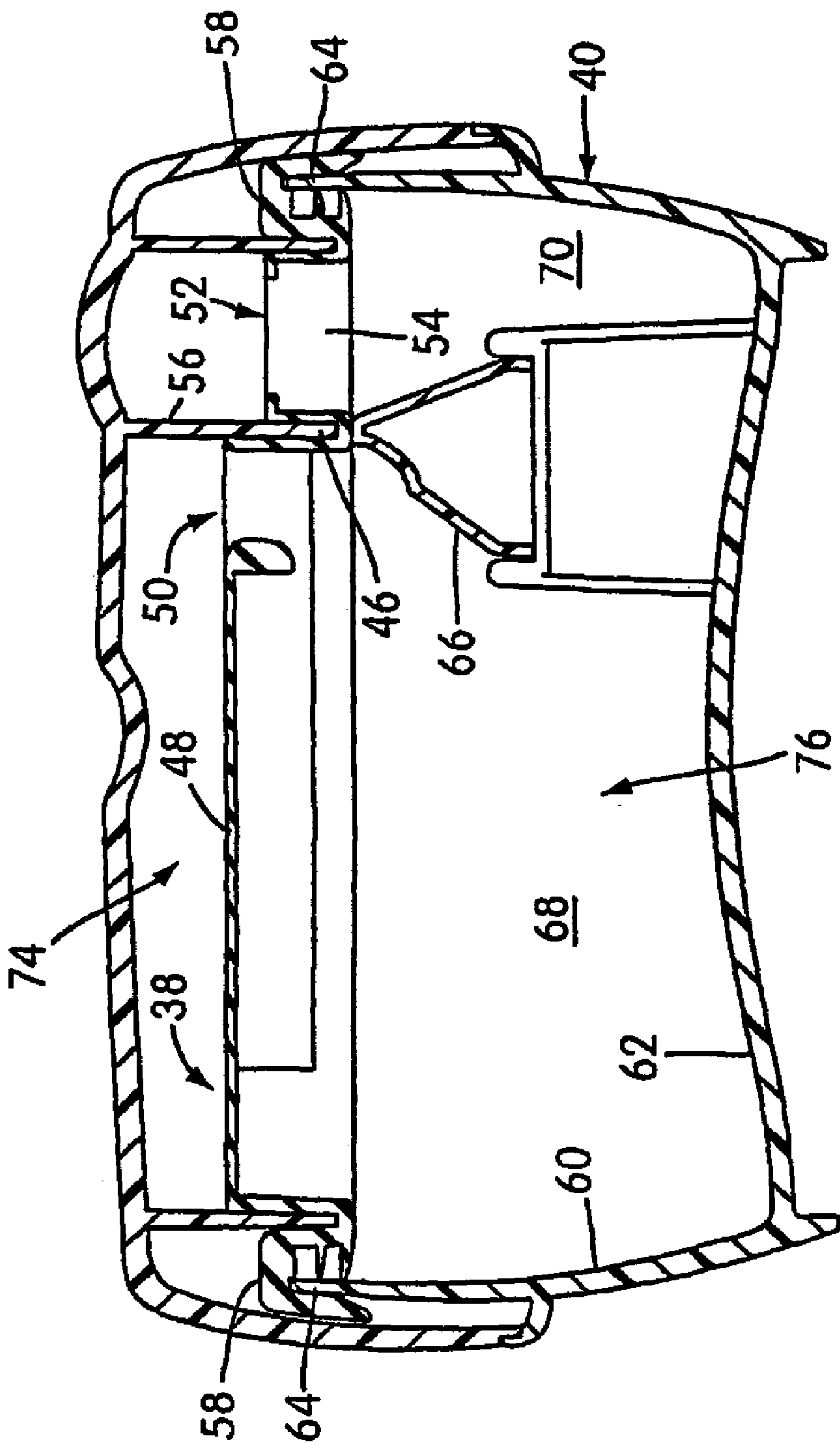


FIG. 8

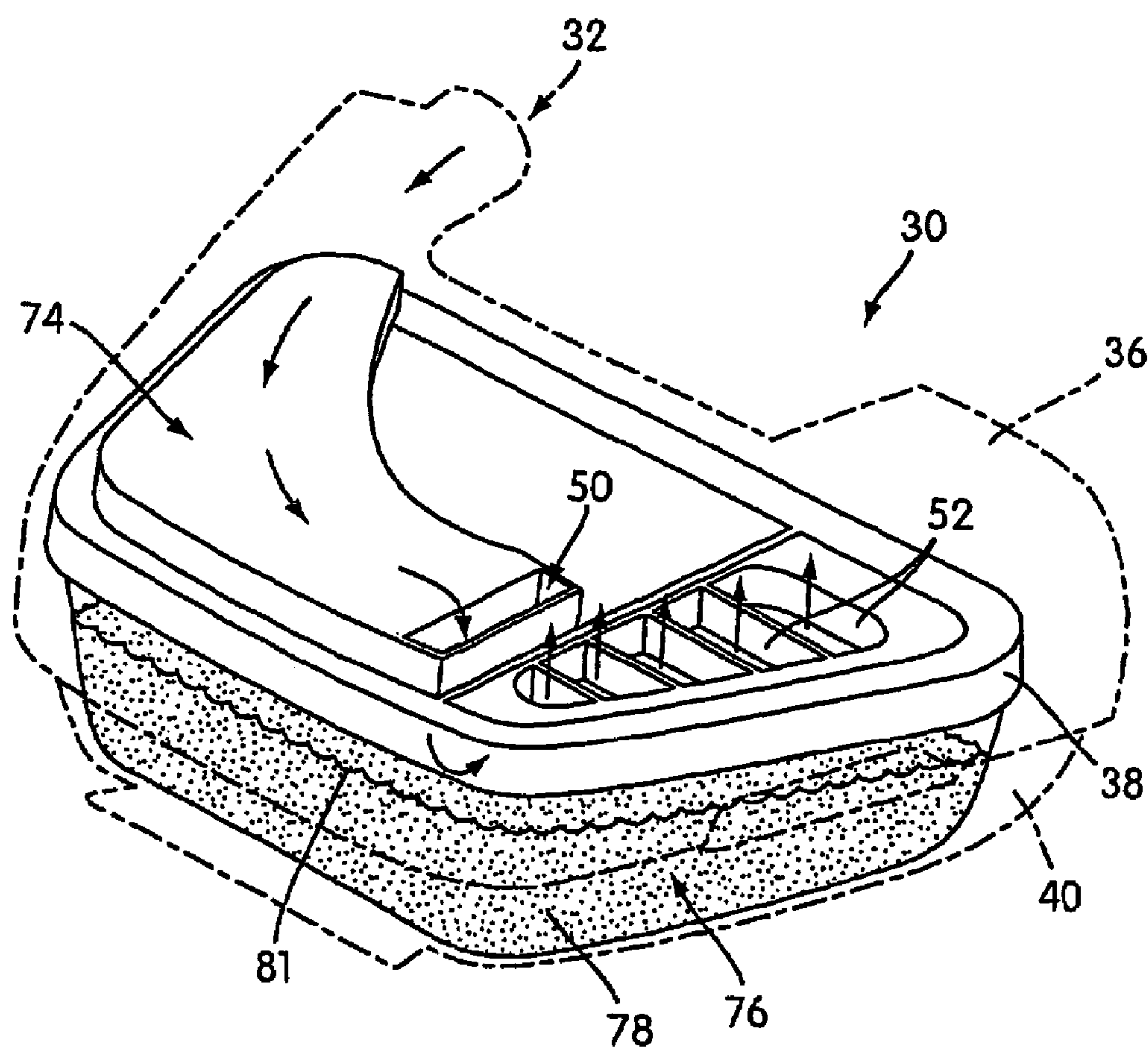


FIG. 9

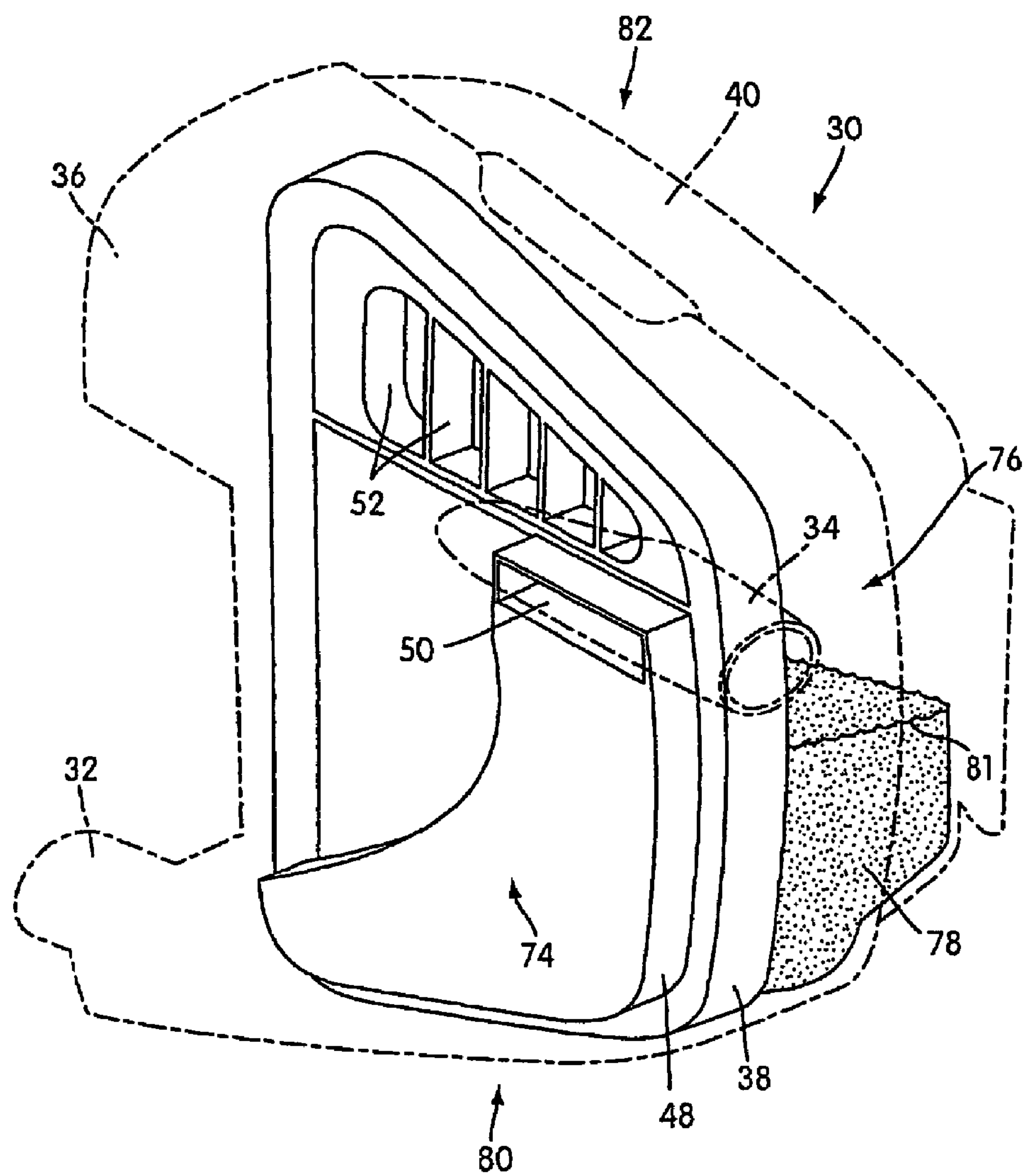


FIG. 10

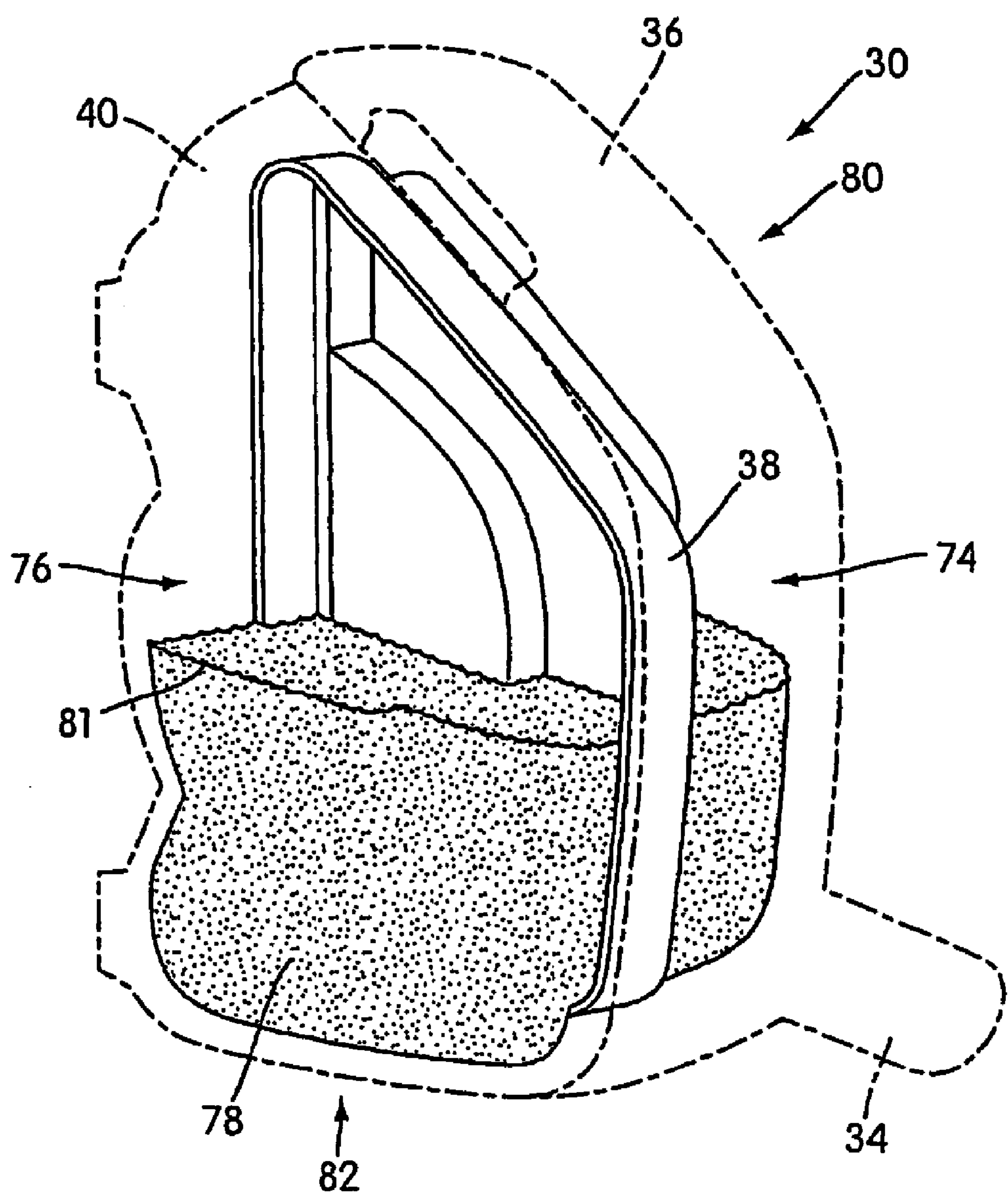
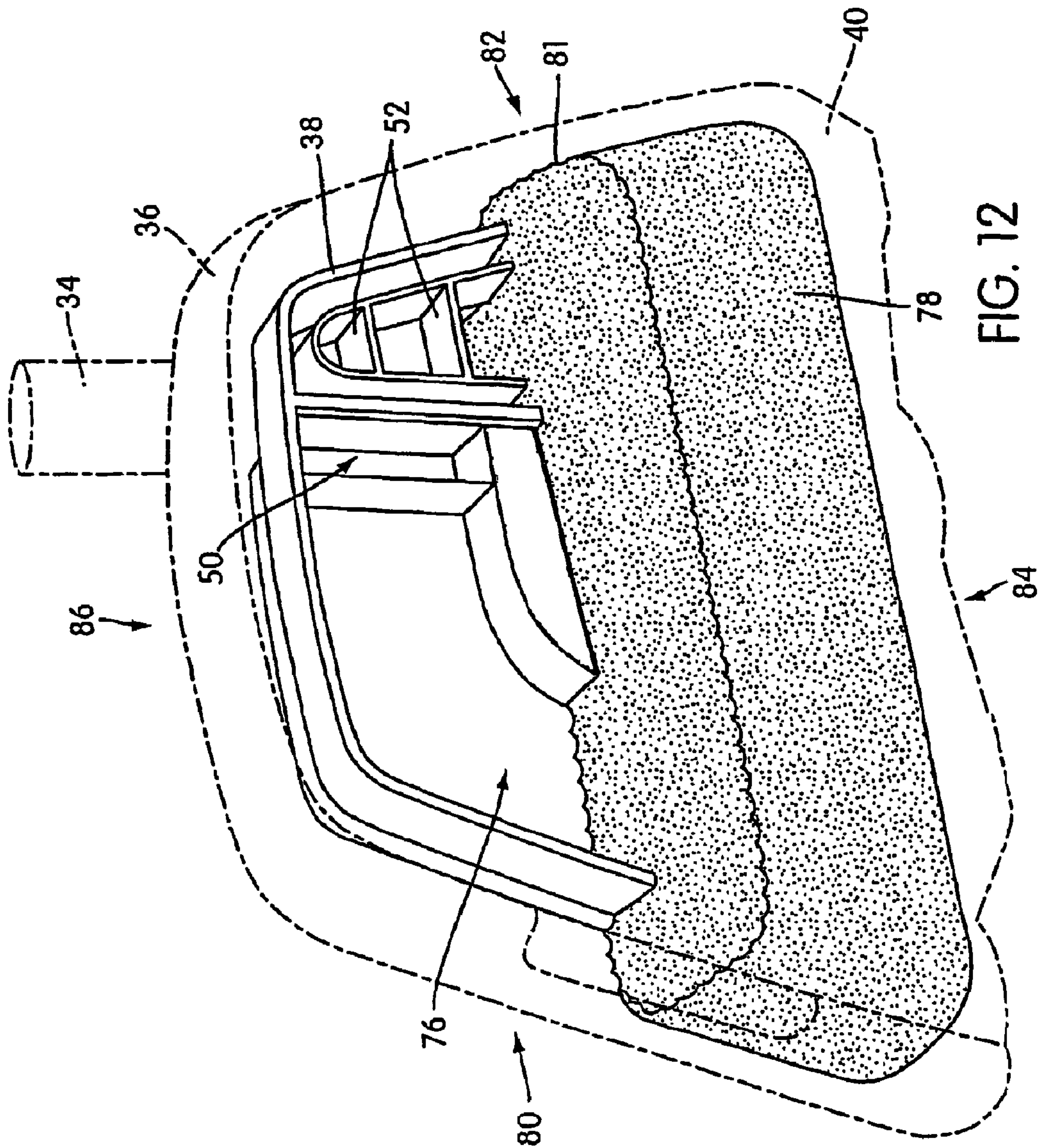
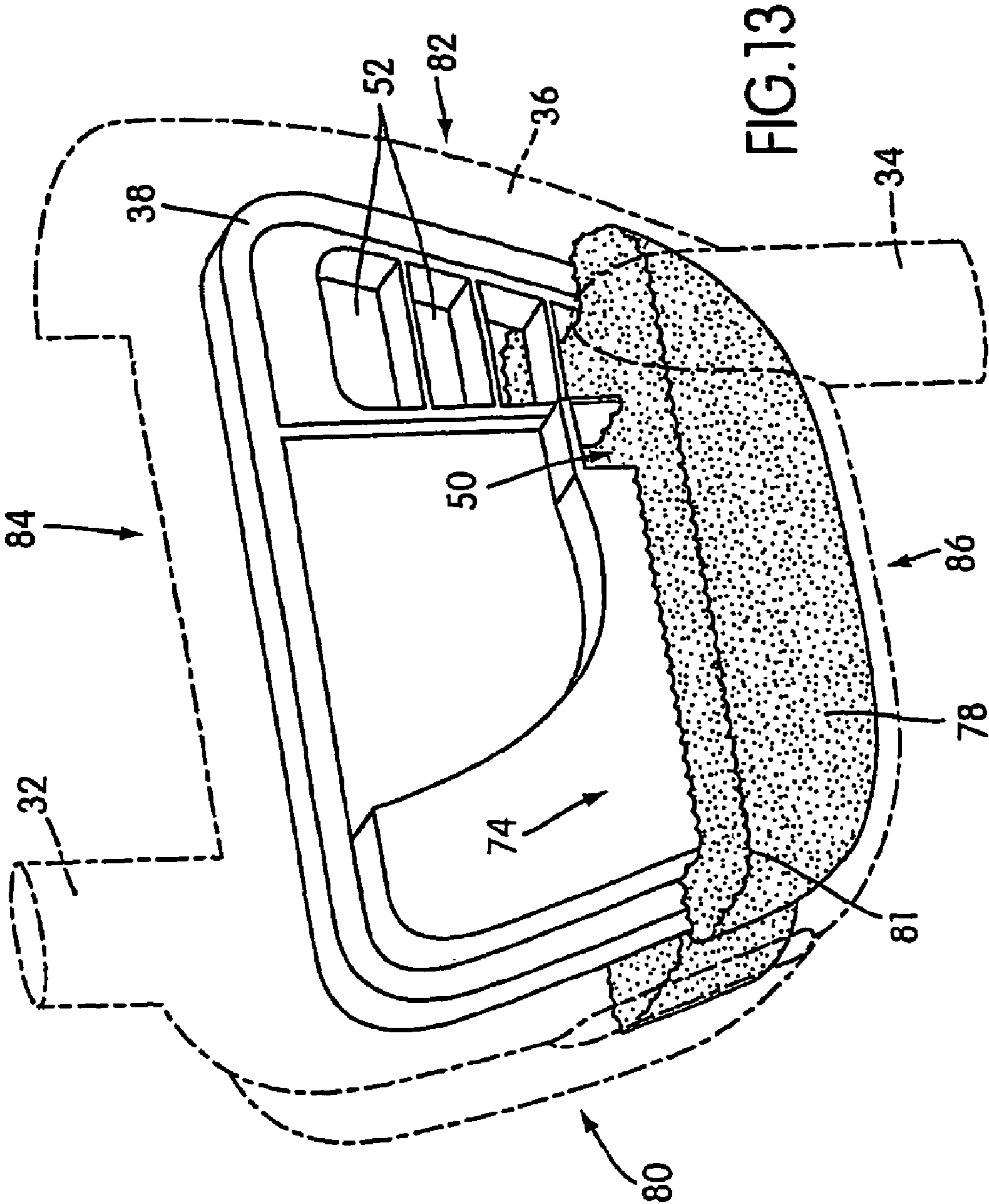
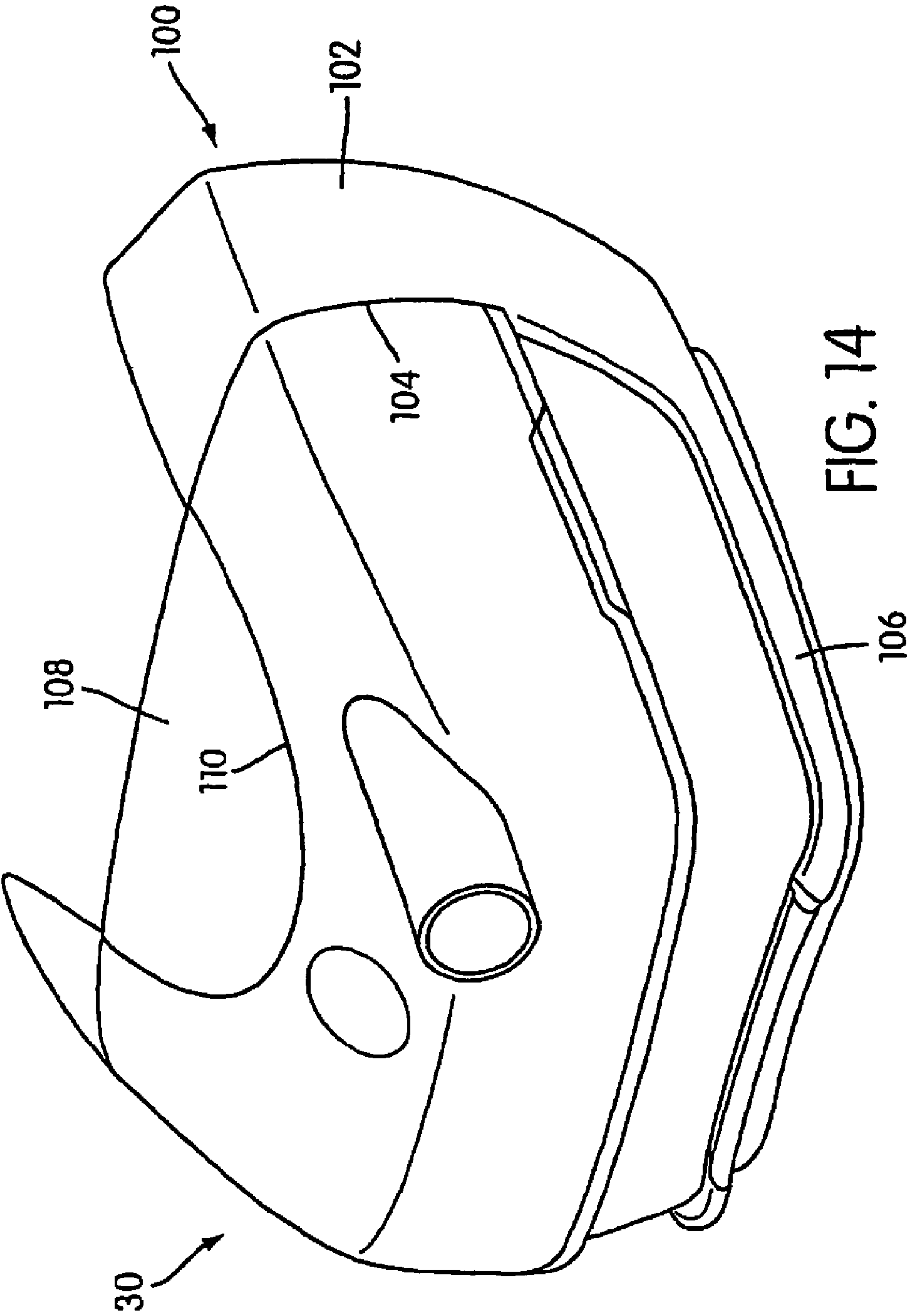


FIG. 11







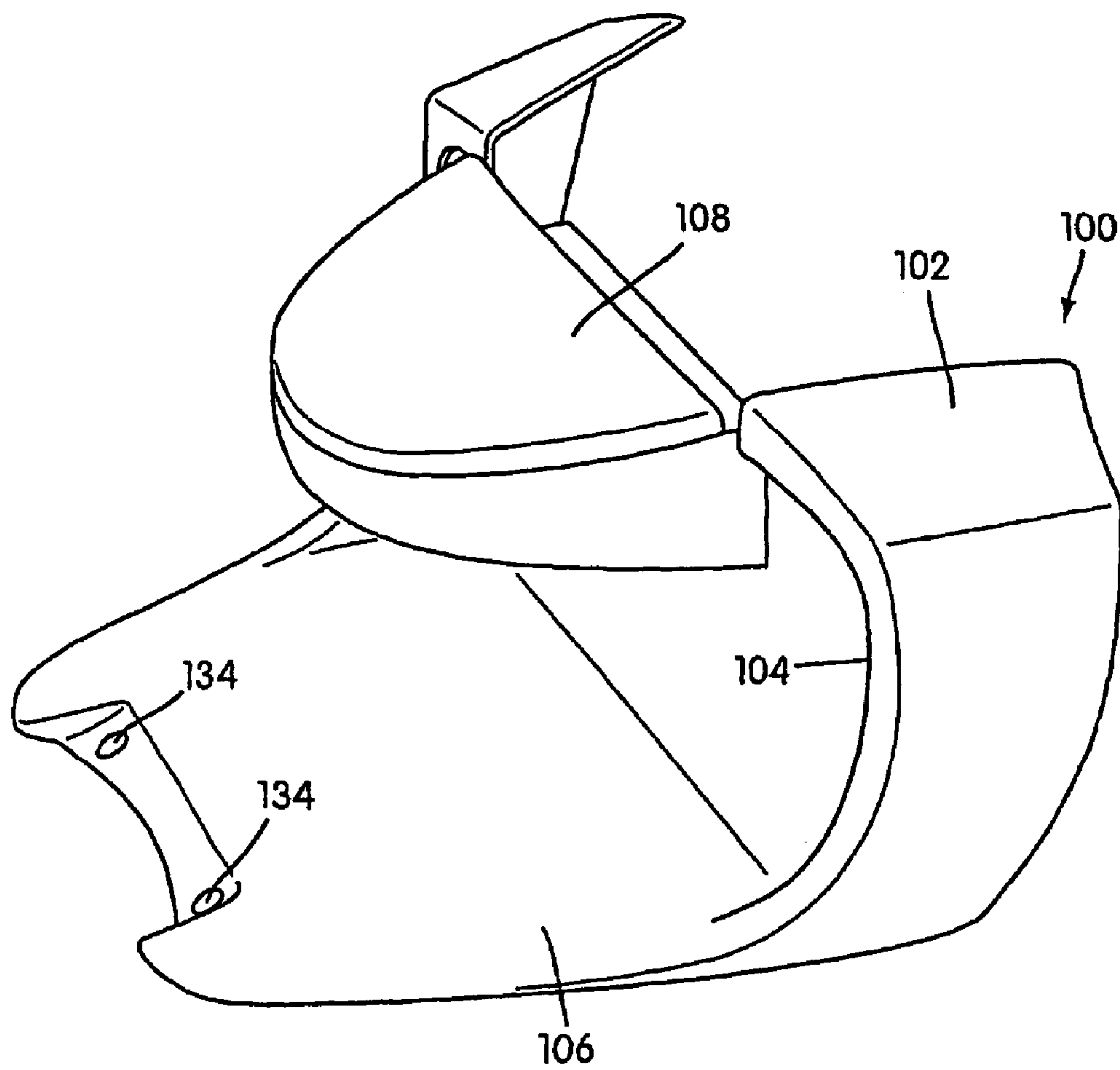


FIG. 15

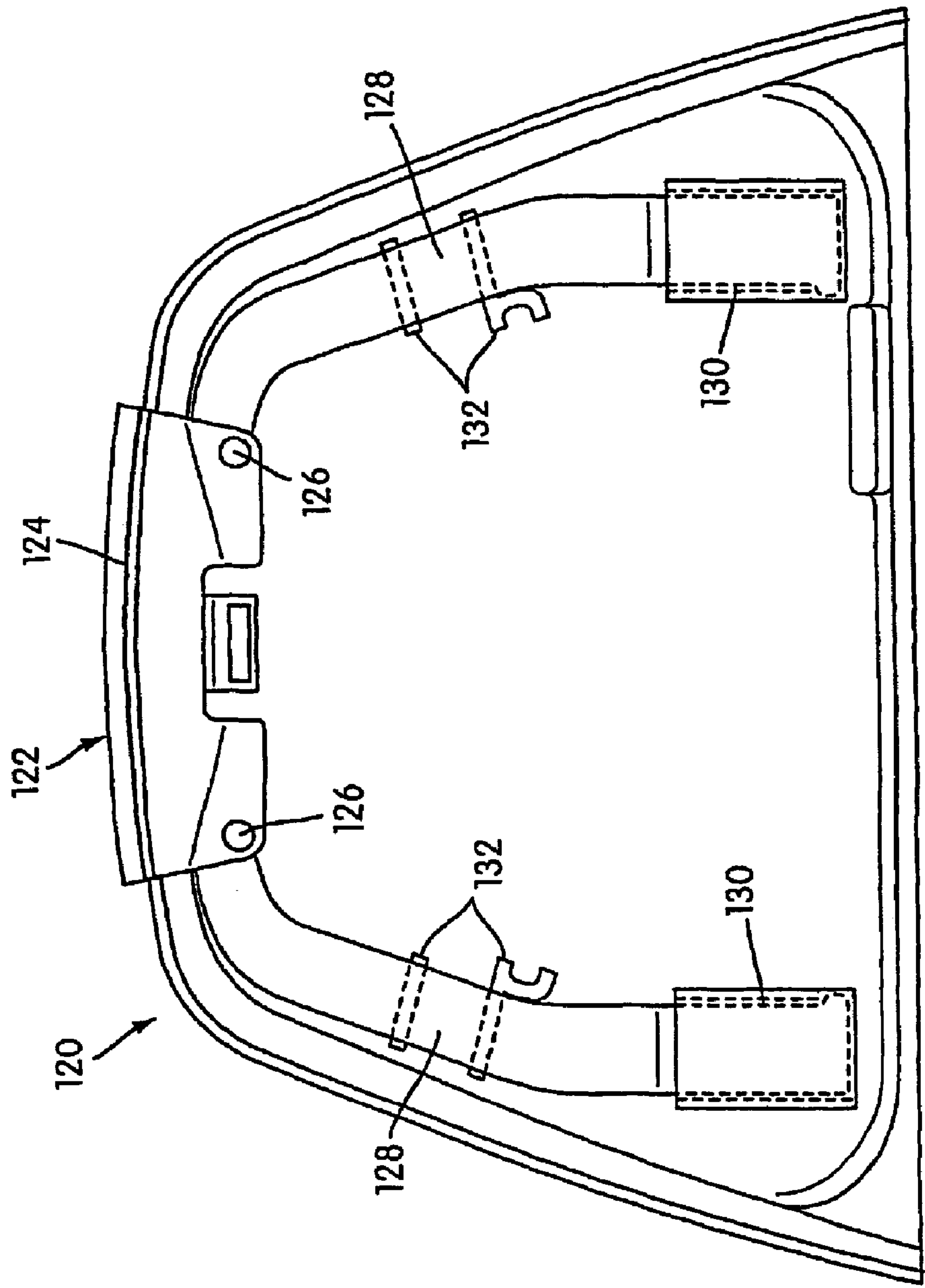


FIG. 16

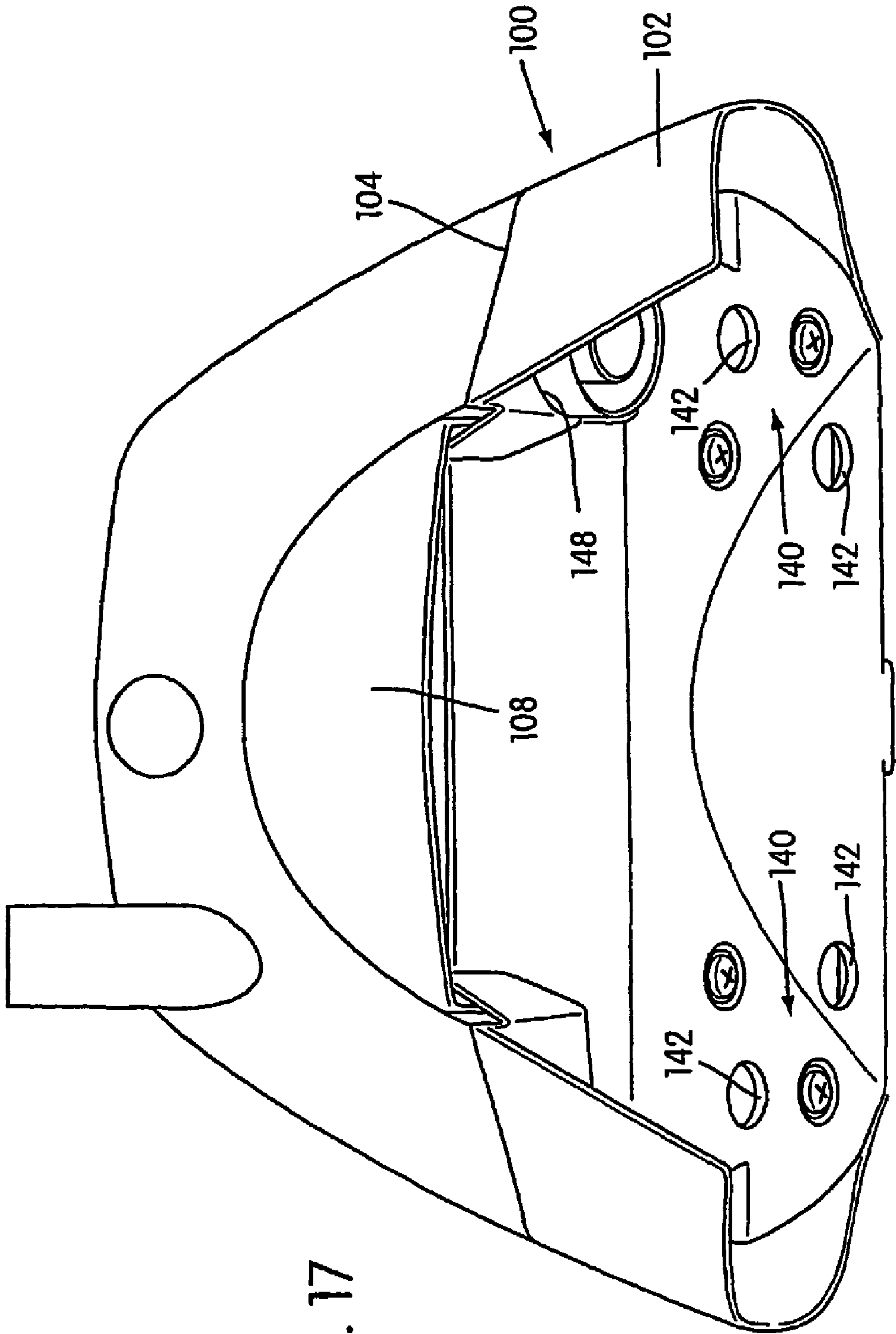


FIG. 17

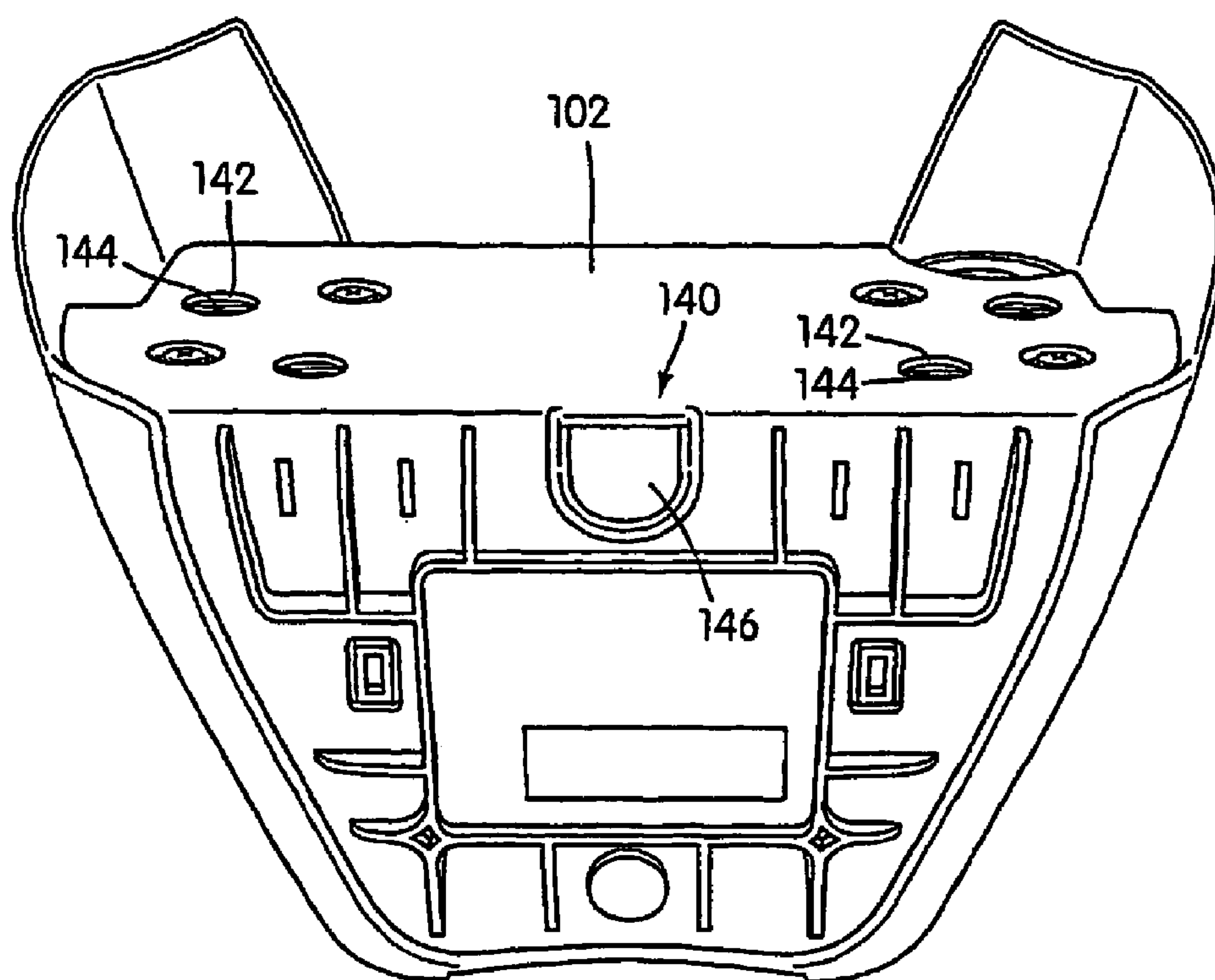
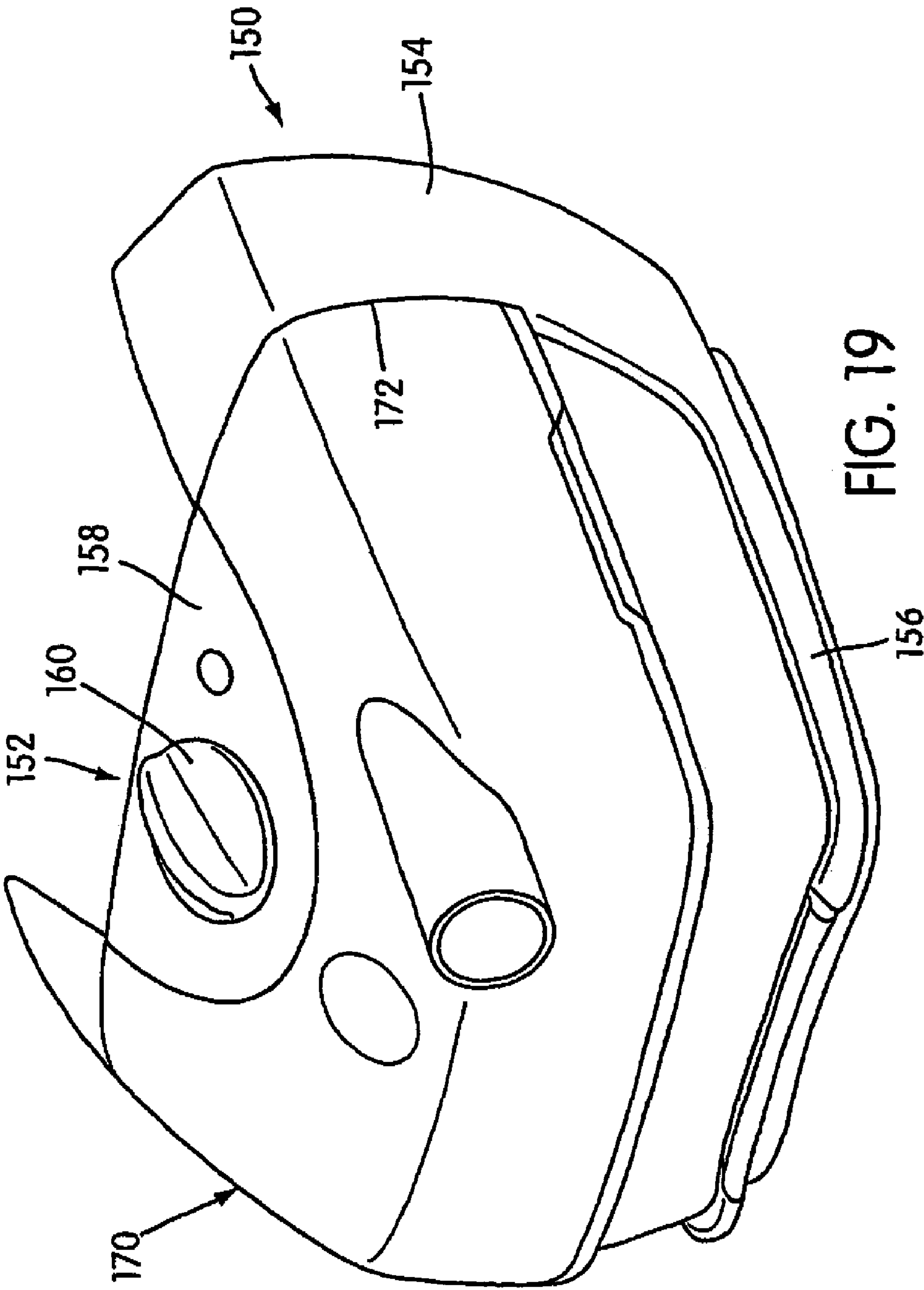


FIG. 18



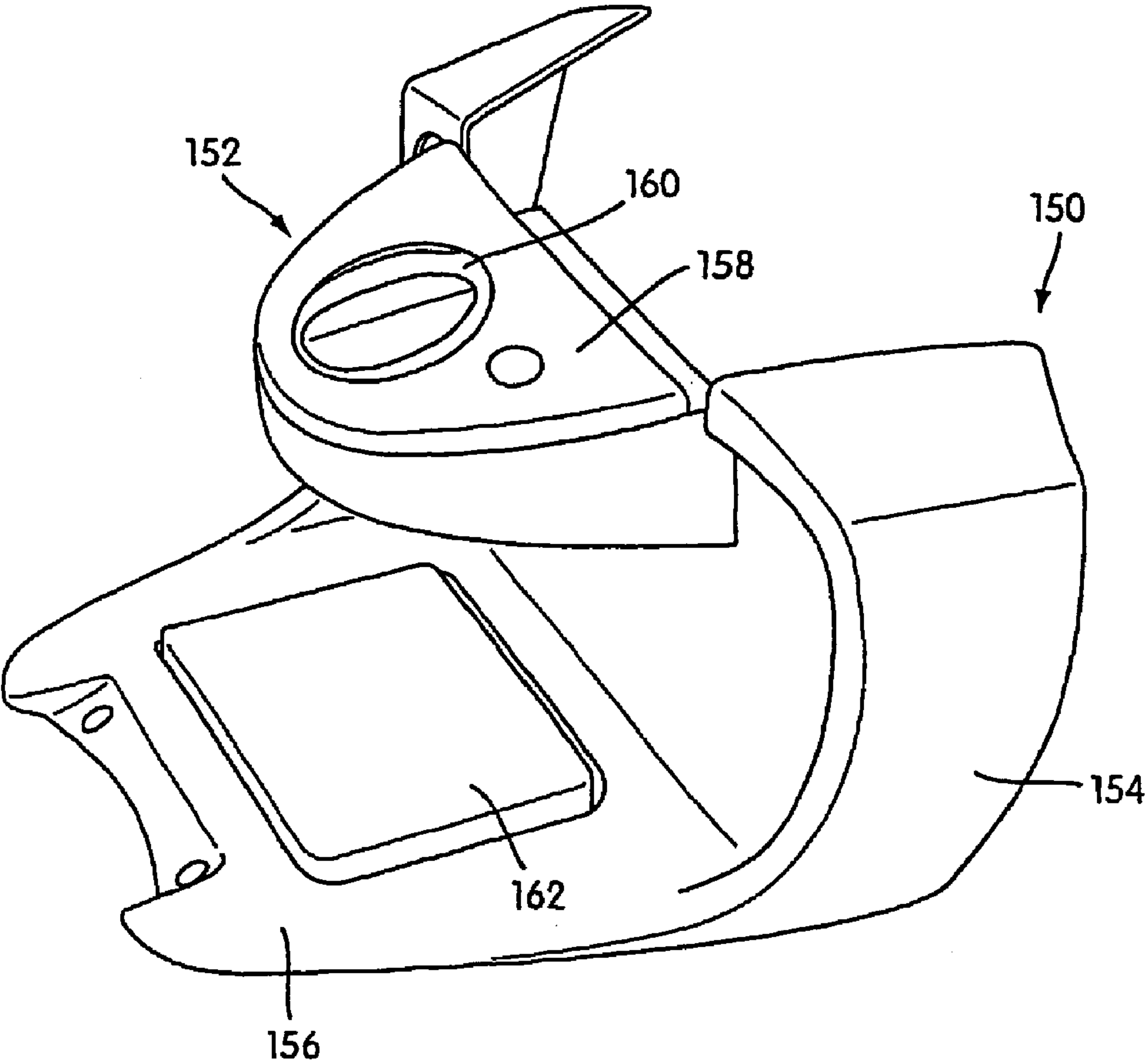


FIG. 20

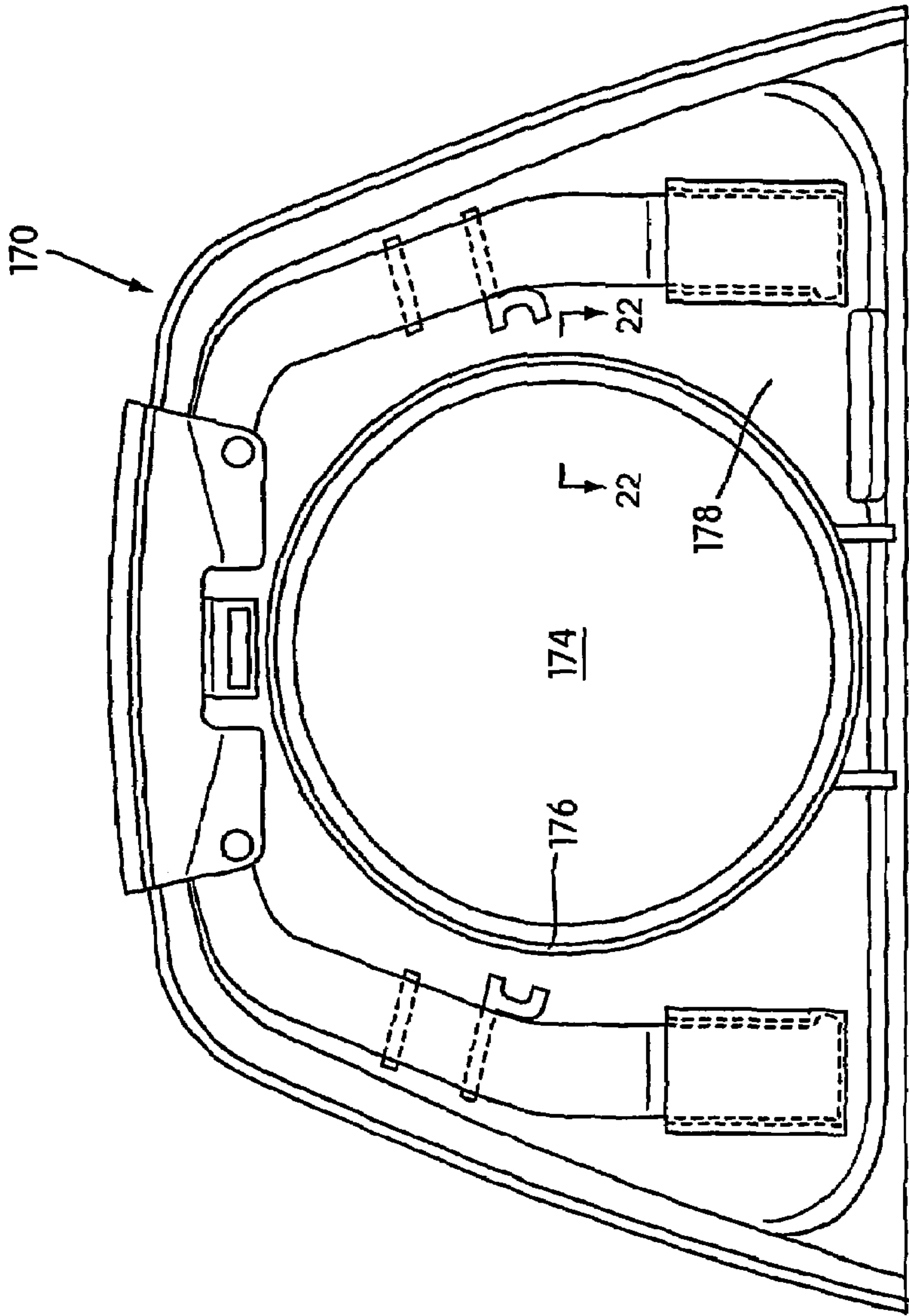


FIG. 21

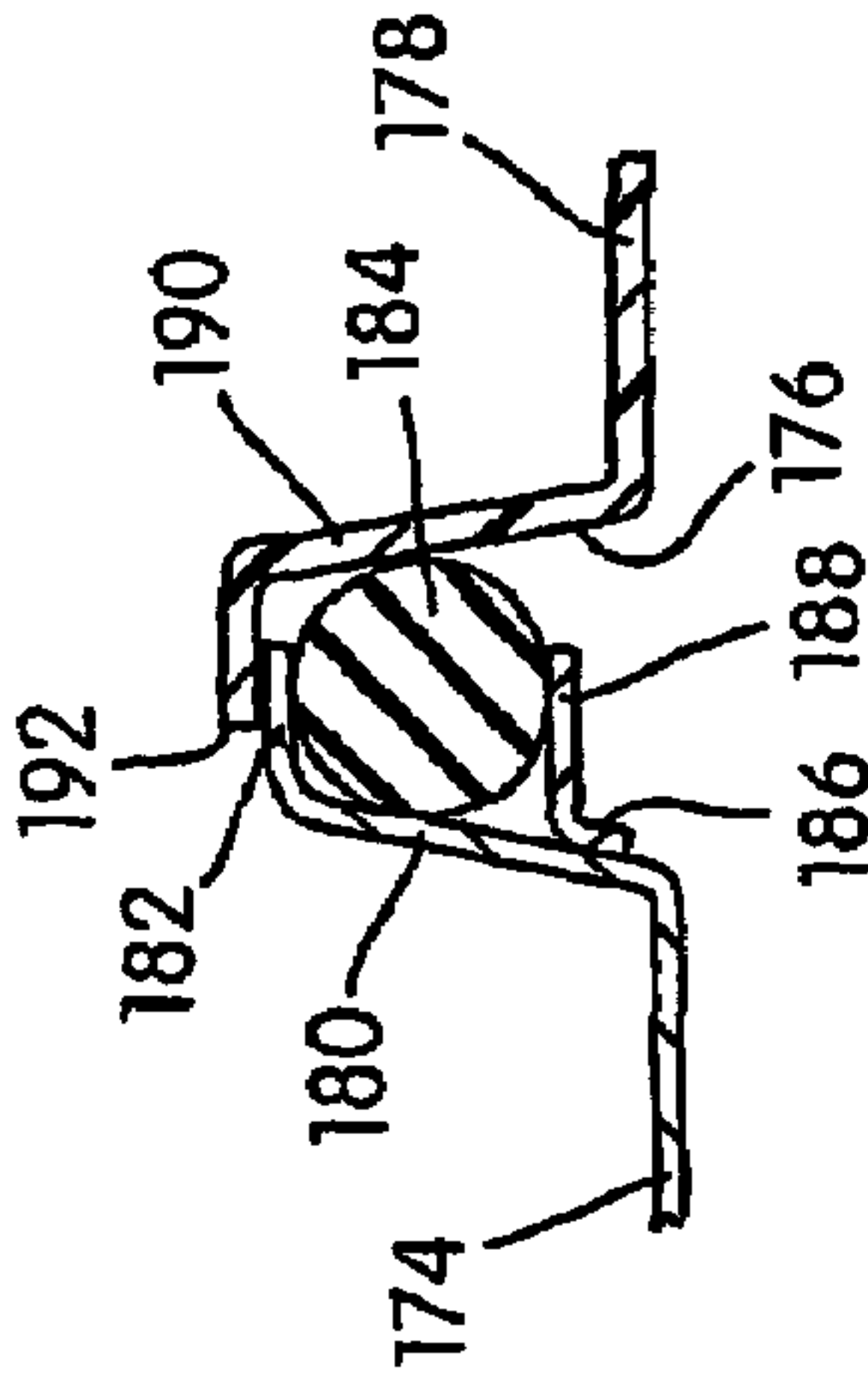


FIG. 22

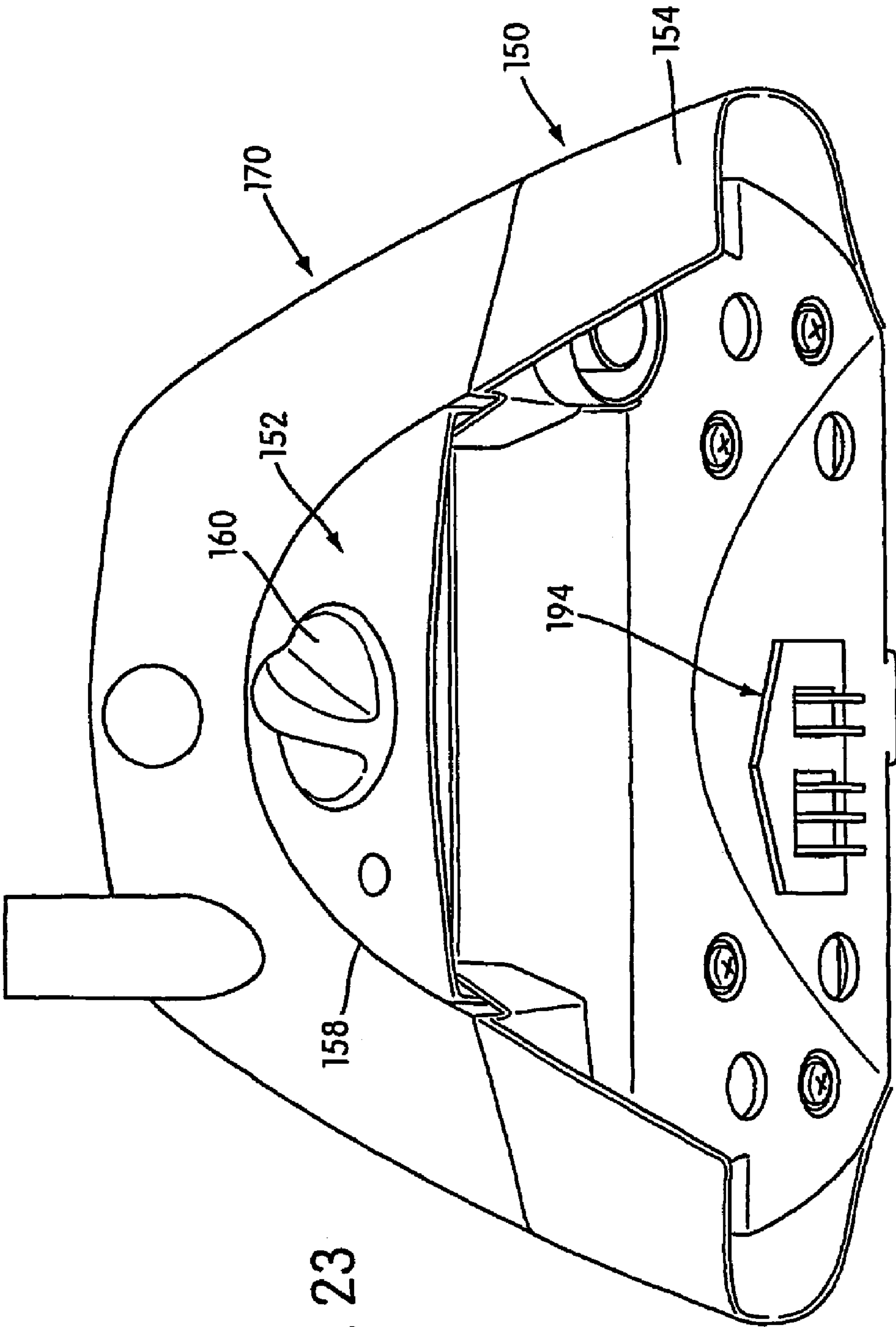


FIG. 23

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; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation *reissue of application Ser. No. 13/100,783, which is an application for reissue of U.S. Pat. No. 7,614,398, filed as Ser. No. 11/181,807 filed Jul. 15, 2005, which 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 entireties.

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 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.

3

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.

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:

4

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;

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

5

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 (generally 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 flat, 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 α , 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 α , 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 β , 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 β , 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. There-

6

fore 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.

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 therethrough 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 on to 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 ensuing 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 ensuing 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 legs 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

11

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 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 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

12

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.]

[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, comprising:

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

a humidifier body inlet adapted to receive a flow of breathable gas;

a humidifier body outlet adapted to deliver the flow of breathable gas with added humidity;

a gas introduction chamber having a gas introduction chamber inlet and a gas introduction chamber outlet, the gas introduction chamber inlet being adapted to receive the flow of breathable gas from the humidifier body inlet; and

a humidification chamber in communication with the gas introduction chamber and the humidifier body outlet, wherein

the gas introduction chamber outlet serves as a humidification chamber inlet,

the gas introduction chamber inlet is oriented to direct the flow of breathable gas in a substantially horizontal direction when the humidifier is in an upright, operating position,

the humidification chamber comprises a bottom portion below the gas introduction chamber when the humidifier is in the upright, operating position, and comprises a side portion beside the gas introduction chamber when the humidifier is in the upright, operating position,

wherein each of the gas introduction chamber and the humidification chamber has an upper boundary that is defined by a common upper wall portion of the humidifier body,

the gas introduction chamber inlet and the gas introduction chamber outlet are positioned above the liquid when the humidifier body retains the maximum volume of liquid and is in the upright, operating position,

the gas introduction and humidification chambers are configured so that when the humidifier body retains the maximum volume of liquid and is rotated from an upright, operating position by about 80°-110°, a maximum level of liquid in the humidifier body remains below at least one of the gas introduction chamber inlet and the gas introduction chamber outlet.

9. The humidifier according to claim 8, wherein a volume of the gas introduction chamber is smaller than a volume of the humidification chamber.

10. The humidifier according to claim 9, wherein the gas introduction chamber inlet and the gas introduction chamber outlet are located at substantially diagonally opposing sections of the gas introduction chamber.

13

11. The humidifier according to claim 9, wherein the volume of the humidification chamber is greater than the predetermined maximum volume of liquid.

12. The humidifier according to claim 8, wherein the humidifier body includes at least one securing element positioned, configured and dimensioned to detachably secure the humidifier body to a connecting structure configured to detachably connect between a CPAP apparatus and the humidifier body.

13. The humidifier according to claim 12, wherein the at least one securing element includes a pair of locking lugs each configured to be received in a respective recess of the connecting structure once the humidifier body is fully inserted relative to the connecting structure.

14. The humidifier according to claim 13, wherein the humidifier body includes an upper portion having an external recess.

15. A humidifier assembly for a CPAP apparatus, the humidifier assembly comprising:

a humidifier comprising a reservoir configured to retain a body of liquid having a predetermined maximum volume, the reservoir comprising a first chamber adapted to receive breathable gas from the CPAP apparatus, and a second chamber adapted to receive a flow of breathable gas from the first chamber; and

a connecting structure configured to connect the CPAP apparatus and the humidifier, the connecting structure comprising:

a base portion to support the humidifier thereon;
a first wall face;

a second wall face opposite the first wall face, the first and second wall faces extending from the base portion and being positioned between the CPAP apparatus and the humidifier when connecting the CPAP apparatus and the humidifier; and

a retaining mechanism configured to detachably secure the connecting structure to the CPAP apparatus, the retaining mechanism being positioned on the first wall face,

wherein the base portion and the second wall face form at least a part of a receptacle adapted to laterally receive the humidifier, and

wherein the first wall face is configured to engage a corresponding face of the CPAP apparatus.

16. The humidifier assembly according to claim 15, wherein at least a portion of the humidifier remains exposed when the humidifier is received within the receptacle.

17. The humidifier assembly according to claim 16, wherein the base comprises a heating element configured to engage a heat conducting plate of the humidifier when the humidifier is retained in the receptacle.

18. The humidifier assembly according to claim 17, wherein the second wall face comprises an extension member extending away from the first wall face, the extension member being configured to interact with the humidifier so that the heat conducting plate is biased into engagement with the heating element.

19. The humidifier assembly according to claim 18, wherein the heating element is a flat plate-like resistance heater.

20. The humidifier assembly according to claim 19, wherein the first wall face and the second wall face each have an opening, and wherein the opening of the first wall face cooperates with the opening configured to define a gas flow passage.

21. The humidifier assembly according to claim 20, wherein the opening in the second wall face is adapted to be

14

fluidly connected to an inlet of the first chamber of the humidifier when the humidifier is received within the receptacle.

22. The humidifier assembly according to claim 21, wherein the first wall face comprises an electrical connecting member configured to engage a corresponding electrical member of the CPAP apparatus.

23. The humidifier assembly according to claim 22, wherein the electrical connecting member is positioned toward a lower portion of the first wall face.

24. The humidifier assembly according to claim 23, wherein the connecting structure further comprises biased locking members that are configured to engage the CPAP apparatus to secure the connecting structure to the CPAP apparatus.

25. The humidifier assembly according to claim 23, wherein an outlet of the first chamber serves as an inlet of the second chamber.

26. The humidifier assembly according to claim 25, wherein the second chamber is configured to contain the predetermined maximum volume of liquid.

27. The humidifier assembly according to claim 25, wherein an inlet of the first chamber faces a horizontal direction when the humidifier is in an upright, operating position.

28. The humidifier assembly according to claim 27, wherein the first chamber inlet and the first chamber outlet are positioned above the maximum volume of liquid when the humidifier is in the upright, operating position.

29. The humidifier assembly according to claim 28, wherein the first and second chambers are configured so that when the reservoir retains the predetermined maximum volume of liquid and is rotated from an upright, operating position by about 80°-110° around an axis parallel to a bottom face of the humidifier, a maximum level of liquid in the humidifier remains below at least one of the first chamber inlet and the first chamber outlet.

30. The humidifier assembly according to claim 29, wherein a volume of the first chamber is smaller than a volume of the second chamber.

31. The humidifier assembly according to claim 30, wherein the first chamber inlet and the first chamber outlet are located at diametrically opposing sections of the first chamber.

32. The humidifier assembly according to claim 31, wherein the volume of the second chamber is greater than the predetermined maximum volume of liquid.

33. The humidifier assembly according to claim 32, wherein the reservoir is formed of a transparent material.

34. The humidifier assembly according to claim 33, wherein the connecting structure further comprising a release member configured to release the CPAP apparatus from engagement with the connecting structure.

35. The humidifier assembly according to claim 34, wherein the release member is provided in the base portion of the housing.

36. The humidifier assembly according to claim 33, wherein the connecting structure is configured to receive and secure the humidifier when the connecting structure and the humidifier are moved laterally toward each other in a first direction and is configured to engage the CPAP apparatus when the connecting structure and the CPAP apparatus are moved laterally toward each other in a second direction, the first and second directions being the same.

37. The humidifier assembly according to claim 15 wherein the retaining mechanism comprises a movable locking member.

15

38. The humidifier assembly according to claim 37 wherein the movable locking member is movable between an engaged position and a disengaged position.

39. The humidifier assembly according to claim 38 wherein the movable locking member is resiliently biased towards the engaged position.

40. The humidifier assembly according to claim 37 further comprising an aperture configured to receive the movable locking member.

41. The humidifier assembly according to claim 15 wherein the retaining mechanism comprises a movable button structure configured to allow manual release of the connecting structure from the CPAP apparatus.

42. The humidifier assembly according to claim 41, wherein the movable button structure is coupled to a locking member.

43. The humidifier assembly according to claim 42, wherein movable button structure is configured such that manual movement of the button structure moves the locking member out of a biased position.

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

a humidifier having a reservoir for a body of liquid, and a fluid passage between an inlet, provided at a rear wall of the humidifier, and an outlet of the humidifier for exposure of a flow of pressurized 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 metallic plate, and
a top cover above the base, the top cover including the outlet; and

a connecting structure configured to allow connection 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 horizontal receptacle within which the humidifier is removably disposed by 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 metallic plate of the base when the humidifier is disposed in the receptacle, a first locking portion configured to assist in locking the humidifier in the horizontal receptacle, a second locking portion configured to assist in locking the connecting structure to the CPAP apparatus.

45. The humidifier assembly according to claim 44, wherein the base and the top cover are detachably connected to each other.

46. The humidifier assembly according to claim 44, wherein the humidifier includes a divider therein that divides an interior of the humidifier into first and second chambers.

47. The humidifier assembly according to claim 46, wherein the first chamber is adapted to receive the pressurized breathable gas from the inlet of the humidifier, and convey the pressurized breathable gas from the first chamber to the second chamber via a passage formed in the divider.

48. The humidifier assembly according to claim 47, wherein a maximum volume of the body of liquid is contained entirely in the second chamber when the humidifier is in a normal, upright operating position.

49. The humidifier assembly according to claim 47, wherein the heating element is upwardly resiliently biased to

16

ensure adequate thermal contact between the heating element and the heat conducting metallic plate.

50. The humidifier assembly according to claim 49, wherein, while the connecting structure is fastened to the CPAP apparatus and the humidifier is locked on the connecting structure, the humidifier is configured to prevent or discourage liquid from the body of liquid from exiting through the inlet of the humidifier into the outlet of the CPAP apparatus, if as a unit the humidifier, the connecting structure and the CPAP apparatus are inadvertently rotated 80-110 degrees from an upright working orientation to each of a plurality of non-upright orientations.

51. The humidifier assembly according to claim 50, wherein the connecting structure includes an upstanding wall portion that extends in a substantially vertical orientation, the humidifier having a rear wall that abuts or is proximate the upstanding wall portion when the humidifier is fully inserted relative to the connecting structure, the upstanding wall portion including an opening that aligns with the inlet of the humidifier when the humidifier is fully inserted relative to the connecting structure, the opening being configured to allow communication of the pressurized breathable gas from the outlet of the CPAP apparatus to the inlet of the humidifier.

52. A CPAP system including the humidifier assembly according to claim 51.

53. The CPAP system according to claim 52, wherein the connecting structure includes a controller to control the heating element of the connecting structure.

54. The humidifier assembly according to claim 44, wherein the connecting structure includes a movable button structure configured to allow manual release of the connecting structure from the CPAP apparatus, the connecting structure being operatively connected to the second locking portion to move a biased locking member of the second locking portion out of a biased position.

55. A humidifier assembly for a CPAP apparatus, comprising

a humidifier configured to retain a body of liquid therein, the humidifier having an inlet configured to receive pressurized breathable gas and an outlet configured to deliver the pressurized breathable gas with added humidity, the humidifier including:

a base, at least a portion of the base being constructed of a heat conducting material,
a cover having the inlet and the outlet of the humidifier, and
a seal between the cover and the base; and

a connecting structure configured to removably 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 including:

a housing providing a base portion to support the humidifier thereon, wherein the base portion includes a heating element in contact with the heat conducting material of the base of the humidifier, and
a retaining structure configured to fasten the connecting structure to the CPAP apparatus,

wherein, while the connecting structure is fastened to the CPAP apparatus and the humidifier is supported on the connecting structure, the humidifier is configured to prevent or discourage liquid from the body of liquid from exiting through the inlet of the humidifier into the outlet of the CPAP apparatus, if as a unit the humidifier, the connecting structure and the CPAP apparatus are rotated 80-110 degrees from an upright working orientation to each of a plurality of non-upright orientations.

17

56. The humidifier assembly of claim 55, wherein the retaining structure includes a locking member configured to lock the connecting structure to the CPAP apparatus.

57. The humidifier assembly of claim 56, further comprising a securing mechanism to detachably lock the humidifier to the connecting structure.

58. The humidifier assembly of claim 57, wherein the connecting structure includes an upstanding wall portion positioned towards a rearward side of the connecting structure, the upstanding wall portion having the retaining structure, the retaining structure being configured to removably fasten the rearward side of the connecting structure to a frontward side of the CPAP apparatus.

59. The humidifier assembly of claim 57, wherein the securing mechanism includes a plurality of locking lugs formed on the humidifier and plurality of recesses provided in the connecting structure, wherein the humidifier is structured for connecting to the connecting structure by moving the humidifier in a generally horizontal direction relative to the connecting structure until a fully inserted position is achieved, at which position the lugs are moveable in a generally vertical direction into the respective recesses, to therefore lock the humidifier against withdrawal from the connecting structure.

60. The humidifier assembly of claim 59, wherein each lug positively engages with a side wall surface of the respective recess when in the fully inserted position, each said side wall surface extending in the generally vertical direction.

61. The humidifier assembly of claim 60, further comprising a biasing element to bias the locking lugs into the respective recesses.

62. The humidifier assembly of claim 61, wherein, to allow removal of the humidifier from the connecting structure, the biasing element is manually movable to allow the lugs to withdraw from engagement with the recesses, at which point the humidifier is pulled out from the connecting structure in the generally horizontal direction.

63. The humidifier assembly of claim 59, wherein, to allow removal of the humidifier from the connecting structure, the lugs are manually movable in the generally vertical direction to withdraw the lugs from engagement with the recesses, at which point the humidifier is pulled out from the connecting structure in the generally horizontal direction.

64. The humidifier assembly of claim 55, wherein the humidifier includes a divider therein that divides an interior of the humidifier into first and second chambers, and wherein the first chamber is adapted to receive the pressurized breathable gas from the inlet of the humidifier, and convey the pressurized breathable gas from the first chamber to the second chamber via a passage formed in the divider.

65. The humidifier assembly of claim 64, wherein a maximum volume of the body of liquid is contained entirely in the second chamber when the humidifier is the upright operating orientation.

66. The humidifier assembly of claim 64, wherein the non-upright orientations include positions where the humidifier is rotated about multiple horizontal axes.

67. The humidifier assembly of claim 66, wherein the non-upright orientations are those which occur when the humidifier is inadvertently rotated at least up to about 80°-110° in both clockwise and counterclockwise orientations relative to the horizontal axes.

68. The humidifier assembly of claim 66, wherein the horizontal axes include a first axis that runs from a front to a back of the humidifier, and a second axis that runs from lateral side to lateral side of the humidifier.

18

69. The humidifier assembly of claim 58, wherein the upstanding wall portion extends substantially vertically upwards from the base portion.

70. The humidifier assembly of claim 69, wherein:

the housing includes rear upper corner portions and rear lateral side portions that extend rearwardly from the upstanding wall portion and form a rearward-most part of the connecting structure, and

the rear upper corner portions and the rear lateral side portions are configured to hold the CPAP apparatus.

71. The humidifier assembly of claim 70, wherein the rear upper corner portions and rear lateral side portions are configured to hold the CPAP apparatus while the retaining structure fastens the connecting structure to the CPAP apparatus.

72. The humidifier assembly of claim 55, wherein the heating element is upwardly resiliently biased to ensure adequate thermal contact between the heating element and the heat conducting material.

73. The humidifier assembly of claim 55, wherein the connecting structure includes an upstanding wall portion extending in a substantially vertical orientation compared to the base of the connecting structure, the humidifier having a rear wall that abuts or is proximate a front wall of the upstanding wall portion when the humidifier is fully inserted relative to the connecting structure, the upstanding wall portion including an opening in the front wall that aligns with the inlet of the humidifier when the humidifier is fully inserted relative to the connecting structure, the opening being configured to allow communication of the pressurized breathable gas from the outlet of the CPAP apparatus to the inlet of the humidifier.

74. The humidifier assembly of claim 73, wherein the inlet of the humidifier comprises a generally cylindrical tube that projects horizontally rearward from the rear wall of the humidifier, and wherein the tube extends into the opening when the humidifier is fully inserted relative to the connecting structure.

75. The humidifier assembly of claim 55, wherein the retaining structure includes a recess adapted to receive a tab or prong of the CPAP apparatus, wherein the recess is configured to receive the tab or prong to detachably lock the connecting structure to the CPAP apparatus.

76. The humidifier assembly of claim 55, wherein a rearward side of the connecting structure comprises at least one electrical connecting member configured to engage a corresponding electrical member of the CPAP apparatus for power supply and control of the heating element.

77. The humidifier assembly of claim 76, wherein the electrical connecting member is positioned toward a lower portion of the rearward side.

78. The humidifier assembly of claim 55, wherein the connecting structure is configured to receive and secure the humidifier when the connecting structure and the humidifier are moved laterally toward each other in a first direction and is configured to engage the CPAP apparatus when the connecting structure and the CPAP apparatus are moved laterally toward each other in a second direction, the first and second directions being the same.

79. A CPAP system including the CPAP apparatus and the humidifier assembly of claim 55.

80. The CPAP system of claim 79, further comprising a button structure to counteract biased engagement between a prong or tab of the CPAP apparatus and a recess of the connecting structure, wherein manual movement of the button structure causes relative movement between the prong or tab and the recess, to unlock the connecting structure from the

CPAP apparatus, at which point the connecting structure and the CPAP apparatus are releasable from one another.

81. The CPAP system of claim 80, wherein the CPAP apparatus includes a controller to control the heating element of the connecting structure, as well as at least one electrical connecting member to allow power supply from the CPAP apparatus to the connecting structure.

82. A CPAP system including the CPAP apparatus and the humidifier assembly of claim 57, further comprising a button structure to counteract biased engagement between a prong or tab of the CPAP apparatus and a recess of the connecting structure, wherein manual movement of the button structure causes relative movement between the prong or tab and the recess, to unlock the connecting structure from the CPAP apparatus, at which point the connecting structure and the CPAP apparatus are releasable from one another.

83. The CPAP system of claim 82, wherein the CPAP apparatus includes a controller to control the heating element of the connecting structure, as well as at least one electrical connecting member to allow power supply from the CPAP apparatus to the connecting structure.

84. The humidifier assembly of claim 55, wherein the connecting structure includes a movable button structure configured to allow manual release of the connecting structure from the CPAP apparatus, the connecting structure being operatively connected to the retaining structure to move a biased locking member of the retaining structure out of a biased position.

85. 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 wall of the humidifier, and an outlet of the humidifier, for exposure of a flow of pressurized breathable gas from the CPAP apparatus to the body of liquid, the humidifier comprising:

a base having a bottom portion constructed of a heat conducting metallic material, side wall portions extending upwardly from the bottom portion, the side wall portions and the bottom portion together being configured to retain a body of liquid therein, and a cover above the base, the cover including the inlet and the outlet; and

a connecting structure configured to allow connection 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 is 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, and a heating element positioned on the lower surface and in thermal contact with the heat conducting metallic material of the base when the humidifier is disposed in the receptacle,

the connecting structure further including a humidifier attaching structure that removably attaches the humidifier in the generally horizontal receptacle, and a CPAP apparatus attaching structure configured to removably attach the connecting structure to the CPAP apparatus, wherein the connecting structure includes an upstanding wall portion that extends in a substantially vertical orientation, the humidifier having a rear wall that abuts or is proximate the upstanding wall portion when the

humidifier is fully inserted relative to the connecting structure, the upstanding wall portion including an opening that aligns with the inlet of the humidifier when the humidifier is fully inserted relative to the connecting structure, the opening being configured to allow communication of the pressurized breathable gas from the outlet of the CPAP apparatus to the inlet of the humidifier,

wherein the inlet of the humidifier comprises a generally cylindrical tube that projects horizontally rearward from the rear wall of the humidifier, and wherein the tube extends into the opening when the humidifier is fully inserted relative to the connecting structure.

86. The humidifier assembly according to claim 85, wherein the base and the cover are detachably connected to each other.

87. The humidifier assembly according to claim 85, wherein the humidifier includes a removable divider therein that divides an interior of the humidifier into first and second chambers.

88. The humidifier assembly according to claim 87, wherein the first chamber is adapted to receive the pressurized breathable gas from the inlet of the humidifier, and convey the pressurized breathable gas from the first chamber to the second chamber via a passage formed in the divider.

89. The humidifier assembly according to claim 87, wherein the humidifier is constructed to prevent or discourage spillback of liquid through the inlet of the humidifier when the humidifier is inadvertently moved from a normal, upright position to each of a plurality of non-upright positions in which the humidifier assembly is not designed to operate.

90. The humidifier assembly according to claim 85, further comprising a seal between the base and the cover.

91. The humidifier assembly according to claim 85, wherein the base is at least partially formed of a transparent material.

92. The humidifier assembly according to claim 85, wherein the heating element is upwardly resiliently biased to ensure adequate thermal contact between the heating element and the heat conducting metallic material.

93. The humidifier assembly according to claim 85, wherein the humidifier attaching structure includes a plurality of recesses of the connecting structure that receive corresponding lugs on the humidifier when the humidifier is fully inserted into the open receptacle.

94. The humidifier assembly according to claim 85, wherein:

the humidifier includes a removable divider therein that divides an interior of the humidifier into first and second chambers, and

the first chamber is adapted to receive the pressurized breathable gas from the inlet of the humidifier, and convey the pressurized breathable gas from the first chamber to the second chamber via a passage formed in the divider.

95. The humidifier assembly according to claim 94, wherein, while the connecting structure is attached to the CPAP apparatus and the humidifier is supported on the connecting structure, the humidifier is configured to prevent or discourage liquid from the body of liquid from exiting through the inlet of the humidifier into the outlet of the CPAP apparatus, if as a unit the humidifier, the connecting structure and the CPAP apparatus are inadvertently rotated 80-110 degrees from an upright working orientation to each of a plurality of non-upright orientations.

96. The humidifier assembly according to claim 85, wherein connecting structure is removably locked to the

21

humidifier and the connecting structure is configured to be removably locked to the CPAP apparatus.

97. The humidifier assembly according to claim 85, wherein the heat conducting metallic material comprises a metallic plate having a horizontal portion and an upstanding wall along at least a portion of the plate, the upstanding wall having a lip positioned at a distal end of the upstanding wall, the lip extending generally parallel to the horizontal portion of the plate.

98. The humidifier assembly according to claim 97, further comprising a resilient seal member positioned at a junction where the plate and the side wall portions of the humidifier meet.

99. The humidifier assembly according to claim 97, further comprising a flange integrally formed with at least one of the side wall portions of the base of the humidifier, the flange and a portion of the plate being positioned to overlap one another in a horizontal plane.

100. A CPAP system including the CPAP apparatus and the humidifier assembly according to claim 85.

101. The CPAP system according to claim 100 wherein the CPAP apparatus includes a controller to control the heating element of the connecting structure.

102. A CPAP system including the humidifier assembly according to claim 95.

103. A CPAP system including the humidifier assembly according to claim 96.

104. The humidifier assembly according to claim 85, wherein the connecting structure includes a movable button structure configured to allow manual release of the connecting structure from the CPAP apparatus, the connecting structure being operatively connected to the CPAP apparatus attaching structure to move a biased locking member of the CPAP apparatus attaching structure out of a biased position.

105. A humidifier, comprising:

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

a humidifier body inlet configured to receive a flow of breathable gas;

a humidifier body outlet adapted to deliver the flow of breathable gas with added humidity;

a gas introduction chamber having a gas introduction chamber inlet and a gas introduction chamber outlet, the gas introduction chamber inlet being adapted to receive the flow of breathable gas from the humidifier body inlet;

a humidification chamber in communication with the gas introduction chamber and the humidifier body outlet, the humidification chamber having a bottom surface comprising heat conductive metallic material, and

a cover that defines an upper boundary of both the gas introduction chamber and at least a portion of the humidification chamber, the cover including the humidifier body outlet, wherein:

the gas introduction chamber outlet serves as a humidification chamber inlet,

the gas introduction chamber inlet faces a horizontal direction when the humidifier is in an upright, operating position,

the humidification chamber comprises a bottom portion below the gas introduction chamber when the humidifier is in the upright, operating position, and comprises a side portion beside the gas introduction chamber when the humidifier is in the upright, operating position,

22

the gas introduction chamber outlet is positioned above the liquid when the humidifier body retains the maximum volume of liquid and is in the upright, operating position, and

the gas introduction chamber and the humidification chamber are configured so that when the humidifier body retains the maximum volume of liquid and is rotated around a horizontal axis parallel to the bottom surface of the humidifier chamber, in each of clockwise and counterclockwise directions, from the upright, operating position to a plurality of non-upright positions, the possibility of liquid flowing from the humidification chamber and out through the humidifier inlet is discouraged or prevented.

106. The humidifier of claim 105, wherein a volume of the gas introduction chamber is smaller than a volume of the humidification chamber.

107. The humidifier of claim 106, wherein the gas introduction chamber inlet and the gas introduction chamber outlet are located at substantively diagonally opposite sections of the gas introduction chamber.

108. The humidifier of claim 107, wherein the volume of the humidification chamber is greater than the predetermined maximum volume of liquid.

109. The humidifier of claim 105, wherein a maximum level of liquid in the humidifier body remains below at least one of the gas introduction chamber inlet and the gas introduction chamber outlet.

110. The humidifier of claim 105, wherein the non-upright positions include positions where the humidifier is inadvertently rotated about multiple horizontal axes.

111. The humidifier of claim 110, wherein the non-upright positions are those which occur when the humidifier is inadvertently rotated in both clockwise and counterclockwise orientations relative to the horizontal axes.

112. The humidifier of claim 110, wherein the horizontal axes include a first axis that runs from a front to a back of the humidifier body, and a second axis that runs from lateral side to lateral side of the humidifier body.

113. The humidifier of claim 110, wherein the horizontal axes are perpendicular.

114. The humidifier of claim 105, wherein the humidifier body includes a side wall that defines a side wall boundary of both the gas introduction chamber and the humidification chamber.

115. The humidifier of claim 114, wherein the humidifier body inlet being positioned on a rear side wall of the humidifier body.

116. The humidifier of claim 114, wherein a lower boundary of the gas introduction chamber and an upper boundary of at least part of the humidifier chamber are formed with a common wall.

117. The humidifier of claim 105, wherein the humidifier body includes at least one securing element positioned, configured and dimensioned to detachably secure the humidifier body to a connecting structure configured to detachably connect between a CPAP apparatus and the humidifier body.

118. The humidifier of claim 117, wherein the at least one securing element includes a pair of locking lugs each configured to be received in a respective recess of the connecting structure once the humidifier body is fully inserted relative to the connecting structure.

119. The humidifier of claim 118, wherein the humidifier body includes an upper portion having an external recess.

23

120. A humidifier, comprising:

a humidifier body comprising:

a humidifier body inlet configured to receive a flow of breathable gas, the humidifier body inlet including a cylindrical tube that extends rearward from a rear wall of the humidifier body;

a humidifier body outlet adapted to deliver the flow of breathable gas with added humidity;

a gas introduction chamber having a gas introduction chamber inlet and a gas introduction chamber outlet, the gas introduction chamber inlet being adapted to receive the flow of breathable gas from the cylindrical tube;

a humidification chamber in communication with the gas introduction chamber and the humidifier body outlet, the humidification chamber having a bottom surface comprising heat conductive metallic material, and

a top cover that defines an upper boundary of both the gas introduction chamber and at least a portion of the humidification chamber, the top cover including the humidifier body outlet, wherein:

the gas introduction chamber outlet serves as a humidification chamber inlet,

the gas introduction chamber outlet is positioned above the maximum volume of liquid when the humidifier body is in the upright, operating position, and

when the humidifier body retains a volume of liquid and is moved from the upright, operating position to each of a plurality of non-upright positions, the possibility of liquid flowing from the humidification chamber and out through the humidifier inlet is discouraged or prevented.

121. The humidifier of claim 120, wherein a volume of the gas introduction chamber is smaller than a volume of the humidification chamber.

122. The humidifier of claim 121, wherein the gas introduction chamber inlet and the gas introduction chamber outlet are located at adjacent wall sections of the gas introduction chamber.

123. The humidifier of claim 122, wherein the volume of the humidification chamber is greater than the predetermined maximum volume of liquid.

124. The humidifier of claim 120, wherein a maximum level of liquid in the humidifier body remains below at least one of the gas introduction chamber inlet and the gas introduction chamber outlet.

125. The humidifier of claim 120, wherein the non-upright positions include positions where the humidifier is inadvertently rotated about multiple horizontal axes.

126. The humidifier of claim 125, wherein the non-upright positions are those which occur when the humidifier is inadvertently rotated in both clockwise and counterclockwise orientations up to about 80-110 degrees relative to the horizontal axes.

127. The humidifier of claim 125, wherein the horizontal axes include a first axis that runs from a front to a back of the humidifier body, and a second axis that runs from lateral side to lateral side of the humidifier body.

128. The humidifier of claim 125, wherein the horizontal axes are perpendicular.

129. The humidifier of claim 120, wherein the rear wall of the humidifier body defines a rear wall boundary for both the gas introduction chamber and the humidification chamber.

130. The humidifier of claim 129, wherein a lower wall boundary of the gas introduction chamber and an upper wall boundary of at least part of the humidifier chamber are formed with a common wall.

24

131. The humidifier of claim 129, wherein at least part of the rear wall boundary spanning the gas introduction chamber and the humidifier chamber is substantially planar in a vertical direction.

132. The humidifier of claim 129, wherein the gas introduction chamber defines a gas path extending at least from the gas introduction chamber inlet to an interior upper surface of the humidifier body.

133. The humidifier of claim 120, wherein the humidifier body includes at least one externally located securing element positioned, configured and dimensioned to detachably secure the humidifier body to a connecting structure configured to detachably connect between a CPAP apparatus and the humidifier body.

134. The humidifier of claim 133, wherein the at least one securing element includes a pair of locking lugs each configured to be received in a respective recess of the connecting structure once the humidifier body is fully inserted relative to the connecting structure.

135. The humidifier of claim 134, wherein the humidifier body includes an upper portion having an external recess.

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

a humidifier to expose of a flow of pressurized breathable gas from the CPAP apparatus to a body of liquid, the humidifier comprising:

an inlet and an outlet, the inlet being provided proximate a rear wall of the humidifier,

a base including a heat conducting metallic plate, and a top cover detachably connected to the base, the top cover including the outlet, and

an elastomeric seal between the base and the top cover; a connecting structure configured to allow connection between the CPAP apparatus and the humidifier and allow communication of an outlet of the CPAP apparatus with the inlet of the humidifier without the need for an external flexible conduit extending between the CPAP apparatus and the connecting structure, the connecting structure comprising:

a housing providing a horizontal receptacle within which the humidifier is removably disposed by 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, and an upwardly biased heating element positioned on the lower surface and in thermal contact with the heat conducting metallic plate of the base when the humidifier is disposed in the receptacle,

a retaining mechanism having at least one biased locking member configured to lock the connecting structure to the CPAP apparatus,

a movable button structure operatively connected to the at least one biased locking member, whereby manual movement of the button structure moves the biased locking member from an engaged position to a disengaged position to allow for manual release of the connecting structure from the CPAP apparatus, and

a retaining portion configured to secure the humidifier in position relative to the connecting structure, the retaining portion extending substantially parallel to the base portion and being spaced above the lower surface of the base portion, the retaining portion having a downwardly facing surface that engages an exterior portion of the humidifier as the humidifier is horizontally loaded into the receptacle, the retaining portion being positioned to constrain the humidifier such that, during assembly, the heat conducting metallic plate of the base of the humidifier slides against the upwardly biased heating element, wherein

25

the inlet provided at the rear wall of the humidifier is positioned to receive the pressurized breathable gas once the humidifier is fully loaded into the receptacle; and

a securing mechanism that releasably locks the humidifier in the horizontal receptacle, wherein, when the connecting structure is locked to the CPAP apparatus and the humidifier is locked on the connecting structure, the humidifier is configured to prevent or discourage liquid from the body of liquid from exiting through the inlet of the humidifier into the outlet of the CPAP apparatus, if as a unit the humidifier, the connecting structure and the CPAP apparatus are rotated from an upright working orientation to each of a plurality of non-upright orientations.

137. The humidifier assembly according to claim 136, wherein the connecting structure includes an upstanding wall portion that extends in a substantially vertical orientation, the rear wall of the humidifier abutting or located proximate the upstanding wall portion when the humidifier is fully inserted relative to the connecting structure, the upstanding wall portion including an opening that aligns with the inlet of the humidifier when the humidifier is fully inserted relative to the connecting structure, the opening being configured to allow communication of the pressurized breathable gas from the outlet of the CPAP apparatus to the inlet of the humidifier.

138. The humidifier assembly according to claim 136, wherein the connecting structure receives and secures the humidifier when the connecting structure and the humidifier are moved horizontally relative to each other and is configured to engage the CPAP apparatus when the connecting structure and the CPAP apparatus are moved horizontally relative to each.

139. The humidifier assembly of claim 136, wherein a side of the connecting structure comprises at least one electrical connecting member configured to engage a corresponding electrical member of the CPAP apparatus for power supply and control of the heating element.

140. The humidifier assembly of claim 139, wherein the electrical connecting member is positioned on a lower portion of the side.

141. The humidifier assembly of claim 136, wherein the humidifier body includes a rear portion having an external recess.

142. The humidifier assembly of claim 136, wherein the exterior portion of the humidifier includes a recess positioned along a rearward side of the humidifier to receive the retaining portion when the humidifier is horizontally moved and fully inserted within the connecting structure.

143. The humidifier assembly of claim 136, wherein the securing mechanism includes at least one movable locking lug that is movable between a locked position and an unlocked position, the securing mechanism further including a biased member that supports the at least one movable locking lug, the biased member being manually operable to move the lug from the locked position to the unlocked position, thereby allowing the humidifier to be horizontally withdrawn from the connecting structure.

144. The humidifier assembly of claim 136, wherein the humidifier includes a gas introduction chamber and a humidification chamber, the gas introduction chamber being positioned to receive the pressurized breathable gas from the inlet of the humidifier, the gas introduction chamber being oriented to direct the pressurized breathable gas in a substantially horizontal direction when the humidifier is in the upright working orientation, the humidifier further including a substantially vertically extending passage oriented to direct

26

the pressurized breathable gas from the gas introduction chamber in a downward direction towards liquid contained in the humidification chamber.

145. The humidifier assembly of claim 136, wherein the plurality of non-upright positions includes up-ended position in which the rear wall of the humidifier is vertically below a front side wall of the humidifier, whereby even if the liquid level within the humidifier is higher than the inlet of the humidifier, liquid is discouraged or prevented from exiting through the inlet.

146. The humidifier assembly of claim 145, wherein the plurality of positions includes two side-lying positions where the rear wall is horizontally spaced from the front side wall of the humidifier, whereby, in said side-lying positions, liquid is discouraged or prevented from exiting through the inlet.

147. The humidifier assembly of claim 136, wherein the connecting structure includes an upstanding wall including an aperture to receive pressurized breathable gas from the CPAP apparatus.

148. The humidifier assembly according to claim 136, further comprising clips to detachably connect the base and the top cover.

149. The humidifier assembly according to claim 136, wherein at least a portion of the humidifier remains exposed when the humidifier is received within the receptacle.

150. The humidifier assembly according to claim 136, wherein rear wall extends in a substantially vertical direction when the humidifier is in the upright working orientation.

151. The humidifier assembly of claim 136, wherein the humidifier includes a gas introduction chamber and a humidification chamber, the gas introduction chamber being positioned to receive the pressurized breathable gas from the inlet of the humidifier, the gas introduction chamber being oriented to direct the pressurized breathable gas in a substantially horizontal direction when the humidifier is in the upright working orientation, the humidifier further including a vertical passage communicating the gas introduction chamber with the humidification chamber, and

wherein the plurality of non-upright positions includes a position in which the inlet faces downward and the passage is positioned at a level higher than the inlet, whereby liquid is discouraged or prevented from moving from the humidification chamber and exiting through the inlet.

152. The humidifier assembly of claim 151, wherein the plurality of positions includes two opposite side-lying positions where the humidifier is rotated in clockwise and counterclockwise manners about a longitudinal axis if the inlet, whereby, in said side-lying positions, liquid is discouraged or prevented from exiting from the humidification chamber through the inlet.

153. A CPAP system including the humidifier assembly according to claim 136.

154. The CPAP system of claim 153, wherein the CPAP apparatus includes a controller to control the heating element of the connecting structure, as well as at least one electrical connecting member to allow power supply from the CPAP apparatus to the connecting structure.

155. A CPAP system including a blower to generate a flow of pressurized breathable gas and the humidifier according to claim 8.

156. A CPAP system including a blower to generate a flow of pressurized breathable gas and the humidifier of claim 105.

157. A CPAP system including a blower to generate a flow of pressurized breathable gas and the humidifier of claim 120.

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : RE46,079 E
APPLICATION NO. : 13/944960
DATED : July 26, 2016
INVENTOR(S) : Virr et al.

Page 1 of 1

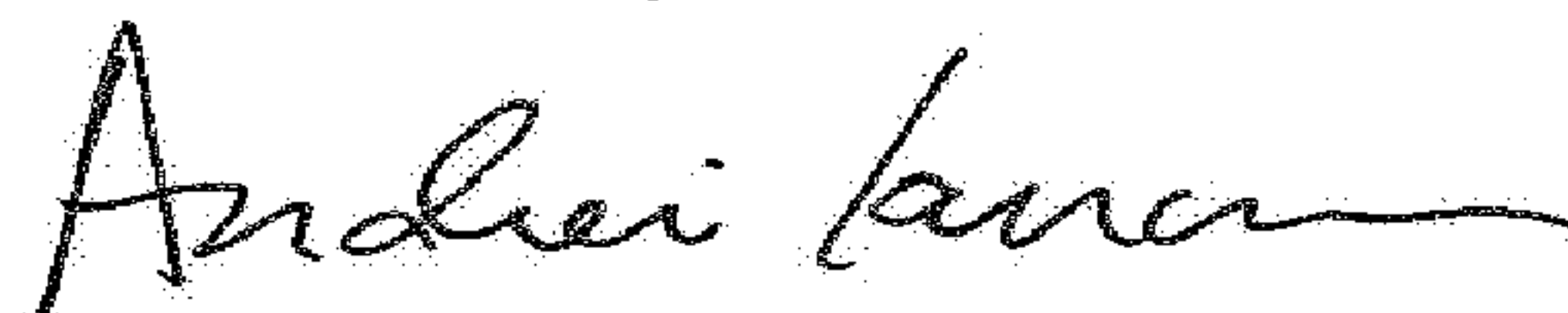
It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Specification

Please insert Line 12 (approx.) of Column 1 as follows:

--Notice: More than one reissue application has been filed for the reissue of U.S. Patent No. 7,614,398. The reissue applications are U.S. Reissue Patent Application Serial No. 15/182,919, filed on June 15, 2016, now U.S. Reissue Patent No. RE46,571 E, issued October 17, 2017, which is a continuation reissue application of U.S. Reissue Patent Application Serial No. 13/944,960 (the present application), filed on August 23, 2013, now U.S. Reissue Patent No. RE46,079 E, issued July 26, 2016, which is a continuation reissue application of U.S. Reissue Patent Application Serial No. 13/100,783, filed on May 4, 2011, now U.S. Reissue Patent No. RE44,453 E, issued August 27, 2013.--

Signed and Sealed this
Fifth Day of June, 2018



Andrei Iancu
Director of the United States Patent and Trademark Office

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : RE46,079 E
APPLICATION NO. : 13/944960
DATED : July 26, 2016
INVENTOR(S) : Virr et al.

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

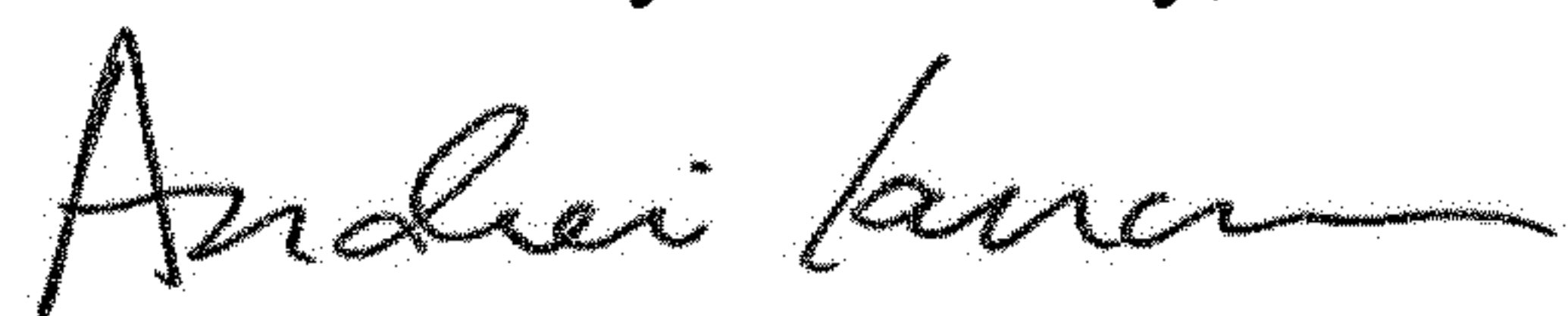
In the Specification

At Column 1, under the heading "CROSS REFERENCE TO RELATED APPLICATIONS," replace Lines 16-20 (approx.), with the following:

-- NOTICE: More than one reissue application has been filed for the reissue of U.S. Patent No. 7,614,398 B2. The reissue applications are U.S. Reissue Patent Application No. 16/232,883, filed December 26, 2018, now U.S. Reissue Patent No. RE48,095 E, issued July 14, 2020, which is a continuation reissue application of U.S. Reissue Patent Application Serial No. 16/231,286, filed on December 21, 2018, now U.S. Reissue Patent No. RE48,118 E, issued July 28, 2020, which is a continuation reissue application of U.S. Reissue Patent Application Serial No. 15/706,811, filed on September 18, 2017, now U.S. Reissue Patent No. RE48,149, issued August 11, 2020, which is a continuation reissue application of U.S. Reissue Patent Application Serial No. 15/182,919, filed on June 15, 2016, now U.S. Reissue Patent No. RE46,571 E, issued October 17, 2017, which is a continuation reissue application of U.S. Reissue Patent Application Serial No. 13/944,960 (the present application), filed on August 23, 2013, now U.S. Reissue Patent No. RE46,079 E, issued July 26, 2016, which is a continuation reissue application of U.S. Reissue Patent Application Serial No. 13/100,783, filed on May 4, 2011, now U.S. Reissue Patent No. RE44,453 E, issued August 27, 2013, which is a reissue application of U.S. Patent Application No. 11/181,807, filed on July 15, 2005, now U.S. Patent No. 7,614,398 B2, issued November 10, 2009, which is a continuation of U.S. Patent Application Serial No. 10/467,382, filed on August 7, 2003, now U.S. Patent No. 6,935,337 B2, issued August 30, 2005, which is the U.S. --

This certificate supersedes the Certificate of Correction issued June 5, 2018.

Signed and Sealed this
Twelfth Day of January, 2021



Andrei Iancu
Director of the United States Patent and Trademark Office