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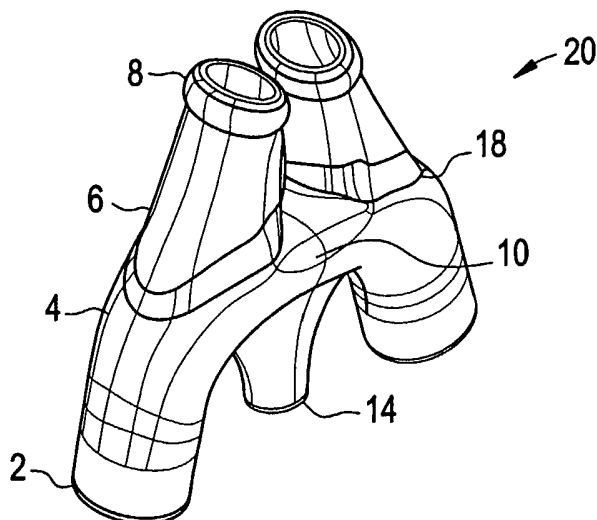
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[Continued on next page]

(54) Title: NASAL VENTILATION INTERFACE AND SYSTEM



(57) Abstract: A ventilation interface and system is described which can be adapted to be connected to a source of ventilation. The ventilation interface and system includes an exhaust port positioned at a midpoint between at least two ventilation connectors. The ventilation interface system may optionally include feed tubes, y-connector, tube holder and headgear.



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NASAL VENTILATION INTERFACE AND SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit to U.S. Provisional Patent Application No. 60/501,028, entitled "Ultimate Performance Cannula," filed September 9, 2003, and U.S. Provisional Patent Application No. 60/492,292, entitled "Variable Exhaust Ports," filed August 5, 2003, the disclosures of which are expressly incorporated by reference herein in its entirety.

10 BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

[0002] Exemplary embodiments of the invention are directed to a nasal ventilation interface adaptable to be connected to a source of ventilation.

15 2. DISCUSSION OF RELATED ART

[0003] Obstructive sleep apnea syndrome (commonly referred to as obstructive sleep apnea, sleep apnea syndrome, and/or sleep apnea) is a medical condition which includes repeated, prolonged episodes of cessation of breathing during sleep. During a period of wakefulness, the muscles of the upper part of the throat passage of an individual keep the passage open, thereby permitting an adequate amount of oxygen to flow into the lungs. During sleep, the throat passage tends to narrow due to the relaxation of the muscles. In those individuals having a relatively normally sized throat passage, the narrowed throat passage remains open enough to continue to permit the adequate amount of oxygen to flow into the lungs. However, in those individuals having a relatively smaller sized throat passage, the narrowed throat

passage prohibits the adequate amount of oxygen from flowing into the lungs.

Additionally, a nasal obstruction, such as a relatively large tongue, and/or certain shapes of the palate and/or the jaw of the individual further prohibit the adequate amount of oxygen from flowing into the lungs.

- 5 **[0004]** The individual having the above-discussed conditions can stop breathing for one or more prolonged periods of time (e.g., 10 seconds or more). The prolonged periods of time during which breathing is stopped, or apneas, are generally followed by sudden reflexive attempts to breathe. The reflexive attempts to breathe are generally accompanied by a change from a relatively deeper stage of sleep to a
- 10 relatively lighter stage of sleep. As a result, the individual suffering from obstructive sleep apnea syndrome generally experiences fragmented sleep that is not restful. The fragmented sleep results in one or more of excessive and/or inappropriate daytime drowsiness, headache, weight gain or loss, limited attention span, memory loss, poor judgment, personality changes, lethargy, inability to maintain concentration, and/or
- 15 depression.

- [0005]** Other medical conditions can also prevent individuals, including adults and infants, from receiving the adequate amount of oxygen into the lungs. For example, an infant who is born prematurely can have lungs that are not developed to an extent necessary to receive the adequate amount of oxygen. Further, prior to, during, and/or
- 20 subsequent to certain medical procedures and/or medical treatments, an individual can be unable to receive the adequate amount of oxygen.

- [0006]** Under these circumstances, it is known to use a ventilation interface to apply a positive pressure to the throat of the individual, thereby permitting the adequate amount of oxygen to flow into the lungs. In the known ventilation interface, oxygen
- 25 and/or room air containing oxygen is delivered through the mouth and/or nose of the

individual. Known types of positive pressure applied by the known ventilation interface include continuous positive airway pressure (CPAP) in which a positive pressure is maintained in the throat passage throughout a respiratory cycle, bi-level positive airway pressure (BiPAP) in which a relatively high positive pressure is maintained during inspiration and a relatively low positive pressure is maintained during expiration, and intermittent mechanical positive pressure ventilation (IPPV) in which a positive pressure is applied when apnea is sensed (i.e., the positive airway pressure is applied intermittently or non-continuously).

[0007] One conventional ventilation interface for the application of such positive pressures includes a face mask that covers the nose and/or mouth, as well as a pair of nasal pillows that are inserted into corresponding nares of the naris.

[0008] In the conventional art, pressure must be applied between the required harness and the head of the individual to maintain the required seal. As a result, the harness is generally uncomfortable to wear, particularly when sleeping. The applied pressure often results in undesirable irritation and sores caused by movement of the mask and harness during periods of both wakefulness and sleep. Further, the required seal is generally difficult to maintain when the mask and harness is moved. The mask also generally applies an undesirable pressure to the sinus area that is adjacent to the nose, causing the nasal sinus airways to narrow. This causes an increase in the velocity of flow through the upper anatomical airways and a decrease in the lateral pressure against the nasal mucosal walls. Additionally, the tubing may fold undesirably exacerbating the above problem. The above-discussed combination of increased flow velocity and decreased pressure results in the removal of moisture from the mucosal walls during inspiration and may cause an undesirable drying and a burning sensation within the nares. As a result, the individual may remove the mask to alleviate these

discomforts, consequently discontinuing the beneficial application of the positive pressure. Additionally the decreased pressure and increased air flow velocity deteriorate the laminar flow between the air input and output portions of the conventional mask.

- 5 **[0009]** For these reasons, it is desirable to provide an improved nasal ventilation interface that overcomes one or more of the above-discussed disadvantages.

SUMMARY OF THE EXEMPLARY EMBODIMENTS OF THE INVENTION

- [0010]** A first exemplary embodiment of the present invention provides a nasal
10 ventilation interface including a cannula connectable to a source of ventilation gas via at least two ventilation connectors including at least one reservoir flange in close proximity with at least one nasal insert. The nasal ventilation interface further includes a seal portion positioned on a distal end of the at least one nasal insert and a central reservoir with at least one exhaust flange and an exhaust port positioned at a
15 midpoint between the at least two ventilation connectors.

- [0011]** In a second exemplary embodiment, a nasal ventilation interface includes a cannula connectable to a source of ventilation gas via at least two ventilation connectors forming a first inflow portion. A reservoir flange forms a second inflow portion with at least one nasal insert. The nasal insert forms a third inflow portion
20 and a first outflow portion. A seal portion with a substantially oval cross section is positioned on a distal end of the nasal insert. A central reservoir forms a second outflow portion. At least one exhaust flange forms a third outflow portion. An exhaust port positioned at a midpoint between the at least two ventilation connectors forms a fourth outflow portion and a fifth outflow portion.

[0012] A third exemplary embodiment describes a ventilation interface system. The system may include feed tubes, a y-connector and headgear engageable with a headgear flange on a cannula. The ventilation connectors are connectable to a source of ventilation gas via the feed tubes and y-connector. The at least two ventilation connectors form a first inflow portion. A reservoir flange forms a second inflow portion. At least one nasal insert and seal portion form a third inflow portion and a first outflow portion. A central reservoir forms a second outflow portion. At least one exhaust flange forms a third outflow portion. An exhaust port positioned at a midpoint between the at least two ventilation connectors forms a fourth outflow portion and a fifth outflow portion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Reference will now be made to the exemplary embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts

[0014] Figure 1 shows a left front elevation view of an exemplary embodiment of a ventilation interface.

[0015] Figure 2 shows a front side view of an exemplary embodiment of a ventilation interface.

[0016] Figure 3 shows a side view of an exemplary embodiment of a ventilation insert of Figure 2.

[0017] Figure 4 shows a bottom view of an exemplary embodiment of the ventilation insert of Figure 2.

[0018] Figure 5 shows a top view of the ventilation insert of Figure 2.

[0019] Figure 6 shows a cross-sectional view taken from line I-I in Figure 5.

[0020] Figure 7 shows an elevated front left view of a second exemplary embodiment of the nasal interface.

[0021] Other embodiments of the invention will be apparent to those skilled in the art

5 from consideration of the specification and practice of the invention disclosed herein.

It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

10 **[0022]** The present invention provides a nasal ventilation interface system that may include a cannula that is configured to be connected to a ventilation source. The cannula may connect to a source of ventilation gas, such as oxygen and/or air containing oxygen. For example, the cannula may include a distal end that connects to a feed tube. The feed tube may then lead to a branch of a y-connector. The y-
15 connector may then have an exterior surface and an interior surface that define a wall portion therebetween, and each of the exterior and interior surfaces may have a substantially circular or oval cross section. The y-connector may then have another branch that is connected with the source of the ventilation gas, such as a mechanical ventilator or some other source of gas. The source may apply a positive pressure
20 through the cannula to the throat of the user, thereby permitting an adequate amount of oxygen or air to flow into the lungs. Although the figures show certain exemplary embodiments of the nasal ventilation system, it is to be understood that the ventilation system can be of any type. One or more exemplary embodiments of the present invention will now be described with reference to the drawings, wherein like
25 reference numbers throughout the several views identify like and/or similar elements.

[0023] For example, as shown in Figure 1, a cannula 20 may include a pair of ventilation connectors 2, at least one reservoir flange 4, at least one nasal insert 6, at least one seal portion 8, a central reservoir 10, an exhaust port 14, and at least one connection portion 18. These and other portions of the cannula 20 will now be further described.

[0024] Ventilation connectors 2 couple the cannula 20 to a ventilation source (not shown). Ventilation connectors 2 may be shaped and configured to connect to a wide variety of ventilation sources, such as a mechanical ventilator, pump, or tank. For example, ventilation connectors 2 may be configured to connect to a source of ventilation gas via one or more feed tubes and a y-connector (not shown). Other types of ventilation connectors may be used as part of the cannula 20.

[0025] Reservoir flange 4 provides a reservoir for air to flow from the ventilation connector 2 to other parts of the cannula 20. For example, reservoir flange 4 may be coupled to the nasal insert 6, the central reservoir 10, and the exhaust flange 12.

[0026] Nasal insert 6 provides a structure for extending the cannula 20 into a user's nares. Nasal insert 6 may comprise at its distal end a seal portion 8. The seal portion 8 may have a substantially oval cross section in order to assist with fitting nasal insert 6 inside a user's nasal passages. The seal portion 8 may also be configured to receive a skirt (not shown) to prevent leakage. Nasal insert 6 may also be coupled at its proximal end to the central reservoir 10.

[0027] The seal portion 8 and/or at least one nasal insert 6 may be made of an elastic material. The elastic material may be chosen such that its resiliency is sufficient to retain the cannula 20 in the nares of a user. Further, the seal portion 8 and/or the nasal insert 6 may expand in response to the positive pressure of the ventilation gas, thereby aiding in the retention of the cannula 8 within the nares. The seal portion 8 may be

retained entirely in the user's nares by friction between the seal portion 8 and the user's nares. Alternatively, the nasal insert 6 and seal portion 8 may be made of less elastic material that deforms only slightly and instead the cannula 20 may be held in place by headgear (not shown) that is attached to the user.

5 **[0028]** Central reservoir 10 provides an additional volume of air or gas that, for example, allows for a decreased flow velocity through cannula 20 without a drop in pressure. In addition, central reservoir 10 may be shaped in a variety of ways to optimize the airflow through the cannula 20.

10 **[0029]** For example, central reservoir 10 may be shaped to allow a laminar flow through the cannula 20 between the nasal insert 6 and the exhaust port 14. In particular, the central reservoir 10 may have a shape and volume that is sufficient to slow the velocity of air or gas without dropping its pressure. This feature may be considered useful in increasing the effectiveness of the cannula 20 for treating sleep apnea.

15 **[0030]** During sleep, the exhalation of a person is driven by the elasticity of the lungs. For patients that use conventional sleep apnea devices, the contraction/contraction of the lungs during exhalation can become static during sleep, which interrupts the adequate exhalation and release of carbon dioxide. This happens frequently with some patients prescribed with conventional sleep apnea devices that use pressures of 3
20 cmH₂O to 25 cm H₂O or higher. These conventional devices sometimes have extreme variations in continuous positive airway pressures, greater than the elasticity of the lung.

25 **[0031]** In contrast, in accordance with some embodiments of the present invention, a ventilation interface system that uses the cannula 20 with the central reservoir 10 can provide the ventilation gas from the ventilation source to the nares at a lower velocity

thereby decreasing a drop in pressure and with improved laminar flow because the central reservoir 10 can hold an increased volume of air or gas. The resulting decrease in flow velocity decreases lateral pressure and in turn decreases the amount of moisture removed from the mucosal walls of a user, which increases the comfort of the user. Accordingly, the ventilation interface system consistent with the principles of the present invention may provide better comfort and functionality and may be more economical to produce over the conventional systems.

[0032] Referring now back to Figure 1, an exhaust port 14 may be provided with central reservoir 10. The exhaust port 14 provides an outlet of air or gas from central reservoir 10 and assists with optimizing the airflow through the cannula 20. For example, as shown in Figure 1, the exhaust port 14 may be positioned on the central reservoir 10 midway between the ventilation connectors 2. The cannula 20 may include a single exhaust port 14 with a substantially circular cross section.

[0033] Alternatively, the exhaust port 14 may be configured with a mechanism, such as a dial or valve, which increases or decreases the size of the internal diameter of the exhaust port 14 and varies the exhaust flow. This would enable various settings to be fitted to the various embodiments of the present invention.

[0034] As one non-limiting example, a doctor could prescribe a particular aperture setting to accommodate a particular patient's needs, thereby reducing the tendency for incoming pressure to overpower the elasticity of the lungs and prevent exhalation. For example, the mechanism may be helpful for CPAP users or other patients prescribed with excessive pressures ranging from 3 cmH₂O to 25 cm H₂O or higher. For some patients, the ranges may be from 5 cmH₂O to 20 cmH₂O, 8 cmH₂O to 15 cmH₂O or 10cmH₂O to 12cmH₂O.

[0035] In addition to treating sleep apnea, the mechanism may be integrated or removable from the cannula 20 and configured to facilitate flow of any type of gas that may be used in a dental office or hospital. For example, the cannula 20 may be fitted with a mechanism to allow for the administration of general anesthesia or other
5 type of gas, such as a local anesthetic gas.

[0036] Referring again back to Figure 1, the cannula 20 may also include the connection portion 18, which provides a coupling structure for nasal insert 6. For example, connection portion 18 may be configured to allow for removable nasal inserts, such as nasal insert 6. Nasal insert 6 may, for example, be removable and
10 replaceable for cleaning or may come in different sizes.

[0037] In addition, connection portion 18 may provide a structure for attaching other components to the cannula 20, such as a flange, connector, or loop for a strap or headgear.

[0038] Referring now to Figure 2, a front side view is shown of an exemplary
15 embodiment of the cannula 20. In addition to the components previously described with reference to Figure 1, an exhaust flange 12 is now illustrated. As shown, the exhaust flange 12 extends from the central reservoir 10 and leads to the exhaust port 14. Figure 2 also shows that the exhaust flange 12 and the exhaust port 14 may be positioned at a midpoint between the ventilation connectors 2. Of course other
20 positions for the exhaust flange 12 and the exhaust port 14 may be used.

[0039] The exhaust flange 12 and exhaust port 14 may be configured to smooth the transition of air releasing out of the central reservoir 10. For example, as shown in Figure 2, the exhaust flange 12 may have a decreasing circumference as it extends to exhaust port 14.

[0040] Referring now to Figures 3, 4, and 5, different views are shown of an exemplary embodiment of the cannula 20. In particular, Figure 3 shows a side view of the cannula 20 and illustrates the general shapes of connectors 2, reservoir flange 4, the nasal insert 6, and the seal portion 8. Figure 4 shows a bottom view of the cannula
5 20 and illustrates the general shapes and locations of the connectors 2, the central reservoir 10, and the exhaust port 14. Figure 5 shows a top view of the cannula 20 and illustrates the general shape and arrangement of the connectors 2, nasal insert 6, and the seal portion 8.

[0041] Figure 6 illustrates a cross-sectional view taken from line I-I in Figure 5 and
10 the general paths of flow through the cannula 20. For example, a first inflow portion 24 may begin in the cannula 20 from a ventilation source (not shown). The reservoir flange 4 forms a second inflow portion 26 which leads to nasal insert 6. Nasal insert 6 then forms a third inflow portion 28, which eventually leads into the nasal passages of the user.

[0042] During exhalation by the user, the nasal insert 6 forms a first outflow portion
15 30. The central reservoir 10 then forms a second outflow portion 32. As noted above, the central reservoir 10 may be shaped and configured such that the velocity of outflow portion 32 may be reduced without substantially affecting the pressure of the inflow portions or outflow portions. The exhaust flange 12 then forms a third outflow
20 portion 34. The exhaust port 14 is configured and shaped to form a fourth outflow portion 36 and a fifth outflow portion 38. The fifth outflow portion 38 is then expelled out of exhaust port 14.

[0043] The exhaust port 14, the nasal insert 6, and the central reservoir 10 may be configured to allow for improved laminar flow by flow portions 24, 26, 28, 30, 32,
25 and 34. In particular, the volume of the central reservoir 10 creates room for the gas

and decreases the flow velocity of these flow portions and decreases the pressure drop. This decrease in flow velocity reduces any dryness and irritation that a user may otherwise have as a result of higher flow velocities which increase the venturi effect along the nasal mucosa membrane. The cannula 20 will increase the desired amount of pressure that prevents the apneas by increasing the number of air molecules.

Additionally, the central reservoir 10 may allow for more laminar flow between the inflow portions 24, 26, and 28 and the outflow portions 30, 32, 34, and 36.. The central reservoir 10 further reduce the likelihood of any tornadic activity between the second inflow portion 26 and second 32 and third 34 outflow portions.

[0044] Furthermore, the exhaust flange 12 and the exhaust port 14 may be shaped and configured to optimize a venturi or similar effect between the third 36 and fourth outflow 38 portions. In particular, the exhaust flange 12 at its top surface 40 may have a certain diameter that decreases as it extends to the exhaust port 14. This narrowing of the exhaust flange 12 and exhaust port 14 may cause a venture effect as outflow portion 36 is expelled into outflow portion 38. As described above, the exhaust port 14 may also include a mechanism, such as an adjustable dial or valve, that adjusts the aperture of the exhaust port 14.

[0045] Figure 7 shows an elevated front left view of another exemplary embodiment of the cannula 20. In particular, in addition to the components shown in Figures 1-5, the cannula 20 may also include at least one headgear flange 16. As previously described, the cannula 20 may be held in place by headgear (not shown), which is attached to the U-shaped headgear connector 16. The headgear flange 16 may be attached to an exterior portion of the cannula 20, such as at the connection portion 18. Headgear (not shown) may attach to the headgear flange 16 and/or connection portion 18 via velcro®, snap, button, latch, loop or any other conventional connecting means.

[0046] Numerous additional modifications and variations of the exemplary embodiment of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, exemplary embodiments of the present invention may be practiced otherwise than as specifically described herein.

5

WHAT IS CLAIMED IS:

1. A nasal ventilation interface comprising:
a cannula connectable to a source of ventilation gas via at least two ventilation connectors;
5 at least one reservoir flange coupled to the ventilation connectors and in close proximity with at least one nasal insert;
at least one seal portion positioned on a distal end of the at least one nasal insert;
a central reservoir between the at least one reservoir flange and the nasal
10 insert;
at least one exhaust flange coupled to the central reservoir; and
an exhaust port coupled to the exhaust flange positioned at a midpoint between the at least two ventilation connectors.
2. The ventilation interface according to claim 1, wherein the exhaust port is
15 configured with an adjustable dial to adjust the aperture of the exhaust port.
3. The ventilation interface according to claim 1, wherein the exhaust port has a decreasing circumference from a proximal portion towards a distal end of the exhaust port.
4. The ventilation interface according to claim 3, wherein an interior wall of
20 the exhaust port maintains a substantially constant diameter.
5. The ventilation interface according to claim 1, further comprising at least one headgear flange.
6. The ventilation interface according to claim 5, wherein the at least one headgear flange is connected a flanged on the outer wall of the cannula.

7. The ventilation interface according to claim 6, wherein the headgear flange is substantially U-shaped.

8. The ventilation interface according to claim 1, wherein at least one of the reservoir flange, nasal insert, and central reservoir are configured to provide laminar
5 flow.

9. The ventilation interface according to claim 1 wherein the exhaust port has a substantially circular cross section.

10. The ventilation interface according to claim 1 wherein the seal portion has a substantially oval cross section.

10 11. The ventilation interface according to claim 1 wherein the seal portion is configured to receive a skirt to prevent leakage.

12. The nasal ventilation interface according to claim 1 further comprising:
means for adjusting an aperture of the exhaust port.

13. The nasal ventilation interface according to claim 1 further comprising:
15 a cannula with means for providing improved laminar flow between at least one of a second inflow portion, a third inflow portion, a first outflow portion, a second outflow portion and a third outflow portion.

14. The nasal ventilation interface according to claim 1 further comprising:
means for slowing the inflowing air velocity decreasing a drop in pressure by
20 allowing additional air molecules to enter the central reservoir while driven by a same pressure setting.

15. A nasal ventilation interface comprising:

a cannula connectable to a source of ventilation gas via at least two ventilation connectors forming a first inflow portion;

a reservoir flange forming a second inflow portion;

5 at least one nasal insert, the at least one nasal insert forming a third inflow portion and a first outflow portion;

at least one seal portion positioned on a distal end of the at least one nasal insert;

a central reservoir forming a second outflow portion;

10 at least one exhaust flange forming a third outflow portion; and

an exhaust port positioned at a midpoint between the at least two ventilation connectors forming a fourth outflow portion and a fifth outflow portion.

16. The ventilation interface according to claim 15, wherein the exhaust port is configured with an adjustable dial to adjust the aperture of the exhaust port.

15 17. The ventilation interface according to claim 15, wherein the exhaust port has a decreasing circumference from a proximal portion towards a distal end of the exhaust port.

18. The ventilation interface according to claim 17, wherein an interior wall of the exhaust port maintains a substantially constant diameter.

20 19. The ventilation interface according to claim 15, further comprising at least one headgear flange.

20. The ventilation interface according to claim 19, wherein the at least one headgear flange is connected to the reservoir outer wall.

25 21. The ventilation interface according to claim 20, wherein the headgear flange is substantially U-shaped.

22. The ventilation interface according to claim 15, wherein at least one of the reservoir flange, nasal insert, and central reservoir are configured to provide laminar flow.

23. The ventilation interface according to claim 15 wherein the exhaust port
5 has a substantially circular cross section.

24. The ventilation interface according to claim 15 wherein the seal portion has a substantially oval cross section.

25. The ventilation interface according to claim 15 wherein the seal portion is configured to receive a skirt to prevent leakage.

10 26. The nasal ventilation interface according to claim 15 further comprising: means for adjusting an aperture of the exhaust port.

27. The nasal ventilation interface according to claim 15 further comprising: a cannula with means for providing improved laminar flow between at least one of a second inflow portion, a third inflow portion, a first outflow portion, a second outflow
15 portion and a third outflow portion.

28. The nasal ventilation interface according to claim 15 further comprising: means for slowing the inflowing air velocity without a drop in pressure by allowing additional air molecules to enter the central reservoir.

29. The nasal ventilation interface according to claim 15 wherein the at least
20 one nasal insert are removable.

30. The nasal ventilation interface according to claim 15 wherein the at least one nasal insert and seal portion create a seal with at least one naris.

31. The nasal ventilation interface according to claim 15 wherein the at least one nasal insert and seal portion create a seal in at least one naris with a slight
25 expansion of the seal portion by a positive airway pressure.

32. The nasal ventilation interface according to claim 15 wherein the at least one nasal insert and seal portion are held in at least one naris by a headgear.

33. A ventilation interface system, comprising:

a source of ventilation gas;

5 a connector having at least one branch that is coupled to the source of ventilation gas; and

a cannula that is connectable to the source of ventilation gas via another branch of the y-connector, wherein the cannula comprises a headgear flange that is engageable with a piece of headgear, at least two ventilation connectors forming a
10 first inflow portion, a reservoir flange forming the first inflow portion into a second inflow portion, at least one nasal insert, the at least one nasal insert forming the second inflow portion into a third inflow portion and providing a path for a first outflow portion, a seal portion positioned on a distal end of the at least one nasal insert, a central reservoir forming the first outflow portion into a second
15 outflow portion, at least one exhaust flange forming the second outflow portion into a third outflow portion, and an exhaust port coupled to the central reservoir and positioned at a midpoint between the at least two ventilation connectors for forming the third outflow portion into the fourth outflow portion and forming the fourth outflow portion into a fifth outflow portion.

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FIG. 1

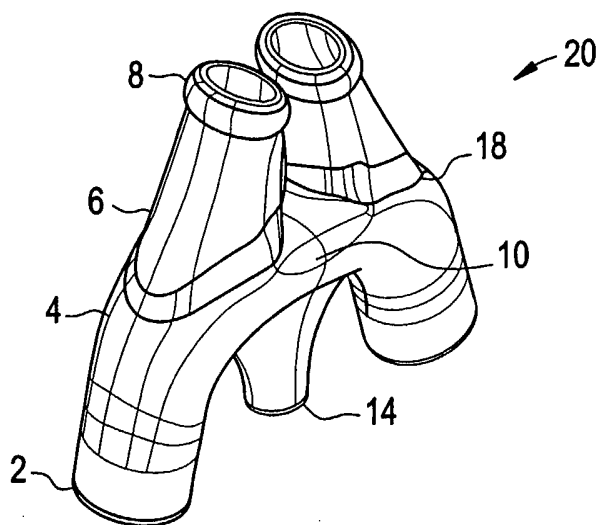


FIG. 2

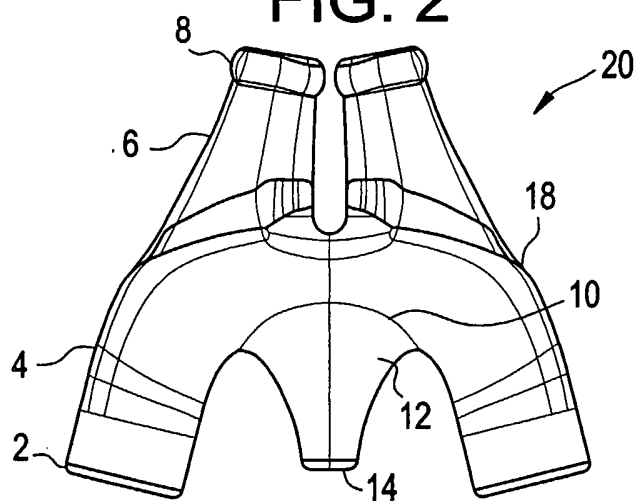
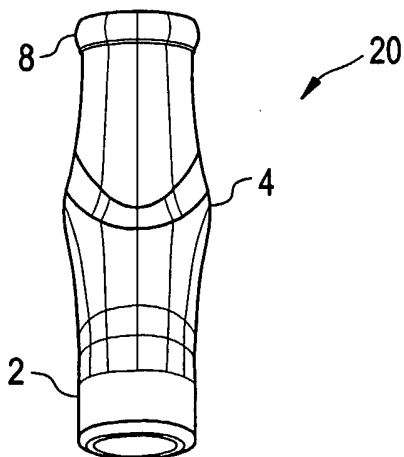


FIG. 3



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FIG. 4

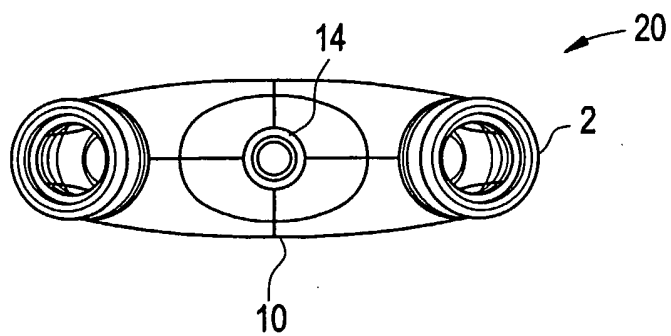
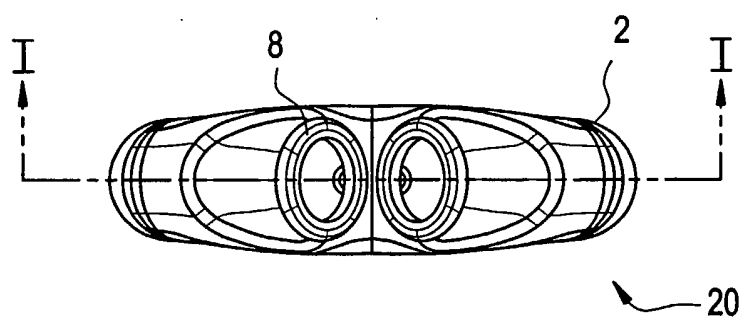


FIG. 5



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FIG. 6

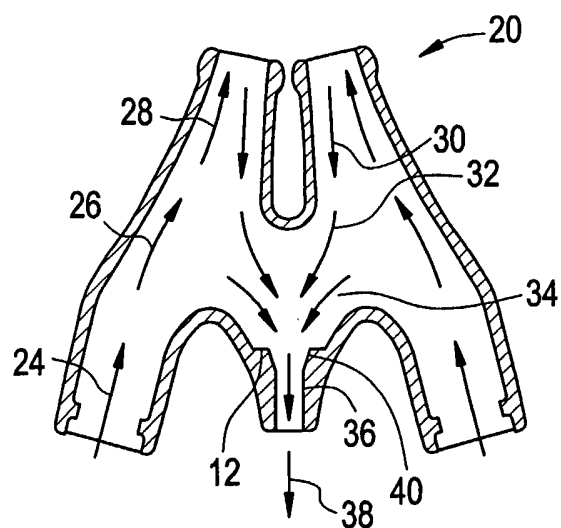


FIG. 7

