

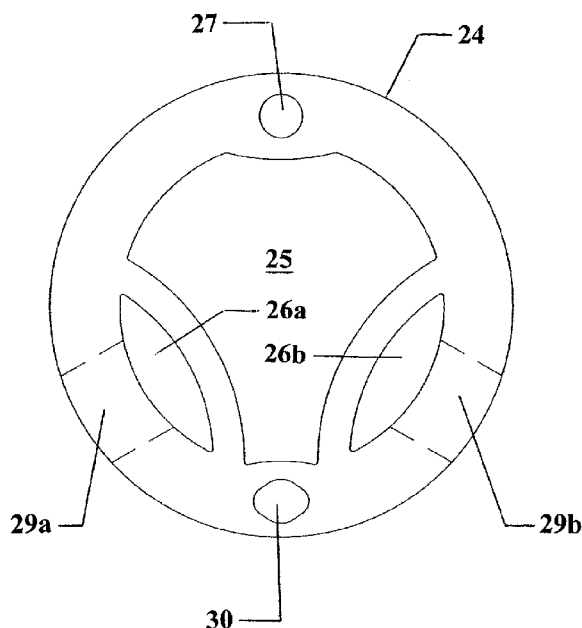


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- (71) Applicant (for all designated States except US): **C. R. BARD, INC.** [US/US]; 730 Central Avenue, Murray Hill, NJ 07974 (US).
- (72) Inventor; and
- (75) Inventor/Applicant (for US only): **TERRY, Richard** [US/US]; 1728 Little Brook Drive, Conyers, GA 30094 (US).
- (74) Agent: **WIGHT, Todd, W.**; Rutan & Tucker LLP, 611 Anton Boulevard, Suite 1400, Costa Mesa, CA 92626 (US).
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[Continued on next page]

(54) Title: ENDOTRACHEAL TUBE HAVING ONE OR MORE ANGULARLY OFFSET SUCTION APERTURES AND METHOD OF MAKING AND/OR USING THE SAME

FIG. 6



(57) Abstract: An endotracheal tube including a main tube with a proximal end and a distal end. An inflatable cuff is arranged on the main tube. The inflatable cuff includes a base and angled sides and is configured to generally match an anatomical shape of a trachea. At least one suction aperture is arranged in an area that is adjacent a proximal end of the cuff. At least one of the at least one suction aperture is angularly offset with respect to a plane passing through a center axis of the main tube when the main tube is bent in use configuration and the at least one suction aperture is angularly offset with respect to a plane passing through a center axis of the cuff and being perpendicular to the base of the cuff.

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ENDOTRACHEAL TUBE HAVING ONE OR MORE ANGULARLY OFFSET SUCTION APERTURES AND METHOD OF MAKING AND/OR USING THE SAME

PRIORITY

[0001] This application claims the benefit of priority to U.S. Provisional Patent Application No. 61/425,593, filed December 21, 2010, which is incorporated by reference in its entirety into this application.

BACKGROUND OF THE INVENTION

Field of Invention

[0002] The invention relates generally to the field of medical devices, e.g., a medical tube, e.g., an endotracheal tube (ET), including an inflatable cuff. According to various embodiments, the endotracheal tube utilizes the novel way of suctioning secretions from the trachea while minimizing the possibility of direct suctioning of the tracheal mucosa.

Discussion of Background Information

[0003] Conventional methods of endotracheal intubation involve the insertion of a tubular device, e.g., an endotracheal tube, into the trachea. The endotracheal tube typically passes through the trachea and terminates above the carina, allowing gases to be directed through the tube and into the lungs.

[0004] A primary objective of this type of treatment is the mechanical ventilation of a patient's lungs, which may be required or appropriate due to the subject's medical condition. In order to create the air pressure necessary to artificially ventilate the lungs, the passageways around the tube are typically sealed, which may be accomplished, e.g., using the inflatable cuff. The cuff is typically located within the trachea about 3-5 centimeters above the carina and is then inflated to expand and seal against the wall of the trachea. This prevents gases from being pumped into the lungs from backing up around the tube.

[0005] Although cuffed endotracheal tubes perform an important service, they can allow secretions to collect proximate the cuff and provide a site for the possible accumulation of pathogens. Various methods have been devised for removing such secretions. For example, a small opening may be provided above the cuff with an associated suction lumen.

Fluids and/or solids (e.g., secretions) can be periodically or continuously removed through the opening and lumen by suction.

[0006] It is also known that cuffed endotracheal tubes often do not self-center within the trachea upon inflation of the cuff. As a result, the suction openings of a particular tube may not be spaced apart from the tracheal wall. For example, due to the curvature of the tube and/or other factors, the suction opening may be located very near the tracheal wall upon cuff inflation. In some instances, the suction opening may actually contact the tracheal wall. In such situations, the tracheal wall membrane may be drawn into the suction opening upon application of a vacuum, thereby occluding the opening. This may prevent the proper removal of secretions from the subglottic space and/or may cause trauma to the tracheal wall.

[0007] Known endotracheal tubes also incorporate pigtail tubing to connect the cuff inflation lumen to an inflation syringe and a suction lumen to deliver suctioning into the trachea from a suction source. These pigtails typically separate from the main tube at a point below where the main tube is typically cut to fit a particular patient. While the pigtail for cuff inflation is small, the pigtail for suctioning is larger and can cause space issues within the limited space of the patient oral cavity. This is especially the case during, e.g., oral care and inspections.

[0008] With current endotracheal tubes, especially those for continuous aspiration of subglottic secretions (i.e., “CASS” type tubes), the suction aperture is placed on the outer edge or side of the main tube curvature. One example is shown in FIGS. 1 and 2 which illustrates an endotracheal tube **1** having a proximal end **2**, a distal end **3**, a main tube **4**, a connector **C** for interfacing with a respiration source, an inflation lumen **7**, a cuff **8**, a suction aperture **9**, and a radiopaque stripe **10**. An inflation device **ID** (or connector for connecting to the same) is used to cause inflation of the cuff **8** by passing a gas through a tube **T** and into the main tube **4**. A suction device **SD** (or connector for connecting to the same) is used to create suction at the suction aperture **9** by allowing gas to pass through an inflation lumen of the tube **4** from the suction aperture **9**. The generally triangularly-shaped cuff **8** includes a proximal end **PE**, a distal end **DE**, a base **BS**, a top side **TS**, and angled sides **S1** and **S2**. As is evident in FIG. 2, the cuff **8** also has curved corners **C1** and **C2** transitioning between the base **BS** and the angled sides **S1** and **S2**. The suction aperture **9** is typically arranged about 8 mm away from the cuff **8** (measured along the axis of the main tube **4**) in order to avoid the portion of the cuff **8** that is glued to the main tube **4**. In this position, the suction aperture **9** is

typically positioned where it will be at the lowest point within the trachea (when the patient is inclined). Because of this position of the suction aperture **9**, it is possible that suction can be applied directly onto the tracheal mucosa wall. This can cause damage to the trachea and cause prolapse of the tissue into the suction aperture. This can, in turn, cause plugging of the suction aperture **9**, and thereby prevent suctioning of the secretions or aspirates. In such endotracheal tubes, the suction aperture **9** is thus arranged at about the six o'clock position (see FIG. 2) relative to the plane of curvature of the main tube **4** and/or relative to a plane that is perpendicular to the base of the triangular shape of the trachea or the base **BS** correspondingly shaped cuff **8**. As a result, the suction aperture **9** points directly to a center area of the base **BS** of the generally triangular-shaped cuff **8**.

[0009] Other examples of devices which utilize anatomically shaped cuffs which generally correspond to a generally triangularly-shaped trachea and/or which arranged the suction opening at the six o'clock position include US 7,089,942 to GREY, US 6,722,368 to SHAIKAH, and US 2009/0038620 to EFRATI, each of which is expressly incorporated by reference in its entirety into this application.

[00010] It would be beneficial to have an endotracheal tube having a suction aperture that is placed or oriented off to one side of the main tube so as to reduce the likelihood of direct suctioning of the tracheal mucosa. In this new position, the suction aperture(s) would have the dual advantage of being less likely to directly suction the tracheal wall and could suction the secretions which accumulate or pool in the corners of the generally triangularly-shaped trachea.

SUMMARY OF THE INVENTION

[00011] According to one non-limiting embodiment of the invention, there is provided a endotracheal tube utilizing a novel way of suctioning secretions from the trachea while minimizing the possibility of direct suctioning of the tracheal mucosa and which overcomes one or more of the deficiencies noted above.

[00012] In embodiments, the invention can utilize conventional cuffs of the type shown in FIG. 2 and/or of the type disclosed in US 7,089,942 to GREY, US 6,722,368 to SHAIKAH, and US 2009/0038620 to EFRATI.

[00013] In embodiments, the invention can utilize ET tubes, as well as any features thereof, of the type disclosed in three concurrently filed PCT applications, claiming the benefit of priority, respectively, to the following: 1) U.S. Provisional Patent Application No. 61/425,584, filed December 21, 2010 with the title “ENDOTRACHEAL TUBE HAVING A RECESSED CUFF, ONE OR MORE SUCTION APERTURES ARRANGED THEREIN, AND/OR A CUFF HAVING STIFFENERS AND METHOD OF MAKING AND/OR USING THE SAME;” 2) U.S. Provisional Patent Application No. 61/425,589, filed December 21, 2010 with the title “ENDOTRACHEAL TUBE HAVING A RECESSED CUFF AND/OR ONE OR MORE SUCTION APERTURES ARRANGED IN A CUFF RECESS AND METHOD OF MAKING AND/OR USING THE SAME;” and 3) U.S. Provisional Patent Application No. 61/425,599, filed December 21, 2010 with the title “ENDOTRACHEAL TUBE HAVING A CUFF ELASTICALLY EXPANDABLE AND NON-ELASTICALLY EXPANDABLE PORTIONS AND METHOD OF MAKING AND/OR USING THE SAME.” The disclosure of each of these documents is expressly incorporated by reference in its entirety into this application.

[00014] The invention takes advantage of the generally triangular shape of the trachea by arranging the suction aperture in an angularly offset position relative to the plane of curvature of the main tube and/or relative to a plane that is perpendicular to the base of the triangular shape of the trachea or the correspondingly shaped cuff. In embodiments, the suction aperture(s) is angularly offset from the plane or from the six o'clock position and oriented more towards the corners of the triangular shaped cuff. Non-limiting embodiments utilize an angle of up to about 30 degrees to one or both sides.

[00015] According to one non-limiting embodiment of the invention, there is provided an endotracheal tube comprising a main tube comprising a proximal end and a distal end and an inflatable cuff arranged on the main tube. The inflatable cuff comprises a base and angled sides and is configured to generally match an anatomical shape of a trachea. At least one suction aperture is arranged in an area that is adjacent a proximal end of the cuff. At least one of the at least one suction aperture is angularly offset with respect to a plane passing through a center axis of the main tube when the main tube is bent in use configuration and the at least one suction aperture is angularly offset with respect to a plane passing through a center axis of the cuff and being perpendicular to the base of the cuff.

[00016] The inflatable cuff may have a generally triangular cross-section shape. The inflatable cuff may have a generally triangular cross-section shape with curved corners. The at least one suction aperture may be generally oriented toward one of the curved corners. The at least one suction aperture may have a center axis that intersects one of the curved corners formed between the base and one of the angled sides. The inflatable cuff may be arranged on the main tube and spaced from the distal end by an amount that is less than a spacing from the proximal end.

[00017] The main tube may comprise at least one integrally formed suction lumen which extends to the at least one suction aperture. The main tube may comprise at least one integrally formed inflation lumen which extends to at least one aperture for inflating the cuff. The at least one inflation lumen may be angularly offset from the plane. The main tube may comprise at least one radiopaque strip or stripe arranged in a wall of the main tube. The at least one radiopaque strip or stripe may be angularly offset from the plane.

[00018] The main tube may comprise at least one suction lumen that is angularly offset from the plane. The main tube may comprise at least one integrally formed suction lumen that is angularly offset from the plane. The main tube may comprise at least one non-circular suction lumen that is angularly offset from the plane. The main tube may comprise a generally circular cross-section shape.

[00019] The at least one suction aperture may form an angle of between about 20 degrees and about 70 degrees relative to the plane. The at least one suction aperture may form an angle of between about 30 degrees and about 60 degrees relative to the plane. The at least one suction aperture may form an angle of about 30 degrees relative to the plane. The at least one suction aperture may form an angle of about 40 degrees relative to the plane. The at least one suction aperture may form an angle of about 45 degrees relative to the plane.

[00020] The at least one suction aperture may comprise two angularly offset suction apertures. The main tube may comprise at least one suction lumen coupled to at least one of the two angularly offset suction apertures. The main tube may comprise at least one suction lumen coupled to each of the two angularly offset suction apertures. The main tube may comprise at least one integrally formed suction lumen coupled to each of the two angularly offset suction apertures. The main tube may comprise two suction lumens each coupled to one of the two angularly offset suction apertures. The main tube may comprise two integrally

formed suction lumens each coupled to one of the two angularly offset suction apertures. The main tube may comprise a generally circular cross-section shape. Each of the two suction apertures may form an angle of between about 20 degrees and about 70 degrees relative to the plane. The angle may be between about 30 degrees and about 60 degrees. The angle may be about 30 degrees. The angle may be about 40 degrees.

[00021] The at least one suction aperture may comprise two angularly offset suction apertures arranged on opposite sides of the plane and each being structured and arranged to suction secretions from different areas on the trachea. The inflatable cuff may have a generally triangular cross-section shape with curved corners. Each suction aperture may be generally oriented toward one of the curved corners. The main tube may comprise two integrally formed suction lumens each coupled to one of the two angularly offset suction apertures. The main tube may comprise a generally circular cross-section shape.

[00022] The main tube may comprise at least one integrally formed inflation lumen which extends to at least one aperture for inflating the cuff. The at least one inflation lumen may be generally oriented on the plane. The main tube may comprise at least one radiopaque strip or stripe arranged in a wall of the main tube. The at least one radiopaque strip or stripe may be generally oriented on the plane.

[00023] The invention also provides for a method for intubation using the endotracheal tube of the type described above, wherein the method comprises inserting at least a portion of an endotracheal tube into a trachea, inflating a cuff of the endotracheal tube, and supplying gas into a patient's lungs via the endotracheal tube.

[00024] The method may further comprise suctioning matter through the at least one suction aperture located adjacent the cuff.

[00025] The invention also provides for a method of making the endotracheal tube of the type described above, wherein the method comprises arranging a cuff on a main tube and arranging a position of at least one suction aperture relative to the cuff such that at least one of the at least one suction aperture is angularly offset with respect to a plane passing through a center axis of the main tube when the main tube is bent in use configuration and the at least one suction aperture is angularly offset with respect to a plane passing through a center axis of the cuff and being perpendicular to a base of the cuff.

[00026] The invention also provides for an endotracheal tube comprising a main tube comprising a proximal end and a distal end, a generally triangular cross-section shaped inflation cuff comprising a base, angled sides, and curved corners, whereby the inflatable cuff is configured to generally match an anatomical shape of a trachea, at least one suction aperture arranged adjacent the inflatable cuff and being generally oriented toward one of the curved corners. At least one of the at least one suction aperture is angularly offset with respect to a plane passing through a center axis of the main tube when the main tube is bent in use configuration, the at least one suction aperture is angularly offset with respect to a plane passing through a center axis of the cuff and being perpendicular to the base of the cuff, and the at least one suction aperture forms an angle of between about 20 degrees and about 70 degrees relative to a plane passing through a center axis of the main tube when the main tube is bent in use configuration.

[00027] The main tube may comprise at least one inflation lumen generally oriented on the plane. The main tube may comprise at least one radiopaque strip or stripe arranged in a wall of the main tube.

[00028] The invention also provides for an endotracheal tube comprising a main tube comprising a proximal end and a distal end, a generally triangular cross-section shaped inflation cuff comprising a base, angled sides, and curved corners, whereby the inflatable cuff is configured to generally match an anatomical shape of a trachea, at least one suction aperture arranged adjacent the inflatable cuff and being generally oriented toward one of the curved corners, and at least one suction lumen arranged in the main tube and extending to the at least one suction aperture. At least one of the at least one suction aperture is angularly offset with respect to a plane passing through a center axis of the main tube when the main tube is bent in use configuration, the at least one suction aperture is angularly offset with respect to a plane passing through a center axis of the cuff and being perpendicular to the base of the cuff, and the at least one suction aperture forms an angle of between about 20 degrees and about 70 degrees relative to a plane passing through a center axis of the main tube when the main tube is bent in use configuration.

[00029] The main tube may comprise at least one integrally formed inflation lumen and at least one radiopaque strip or stripe arranged in a wall of the main tube.

BRIEF DESCRIPTION OF DRAWINGS OF THE EXEMPLARY EMBODIMENTS

[00030] The present invention is further described in the detailed description which follows, in reference to the noted plurality of drawings by way of non-limiting examples of exemplary embodiments of the present invention, in which like reference numerals represent similar parts throughout the several views of the drawings, and wherein:

[00031] FIG. 1 shows a side perspective view of endotracheal tube of the type conventionally used in intubation;

[00032] FIG. 2 shows a cross-section view of the main tube in FIG. 1 and facing the proximal end of the cuff so as to illustrate the generally triangularly-shaped configuration of the cuff;

[00033] FIG. 3 shows a cross-sectional view of a main tube of the invention and illustrates how the conventional main tube of FIG. 2 can be rotated so as to assume the position shown in FIG. 3;

[00034] FIG. 4 shows a view similar to that shown in FIG. 2, but utilizing the main tube shown in FIG. 3 in accordance with an exemplary embodiment of the invention;

[00035] FIG. 5 shows a side perspective view of an endotracheal tube using the main tube and cuff arrangement shown in FIGS. 3 and 4 in accordance with an exemplary embodiment of the invention;

[00036] FIG. 6 shows a cross-sectional view of another embodiment of a main tube in accordance with an exemplary embodiment of the invention;

[00037] FIG. 7 shows a view similar to that shown in FIG. 4, but utilizing the main tube shown in FIG. 6 in accordance with an exemplary embodiment of the invention;

[00038] FIG. 8 shows a view similar to that shown in FIG. 7, but utilizing another embodiment of the main tube in accordance with an exemplary embodiment of the invention;

[00039] FIG. 9 shows a view similar to that shown in FIG. 8, but utilizing another embodiment of the main tube in accordance with an exemplary embodiment of the invention;

[00040] FIG. 10 shows a view similar to that shown in FIG. 3, but utilizing another embodiment of the main tube in accordance with an exemplary embodiment of the invention;

[00041] FIG. 11 shows a view similar to that shown in FIG. 10, but utilizing another embodiment of the main tube in accordance with an exemplary embodiment of the invention;

[00042] FIG. 12 shows a view similar to that shown in FIG. 10, but utilizing another embodiment of the main tube in accordance with an exemplary embodiment of the invention; and

[00043] FIG. 13 shows a view similar to that shown in FIG. 12, but utilizing another embodiment of the main tube in accordance with an exemplary embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[00044] The following description should be read with reference to the drawings, in which like elements in different drawings are identically numbered. The drawings, which are not necessarily to scale, depict selected embodiments and are not intended to limit the scope of the invention. The detailed description illustrates by way of example, not by way of limitation, the principles of the invention. This description will enable one skilled in the art to make and use the invention, and describes several embodiments, adaptations, variations, alternatives and uses of the invention, including what is presently believed to be the best mode of carrying out the invention.

[00045] As used herein, the reference terms "proximal" and "distal" (proximal being closer than distal) refer to proximity with respect to a health care professional inserting the endotracheal tube into a patient. For example, the region or section of the endotracheal tube that is closest to the health care professional during insertion is referred to herein as "proximal," while a region or section of the endotracheal tube closest to the patient's lungs is referred to as "distal."

[00046] FIGS. 3-13 show non-limiting or exemplary embodiments of the invention wherein like numbers refer to same and like parts. The present invention broadly relates to medical tubes (e.g., endotracheal, tracheostomy, or oropharyngeal tubes or other tubes or catheters) adapted to be intubated into one or more passageways (e.g., the trachea and/or pharynx) of a patient, subject or user in connection with a medical procedure. For example, certain embodiments are directed toward endotracheal tubes inserted into a subject's trachea

to facilitate mechanical ventilation of the lungs. Certain embodiments include tubes having an improved configuration for periodic removal of fluids and/or solids that collect adjacent an inflatable cuff used to seal, secure, and/or position the tube against the tracheal wall. The endotracheal tube of the invention, in embodiments, includes at least one suction aperture arranged in an offset position and/or located as described herein which advantageously suctions secretions from the trachea while minimizing the possibility of direct suctioning of the tracheal mucosa. As used throughout this document, the terms "subject", "patient" or "user" may include any human or other animal.

[00047] With reference to FIGS. 3-5, there is shown one non-limiting embodiment of an endotracheal tube **11** in accordance with the invention. Like the embodiment shown in FIGS. 1-2, the embodiment of FIGS. 3-5 has a proximal end **12**, a distal end **13**, a main tube **14**, a connector **C** for interfacing with a respiration source, an inflation lumen **17**, a cuff **18**, a suction aperture **19**, and a radiopaque stripe **20**. An inflation device is used to cause inflation of the cuff **18** by passing a gas through a tube and into the main tube **14**. The generally triangular-shaped cuff **18** includes a proximal end, a distal end, a base **BS**, a top side, and angled sides **S1** and **S2**. As is evident in FIG. 4, the cuff **18** also has curved corners transitioning between the base **BS** and the angled sides **S1** and **S2**.

[00048] The embodiment of FIGS. 3-5 is thus substantially similar to that shown in FIGS. 1-2 except that the main tube **14** is, in embodiments, rotated to the angle "B" (see FIG. 4). As a result, a center axis of the suction aperture **19** is oriented (and/or rotated) more towards one of the corners of the generally triangular-shaped cuff **18** relative to a vertical plane or the plane passing through the center axis of the main tube **14**, when the main tube **14** is bent into the shape shown in FIG. 5. By way of non-limiting example, the angle "B" can be between about 20 degrees and about 70 degrees, and can be, in embodiments, between about 30 degrees and about 60 degrees. In embodiments, the angle "B" can, in particular, be between about 30 degrees and 45 degrees, and most particularly, can be about 30 degrees.

[00049] As is apparent from FIGS. 3 and 4, the suction lumen **16** and inflation lumen **17** can also be oriented in the same way as the suction aperture **19**. In embodiments, the radiopaque stripe **20** is oriented by a substantially similar angle relative to the three o'clock position shown in FIG. 2.

[00050] In embodiments, the main tube **14** can be a one-piece member whereby the suction lumen **16** and the inflation lumen **17**, also optionally the radiopaque stripe **20**, are integrally formed therewith. By way of non-limiting example, the main tube **14** can be made of any medical grade plastic and can be generally circular in cross-section shape. Alternatively, the main tube **14** can have other shapes such as oval (not shown). In embodiments, the ventilation lumen **15** can be generally non-circular in cross-section shape. Alternatively, the ventilation lumen **15** can have other shapes. In embodiments, the suction lumen **16** can be generally oval in cross-section shape. Alternatively, the suction lumen **16** can have other shapes such as circular (see e.g., FIG. 8). In embodiments, the inflation lumen **17** can be generally circular in cross-section shape. Alternatively, the inflation lumen **17** can have other shapes.

[00051] In embodiments, the suction aperture **19** can be arranged about 8 mm away from the cuff **18** in order to avoid the portion of the cuff **18** that is glued to the main tube **14** (see FIG. 5). In this and other embodiments discussed herein, other distances can also be utilized provided they function to remove secretions and do not otherwise interfere with the proper functioning or use of the cuff **18**. In this position, the suction aperture **19** is positioned angularly offset from where it will be at the lowest point within the trachea (when the patient is inclined). Because of this position of the suction aperture **19**, it is less likely that suction can be applied directly onto the tracheal mucosa wall. With this angularly offset arrangement of the suction aperture **19**, there is a lower possibility of causing damage to the trachea and prolapse of the tissue into the suction aperture **19**. Furthermore, because of the angularly offset arrangement of the suction aperture **19**, there is a lower likelihood of plugging of the suction aperture **19**, which, in turn, ensures that suctioning of the secretions or aspirates can continue even if the main tube **14** is in contact with the trachea. The arrangement of FIGS. 3-5 also advantageously allows suction of the secretions which accumulate or pool in a corner of the generally triangularly-shaped trachea.

[00052] In the embodiment of FIGS. 3-5, the suction aperture **19** is thus arranged at about the seven o'clock position instead of the six o'clock position shown in FIG. 2. In embodiments, the suction aperture **19** can also be arranged at about the eight o'clock position instead of the six o'clock position shown in FIG. 2. In other embodiments, the suction aperture **19** can also be arranged between about the seven and about the eight o'clock positions, instead of the six o'clock position shown in FIG. 2. As a result, the suction

aperture **19** does not point directly to a center area of the base **BS** of the generally triangular-shaped cuff **18** (as in FIG. 2) and instead points more toward one of the corners of the generally triangular-shaped cuff **18** (see FIG. 4).

[00053] The embodiment of FIGS. 6-7 is similar to that shown in FIGS. 3-5 except that the main tube **24** utilizes, in embodiments, two angularly offset suction apertures **29a** and **29b** (oriented similar to the angle “B” in FIG. 4). As a result, a center axis of each suction aperture **29a** and **29b** is oriented (and/or rotated) more towards one of the corners of the generally triangular-shaped cuff **28** relative to a vertical plane or the plane passing through the center axis of the main tube **24**, when the main tube **24** is bent into the shape shown in, e.g., FIGS. 2 or 5. By way of non-limiting example, the angle can be between about 20 degrees and about 70 degrees, and can be, in embodiments, between about 30 degrees and about 60 degrees. In embodiments, the angle can, in particular, be between about 30 degrees and 45 degrees, and most particularly, can be about 30 degrees.

[00054] As is apparent from FIGS. 6 and 7, the suction lumens **26a** and **26b** can be oriented or arranged at the same angle as the suction apertures **29a** and **29b** relative to the plane or vertical axis. The inflation lumen **27** can be oriented or arranged on the plane or vertical axis. In embodiments, the radiopaque stripe **30** is similarly oriented on the plane or six o'clock position as shown FIG. 7.

[00055] In embodiments, the main tube **24** can be a one-piece member whereby the suction lumens **26a** and **26b** and the inflation lumen **27**, also optionally the radiopaque stripe **30**, are integrally formed therewith. By way of non-limiting example, the main tube **24** can be made of any medical grade plastic and can be generally circular in cross-section shape. Alternatively, the main tube **24** can have other shapes such as oval (not shown). In embodiments, the ventilation lumen **25** can be generally non-circular in cross-section shape. Alternatively, the ventilation lumen **25** can have other shapes. In embodiments, the suction lumens **26a** and **26b** can be generally oval in cross-section shape. Alternatively, the suction lumens **26a** and **26b** can have other shapes such as circular (see e.g., FIG. 9). In embodiments, the inflation lumen **27** can be generally circular in cross-section shape. Alternatively, the inflation lumen **27** can have other shapes.

[00056] In embodiments, the suction apertures **29a** and **29b** can be arranged about 8 mm away from the cuff **28** in order to avoid the portion of the cuff **28** that is glued to the

main tube **24**. In this position, both suction apertures **29a** and **29b** are positioned angularly offset from where it will be at the lowest point within the trachea (when the patient is inclined). In embodiments, both suction apertures **29a** and **29b** are angularly offset by substantially the same amount or angle. As in the previous embodiment, because of this position of the suction apertures **29a** and **29b**, it is less likely that suction can be applied directly onto the tracheal mucosa wall. With this angularly offset arrangement of the suction apertures **29a** and **29b**, there is a lower possibility of causing damage to the trachea and prolapse of the tissue into the suction apertures **29a** and **29b**. Furthermore, because of the angularly offset arrangement of the suction apertures **29a** and **29b**, there is a lower likelihood of plugging of the suction apertures **29a** and **29b**, which, in turn, ensures that suctioning of the secretions or aspirates can continue even if the main tube **24** is in contact with the trachea. The arrangement of FIGS. 6-7 also advantageously allows suction of the secretions which accumulate or pool in both corners of the generally triangular-shaped trachea.

[00057] In the embodiment of FIGS. 6-7, the suction apertures **29a** and **29b** are thus arranged at about the five and seven o'clock positions respectively instead of the six o'clock position shown in FIG. 2. In embodiments, the suction apertures **29a** and **29b** can also be arranged at about the four and eight o'clock positions respectively instead of the six o'clock position shown in FIG. 2. In other embodiments, the suction apertures **29a** and **29b** can also be arranged between about the four and about five o'clock positions and between about the seven and about the eight o'clock positions, instead of the six o'clock position shown in FIG. 2. As a result, each suction aperture **29a** and **29b** does not point directly to a center area of the base **BS** of the generally triangular-shaped cuff **28** (as in FIG. 2), and instead points more toward one of the corners of the generally triangular-shaped cuff **28** (see FIG. 7).

[00058] The embodiment of FIG. 8 is similar to that shown in FIGS. 3-5 in that the main tube **34** is, in embodiments, has a suction aperture angularly offset to the angle "B". As a result, a center axis of the suction aperture **39** is oriented (and/or rotated) more towards one of the corners of the generally triangular-shaped cuff **38** relative to a vertical plane or the plane passing through the center axis of the main tube **34**, when the main tube **34** is bent (i.e., into the shape shown in FIG. 5). By way of non-limiting example, the angle "B" can be between about 20 degrees and about 70 degrees, and can be, in embodiments, between about 30 degrees and about 60 degrees. In embodiments, the angle "B" can, in particular, be between about 30 degrees and 45 degrees, and most particularly, can be about 30 degrees.

[00059] As is apparent from FIG. 8, the suction lumen **36** can be oriented at the angle “B” while the inflation lumen **37** can be oriented along the plane of the vertical axis. In embodiments, the radiopaque stripe **40** is also oriented along the plane and/or at the six o’clock position shown in FIG. 8.

[00060] In embodiments, the main tube **34** can be a one-piece member whereby the inflation lumen **37**, also optionally the radiopaque stripe **40**, are integrally formed therewith. The suction lumen **36**, however, can be a separately formed member and/or can be formed with the main tube **34** and spaced apart from the main tube **34**. The suction lumen **36** extends to the suction aperture **39** and has a center axis which is generally parallel to an axis of the main tube **34**. By way of non-limiting example, the main tube **34** can be made of any medical grade plastic and can be generally circular in cross-section shape. Alternatively, the main tube **34** can have other shapes such as oval (not shown). In embodiments, the ventilation lumen **35** can be generally circular in cross-section shape. Alternatively, the ventilation lumen **35** can have other shapes. In embodiments, the suction lumen **36** can be generally circular in cross-section shape. Alternatively, the suction lumen **36** can have other shapes such as oval. In embodiments, the inflation lumen **37** can be generally circular in cross-section shape. Alternatively, the inflation lumen **37** can have other shapes.

[00061] In embodiments, and like previous embodiments, the suction aperture **39** can be arranged about 8 mm away from the cuff **38** in order to avoid the portion of the cuff **38** that is glued to the main tube **34**. In this position, the suction aperture **39** is positioned angularly offset from where it will be at the lowest point within the trachea (when the patient is inclined). Because of this position of the suction aperture **39**, it is less likely that suction can be applied directly onto the tracheal mucosa wall. With this angularly offset arrangement of the suction aperture **39**, there is a lower possibility of causing damage to the trachea and prolapse of the tissue into the suction aperture **39**. Furthermore, because of the angularly offset arrangement of the suction aperture **39**, there is a lower likelihood of plugging of the suction aperture **39**, which, in turn, ensures that suctioning of the secretions or aspirates can continue even if the main tube **34** is in contact with the trachea. The arrangement of FIG. 8, like that of FIGS. 3-5, also advantageously allows suction of the secretions which accumulate or pool in a corner of the generally triangularly-shaped trachea.

[00062] In the embodiment of FIG. 8, the suction aperture **39** is thus arranged at about the seven o’clock position instead of the six o’clock position shown in FIG. 2. In

embodiments, the suction aperture **39** can also be arranged at about the eight o'clock position instead of the six o'clock position shown in FIG. 2. In other embodiments, the suction aperture **39** can also be arranged between about the seven and about the eight o'clock positions, instead of the six o'clock position shown in FIG. 2. As a result, the suction aperture **39** does not point directly to a center area of the base **BS** of the generally triangular-shaped cuff **38** (as in FIG. 2) and instead points more toward one of the corners of the generally triangular-shaped cuff **38** (see FIG. 8).

[00063] The embodiment of FIG. 9 is similar to that shown in FIG. 8 in that the main tube **44** is, in embodiments, has a suction aperture **49a** that is angularly offset. However, this embodiment also utilizes another a suction aperture **49b** that is angularly offset. As a result, a center axis of each suction aperture **49a** and **49b** is oriented (and/or rotated) more towards one of the corners of the generally triangular-shaped cuff **48** relative to a vertical plane or the plane passing through the center axis of the main tube **44**, when the main tube **44** is bent (i.e., into the shape shown in FIG. 5). By way of non-limiting example, the angle of each side of the vertical plane or axis can be between about 20 degrees and about 70 degrees, and can be, in embodiments, between about 30 degrees and about 60 degrees. In embodiments, the angle can, in particular, be between about 30 degrees and 45 degrees, and most particularly, can be about 30 degrees.

[00064] As is apparent from FIG. 9, the suction lumens **46a** and **46b** can each be oriented at the same angle while the inflation lumen **47** can be oriented along the plane of the vertical axis. In embodiments, the radiopaque stripe **50** is also oriented along the plane and/or at the six o'clock position shown in FIG. 9.

[00065] In embodiments, the main tube **44** can be a one-piece member whereby the inflation lumen **47**, also optionally the radiopaque stripe **50**, are integrally formed therewith. The suction lumens **46a** and **46b**, however, can be separately formed members and/or can be formed with the main tube **44** and spaced apart from the main tube **44**. The suction lumens **46a** and **46b** respectively extend to the suction apertures **49a** and **49b** and each have a center axis which is generally parallel to an axis of the main tube **44**. By way of non-limiting example, the main tube **44** can be made of any medical grade plastic and can be generally circular in cross-section shape. Alternatively, the main tube **44** can have other shapes such as oval (not shown). In embodiments, the ventilation lumen **45** can be generally circular in cross-section shape. Alternatively, the ventilation lumen **45** can have other shapes. In

embodiments, the suction lumens **46a** and **46b** can each be generally circular in cross-section shape. Alternatively, the suction lumens **46a** and **46b** can have other shapes such as oval. In embodiments, the inflation lumen **47** can be generally circular in cross-section shape. Alternatively, the inflation lumen **47** can have other shapes.

[00066] In embodiments, and like previous embodiments, the suction apertures **49a** and **49b** can be arranged about 8 mm away from the cuff **48** in order to avoid the portion of the cuff **48** that is glued to the main tube **44**. In this position, the suction apertures **49a** and **49b** are each positioned angularly offset from where it will be at the lowest point within the trachea (when the patient is inclined). Because of this position of the suction apertures **49a** and **49b**, it is less likely that suction can be applied directly onto the tracheal mucosa wall. With this angularly offset arrangement of the suction apertures **49a** and **49b**, there is a lower possibility of causing damage to the trachea and prolapse of the tissue into the suction apertures **49a** and **49b**. Furthermore, because of the angularly offset arrangement of the suction apertures **49a** and **49b**, there is a lower likelihood of plugging of the suction apertures **49a** and **49b**, which, in turn, ensures that suctioning of the secretions or aspirates can continue even if the main tube **44** is in contact with the trachea. The arrangement of FIG. 9, like that of FIGS. 6-7, also advantageously allows suction of the secretions which accumulate or pool in the corners of the generally triangular-shaped trachea.

[00067] In the embodiment of FIG. 9, the suction apertures **49a** and **49b** are thus arranged at about the five and seven o'clock positions respectively instead of the six o'clock position shown in FIG. 2. In embodiments, the suction apertures **49a** and **49b** can also be arranged at about the four and eight o'clock positions respectively instead of the six o'clock position shown in FIG. 2. In other embodiments, the suction apertures **49a** and **49b** can also be arranged between about the four and about five o'clock positions and between about the seven and about the eight o'clock positions, instead of the six o'clock position shown in FIG. 2. As a result, each suction aperture **49a** and **49b** does not point directly to a center area of the base of the generally triangular-shaped cuff **48** (as in FIG. 2), and instead points more toward one of the corners of the generally triangular-shaped cuff **48**.

[00068] The embodiment of FIG. 10 is substantially similar to that shown in FIGS. 3-5 except that the main tube **54** utilizes, in embodiments, an enlarged suction lumen **56** and locates the inflation lumen **57** at about the twelve o'clock position while the radiopaque strip **60** is located at about the three o'clock position. Like the embodiment of FIGS. 3-5, this

embodiment utilizes an angularly offset suction aperture **59**. As a result, a center axis of the suction aperture **59** is oriented more towards one of the corners of the generally triangular-shaped cuff **58** relative to a vertical plane or the plane passing through the center axis of the main tube **54**, when the main tube **54** is bent. By way of non-limiting example, the angle can be between about 20 degrees and about 70 degrees, and can be, in embodiments, between about 30 degrees and about 60 degrees. In embodiments, the angle can, in particular, be between about 30 degrees and 45 degrees, and most particularly, can be about 30 degrees.

[00069] As is apparent from FIG. 10, the suction lumen **56** and inflation lumen **57** can be oriented so that their center axis is on the plane while the suction aperture **59** is angularly offset therefrom. In embodiments, the radiopaque stripe **60** is oriented at about the three o'clock position and/or at the same position as shown in FIG. 2.

[00070] In embodiments, the main tube **54** can be a one-piece member whereby the suction lumen **56** and the inflation lumen **57**, also optionally the radiopaque stripe **60**, are integrally formed therewith. By way of non-limiting example, the main tube **54** can be made of any medical grade plastic and can be generally circular in cross-section shape. Alternatively, the main tube **54** can have other shapes such as oval (not shown). In embodiments, the ventilation lumen **55** can be generally non-circular in cross-section shape. Alternatively, the ventilation lumen **55** can have other shapes. In embodiments, the suction lumen **56** can be generally C-shaped in cross-section shape. Alternatively, the suction lumen **56** can have other shapes. In embodiments, the inflation lumen **57** can be generally circular in cross-section shape. Alternatively, the inflation lumen **57** can have other shapes.

[00071] In embodiments, the suction aperture **59** can be arranged about 8 mm away from the cuff **58** in order to avoid the portion of the cuff **58** that is glued to the main tube **54**. As in previous embodiments, other distances can also be utilized provided they function to remove secretions and do not otherwise interfere with the proper functioning or use of the cuff **58**. In this position, the suction aperture **59** is positioned angularly offset from where it will be at the lowest point within the trachea (when the patient is inclined). Because of this position of the suction aperture **59**, it is less likely that suction can be applied directly onto the tracheal mucosa wall. With this angularly offset arrangement of the suction aperture **59**, there is a lower possibility of causing damage to the trachea and prolapse of the tissue into the suction aperture **59**. Furthermore, because of the angularly offset arrangement of the suction aperture **59**, there is a lower likelihood of plugging of the suction aperture **59**, which,

in turn, ensures that suctioning of the secretions or aspirates can continue even if the main tube **54** is in contact with the trachea. The arrangement of FIG. 10 also advantageously allows suctioning of the secretions which accumulate or pool in a corner of the generally triangularly-shaped trachea.

[00072] In the embodiment of FIG. 10, the suction aperture **59** is thus arranged at about the seven o'clock position instead of the six o'clock position shown in FIG. 2. In embodiments, the suction aperture **59** can also be arranged at about the eight o'clock position instead of the six o'clock position shown in FIG. 2. In other embodiments, the suction aperture **59** can also be arranged between about the seven and about the eight o'clock positions, instead of the six o'clock position shown in FIG. 2. As a result, the suction aperture **59** does not point directly to a center area of the base of the generally triangular-shaped cuff **58** (as in FIG. 2) and instead points more toward one of the corners of the generally triangular-shaped cuff **58**.

[00073] The embodiment of FIG. 11 is substantially similar to that shown in FIG. 10 except that the main tube **64** utilizes, in embodiments, two suction apertures **69a** and **69b** which are in communication with a single suction lumen **66**. The embodiment otherwise functions like the embodiments of FIGS. 6 and 9 described above.

[00074] The embodiment of FIG. 12 is substantially similar to that shown in FIG. 10 except that the main tube **74** utilizes, in embodiments, an radiopaque stripe **80** oriented at about the six o'clock position. The embodiment otherwise functions like the embodiments of FIG. 8 described above.

[00075] The embodiment of FIG. 13 is substantially similar to that shown in FIG. 11 except that the main tube **84** utilizes, in embodiments, a separating wall to define two separate suction lumens **86a** and **86b** and locates the radiopaque stripe **90** at about the six o'clock position. The embodiment otherwise functions like the embodiments of FIGS. 7 and 9 described above.

[00076] The main tube member may, in embodiments, be constructed from a suitable polymeric material, such as polyvinyl chloride, polyethylene or polypropylene, with PVC being advantageous. The components of the assembly disclosed herein can also be made from various well-known materials. The components the main tube can be molded or extruded according to well-known manufacturing techniques.

[00077] Materials commonly used to make the main tube member include, but are not limited to thermoplastic polymers and thermoplastic elastomers (TPE). In embodiments, materials which are environmentally green in nature and have no extractables can be utilized. Other materials include, but are not limited to natural rubber latexes (available, for example, from Guthrie, Inc., Tucson, Ariz.; Firestone, Inc., Akron, Ohio; and Centrotrade USA, Virginia Beach, Va.), silicones (available, for example, from GE Silicones, Waterford, N.Y., Wacker Silicones, Adrian, Mich.; and Dow Corning, Inc., Midland, Mich.), polyvinyl chlorides (available, for example, from Kaneka Corp., Inc., New York, N.Y.), polyurethanes (available, for example, from Bayer, Inc., Toronto, Ontario, Rohm & Haas Company, Philadelphia, Pa.; and Ortec, Inc., Greenville, S.C.), plastisols (available, for example, from G S Industries, Bassett, Va.), polyvinyl acetate, (available, for example from Acetex Corp., Vancouver, British Columbia) and methacrylate copolymers (available, for example, from Heveatex, Inc., Fall River, Mass.). Any combination of the foregoing materials may also be used in making ET tubes.

[00078] The invention also provides for a method for intubation using the assembly of FIGS. 3-13, which includes inserting at least a distal portion of the endotracheal tube into a trachea, inflating the cuff, and supplying gas into a patient's lungs via the endotracheal tube. The method can further include suctioning matter through the one or more angularly offset suction apertures located adjacent the cuff.

[00079] The invention also provides for a method of making a device for intubation shown FIGS. 3-13, and specifically making the at least one suction aperture of the main tube be angularly offset so as to be oriented more towards one of the corners of the substantially triangularly-shaped cuff than to a base thereof.

[00080] The invention has been described and specific examples of the invention have been portrayed. While the invention has been described in terms of particular variations and illustrative figures, those of ordinary skill in the art will recognize that the invention is not limited to the variations of figures described. In addition, where methods and steps described above indicate certain events occurring in certain order, those of ordinary skill in the art will recognize that the ordering of certain steps may be modified and that such modifications are in accordance with the variations of the invention. Additionally, certain of the steps may be performed concurrently in a parallel process when possible, as well as performed sequentially as described above. Therefore, to the extent there are variations of the invention, which are

within the spirit of the disclosure or equivalent to the inventions found in the claims, it is the intent that this patent will cover those variations as well. Finally, all publications and patent applications cited in this specification are herein incorporated by reference in their entirety as if each individual publication or patent application were specifically and individually put forth herein.

[00081] It is noted that the foregoing examples have been provided merely for the purpose of explanation and are in no way to be construed as limiting of the present invention. While the present invention has been described with reference to an exemplary embodiment, it is understood that the words which have been used herein are words of description and illustration, rather than words of limitation. Changes may be made, within the purview of the appended claims, as presently stated and as amended, without departing from the scope and spirit of the present invention in its aspects. Although the present invention has been described herein with reference to particular means, materials and embodiments, the present invention is not intended to be limited to the particulars disclosed herein; rather, the present invention extends to all functionally equivalent structures, methods and uses, such as are within the scope of the appended claims.

CLAIMS

What is claimed is:

1. An endotracheal tube, comprising:
a main tube including a proximal end and a distal end;
an inflatable cuff arranged on the main tube, the inflatable cuff including a base and angled sides, and configured to generally match an anatomical shape of a trachea; and
at least one suction aperture arranged in an area that is adjacent a proximal end of the cuff, wherein at least one of:
the at least one suction aperture is angularly offset with respect to a plane passing through a center axis of the main tube when the main tube is bent in use configuration; and
the at least one suction aperture is angularly offset with respect to a plane passing through a center axis of the cuff and being perpendicular to the base of the cuff.
2. The endotracheal tube of claim 1, wherein the inflatable cuff has a generally triangular cross-section shape.
3. The endotracheal tube of claim 1, wherein the inflatable cuff has a generally triangular cross-section shape with curved corners.
4. The endotracheal tube of claim 3, wherein the at least one suction aperture is generally oriented toward one of the curved corners.
5. The endotracheal tube of claim 3, wherein the at least one suction aperture has a center axis that intersects one of the curved corners formed between the base and one of the angled sides.
6. The endotracheal tube of claim 1, wherein the inflatable cuff is arranged on the main tube and spaced from the distal end by an amount that is less than a spacing from the proximal end.
7. The endotracheal tube of claim 1, wherein the main tube comprises at least one integrally formed suction lumen which extends to the at least one suction aperture.

8. The endotracheal tube of claim 1, wherein the main tube comprises at least one integrally formed inflation lumen which extends to at least one aperture for inflating the cuff.
9. The endotracheal tube of claim 8, wherein the at least one inflation lumen is angularly offset from the plane.
10. The endotracheal tube of claim 1, wherein the main tube comprises at least one radiopaque strip or stripe arranged in a wall of the main tube.
11. The endotracheal tube of claim 10, wherein the at least one radiopaque strip or stripe is angularly offset from the plane.
12. The endotracheal tube of claim 1, wherein the main tube comprises at least one suction lumen that is angularly offset from the plane.
13. The endotracheal tube of claim 1, wherein the main tube comprises at least one integrally formed suction lumen that is angularly offset from the plane.
14. The endotracheal tube of claim 1, wherein the main tube comprises at least one non-circular suction lumen that is angularly offset from the plane.
15. The endotracheal tube of claim 14, wherein the at least one suction aperture is forms an angle of between about 20 degrees and about 70 degrees relative to the plane.
16. The endotracheal tube of claim 1, wherein the main tube comprises a generally circular cross-section shape.
17. The endotracheal tube of claim 1, wherein the at least one suction aperture is forms an angle of between about 20 degrees and about 70 degrees relative to the plane.
18. The endotracheal tube of claim 1, wherein the at least one suction aperture is forms an angle of between about 30 degrees and about 60 degrees relative to the plane.
19. The endotracheal tube of claim 1, wherein the at least one suction aperture is forms an angle of about 30 degrees relative to the plane.
20. The endotracheal tube of claim 1, wherein the at least one suction aperture is forms an angle of about 40 degrees relative to the plane.

21. The endotracheal tube of claim 1, wherein the at least one suction aperture is forms an angle of about 60 degrees relative to the plane.

22. The endotracheal tube of claim 1, wherein the at least one suction aperture comprises two angularly offset suction apertures.

23. The endotracheal tube of claim 22, wherein the main tube comprises at least one suction lumen coupled to at least one of the two angularly offset suction apertures.

24. The endotracheal tube of claim 22, wherein the main tube comprises at least one suction lumen coupled to each of the two angularly offset suction apertures.

25. The endotracheal tube of claim 22, wherein the main tube comprises at least one integrally formed suction lumen coupled to each of the two angularly offset suction apertures.

26. The endotracheal tube of claim 22, wherein the main tube comprises two suction lumens each coupled to one of the two angularly offset suction apertures.

27. The endotracheal tube of claim 22, wherein the main tube comprises two integrally formed angularly offset suction lumens each coupled to one of the two angularly offset suction apertures.

28. The endotracheal tube of claim 22, wherein the main tube comprises a generally circular cross-section shape.

29. The endotracheal tube of claim 22, wherein each of the two suction apertures is forms an angle of between about 20 degrees and about 70 degrees relative to the plane.

30. The endotracheal tube of claim 29, wherein the angle is between about 30 degrees and about 60 degrees.

31. The endotracheal tube of claim 30, wherein the angle is about 30 degrees.

32. The endotracheal tube of claim 30, wherein the angle is about 40 degrees.

33. The endotracheal tube of claim 1, wherein the at least one suction aperture comprises two angularly offset suction apertures arranged on opposite sides of the plane and each being structured and arranged to suction secretions from different areas on the trachea.

34. The endotracheal tube of claim 33, wherein the inflatable cuff has a generally triangular cross-section shape with curved corners.

35. The endotracheal tube of claim 34, wherein each suction aperture is generally oriented toward one of the curved corners.

36. The endotracheal tube of claim 33, wherein the main tube comprises two integrally formed suction lumens each coupled to one of the two angularly offset suction apertures.

37. The endotracheal tube of claim 33, wherein the main tube comprises a generally circular cross-section shape.

38. The endotracheal tube of claim 33, wherein each of the two suction apertures is forms an angle of between about 20 degrees and about 70 degrees relative to the plane.

39. The endotracheal tube of claim 1, wherein the main tube comprises at least one integrally formed inflation lumen which extends to at least one aperture for inflating the cuff.

40. The endotracheal tube of claim 39, wherein the at least one inflation lumen is generally oriented on the plane.

41. The endotracheal tube of claim 39, wherein the main tube comprises at least one radiopaque strip or stripe arranged in a wall of the main tube.

42. The endotracheal tube of claim 41, wherein the at least one radiopaque strip or stripe is generally oriented on the plane.

43. A method for intubation using the endotracheal tube of any one of claims 1-42, the method comprising:

- inserting at least a portion of an endotracheal tube into a trachea;
- inflating a cuff of the endotracheal tube; and
- supplying gas into a patient's lungs via the endotracheal tube.

44. The method of claim 43, further comprising suctioning matter through the at least one suction aperture located adjacent the cuff.

45. A method of making the endotracheal tube of any one of claims 1-42, the method comprising:

- arranging a cuff on a main tube; and

- arranging a position of at least one suction aperture relative to the cuff such that at least one of:

- the at least one suction aperture is angularly offset with respect to a plane passing through a center axis of the main tube when the main tube is bent in use configuration; and

- the at least one suction aperture is angularly offset with respect to a plane passing through a center axis of the cuff and being perpendicular to a base of the cuff.

46. An endotracheal tube, comprising:

- a main tube including a proximal end and a distal end;

- a generally triangular cross-section shaped inflation cuff comprising a base, angled sides, and curved corners, whereby the inflatable cuff is configured to generally match an anatomical shape of a trachea; and

- at least one suction aperture arranged adjacent the inflatable cuff and generally oriented toward one of the curved corners, wherein at least one of:

- the at least one suction aperture is angularly offset with respect to a plane passing through a center axis of the main tube when the main tube is bent in use configuration;

- the at least one suction aperture is angularly offset with respect to a plane passing through a center axis of the cuff and being perpendicular to the base of the cuff; and

- the at least one suction aperture forms an angle of between about 20 degrees and about 70 degrees relative to a plane passing through a center axis of the main tube when the main tube is bent in use configuration.

47. The endotracheal tube of claim 46, wherein the main tube comprises at least one inflation lumen generally oriented on the plane.

48. The endotracheal tube of claim 47, wherein the main tube comprises at least one radiopaque strip or stripe arranged in a wall of the main tube.

49. An endotracheal tube, comprising:
- a main tube including a proximal end and a distal end;
 - a generally triangular cross-section shaped inflation cuff comprising a base, angled sides, and curved corners, whereby the inflatable cuff is configured to generally match an anatomical shape of a trachea;
 - at least one suction aperture arranged adjacent the inflatable cuff and generally oriented toward one of the curved corners; and
 - at least one suction lumen arranged in the main tube and extending to the at least one suction aperture, wherein at least one of:
 - the at least one suction aperture is angularly offset with respect to a plane passing through a center axis of the main tube when the main tube is bent in use configuration;
 - the at least one suction aperture is angularly offset with respect to a plane passing through a center axis of the cuff and being perpendicular to the base of the cuff; and
 - the at least one suction aperture forms an angle of between about 20 degrees and about 70 degrees relative to a plane passing through a center axis of the main tube when the main tube is bent in use configuration.
50. The endotracheal tube of claim 49, wherein the main tube comprises at least one integrally formed inflation lumen and at least one radiopaque strip or stripe arranged in a wall of the main tube.

FIG. 1

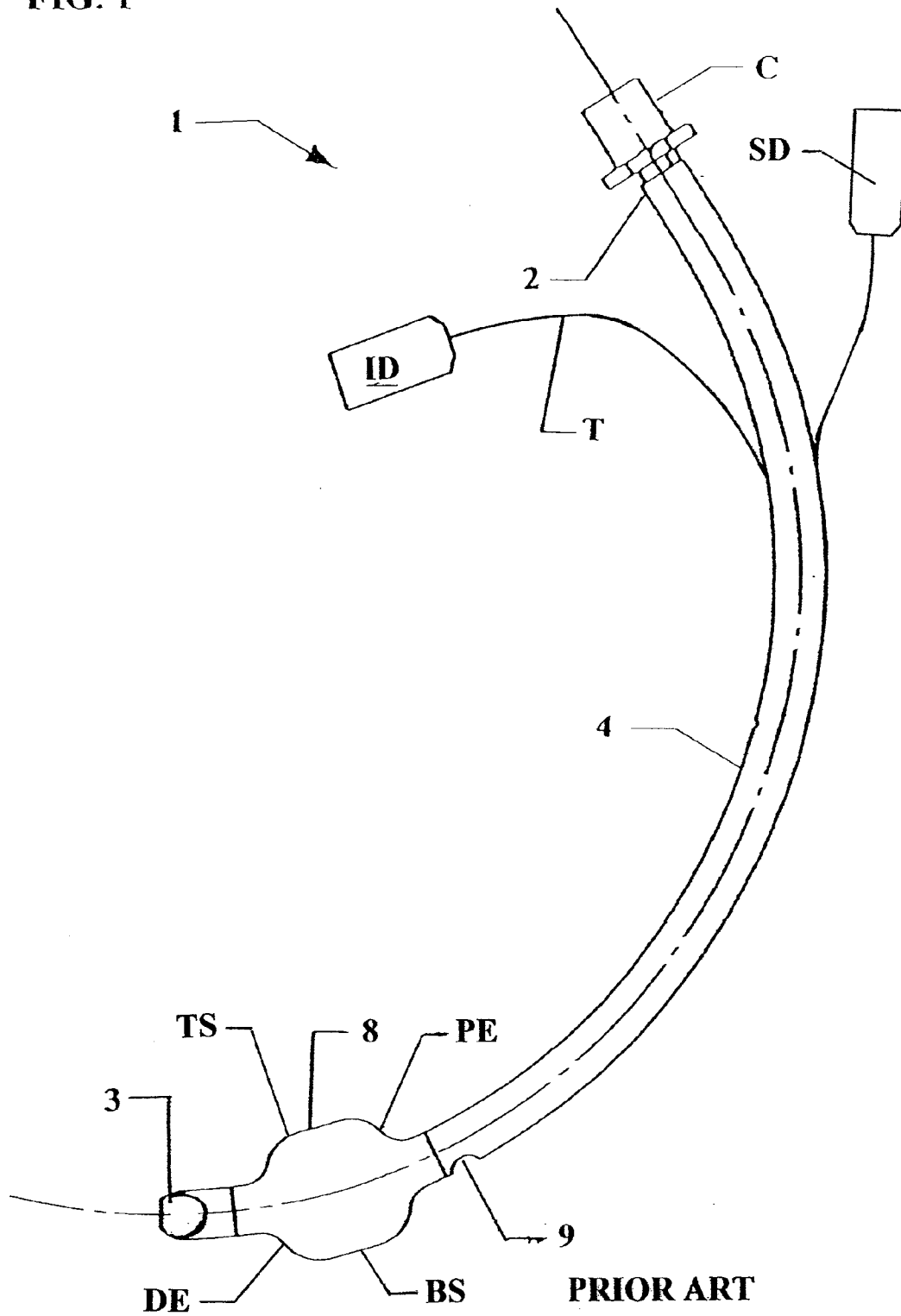


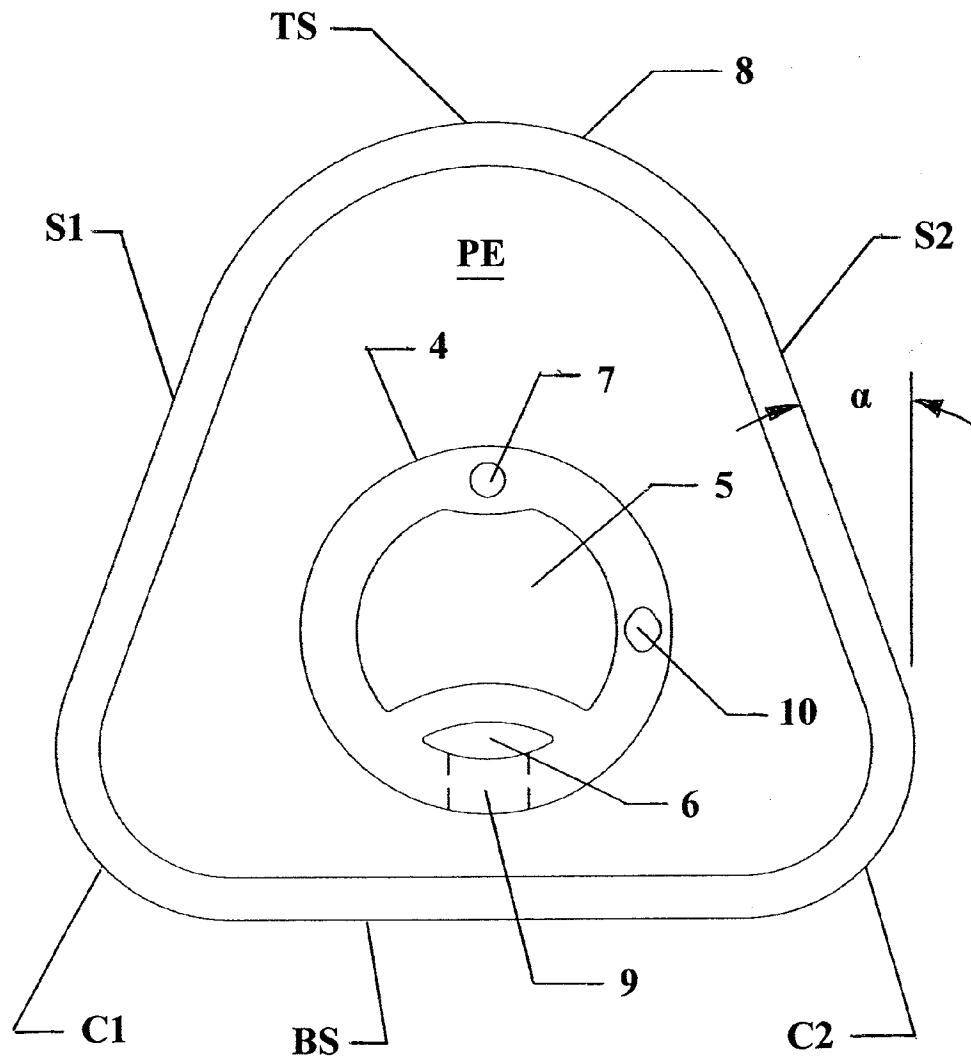
FIG. 2

FIG. 3

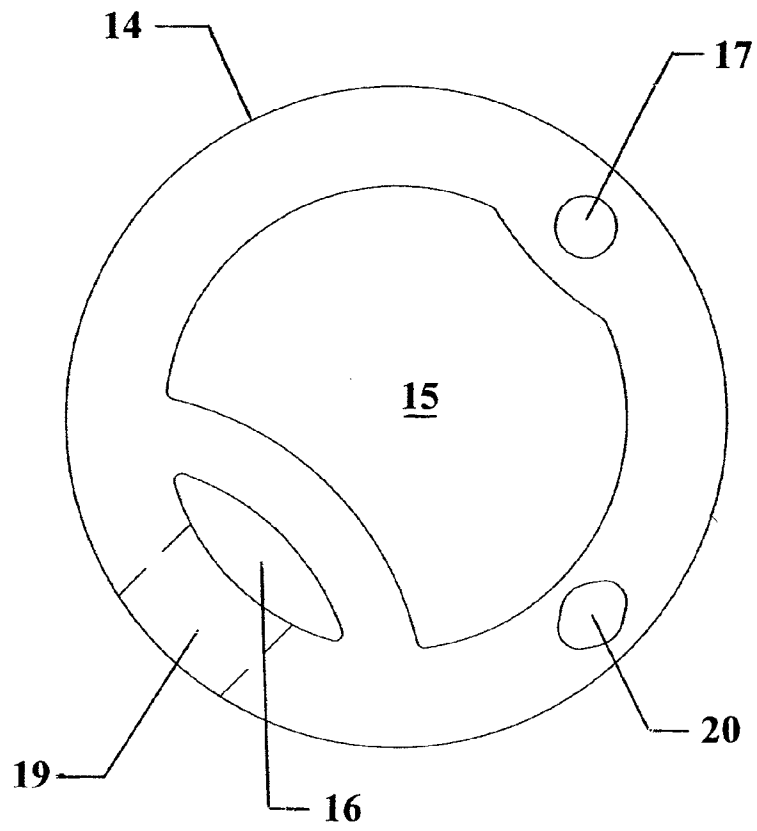
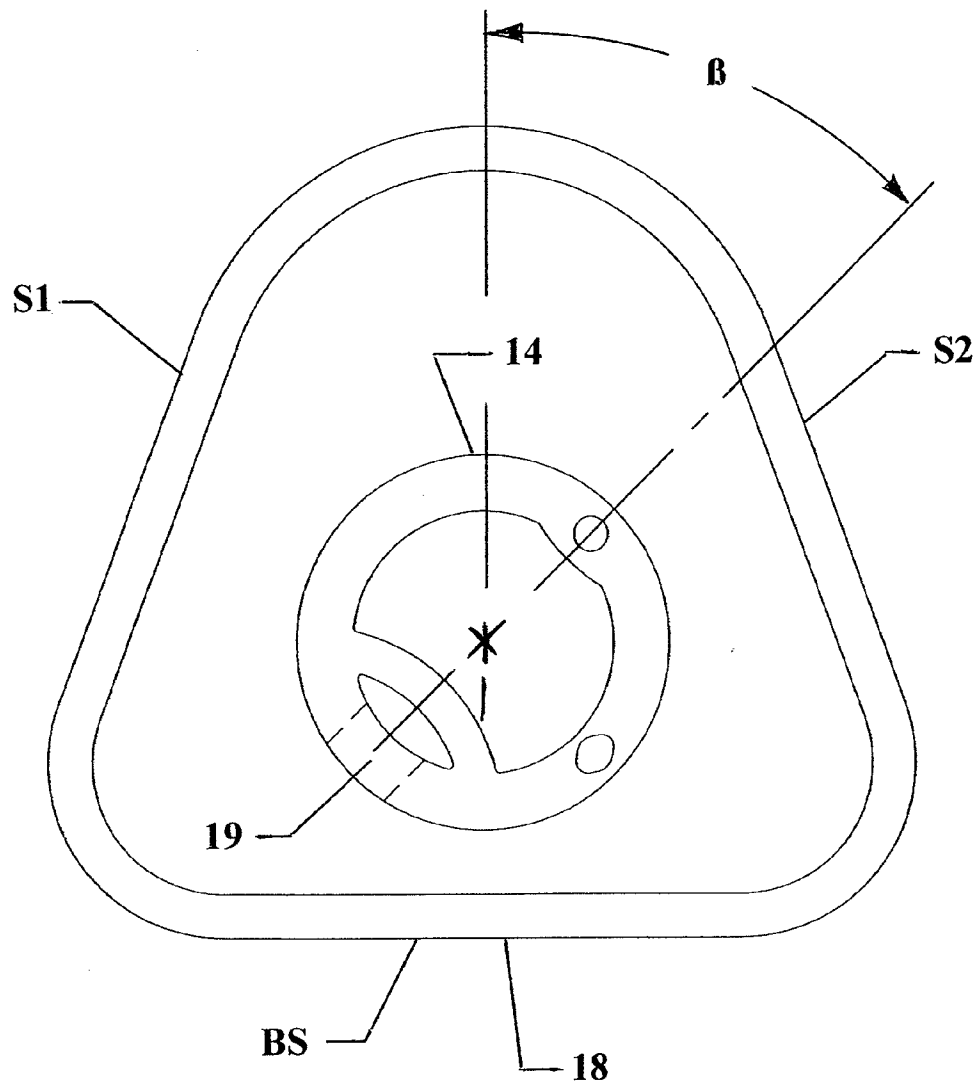


FIG. 4

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FIG. 5

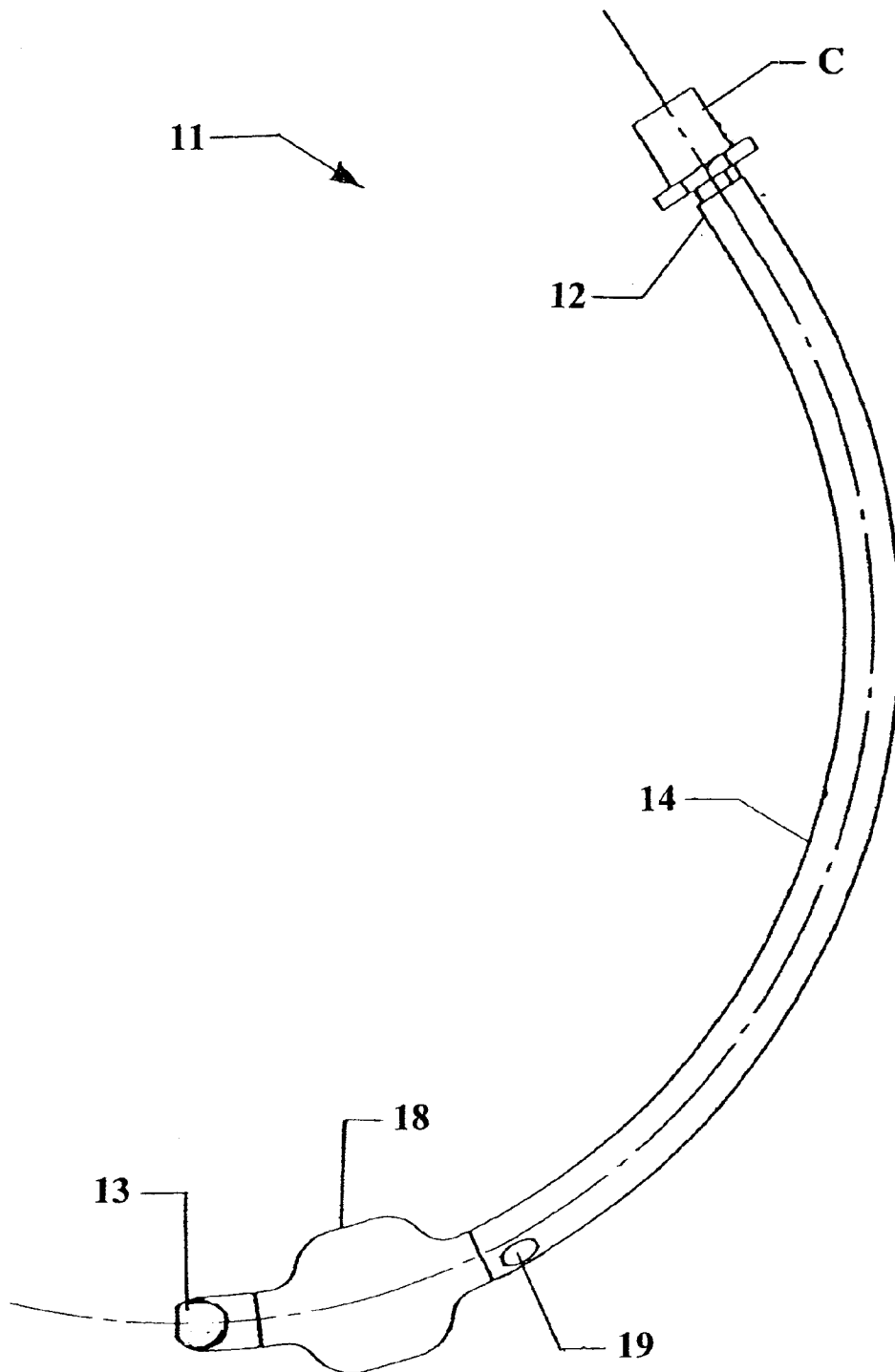


FIG. 6

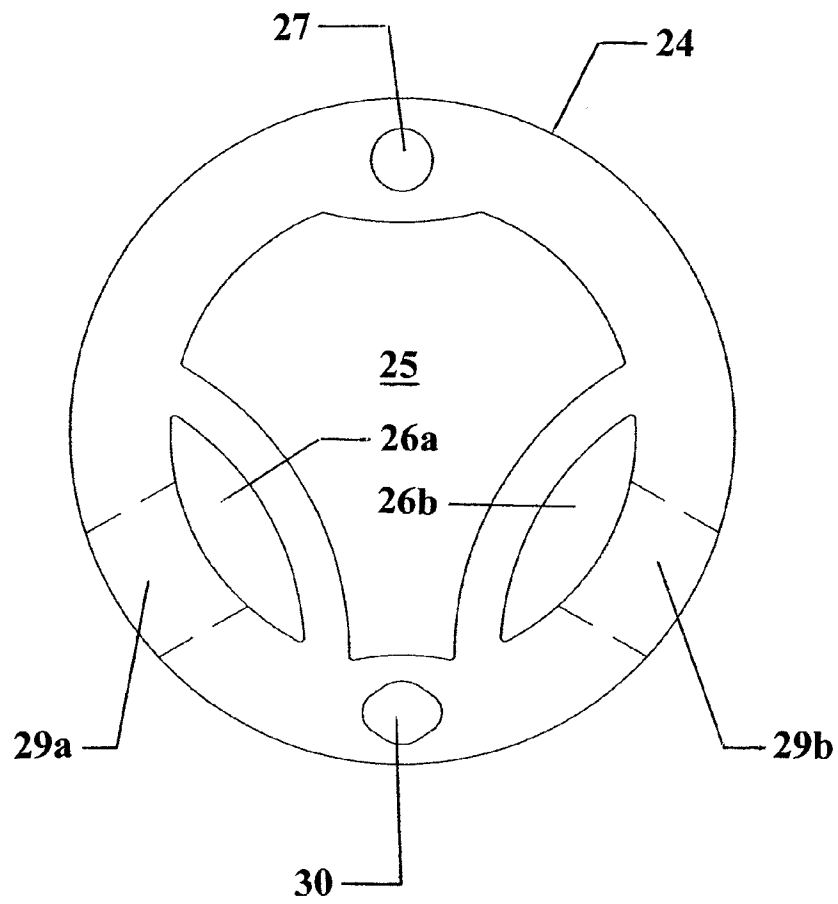


FIG. 7

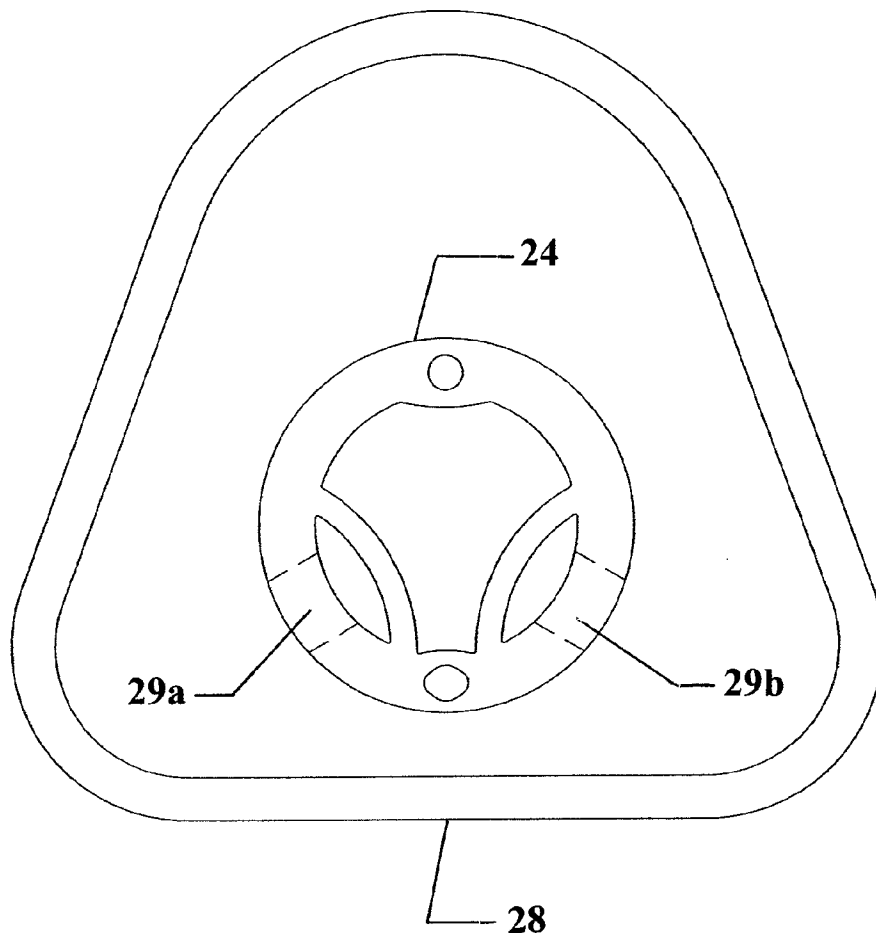


FIG. 8

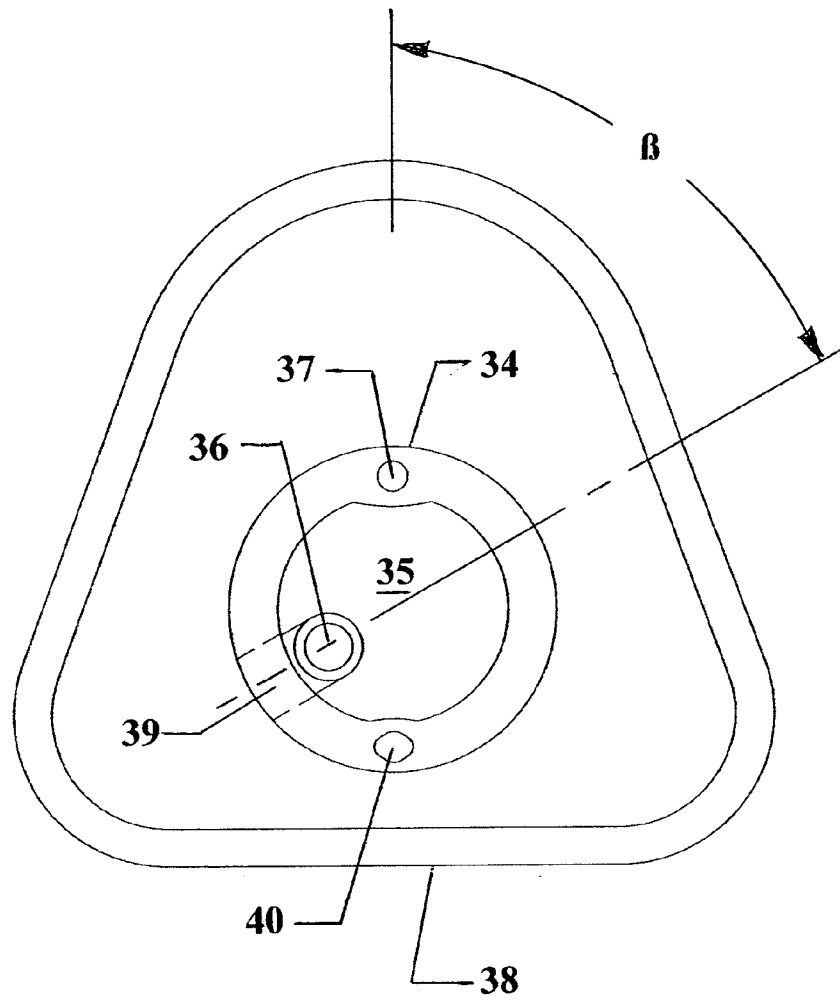


FIG. 9

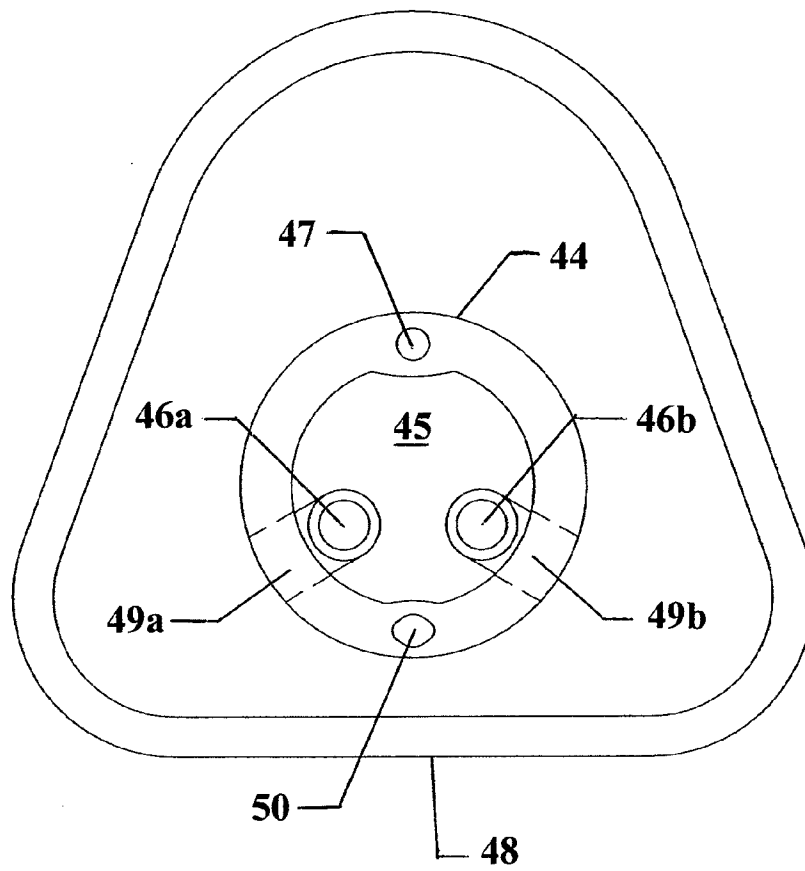


FIG. 10

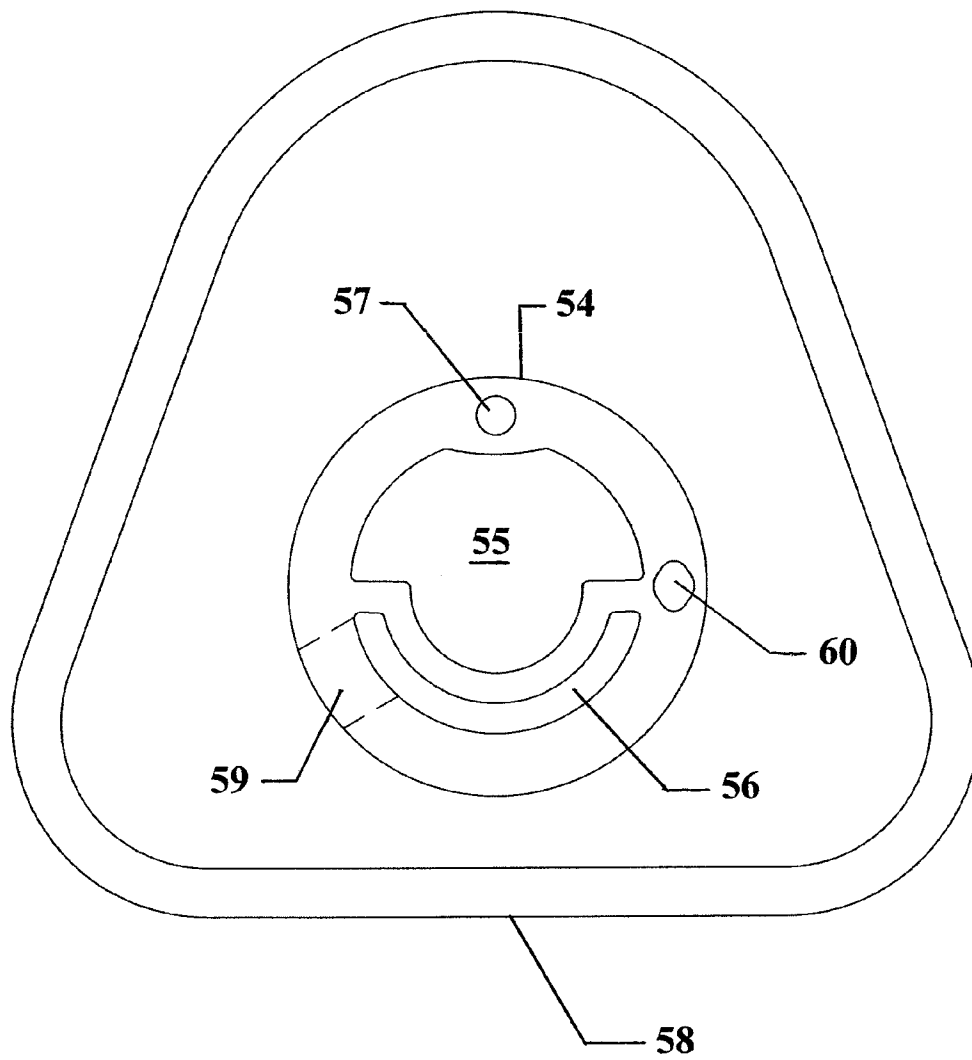


FIG. 11

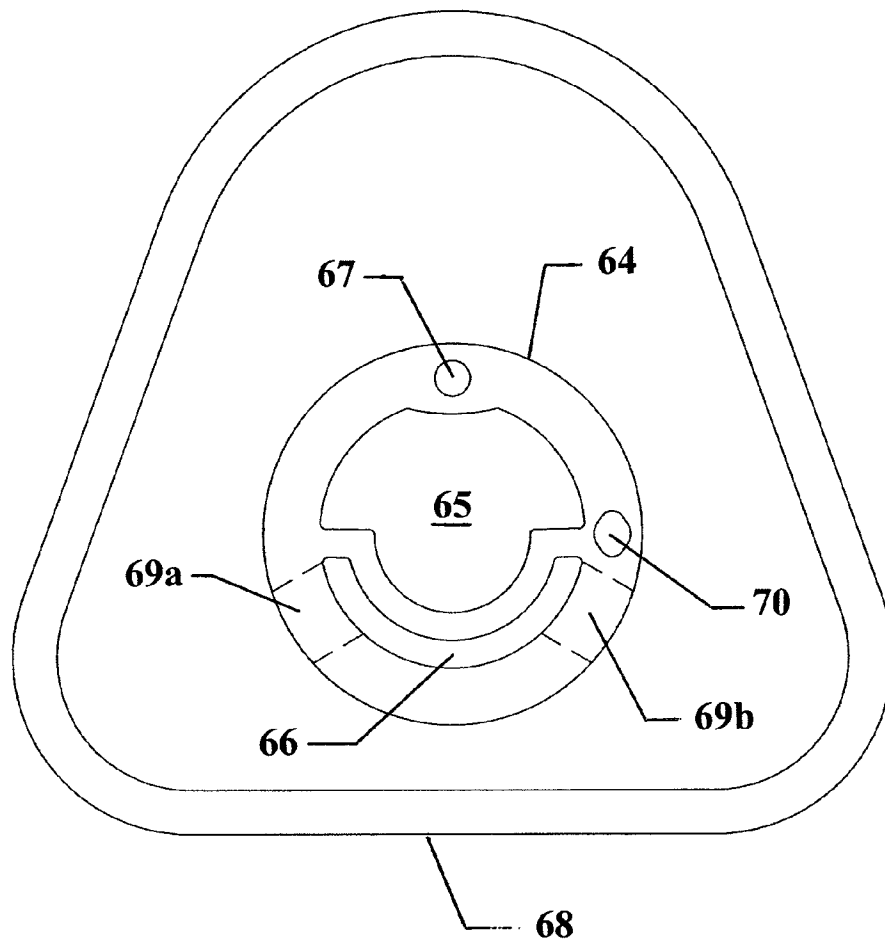


FIG. 12

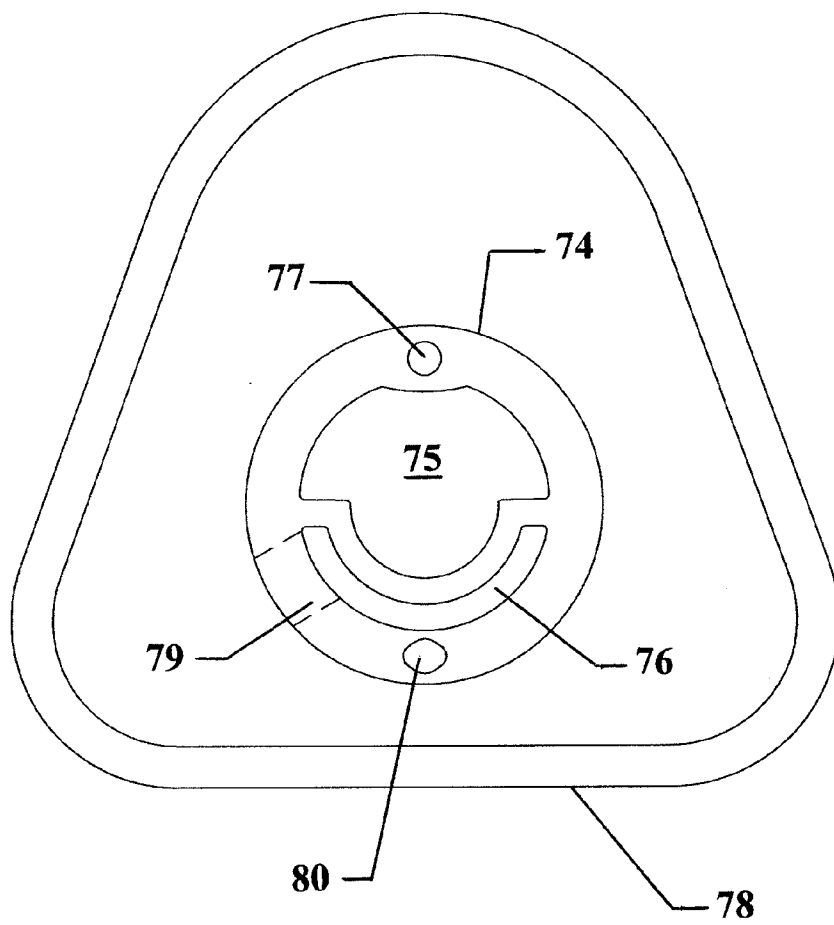


FIG. 13

