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(12) United States Patent
Ip et al.

(10) **Patent No.: US 12,390,208 B2**

(45) **Date of Patent: Aug. 19, 2025**

(54) **WOUND RETRACTOR AND DIFFUSER**

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(73) Assignee: **Fisher & Paykel Healthcare Limited**, Auckland (NZ)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **18/462,813**

(22) Filed: **Sep. 7, 2023**

(65) **Prior Publication Data**

US 2024/0074743 A1 Mar. 7, 2024

Related U.S. Application Data

(63) Continuation of application No. 17/132,565, filed on Dec. 23, 2020, now Pat. No. 11,779,321, which is a

(Continued)

(51) **Int. Cl.**

A61B 17/02	(2006.01)
A61B 17/34	(2006.01)
A61B 90/40	(2016.01)

(52) **U.S. Cl.**

CPC ***A61B 17/0218*** (2013.01); ***A61B 17/02*** (2013.01); *A61B 2017/0212* (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC . A61B 17/0218; A61B 17/02; A61B 17/3423; A61B 2090/401; A61B 2217/005; A61M 16/16

(Continued)

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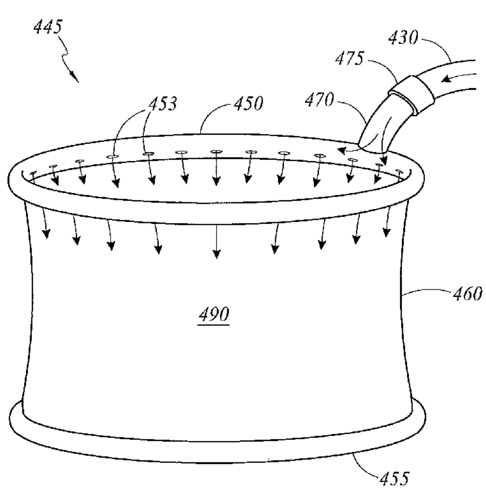
Assistant Examiner — Tara E Carter

(74) *Attorney, Agent, or Firm* — Knobbe Martens Olson & Bear LLP

(57) **ABSTRACT**

A diffuser for use with a wound retractor and configured to deliver gases includes an interface tube for connecting to a gases supply and a diffuser interface positioned at a proximal end of the interface tube, the diffuser interface configured for delivering gases received from the gases supply through the interface tube, and the diffuser interface comprising a diffusion mechanism configured to deliver gases in a diffusion direction. A wound retractor with an integrated diffuser is also disclosed. The wound retractor includes an upper ring, a lower ring, a sleeve extending between and connecting the upper ring to the lower ring, and an integrated diffuser interface having a gases inlet and a diffusion mechanism.

20 Claims, 25 Drawing Sheets



Related U.S. Application Data

continuation of application No. 15/539,575, filed as application No. PCT/NZ2015/050219 on Dec. 23, 2015, now Pat. No. 10,925,591.

(60) Provisional application No. 62/096,469, filed on Dec. 23, 2014.

(52) **U.S. Cl.**
CPC ... *A61B 2017/0225* (2013.01); *A61B 17/3423* (2013.01); *A61B 2017/349* (2013.01); *A61B 2017/3492* (2013.01); *A61B 2090/401* (2016.02); *A61B 2217/005* (2013.01)

(58) **Field of Classification Search**
USPC 600/201–245
See application file for complete search history.

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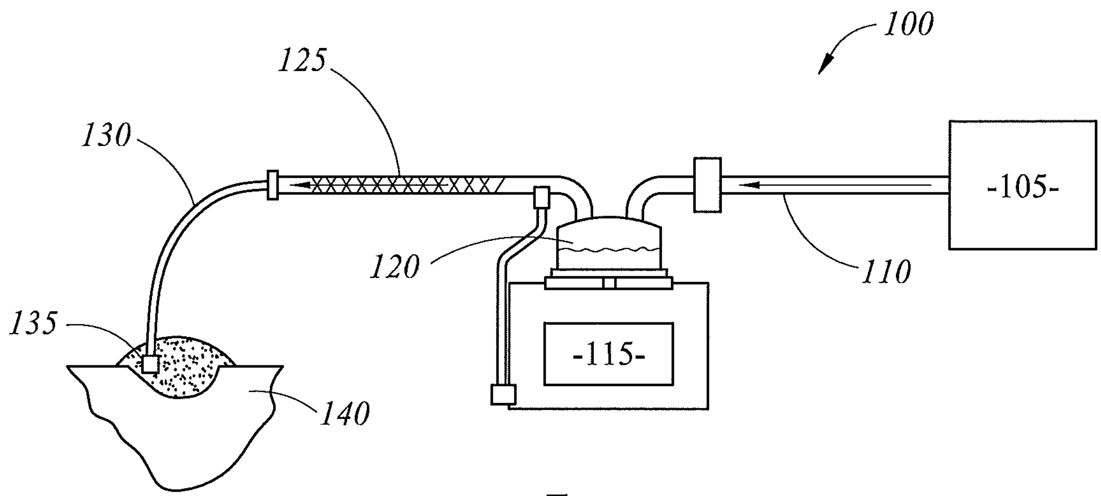
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FIG. 1A

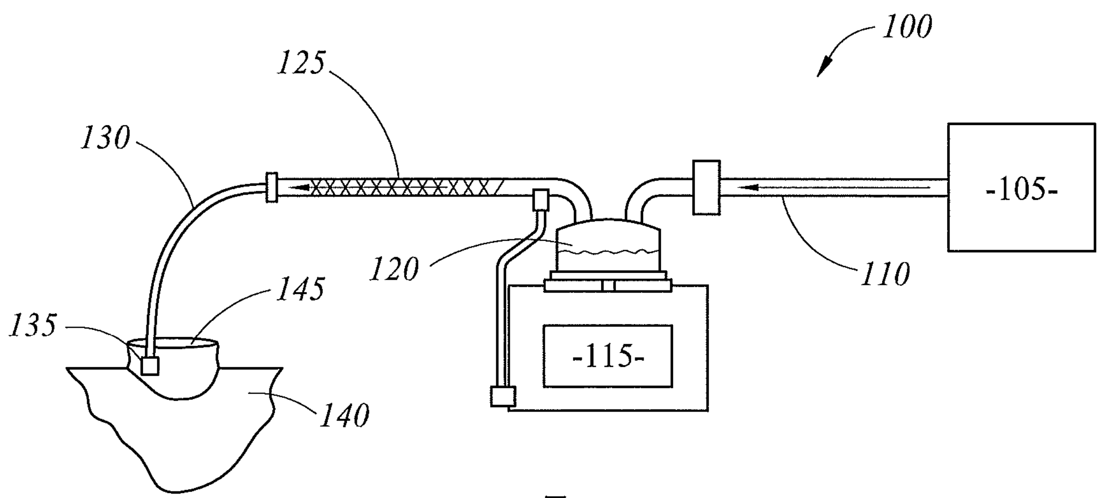
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FIG. 1B

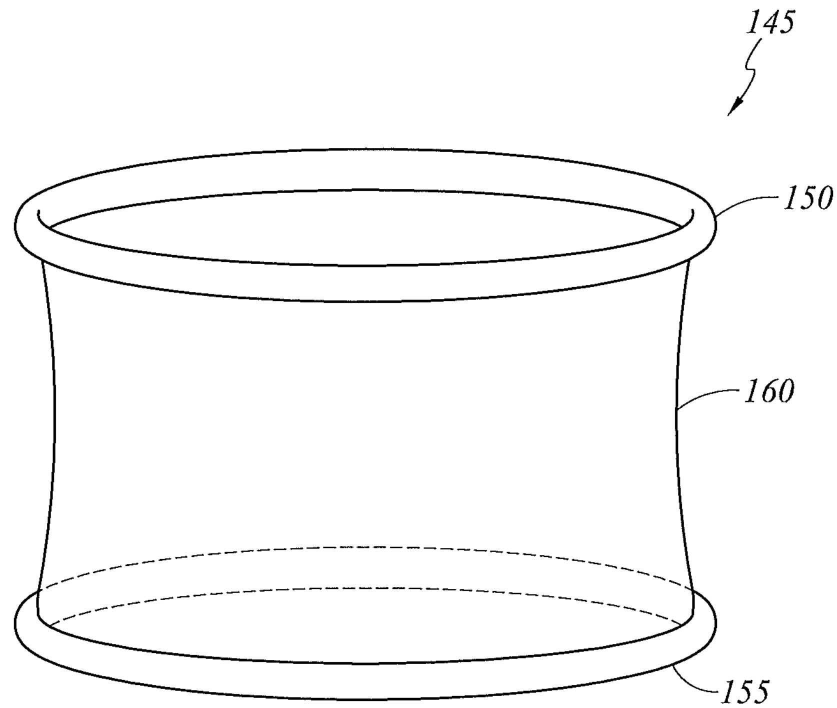
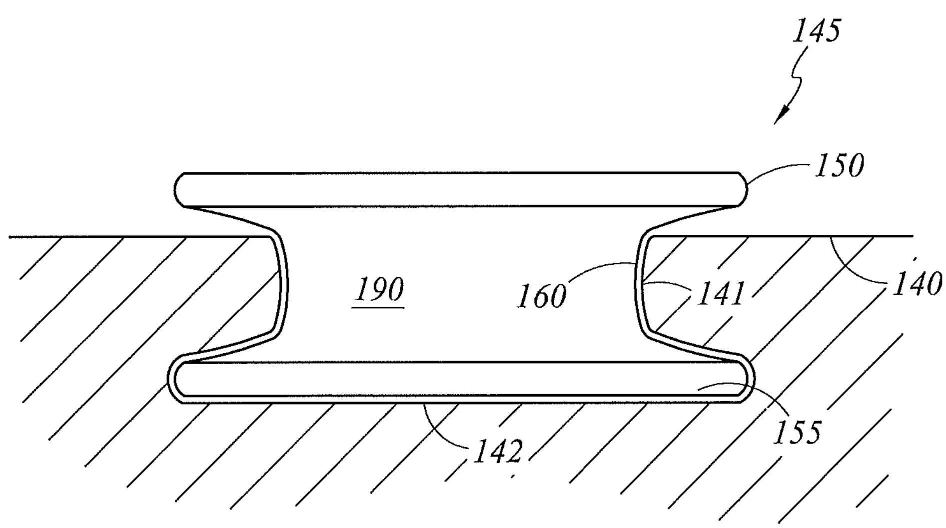


FIG. 2A



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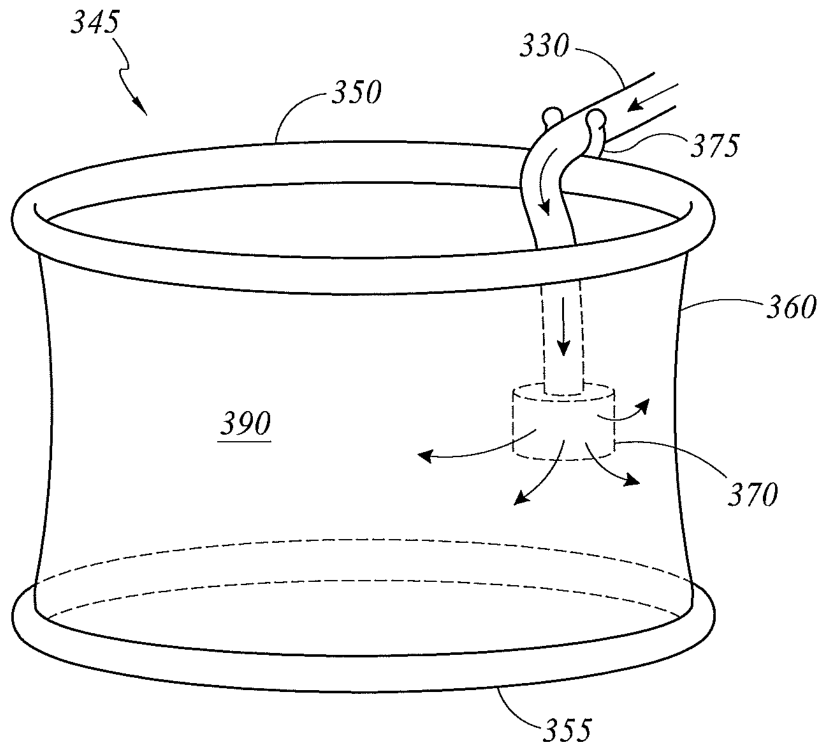


FIG. 3A

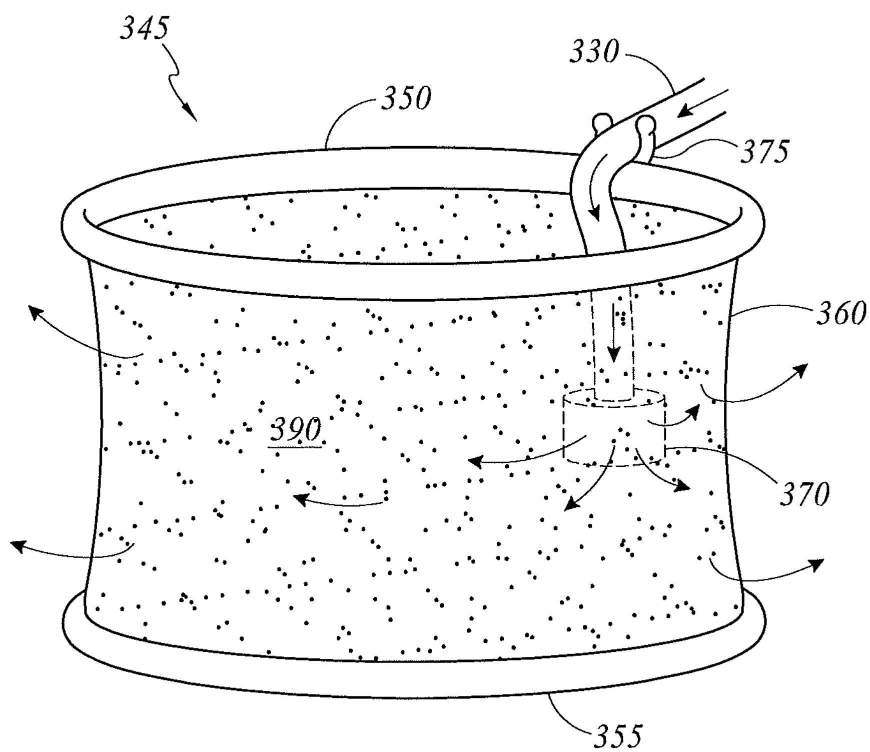


FIG. 3B

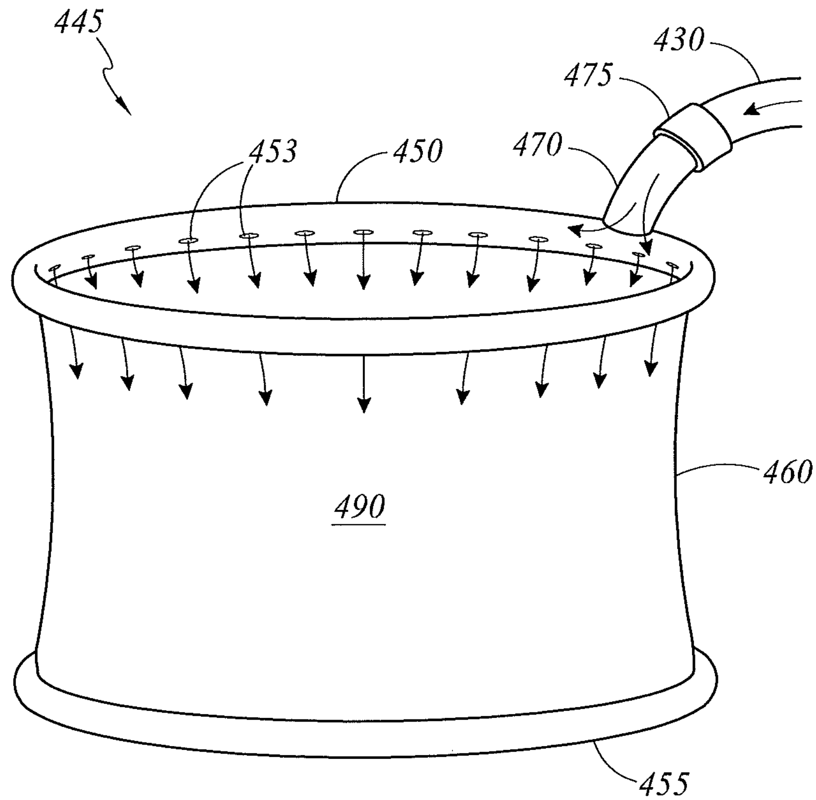


FIG. 4A

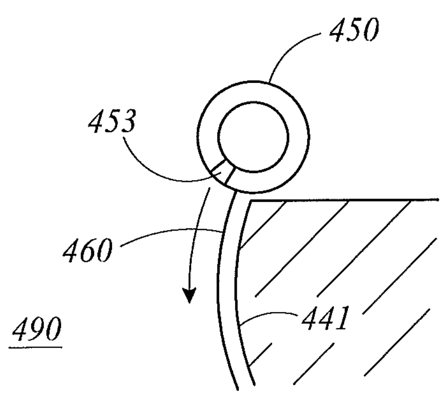


FIG. 4B

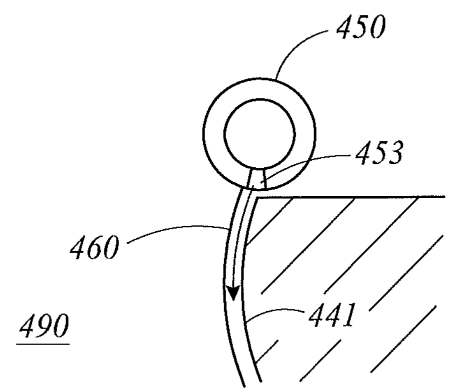


FIG. 4C

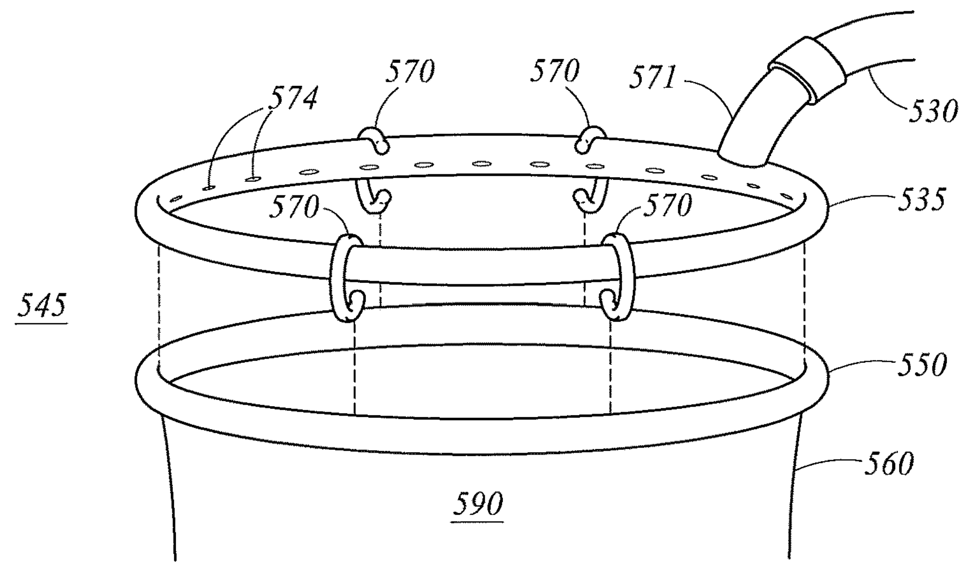


FIG. 5A

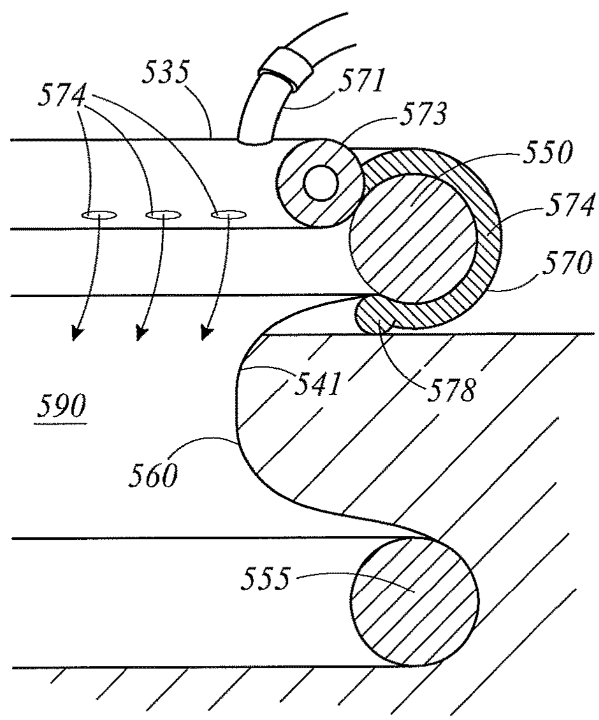
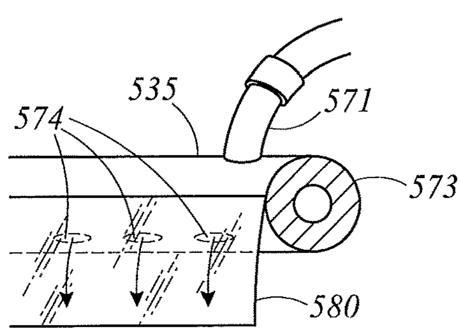


FIG. 5B



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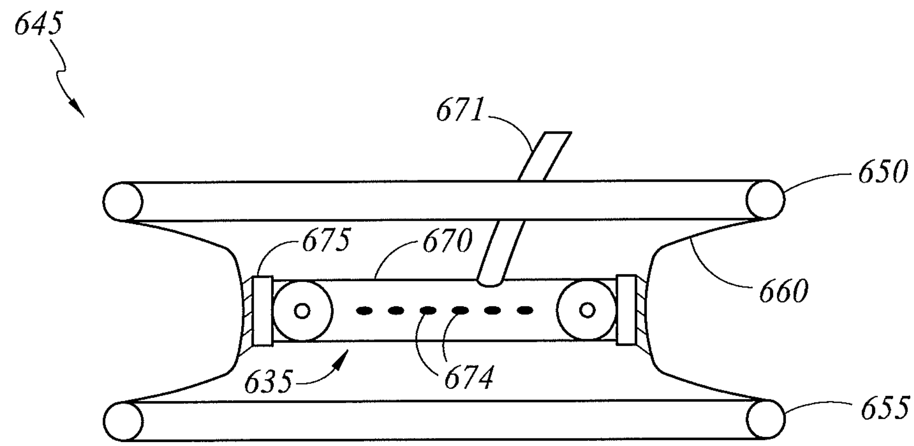


FIG. 6A

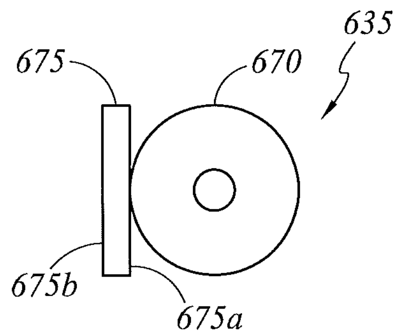


FIG. 6B

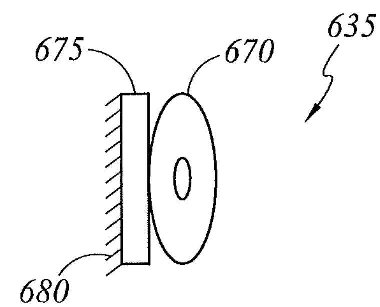


FIG. 6C

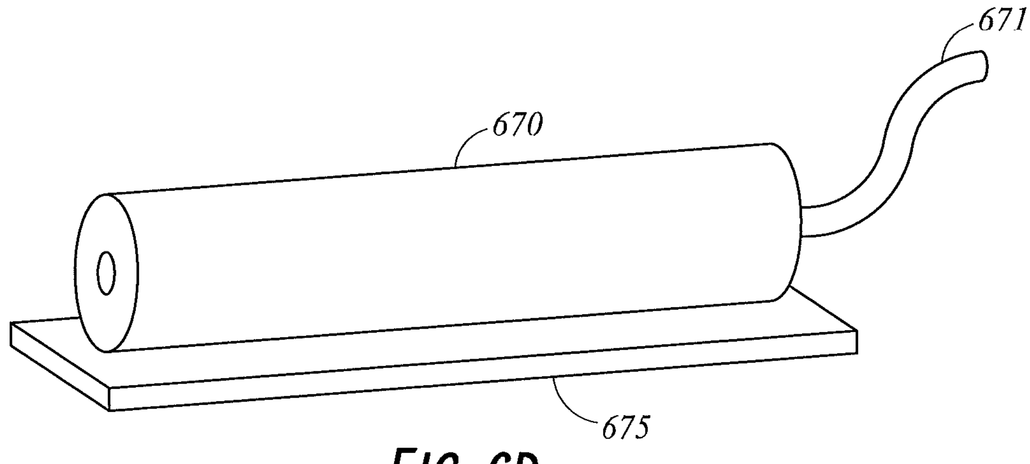


FIG. 6D

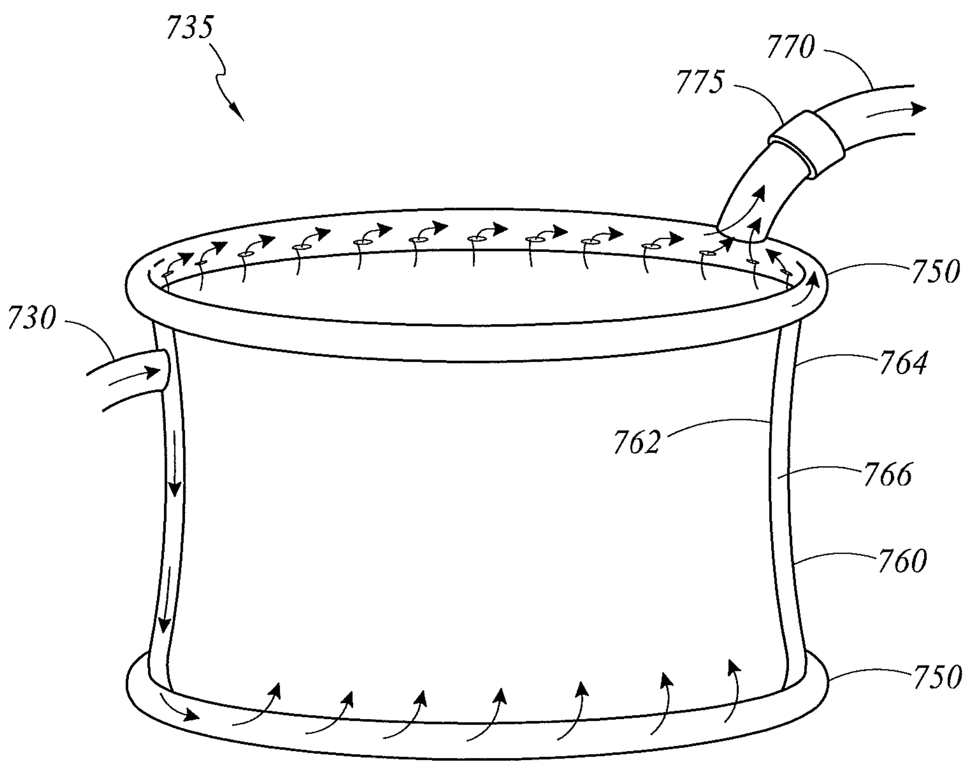


FIG. 7

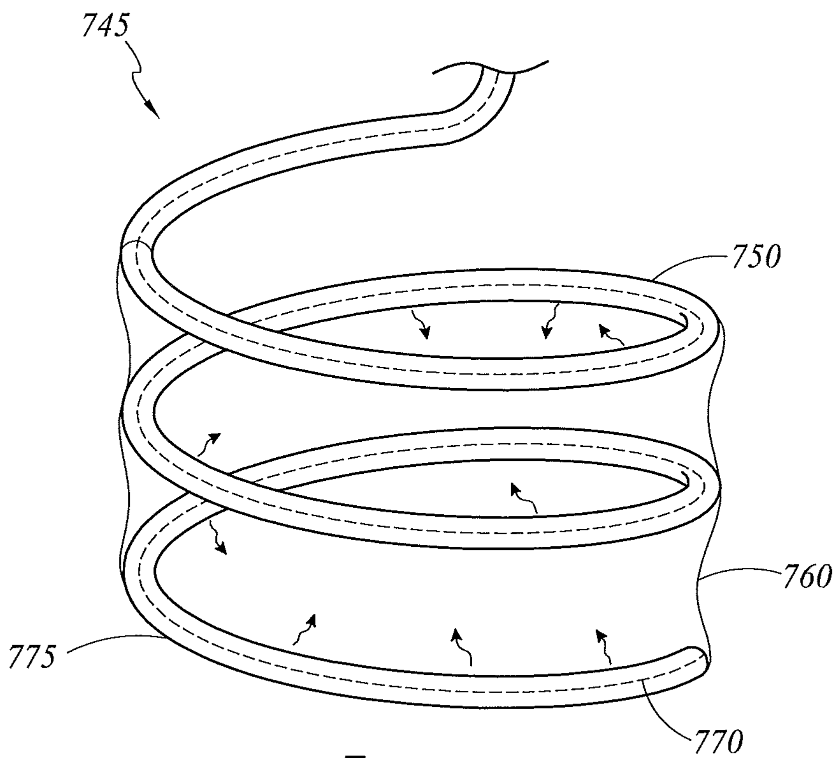
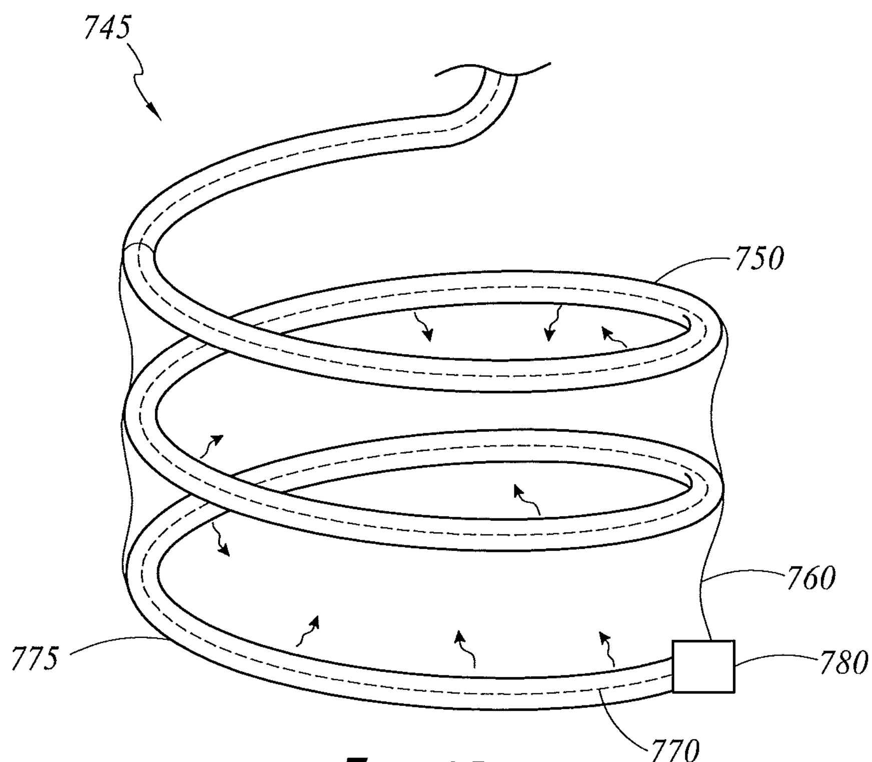


FIG. 8A



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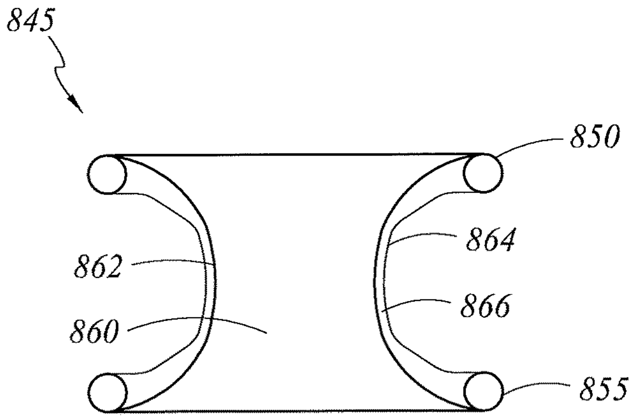

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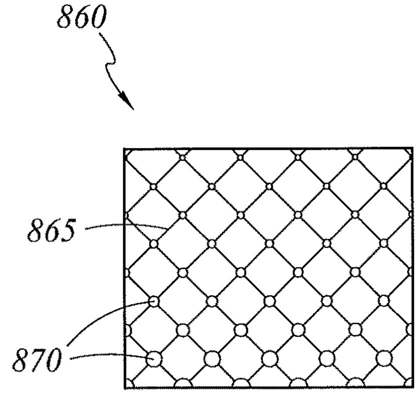

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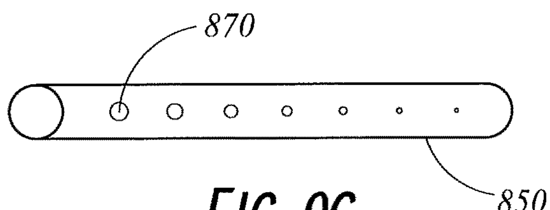


FIG. 9C

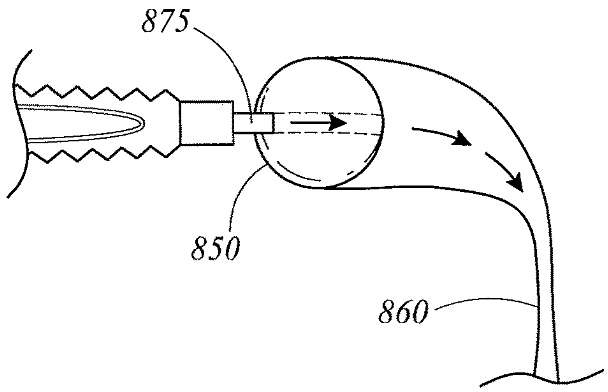


FIG. 9D

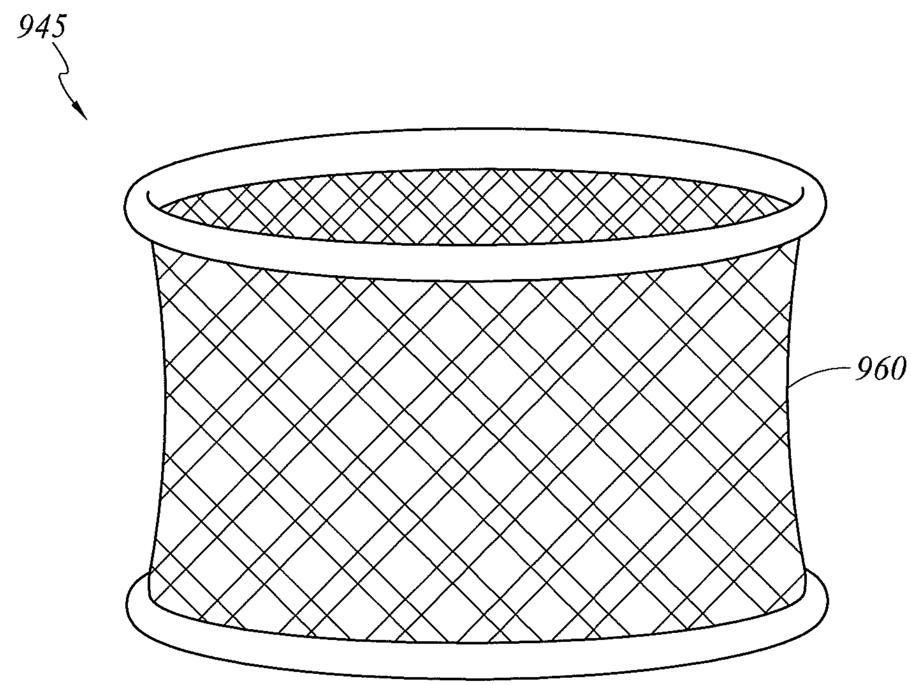
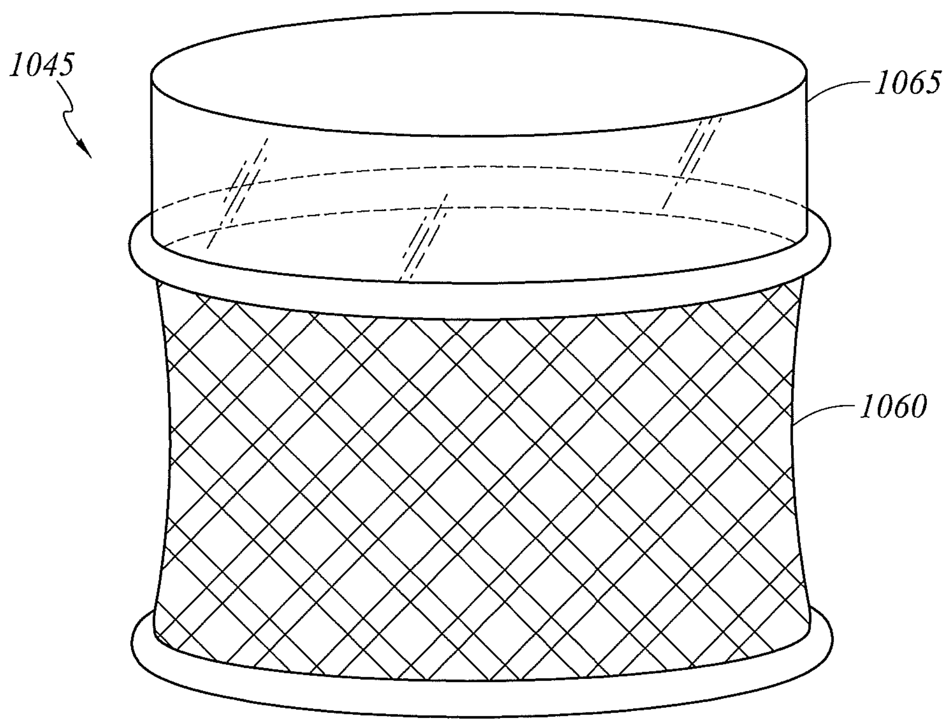


FIG. 10



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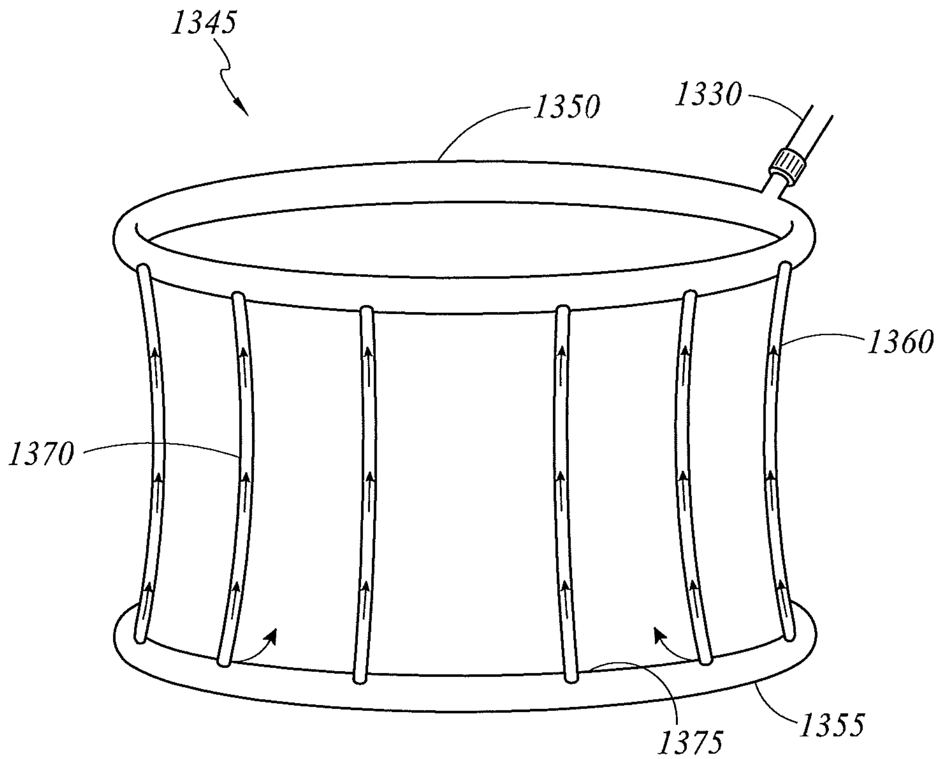
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FIG. 12

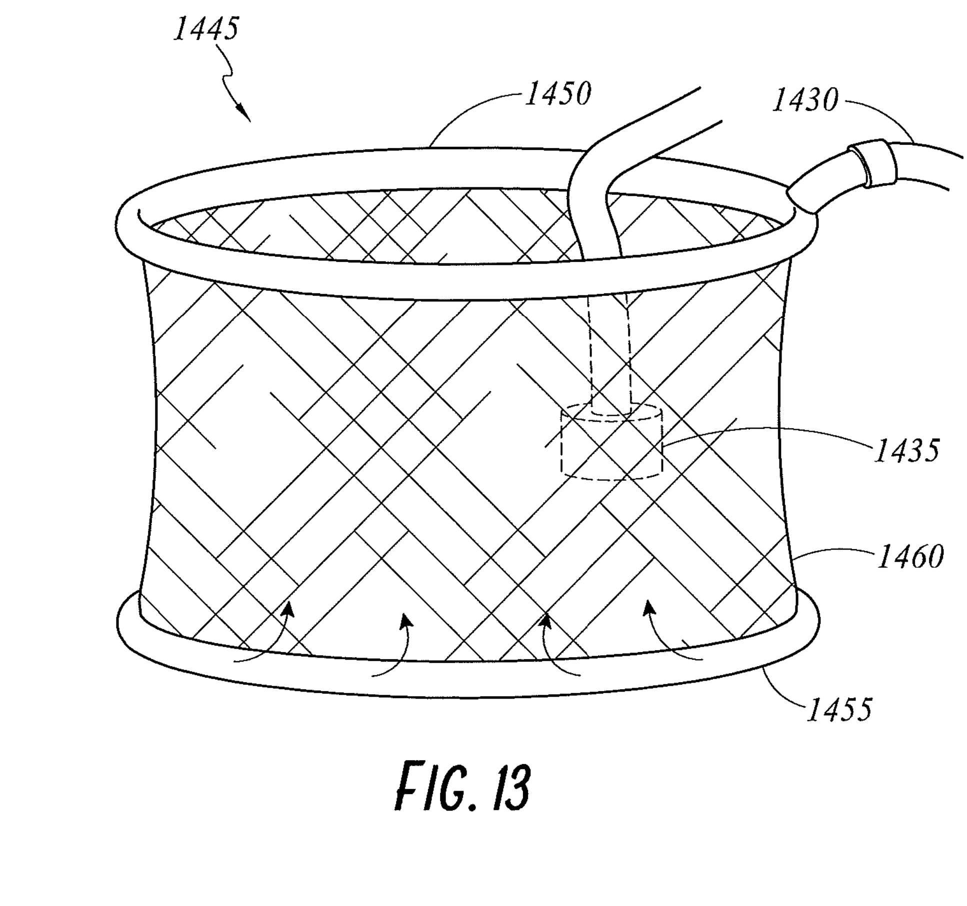
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FIG. 13

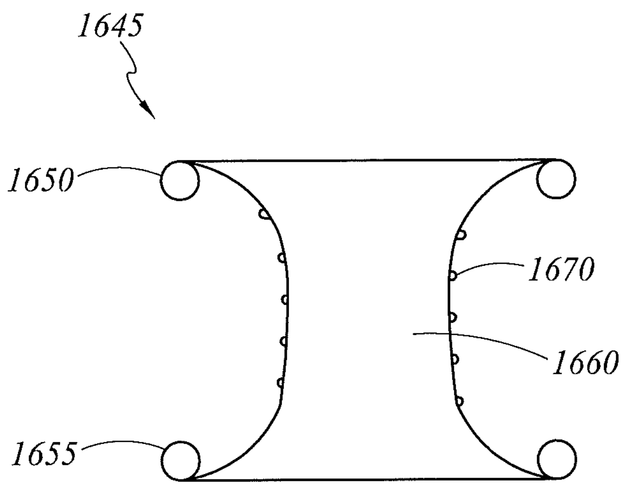

FIG. 14A

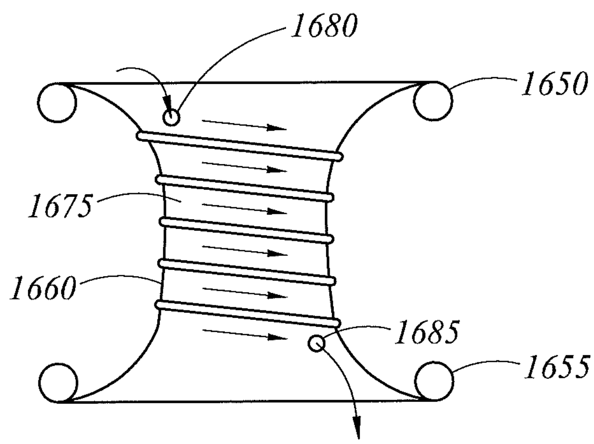

FIG. 14B

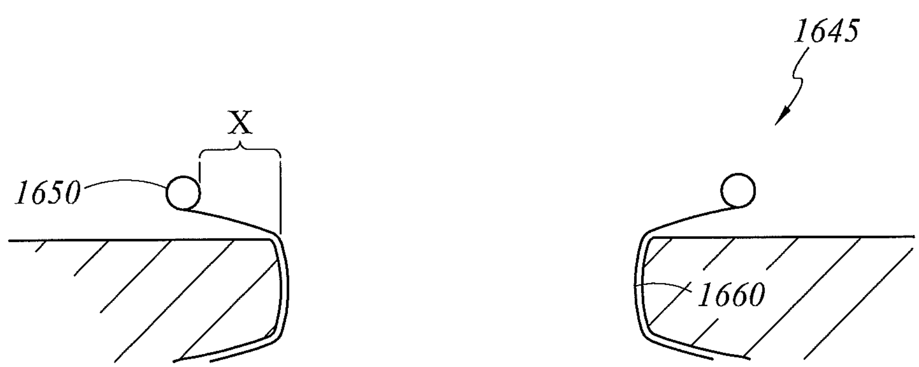

FIG. 14C

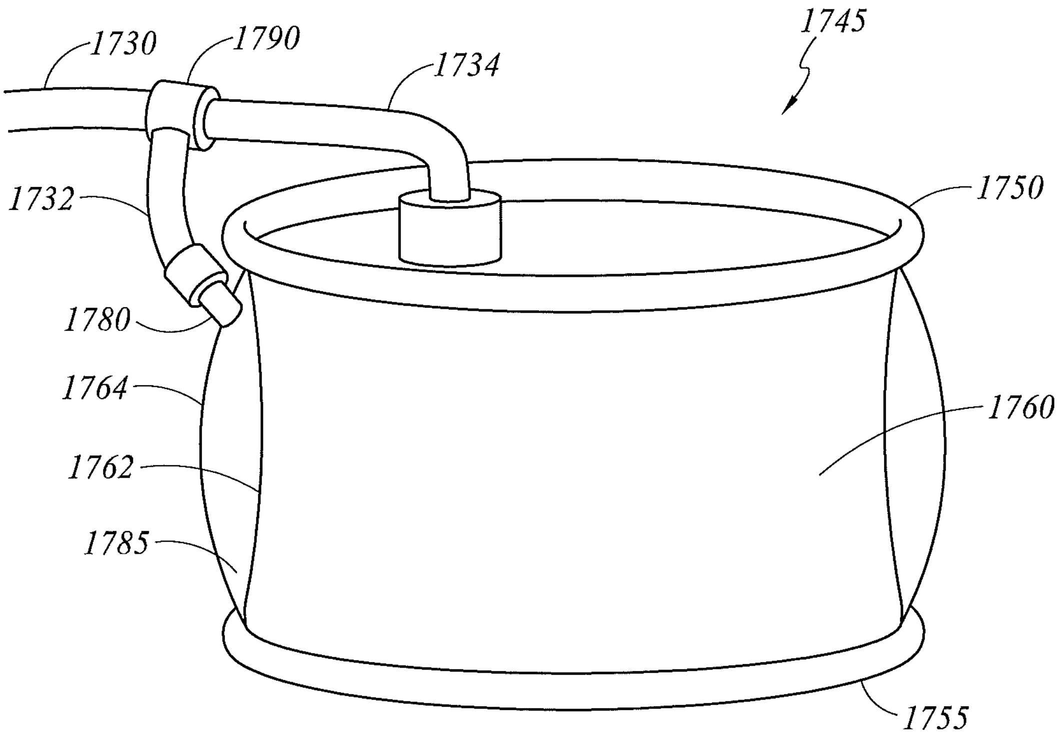

FIG. 15A

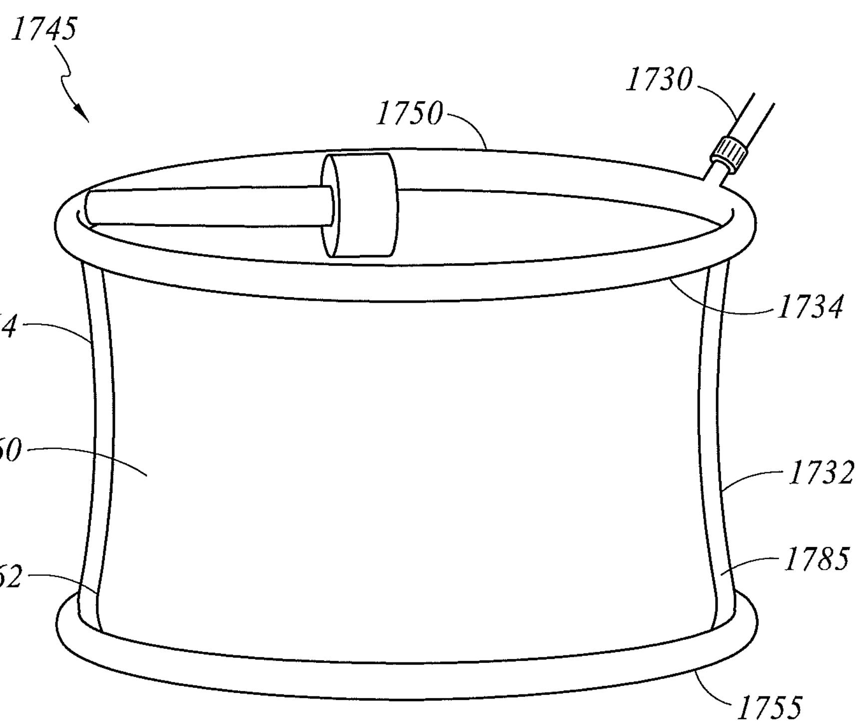

FIG. 15B

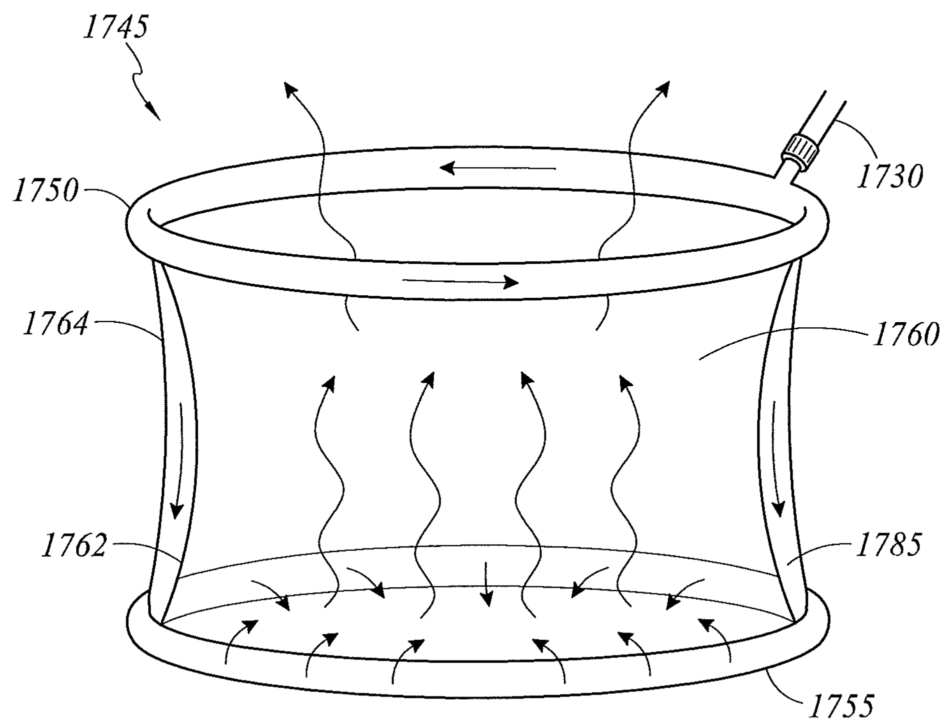

FIG. 15C

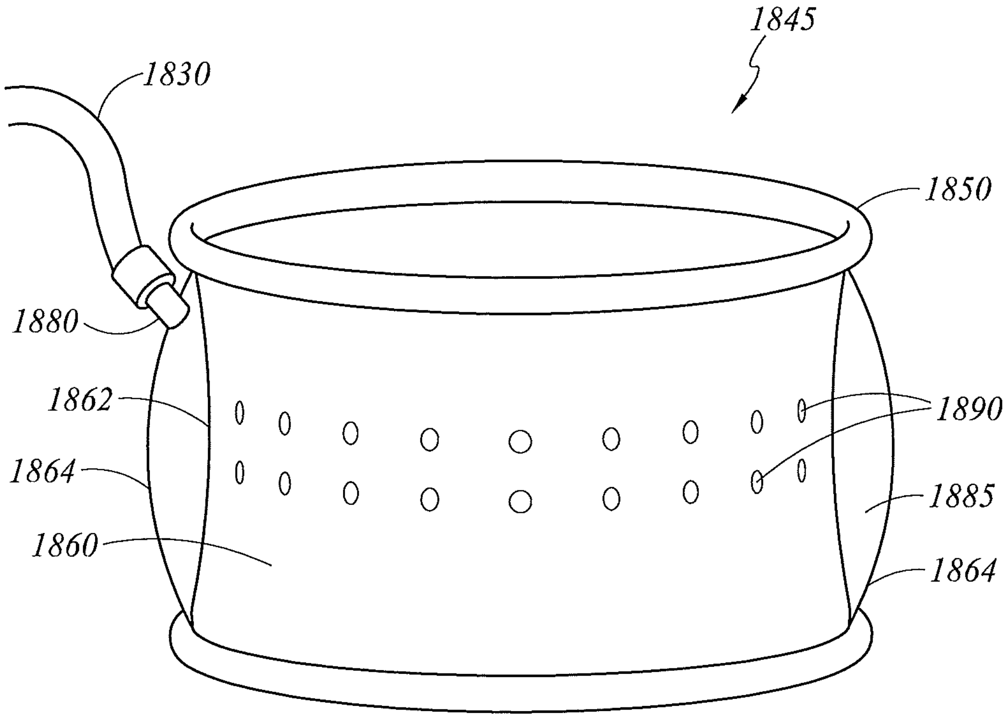
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FIG. 16

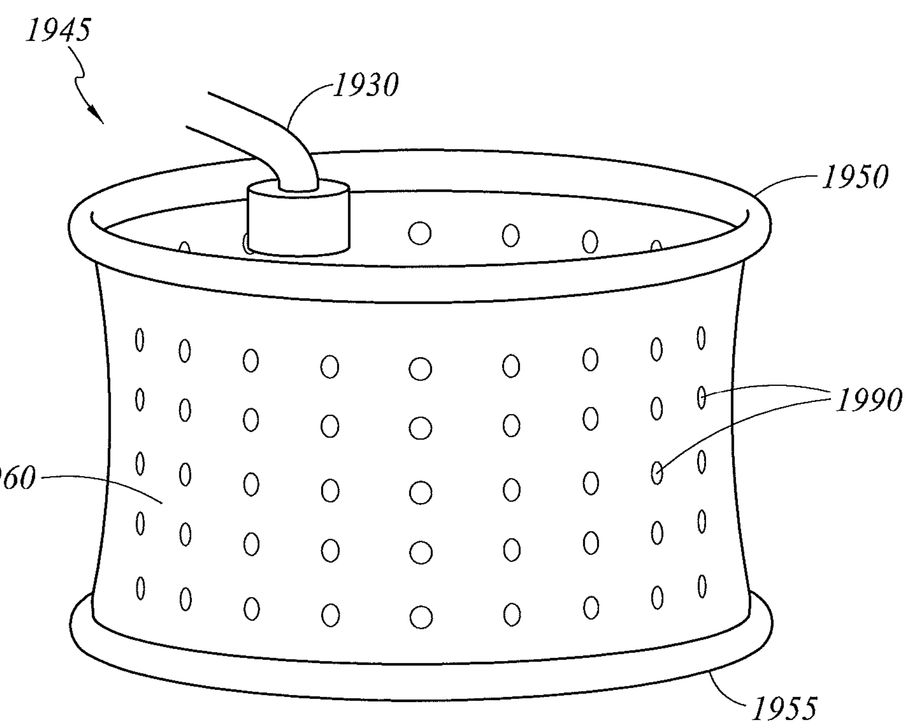
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FIG. 17

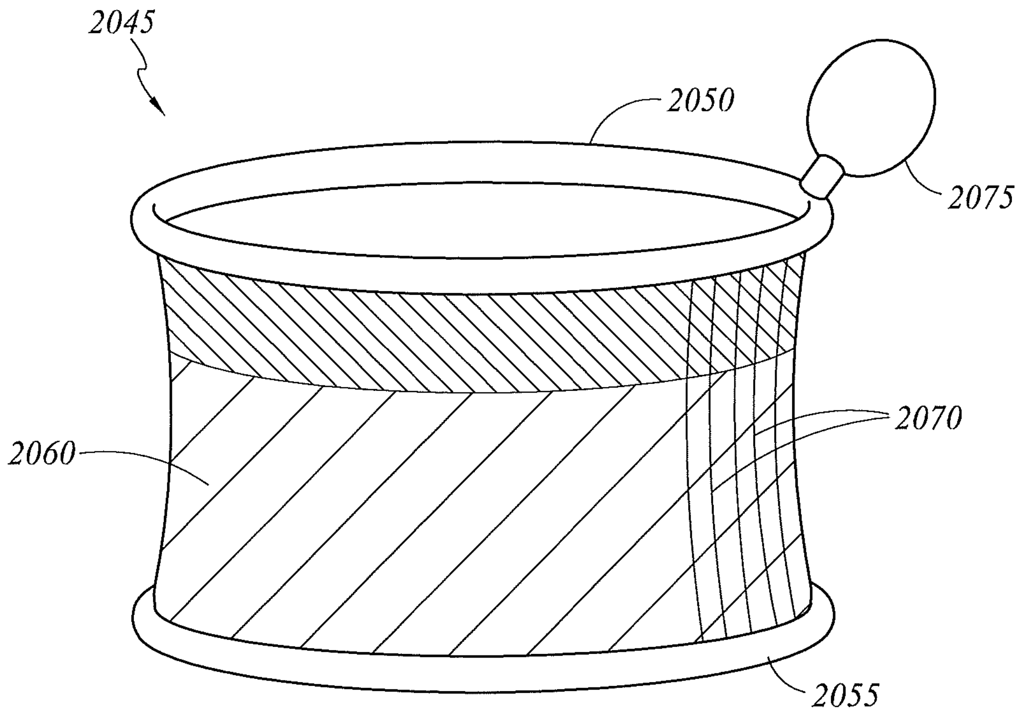

FIG. 18A

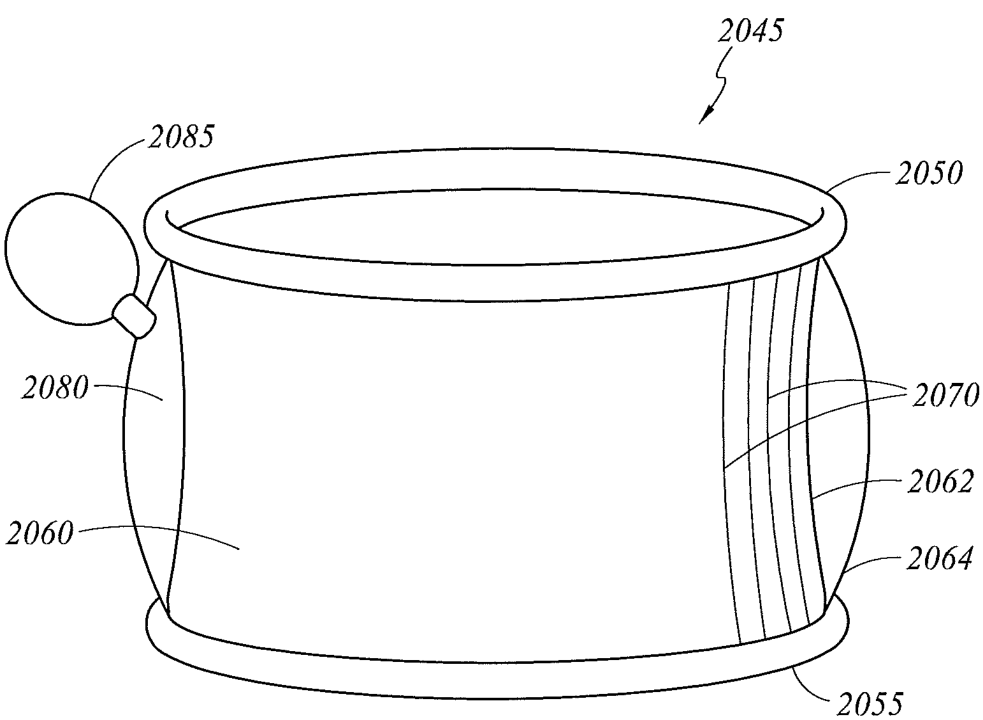

FIG. 18B

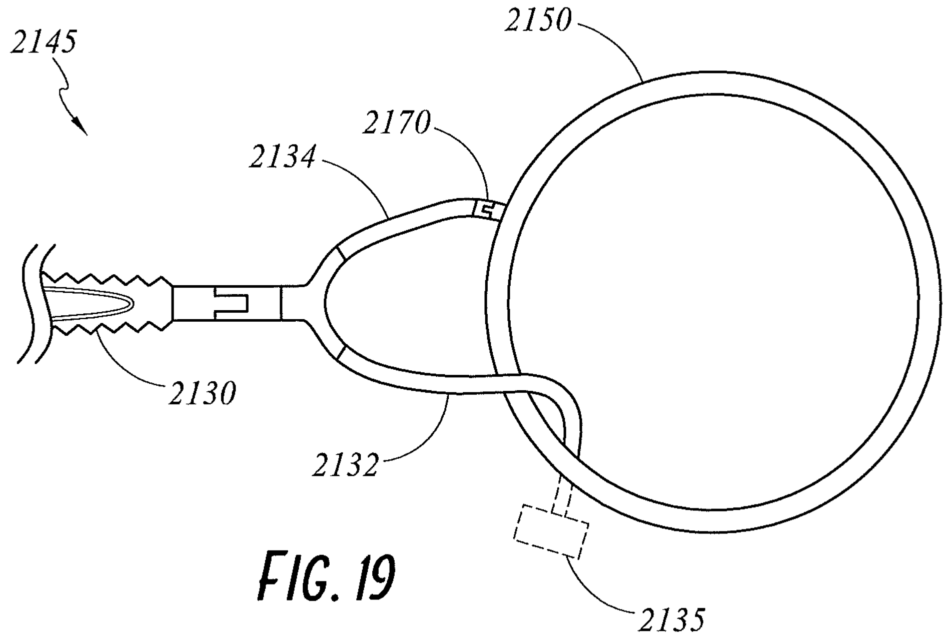
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FIG. 19

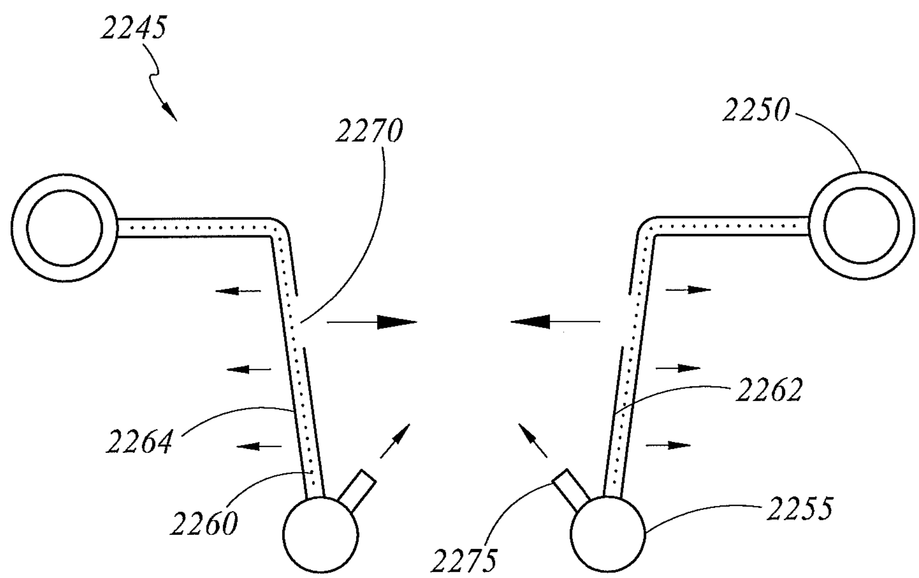
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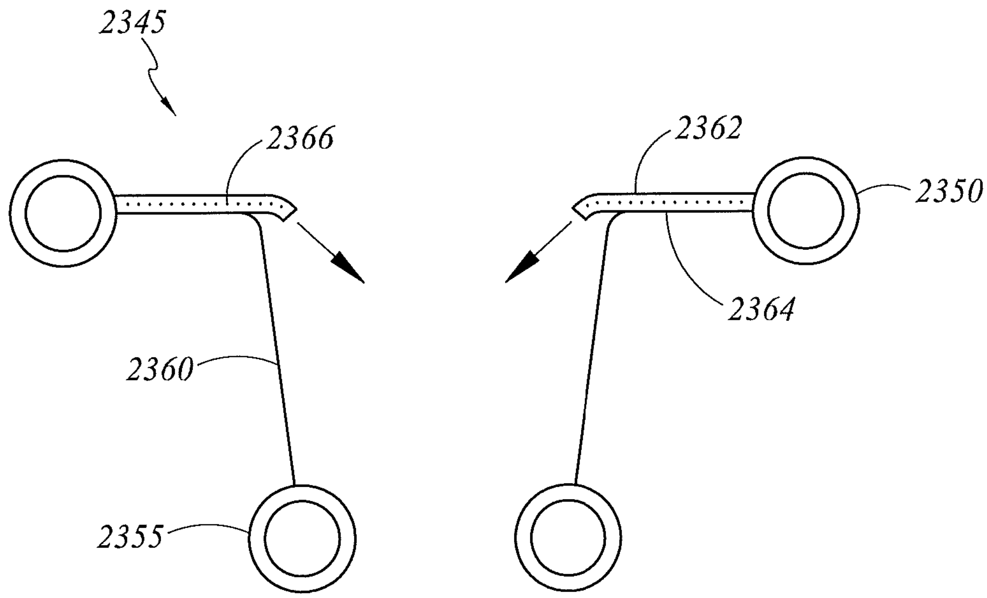
FIG. 20



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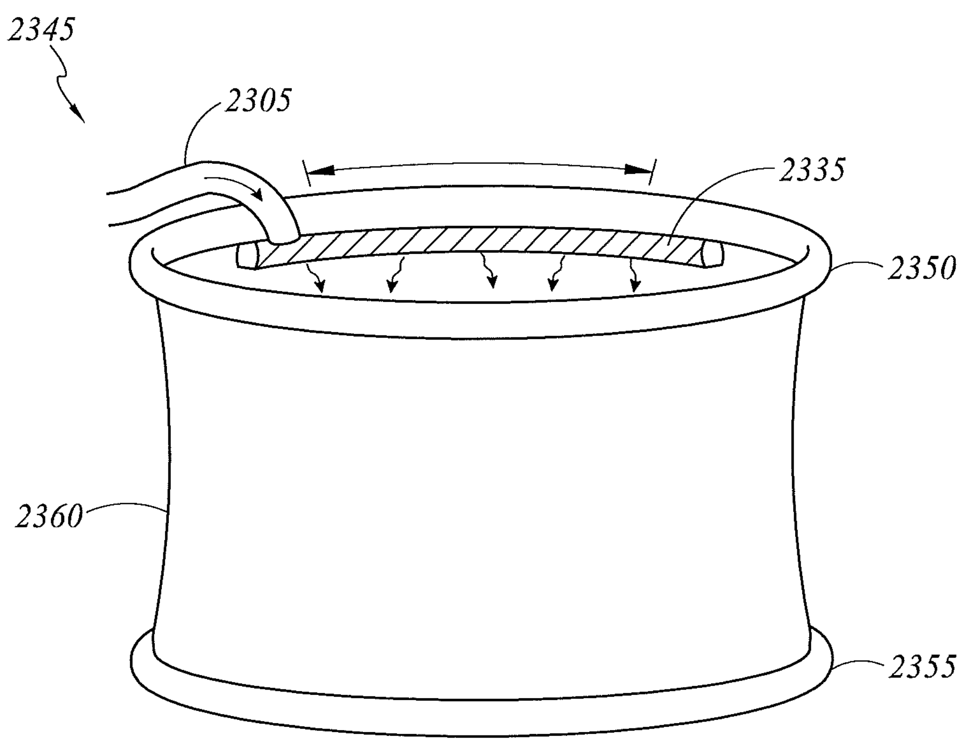

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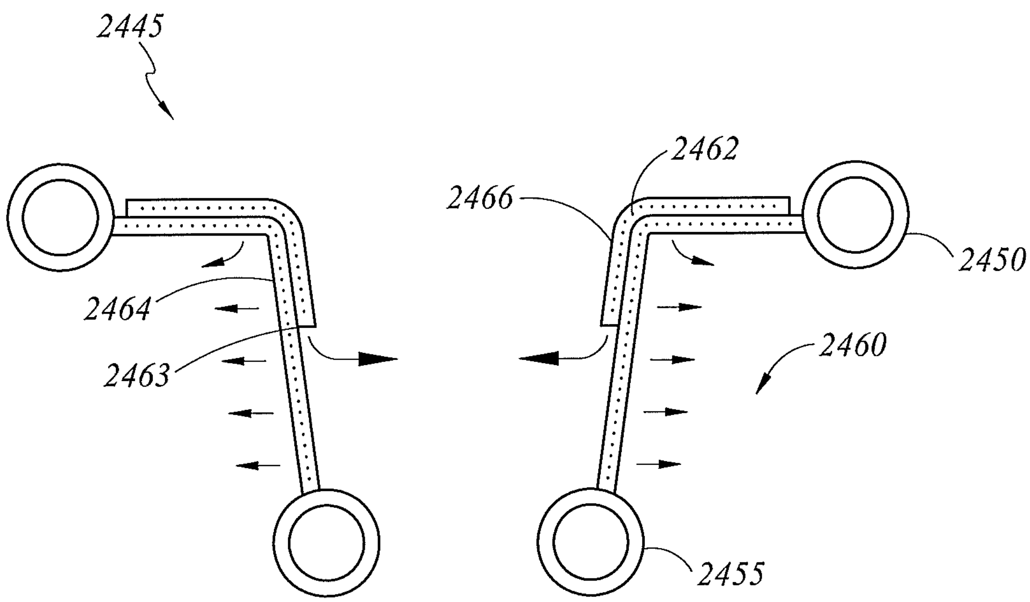

FIG. 22A

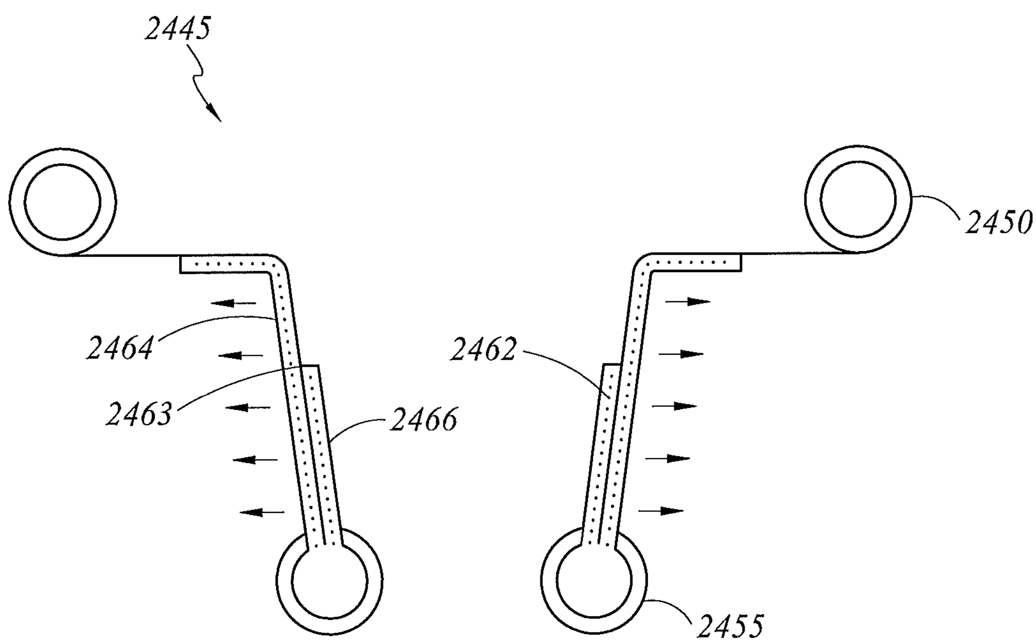

FIG. 22B

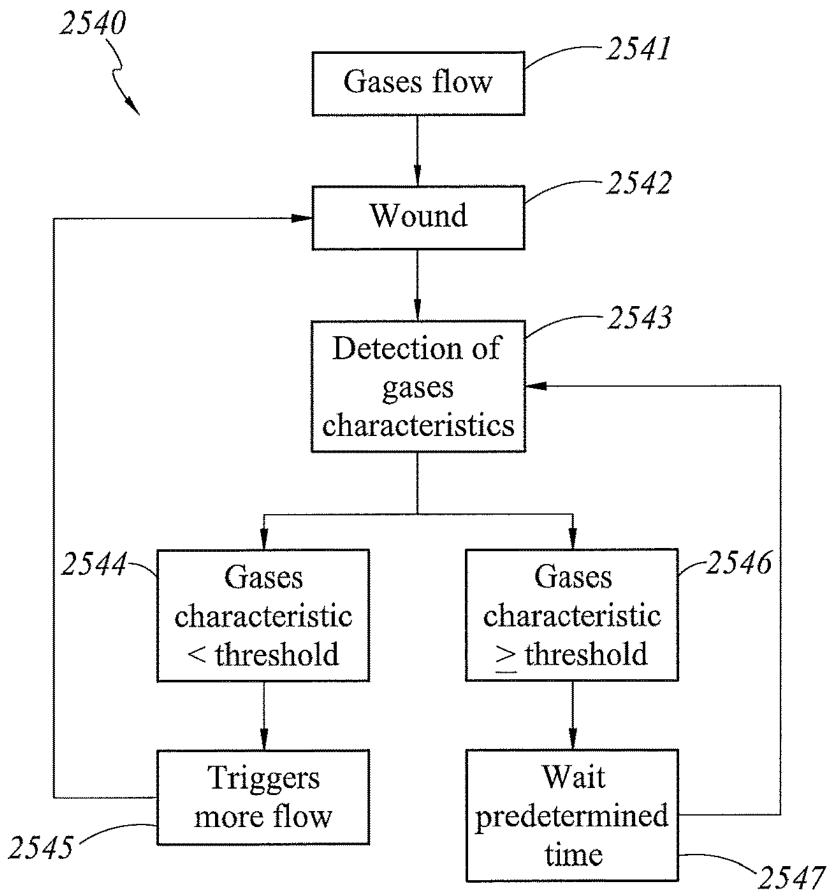
2540
Gases flow
2541
Wound
2542
Detection of gases characteristics
2543
2544
Gases characteristic < threshold
2546
Gases characteristic ≥ threshold
Triggers more flow
2545
Wait predetermined time
2547

FIG. 23

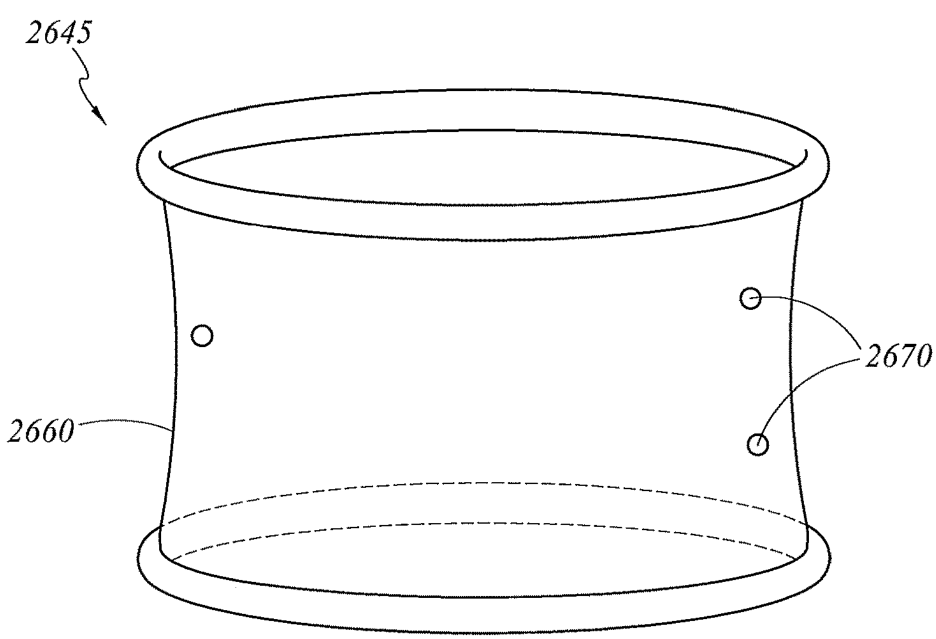
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FIG. 24

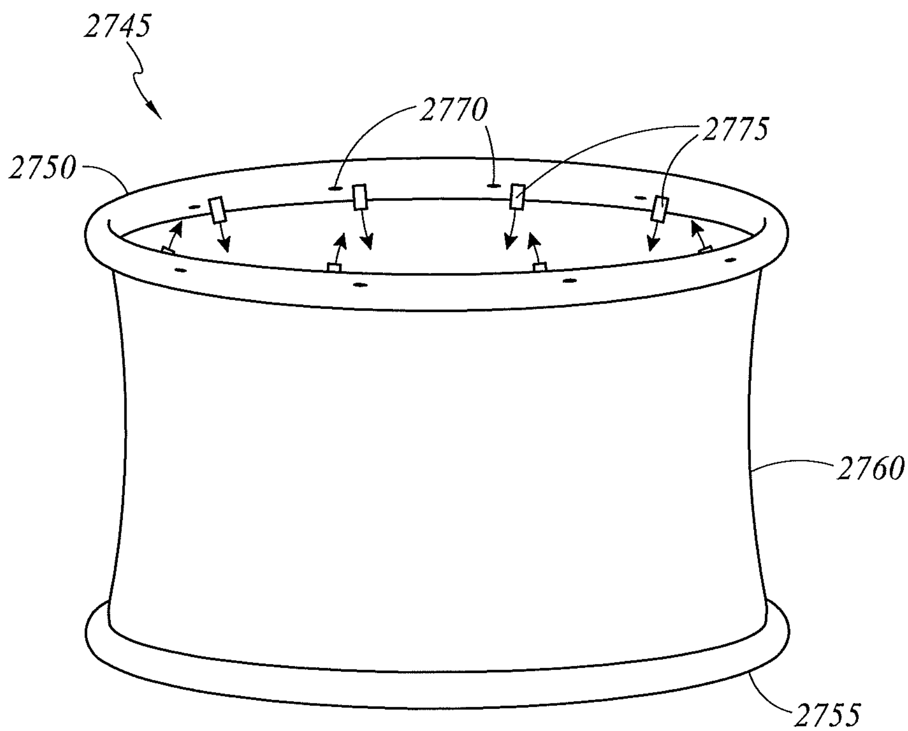

FIG. 25

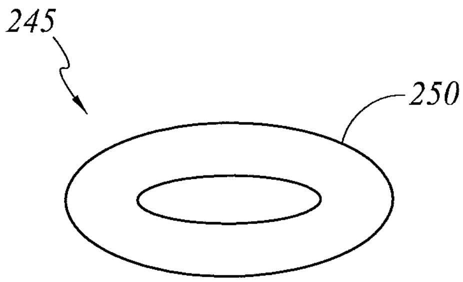

FIG. 26A

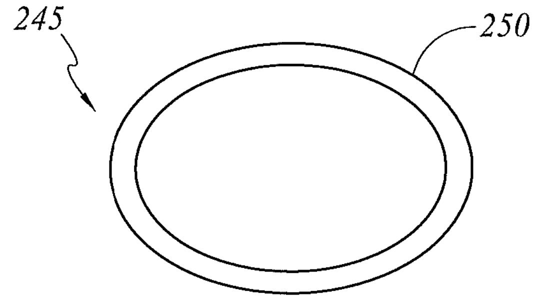

FIG. 26B

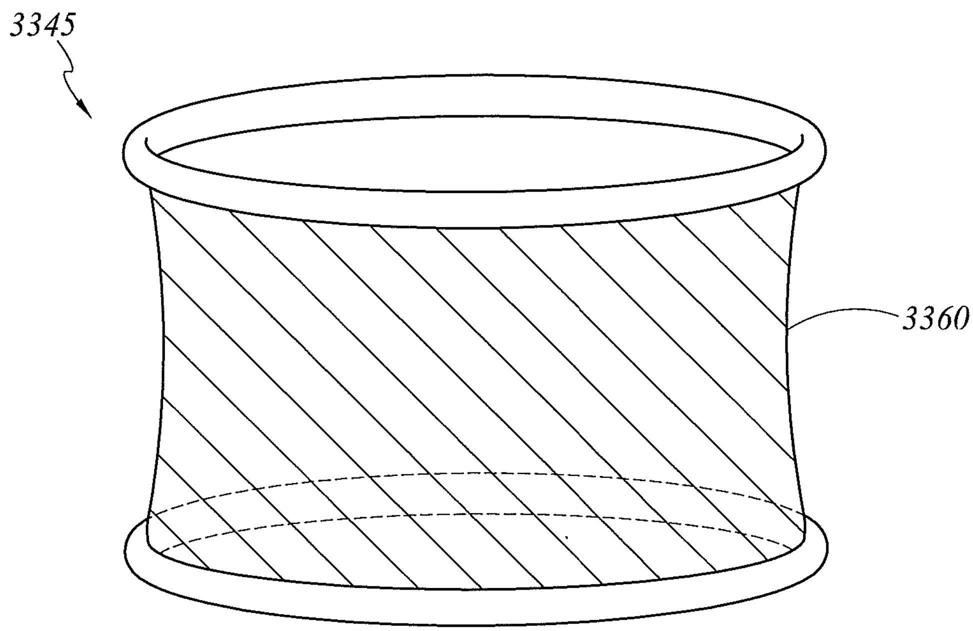

FIG. 27

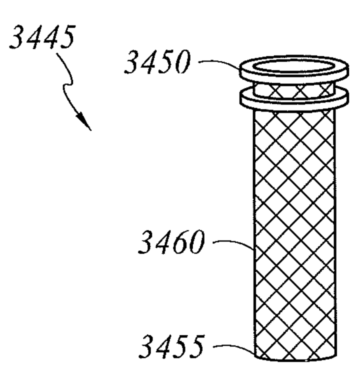

FIG. 28A

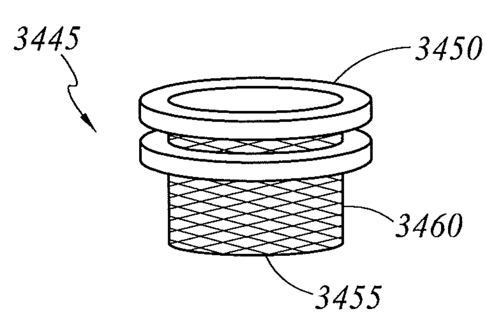

FIG. 28B

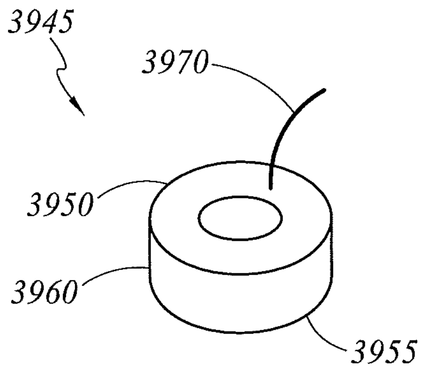

FIG. 29A

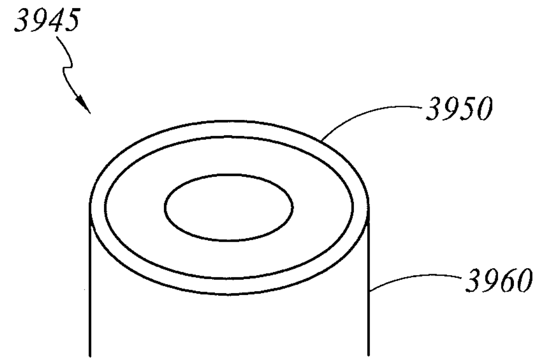

FIG. 29B

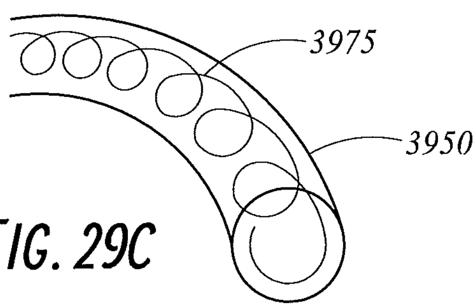

FIG. 29C

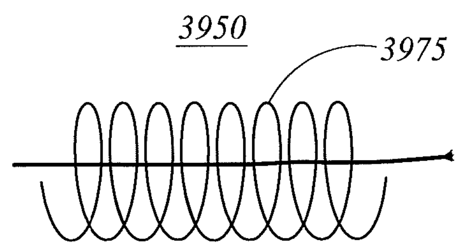

FIG. 29D

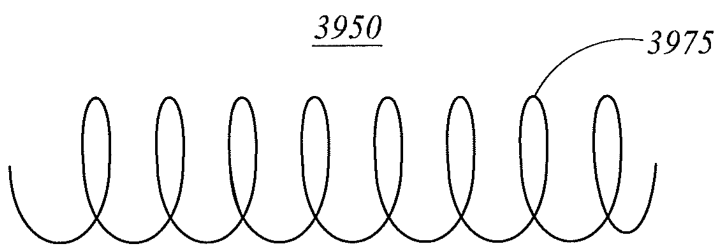

FIG. 29E

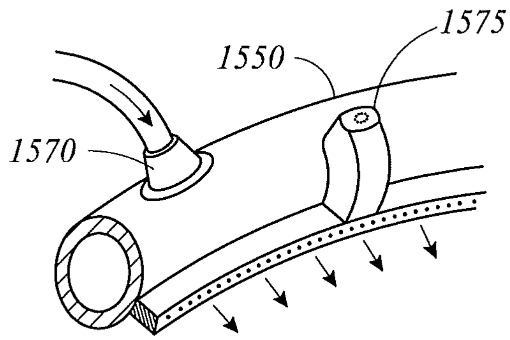

FIG. 30A

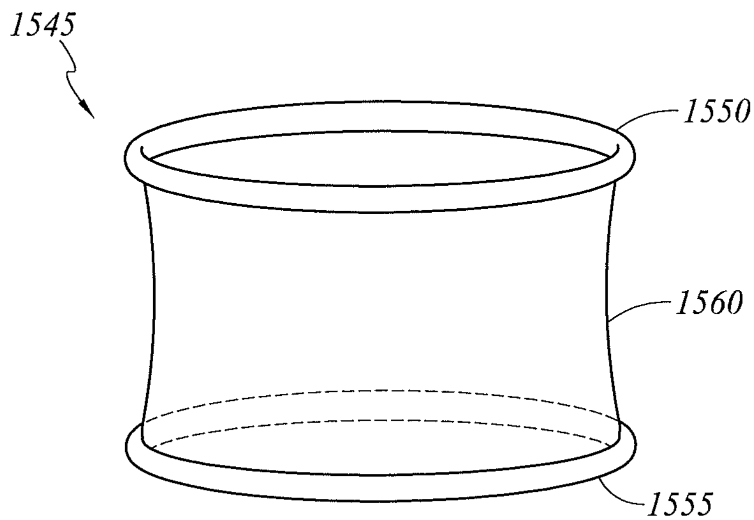

FIG. 30B

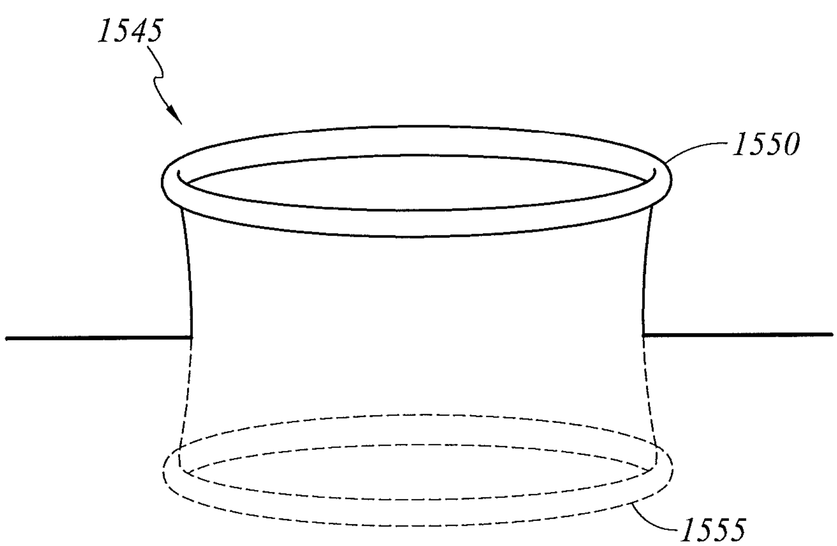

FIG. 30C

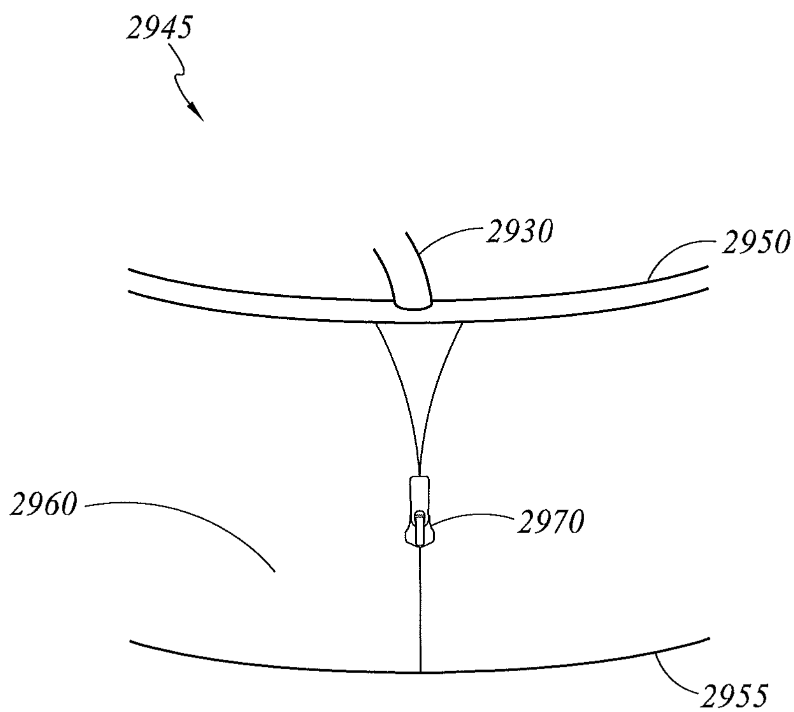

FIG. 31

WOUND RETRACTOR AND DIFFUSER

INCORPORATION BY REFERENCE TO ANY PRIORITY APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 17/132,565, filed Dec. 23, 2020, which is a continuation of U.S. patent application Ser. No. 15/539,575, filed Jun. 23, 2017, which is a U.S. National Phase of International Patent Application No. PCT/NZ2015/050219, filed Dec. 23, 2015, which claims priority to U.S. Provisional Application No. 62/096,469, filed Dec. 23, 2014, which is incorporated herein by reference in its entirety. Any and all applications for which a foreign or domestic priority claim is identified in the Application Data Sheet as filed with the present application are hereby incorporated by reference under 37 C.F.R. § 1.57.

FIELD OF THE DISCLOSURE

The present disclosure relates generally to wound retractors, and more particularly to improvements to wound retractors that may provide for delivery of medical gases to a wound cavity via a diffuser.

BACKGROUND

Surgical procedures, such as open surgery or laparoscopic surgery, for example, colorectal, thoracic, cardiac, obstetrics or gynaecologic surgery, expose tissues of a patient to atmospheric conditions. This may lead to desiccation and evaporative cooling of the wound.

In some instances, gases, for example, carbon dioxide, are used to create a workspace for a surgeon during a laparoscopic surgery. The gases are provided from a gases source, such as an insufflator, that regulates the gases pressure. The gases can be humidified by a humidification apparatus. In open surgery, gases can be used to create a protective space in which the surgeon can work on a wound. Heating and humidification of the gases helps to protect the wound from the harmful effects of cold, dry gases.

In open surgery, a wound retractor provides the surgeon access to the wound by exposing the anatomy on which the procedure is being performed. This creates a cavity in which the surgeon can work. One common type of wound retractor includes a pair of flexible concentric rings with a sleeve spanning there between. The wound retractor can be inserted into the opening of the patient cavity, with the lower ring in contact with the wound. Tension may be applied to the upper ring, for example, by rolling the ring. This causes the sleeve to become taut such that the wound retractor enlarges the wound entry, providing better access for the surgeon. In some instances, wound retractors are self-retaining and, once positioned, require minimal readjustment during the procedure.

Many prior art wound retractors require a user to perform multiple complex steps to insert the retractor into the cavity. Further, different wound geometries may prove difficult to effectively retract. The provision of gases into the cavity requires an additional instrument (in addition to the wound retractor) to be within the cavity. Due to limited space available within the cavity, this may obstruct or inconvenience the surgeon.

SUMMARY

The present disclosure describes wound retractors that can be used to supply gases to a wound during surgical procedures. Embodiments are disclosed wherein the wound retractor includes or is attachable to mechanisms that more accurately and effectively deliver gases to a patient. In an embodiment, the wound retractor provides heated and humidified gases to the wound as a single device. This may reduce the number of components within the workspace of the surgeon. This may also eliminate the step of positioning a separate diffuser within the cavity.

According to at least one aspect of the present disclosure, a diffuser for use with a wound retractor and configured to deliver gases can have one, some, or all of the following features, as well as other features described herein. The diffuser comprises an interface tube. The interface tube comprises a proximal end and a distal end. The distal end is configured to connect to a gases supply. The diffuser comprises a diffuser interface positioned at the proximal end. The diffuser interface is configured for receiving gases from the gases supply through the interface tube. The diffuser interface comprises a diffusion mechanism configured for delivering gases in a diffusion direction.

The interface tube may comprise a branching interface tube. The proximal end of the branching interface tube may comprise a plurality of proximal ends. The diffuser interface may comprise a plurality of diffuser interfaces each positioned at one of the plurality of proximal ends. The diffuser interface may be integrated with the interface tube. The diffuser interface may be attachable to the interface tube. The interface tube may comprise a flexible material. The flexible material may be floppy. The flexible material may be malleable. The interface tube may comprise a rigid material. The diffuser interface may comprise a complete ring shape. The diffuser interface may comprise a partial ring shape. The diffuser interface may branch to one or more outlets.

The diffusion mechanism may comprise one or more perforations formed in the diffuser interface. At least one of the perforations may be configured to provide non-laminar gases flow. At least one of the perforations may be configured to provide laminar gases flow. At least one of the perforations may be any shape, including rectangular or circular. At least one of the perforations may have a linear or curved cross-sectional profile. At least one of the perforations may have a trumpet-shaped cross-sectional profile. The diffusion mechanism may comprise a mesh. The diffusion mechanism may comprise an open cell foam. The diffusion mechanism may comprise a gases permeable membrane. The diffusion direction may be toward a cavity within the wound retractor. The diffusion direction may be inward, toward the center of the cavity. The diffusion direction may be downward, toward the bottom of the cavity. The diffusion direction may be toward a wound edge. The diffusion direction may be omnidirectional.

The diffuser may comprise a coupling mechanism configured to secure the diffuser to the wound retractor. The coupling mechanism may be selectively attachable to the diffuser. The coupling mechanism may be positioned on the interface tube. The coupling mechanism may be positioned on the diffuser interface. The coupling mechanism may comprise a clip. The clip may be biased in the open position (for example, using a spring) or in the closed position (for example, a peg, bulldog, or reverse spring-loaded clip). The clip may be an adjust-and-lock clip (for example, a grub screw with a ball and socket). The coupling mechanism may comprise a malleable member. For example, the malleable member may be a malleable arm configured to wrap around a portion of the wound retractor. The coupling mechanism may comprise an adhesive. The coupling mechanism may be configured to secure the diffuser to the wound retractor via a friction fit.

The wound retractor may comprise an upper ring, a lower ring, and a sleeve extending between and connecting the upper ring and the lower ring, and the coupling mechanism may be configured to secure the diffuser to the wound retractor at the upper ring. The wound retractor may comprise an upper ring, a lower ring, and a sleeve extending between and connecting the upper ring and the lower ring, and the coupling mechanism may be configured to secure the diffuser to the wound retractor at the lower ring. The wound retractor may comprise an upper ring, a lower ring, and a sleeve extending between and connecting the upper ring and the lower ring, and the coupling mechanism may be configured to secure the diffuser to the wound retractor at the sleeve. The wound retractor may comprise a conventional metal retractor, and the coupling mechanism may be configured to secure the diffuser to a portion of the metal retractor. The diffuser may comprise a coupling mechanism configured to secure the diffuser to another surgical instrument.

According to at least one aspect of the present disclosure, a wound retractor can have one, some, or all of the following features, as well as other features described herein. The wound retractor comprises an upper ring. The wound retractor comprises a lower ring. The wound retractor comprises a sleeve extending between and connecting the upper ring to the lower ring. The wound retractor comprises a diffuser interface. The diffuser interface comprises a gases inlet and a diffusion mechanism.

The wound retractor may comprise an interface tube. The interface tube may comprise a distal end configured to connect to a gases supply. The interface tube may comprise a proximal end configured to connect to the gases inlet. The interface tube may comprise a branching interface tube. The proximal end of the branching interface tube may comprise a plurality of proximal ends. The diffuser interface may comprise a plurality of diffuser interfaces each positioned at one of the plurality of proximal ends. The diffuser interface may be integrated with the interface tube. The diffuser interface may be attachable to the interface tube. The interface tube may comprise a flexible material. The flexible material may be floppy. The flexible material may be malleable. The interface tube may comprise a rigid material. The gases inlet may be positioned on the upper ring. The gases inlet may be positioned on the lower ring. The gases inlet may be positioned on the sleeve.

The diffuser interface may be integrated with the upper ring. The upper ring may comprise a hollow gases channel and the diffusion mechanism may be integrated into the upper ring. The diffuser interface may be integrated with the lower ring. The lower ring may comprise a hollow gases channel and the diffusion mechanism may be integrated into the lower ring. The diffuser interface may be integrated with the sleeve. The sleeve may comprise an inner layer and an outer layer separated by a space. At least one of the inner layer or the outer layer may be configured to be at least partially removable. The diffuser interface may comprise a spiral conduit attached to the sleeve. The spiral conduit may be attached to an inner surface of the sleeve. The diffuser interface may comprise one or more ribs attached to an outer surface of the sleeve. The ribs may be configured to define gases channels between the outer surface of the sleeve and a wound edge in use.

The diffusion mechanism may comprise one or more perforations formed in the diffuser interface. At least one of the perforations may be configured to provide non-laminar gases flow. At least one of the perforations may be configured to provide laminar gases flow. The diffusion mechanism may comprise a mesh. The diffusion mechanism may comprise an open cell foam. The diffusion mechanism may comprise a gases permeable membrane. The sleeve may be gases permeable.

The wound retractor may comprise a gases pathway within the diffuser interface. The gases pathway may comprise a directly plumbed pneumatic connection with at least one of the upper ring, the lower ring, or a pocket formed within the sleeve. The gases pathway may comprise a pocket formed between an inner layer of the sleeve and an outer layer of the sleeve. The pocket may connect a gases channel in the upper ring with a gases channel in the lower ring. The gases pathway may comprise one or more tubes extending between the upper ring and the lower ring. At least one of the tubes may be adjacent to an inner surface of the sleeve. At least one of the tubes may be adjacent to an outer surface of the sleeve. The gases pathway may comprise a porous material. The porous material may comprise a foamed or a sintered material.

The wound retractor may comprise one or more valves configured to control gases flow from the diffuser interface. At least one of the valves may be manually controllable. The wound retractor may comprise one or more gases flow rate sensors. At least one of the valves may be automatically controllable based at least in part on data received from the gases flow rate sensors.

According to at least one aspect of the present disclosure, a wound retractor can have one, some, or all of the following features, as well as other features described herein. The wound retractor comprises an upper ring, a lower ring, and a sleeve extending between and connecting the lower ring to the upper ring, wherein the sleeve is gases permeable.

The sleeve may comprise a gases permeable material. The sleeve may comprise perforations configured to allow gases to pass through. The wound retractor may comprise a sleeve extender. The sleeve extender may extend above the wound retractor. The sleeve extender may increase the depth of a cavity within the wound retractor. The sleeve extender may be permeable to gases. The sleeve extender may be impermeable to gases. The sleeve extender may be attachable to the upper ring. The sleeve extender may be attachable to the lower ring. The sleeve extender may be attachable to the sleeve.

The sleeve may be configured to direct gases flow. The sleeve may comprise an absorbent material. The absorbent material may be positioned on an outer layer of the sleeve. The absorbent material may be positioned on an inner layer of the sleeve. The absorbent material may be configured to absorb water, a medicament, or a therapeutic liquid. The absorbent material may comprise a chemical configured to produce an exothermic reaction when wetted. The wound retractor may comprise an ampule. The ampule may be configured to hold water, a medicament, or a therapeutic liquid. The ampule may be attached to the upper ring, the lower ring, or the sleeve. The sleeve may comprise an inner layer and an outer layer separated by a space. At least one of the inner layer and the outer layer may be configured to be at least partially removable. The wound retractor may comprise a volume of foam attached to an outer surface of the sleeve.

At least one of the upper ring and the lower ring may be configured to go through a transformation between a larger diameter state and a smaller diameter state. The transformation may be actuated by application of an electrical current.

The transformation may be actuated by application of pneumatic pressure. The transformation may be actuated by a mechanical feature of the upper ring and/or the lower ring. The mechanical feature may be a tethered coil or spring, mechanical iris, or expandable truss. The sleeve may comprise a zipper.

For purposes of summarizing the disclosed systems and apparatus, certain aspects, advantages, and novel features of the disclosed systems and apparatus have been described herein. It is to be understood that not necessarily all such advantages may be achieved in accordance with any particular embodiment of the disclosed systems and apparatus. Thus, the disclosed systems and apparatus may be embodied or carried out in a manner that achieves or optimizes one advantage or group of advantages as taught herein without necessarily achieving other advantages as may be taught or suggested herein.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present disclosure will be described with respect to the following figures, which are intended to illustrate and not to limit the preferred embodiments. In the figures, similar elements have similar reference numerals.

FIG. **1**A illustrates a schematic view of a gases delivery system for use during a surgical procedure according to an embodiment of the present disclosure.

FIG. **1**B illustrates a schematic view of the gases delivery system of FIG. **1**A used with a wound retractor according to an embodiment of the present disclosure.

FIGS. **2**A and **2**B illustrate various views of a wound retractor according to embodiments of the present disclosure.

FIGS. **3**A and **3**B illustrate perspective views of a wound retractor including features for clipping a diffuser onto the wound retractor according to embodiments of the present disclosure.

FIGS. **4**A through **4**C illustrate various views of a wound retractor including a diffusing upper ring according to embodiments of the present disclosure.

FIGS. **5**A through **5**C illustrate various views of a wound retractor including a ring-shaped diffuser interface that can be clipped onto a ring of the wound retractor according to embodiments of the present disclosure.

FIGS. **6**A through **6**D illustrate various views of a wound retractor including a diffuser interface that is attachable to the wound retractor according to embodiments of the present disclosure.

FIG. **7** illustrates a perspective view of a wound retractor configured for scavenging smoke or gases from a cavity according to an embodiment of the present disclosure.

FIGS. **8**A and **8**B illustrate perspective views of a wound retractor including a spiral conduit according to embodiments of the present disclosure.

FIGS. **9**A through **9**D illustrate various views of a wound retractor including a sleeve defining a pocket with channels according to embodiments of the present disclosure.

FIG. **10** illustrates a perspective view of a wound retractor configured to diffuse gases into a cavity and/or to a wound edge according to an embodiment of the present disclosure.

FIG. **11** illustrates a perspective view of a wound retractor including a sleeve extender according to an embodiment of the present disclosure.

FIG. **12** illustrates a perspective view of a wound retractor including a plurality of channels pneumatically connecting an upper ring with a lower ring according to an embodiment of the present disclosure.

FIG. **13** illustrates a perspective view of a wound retractor including an absorbent sleeve according to an embodiment of the present disclosure.

FIGS. **14**A through **14**C illustrate cross-sectional views of a wound retractor including a rib on a sleeve according to embodiments of the present disclosure.

FIGS. **15**A through **15**C illustrate perspective views of a wound retractor including bifurcated interface tubes according to embodiments of the present disclosure.

FIG. **16** illustrates a perspective view of a wound retractor configured to deliver gases through a pocket in a sleeve according to an embodiment of the present disclosure.

FIG. **17** illustrate a perspective view of a wound retractor including a perforated sleeve according to an embodiment of the present disclosure.

FIGS. **18**A and **18**B illustrate perspective views of a wound retractor configured to wick and/or heat liquid according to embodiments of the present disclosure.

FIG. **19** illustrates a top view of a wound retractor including a bifurcating interface tube according to an embodiment of the present disclosure.

FIG. **20** illustrates a cross-sectional view of a wound retractor with a multi-layer sleeve according to an embodiment of the present disclosure.

FIGS. **21**A and **21**B illustrate various views of a wound retractor with an adjustable diffuser according to embodiments of the present disclosure.

FIGS. **22**A and **22**B illustrate cross-sectional views of a wound retractor including an inner foam layer configured to contact a wound edge according to embodiments of the present disclosure.

FIG. **23** illustrates a flow chart of a method implemented by a control system for controlling gases flow to a wound according to an embodiment of the present disclosure.

FIG. **24** illustrates a perspective view of a wound retractor including sensors controlled using the control system of FIG. **23** for measuring a characteristic of gases within a cavity according to an embodiment of the present disclosure.

FIG. **25** illustrates a perspective view of a wound retractor including a plurality of sensors and a plurality of independently controllable gases outlets according to an embodiment of the present disclosure.

FIGS. **26**A and **26**B illustrate perspective views of an upper ring of a wound retractor in a first state and a second state according to embodiments of the present disclosure.

FIG. **27** illustrates a perspective view of a wound retractor including a sleeve comprising a temperature responsive material according to an embodiment of the present disclosure.

FIGS. **28**A and **28**B illustrate perspective views of a wound retractor in a first state and a second state according to embodiments of the present disclosure.

FIGS. **29**A through **29**E illustrate various views of a wound retractor that can transition between a first state and a second state by use of a tether according to embodiments of the present disclosure.

FIGS. **30**A through **30**C illustrate various views of a wound retractor including an inflatable upper ring and an inflatable lower ring according to embodiments of the present disclosure.

FIG. **31** illustrates a partial perspective view of a wound retractor including a zipper on the sleeve according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

The following description is merely illustrative in nature and is in no way intended to limit the scope of the present disclosure or its application or uses. For purposes of clarity, the same or similar reference numbers will be used in the drawings to identify similar elements. However, for the sake of convenience, certain features present or annotated with reference numerals in some figures of the present disclosure are not shown or annotated with reference numerals in other figures of the present disclosure. Unless the context clearly requires otherwise, these omissions should not be interpreted to mean that features omitted from the drawings of one figure could not be equally incorporated or implemented in the configurations of the disclosed methods, apparatus and systems related to or embodied in other figures. Conversely, unless the context clearly requires otherwise, it should not be assumed that the presence of certain features in some figures of the present disclosure means that the disclosed methods, apparatus and systems related to or embodied in such figures must necessarily include these features.

It is to be understood that the systems and apparatus disclosed herein can exist in any combination or permutations. Thus, features from different embodiments can be synergistically combined without departing from the scope of the disclosed apparatus and systems.

FIG. **1**A illustrates a schematic view of a gases delivery system **100** for use during a surgical procedure according to an embodiment of the present disclosure. The surgical procedure could be either laparoscopic or open surgery. The gases delivery system **100** includes a gases source **105**, a gases supply tube **110**, a humidification apparatus **115**, a delivery tube **125**, an interface tube **130**, and an interface **135**. The humidification apparatus **115** includes a humidification chamber **120**. Gases from the gases source **105** travel through the gases supply tube **110** to the humidification apparatus **115** where they are heated and humidified. The gases are then delivered to a patient **140** via the delivery tube **125**, the interface tube **130**, and the interface **135**, respectively. The term “gases” is used herein broadly to refer to any gas and/or combination of gases that may be used in surgical applications, such as, carbon dioxide, helium, air, carbon dioxide combined with nitrous, carbon dioxide combined with oxygen, among others. Other gases and combinations also fall within the scope of the present disclosure. In an embodiment, the delivery tube **125** and the interface tube **130** comprise a single tube that delivers the humidified gases to the interface **135**. In an embodiment, a single component integrates the delivery tube **125**, the interface tube **130**, and the interface **135**.

FIG. **1**B illustrates a schematic view of the gases delivery system **100** used with a wound retractor **145** according to an embodiment of the present disclosure. The wound retractor **145** may be used to increase the workspace of the surgeon, increase accessibility to the wound, improve visualisation of the wound, and reduce trauma to the patient **140** during the procedure, among other purposes.

In an embodiment, the humidification apparatus **115** generates humidity via a mechanism other than pass-over humidification, such as, for example, a heated absorbent material that holds water. Thus, the humidification apparatus **115** can be a compact component and easily integrated into the system. In an embodiment, the humidification apparatus **115** may be integral to the delivery tube **125** and/or the interface tube **130**. In an embodiment, the humidification apparatus **115** is configured to be in-line with the delivery tube **125** and/or the interface tube **130**. This may allow the humidification apparatus **115** to be proximal to the patient **140**.

FIG. **2**A illustrates a perspective view of the wound retractor **145**, and FIG. **2**B illustrates a cross-sectional view of the wound retractor **145** in use, according to embodiments of the present disclosure. In an embodiment, the wound retractor **145** comprises an upper ring **150**, a lower ring **155**, and a sleeve **160** extending between and connecting the upper ring **150** and the lower ring **155**. The sleeve **160** may comprise a flexible material, such as a film, that may be permeable or impermeable to liquids and/or gases. The sleeve **160** may be robust so as to reduce or eliminate the likelihood of tears or punctures. In an embodiment, the sleeve **160** is at least partially transparent. In an embodiment, the sleeve **160** is opaque.

As illustrated in FIG. **2**B, in use on the body of the patient **140** during a procedure, the sleeve **160** seals against a wound edge **141**. The sleeve **160** is configured to retract the wound edge **141** and to prevent exposure of the wound edge **141** to bacteria. The seal may also isolate the wound edge **141** from exposure to gases delivered to the wound **142** during the procedure. The wound edge **141**, as described herein, is a part of the wound **142** that sits against an outer layer of the sleeve **160**, and thus, is located around the perimeter of the area enclosed by the wound retractor **145**. The wound **142**, as described herein, refers to the tissue that lies within the wound retractor **145** when the wound retractor **145** is inserted into the patient **140**. The wound retractor **145** forms a cavity **190**, which, as described herein, refers to the area created by the wound retractor **145** that provides access to the wound **142**. With the wound retractor **145** in place, the wound **142** is accessible through the opening in the upper ring **150** and the cavity **190**.

To insert the wound retractor **145** into the patient **140**, the lower ring **155** is inserted into an incision such that it is adjacent to the wound **142**. The upper ring **150** is then positioned above the wound **142**. Tension may be applied to the sleeve **160**, for example, by rotating or rolling the upper ring **150**, causing the sleeve **160** to fit snugly against the wound edge **141**, thus creating the cavity **190** within the wound retractor **145**. The upper ring **150** and the lower ring **155** can be made from a flexible plastic material. The upper ring **150** and the lower ring **155** may be manipulated into place adjacent to the wound **142**, for example by compression, but expand to their original shapes following insertion.

As discussed above, the sleeve **160** of the wound retractor **145** seals against the wound edge **141**. In an embodiment, the sleeve **160** comprises a gases impermeable material that isolates the wound edge **141** from exposure to gases delivered to the cavity **190** (for example, using the gases delivery system **100**). In an embodiment, the sleeve **160** comprises a gases permeable material that exposes the wound edge **141** to gases delivered to the cavity **190**. In some embodiments, gases delivered to the cavity **190** may have a beneficial effect when exposed to the wound edge **141**.

Gases such as carbon dioxide have been shown to have a beneficial effect, known as the Bohr Effect, when in contact with body tissue. The Bohr Effect occurs due to an increased partial pressure of carbon dioxide in the blood, which causes the blood pH to decrease. As a result, oxygen is less tightly bound to the haemoglobin within the erythrocytes. Thus, an increased exposure of tissue to carbon dioxide increases oxygen release within the tissue. This increases the speed of wound healing and reduces the risk of surgical site infection and post-operative pain.

In an embodiment, other gases or combinations of gases provide beneficial effects to body tissue. For example, but without limitation: a combination of carbon dioxide and nitrous provides a local anaesthetic effect when in contact with tissue; a combination of carbon dioxide and oxygen further increases tissue oxygenation; and helium reduces tissue acidosis. It is to be understood that use of these gases, or other gases not listed above also fall within the scope of the disclosed apparatus and systems.

FIGS. **3**A and **3**B illustrate perspective views of a wound retractor **345** including features for clipping a diffuser **370** onto the wound retractor **345** according to embodiments of the present disclosure. In an embodiment, the diffuser **370** is a conventional diffuser. The wound retractor **345** includes an upper ring **350**, a lower ring **355**, and a sleeve **360** extending between and connecting the upper ring **350** and the lower ring **355** and creating a cavity **390** in use. In the illustrated embodiment, a coupling mechanism **375** is attached to the upper ring **350**. The coupling mechanism **375** may be a compliant or mechanical clip, or other suitable structure. The coupling mechanism **375** is configured to secure an interface tube **330** and/or the diffuser **370** to the upper ring **350**, thus holding the diffuser **370** in position during a procedure. In an embodiment, the diffuser **370** is secured in position so as to be located within the cavity **390**. In an embodiment, the diffuser **370** is positioned proximate the sidewall of the sleeve **360**. Thus, the diffuser **370** delivers gases to the cavity **390**. The wound retractor **345** including a coupling mechanism **375** may reduce frustration of a surgeon caused by a loose or unsecured diffuser positioned within the limited workspace.

In an embodiment, the coupling mechanism **375** may be integrally molded with the upper ring **350**. In an embodiment, the coupling mechanism **375** may comprise a separate part that is attached to the upper ring **350**. For example, the coupling mechanism **375** may be attached with adhesives or snap-fit onto the upper ring **350**. Thus, the coupling mechanism **375** may be permanently or removably attached to the upper ring **350**. The coupling mechanism **375** may be a rigid or compliant part that receives the interface tube **330** and/or the attached diffuser **370**. In an embodiment, the coupling mechanism **375** comprises prong-like structures that are configured to flex to allow insertion and securement of the interface tube **330** and/or the attached diffuser **370**.

Although described above, and illustrated in the figures, as attached to the upper ring **350**, in an embodiment, the coupling mechanism **375** may be attached to the lower ring **355** or to the sleeve **360**. In an embodiment, the coupling mechanism **375** may comprise multiple coupling mechanisms, and the upper ring **350** and the lower ring **355** may each include one or more of the coupling mechanisms **375**.

In the embodiment illustrated in FIG. **3**A, the sleeve **360** is formed from a material that is impermeable to gases. Thus, gases diffusing from the diffuser **370** are generally contained within the cavity **390**. In the embodiment illustrated in FIG. **3**B, the sleeve **360** is formed from a material that is permeable to gases. For example, the sleeve **360** may be perforated with holes or comprise a gases permeable mesh or other gases permeable material. Thus, gases diffusing from the diffuser **370** into the cavity **390** can pass through the sleeve **360** to the wound edge **141**. As a result, the wound edge **141** benefits from the heated, humidified gases.

FIGS. **4**A through **4**C illustrate various views of a wound retractor **445** including a diffusing upper ring **450** according to embodiments of the present disclosure. FIG. **4**A illustrates a perspective view of the wound retractor **445** including the diffusing upper ring **450**, a lower ring **455**, and a sleeve **460** extending between and connecting the diffusing upper ring **450** and the lower ring **455** and creating a cavity **490** in use. The diffusing upper ring **450** may be hollow, defining a flow path for gases therein. The diffusing upper ring **450** may include a gases inlet **470**. The gases inlet **470** may be connectable to an interface tube **430** for receiving gases from a gases source. The gases inlet **470** may include a connector **475** for connecting to the interface tube **430**.

The diffusing upper ring **450** may include one or more perforations **453** along a lower surface of the diffusing upper ring **450**. The perforations **453** may be configured to direct gases into the cavity **490** and toward the wound. The perforations **453** may be directed openings. FIG. **4**B illustrates a partial cross-sectional view of the diffusing upper ring **450** according to an embodiment of the present disclosure, where the perforations **453** are configured to direct gases along an inner wall of the sleeve **460** and into the cavity **490**. FIG. **4**C illustrates a partial cross-sectional view of the diffusing upper ring **450** according to an embodiment of the present disclosure, where the perforations **453** are configured to direct gases along an outer wall of the sleeve **460**, between the sleeve **460** and the wound edge **441**. In an embodiment, the gases may be directed downward. In an embodiment, the gases may be directed across the opening of the cavity **490**, at least in part to create an air curtain effect. Such a configuration may reduce or prevent contaminants, such as bacteria, from reaching or settling on the wound or the wound edge **441**. In an embodiment, the sleeve **460** is gases permeable such that the gases are also delivered through the sleeve **460** to the wound edge **441**.

Although the embodiments disclosed herein have been described in reference to the upper ring **450**, in an embodiment, the perforations and gases inlet may be included on the lower ring **455** instead of or in addition to the upper ring **450**.

FIGS. **5**A through **5**C illustrate various views of a wound retractor **545** including a ring-shaped diffuser interface **535** that can be clipped onto a ring of the wound retractor **545** according to embodiments of the present disclosure. FIG. **5**A illustrates an exploded partial perspective view of the wound retractor **545**. The wound retractor **545** includes an upper ring **550**, a lower ring **555**, and a sleeve **560** extending between and connecting the upper ring **550** and the lower ring **555**. The diffuser interface **535** may include one or more coupling mechanisms **570** that are configured to attach the diffuser interface **535** to the upper ring **550**. In an embodiment, the coupling mechanisms **570** extend at least partially around the perimeter of the upper ring **550**. In an embodiment, the coupling mechanisms **570** extend fully around the perimeter of the upper ring **550**. In an embodiment, the coupling mechanisms **570** comprise one or more discrete clips that are used to couple the diffuser interface **535** to the upper ring **550** at several locations. In an embodiment, the coupling mechanisms **570** clip onto the outside of the upper ring **550**. In an embodiment, the coupling mechanisms **570** are reversibly clipped onto the outside of the upper ring **550**. The coupling mechanisms **570** can be attached to, for example, the wound retractor **145**, as well as other wound retractors. In an embodiment, the coupling mechanisms **570** and the diffuser interface **535** are separate pieces, while, in other embodiments, they are integrally formed.

FIG. **5**B illustrates a partial cross-sectional view of the wound retractor **545** and the diffuser interface **535**, where one of the coupling mechanisms **570** may include a clip **574** that is attached (either permanently or removably) to a surface of the diffuser interface **535**. In an embodiment, the clip **574** is attached to the diffuser interface **535** at a lower surface of the diffuser interface **535**. In an embodiment, the clip **574** is attached to the diffuser interface **535** at a side surface of the diffuser interface **535**. In an embodiment, the clip **574** is attached to the diffuser interface **535** at an upper surface of the diffuser interface **535**. In an embodiment, the clip **574** extends around the outside of the upper ring **550**. A hook **578** is formed at the end of the clip **574** and helps to secure the clip **574** onto the upper ring **550**. The sleeve **560** extends from the base of the upper ring **550**, over the top of the hook **578**, and to the lower ring **555**.

The diffuser interface **535** may comprise a gases permeable material that enables gases to diffuse into the cavity. In an embodiment, the diffuser interface **535** comprises directed openings **574**. The directed openings **574** as described herein refer to perforations designed to direct the flow of gases. For example, the directed openings **574** may comprise openings, channels, or holes with specific shapes. The shapes may be designed to reduce the velocity of the gases. The gases permeable material comprising perforations may be a plastics material. In an embodiment, the material may be a semi-rigid or rigid plastics material. The directed openings **574** can be present around the entire perimeter of the diffuser interface **535** or only in certain locations on the diffuser interface **535**. In an embodiment, the gases permeable material of the diffuser interface **535** comprises a foam material or an open cell foam material.

The diffuser interface **535** may comprise a ring; that is, the diffuser interface **535** may be ring-shaped. The diffuser interface **535** may comprise a tube **573** with a hollow cross-section, as illustrated in FIG. **5**B. A gases inlet **571** connects with an interface tube **530** to allow gases to enter the tube **573**. The gases are then diffused into the cavity via the gases permeable material of the diffuser interface **535** or the directed openings **574**. In an embodiment, the diffuser interface **535** may comprise an impermeable side, cover, or film to prevent or reduce the likelihood of gases diffusing into the wound edge. In an embodiment, the entirety of the diffuser interface **535** is gases permeable such that gases diffuse into the cavity through the sleeve **560** to the wound edge. In an embodiment, the diffuser interface **535** may not comprise a full ring shape; that is, the diffuser interface **535** may comprise only an arcuate shape that extends partially around the upper ring **550**.

FIG. **5**B illustrates a partial cross-sectional view of the wound retractor **545** and the diffuser interface **535**. The diffuser interface **535** comprises a bifurcating structure, or a structure with multiple gases entry points. In an embodiment, the diffuser interface **535** comprises a foamed material or an open cell foam material. In an embodiment, the diffuser interface **535** comprises directed openings. In an embodiment, the diffuser interface **535** comprises perforations to provide gases to the cavity. The perforations may alter in size, such that larger perforations are proximal the wound. This improves diffusion of the gases to the wound through the perforations and maintains a more consistent flow rate along the length of the sleeve **560**. The bifurcating structure allows at least a part of the diffuser interface **535** to be positioned within the cavity, for example, tucked beneath the skin of the patient and out of the way of the surgeon. Thus, the diffuser interface **535** is less obtrusive during the procedure. The surgeon can arrange the position of the diffuser interface **535** within the cavity.

The diffuser interface **535** has a large area in which to diffuse the gases to the cavity. In an embodiment, the diffuser interface **535** comprises different shapes, such as, for example, a flat diffuser. In an embodiment, the diffuser interface **535** comprises a memory such that the diffuser interface **535** can maintain its manipulated shape. The diffuser interface **535** pneumatically connects with the interface tube **530**.

In an embodiment, the sleeve **560** is impermeable to gases flow. In an embodiment, the sleeve **560** is permeable to gases flow such that gases diffuse into both the cavity and the wound edge.

In an embodiment, the diffuser interface **535** couples with the upper ring **550**. The coupling mechanism **570** couples the diffuser interface **535** with the upper ring **550**. In an alternative, adhesives or welding can couple the diffuser interface **535** with the upper ring **550**. The diffuser interface **535** is configured to be a separate component to the wound retractor **545**. Thus, in an embodiment, the diffuser interface **535** is configured to couple with, for example, the wound retractor **145** or other wound retractors.

In an embodiment, the lower ring **555** comprises a clip or additional coupling mechanism to couple with the diffuser interface **535**. The clip or additional coupling mechanism may be used in addition to the coupling mechanism **570**, or instead of the coupling mechanism **570**. In an embodiment, the coupling mechanism **570** is positioned to couple the diffuser interface **535** with the lower ring **555**.

In an embodiment, the diffuser interface **535** is configured to be positioned outside the cavity. The diffuser interface **535** is manipulated to fit between the wound edge and the wound retractor **545**. This reduces obstruction to the surgeon during the procedure. Also, the wound edge receives heated and humidified gases from the diffuser interface **535**. The sleeve **560** comprises a gases permeable material such that gases diffuse through the sleeve **560** into the cavity.

FIG. **5**C illustrates a partial cross-sectional view of the diffuser interface **535** with a sheet **580** bonded to the diffuser interface **535** so that gases directed out of the openings **574** travel down between the wound edge and the sheet **580** and exit into the wound at the base of the sheet **580**. The sheet **580** may have ridges on the interior surface to form channels for gases to travel down between the sheet **580** and the wound edge. This embodiment may be used with retractors that do not have integrated sleeves, such as old style metal retractors.

Although the wound retractor **545** has been described above with reference to the diffuser interface **535** clipping to the upper ring **550**, in an embodiment, the diffuser interface **535** may be clipped to the lower ring **560** in the same manner.

FIG. **6**A illustrates a cross-sectional view of an embodiment of a wound retractor **645** with an embodiment of a diffuser interface **635** that is attachable to a sleeve **660**. The wound retractor **645** includes an upper ring **650**, a lower ring **655**, and the sleeve **660** extending between and connecting the upper ring **650** and the lower ring **655**. FIGS. **6**B through **6**D illustrate additional views of the diffuser interface **635** of FIG. **6**A.

The diffuser interface **635** is configured to couple with the sleeve **660** to provide gases to the cavity. In the illustrated embodiment, the diffuser interface **635** comprises a tube **670** and a coupling member **675**. The coupling member **675** is configured to attach (either permanently or removably) to the sleeve **660** as described below. In an embodiment, the coupling member **675** is configured to be made from sprung steel. In an embodiment, the coupling member **675** is configured to be made from a flexible plastics material. The tube **670** is configured to be permeable to gases. In an embodiment, the tube **670** includes directed openings **674** or perforations.

As illustrated in FIG. **6**B, a first surface **675***a* of the coupling member **675** is configured to couple to the tube **670**. A second surface **675***b* of the coupling member **675** is configured to couple with the sleeve **660**. The coupling member **675** may couple with the tube **670** via adhesives, clipping mechanisms, welding, or other suitable method. In an embodiment, the coupling member **675** is permanently coupled with the tube **670**. In an embodiment, the coupling member **675** removably couples with the sleeve **660** via adhesives or a clipping mechanism. In an embodiment, the coupling member **675** is integrated into the sleeve **660**. In an embodiment, the coupling member **675** is permanently coupled with the sleeve **660**, such as, for example, by a snap-fit mechanism, adhesives or welding.

In an embodiment, the coupling member **675** comprises a grip **680**, as illustrated in FIG. **6**C. In an embodiment, the grip **680** is a rubberized grip. The grip **680** may provide a surface able to be grasped by a user during setup or installation of the diffuser interface **635**. In an embodiment, the grip **680** provides a roughened surface that facilitates better coupling between the coupling member **675** and the sleeve **660**. In an embodiment, the grip **680** increases the friction between the coupling member **675** and the sleeve **660**.

In an embodiment, the diffuser interface **635** is integral to the wound retractor **645**. In an embodiment, the diffuser interface **635** is a separate part that is removably or permanently coupled with the wound retractor **645**. The diffuser interface **635** may be configured to couple with the wound retractor **645** prior to or after insertion of the wound retractor **645** into the cavity. In an embodiment, tension is applied to the diffuser interface **635** to facilitate insertion of the wound retractor **645** into the cavity. Tension may, for example, reduce the size of the diffuser interface **635** during insertion. FIG. **6**C illustrates the diffuser interface **635** in a contracted state while under tension. Removal of the tension allows the diffuser interface **635** to expand. FIG. **6**B illustrates the diffuser interface **635** in an expanded state once the tension has been removed. Expansion causes the diffuser interface **635** to be positioned proximal to the wound.

In an embodiment, the diffuser interface **635** presses into the wound. This may allow for localized diffusion of gases to the wound. In an embodiment, the diffuser interface **635** is configured to couple with, for example, the sleeve **160** of the wound retractor **145**. Thus, the diffuser interface **635** may be a modular part that is used to adapt the wound retraction systems.

As mentioned above, the coupling member **675** is configured to couple the tube **670** to the sleeve **660**. In an embodiment, the coupling member **675** couples the tube **670** to an inner surface of the sleeve **660** (as illustrated in FIG. **6**A). In an embodiment, the sleeve **660** is made from a gases permeable material or comprises a gases outlet to facilitate gases movement from inside the cavity to the wound edge. In an embodiment, the gases outlet comprises a valve that controls gases movement to the wound edge. In an embodiment, the sleeve **660** is made from a gases impermeable material and the gases are generally contained within the cavity.

In an embodiment, the coupling member **675** couples the tube **670** to an outer surface of the sleeve **660**. In an embodiment, the sleeve **660** may comprise a gases permeable material to allow gases to diffuse into the cavity. In an embodiment, the sleeve **660** may comprise a gases inlet such that gases can enter the cavity. In an embodiment, the gases inlet comprises a valve to control the gases flow into the cavity. Thus, both the wound edge and the cavity receive heated, humidified gases.

The tube **670** may comprise a gases permeable material, for example, a foam or an open cell foam such that gases diffuse through the tube into the cavity or wound edge, or may be made from a gases impermeable material and include directed openings **674** or perforations. The diffuser interface **635** may be configured to wrap at least partially around a surface of the sleeve **660**. In an embodiment, the diffuser interface **635** is configured to wrap around the full perimeter of the sleeve **660**. In an embodiment, multiple diffuser interfaces **635** are used to deliver gases and may be positioned on multiple locations on the sleeve **660**. Thus, delivery of gases may target specific areas of the cavity or may be used to provide additional gases to the cavity or the wound edge. In an embodiment, at least one diffuser interface **635** is positioned on both the inner and outer surface of the sleeve **660**. Thus, the wound edge and the cavity are sufficiently provided with gases throughout the procedure. In an embodiment, the tube **670** may not comprise a fully enclosed wall, but a partial wall. For example, the tube **670** may be helical in shape or may resemble a horseshoe.

The diffuser interface **635** may include a gases inlet **671** that couples the diffuser interface **635** to a gases source (not shown). The gases inlet **671** may connect to a side of the tube **670** (as illustrated in FIG. **6**A) or an end of the tube **670** (as illustrated in FIG. **6**D). In an embodiment, a connector may facilitate coupling between the gases inlet **671** and an interface tube (not shown) which is connected to the gases source. In an embodiment where multiple diffuser interfaces **635** are used, a single interface tube may be bifurcated such that each of the gases inlets **671** of the multiple diffuser interfaces **635** are supplied with gases from the gases source. The interface tube and/or gases inlets may be configured to be a highly flexible.

Although the diffuser interface **635** has been described as attaching to the sleeve **660**, in an embodiment, the diffuser interface **635** may be configured to attach to the upper ring **650** and/or the lower ring **655**.

FIG. **7** illustrates a perspective view of a wound retractor **735** configured for scavenging smoke or gases from the cavity according to an embodiment of the present disclosure. The wound retractor **735** comprises an upper ring **750**, a lower ring **755** and a sleeve **760** extending between and connecting the upper ring **750** and the lower ring **755**. In the illustrated embodiment, the sleeve **760** comprises an inner layer **762** and an outer layer **764** that define a pocket **766** there between. The pocket **766** is configured to receive gases from an interface tube **730**. The lower ring **755** may be a hollow ring that is configured to receive gases from the pocket **766**. In an embodiment, gases enter the pocket **766** from the interface tube **730**, are communicated to the lower ring **755**, and are released from the lower ring **755** via at least one gases outlet to the cavity. In an embodiment, at least one of the inner layer **762** and/or the outer layer **764** comprises a gases permeable material. This may allow gases to permeate out of the pocket and into the cavity and/or to the wound edge, respectively. In an embodiment, the lower ring **755** comprises a gases permeable material such that the gases diffuse through the lower ring **755** into the cavity. In an embodiment, the interface tube **730** is connected directly to the hollow lower ring **755**. Thus, in an embodiment, the multi-layer sleeve **760** can be replaced with a single layer sleeve **760**. In an embodiment, the sleeve **760** can be formed from a gases impermeable material.

In the illustrated embodiment, the upper ring **750** is configured to scavenge gases, such as smoke, or waste gases, from the cavity. The upper ring **750** may be configured to apply a suctioning force to the cavity to remove the gases. In an embodiment, the upper ring **750** comprises a vacuum source. In an embodiment, an external vacuum source is used to generate the suction, for example, a vacuum port within the operating theatre. In an embodiment, the upper ring **750** is a hollow ring that receives the scavenged gases from the cavity. The upper ring **750** is configured to be pneumatically coupled to a scavenging tube **770**. The gases are removed from the cavity via the scavenging tube **770**. The scavenging tube **770** removes the gases to a gases reservoir wherein the gases are filtered before exhausting to the atmosphere. In an embodiment, the gases are recirculated into the cavity. In some such embodiments, the gases are filtered to remove contaminants and/or entrained air before recirculation into the cavity.

In an embodiment, a valve **775** on the scavenging tube **770** controls the amount of gases removed from the cavity. This allows a minimum gases condition—such as gases concentration, temperature, and/or humidity—to be maintained within the cavity during the procedure. In an embodiment, multiple valves **775** are present in the system, for example, an inlet valve and an outlet valve. The inlet valve may be configured to control the flow rate of the gases entering the cavity via the interface tube **730**. The outlet valve may be configured to control the flow rate of the gases leaving the cavity via the scavenging tube **770**, with respect to the monitored pressure of the incoming gases. A higher flow rate of gases entering the cavity than leaving the cavity maintains a sufficient level of gases within the cavity.

FIGS. **8**A and **8**B illustrate perspective views of a wound retractor **745** including a spiral conduit **750** according to embodiments of the present disclosure. The spiral conduit **750** is coiled around the wound retractor **745**. The spiral conduit **750** is coated with the sleeve **760**. In an embodiment, the spiral conduit **750** comprises a foamed material. In an embodiment, the spiral conduit **750** comprises a flexible spine **770**. The flexible spine **770** can be adjusted or manipulated prior to insertion into the cavity. The adjustment can change the height, diameter or pitch of the spiral conduit **750**. The flexible spine **770** can comprise, for example, metallic filaments, a spring, or a plastic bead. In an embodiment, use of a spring creates a tendency in the spiral conduit **750** to return to its relaxed state when compressed. Thus, the flexible spine **770** provides structure to the wound retractor **745**, such that the sleeve **760** can hold the tissue in place within the cavity.

In an embodiment, the flexible spine **770** is enclosed within an outer sleeve **775**. In an embodiment, the outer sleeve **775** can replace the flexible spine **770**. The outer sleeve **775** can pneumatically connect with a gases source via an interface tube (not shown). In an embodiment, the outer sleeve **775** comprises a foamed material. In an embodiment, the spiral conduit **750** forms the interface. Gases can diffuse from the spiral conduit **750** or the outer sleeve **775** and into the cavity.

In an embodiment, the outer sleeve **775** is permeable to gases such that the gases can also diffuse into the wound edge. Thus, the wound edge also benefits from exposure to the gases.

In an embodiment, the gases can inflate the spiral conduit **750**. Thus, the gases can provide additional structure to the spiral conduit **750** within the cavity. Inflation of the spiral conduit **750** causes additional tension to be applied to the sleeve **760**. This enables further retraction of the tissue, thereby creating an enlarged workspace for the surgeon.

FIG. **8**B illustrates an embodiment wherein the outer sleeve **775** is impermeable to gases and liquids. The outer sleeve **775** comprises a gases outlet **780** at the base that allows gases to enter the cavity. In an embodiment, the gases outlet **780** may comprise a valve. The valve may allow gases to enter the cavity once a predetermined pressure is exceeded in the outer sleeve **775**. Gases entry at the base of the wound retractor **745** may fill the cavity with gases more effectively due to characteristics of the gases flow; for example, gases denser than air will expel air from the cavity as the cavity is filled from the bottom. As a result, this embodiment provides the advantage of better filling the cavity due to the location of the gases outlet **780**.

FIGS. **9**A through **9**D illustrate various views of a wound retractor **845** including a sleeve **860** defining a pocket **866**, channels **865**, and perforations **870** according to embodiments of the present disclosure. The wound retractor **845** also includes an upper ring **850** and a lower ring **855**. FIG. **9**A illustrates a cross-sectional view of the wound retractor **845**. FIG. **9**B illustrates a portion of the sleeve **860**. FIG. **9**C illustrates a detailed view of the upper ring **850**. FIG. **9**D illustrates a partial cross-sectional view of an embodiment where gases can be delivered into the sleeve **860** through the upper ring **850**.

As best seen in FIG. **9**A, the sleeve **860** comprises an inner layer **862** and an outer layer **864** with a pocket **866** defined in between. As illustrated in FIG. **9**B, the sleeve **860** may include channels **865**. The channels **865** may be located on the inner layer **862**, the outer layer **864**, or both layers. In an embodiment, the channels **865** are defined in the pocket **860** between the inner and the outer layers. The channels **865** define enclosed passageways through which gases may flow. The channels **865** may be arranged, as illustrated in FIG. **9**B, in a grid-like pattern, although other arrangements, for example, channels extending in only a single direction, curved channels, spiral channels, etc., are possible.

In an embodiment, the sleeve **860** includes perforations **870** as illustrated in FIG. **9**B. The perforations **870** may be located along the channels **865** and provide outlets for gases flowing within the channels. In an embodiment, the perforations **870** may alter in size depending on their location with regard to a gases inlet (for example, inlet **875** of FIG. **9**D) to aid with distribution of the gases. For example, the perforations **870** distal to the gases inlet **875** may be larger than perforations **870** proximally located relative to the gases inlet **875**.

FIG. **9**D illustrates a gases inlet **875**, through which the gases can enter the pocket **866** in the sleeve **860**. In an embodiment, the channels **865** lead to perforations **870** in the sleeve **860**, through which the gases diffuse. The channels **865** direct the gases flow along a desired path. In an embodiment, perforations in the inner layer **862** enable gases to be specifically delivered to the wound. In an embodiment, perforations in the outer layer **864** enable gases to be specifically delivered to the wound edge. In an embodiment, perforations in both the inner layer **862** and the outer layer **864** enable gases to be delivered to both the wound and the wound edge. FIG. **9**C illustrates that, in an embodiment, the upper ring **850** (or the lower ring **855**) may also include perforations **870** for delivering gases. The size of the perforations **870** on the ring may vary with distance from the inlet to control the distribution of gases. In an embodiment, at least one of the upper ring **850** and the lower ring **855** comprises directed openings to distribute the gases. In an embodiment, the sleeve **860**, the upper ring **850**, and the lower ring **855**, each comprises perforations **870** to better distribute the gases. In an embodiment, the perforations **870** may be omitted, and the channels **865** and/or the sleeve **860** may comprise a gases permeable material.

The perforations **870** may be positioned on the inner layer **862** and/or the outer layer **864**. When positioned on the inner layer **862**, gases are distributed inside the cavity. When positioned on the outer layer **864**, gases are distributed to the wound edge. In an embodiment, the perforations **870** may be evenly distributed on the wound retractor **845**. In an embodiment, the perforations **870** may be distributed on only a portion of the wound retractor **845** (for example, a section of the sleeve **860**).

As illustrated in FIG. **9**D, in an embodiment, gases may enter the wound retractor **845** via an inlet in the upper ring **850** (or in the lower ring **855**). In an embodiment, the sleeve **860** may include an inlet configured to receive gases into the pocket **860** and/or channels **865**.

Embodiments of the wound retractor **845** replace traditional diffuser interface components by including a gases dispersal means within the wound retractor **845**. This may reduce the number of items required during a procedure and, as such, reduce the complexity of setup and the number of steps required. This may also reduce the number of instruments that are positioned within the cavity, thereby improving the workspace of the surgeon. Features of the wound retractor **845** may be integrated into any other wound retractor described herein.

FIG. **10** illustrates a perspective view of a wound retractor **945** that is configured to diffuse gases into the cavity and/or to the wound edge. The wound retractor **945** includes an upper ring, a lower ring, and a sleeve **960** extending between and connecting the upper ring and the lower ring. The sleeve **960** may be formed from a gases permeable material such that gases can diffuse into the wound or the wound edge. In an embodiment, the sleeve **960** comprises an open cell foam. In an embodiment, the orientation of fibres in the material of the sleeve **960** can provide a tortuous path such that gases can diffuse through the sleeve **960** but contaminants are trapped and thus prevented from or substantially prevented from entering the wound edge area. In an embodiment, the sleeve **960** can be formed from gases permeable film, for example Tyvek or other spunbonded olefin fibers. The film can be chosen such that gases can pass through the film but contaminants that are larger than gases are occluded from passing through the film to the wound edge. Examples of such films include those commonly used in food packing, such as low-, linear low-, and high-density polyethylene (LDPE, LLDPE, and HDPE, respectively), polypropylene (PP), and biaxially oriented polypropylene (BOPP). The features of the sleeve **960** described in reference to FIG. **10** may be integrated into any of the other wound retractors described herein.

FIG. **11** illustrates a wound retractor **1045** that includes an embodiment of a sleeve **1060** and a sleeve extension **1065**. The sleeve extension **1065** can be used to increase the depth of the cavity. In an embodiment, the sleeve extension **1065** may be configured to increase the depth of the cavity by about 0.5 cm to about 10 cm, or to about 50 cm. This may be beneficial as it may increase the volume of gases that are contained within the cavity.

The sleeve extension **1065** can be formed from the same material as the sleeve **1060** (or any other sleeve described throughout this disclosure). In an embodiment, the sleeve extension **1065** may be made from a different material than that of the sleeve **1060**. For example, the sleeve **1060** may comprise a gases permeable material while the sleeve extension **1065** may comprise a material that is impermeable to gases. The impermeability of the sleeve extension **1065** may reduce gases being lost to the atmosphere. This may be especially relevant in embodiments wherein the sleeve extension **1065** extends slightly above the wound. It is to be understood that the sleeve extension **1065** may be combined with other embodiments discussed herein.

In the illustrated embodiment of FIG. **11**, the sleeve extension **1065** is formed integrally with the sleeve **1060**. In other embodiments, however, the sleeve extension **1065** can be a separate piece. The sleeve extension **1065** can be coupled with the wound retractor **1045**, for example, to an upper ring **1050** thereof, using, for example, adhesives, clipping, or hook and loop mechanisms.

In an embodiment, the sleeve extension **1065** is configured as a flexible, hollow sleeve. In this embodiment, the sleeve extension **1065** may be configured to inflate when supplied with gases from the gases source (in other words, when gases are pumped into the hollow space within the sleeve extension **1065**). In an embodiment, the sleeve extension **1065** comprises a gases inlet to facilitate entry of gases into the sleeve extension **1065**. In an embodiment, the gases inlet comprises a valve, for example, a one-way valve, to regulate the flow of gases into the sleeve extension **1065**. Inflation of the sleeve extension **1065** causes the sleeve extension **1065** to be soft and pliable in use. This allows the surgeon to manipulate the sleeve extension **1065** during use. The sleeve extension **1065** is configured to couple with, for example, the wound retractor **1045** or any other wound retractor described herein or elsewhere via coupling mechanisms, such as those discussed above.

FIG. **12** illustrates a perspective view of a wound retractor **1345** including channels **1370** that pneumatically connect an upper ring **1350** with a lower ring **1355** according to an embodiment of the present disclosure. In an embodiment, the channels may extend along a sleeve **1360** extending between and connecting the upper ring **1350** and the lower ring **1355**. In the illustrated embodiment, the upper ring **1350** couples with an interface tube **1330** via a gases inlet. In the illustrated embodiment, the upper ring **1350** is hollow, providing a pathway through which gases from the interface tube **1330** pass. The sleeve **1360** includes vertically extending channels **1370**. In an embodiment, the vertically extending channels **1370** extend from the upper ring **1350** to the lower ring **1355**. That is, the channels **1370** extend between the upper ring **1350** and the lower ring **1355** in a direction that is perpendicular to that of either ring. The channels **1370** pneumatically connect the upper ring **1350** with the lower ring **1355**. Gases move from the upper ring **1350**, through the channels **1370**, to the lower ring **1355**. In an embodiment, the channels **1370** comprise hollow spines that transfer gases from the upper ring **1350**. In an embodiment, the lower ring **1355** may include an inlet for connecting the interface tube **1330** and the channels **1370** may allow gases to flow from the lower tube **1350** to the upper tube **1370**. In an embodiment, the channels **1370** need not be vertical. For example, the channels may extend at an angle with respect to vertical, may include curved sections, etc. In an embodiment, the wound retractor **1345** may include only a single channel **1370**, while in other embodiments, the wound retractor **1345** may include a plurality of channels **1370**.

In an embodiment, the channels **1370** are permeable to gases, such that the gases can diffuse to the space between the channels **1370** and to the wound edge. In an embodiment, the channels **1370** comprise directed openings or perforations to move gases to the space between the channels **1370** and to the wound edge. In an embodiment, the lower ring **1355** comprises a foam material, or directed openings, such that the gases can diffuse through the lower ring **1355**. In an embodiment, the lower ring **1355** comprises at least one outlet **1375** through which the gases can move into the cavity. In an embodiment, at least one of the outlets **1375** allows gases to also move into the wound edge area. In an embodiment, the outlets **1375** may be shaped to encourage the gases to exit the lower ring **1355** in a direction that encourages filling of the cavity.

In an alternative embodiment, the channels **1370** take the form of a spine that extends vertically between the upper ring **1350** and the lower ring **1355**. The upper ring **1350** comprises a gases permeable structure while still providing rigidity to the wound retractor **1345**. Thus, gases are configured to diffuse from the upper ring **1350** into the space created between the spines. As a result, gases are exposed to the wound edge. The lower ring **1355**, as described above, enables movement of gases between the wound edge and the cavity, either via a gases permeable foam material or by outlets **1375** in the lower ring **1355**. In an embodiment, the sleeve **1360** comprises a gases permeable material to diffuse gases between the wound edge and the cavity. The features described in reference to FIG. **12** may be incorporated into any of the wound retractors described throughout this disclosure.

FIG. **13** illustrates a perspective view of a wound retractor **1445** including an absorbent sleeve **1460** according to an embodiment of the present disclosure. In the illustrated embodiment, the wound retractor **1445** includes an upper ring **1450**, a lower ring **1455**, and the sleeve **1460** extending between and connecting the upper ring **1450** and the lower ring **1455**. The sleeve **1460** is made from an absorbent material, for example a foamed plastic polymer. In use, the absorbent sleeve **1460** can be soaked in a solution prior to insertion of the wound retractor **1445**. The sleeve **1460** absorbs the solution and, when in place in the wound, delivers the solution to the wound edge. The solution may be, for example, an alcohol, a therapeutic, or an acidic solution. In an embodiment, the sleeve **1460** may further include an outer layer or coating comprising the solution, such that the wound retractor **1445** is pre-packaged with the solution.

In an embodiment, alcohol solutions can be used for wound preparation prior to the procedure, which may reduce the steps required to prepare the wound for surgery. In an embodiment, the sleeve **1460** can be soaked in a therapeutic solution that is applied indirectly to the wound by the wound retractor **1445**. For example, the wound retractor **1445** could be soaked in any one of an anaesthetic substance, an anti-inflammatory substance or an antibacterial substance. In an embodiment, soaking the sleeve **1460** in an acidic solution encourages oxygen release into the tissue via the Bohr Effect, as discussed elsewhere herein. This may lead to reduced risk of surgical site infection and improve the recovery of the patient **140**. In an embodiment, the sleeve **1460** is soaked in an anti-adhesive substance. It is to be understood that the sleeve **1460** can be soaked in any combination of the substances described above or other suitable solutions. The features of the absorbent sleeve **1460** described in reference to FIG. **13** may be incorporated into any of the other wound retractors described herein.

In an embodiment, the wound retractor **1445** receives a diffuser interface **1435** that connects with a gases source and provides gases to the cavity. In an embodiment, the upper ring **1450** takes the place of the diffuser interface **1435** by connecting to an interface tube **1430** provides gases to the upper ring **1450**. The upper ring **1450**, thus, may diffuse gases into the cavity. The upper ring **1450** may be made from, for example, a gases permeable material, as discussed in the embodiments above.

FIGS. **14**A through **14**C illustrate cross-sectional views of a wound retractor **1645** including a rib **1670** on a sleeve according to embodiments of the present disclosure. The wound retractor **1645** includes an upper ring **1650**, a lower ring **1655**, and a sleeve **1660** extending between and connecting the upper ring **1650** and the lower ring **1655**. In the illustrated embodiment, the sleeve **1660** includes a rib **1670** which is continuously wrapped around the outside of the sleeve **1660**. The rib **1670** may be formed from a plastics material. The rib **1670** may be semi-rigid, such that it can hold the sleeve **1660** out from the wall of the wound edge. That is, the rib **1670** is configured to contact the wound edge and separate the sleeve **1660** therefrom. Thus, spaces between the rib **1670** provide a pathway **1675** (as illustrated with arrows in FIG. **14**B) through which gases can flow between the sleeve **1660** and the wound edge. The pathway **1675** may cause gases to flow spirally around the sleeve **1660** as shown by the arrows in FIG. **14**B. The depth of the pathway **1675** is chosen such that it does not negatively impact the workspace of the surgeon. In an embodiment, the gases are exposed to the wound edge as they move along the pathway **1675**. The rib **1675** may be configured in a number of ways. For example, it may be configured as a single spiral-wrapped rib as illustrated, for example, in FIG. **14**B. In other embodiments, the wound retractor **1645** may comprise a plurality of ribs.

The gases may enter the pathway **1675** through a gases inlet **1680** located in the sleeve **1660**. The gases may travel through the pathway **1675** and leave via a gases outlet **1685**. In an embodiment, gases exiting the outlet **1685** are deposited into the cavity. Each of the gases inlet **1680** and the gases outlet **1685** may comprise a hole through the sleeve **1660**. In an embodiment, one or both of the gases inlet **1680** and the gases outlet **1685** may comprise a valve. In an embodiment, one of the gases inlet **1680** and the gases outlet **1685** may comprise a hole and the other a valve. The gases inlet **1680** connects the gases flow with the pathway **1675**. The gases outlet **1685** connects the gases flow with the cavity. In an embodiment, the gases inlet **1680** may receive gases from the upper ring **1650**. In an embodiment, the gases outlet **1685** may deposit gases into or near the lower ring **1655**.

In the illustrated embodiment, the gases inlet **1680** is located near the top of the sleeve **1660** and the gases outlet **1685** is located near the bottom of the sleeve **1660**. In an embodiment, the gases may flow in the reverse direction. Thus, the gases inlet **1680** may be located near the bottom of the sleeve **1660** and the gases outlet **1685** may be located near the top of the sleeve **1660**. The gases are supplied to the wound retractor **1645** from a gases source, such as, for example, the gases source **105**.

In an embodiment, the gases inlet **1680** and the gases outlet **1685** are both positioned at or near the same height on the sleeve **1660**. For example, both the gases inlet **1680** and the gases outlet **1685** are located at or near the bottom of the sleeve **1660** or at or near the top of the sleeve **1660**. Thus, the pathway **1675** comprises a loop, dual pathway, or return pathway, such as, for example, a double helix. In an embodiment, the pathway **1675** exposes the gases to the wound edge before supplying the gases to the cavity.

Once the gases leave the pathway **1675**, they are supplied to the cavity. In an embodiment, perforations in the sleeve **1660** pneumatically connect the pathway **1675** with the cavity. The perforations may alter in size along the sleeve

1660. For example, the perforations proximal the gases inlet **1680** may be smaller than perforations distal to the gases inlet. The size of the perforations may incrementally change with increasing distance from the gases inlet. As a result, the gases may leak out of the perforations, while maintaining the backpressure within the pathway **1675**. In an embodiment, the sleeve **1660** comprises a gases permeable material. In an embodiment, the sleeve **1660** comprises a gases impermeable material.

In an embodiment, the rib **1670** comprises a gases permeable material. In an embodiment, the rib **1670** comprises directed openings. Thus, gases from within the pathway **1675** diffuse via the rib **1670** into the cavity. In an embodiment, the rib **1670** forms the pathway **1675**. Thus, the gases travel via the rib **1670** to the gases outlet **1685**, where the gases are distributed to the cavity. In an embodiment, the rib **1670** is permeable to gases such that the gases diffuse into the wound edge as they travel along the rib **1670**. In an embodiment, the rib **1670** comprises perforations to encourage the gases to leak into the wound edge.

FIG. **14**C illustrates an example embodiment of the wound retractor **1645** wherein the upper ring **1650** is displaced from the sleeve **1660** by a distance x due to the tension in the upper ring **1650**.

FIGS. **15**A through **15**C illustrate perspective views of a wound retractor **1745** including bifurcating interface tubes according to embodiments of the present disclosure. The wound retractor **1745** includes an upper ring **1750**, a lower ring **1755**, and a sleeve **1760** extending between and connecting the upper ring **1750** and the lower ring **1755**. The sleeve **1760** may comprise a material that is impermeable to gases.

As illustrated in FIG. **15**A, the sleeve **1760** may comprise an inner layer **1762** and an outer layer **1764**. The inner layer **1762** and the outer layer **1764** may define a pocket **1785** there between. The wound retractor **1745** further comprises an interface tube **1730**. As illustrated in FIG. **15**A, the interface tube **1730** is a bifurcating tube. The interface tube **1730** comprises a first leg **1732** and a second leg **1734**. The first leg **1732** of the interface tube **1730** is configured to pneumatically connect with a gases inlet **1780** near the upper ring **1750**. The gases inlet **1780** may be pneumatically connected with the pocket **1785**. The gases are thus provided to the pocket **1785** from the interface tube **1730**. The second leg **1734** of the interface tube **1730** is configured to connect with a conventional diffuser or a diffuser interface comprising directed openings. The second leg **1734** may be configured to provide gases to the cavity. In an embodiment, the diffuser can be, for example, flat, or shaped as a paddle, which enables it to be tucked into the wound retractor **1745** and out of the way of the surgeon during the procedure. In an embodiment, the diffuser comprises directed openings, and thus the shape can be optimised to fit unobtrusively within the wound retractor **1745**. It is to be understood that different diffuser shapes or configurations, or combinations of shapes can also be used.

In an embodiment, the outer layer **1764** of the sleeve **1760** is gases permeable such that gases are provided from the pocket **785** to the wound edge. In an embodiment, the inner layer **1762** of the sleeve **1760** can be made from a gases permeable material. Thus, gases can be provided to the pocket **1785** and can diffuse into the cavity via the inner layer **1762** of the sleeve **1760**. Alternatively, gases can be provided to the cavity, and can diffuse through the inner layer **1762** and the outer layer **1764** of the sleeve **1760** to the wound edge. In an embodiment, the pocket **1785** is formed between the inner layer **1762** and the wound edge. Thus, gases diffuse directly to the wound edge. As discussed, in an embodiment, the inner layer **1762** may comprise a gases permeable material to allow gases to diffuse into the cavity. In an embodiment, the inner layer **1762** and/or the outer layer **1764** of the sleeve **1760** are gases impermeable. In an embodiment, the inner layer **1762** and/or the outer layer **1764** of the sleeve **1760** may include perforations or directed openings that allow gases to flow there through.

FIG. **15**A also illustrates a control mechanism that can be used to control the distribution of the gases between the first leg **1732** and the second leg **1734**. The control mechanism can take the form of, for example, a pressure valve **1790**. The control mechanism acts to control the proportion of the gases flow that enters the cavity compared with the pocket **1785**. In an embodiment, the control mechanism may be located at the junction of the first leg **1732** and the second leg **1734**. In an embodiment, each of the first leg **1732** and the second leg **1734** include valves to control the flow therethrough.

FIG. **15**B illustrates an example embodiment in which the interface tube **1730** is configured to pneumatically connect with the upper ring **1750**. In this embodiment, gases move from the interface tube **1730** to the hollow upper ring **1750** and into the pocket **1785** within the sleeve **1760**. For example, the hollow upper ring **1750** may include directed openings, perforations, or a gases permeable material that allows gases to flow from the upper ring **1750** into the pocket **1785**.

FIG. **15**C illustrates an example embodiment of the wound retractor **1745** wherein the interface tube **1730** delivers gases to the lower ring **1755**. In an embodiment, the interface tube **1730** couples with the upper ring **1750**. The upper ring **1750** is hollow such that the gases can be delivered to the upper ring **1750**, into the pocket **1785**, and into the lower ring **1755**. In an embodiment, the interface tube **1730** couples with the sleeve **1760** such that gases are delivered directly into the pocket **1785**. The gases may be transferred to the lower ring **1755** from the pocket **1785**, from where they are diffused. In an embodiment, a pneumatic connection exists between the upper ring **1750** and the pocket **1785**. As a result, gases delivered to the upper ring **1750** move to the lower ring **1755** via the pocket **1785**.

In an embodiment, the lower ring **1755** pneumatically couples with the pocket **1785**. In an embodiment, the upper ring **1750** acts as a reservoir for the gases. An additional tube or tube extension can transport the gases from the upper ring **1750** to the lower ring **1755**. The lower ring **1755** is at least partially hollow. Gases diffuse from the lower ring **1755** into the cavity. At least a part of the lower ring **1755** comprises a gases permeable material, such as, for example, directed openings, foam or open cell foam. Diffusing from the lower ring **1755** enables manipulation of the upper ring **1750** without impacting gases delivery. In an embodiment, the features described in reference to FIGS. **15**A-**15**C may be incorporated into any of the other embodiments of wound retractors described herein.

FIG. **16** illustrates a perspective view of a wound retractor **1845** configured to deliver gases through a pocket in a sleeve **1860** according to an embodiment of the present disclosure. The wound retractor **1845** includes an upper ring **1850**, a lower ring **1855**, and the sleeve **1860** extending between and connecting the upper ring **1850** and the lower ring **1855**. The sleeve **1860** comprises an inner layer **1862** and an outer layer **1864**, which define a pocket **1885**. The pocket **1885** is configured to receive gases from a gases inlet **1880**. The gases inlet **1880** is configured to pneumatically couple with an interface tube **1830**. In an embodiment, the pocket **1885** is defined as the space between the inner layer **1862** and the wound edge. Thus, gases supplied to the pocket **1885** diffuse directly to the wound edge. In an embodiment, the inner layer **1862** is permeable to gases. Thus, gases supplied to the cavity diffuse through the inner layer **1862** to the wound edge.

In the illustrated embodiment, the inner layer **1862** of the sleeve **1860** comprises perforations **1890** that pneumatically couple the pocket **1885** with the cavity. As a result, gases that enter the pocket **1885** via the gases inlet **1880** move from the pocket **1885** to the cavity via the perforations **1890**. This may reduce the risk of external contamination within the wound or wound edge. The number and/or distribution of perforations **1890** can be varied. In an embodiment, the perforations **1890** can be of varying sizes and shapes. For example, the perforations **1890** can be between 0.001 mm and 1.0 mm in diameter. In an embodiment, the perforations **1890** are between 0.001 mm and 0.01 mm. In an embodiment, the perforations **1890** are between 0.01 mm and 1.0 mm. In an additional example, the perforations **1890** are substantially circular in shape. The perforations **1890** may be configured to cause a backpressure to exist as gases move into the cavity from the pocket **1885**. As pressurisation of the gases occurs via the easiest path, the gases flow may change over the course of the procedure.

A diffuser may be configured to deliver gases to the pocket **1885**. Thus, the diffuser may be positioned within the pocket **1885** in an embodiment. This may be advantageous because when the diffuser is not positioned within the cavity this may reduce inconvenience to the surgeon because the diffuser is not within the workspace area. Thus, the wound retractor **1845** may be used to reduce the total number of instruments within the cavity.

In an embodiment, the outer layer **1864** is permeable to gases. This allows the gases within the pocket **1885** to diffuse through the outer layer **1864** to the wound edge. As a result, the wound edge is exposed to heated and humidified gases. The features of the wound retractor **1845** may be integrated into any other wound retractor described herein.

FIG. **17** illustrates a perspective view of a wound retractor **1945** including a perforated sleeve according to an embodiment of the present disclosure. The wound retractor **1945** comprises an upper ring **1950**, a lower ring **1955**, and a sleeve **1960** extending between and connecting the upper ring **1950** and the lower ring **1955**. The sleeve **1960** includes perforations **1990**, such as those described in reference to FIG. **16**. The perforations **1990** are configured to pneumatically couple the cavity with the area of the wound edge. That is, gases in the cavity can flow through the perforations **1990** and contact the wound edge. In the illustrated embodiment, gases enter the cavity from a diffuser positioned at the end of an interface tube **1930** within the cavity. The gases move through the perforations **1990** into the area of the wound edge. Thus, with the wound retractor **1945** both the tissues within the cavity and at the wound edge may be exposed to heated and humidified gases. The features of the wound retractor **1945** may be integrated into any other wound retractor described herein.

FIG. **18**A illustrates a perspective view of a wound retractor **2045** configured to wick and/or liquid according to an embodiment of the present disclosure. The wound retractor **2045** includes an upper ring **2050**, a lower ring **2055**, and a sleeve **2060** extending between and connecting the upper ring **2050** and the lower ring **2055**. The sleeve **2060** may include channels **2070** formed therein. In an embodiment, the channels **2070** are positioned on the outside of the sleeve **2060**. In an embodiment, the channels **2070** are positioned on the inside of the sleeve **2060**. In an embodiment, the channels **2070** are formed by small tubes welded to a surface of the sleeve **2060**. In an embodiment, the channels **2070** are formed by bonding multiple concentric sleeves **2060** together from top to bottom at intervals around the circumference to create vertical channels between the sleeves **2060**. The channels **2070** are configured to wick liquid such as liquid source **2075**. In an embodiment, the channels **2070** are further configured to store the water or other liquid. A reservoir or feed set may act as the water source **2075**.

In an embodiment, the wound retractor **2045** includes a heating mechanism that heats the water within the channels **2070**. In an embodiment, the wound retractor **2045** includes a heating mechanism but does not include the channels **2070**. In an embodiment, the heating mechanism comprises a heater wire. The heater wire can be connected to an external power source. A connector at or near the lower ring **2055** can connect the heater wire with the external power source. In an embodiment, the connector can be positioned at or near the upper ring **2050**. The heater wire can be substantially wrapped around the sleeve **2060**. In an embodiment, the heater wire can be configured to heat at least a portion of the sleeve **2060**. In an embodiment, a plurality of heater wires can extend from the lower ring **2055**. In an embodiment, the plurality of heater wires can be at least partially associated with the channels **2070**. The heater mechanism may facilitate evaporation of the water within the channels **2070**.

In an embodiment, the sleeve **2060** can be heated passively, such as, for example, using body heat. For example, the sleeve **2060** can comprise a thermally conductive material. Because the sleeve **2060** is in close proximity to body tissue, heat from the body can warm the sleeve **2060**. This may facilitate evaporation of the water within the channels **2070**.

In an embodiment, the sleeve **2060** can be coated in a chemical layer. Once activated, the chemical layer causes an exothermic reaction. The reaction causes heat to be applied to the water within the channels **2070**. Thus, the water within the channels **2070** is heated and humidified. Example chemicals and activations methods are described in greater detail below.

FIG. **18**B illustrates an embodiment wherein the sleeve **2060** includes an inner layer **2062** and an outer layer **2064** with a pocket **2080** being defined therein. Chemicals can be integrated into the pocket **2080**. As above, activation of the chemicals may cause an exothermic reaction, causing the water within the channels **2080** to vaporise. The channels **2080** can be located on the inner layer **2062**, the outer layer **2064**, or both the inner layer **2062** and the outer layer **2064**. Thus, the exothermic reaction may indirectly heat the channels **2070**.

Activation mechanisms comprise, for example, an ampule **2085** comprising a second chemical (for example, as illustrated in FIG. **18**B). The ampule **2085** may be located externally from the wound retractor **2045**. In an embodiment, the ampule **2085** may be integrated within the sleeve **2060** or the pocket **2080**. The second chemical, when combined with the chemicals of the sleeve **2060**, may cause an exothermic reaction. To combine the chemicals, the ampule **2085** may be compromised or broken. In an example, a flexible ampule **2085** may comprise a valve or narrowing such that the second chemical is unable to combine with the first. A force can be applied to the ampule **2085**. For example, the ampule **2085** may be squeezed to urge the second chemical to interact with the first. In a further example, an external power source can apply heat to the chemicals to activate the exothermic reaction. In yet a further example, body heat from the patient **140** may activate the exothermic reaction of the chemicals.

In an embodiment, positioning the heating mechanism at or near the lower ring **2055** may be beneficial because force is often applied to the upper ring **2050** to tension the sleeve **2060**, such as, for example, rolling the upper ring **2050**. Thus, positioning components at or near the lower ring **2055** may provide a more consistent position, thus improving the usability of the wound retractor **2045**. This position is less susceptible to change upon installation or during manipulation of the wound retractor **2045** within the cavity.

FIG. **19** illustrates a top view of a wound retractor **2145** including a bifurcating interface tube according to an embodiment of the present disclosure. The wound retractor **2145** includes an upper ring **2150** and an interface tube **2130**. The interface tube **2130** comprises a bifurcating tube. Thus, the interface tube **2130** comprises a first leg **2132** and a second leg **2134**. The first leg **2132** comprises a diffuser interface **2135**. In an embodiment, the diffuser interface **2135** may be a conventional diffuser. In an embodiment, the diffuser interface **2135** comprises directed openings to distribute the gases. The diffuser interface **2135** may be positioned at the end of the first leg **2132** and configured to be positioned into the cavity of the wound retractor **2145** to provide gases to the wound. In an embodiment, the first leg **2132** of the interface tube **2130** is at least partially rigid. This may allow the first leg **2132** to be manipulated by the user. The first leg **2132** may comprise a material with a memory property, such that the first leg **2132** remains in a relatively set position after manipulation by the user. The first leg **2132** may be readjusted during use. As a result, the first leg **2132** can be positioned by a user to reduce interference of the first leg **2132** during a procedure.

The second leg **2134** of the interface tube **2130** pneumatically connects with the upper ring **2150** of the wound retractor **2145**. The upper ring **2150** may be hollow, and thus, a gases pathway may be provided therein. Thus, gases can flow from the interface tube **2130** and into the upper ring **2150** via the second leg **2134**. In an embodiment, the upper ring **2150** may comprise a gases permeable material. This may allow gases to diffuse to the wound edge from the upper ring **2150**. In an embodiment, the gases permeable material comprises directed openings.

In an embodiment, the diffuser interface **2135** is configured to be positioned near to the wound edge on the outer side of the wound retractor **2145**. In this embodiment, the gases permeable upper ring **2150** is configured to deliver gases to the cavity and the diffuser interface **2135** is configured to deliver gases to the wound edge.

In an embodiment, the upper ring **2150** connects with the second leg **2134** via a connector **2170**. The connector **2170** may pneumatically occlude the gases from the second leg **2134**. Thus, at least a portion of the connector **2170** comprises a gases permeable region to allow gases to diffuse from the second leg **2134** into the wound edge. In an embodiment, at least a part of the interface tube **2130** comprises a gases permeable material to allow gases to diffuse into the wound edge. In an embodiment, at least a part of the diffuser interface **2135** comprises directed openings to allow gases to diffuse into the wound edge.

The wound retractor **2145** may comprise a sleeve (not shown) similar to those discussed above. Thus, the sleeve can be permeable to gases, which may further facilitate gases transfer between the wound edge and the cavity. In an embodiment, the sleeve may be gases impermeable. The features of the wound retractor **2145** may be integrated into any other wound

FIG. **20** illustrates a cross-sectional view of a wound retractor **2245** with a multi-layer sleeve according to an embodiment of the present disclosure. The wound retractor **2245** includes an upper ring **2250**, a lower ring **2255**, and a sleeve **2260** extending between and connecting the upper ring **2250** and the lower ring **2255**. The sleeve **2260** comprises multiple layers, such as, for example, an impermeable film **2262** and a gases permeable material **2264**. In an embodiment, the gases permeable material comprises an open cell foam. In the illustrated embodiment, the impermeable film **2262** is adjacent to the cavity (in other words, the impermeable film **2262** is on the inside of the sleeve), while the gases permeable material **2264** is adjacent to the wound edge.

The impermeable film **2262** may include apertures **2270** through which gases can enter the cavity. The apertures **2270** expose the cavity to the gases permeable material **2264**. This allows the gases to diffuse through the gases permeable material **2264** and into the cavity.

The upper ring **2250** may be a substantially hollow ring that is configured to receive the gases. Gases can move from the upper ring **2250** to the sleeve **2260**. Here, the gases diffuse into the cavity or to the wound edge as discussed. Remaining gases can enter the lower ring **2255** from the sleeve **2260**. In an embodiment, the lower ring **2255** is substantially hollow and comprises a gases outlet **2275**. The gases outlet **2275** may be configured to move gases from the lower ring **2255** into the cavity.

A gases source may connect with the upper ring **2250** using, for example, a connector. The connector may be configured to provide a pneumatic connection between the gases source and the upper ring **2250**. Thus, gases move into the substantially hollow upper ring **2250** and can be distributed to the patient **140**.

In an embodiment, the lower ring **2255** is configured to receive the gases from the gases source. Thus, gases move from the lower ring **2255** into the sleeve **2260** and into the substantially hollow upper ring **2250**. The apertures **2270** move the gases into the cavity. In an embodiment, both the lower ring **2255** and the upper ring **2250** are configured to receive gases from the gases source.

In an embodiment, the layers of the sleeve **2260** are reversed such that the impermeable film **2262** is adjacent to the wound edge. Thus, the apertures **2270** allow gases to move into the wound edge region. The gases permeable material **2264** is adjacent to the cavity, which allows gases to diffuse into the cavity. The features of the wound retractor **2245** may be integrated into any of the other wound retractors described herein.

FIGS. **21**A and **21**B illustrate various views of a wound retractor with an adjustable diffuser according to embodiments of the present disclosure. FIG. **21**A illustrates a cross-sectional view of a wound retractor **2345** with a pocket formed between inner and outer sleeve layers. The wound retractor **2345** includes an upper ring **2350**, a lower ring **2355**, and a sleeve **2360** extending between and connecting the upper ring **235** and the lower ring **2355**. The sleeve **2360** comprises an inner layer **2362** and an outer layer **2364** with a pocket **2366** defined therein. The inner layer **2362** and the outer layer **2364** may be configured to be impermeable to gases. The inner layer **2362** is configured to be adjacent to the cavity, while the outer layer **2364** is configured to be adjacent to the wound edge. The inner layer **2362** of the sleeve **2360** may be configured to be torn, cut away, or otherwise removed at or near the wound height. Tearing of the inner layer **2362** exposes the gases permeable material within the pocket **2366** to the cavity. As a result, gases diffuse into the cavity. The inner layer **2362** of the sleeve **2360** may include perforations. The perforations may aid with tearing of the inner layer **2362**. The perforations may indicate suitable tear points. Thus, the height of the tear of the inner layer **2362** is customisable to suit different wound heights. FIG. **21**A illustrates the wound retractor **2345** with the inner layer **2362** torn away, thus allowing gases to diffuse into the cavity.

In an embodiment, the sleeve **2360** is bifurcated to form a detached portion of the inner layer **2362**. The detached portion of the inner layer **2362** may function as a flap that can be torn to expose the gases permeable material within the pocket **2366**. Thus, the outer layer **2364** continues to span between the upper ring **2350** and the lower ring **2355** such that the tissues are held in place during the procedure, while the inner layer **2362** only partially spans the distance between the two rings.

The upper ring **2350** may be substantially hollow and may be configured to receive the gases from the gases source as described elsewhere herein. The gases can then diffuse from the upper ring **2350** into the gases permeable material within the pocket **2366**, ready to enter the cavity via the torn edge. In an embodiment, a gases outlet is configured to be positioned on the lower ring **2355**. The gases outlet can deliver gases to the cavity or to the wound edge.

In an embodiment, the lower ring **2355** is configured to receive gases from the gases source. Thus, the pocket **2366** comprising the gases permeable material is located proximal to the lower ring **2355**. The detached portion of the inner layer **2362** is configured to be torn such that gases enter the cavity.

In an embodiment, the outer layer **2364** is configured to be torn to expose the pocket **2366**. Thus, the wound edge benefits from the exposure to heated, humidified gases. A gases outlet is positioned on the lower ring **2355** and is configured to deliver gases to the cavity.

FIG. **21**B illustrates a perspective view of the wound retractor **2345** that comprises the upper ring **2350**, the lower ring **2355**, and a sleeve **2360** extending between and connecting the upper ring **2350** and the lower ring **2355**. In the illustrated embodiment, the upper ring **2350** is configured to comprise a material impermeable to gases flow. A diffuser interface **2335**, such as a conventional diffuser, is configured to couple with the upper ring **2350**. The diffuser interface **2335** is configured to be coupled to at least a part of the upper ring **2350**. In an embodiment, the diffuser interface **2335** is configured to be coupled to the entirety of the upper ring **2350**. Coupling can occur, for example, via adhesives, hook and loop mechanisms, clipping or snap-fitting the diffuser interface **2335** into place, for example, as described elsewhere herein. The coupling can be configured to be removable. In an embodiment, the coupling can be configured to be permanent. In an embodiment, the diffuser interface **2335** can be coupled with, for example, any wound retractor described herein. Thus, the diffuser interface **2335** can be integrated with different wound retraction systems. Coupling between the diffuser interface **2335** and the wound retractor **145** is configured to be quick and simple and to require minimal, if any, training. In an embodiment, the diffuser interface **2335** can be integrated with the upper ring **2350**. Thus, the wound retractor **2345** comprises a single component, which can be inserted into the cavity without adaptation.

The diffuser interface **2335** may comprise a gases permeable material, such as, for example, directed openings, a foam or an open cell foam. The diffuser interface **2335** may be configured to be adjustable. For example, the diffuser interface **2335** can be cut or torn depending on the size of the wound. In an embodiment, the diffuser interface **2335** comprises perforations to indicate possible tear locations. In an embodiment, the diffuser interface **2335** can be configured to be torn prior to insertion into the cavity. In an embodiment, the diffuser interface **2335** can be configured to be torn following insertion into the cavity. Gases flow from a gases source **2305** and into the diffuser interface **2335**. From here, gases are configured to diffuse into the cavity.

In an embodiment, multiple diffuser interfaces **2335** are provided to the user. The multiple diffuser interfaces **2335** can span a range of sizes. In an embodiment, a larger size may correspond to an increased length. Thus, the diffuser interface **2335** can be chosen to fit the size of the wound.

In an embodiment, the diffuser interface **2335** can be coupled with the lower ring **2355**. Thus, the upper ring **2350** can be rolled to provide tension to the sleeve **2360**. In an embodiment, the gases source **2305** is positioned within the cavity. In an embodiment, the gases source **2305** is positioned outside of the cavity. The features of the wound retractor **2345** may be integrated into any of the wound retractors described herein.

FIGS. **22**A and **22**B illustrate cross-sectional views of a wound retractor **2445** including an inner foam layer configured to contact a wound edge according to embodiments of the present disclosure. The wound retractor **2445** includes an upper ring **2450**, a lower ring **2455**, and a sleeve **2460** extending between and connecting the upper ring **2450** and the lower ring **2455**. The upper ring **2450** may be substantially hollow and may be configured to receive gases from a gases source. The sleeve **2460** comprises an inner layer **2462** and an outer layer **2464**. The inner layer **2462** comprises a film coating or layer **2466**. The film coating or layer **2466** may be impermeable to gases. The inner layer **2462** and the outer layer **2464** may comprise a gases permeable material, such as, for example, an open cell foam. Gases within the upper ring **2450** move into the gases permeable material of the inner layer **2462** and the outer layer **2464**. Gases within the outer layer **2464** diffuse into the wound edge region. As a result, the wound edge benefits from exposure to heated, humidified gases.

The inner layer **2462** may extend only partially along the outer layer **2464**. The inner layer **2462** extends along the outer layer **2464** proximal to the upper ring **2450**. In an embodiment, the film coating or layer **2466** coats a single side of the inner layer **2462**. As a result, an aperture **2463** of the inner layer **2462** exposes the gases permeable material to the cavity. Gases diffuse through the aperture **2463** into the cavity. The position of the aperture **2463** is chosen to control the position at which the gases are released into the cavity.

FIG. **22**B illustrates a cross-sectional view of the wound retractor **2445**, wherein the lower ring **2455** is substantially hollow and is configured to receive the gases from the gases source. The inner layer **2462** extends only partially along the outer layer **2464**. The inner layer **2462** extends along the outer layer **2464** proximal to the lower ring **2455**. Thus, gases enter the wound retractor **2445** at the lower ring **2455** and diffuse into the gases permeable material of the inner layer **2462** and the outer layer **2464** of the sleeve **2460**. The aperture **2463** of the inner layer **2462** exposes the gases permeable material to the cavity. Thus, gases diffuse from the gases permeable material into the cavity.

In the illustrated embodiment, the upper ring **2450** can be rolled into position, such that the sleeve **2460** is under tension during the procedure. This results in the sleeve **2460** sufficiently holding the tissue in place during the procedure. The features of the wound retractor **2445** may be integrated into any of the wound retractors described herein.

FIG. **23** illustrates a flow chart of a method implemented by a control system **2540** for controlling gases flow to a wound **2542** according to an embodiment of the present disclosure. The control system **2540** includes multiple steps that heat and humidify the wound **2542**. At block **2541**, gases flow into the wound **2452**. The gases may be distributed using any of the wound retractors described herein. A sensor is positioned within the cavity. The sensor may be located on, for example, an interface or a wound retractor. The sensor is configured to determine a characteristic of the gases flow at block **2543**. The control system **2540** determines if the measured characteristic is above a predetermined threshold at block **2546** or below a predetermined threshold at block **2544**. If the characteristic is below a predetermined threshold, such as that shown at **2544**, the control system triggers more flow **2545** to enter the wound **2542**. Following additional flow into the wound **2542**, the control system **2540** continues to detect the characteristic of the gases flow. In an embodiment, the control system **2540** is configured to wait a predetermined period of time before determining a characteristic of the gases **2543** via the sensor, following the triggering of more flow **2545**. In an embodiment, the control system **2540** controls the flow **2545** by comparing a predetermined threshold to another characteristic of the system, such as the type and/or size of wound retractor or diffuser in use, which could be determined automatically or via user input.

Alternatively, following detection of the gases characteristic at **2543**, the gases characteristic may be determined to be equal to or greater than a predetermined threshold, such as at block **2546**, for example. In this instance, the control system **2540** is configured to wait a predetermined time **2547** before returning to **2543** to detect a characteristic of the gases flow. Thus, determination and feedback regarding the characteristic of the gases flow uses closed loop control in at least one configuration.

In an embodiment, the sensor is configured to determine a concentration of the gases. Thus, the control system **2540** is configured to regulate the gases flow based on the gases concentration. In an embodiment, the predetermined threshold of the concentration of the gases flow may be, for example, between 50%-100%. In an embodiment, the predetermined threshold of the concentration of the gases flow may be between 75%-100%. In an embodiment, the predetermined threshold of the concentration of the gases flow may be between 50%-75%. In an embodiment, the predetermined threshold of the concentration of the gases flow may be between 75%-90%. In an embodiment, the predetermined threshold of the concentration of the gases flow may be between 90%-100%. In some instances, a higher gases concentration may be more beneficial to the patient **140**.

In an embodiment, multiple sensors are configured to determine concentrations of different gases. For example, a sensor may be configured to regulate the flow of carbon dioxide (CO_2) using any of the predetermined concentration thresholds described above. In an embodiment, another sensor may be configured to regulate the flow of oxygen (O_2) or nitrous oxide (N_2O) using a predetermined concentration threshold between 0%-5%. In an embodiment, the predetermined threshold of the concentration of O_2 or N_2O may be between 5%-50%.

The predetermined time may be configured to be anywhere between 1 and 30 minutes. More preferably, the predetermined time may be between 1 and 10 minutes. In an embodiment, the predetermined time is less than 1 minute, for example, 10 seconds or 30 seconds. It is to be understood that different time periods also fall within the scope of the disclosed apparatus and systems. Any of the wound retractors described herein may be used with the control system **2540**.

FIG. **24** illustrates a perspective view of a wound retractor **2645** including sensors controlled using the control system of FIG. **23** according to an embodiment of the present disclosure. The wound retractor **2645** comprises a sensor **2670** configured to detect a characteristic of the gases flow. The sensor **2670** may detect, for example, tissue oxygen concentration using direct measurements, such as, for example, a tissue oxygen probe, or using indirect measurements, such as, for example, by gases concentration, humidity or gases temperature. The control system **2540** may use the sensed characteristic to determine if the characteristic is equal to or above a predetermined threshold **2546**. The control system **2540** may actuate a control pathway to ensure the characteristic meets the threshold condition.

If the sensor **2670** is configured to detect a concentration of the gases flow, or tissue oxygenation concentration, the control system **2540** can cause additional flow to enter the cavity. In an embodiment, multiple sensors **2670** can be used to determine a single characteristic of the gases flow, or multiple characteristics of the gases flow.

For example, if the characteristic identified by the sensor is temperature, and the temperature is determined to be below a predetermined threshold, the control system **2540** may activate additional heating. The heating may take the form of active heating mechanisms, an exothermic reaction from a chemical source, or passive heating mechanisms, such as body heat, for example. An example of an active heating mechanism is a heater wire. The heater wire connects with an external power supply. Heat through the heater wire can be controlled via the control system **2540**.

In an additional example, a humidity sensor determines the humidity of the gases. If the humidity is determined to be below a desired threshold, the dew point temperature of the gases is increased. In an embodiment, this occurs by increasing the temperature of the water within the humidification chamber **120**. Alternatively, if the humidity sensor determines that the humidity is above a desired threshold, the dew point temperature of the gases is decreased. Thus, for example, the temperature of the water within the humidification chamber **120** is decreased.

In an embodiment, chemicals could be used to generate an exothermic reaction. For example, an exothermic reaction could be generated using a supersaturated solution of sodium acetate in water. The heat produced by the reaction could be controlled by controlling the amount of reacting chemicals. For example, the wound retractor **2645** may comprise a sleeve **2660** that is coated with a chemical layer. The sleeve **2660** may be segmented such that chemicals can be contained within different segments. Thus, different segments may be actuated at different times to control the rate of the reaction. Actuation of the chemical layer may comprise gases or chemicals contacting the chemical layer.

In an embodiment, the control system **2540** can be configured to connect with the sensor **2670** via a wired connection or a wireless connection. The control system **2540** can be an external component to the wound retractor **2645**. In an embodiment, the control system **2540** can be configured to removably couple with the wound retractor **2645**. In an embodiment, the control system **2540** can permanently couple with the wound retractor **2645**. In an embodiment, the control system **2540** can be integrated into the wound retractor **2645**.

FIG. **25** illustrates a perspective view of a wound retractor **2745** that is configured with multiple sensors **2770** according to an embodiment of the present disclosure. The wound retractor **2745** includes an upper ring **2750**, a lower ring **2755**, and a sleeve **2760** extending between and connecting the upper ring **2750** and the lower ring **2755**. The wound retractor **2745** also includes a plurality of sensors **2770**. In an embodiment, a single sensor **2770** is used. The sensors **2770** can be integrated into the upper ring **2750**. The sensors **2770** can be configured to sense a characteristic at different regions of the upper ring **2750**. In an embodiment, the sensors **2770** are, for example, an accelerometer or a gyroscope. Hence, the sensors **2770** can be used to determine the orientation of the upper ring **2750**. Each of the sensors **2770** may be independently coupled with a control system, for example the control system **2540** described above. The control system may enable selective diffusion of gases into the cavity with regards to orientation.

In the illustrated embodiment, the upper ring **2750** is integrated with an interface. The upper ring **2750** can, therefore, diffuse gases into the cavity. In an embodiment, the upper ring **2750** comprises a gases permeable material, for example, directed openings, such that the gases can be diffused into the cavity. In an embodiment, the upper ring **2750** comprises multiple gases outlets **2775** that can be independently controlled. Thus, gases delivery into the cavity can be optimised for different orientations or changes during the procedure in the orientation of the wound retractor **2745**. This may lead to more specific gases delivery, and thus, also reduce wastage of gases. For example, the gases may be delivered to the highest point of the wound retractor **2745** to improve filling of the cavity.

In an embodiment, the gases outlets **2775** may comprise valves, such as, for example, float valves. The valves may actuate at different orientations due to the quantity of gases present at or near the valve. Thus, the valves comprise a passively actuating system through which gases can differentially enter the cavity.

In an embodiment, the gases outlets **2775** can be positioned within the sleeve **2760** of the wound retractor **2745**. In an embodiment, the gases outlets **2775** can be positioned on the lower ring **2755**. In an embodiment, the gases outlets **2775** can be positioned on a ring-shaped diffuser that can be clipped onto the wound retractor **2745**, similar to the ring-shaped diffuser interface **535**. These embodiments have the added benefit that the upper ring **2750** can be rolled to tension the sleeve **2760** without impacting the gases delivery into the cavity. The features of the wound retractor **2745** may be integrated with any of the wound retractors described herein.

FIGS. **26**A and **26**B illustrate perspective views of a wound retractor **245** comprising an upper ring **250** that has a first state and a second state according to embodiments of the present disclosure. In an embodiment, the upper ring **250** comprises a material that changes shape when stimulated with an electric field, such as an electroactive polymer. Upon stimulation with an electric field, the upper ring **250** moves from the first state, as illustrated in FIG. **26**A, to the second state, as illustrated in FIG. **26**B. In the first state, the upper ring **250** may be flexible and pliable. In the second state, the upper ring **250** may be substantially rigid. In the second state, the upper ring **250** may pull the sleeve (not shown) taut, retracting the wound to create the cavity. The stimulation with an electric field can be performed following insertion of the wound retractor **245** into the cavity. The electric field can be created using a power source (not shown). In an embodiment, the power source may be external to the wound retractor **245**. In an embodiment, the power source may be integrated with the wound retractor **245**.

In an embodiment, the electric charge is continuously applied to the upper ring **250** to maintain the second state within the cavity. Once the electric charge is removed, the upper ring **250** reverts back to the first state. In an embodiment, the electric charge may be discretely applied to move the upper ring **250** from the first state to the second state. A sequential application of electric charge may cause the upper ring **250** to revert to the first state.

Although the upper ring **250** is illustrated in FIGS. **26**A and **26**B, the same principles described herein may be applied to a lower ring alternatively or additionally.

FIG. **27** illustrates a perspective view of a wound retractor **3345** including a sleeve **3360** comprising a temperature responsive material, such as, for example, a heat shrink material, according to an embodiment of the present disclosure. The sleeve **3360** can comprise a polymeric material, such as fluoropolymers, elastomers, silicone, or polyolefins. The materials can be configured such that the sleeve **3360** shrinks in response to body heat, such as, for example, upon contact with the wound edge. In an embodiment, the sleeve **3360** can be configured to shrink due to heating of a heater wire that is coupled with the sleeve **3360**. The heating wire may be embedded into the sleeve **3360** or positioned on the surface thereof. In an embodiment, a chemical reaction between the sleeve **3360** and the wound edge may cause the sleeve **360** to retract.

In an embodiment, the materials can be configured to shrink solely along a single axis, for example, either radially or longitudinally. In an embodiment, the materials can be configured to shrink more along one axis than another. This may be achieved due to the orientation of the fibres within the sleeve **3360**, the weave of the sleeve **3360**, or the properties of the materials used, such as, for example, an anisotropic material. In an embodiment, this axis is the longitudinal axis. Shrinkage of the sleeve **3360** may apply tension such that the cavity is created and maintained within the body.

FIGS. **28**A and **28**B illustrate perspective views of a wound retractor **3445** according to embodiments of the present disclosure. The wound retractor **3445** comprises an upper ring **3450**, a lower ring **3455**, and a sleeve **3460** extending between and connecting the upper ring **3450** and the lower ring **3455**. The upper ring **3450** comprises a first state, as illustrated in FIG. **28**A, and a second state, as illustrated in FIG. **28**B. In an embodiment, the sleeve **3460** is permeable to gases and liquids. In an embodiment, the sleeve **3460** is impermeable to gases. In the first state, the upper ring **3450** comprises a coiled, compressed or dissembled state. To move from the first state to the second state, the upper ring **3450** is manipulated or assembled such that it clicks into place. In an embodiment, the mechanism to move the wound retractor **3445** from the first state **3452** to the second state **3454** comprises a reversible snap-fit mechanism or other mechanism that is easily actuated by a user. The second state is an expanded state for use within the cavity. The expanded state pushes back the wound edge, thereby creating the cavity. This increases access to the wound.

To remove the wound retractor **3445**, the upper ring **3450** is manipulated back into the first state and withdrawn from the cavity. In the illustrated embodiment, the first state is smaller in size when compared with the second state. The upper ring **3450** in the first state is more easily manipulated through confined spaces. The sleeve **3460** comprises a flexible material that is stretched from the first state to the second state.

FIGS. **29**A through **29**E illustrate various views of a wound retractor **3945** that can transition between a first state and a second state by use of a tether according to embodiments of the present disclosure. The wound retractor **3945** comprises an upper ring **3950**, a lower ring **3955**, and a tether **3970**. The lower ring **3955** is a rigid structure. The upper ring **3950** comprises a biasing mechanism, such as, for example, a spring **3975**. The spring **3975** is compressed in a first state, as illustrated in FIG. **29**A. Thus, in the first state, the upper ring **3950** may have a compressed and reduced in size compared with, for example, the upper ring **150**, and with a second state, as illustrated in FIG. **29**B. The tether **3970** is coupled with the upper ring **3950** and holds the spring **3975** in the first state.

To move the upper ring **3950** from the first state to the second state, the tether **3970** is pulled, disengaged, torn, or otherwise removed from the spring **3975**. This releases the spring **3975**, causing the upper ring **3950** to expand, providing sufficient workspace for the surgeon. The second state provides a state in which tension is applied to a sleeve **3960** to sufficiently retract the tissues within the cavity. In an embodiment, the tether **3970** comprises a cord or tab. The tether **3970** is configured to be pulled, activating the second state, following insertion of the wound retractor **3945** into the cavity.

The upper ring **3950** comprises a soft material which is flexible such that it can move between the first state and the second state. The spring **3975** is coiled within the upper ring **3950**, as illustrated in the cross-section of FIG. **29**C. FIGS. **29**D and **29**E qualitatively show the change in pitch that occurs as the spring **3975** moves between the first state and the second state. Although the previous description describes the upper ring **2950**, it could equally be applied to a lower ring of a wound retractor.

FIGS. **30**A through **30**C illustrate various views of a wound retractor **1545** including an inflatable upper ring and an inflatable lower ring according to embodiments of the present disclosure. The wound retractor **1545** comprises an upper ring **1550**, a lower ring **1555**, and a sleeve **1560** extending between and connecting the upper ring **1550** and the lower ring **1555**. Gases are provided to the wound retractor **1545** from a gases source. The upper ring **1550** and the lower ring **1555** each comprise flexible, hollow rings that are configured to be inflated by the gases. The upper ring **1550** and the lower ring **1555** each comprise a gases inlet **1570**. FIG. **17**A illustrates an example wherein the upper ring **1550** comprises the gases inlet **1570**. The gases inlet **1570** can take the form of a valve, such as, for example, a one-way valve, to allow entry of the gases.

The upper ring **1550** and the lower ring **1555** each comprises a first state, as illustrated in FIG. **17**B, and a second state, as illustrated in FIG. **17**C. The upper ring **1550** and the lower ring **1555** are uninflated in the first state. Inflation of the upper ring **1550** and the lower ring **1555** occurs in the second state. The second state causes the sleeve **1560** to become taut, such that the tissues are sufficiently retracted. Gases entering the upper ring **1550** and the lower ring **1555** via the gases inlet **1570** cause the upper ring **1550** and the lower ring **1555** to move from the first state to the second state.

In an embodiment, a valve **1575** allows the gases to diffuse into the cavity. In an embodiment, the upper ring **1550** and the lower ring **1555** each at least partially comprises a gases permeable material to allow the gases to diffuse into the cavity and the wound edge. In an embodiment, the valve **1575** can be used in combination with the gases permeable material to allow gases to move between the upper ring **1550** and the lower ring **1555** and into the cavity and the wound edge.

The second state creates additional wound depth, thus increasing the height of the cavity. This increases the amount of gases that can be held within the cavity. The upper ring **1550** comprises a flexible material that remains soft and pliable in the second state. This allows the surgeon to manipulate the upper ring **1550** in use, even in the second state.

In an embodiment, the valve **1575** is on one of the upper ring **1550** and the lower ring **1555**. For example, the valve **1575** may be on the lower ring **1555** such that gases are diffused into the cavity from the lower ring **1555**. In a second example, the valve **1575** may be on the upper ring **1550** such that the gases diffuse into the cavity from the upper ring **1550**.

The wound retractor **1545** is inserted into the cavity in the first state. Thus, the wound retractor **1545** is inserted into the cavity prior to inflation of the upper ring **1550** and the lower ring **1555** and, thus, before tension has been applied to the sleeve **1560**. As a result, the wound retractor **1545** is easily manipulated and is simple to install. Once installed, the gases source can be connected to the gases inlet **1570**, causing the upper ring **1550** and the lower ring **1555** to enter the second state. Removal of the gases source **105** causes the upper ring **1550** and the lower ring **1555** to revert to the first state **1580**. Thus, the wound retractor **1545** is removed from the cavity in the first state. This allows for easy removal of the wound retractor **1545**.

In an embodiment, only the upper ring **1550** moves between the first state and the second state. In an embodiment, only the lower ring **1555** moves between the first state and the second state. In an embodiment, the upper ring **1550**, the lower ring **1555**, and the sleeve **1560** are inflated within the cavity upon connection to the gases source. The sleeve **1560** may be pneumatically coupled with the upper ring **1550** and the lower ring **1555**. Gases may be diffused to the cavity and the wound edge as described above. In an embodiment, the sleeve **1560** comprises a gases permeable material such that gases diffuse into the cavity. In an embodiment, the sleeve **1560** comprises a gases permeable material such that gases diffuse into the wound edge. In an embodiment, the sleeve **1560** comprises a gases permeable material such that gases diffuse into both the cavity and the wound edge.

FIG. **31** illustrates a partial perspective view of a wound retractor **2945** including a zipper on the sleeve according to an embodiment of the present disclosure. The wound retractor **2945** comprises an upper ring **2950**, a lower ring **2955**, and a sleeve **2960** extending between and connecting the upper ring **2950** and the lower ring **2955**. A coupling mechanism extends between the upper ring **2950** and the lower ring **2955**. In an embodiment, the coupling mechanism comprises a tongue and groove mechanism or a zipper **2970**. In an embodiment, the coupling mechanism comprises a button arrangement or a press seal mechanism.

The zipper **2970** comprises a partially open state and a closed state. The partially open state occurs proximal to the upper ring **2950**. The partially opened state exposes at least a part of the cavity to the ambient. While in the closed state the wound retractor **2945** resembles, for example, the wound retractor **145**.

The partially open state improves usability of the wound retractor **2945**. The upper ring **2950** is configured to be rolled to provide tension to the sleeve **2960**. Thus, the partially open state provides access to the upper ring **2950** while rolled. For example, an interface tube **2930** may connect with a gases outlet within the upper ring **2950**. Gases may be supplied to the cavity from the gases outlet. A passage exists and remains open between the gases outlet and the cavity. The passage exists between the folds of the upper ring **2950** and the exposure to the wound that is caused by the partially open state. This passage remains open even when the upper ring **2950** is rolled into place. Thus, the user can arrange the wound retractor **2945** to fit the wound while gases movement continues between the interface tube **2930** and the cavity via the gases outlet.

In an embodiment, the gases outlet is configured to be positioned on the zipper **2970**. In an embodiment, the gases outlet is permanently positioned on the zipper **2970**, for example, via adhesives or welding. In an embodiment, the gases outlet is integral to the zipper **2970**. In an embodiment, the gases outlet is removably coupled with the zipper **2970**, for example, by a clip or a hook and loop mechanism. Thus, gases are released from the gases outlet positioned on the zipper **2970**, into the cavity. In an embodiment, the gases outlet is configured to release gases into the wound edge region. In an embodiment, the gases outlet is configured to release gases to both the wound edge region and the cavity.

The zipper **2970** may be adjusted to suit the size or height of the wound. Thus, gases are delivered near the wound.

In an embodiment, the sleeve **2960** is impermeable to gases. In an embodiment, the sleeve **2960** is permeable to gases. Thus, gases are provided to the wound edge and also to the cavity. In an embodiment wherein the gases outlet delivers gases to the wound edge, a gases permeable embodiment of the sleeve **2960** enables gases to also be delivered to the cavity.

Reference to any prior art in this specification is not, and should not be taken as, an acknowledgement or any form of suggestion that that prior art forms part of the common general knowledge in the field of endeavour in any country in the world.

Where in the foregoing description reference has been made to integers or components having known equivalents thereof, those integers are herein incorporated as if individually set forth.

Unless the context clearly requires otherwise, throughout the description and the claims, the words "comprise," "comprising," and the like, are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense, that is to say, in the sense of "including, but not limited to."

The disclosed apparatus and systems may also be said broadly to consist in the parts, elements, and features referred to or indicated in the specification of the application, individually or collectively, in any or all combinations of two or more of said parts, elements, or feature.

It should be noted that various changes and modifications to the embodiments described in the present disclosure will be apparent to those skilled in the art. Such changes and modifications may be made without departing from the spirit and scope of the disclosed apparatus and systems and without diminishing its attendant advantages. For instance, various components may be repositioned as desired. Moreover, features from different embodiments may be combined as desired. It is therefore intended that such changes and modifications be included within the scope of the disclosed apparatus and systems. Moreover, not all of the features, aspects, and advantages are necessarily required to practice the disclosed apparatus and systems. Accordingly, the scope of the disclosed apparatus and systems is intended to be defined only by the claims that follow.

What is claimed is:

1. A diffuser configured to deliver a diffuse gases flow across a cavity during open surgery, the diffuser comprising:

an interface tube comprising a proximal end and a distal end, the distal end configured to connect to a gases supply; and

a diffuser interface positioned at the proximal end of the interface tube, the diffuser interface configured for receiving gases from the gases supply through the interface tube, the diffuser interface comprising:

a diffusion mechanism comprising a gas permeable material configured to allow the gases to be directed across an opening of the cavity;

a gases outlet configured to be positioned outside of the cavity; and

an impermeable material.

2. The diffuser of claim **1**, wherein the interface tube comprises a branching interface tube, wherein the proximal end comprises a plurality of proximal ends of the branching interface tube, and wherein the diffuser interface comprises a plurality of diffuser interfaces, each positioned at one of the plurality of proximal ends.

3. The diffuser of claim **1**, wherein the diffuser interface is integrated with the interface tube or the diffuser interface is attachable to the interface tube.

4. The diffuser of claim **1**, wherein the interface tube comprises a flexible and/or malleable material, or wherein the interface tube comprises a rigid material.

5. The diffuser of claim **1**, wherein the diffuser interface comprises one of:

a complete ring shape;

a partial ring shape; or

a tube with a hollow cross-section such that the gases enter the tube and are then diffused into the cavity via the diffusion mechanism.

6. The diffuser of claim **1**, wherein the diffuser interface branches to a plurality of gases outlets, the plurality of gases outlets including the gases outlet.

7. The diffuser of claim **1**, wherein the diffusion mechanism comprises one of:

one or more perforations formed in the diffuser interface; or

a mesh.

8. The diffuser of claim **1**, wherein the diffusion mechanism comprises one or more perforations and:

at least one of the one or more perforations is configured to provide non-laminar gases flow;

at least one of the one or more perforations is configured to provide laminar gases flow; or

at least one of the one or more perforations is larger proximal to the cavity than another of the one or more perforations distal to the cavity.

9. The diffuser of claim **1**, wherein the gas permeable material comprises a foam material or an open cell foam.

10. The diffuser of claim **9**, wherein the foam material or open cell foam is in or at the gases outlet.

11. The diffuser of claim **1**, wherein the diffuser is configured to be used with a wound retractor and comprises a coupling mechanism configured to secure the diffuser to the wound retractor.

12. The diffuser of claim **11**, wherein the coupling mechanism is:

selectively attachable to the diffuser;

positioned on the interface tube; or

positioned on the diffuser interface.

13. The diffuser of claim **11**, wherein the coupling mechanism comprises:

a clip;

a malleable member; or

an adhesive.

14. The diffuser of claim **11**, wherein the coupling mechanism is configured to secure the diffuser to the wound retractor via a friction fit.

15. The diffuser of claim **11**, wherein the wound retractor comprises an upper ring, a lower ring, and a sleeve extending between and connecting the upper ring and the lower ring, and wherein:

the coupling mechanism is configured to secure the diffuser to the wound retractor at the upper ring,

the coupling mechanism is configured to secure the diffuser to the wound retractor at the lower ring, or

the coupling mechanism is configured to secure the diffuser to the wound retractor at the sleeve.

16. The diffuser of claim **1**, further comprising a coupling mechanism configured to secure the diffuser to another surgical instrument.

17. The diffuser of claim **1**, wherein the diffuser interface comprises a bifurcating structure or a structure with multiple gases entry points.

18. The diffuser of claim **1**, wherein the impermeable material is configured to reduce gases diffusing into a wound edge of the cavity.

19. The diffuser of claim **1**, wherein the impermeable material is an impermeable side, cover, or film.

20. The diffuser of claim **1**, wherein the gases directed across the opening of the cavity create an air curtain effect over the cavity.

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