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(54) **WOUND RETRACTOR**

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(60) Provisional application No. 61/484,362, filed on May 10, 2011.

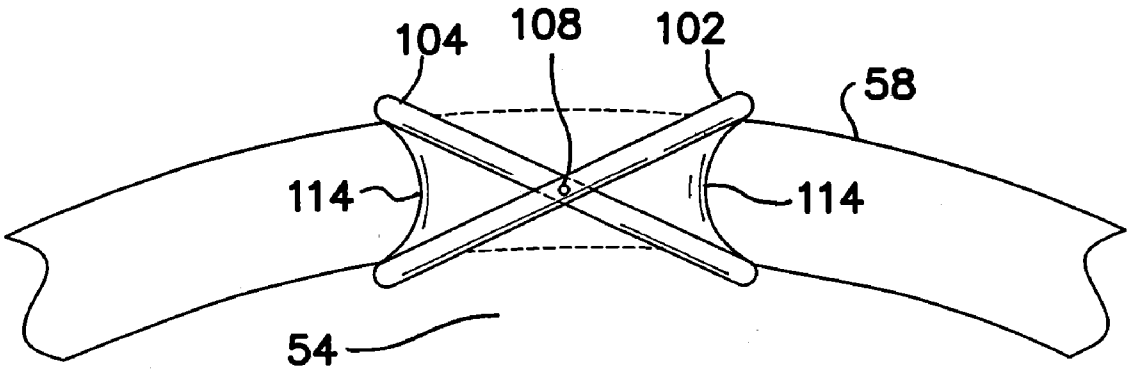
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CPC ***A61B 17/0293*** (2013.01); ***A61B 17/0218*** (2013.01)

(57) **ABSTRACT**

A retraction device that optionally includes a sheath that traverses from outside the body to a body cavity inside the body. The retraction device may include an outer retention ring and a plurality of shapeable extending elements coupled to the retention ring and extending distally therefrom, the extending elements being configured to transition from a first, low-profile, insertion condition to a second, expanded, high-profile retention condition in which distal ends of the extending elements extend radially outwardly. Alternatively, the retraction device may include an outer ring having a substantially annular shape with an adjustable circumference, the outer ring being divided into a plurality of curved ring segments, with a substantially tubular structure extending distally from the outer ring, wherein the diameter of the outer ring is increased by moving the curved ring segments further apart and the diameter is decreased by moving the curved ring segments closer together.



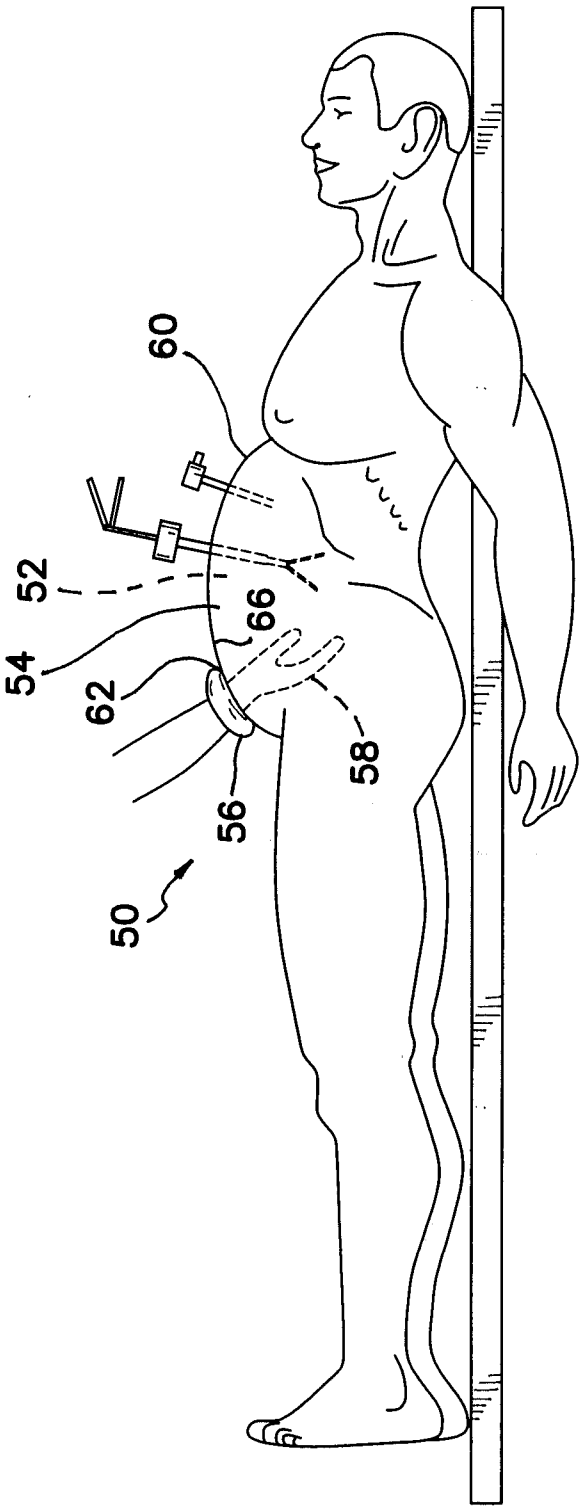


FIG. 1

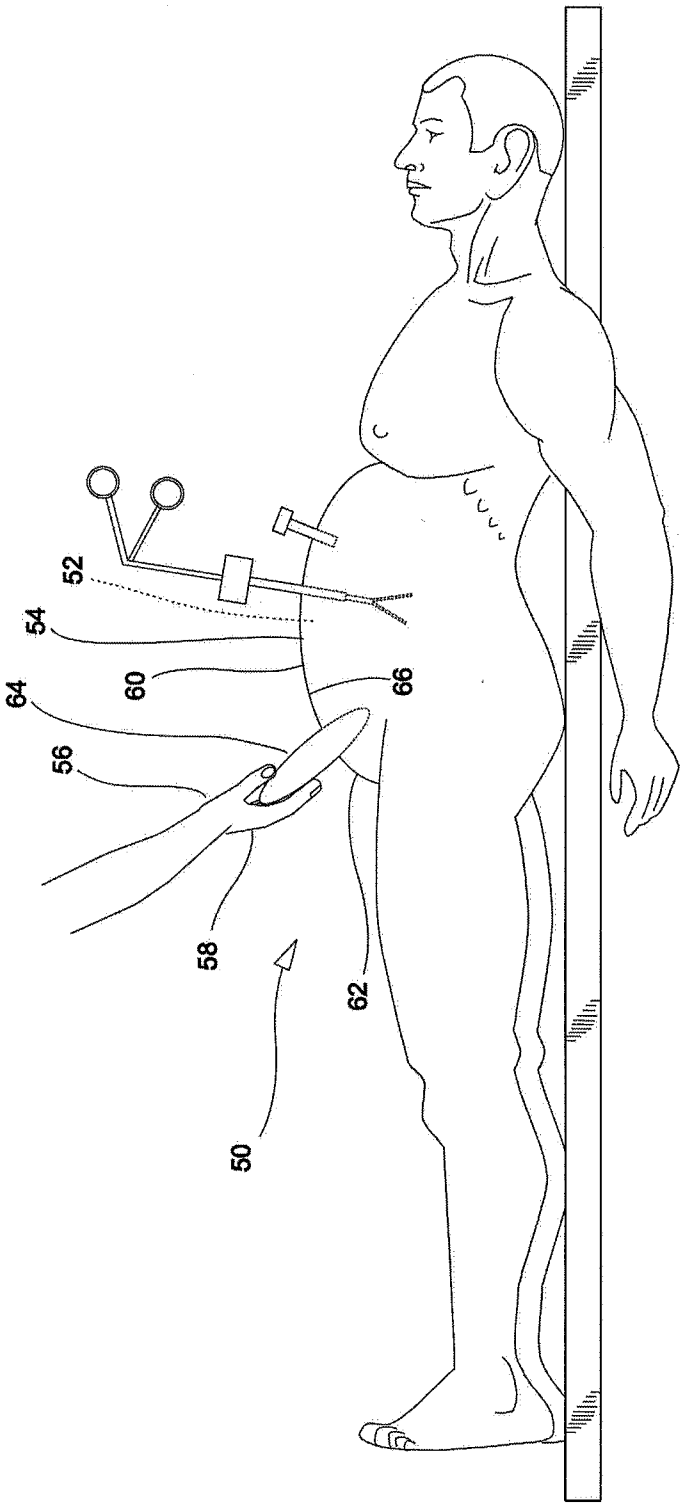


FIG. 2

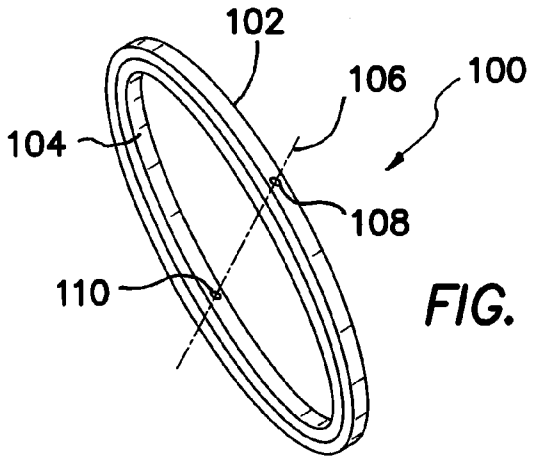


FIG. 3

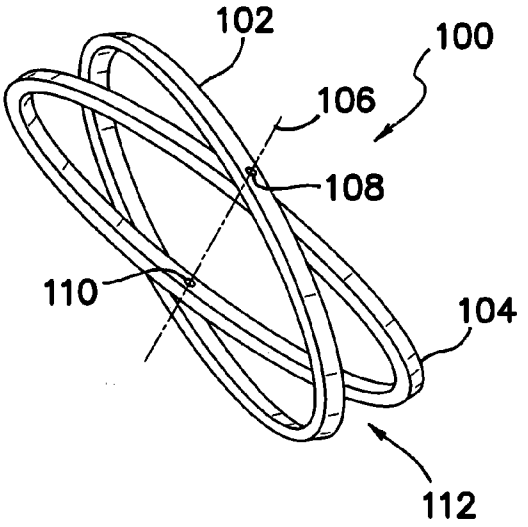


FIG. 4

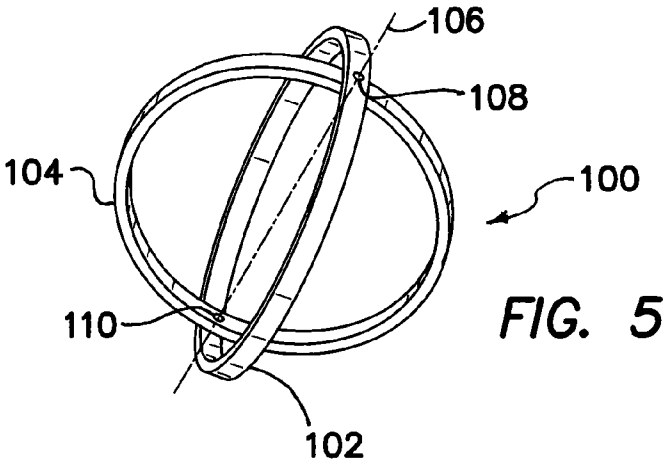


FIG. 5

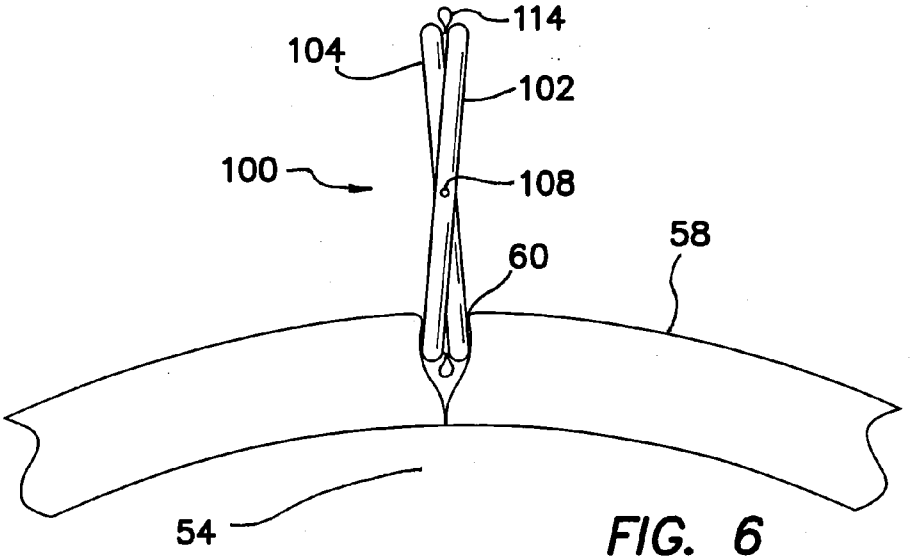


FIG. 6

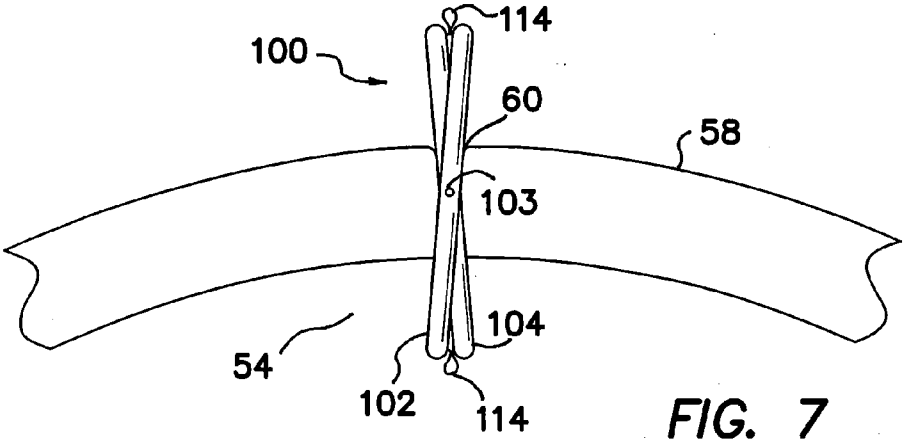
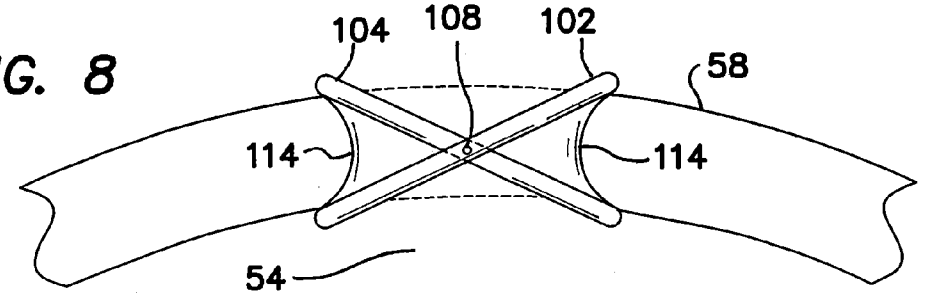


FIG. 7

FIG. 8



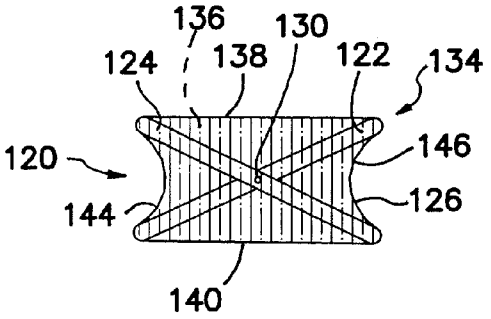


FIG. 9

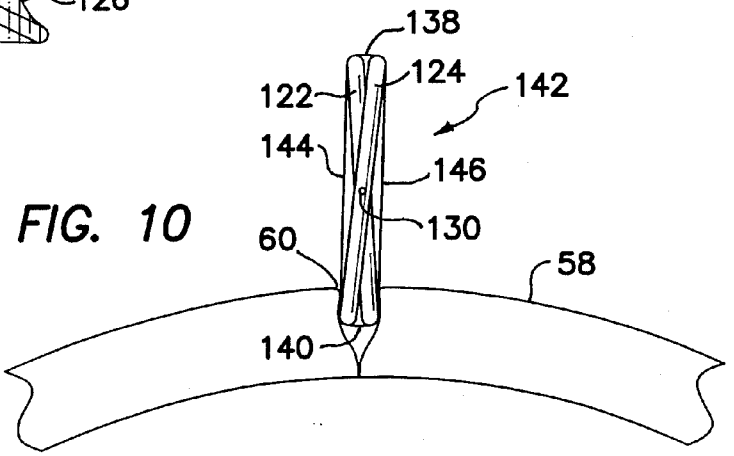


FIG. 10

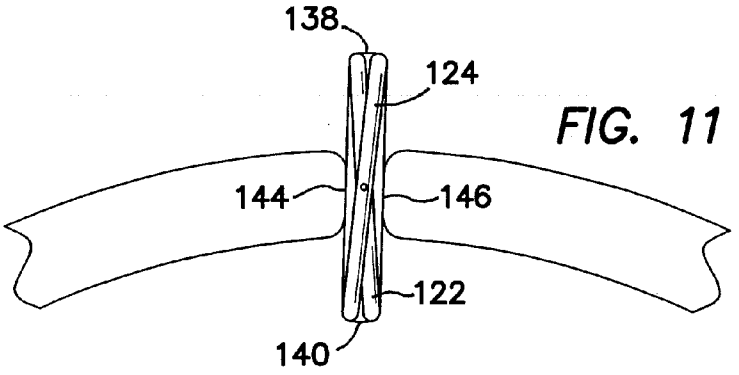


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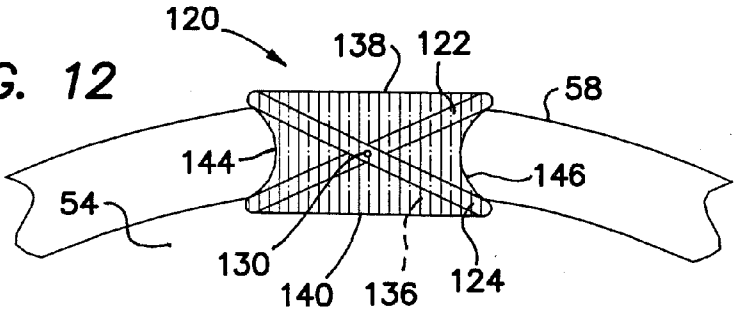


FIG. 12

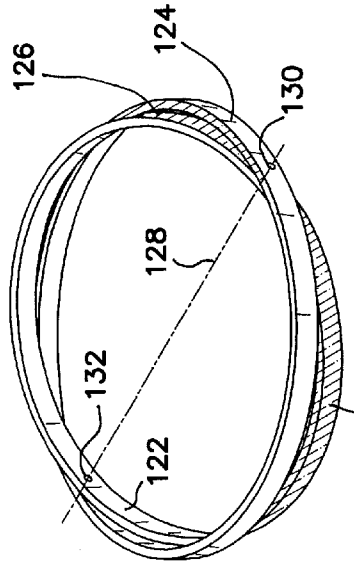


FIG. 14

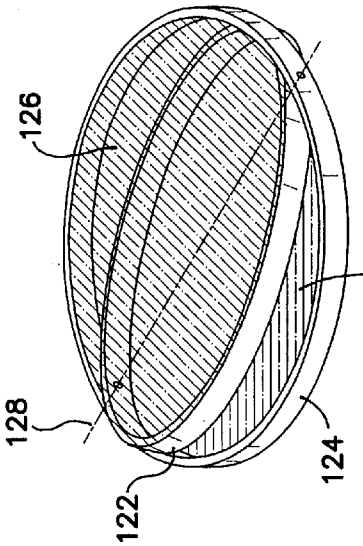


FIG. 16

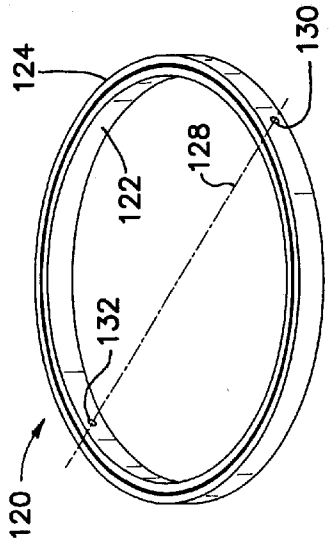


FIG. 13

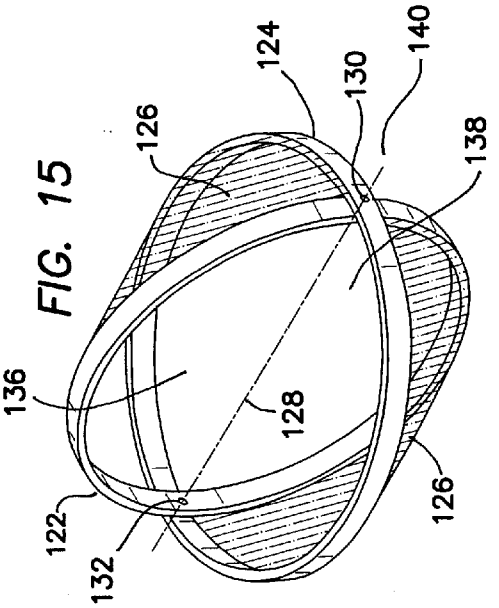


FIG. 15

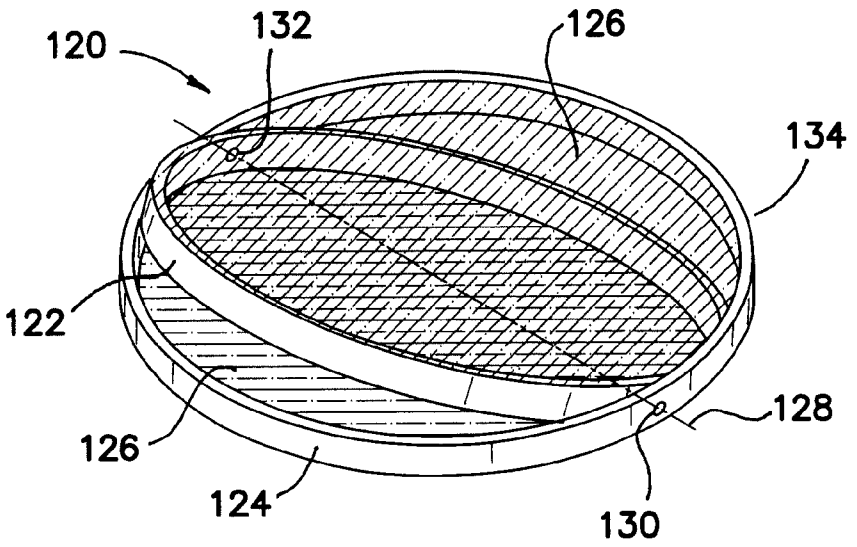


FIG. 17

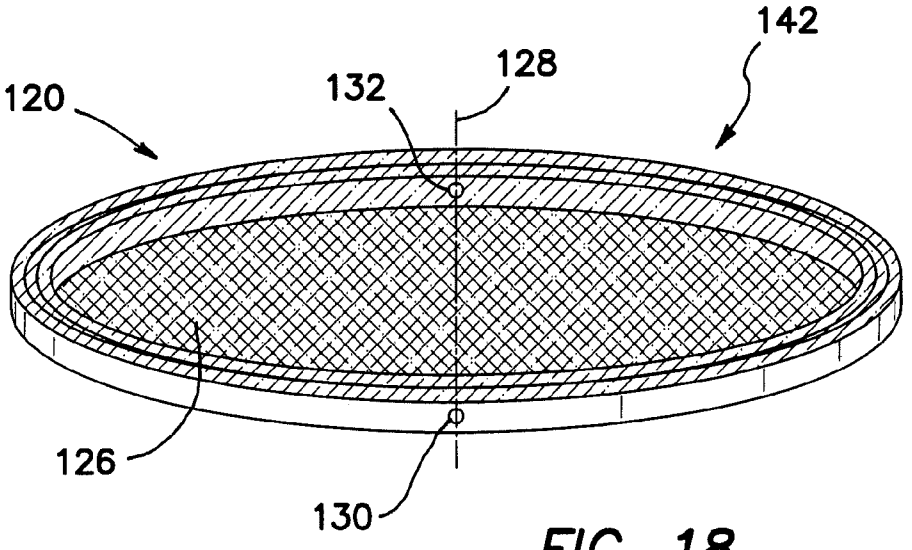


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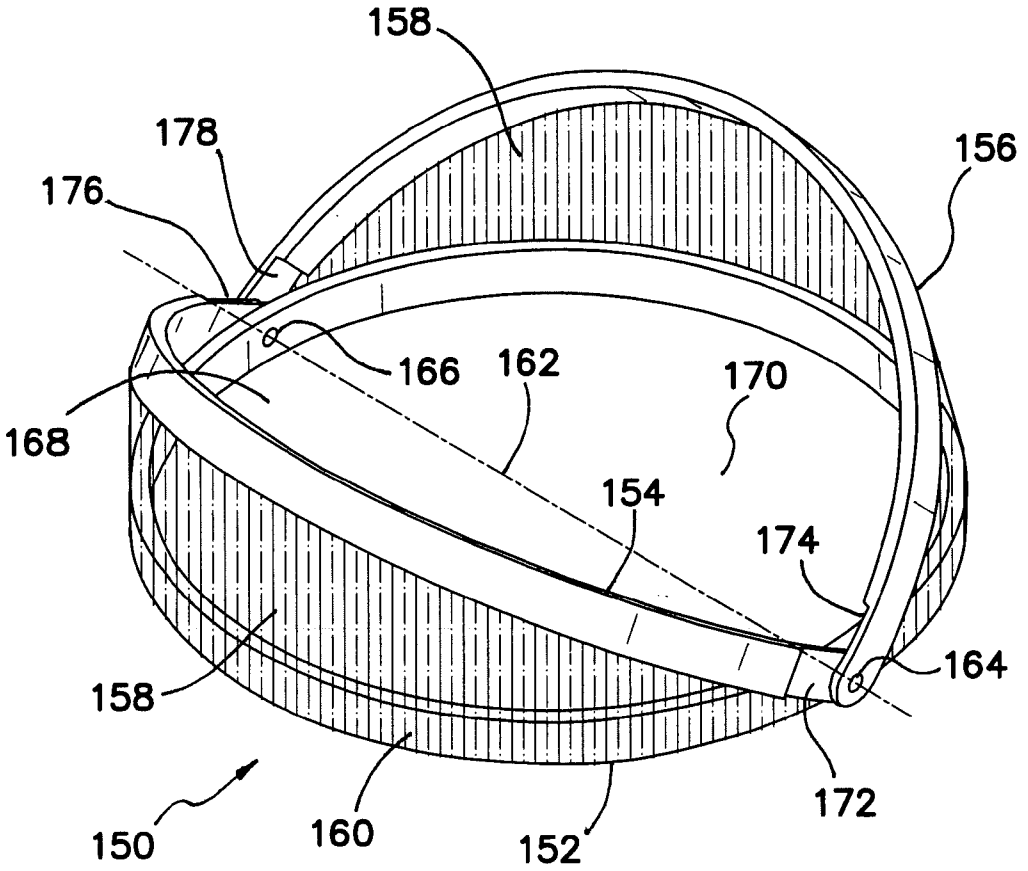
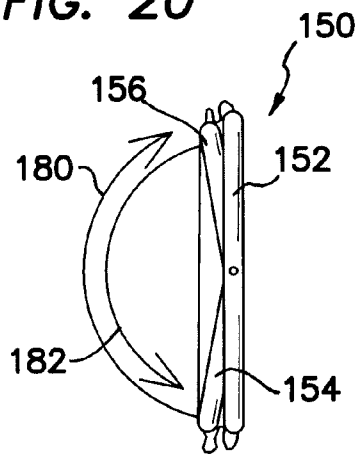


FIG. 19

FIG. 20



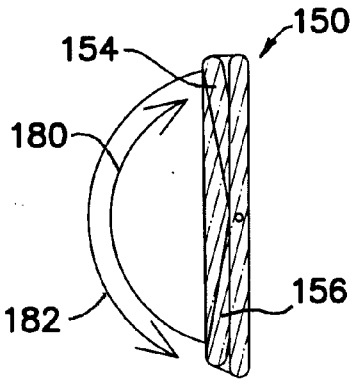


FIG. 21

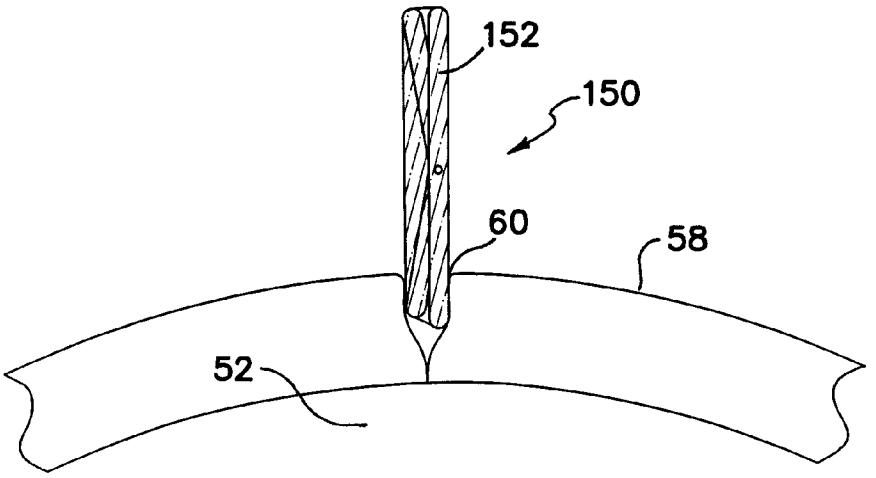


FIG. 22

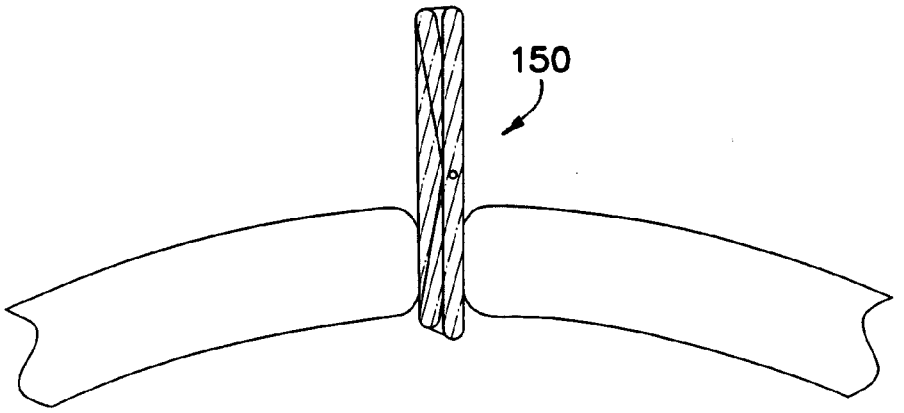


FIG. 23

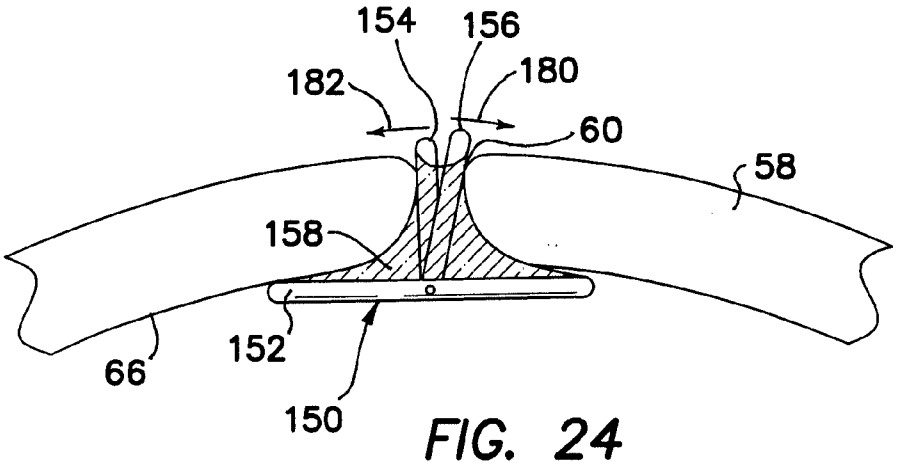


FIG. 24

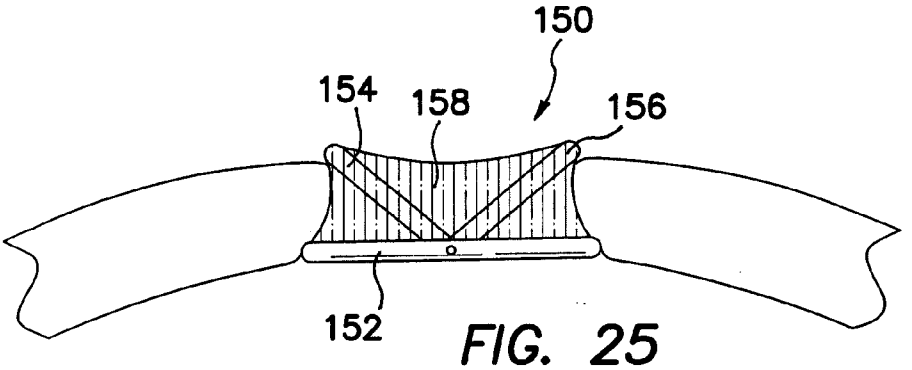


FIG. 25

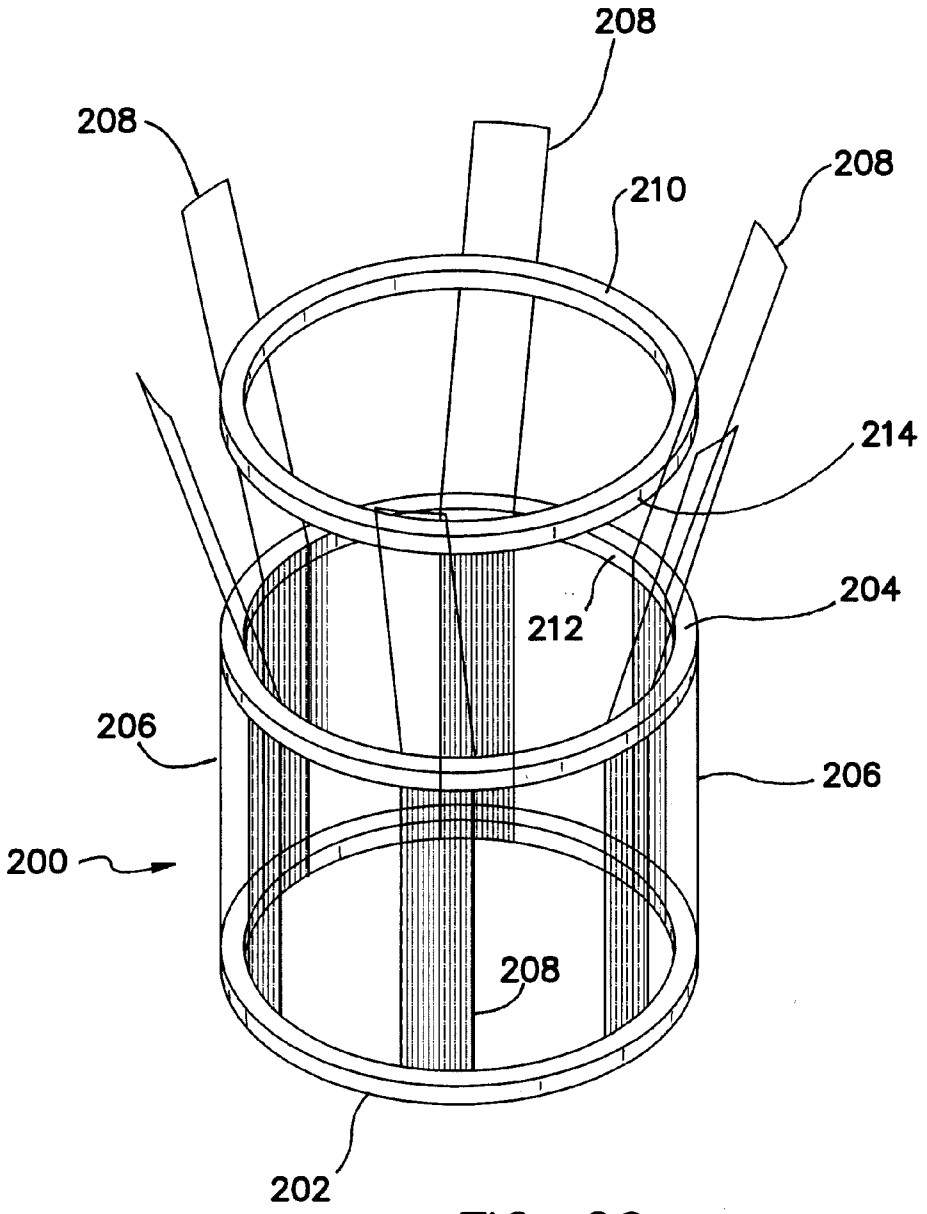


FIG. 26

FIG. 27

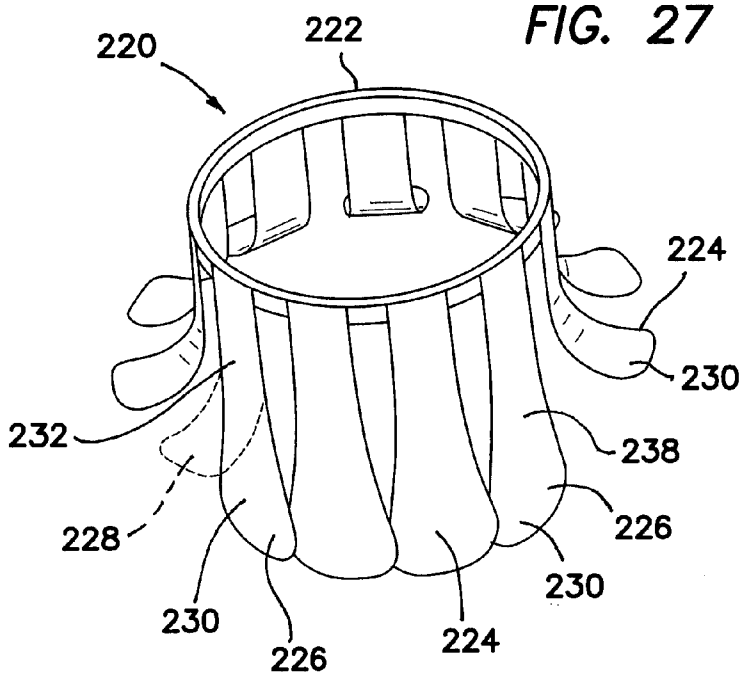
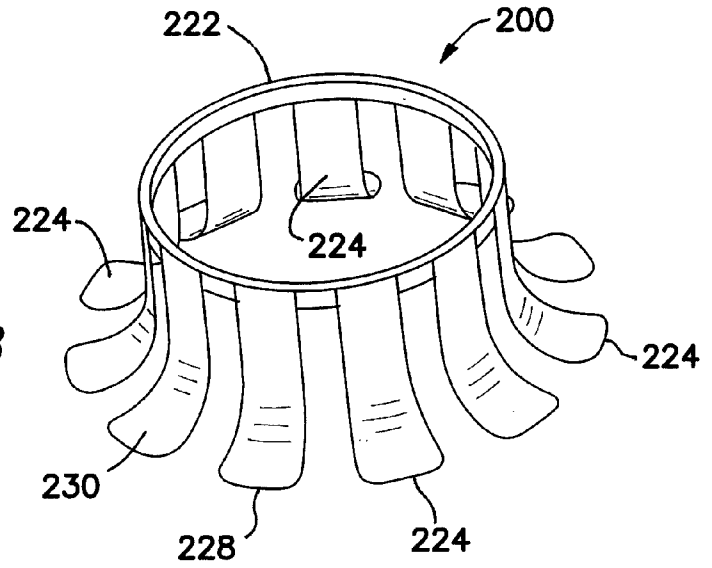

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FIG. 28


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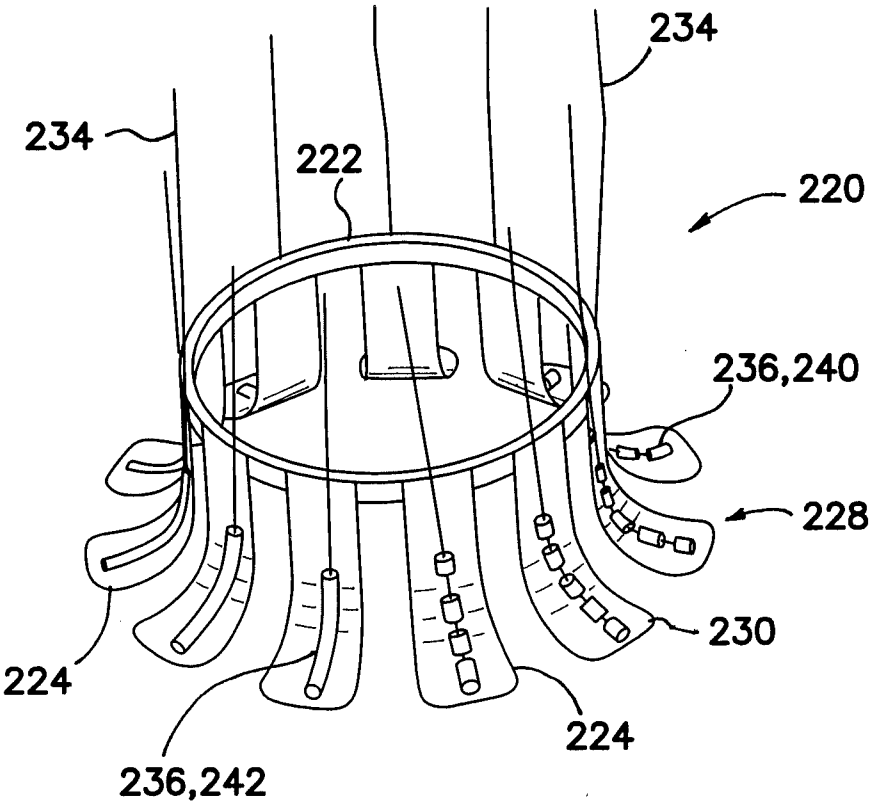


FIG. 29

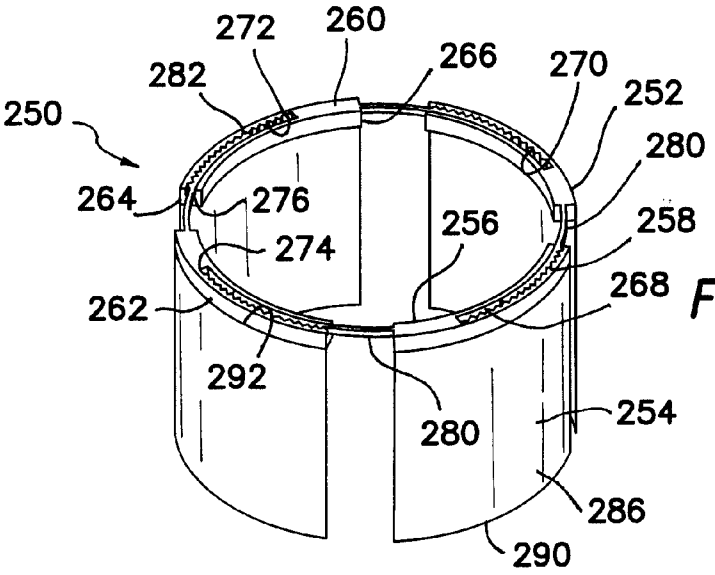


FIG. 30

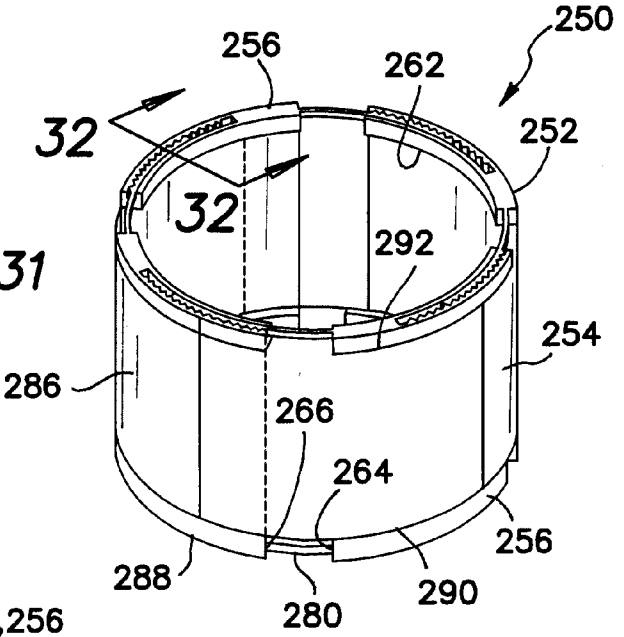


FIG. 31

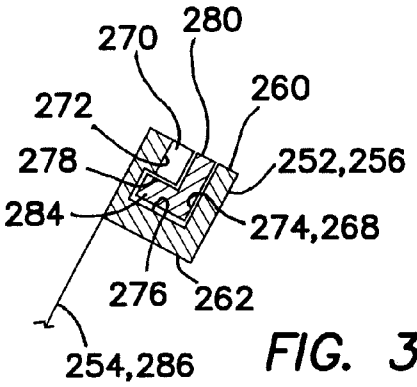


FIG. 32

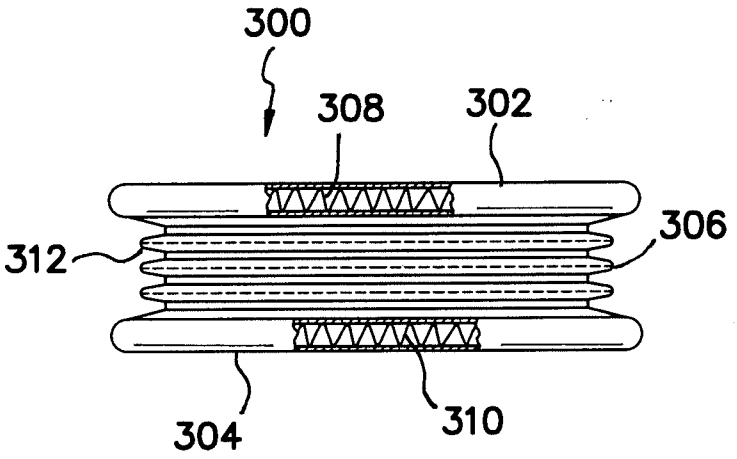


FIG. 33

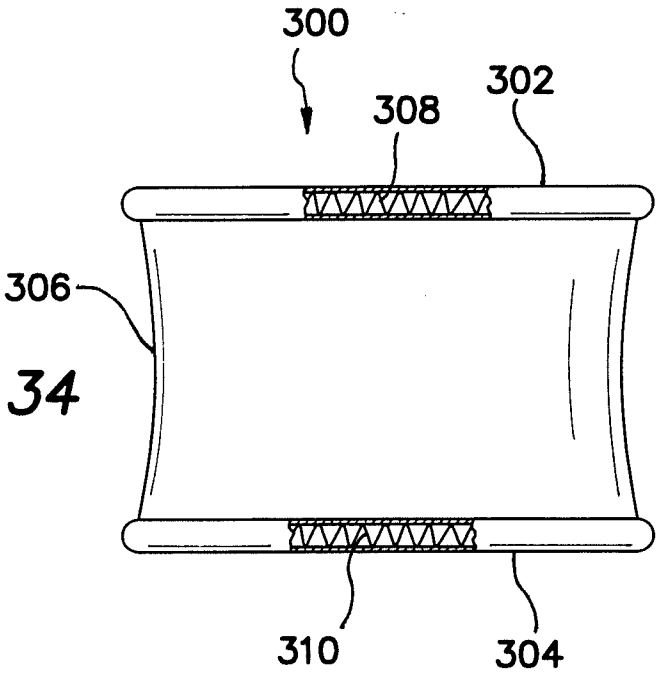


FIG. 34

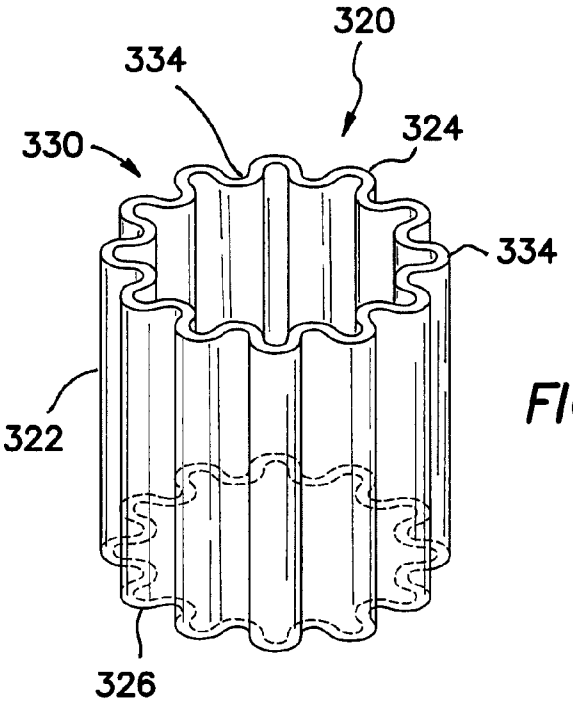


FIG. 35

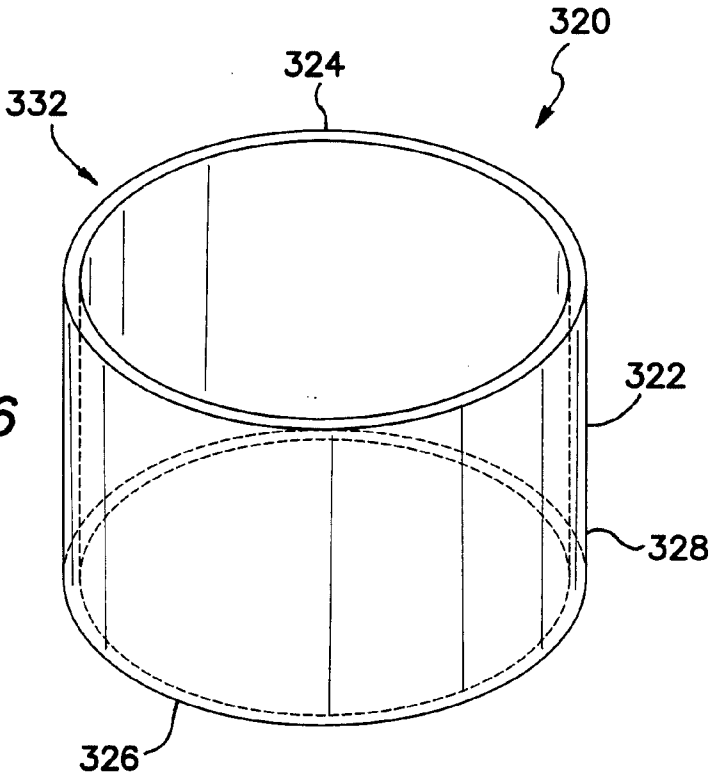


FIG. 36

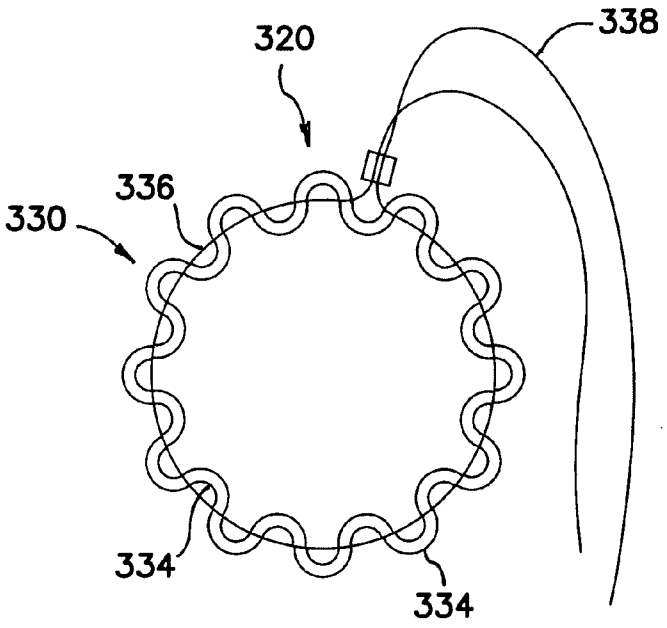


FIG. 37

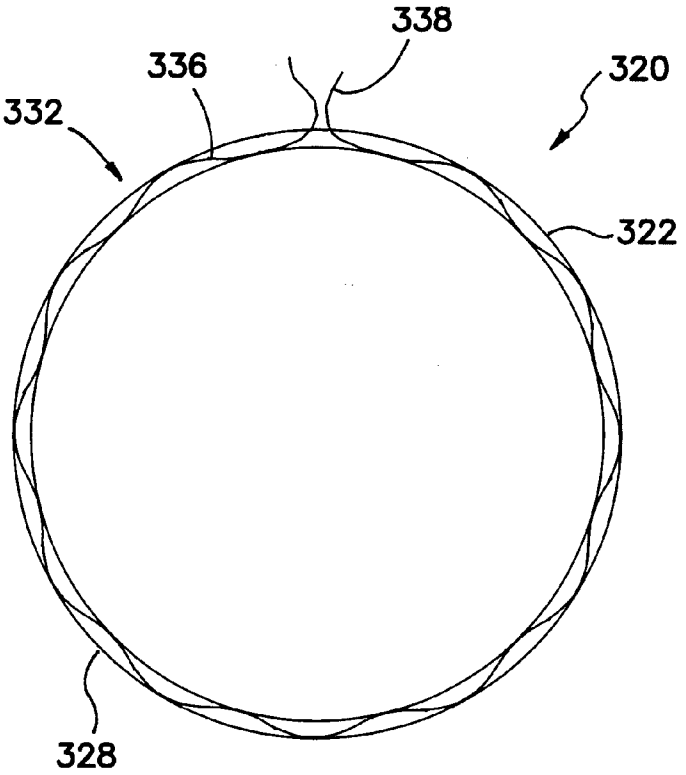


FIG. 38

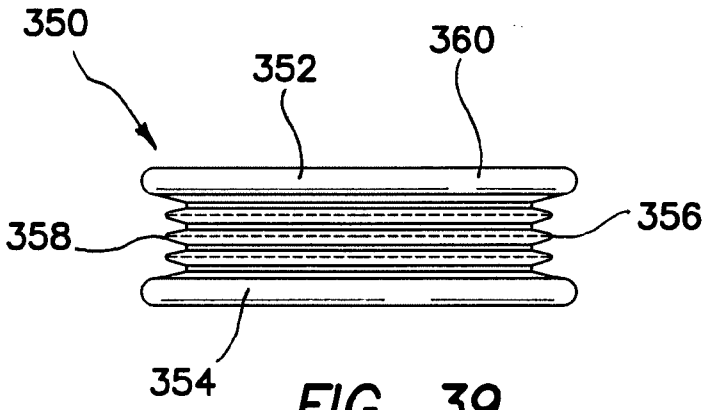


FIG. 39

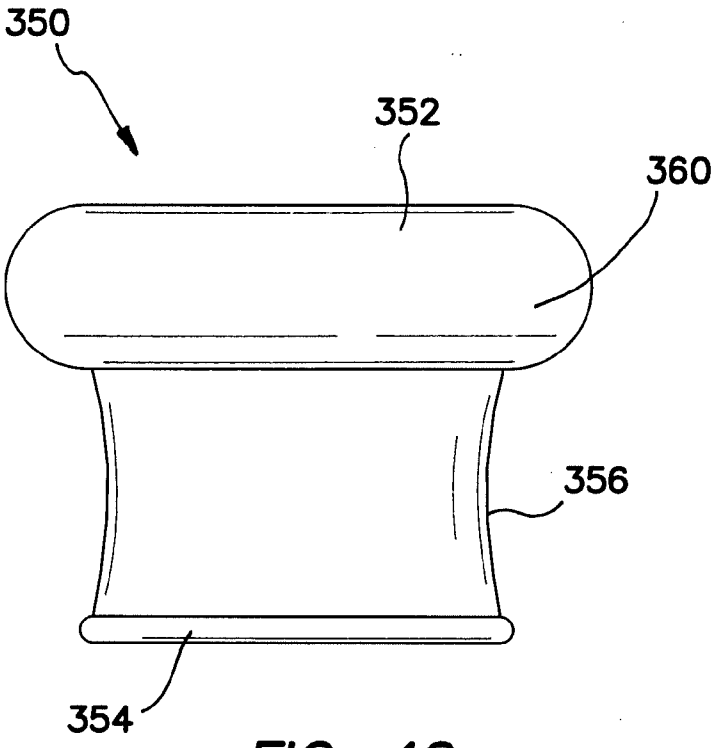


FIG. 40

WOUND RETRACTOR

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. application Ser. No. 14/309,594, filed on Jun. 19, 2014, which is a division of U.S. patent application Ser. No. 13/467,825, now U.S. Pat. No. 8,758,236, filed on May 9, 2012, which claims benefit of U.S. Provisional Patent Application No. 61/484,362, filed on May 10, 2011, the disclosures of which are hereby incorporated by reference as if set forth in full herein.

BACKGROUND

[0002] Tissue retraction during surgery is commonly accomplished by placing opposed instruments within an incision and spreading the incision open with the instruments. Another method includes the use of circumferentially expandable plates or segments that expand to enlarge an incision. The enlarged incision is held open by the expanded device. Additionally, the retraction device may be configured to isolate the incised walls so that they are not contaminated as a surgery proceeds.

[0003] Other retraction devices according to the prior art include a pair of opposed, flexible rings where a first ring is placed on one side of a body wall, a second ring is placed on the opposite side of the body wall, and a thin film of waterproof material is stretched between the two rings. Some configurations of these devices can be difficult to place and may require the use of an assistant to attain proper tensioning.

[0004] There remains a need for an easily placed and easily adjustable retraction device for maintaining retraction of an incision during a surgical procedure.

SUMMARY

[0005] The present invention provides a device that may be inserted into a surgical incision in a first condition and subsequently expanded or reshaped to retract the incision. The invention also contemplates the use of an impermeable film or sheet associated with the tissue-contacting portions to provide a fluid tight and gastight barrier that is sized and configured to prevent transfer of biological components.

[0006] In one embodiment of the invention, the retraction device includes a proximal retention ring and a plurality of shapeable extending elements that are coupled to the proximal retention ring and extend distally from the proximal retention ring. The extending elements are configured to transition from a first, low-profile, insertion condition to a second, expanded, high-profile retention condition in which distal ends of the extending elements extend radially outwardly.

[0007] The retraction device may also include a circumferential sheath positioned within a lumen of the retraction device. The proximal retention ring may be adapted to abut against an outer surface of the body wall. The extending elements may be made of strips of sheet metal having an axially semicircular cross section with each of the extending elements oriented with the outer curve of the semicircular cross section positioned radially outwardly and being adapted to transform to a second, curved, high-profile condition when bent inwardly on the outer semicircular surface. The extending elements may be made of spring steel. In one aspect, the extending elements may be made of a shape-memory material such that at a first temperature, the extending elements are in a first, substantially straight condition, and at a second, higher temperature, the extending elements transform to a second, curved condition where the distal ends of the extending elements extend radially outwardly. The shape-memory material may include nickel-titanium alloy.

[0008] In one aspect, the retraction device may also include a plurality of pull wires with each of the pull wires being coupled to a distal portion of a respective extending element and configured to deflect the respective extending element radially outwardly when the pull wire is pulled proximally. The retraction device may also include a circumferential sheath positioned within a lumen of the retraction device. The proximal retention ring may be adapted to abut against an outer surface of the body wall. The extending elements may be made of spring steel. The pull wires may be deployed either collectively or individually. In one aspect, the retraction device a pull wire retainer may be positioned along the length of the outer surface of each of the extending elements and each of the pull wires may traverse through a respective pull wire retainer. Each pull wire retainer may include a tube with the respective pull wire traversing through the tube. In another aspect, each pull wire retainer may include at least one eyelet with the pull wires traversing through the respective eyelets. The at least one eyelet may include a plurality of eyelets that is longitudinally aligned along the length of the respective extending element with the pull wires traversing through the respective plurality of eyelets.

[0009] In another embodiment of the invention, the retraction device may include an outer ring having a substantially annular shape with an adjustable circumference, a substantially tubular structure extending distally from the outer ring, and means for adjusting the circumference of the outer ring. The outer ring is divided into a plurality of curved ring segments. Each of the curved ring segments includes a first, proximal side, a second, distal side, a first end about the circumference of the outer ring, and a second end about the circumference of the outer ring. The substantially tubular structure is divided into a plurality of elongate tube segments. Each of the tube segments is coupled to a respective curved ring segment and extends distally from the respective curved ring segment. The diameter of the outer ring is increased by moving the curved ring segments further apart and is decreased by moving the curved ring segments closer together.

[0010] Each of the tube segments of the tubular structure may extend circumferentially between the first end and second end of the respective curved ring segment to which it is coupled such that there is substantially no overlap between adjacent tube segments. In another aspect, each of the tube segments may extend circumferentially beyond at least one of the first and second ends of the respective curved ring segment to which it is coupled such that adjacent tube segments overlap. The profile of each of the tube segments may substantially follow the curve of the respective curved ring segment to which it is coupled. The curved ring segments may be flexible to maintain a substantially circumferential shape of the outer ring as the diameter of the outer ring is adjusted. Each of the tube segments may be substantially flexible so as to follow changes of the curve of the respective curved ring segment to which it is coupled. The means for adjusting the circumference of the outer ring may include a ratcheting mechanism that is adapted to couple adjacent curved ring segments of the outer ring together to form the annular shape of the outer ring. In one aspect, the retraction device includes

an inner ring that is coupled to a distal end of the tubular structure. The inner ring is substantially opposite to the outer ring.

[0011] In one aspect, the ratcheting mechanism may include a groove in the proximal surface of each of the curved ring segments, a plurality of ratchet teeth positioned in each of the grooves, an elongate protuberance extending from the second end of each of the curved ring segments, and at least one ratchet tooth positioned on each of the protuberances. The grooves may substantially follow the curve of the respective curved ring segment and be open to the first end of the respective curved ring segment. The groove forms a first, outer curved surface and a second, inner curved surface. The protuberances may be adapted to mate with the groove in an adjacent curved ring segment. The at least one ratchet tooth on the protuberance is adapted to interact with the ratchet teeth in the groove of the respective adjacent curved ring segment. The first end of each of the curved ring segments may be positioned adjacent the second end of an adjacent curved ring segment and the elongate protuberance of each curved ring segment may be inserted into the groove of the other adjacent curved ring segment such that the at least one ratchet tooth on the elongate protuberance interacts with the ratchet teeth in the groove. The ratchet teeth may be positioned on the first, outer curved surface of the groove of the respective curved ring segment or on the second, inner curved surface of the groove of the respective curved ring segment. Alternatively, the ratchet teeth may be positioned on a distal surface of the groove of the respective curved ring segment. In one aspect, the retraction device also includes a retention channel that is positioned in each of the grooves in at least one of the first, outer curved surface and second, inner curved surface of the respective groove. A lip is positioned on each of the elongate protuberances. The lip extends longitudinally along the length of the respective protuberance and is adapted to interact with the retention channel in the groove of the respective adjacent curved ring segment.

[0012] In another embodiment of the invention, the retraction device includes a tubular sheath having a first, proximal end and a second, distal end, a first, folded condition in which the sheath has a first circumference, and a second, unfolded condition in which the sheath has a second circumference that is larger than the first circumference. The sheath is sufficiently long to fit completely through the body wall. In the first, folded condition, the sheath has undulations about its circumference. The sheath is biased toward the second, unfolded condition. The sheath may be compressed to the first, folded condition such that when the force holding the sheath in the first, folded condition is removed, the sheath opens to the second, unfolded condition.

[0013] The sheath may be formed from a malleable, substantially circular member. In one aspect, the retraction device also includes means to compress the sheath into the first, folded condition. The compressing means may include a drawstring that is threaded through the undulations of the sheath. The sheath may be adapted to be compressed into the first, folded condition when the drawstring is pulled radially away from the sheath and to expand to the second, unfolded condition when the drawstring is subsequently released.

[0014] In another embodiment of the invention, the retraction device includes a first, outer ring, a second, inner ring, a substantially cylindrical sleeve that is coupled to the first and second rings, a first biasing member that is associated with the first, outer ring, and a second biasing member that is associated with the second, inner ring. The first biasing member biases the first ring radially outwardly and the second biasing member biases the second ring radially outwardly. The first and second biasing members place the cylindrical sleeve in tension to retract the incision.

[0015] The first and second biasing members may each include a spring-like core that positioned within the first and second outer ring, respectively. The cylindrical sleeve may include radial folds that allow the cylindrical sleeve to transition between a first, axially compressed state and a second, axially extended state. In the first, axially compressed state, the retraction device may be further compressed radially at opposing points along the inner and outer rings to transform the retraction device into a low profile, elongate, substantially oval shape to facilitate insertion into the incision.

[0016] In another embodiment of the invention, the retraction includes a first, outer ring a second, inner ring, and a substantially cylindrical sleeve coupled to the first and second rings. The outer ring is sized and configured to remain outside a body cavity. The inner ring is flexible and is adapted to be compressed radially at opposing points along its circumference to transform the inner ring into an elongate, oval shape to facilitate insertion into the incision and into a body cavity. The cylindrical sleeve is configured to be tensioned between the first ring and the second ring. The first ring includes a substantially hollow, inflatable structure. The retraction device is adapted to increase tension on the sleeve to retract the incision by inflating the first ring when the first ring is positioned outside the body and the second ring is positioned in the body cavity. In one aspect, the cylindrical sleeve includes radial folds that allow the cylindrical sleeve to transition between a first, axially compressed state and a second, axially extended state.

[0017] These and other features of the invention will become more apparent with a discussion of the various embodiments in reference to the associated drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIG. **1** is a side view of a hand assisted laparoscopic procedure where a retraction device is in place;

[0019] FIG. **2** is a side view of a hand assisted laparoscopic procedure showing the placement of a retraction device;

[0020] FIG. **3** is a perspective view of a frame for a hinged retraction device in a folded, low profile, insertion condition;

[0021] FIG. **4** is a perspective view of the frame for the hinged retraction device of FIG. **3** in a low profile, mid-deployment condition;

[0022] FIG. **5** is a perspective view of the frame for the hinged retraction device of FIG. **3** in an open condition;

[0023] FIG. **6** is a side view of a hinged retraction device in a folded, low profile condition suitable for insertion into an incision;

[0024] FIG. **7** is a side view of the hinged retraction device of FIG. **6** in a folded, low profile condition fully inserted into the incision and into a body cavity;

[0025] FIG. **8** is a side view of the hinged retraction device of FIG. **6** fully inserted into the incision and fully deployed within the body cavity to retract the incision;

[0026] FIG. **9** is a side view of a cross-ring retraction device in a non-tensioned condition prior to insertion into an incision in a body wall;

[0027] FIG. **10** is a side view of the cross-ring retraction device of FIG. **9** in a fully tensioned, folded, low profile condition suitable for insertion through the incision in the body wall;

[0028] FIG. **11** is a side view of the insertion step of the cross-ring retraction device of FIG. **9** through the incision in the body wall;

[0029] FIG. **12** is a side view of the deployment step of the cross-ring retraction device of FIG. **9** where the cross-ring retraction device is allowed to assume a preset tension to retract the incision in the body wall;

[0030] FIG. **13** is a perspective view of the cross-ring retraction device of FIG. **9** in a stored condition;

[0031] FIG. **14** is a perspective view of the cross-ring retraction device of FIG. **9** as it is prepared for tensioning prior to insertion through the incision in the body wall;

[0032] FIG. **15** is a perspective view of the cross-ring retraction device of FIG. **9** partially tensioned prior to insertion through the incision in the body wall;

[0033] FIG. **16** is a perspective view of the cross-ring retraction device of FIG. **9** partially tensioned prior to insertion through the incision in the body wall;

[0034] FIG. **17** is a perspective view of the cross-ring retraction device of FIG. **9** partially tensioned prior to insertion through the incision in the body wall prior to the step of reducing the insertion profile by compressing the cross-ring along the folding axis into an oval shape;

[0035] FIG. **18** is a perspective view of the cross-ring retraction device of FIG. **9** fully tensioned prior to insertion through the incision in the body wall and further prepared by compressing the cross-ring along the folding axis into an oval shape;

[0036] FIG. **19** is a perspective view of a cross-ring retraction device that comprises a first rigid ring and a plurality of folding portions;

[0037] FIG. **20** is a side view of the cross-ring retraction device of FIG. **19** in a stored condition, prior to tensioning;

[0038] FIG. **21** is a side view of the cross-ring retraction device of FIG. **19** prepared for use by rotating the folding members;

[0039] FIG. **22** is a side view of the cross-ring retraction device of FIG. **19** as it is inserted into the incision in the body wall;

[0040] FIG. **23** is a side view of the cross-ring retraction device of FIG. **19** as it is further inserted into the incision in the body wall on its way to being fully inserted through the incision and completely into the body cavity;

[0041] FIG. **24** is a side view of the cross-ring retraction device of FIG. **19** rotated into the deployed position with the rigid ring against the inner surface of the body wall and the folding portions rotated partially back toward the stored condition and extending through the incision in the body wall;

[0042] FIG. **25** is a side view of the cross-ring retraction device of FIG. **19** as it is fully inserted through a body wall and allowed to assume a deployed condition as it attempts to assume the stored condition;

[0043] FIG. **26** is a perspective view of a wound retraction device having a plurality of straps for providing tension between a first retention ring and a second retention ring;

[0044] FIG. **27** is a perspective view of a ring-shaped retraction device having a plurality of shapeable extensions in a first condition;

[0045] FIG. **28** is a perspective view of the ring-shaped retraction device of FIG. **27** having the plurality of shapeable extensions in a second, deployed condition;

[0046] FIG. **29** is a perspective view of a ring-shaped retraction device, similar to the ring-shaped retraction device of FIG. **27**, including pull wires for changing the shape of the extensions;

[0047] FIG. **30** is a perspective view of a ring-shaped retraction device having a plurality of adjustable retracting portions that allow adjustment of the ring diameter;

[0048] FIG. **31** is a perspective view of a ring-shaped retraction device having a plurality of adjustable retracting portions that allow adjustment of the ring diameter and having overlapping extensions;

[0049] FIG. **32** is a section view taken from line **32-32** in FIG. **31** and depicted at a larger scale;

[0050] FIG. **33** is a side view of an adjustable wound retraction device having two rings and a sheath comprising bellows in a low profile, insertion condition;

[0051] FIG. **34** is a side view of the adjustable wound retraction device of FIG. **33** in a deployed, retracting condition;

[0052] FIG. **35** is a perspective view of a malleable retraction ring in a closed condition for insertion into an incision;

[0053] FIG. **36** is a perspective view of the malleable retraction ring of FIG. **35** in a fully open, deployed condition;

[0054] FIG. **37** is a plan view of the malleable retraction ring of FIG. **35** in a closed condition for insertion into an incision with the retraction ring being held closed by a drawstring;

[0055] FIG. **38** is a perspective view of the malleable retraction ring of FIG. **37** in a fully open, deployed condition;

[0056] FIG. **39** illustrates an expandable and retractable anchoring ring having inflatable portions in a low profile, uninflated, insertion condition; and

[0057] FIG. **40** illustrates the expandable and retractable anchoring ring of FIG. **39** in an inflated, deployed condition.

DESCRIPTION

[0058] With reference to the drawings, FIGS. **1** and **2** depict a hand assisted laparoscopic surgery **50** where an abdominal cavity **52** is created within an abdominal region **54** of a body by the introduction of a pressurized gas. A retraction device **56** is shown having a human hand **58** therethrough. To deploy the retraction device **56** within a patient's abdominal wall **60**, a surgical incision **62** is made through the abdominal wall and the retraction device is inserted and subsequently deployed to retract and enlarge the incision. The retraction device **56** may include a first, outer retention member, a second, inner retention member, and a membrane or sleeve coupled between the first retention member and the second retention member. The retraction device **56** may be shapeable **64** to facilitate placement through a small incision **62**. The retraction device **56** may be held by a hand in a low profile shape and condition **64** as it is inserted through the incision **62** and subsequently released so that the first, outer retention member and the second, inner retention member stretch the membrane between an outer surface of the body wall **60** and an inner surface **66** of the body wall.

[0059] Referring to FIGS. **3-8**, a retraction device **100** is shown having a first, outer ring **102** and a second, inner ring **104** that are substantially concentric with each other. The first and second rings **102**, **104** may be semi-rigid and hinged along a common axis **106** that forms a first hinge **108** and a

second hinge **110** that couple the first ring **102** and the second ring **104** together with the hinges being positioned substantially opposite each other on the circumference of the first and second rings. The retraction device **100** may transition from a first, concentric state (FIG. **3**) to a second, angular state (FIGS. **4**, **5** and **8**) **112** where the first and second rings **102**, **104** are rotated about the axis **106** and form an angle between the planes of the first and second rings. The form of the retraction device **100** generally resembles a collapsible gyroscope. A gastight tubular membrane or sheath **114** (FIGS. **6-8**) is coupled around the circumference of the first ring **102** and around the circumference of the second ring **104** such that when the first and second rings are in the second, angular state, the sheath is substantially cylindrical.

[0060] The first and second rings **102**, **104** are first compressed together to form a substantially concentric structure (FIGS. **6** and **7**) where the wall of the membrane or sheath **114** is either not tensioned or only lightly tensioned. The compressed, concentric structure may be further streamlined by compressing the first and second rings **102**, **104** along the axis between the first and second hinges **108**, **110** to facilitate insertion of the retraction device **100** into the incision **62** in the body wall **60**. The further streamlining along the axis significantly elongates the retraction device **100** so that it can slide through a small incision **62**. Once the retraction device **100** has been inserted into the incision **62** to about the midpoint of the device, with the axis between the first and second hinges **108**, **110** being positioned substantially parallel to the abdominal wall **60** and parallel to the incision, the retraction device is unfolded and deployed so that the membrane or sleeve **114** is stretched within the incision **62**. As the two rings **102**, **104** of the device **100** are rotated about the axis **106** between the first and second hinges **108**, **110**, the membrane or sleeve **114** places retracting tension upon the tissue surrounding the membrane or sleeve. The first ring **102** and the second ring **104** now traverse the incision **62** and the extending portions of the rings abut the outer surface of the body wall **60** and the inner surface **66** of the body wall. This arrangement maintains the retraction device **100** in place within the incision **62** and also retracts and enlarges the incision.

[0061] The retraction device **100** includes means for maintaining the retraction device in the second, angular state **105**. Such maintaining means may include a ratchet mechanism that is positioned proximate at least one of the first and second hinges **108**, **110**. The ratchet mechanism may be positioned proximate each of the first and second hinges **108**, **110**. Alternatively, the maintaining means may include a valve structure mounted onto the retraction device external the body wall **60**. Other means for maintaining the retraction device **100** in the open, deployed condition include any suitable mechanical means that is well known in the art.

[0062] The first and second rings **102**, **104** may be made from a semi-rigid plastic material having sufficient strength to normally form a circle when no external forces are applied. Alternatively, the first and second rings **102**, **104** may include a metal or plastic reinforcing member placed within an elastomeric hollow or tubular structure forming the first and second rings. The rings **102**, **104** may also be made of a spring-like metal structure where the rings are formed from a flat metal spring or a round metal spring. Additionally, the rings **102**, **104** may be formed of a shapeable or malleable metallic material or composite. Alternatively, one of the first and second rings **102**, **104** may be made from a material having a first characteristic and the other one of the first and second rings may be made from a second material having a second characteristic. More particularly, the first ring **102** may be made of a more rigid material than the second ring **104**. For example, the first ring **102** may be made of a semi-rigid metal or plastic and the second ring **104** may be made of a plastic or other material less rigid than the material of which the first ring is made. When the first and second rings **102**, **104** are compressed together (FIG. **3**), the circumference of the second ring is collapsed to fit within the circumference of the first ring.

[0063] The membrane or sheath **114** may be formed from an elastomeric material or a thin, non-distensible material. The elastomeric materials may include silicone, polyisoprene, latex, vinyl and polyurethane. The non-elastic materials may include polyester, Mylar, polyethylene, and the like. These materials may be reinforced with a fabric or woven material to increase strength and durability.

[0064] Referring to FIGS. **9** through **18**, a cross-ring wound retraction device **120** includes first and second retracting portions or rings **122**, **124** and a gastight, stretchable, tubular membrane, or sheath **126**, that may be tensioned between the retracting portions. The first and second retracting portions **122**, **124** are substantially concentric. The first and second retracting portions **122**, **124** may be hinged along a common axis **128**, thereby forming first and second hinges **130**, **132** that couple the first and second retracting portions together. The hinges **130**, **132** are positioned substantially opposite each other on the circumference of the first and second retracting portions **122**, **124**. The sheath **126** is coupled to each of the first and second retracting portions **122**, **124**.

[0065] The cross-ring retraction device **120** may be supplied in a first, relaxed state **134** (FIG. **9**) where the circumferential elastomeric sheath **126** is substantially non-tensioned or relaxed. In the first, relaxed state **134**, an angle is formed between the planes of the first and second rings **122**, **124** and there is a substantial through lumen **136** between the proximal end **138** and the distal end **140** of the retraction device **120**. To place the retraction device **120** in a second, tensioned state **142**, the profile of the retraction device may be reduced and deformed to facilitate placement through a small surgical incision **62** by rotating the retracting portions **122**, **124** toward each other across the proximal **138** and distal **140** opening planes such that the first and second rings become substantially concentric. The elastomeric sheath **126** is subsequently stretched longitudinally between the proximal end **138** and the distal end **140**, thereby placing the sheath in tension, with the opening of the lumen **136** being reduced and substantially occluded and the retraction device becoming substantially flat (see FIGS. **13-18**). Additionally, once the retraction device **120** has been thus flattened, it may be streamlined further into an oval shape (FIG. **18**) by compressing the rings **122**, **124** along the axis **128** of the first and second hinges **130**, **132**. The retraction device **120**, in the flattened, streamlined condition (FIG. **18**) will fit through a much smaller incision **62** than is the case when the device is at rest **134**. The retraction device **120** may be urged through a surgical defect, such as an incision **62** (FIGS. **1** and **2**), in a body wall **60** and subsequently allowed to assume the first relaxed state **134** in response to the release of the tension upon the elastomeric sheath **126**. The lumen **136**, including the proximal and distal openings **138**, **140** thereof, will open as the retraction device **120** assumes an open, deployed condition (FIG. **12**). The elastomeric sheath **126** forms a continu-

ous, gastight barrier **144**, **146** between the lumen **136** of the retraction device **120** and the tissue of the retracted incision or defect **62**.

[0066] The elastomeric material of which the sheath **126** is made may be chosen to provide a range of retracting forces. For instance, a light weight, thin-walled, more elastic material yields a light retraction force in comparison to a thick-walled, less elastic material. Various diameters of retraction rings **122**, **124** may be combined with various qualities of elastomeric material to yield retraction devices that accommodate a wide range of body wall conditions or types. The present invention also contemplates the use of rigid or semi-rigid plastic or spring metal for the construction of the first and second retracting portions or rings **122**, **124**.

[0067] Referring to FIGS. **19** through **25**, a retraction device **150** may include a distal continuous ring **152**, a first half ring **154** hinged to the distal continuous ring, a second half ring **156** hinged to the distal continuous ring, and a gastight, circumferential elastomeric sheath **158** coupled between the distal ring and the first and second half rings. The sheath **158** may also be coupled directly between the first and second half rings **154**, **156**.

[0068] One or both of the first and second half rings **154**, **156** may be positioned along the outer surface **160** of the distal continuous ring **152** and hinged along a common axis **162**, thereby forming a first hinge **164** and a second hinge **166** that couple the first and second half rings to each other and to the distal continuous ring with the hinges being positioned substantially opposite each other on the circumference of the distal continuous ring (FIG. **19**). Alternatively, one or both of the first and second half rings **154**, **156** may be positioned along the inner surface of the distal continuous ring **152** (FIGS. **20-25**). In a first, neutral condition (FIG. **19**), the first half ring **154** is positioned on a first side **168** of the axis **162**, proximal the distal continuous ring **152**, and the second half ring **156** is positioned on a second, opposite side **170** of the axis proximal the distal continuous ring.

[0069] A first end portion **172** of the first half ring **154** and a first end portion **174** of the second half ring **156** overlap each other and a second end portion **176** of the first half ring and a second end portion **178** of the second half ring overlap each other. The first and second end portions **172**, **176** of the first half ring **154** may be positioned between the distal continuous ring **152** and the first and second end portions **174**, **178** of the second half ring **156**, respectively, so that the first and second half rings may rotate past each other. The retraction device may transition to a second, tensioned condition (FIG. **21**) by folding the first half ring **154** and the second half ring **156** flat and in alignment with the distal continuous ring **152**. In the second, tensioned condition, the first half ring, the second half ring and the distal continuous ring may be substantially concentric.

[0070] Preparing the retraction device **150** for insertion into an incision **62** in a body wall **60** includes transitioning the retraction device from the first, neutral condition to a second, tensioned condition. The transition from the first, neutral condition (FIG. **19**) to the second, tensioned condition (FIG. **21**) includes the first half ring **154** being rotated about the hinges **164**, **166** in a first direction **180** to a position on the second side **170** of the axis **162** and proximal the distal continuous ring **152**, thereby placing the portion of the sheath **158** that is coupled between the distal ring and the first half ring in tension (FIGS. **20** and **21**). The second half ring **156** is rotated about the hinges **164**, **166** in a second, opposite direction **182** to a position on the first side **168** of the axis **162** and proximal the distal continuous ring **152**, thereby placing the portion of the sheath **158** that is coupled between the distal ring and the second half ring in tension (FIGS. **20** and **21**). The first and second half rings **154**, **156** may be rotated about the hinges **164**, **166** further until they are substantially concentric with the distal continuous ring **152**. The retraction device **150** may be further streamlined by compressing the distal continuous ring **152** and the first and second half rings **154**, **156** along the axis **162** between the first and second hinges **164**, **166**, thereby elongating the retraction device **150** to facilitate insertion of the retraction device into the incision **62** more easily (FIGS. **22** and **23**).

[0071] The retraction device **150** is inserted completely through the incision **62** and completely into the body cavity **52**. With the retraction device **150** positioned completely within the body cavity **52**, the second half ring **156** is rotated back in the first direction **180** and the first half ring **154** is rotated back in the second direction **182** until the first and second half rings are substantially perpendicular to the distal continuous ring **152**, substantially parallel to each other and proximal to the distal continuous ring (see FIG. **24**). The first and second half ring **154**, **156** are pulled proximally through the incision **62** until the distal continuous ring **152** abuts against the inner surface **66** of the body wall **60** and the first and second half ring are partially protruding from the incision. The first and second half ring **154**, **156** are released and allowed to assume a nearly neutral condition (FIG. **25**), thereby circumferentially retracting the incision **62**.

[0072] With reference to FIG. **26**, a retraction device **200** is shown having a first, distal retention ring **202**, a second, proximal retention ring **204**, a circumferential, tubular sheath **206** coupled to the first and second retention rings, a plurality of tensioning straps **208** and a proximal lock ring **210**. The distal retention ring **202** may be made from a shapeable or malleable material that may be deformed for easy insertion through a small body wall incision and subsequently allowed to assume a generally circular condition. The proximal retention ring **204** may be made from a material more rigid than the distal retention ring **202**. Each of the plurality of straps **208** is coupled to the distal retention ring **202** and extends proximally through a lumen of the sheath **206** and the proximal retention ring **204**. The proximal lock ring **210** is sized and configured to capture the straps **208** between an inner surface **212** of the proximal retention ring **204** and an outer surface **214** of the lock ring **210**. At least one of the inner surface **212** of the proximal retention ring **204** and the outer surface **214** of the lock ring **210** may be beveled. The invention contemplates the use of a strong, thin, non-elastic material, such as a fabric, for the construction of the straps **208**.

[0073] In use, the distal retention ring **202** is deformed and inserted into a body cavity **52** through an incision **62** in a body wall **60**. The proximal retention ring **204** is allowed to rest upon the outer surface of the body wall **60**. The lock ring **210** is placed within a lumen of the proximal retention ring **204** with the straps **208** exiting between the proximal retention ring and the lock ring. The straps **208** may be pulled proximally to achieve the appropriate tension and subsequent retraction of the incision. The lock ring **210** responds to the tension of the straps **208** by wedging against the inner surface **212** of the proximal retention ring **204** and substantially preventing the straps from slipping distally between the lock ring and the proximal retention ring. Removal of the retraction device **200** is accomplished by pulling at least one of the

straps **208** proximally slightly to release the lock ring **210** from the proximal ring **204** and removing the lock ring to release the tension on the straps. With the tension of the straps **208** removed, the distal ring **202** may be removed from the body cavity **52** through the incision.

[0074] Referring to FIGS. **27-29**, a wound retraction device **220** includes a proximal retention ring **222** and a plurality of shapeable, distally extending, retraction elements **224** coupled to the proximal retention ring and extending distally therefrom. The extending, retraction elements **224** are configured to transition from a first, low-profile, insertion condition **226** (FIG. **27**) to a second, expanded, high-profile retention condition **228** in which distal ends of the extending elements extend radially outwardly (FIG. **28**). The retention ring **222** may be sized and configured to hold the extending elements **224** in a generally perpendicular position to the plane of the retention ring. Alternatively, the extending elements **224** may extend radially inwardly to facilitate insertion or the retraction device **220** into the incision **62**. The extending elements **224** may be malleable so as to be shaped into a retracted state within an incision or they may be sized and configured to snap between a first, inwardly disposed condition to the second, outwardly disposed condition **228** in a détente relationship. A circumferential sheath may be associated with the retraction device **220** and positioned either between the extending elements **224** and adjacent tissue or within a lumen of the retraction device as a separate component.

[0075] In use, the extending elements **224** are inserted into a surgical incision **62** (FIGS. **1** and **2**) in a body wall **60** and advanced distally until the proximal retention ring **222** is substantially abutted against an outer surface of the body wall. A surgeon may then insert his hand distally through the retention ring **222** and bend a distal portion **230** of each of the extending elements **224** radially outwardly such that the distal portions of the extending elements are placed against an inner surface **66** of the body wall **60**.

[0076] The extending elements **224** may be made of thin strips of sheet metal, such as spring steel, having a cupped or axially semicircular cross section resembling a steel tape measure or a slat of a venetian blind. Each of the extending elements **224** is oriented with the outer curve **232** of the semicircular cross section positioned radially outwardly. The extending elements **224** easily exist in the first, straight, insertion condition **226**. However, once bent inwardly on the outer semicircular surface **232**, the extensions transform to the second, curved, high-profile condition **228** for retention in the incision.

[0077] The extensions **224** may be made of a shape-memory material, such as nickel-titanium alloy. At a first temperature, the extending elements **224** made of nickel-titanium alloy may be in a first, substantially straight condition **226**, and when placed in an environment having a second, higher temperature, the extensions transform to a second, curved condition **228** with the distal ends of the extending elements extending radially outwardly. For example, the device **220** may be held in a relatively cold environment, such as in ice water, and subsequently inserted into a warm environment where the temperature is higher, such as in a live body. The shape of nickel-titanium alloy extending elements **224** changes according to a preset condition.

[0078] Referring to FIG. **29**, the wound retraction device **220** may include a plurality of pull wires **234** with each pull wire corresponding with a respective extending element **224**. Each of the pull wires **234** is coupled to a distal portion **230** of a respective extending element **224** and configured such that when the pull wire is pulled proximally, the distal portion of the respective extending element deflects radially outwardly. Each pull wire **234** forces the distal portion **230** of the respective extending element **224** to exhibit a shape that is determined by the tension of the pull wire. The pull wires **234** may be deployed collectively or individually to bend the extending elements **224**. Each of the pull wires **234** may traverse through a pull wire retainer **236** that is positioned along the length of the outer surface **238** of a respective extending element **224**. Each pull wire retainer **236** may include at least one eyelet **240**, tube **242** or other similarly functioning device. The pull wire retainers **236** function to limit the distance that the pull wires **234** deviate from the outer surface **238** of the extending elements **224** when the pull wires are pulled proximally to deflect the distal portions **230** of the extending elements. The pull wire retainers **236** may be longitudinally aligned along the length of the outer surface **238** of the extending element **224**.

[0079] Referring to FIGS. **30-32**, a wound retraction device **250** includes an outer ring **252** having a substantially annular shape with an adjustable circumference and a substantially tubular structure **254** extending distally from the outer ring. The outer ring **252** is divided into a plurality of curved ring segments **256** with adjacent curved ring segments being coupled together by means for adjusting the circumference, such as a ratcheting mechanism **258**, to form the annular shape. Each of the curved ring segments **256** includes a first, proximal side **260**, a second, distal side **262**, a first end **264** about the circumference of the outer ring **252** and a second end **266** about the circumference of the outer ring. The curved ring segments **256** may be flexible to maintain a substantially circumferential shape of the outer ring **252** as the diameter of the outer ring is adjusted.

[0080] The ratcheting mechanism **258** may include a groove **268** in the proximal surface **260** of each of the curved ring segments **256**. The groove **268** substantially follows the curve of the curved ring segment **256** and is opened to the first end **264** of the curved ring segment. The groove **268** includes a plurality of ratchet teeth **270** positioned, for example, on a first, outer curved surface **272** of the groove. Alternatively, the ratchet teeth **270** may be positioned on a second, inner curved surface **274** of the groove **268** or on the distal surface **276** of the groove. The groove **268** may also include a retention channel **278** in at least one of the outer and inner curved surfaces **272**, **274** of the groove.

[0081] Each of the curved ring segments **256** also includes a flexible, elongate protuberance **280** extending from the second end **266** of the curved ring segment adapted to mate with the groove **268** in an adjacent curved ring segment. The elongate protuberance **280** includes at least one ratchet tooth **282** that interacts with the ratchet teeth **270** in the groove **268** of the curved ring segment **256** adjacent the elongate protuberance. Forming the outer ring **252** includes aligning the curved ring segments **256** together circumferentially with the first end **264** of each of the curved ring segments positioned adjacent the second end **266** of an adjacent curved ring segment and inserting the elongate protuberance **280** of each of the curved ring segments into the groove **268** of the other adjacent curved ring segment such that the at least one ratchet tooth **282** on the elongate protuberance interacts with the ratchet teeth **270** in the groove.

[0082] To substantially prevent the elongate protuberance **280** of one curved ring segment **256** from inadvertently slipping out of the groove **268** of the adjacent curved ring segment, the elongate protuberance may include a lip **284** (FIG. **32**) extending longitudinally along the length of the elongate protuberance and adapted to interact with the retention channel **278** in the groove of the adjacent curved ring segment. The diameter of the outer ring **252** is adjusted by inserting and retracting the elongate protuberances **280** within the grooves **268** of the adjacent curved ring segments **256**. The diameter of the outer ring **252** is increased as the curved ring segments **256** are moved further apart and the diameter is decreased as the curved ring segments are moved closer together.

[0083] As with the outer ring **252**, the substantially tubular structure **254** is also divided into a plurality of elongate tube segments **286** with each of the tube segments being coupled to a respective curved ring segment **256** and extending distally from the respective curved ring segment. The tube segments **286** may each extend circumferentially between the first end **264** and the second end **266** of the curved ring segment **256** to which the respective tube segment is coupled (FIG. **30**) such that there is no overlap between adjacent tube segments. Alternatively, each of the tube segments **286** may extend circumferentially beyond at least one of the first and second ends **264**, **266** of the curved ring segment to which the respective tube segment is coupled (FIG. **31**) such that adjacent tube segments may overlap each other. The profile of the tube segments **286** may substantially follow the curve of the curved ring segment **256** to which the respective tube segment is coupled. The tube segments **286** may be flexible so as to follow any change of the curve of the curved ring segments **256** to which the respective tube segments are coupled. The tube segments **286** may be made of a biocompatible material, such as a metallic or polymeric material.

[0084] Referring to FIG. **31**, the retraction ring **250** may include an inner ring **288** that is substantially opposite to the outer ring **252** to maintain the diameter of the tubular structure **254** at the distal end **290** of the tubular structure substantially the same as the diameter at the proximal end **292** of the tubular structure. The inner ring **288** includes the ratcheting mechanism **258**, but with the groove **268** positioned on the distal surface of the curved ring segments **256**. In use, with both the outer ring **252** and the inner ring **288** retracted to their smallest respective diameters, the distal end **262** of the wound retraction device **250**, including the inner ring, may be inserted through a small incision **62** (FIGS. **1** and **2**) in a body wall **60** and into a body cavity **52**. The inner ring **288** may be expanded to a larger diameter to deploy the inner ring in the form of a distal retention member. With the inner ring **288** deployed, the outer ring **252** may be adjusted to a larger diameter to provide tension upon the tube segments **286**, thereby providing circumferential retraction of the incision.

[0085] For retraction rings **250** that do not include the inner ring **288**, the distal ends **290** of the tube segments **286** may be inserted into the incision **62** and into the body cavity **52**. The outer ring **252** may be adjusted to a larger diameter to provide tension upon the tube segments **286**, thereby providing circumferential retraction of the incision **62**. The tube segments **286** are sufficiently strong to maintain retraction of the incision **62** without substantially deflecting the tube sections.

[0086] Referring to FIGS. **33** and **34** a circumferential surgical retraction device **300** includes a first, substantially annular, outer ring **302** and a second, substantially annular, inner ring **304**. The first and second rings **302**, **304** are separated by a substantially gastight cylindrical sleeve **306**. The first and second rings **302**, **304** may be made of a substantially flexible material, such as a polymeric material, and may be reinforced with a first and second biasing member **308**, **310**, respectively, such as a spring-like core positioned in each of the first and second rings, that biases the first and second rings radially outwardly. Biasing the first and second rings **302**, **304** radially outwardly subsequently biases the retraction device **300** toward a shorter axial length. The cylindrical sleeve **306** is coupled to the first and second rings **302**, **304**. The cylindrical sleeve **306** may include a bellows **312**, or radial folds, that allow the cylindrical sleeve to transition between a first, axially compressed state (FIG. **33**) and a second, axially extended state (FIG. **34**).

[0087] With the retraction device **300** in the first, axially compressed state (FIG. **33**), the retraction device may be further compressed radially at opposing points along the inner and outer rings **302**, **304** to transform the retraction device into a low profile, elongate, oval shape to facilitate insertion into an incision **62** (FIGS. **1** and **2**). The retraction device **300** is advanced through the incision **62** until the inner ring **304** is completely within the body cavity **52**. The radial compression is released from the inner ring **304** and the inner ring is permitted to assume its substantially circular configuration. The outer ring **302** is pulled proximally through the incision, thereby pulling the inner ring **304** into sealing contact with the inner surface **66** of the body wall **60** and stretching the bellows **312** of the cylindrical sleeve **306**. The outer ring **302** is pulled proximally until the outer ring is outside the incision **62** and the retraction device is in the second, axially extended state (FIG. **34**). The first biasing member **308** in the outer ring **302** biases the outer ring radially outward and into sealing contact with the outer surface of the body wall **60**. With the biasing member **308**, **310** in each of the outer and inner rings **302**, **304** biasing the rings radially outward, the cylindrical sleeve **306** is placed in tension and retracts the incision **62**. Following the surgical procedure, removal of the retraction device **300** is accomplished by reaching into the body cavity **52** and pulling the inner ring **304** proximally through the incision **62**, thereby removing the cylindrical sleeve **306** from the incision.

[0088] Referring to FIGS. **35** and **36**, a wound retraction device **320** includes a gastight, tubular membrane or sheath **322** having a first, proximal end **324** and a second, distal end **326**. The sheath **322** is sufficiently long to fit completely through a body wall, such as an abdominal wall **60** (FIGS. **1** and **2**). The sheath **322** includes a malleable, generally circular member **328** that assumes a first circumference (FIG. **35**) when compressed to a first, folded condition **330** and a second, larger circumference (FIG. **36**) when unfolded to a second, unfolded condition **332**. The sheath **322** is biased toward the second, unfolded condition **332**. The sheath **322** may be compressed to the first, folded condition **330** by means of a circularly retracting tool or even by a surgeon's hands. In the first, folded condition **330**, the sheath **322** may include undulations **334** about its circumference. When the force holding the sheath **322** in the folded condition **330** is removed, the sheath opens to the second, unfolded condition **332**.

[0089] In use, the sheath **322** is compressed to the first, folded condition **330** and inserted into an incision **62** in a body wall **60**. When the sheath **322** is positioned completely across the body wall **60**, the force holding the sheath in the folded

condition is removed and the sheath expands to the second, unfolded condition **332** and retracts the incision through which it is placed.

[0090] The folded and unfolded conditions of the sheath **322** may represent a détente relationship where the first, folded, condition (FIG. **35**) is a relaxed, non-tensioned condition or a compressed condition and where the second, unfolded, condition (FIG. **36**) is a fixed, over-centered, condition having sufficient hoop strength to resist compression or refolding. The sheath **322** in the second unfolded condition **332** may include means to prevent the sheath from shifting position within the retracted wound, such as undulations or protrusions on the outer surface of the sheath. Alternate embodiments may include midpoint conditions between a first, folded condition and a second, unfolded condition.

[0091] Referring to FIG. **37**, the wound retraction device **320** of FIGS. **35** and **36** may include means for compressing the sheath **322** into the first, folded condition **330**. Such means may include a drawstring **336**. The drawstring **336** may include a flexible string **338** that is threaded through the undulations **334** of the sheath **322**. The string **338** may include cord, twine, cable, thread, or similar materials that are well known in the art. To compress the sheath **322** into the first, folded condition **330**, the drawstring **336** is pulled radially away from the sheath. When the drawstring **336** is released (FIG. **38**), the sheath **322** assumes the second, unfolded condition **332**.

[0092] Referring to FIGS. **39** and **40**, a circumferential retraction device **350** includes a first, outer retention ring **352**, a second, inner, flexible or shapeable retention ring **354** and a gastight, substantially cylindrical sleeve **356** coupled to the first and second rings. The outer retention ring **352** is sized and configured to remain outside a body cavity **52**. The inner retention ring **354** is sized and configured for insertion into and through a surgical incision **62** in a body wall **60** and into the body cavity **52**. The cylindrical sleeve **356** is configured to be tensioned between the first ring **352** and the second ring **354** to retract the incision **62** in the body wall **60**. The cylindrical sleeve **356** may include a bellows **358**, or radial folds, that allow the cylindrical sleeve to transition between a first, axially compressed state (FIG. **39**) and a second, axially extended state (FIG. **40**).

[0093] With the retraction device **350** in the first, axially compressed state (FIG. **39**), the second, inner retention ring **354** may be compressed radially at opposing points along its circumference to transform the circular second retention ring into an elongate, oval shape to facilitate insertion into an incision **62** (FIGS. **1** and **2**). The second ring **354** is advanced through the incision **62** until it is completely within the body cavity **52**. The radial compression is released from the second ring **354** and the second ring is permitted to assume its substantially circular configuration. The first ring **352** includes a substantially hollow, inflatable structure **360** that may be enlarged by pressurization with gas or fluid. With the retraction device **350** positioned in the incision **62**, the first, outer ring **352** may be inflated (FIG. **40**), thereby placing increasing tension on the gastight sleeve **356**. Since the second, inner ring **354** cannot be drawn into the incision, the increasing tension on the sleeve **356** retracts and enlarges the incision through which it extends.

[0094] It will be understood that many modifications can be made to the disclosed embodiments without departing from the spirit and scope of the invention. For example, various sizes of the surgical device are contemplated as well as various types of constructions and materials. It will also be apparent that many modifications can be made to the configuration of parts as well as their interaction. For these reasons, the above description should not be construed as limiting the invention, but should be interpreted as merely exemplary of the embodiments.

1. A retraction device, comprising:
a proximal retention ring; and
a plurality of shapeable extending elements coupled to the proximal retention ring and extending distally therefrom, the extending elements being configured to transition from a first, low-profile, insertion condition to a second, expanded, high-profile retention condition in which distal ends of the extending elements extend radially outwardly.

2. The retraction device of claim **1**, further comprising a circumferential sheath positioned within a lumen of the retraction device.

3. The retraction device of claim **1**, the proximal retention ring being adapted to abut against an outer surface of the body wall.

4. The retraction device of claim **1**, wherein:
the extending elements being made of a shape-memory material;
at a first temperature, the extending elements being in a first, substantially straight condition; and
at a second, higher temperature, the extending elements transforming to a second, curved condition where the distal ends of the extending elements extending radially outwardly.

5. The retraction device of claim **4**, the extending elements being formed of nickel-titanium alloy.

6. The retraction device of claim **1**, further comprising a plurality of pull wires, each of the pull wires being coupled to a distal portion of a respective extending element and configured to deflect the respective extending element radially outwardly when the pull wire is pulled proximally.

7. The retraction device of claim **6**, the extending elements being made of spring steel.

8. The retraction device of claim **6**, further comprising a pull wire retainer positioned along the length of the outer surface of each of the extending elements, each of the pull wires traversing through a respective pull wire retainer.

9. The retraction device of claim **8**, each pull wire retainer including a tube, the respective pull wire traversing through the tube.

10. The retraction device of claim **8**, each pull wire retainer including at least one eyelet, the pull wires traversing through the respective eyelets.

11. The retraction device of claim **10**, each pull wire retainer including a plurality of eyelets longitudinally aligned along the length of the respective extending element, the pull wires traversing through the respective plurality of eyelets.

12. A retraction device, comprising:
an outer ring having a substantially annular shape with an adjustable circumference, the outer ring being divided into a plurality of curved ring segments, each of the curved ring segments including a first, proximal side, a second, distal side, a first end about the circumference of the outer ring, and a second end about the circumference of the outer ring;
a substantially tubular structure extending distally from the outer ring, the substantially tubular structure being divided into a plurality of elongate tube segments, each

of the tube segments being coupled to a respective curved ring segment and extending distally from the respective curved ring segment; and

means for adjusting the circumference of the outer ring,

wherein the diameter of the outer ring being increased by moving the curved ring segments further apart and the diameter being decreased by moving the curved ring segments closer together.

13. The retraction device of claim **12**, each of the tube segments of the tubular structure extending circumferentially between the first end and second end of the respective curved ring segment to which it is coupled such that there is substantially no overlap between adjacent tube segments.

14. The retraction device of claim **12**, each of the tube segments extending circumferentially beyond at least one of the first and second ends of the respective curved ring segment to which it is coupled such that adjacent tube segments overlap.

15. The retraction device of claim **12**, the means for adjusting the circumference of the outer ring including a ratcheting mechanism, the ratcheting mechanism being adapted to couple adjacent curved ring segments of the outer ring together to form the annular shape of the outer ring.

16. The retraction device of claim **15**, the ratcheting mechanism including:

a groove in the proximal surface of each of the curved ring segments, the grooves substantially following the curve of the respective curved ring segment and being open to the first end of the respective curved ring segment, the groove forming a first, outer curved surface and a second, inner curved surface;

a plurality of ratchet teeth positioned in each of the grooves;

an elongate protuberance extending from the second end of each of the curved ring segments, the protuberances being adapted to mate with the groove in an adjacent curved ring segment; and

at least one ratchet tooth positioned on each of the protuberances, the at least one ratchet tooth being adapted to interact with the ratchet teeth in the groove of the respective adjacent curved ring segment.

17. The retraction device of claim **16**, wherein:

the first end of each of the curved ring segments being positioned adjacent the second end of an adjacent curved ring segment; and

the elongate protuberance of each curved ring segment being inserted into the groove of the other adjacent curved ring segment such that the at least one ratchet tooth on the elongate protuberance interacts with the ratchet teeth in the groove.

18. The retraction device of claim **16**, the ratchet teeth being positioned on the first, outer curved surface of the groove of the respective curved ring segment.

19. The retraction device of claim **16**, the ratchet teeth being positioned on the second, inner curved surface of the groove of the respective curved ring segment.

20. The retraction device of claim **16**, the ratchet teeth being positioned on a distal surface of the groove of the respective curved ring segment.

21. The retraction device of claim **16**, further comprising:

a retention channel positioned in each of the grooves in at least one of the first, outer curved surface and second, inner curved surface of the respective groove;

a lip positioned on each of the elongate protuberances, the lips extending longitudinally along the length of the respective protuberance and being adapted to interact with the retention channel in the groove of the respective adjacent curved ring segment.

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