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(54) **VARIABLE COMPOSITE SHEATH WITH INTERRUPTED SECTIONS**

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This patent is subject to a terminal disclaimer.

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(51) **Int. Cl.**⁷ **A61B 17/22**

(52) **U.S. Cl.** **606/127; 606/128; 606/106; 606/206; 606/264; 606/265**

(58) **Field of Search** 606/127, 206, 606/205, 113, 52, 110, 114, 159, 167, 185, 45, 50, 51, 49; 600/562, 564; 604/264, 265

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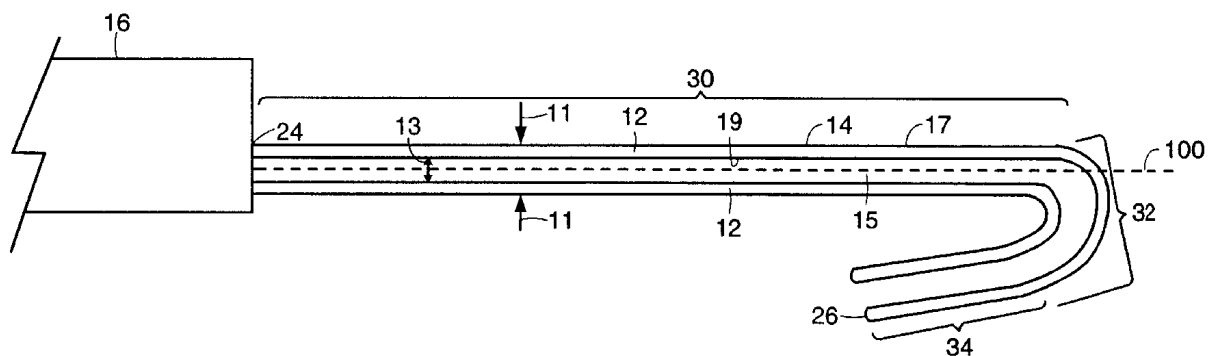
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(57) **ABSTRACT**

A medical device includes a handle, a sheath, and an object-engaging unit. The distal end portion of the sheath is strong enough to resist being deformed by the object-engaging unit, yet another portion of the sheath is flexible enough to bend sufficiently.

43 Claims, 15 Drawing Sheets



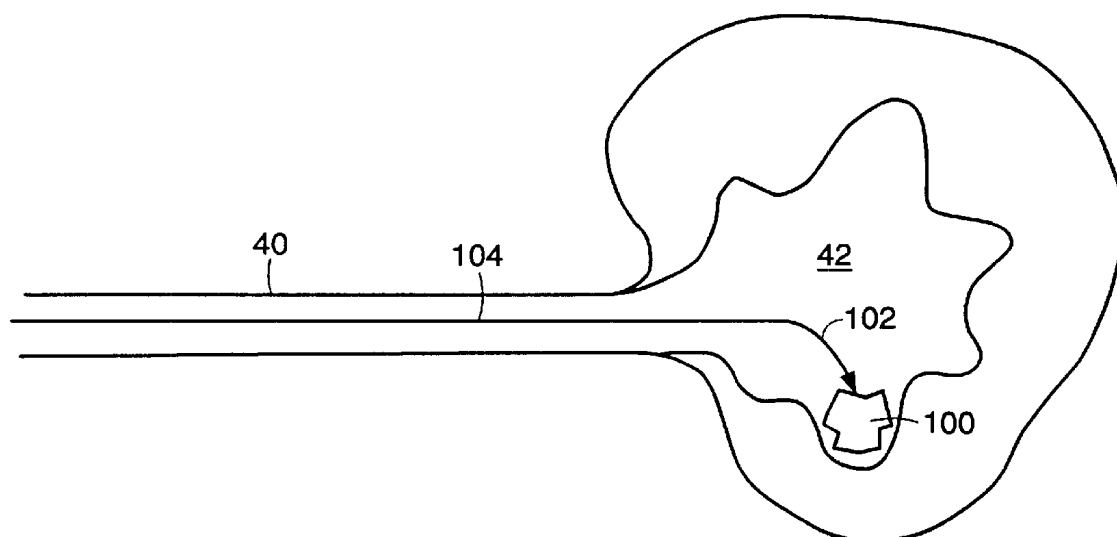
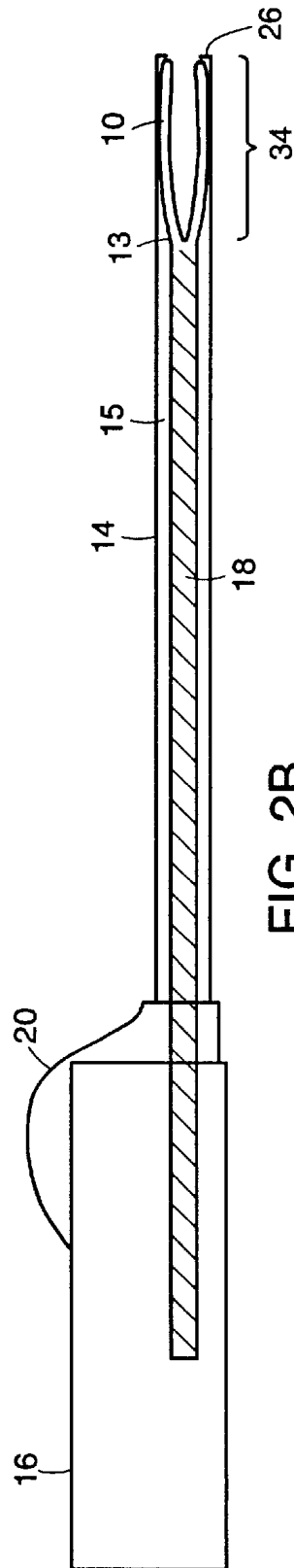
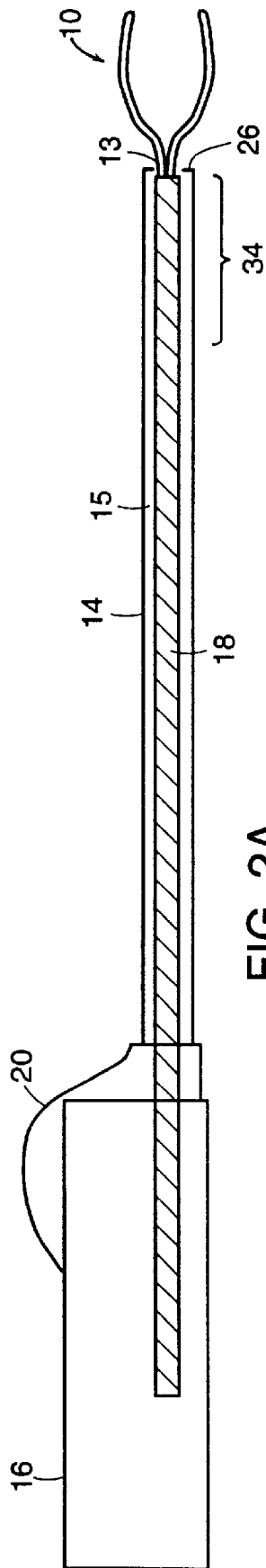
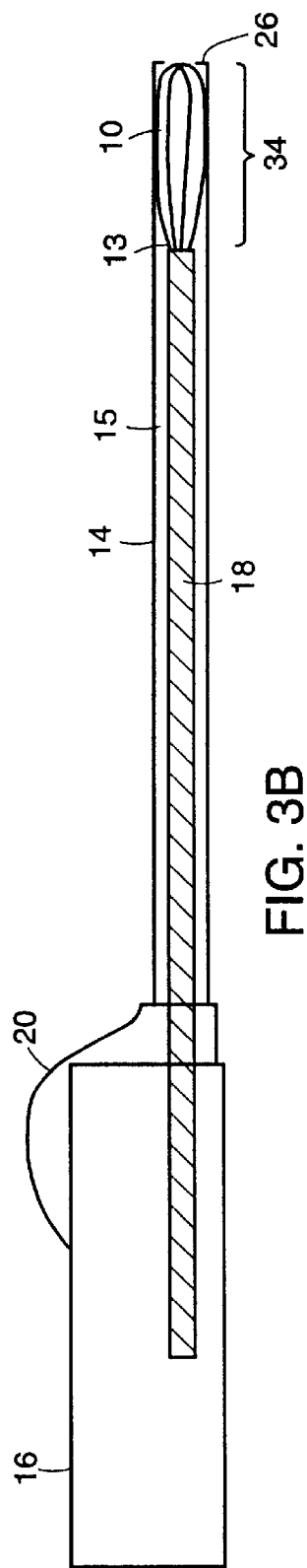
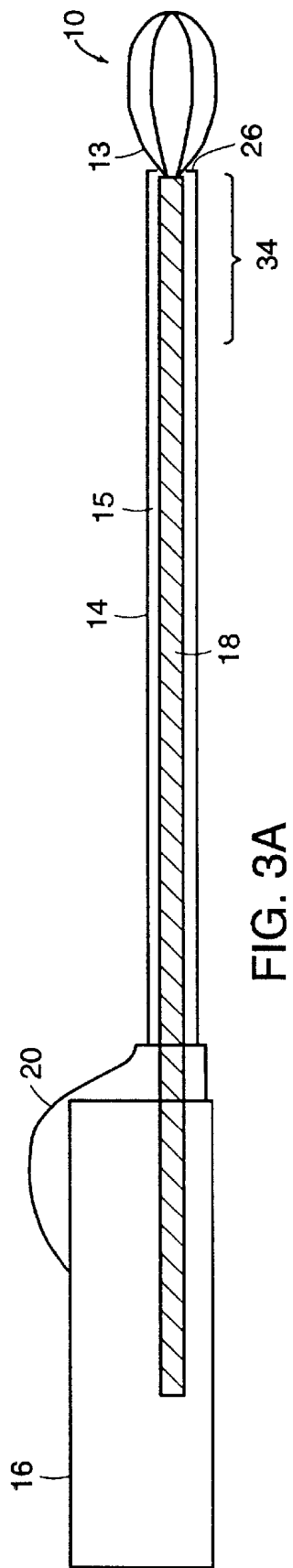
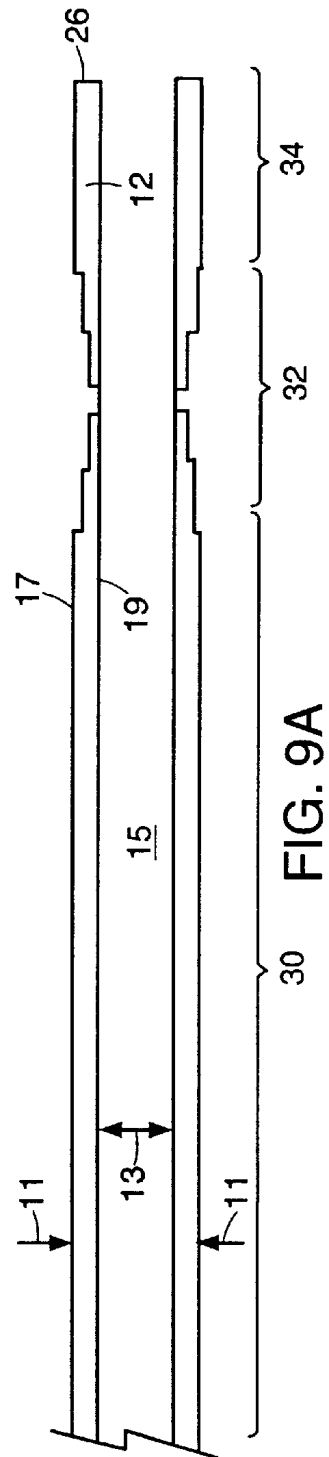
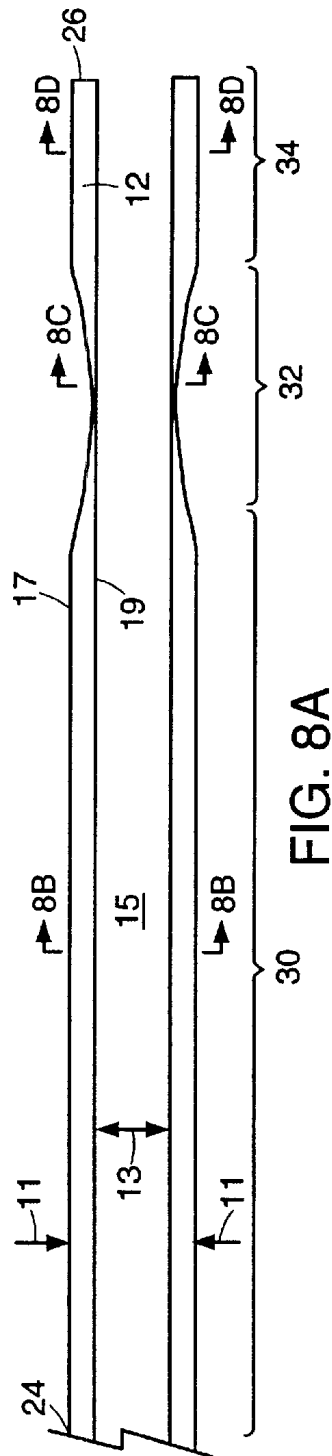
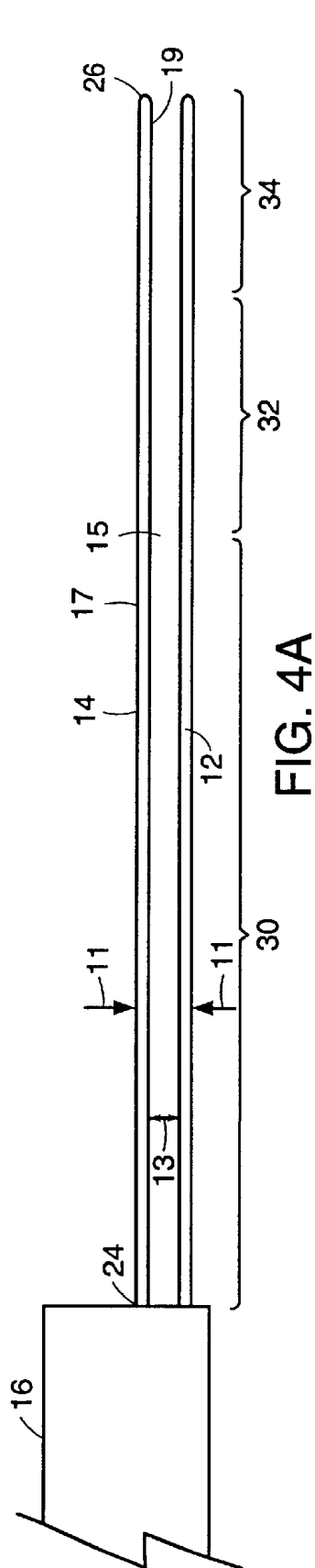


FIG. 1







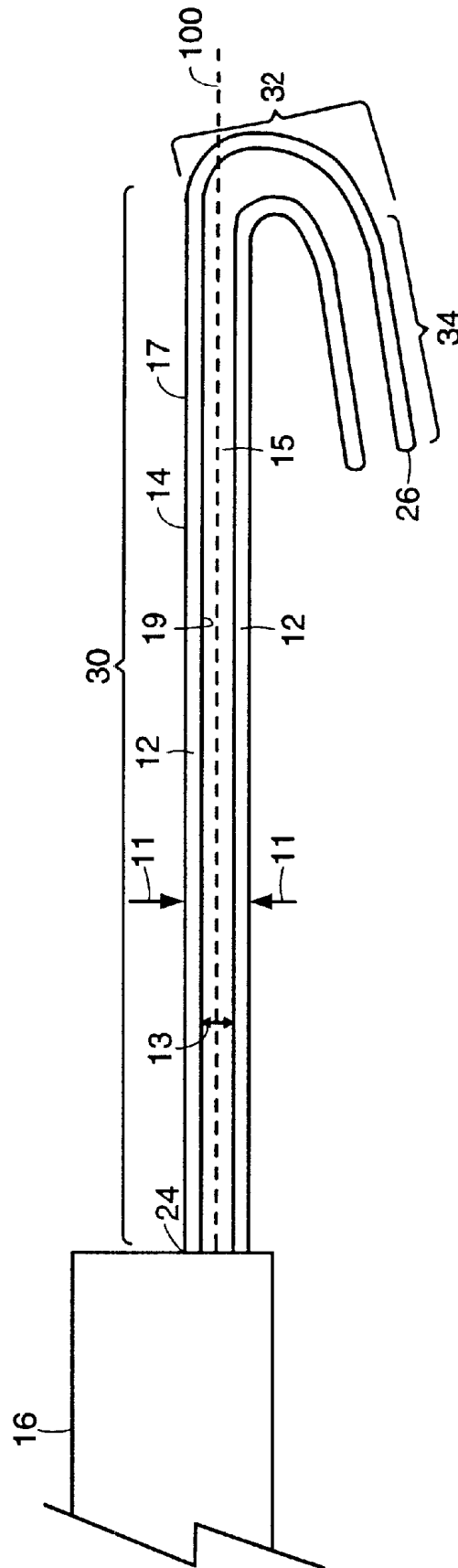


FIG. 4B

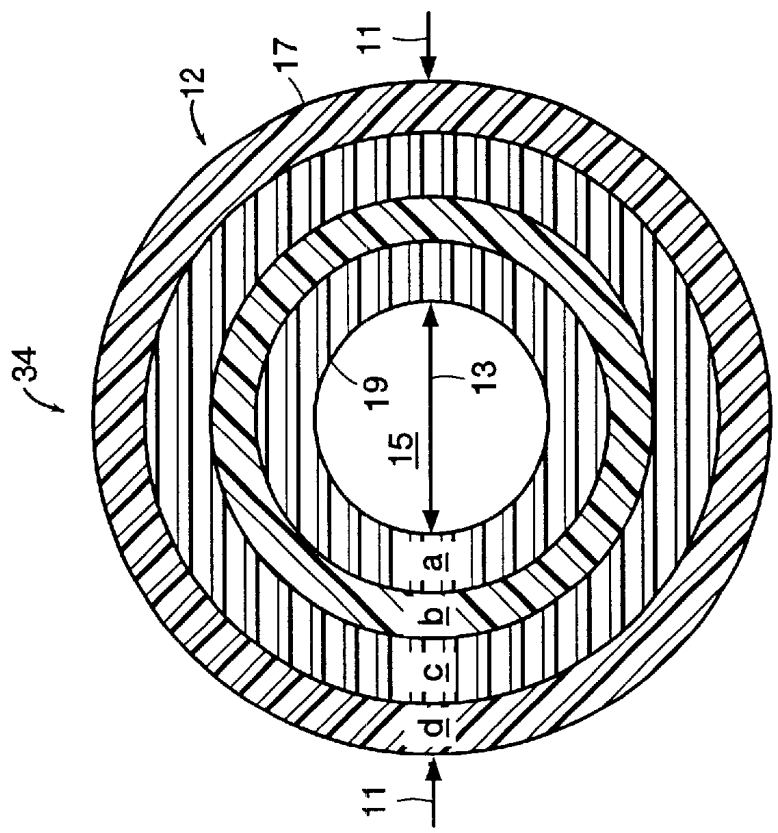


FIG. 5A

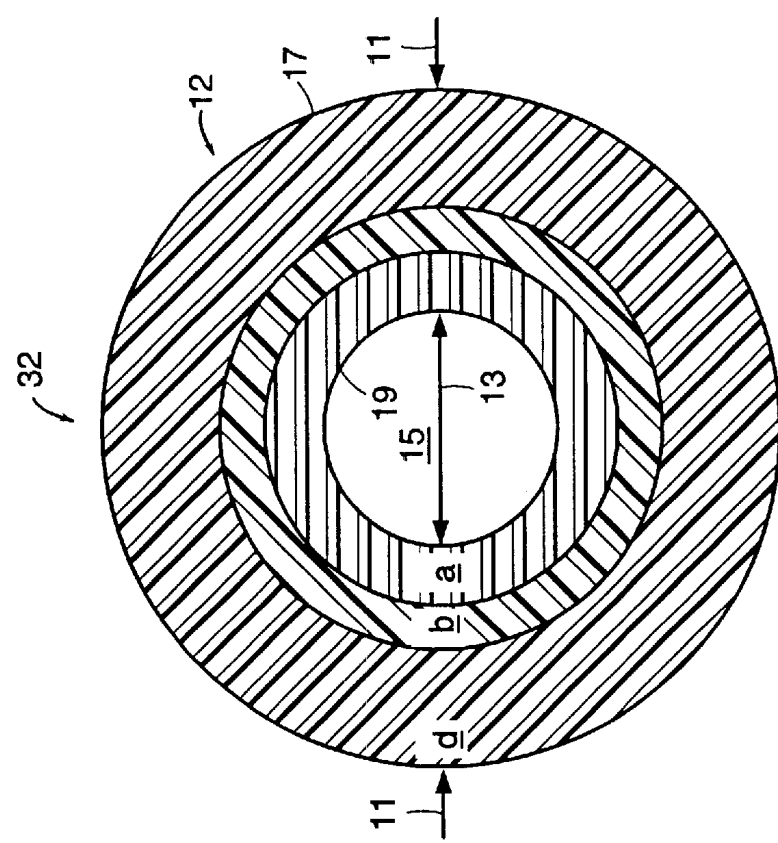


FIG. 5B

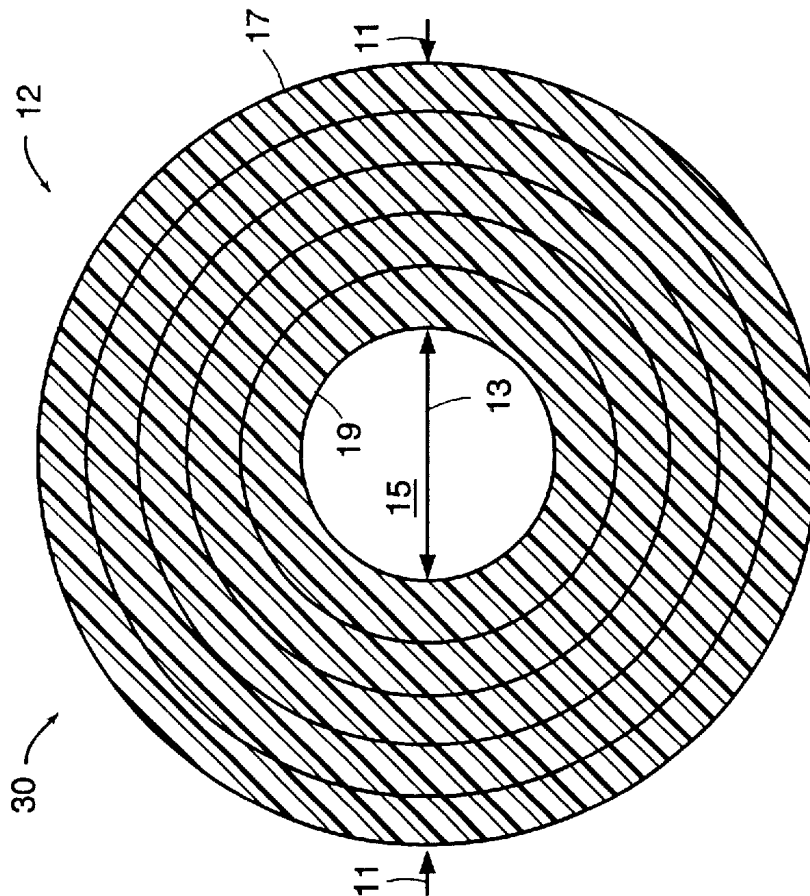


FIG. 6A

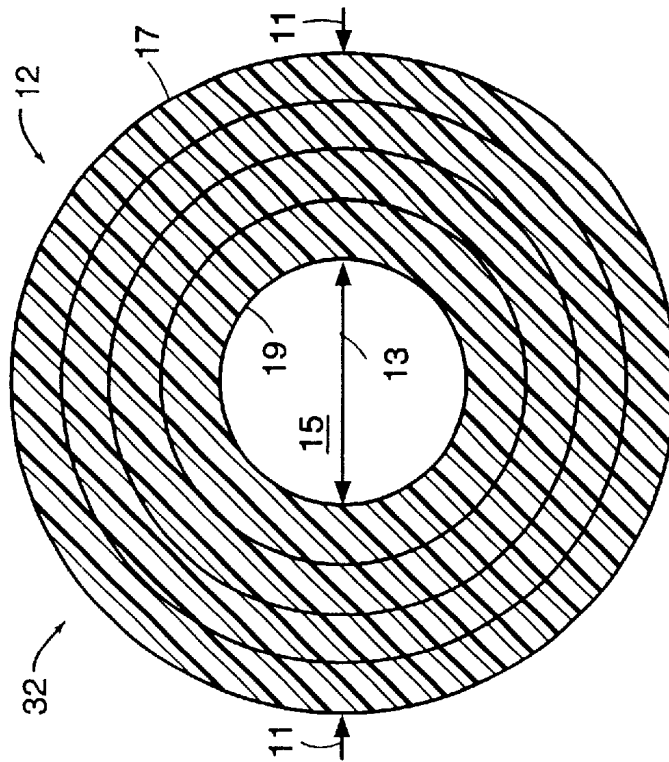
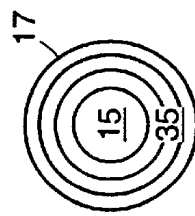
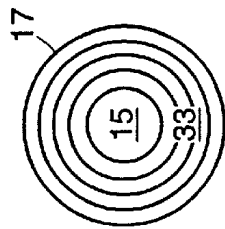
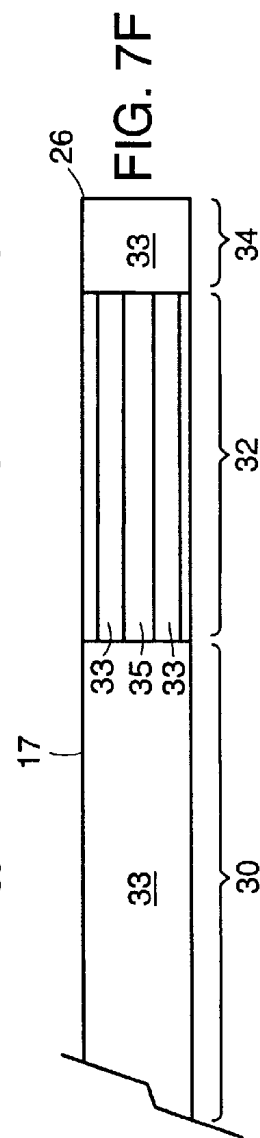
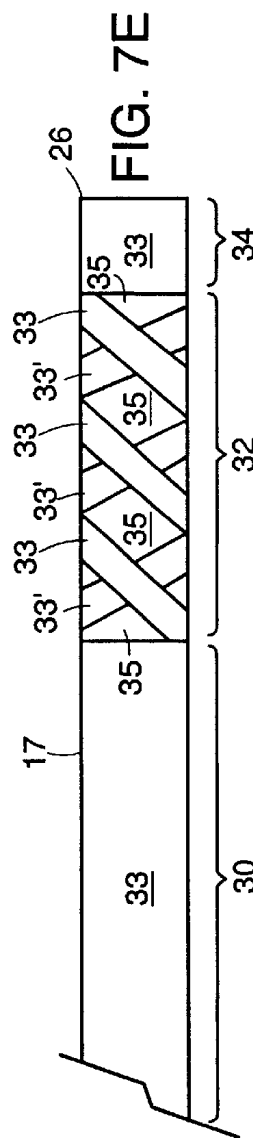
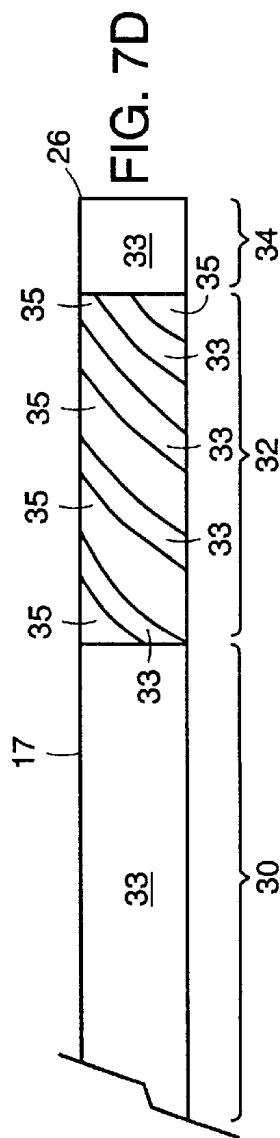
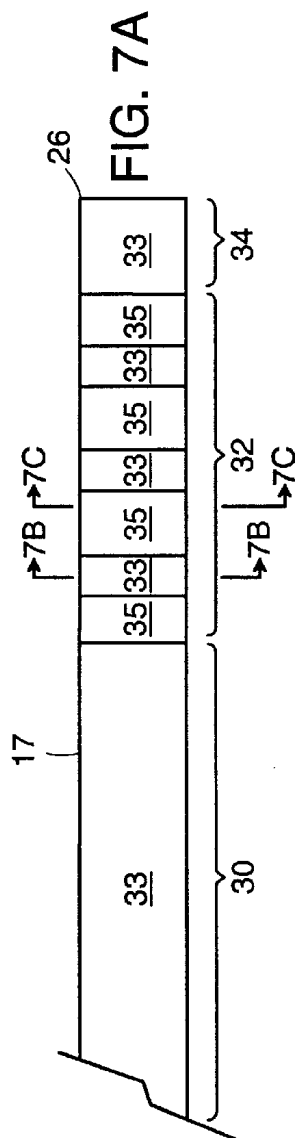


FIG. 6B



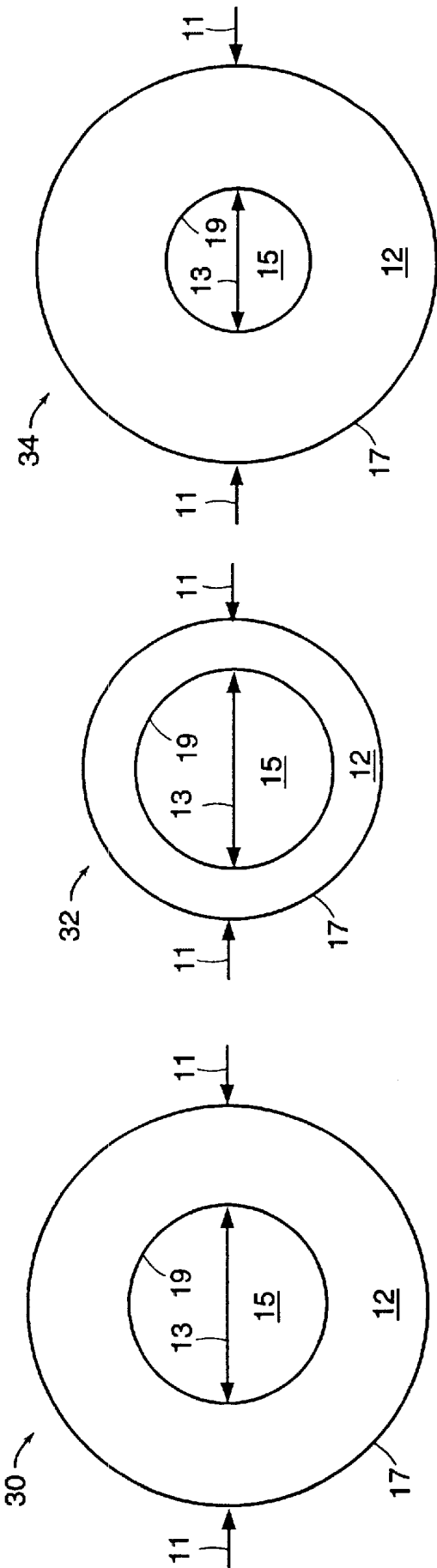


FIG. 8D

FIG. 8C

FIG. 8B

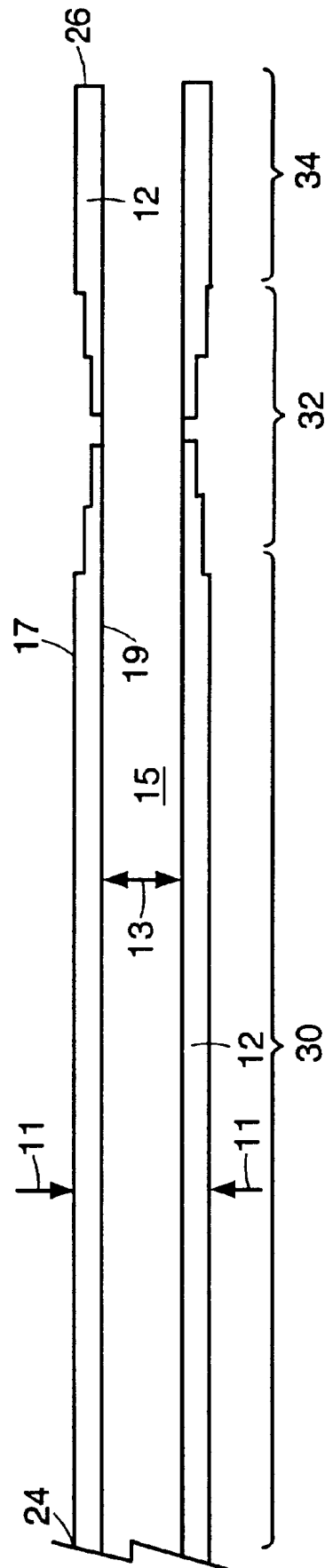


FIG. 9B

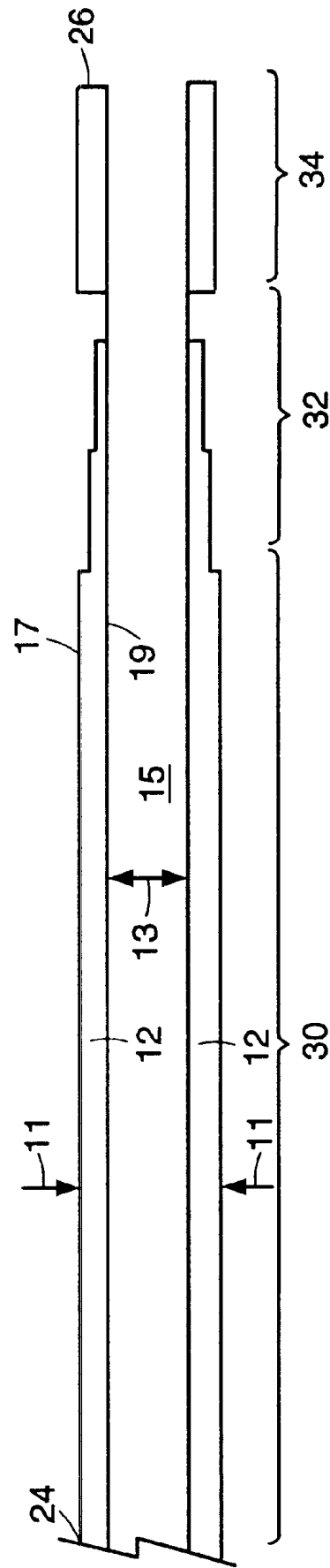


FIG. 9C

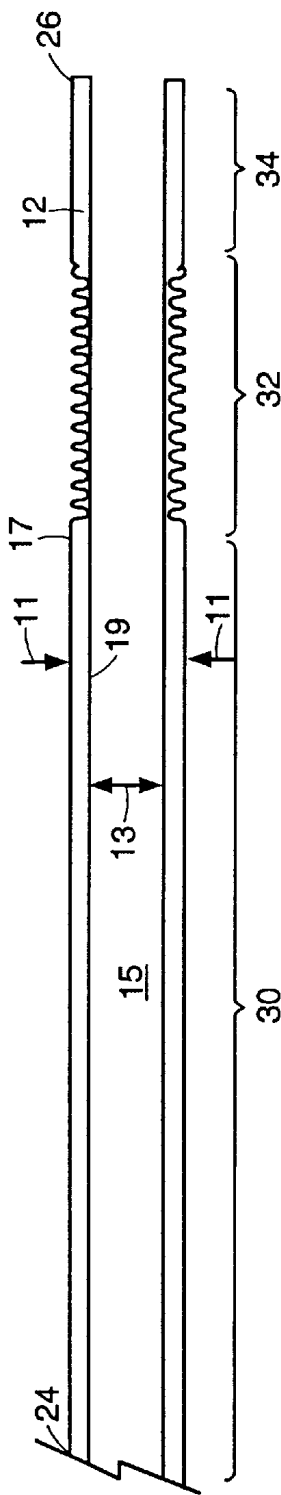


FIG. 9D

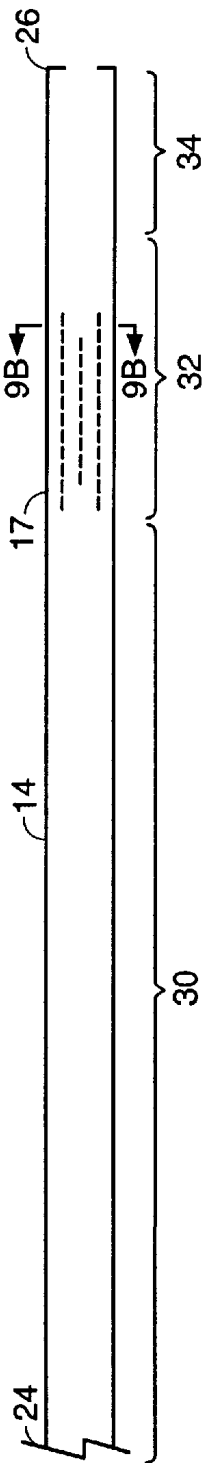


FIG. 10A

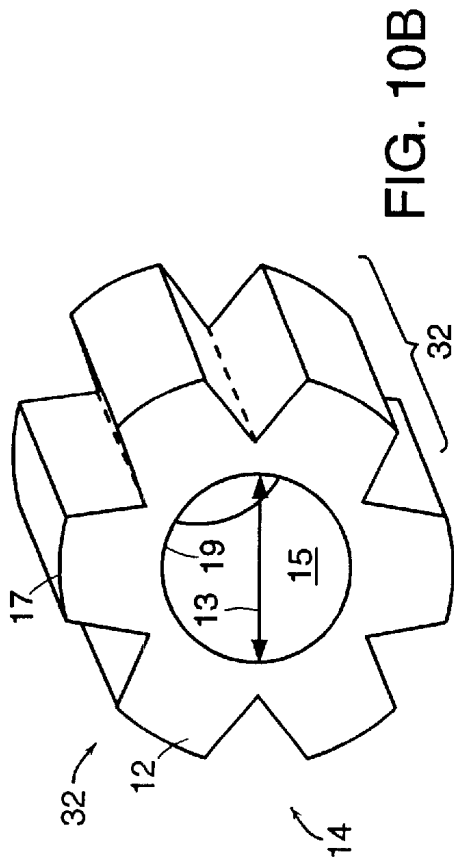


FIG. 10B

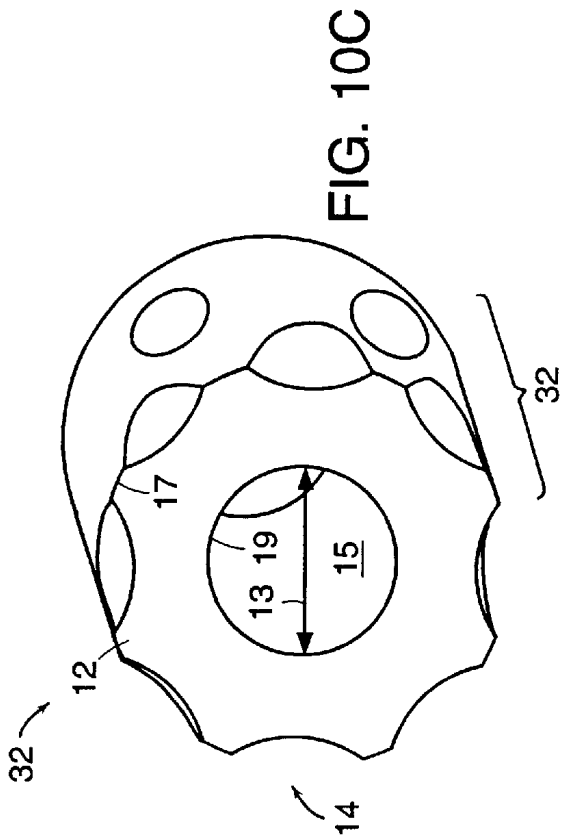


FIG. 10C

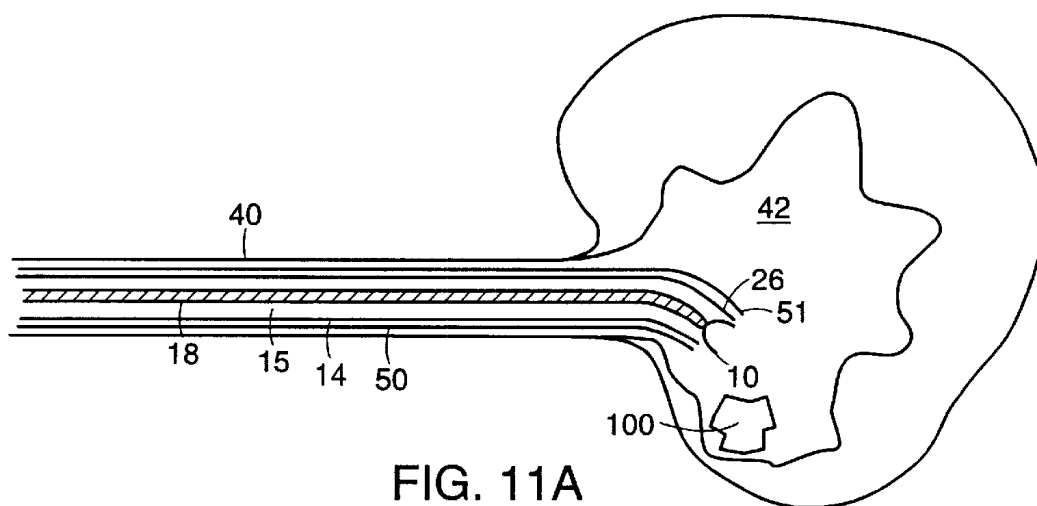
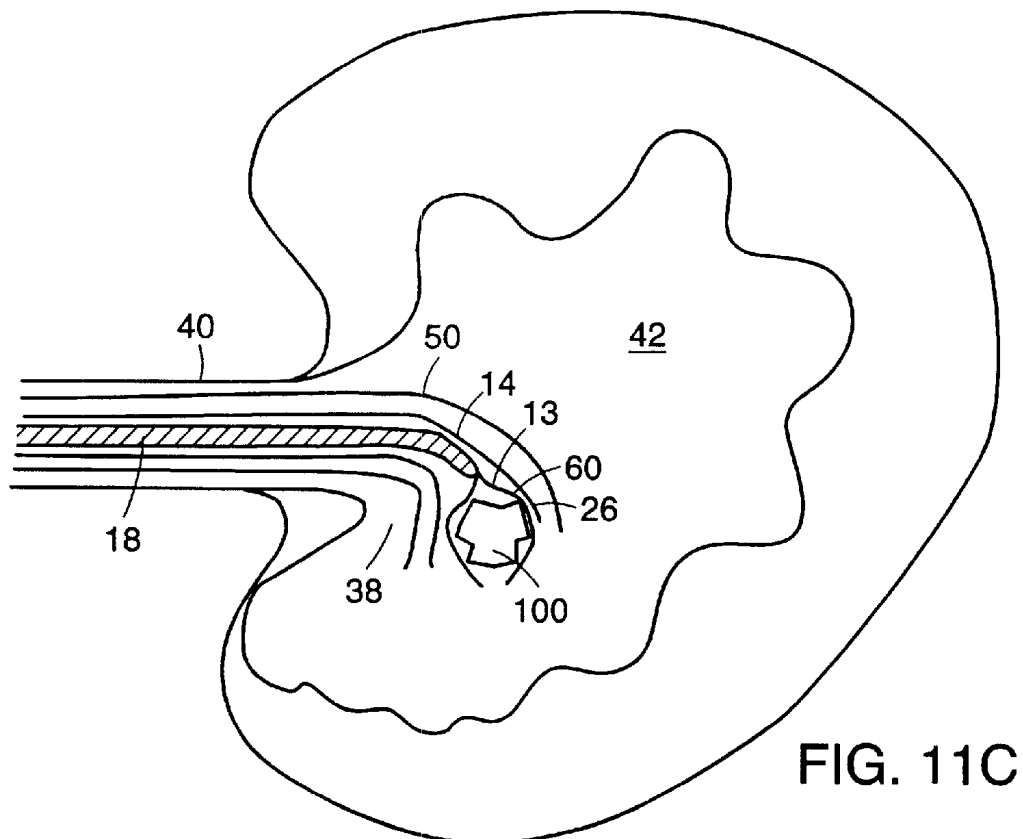
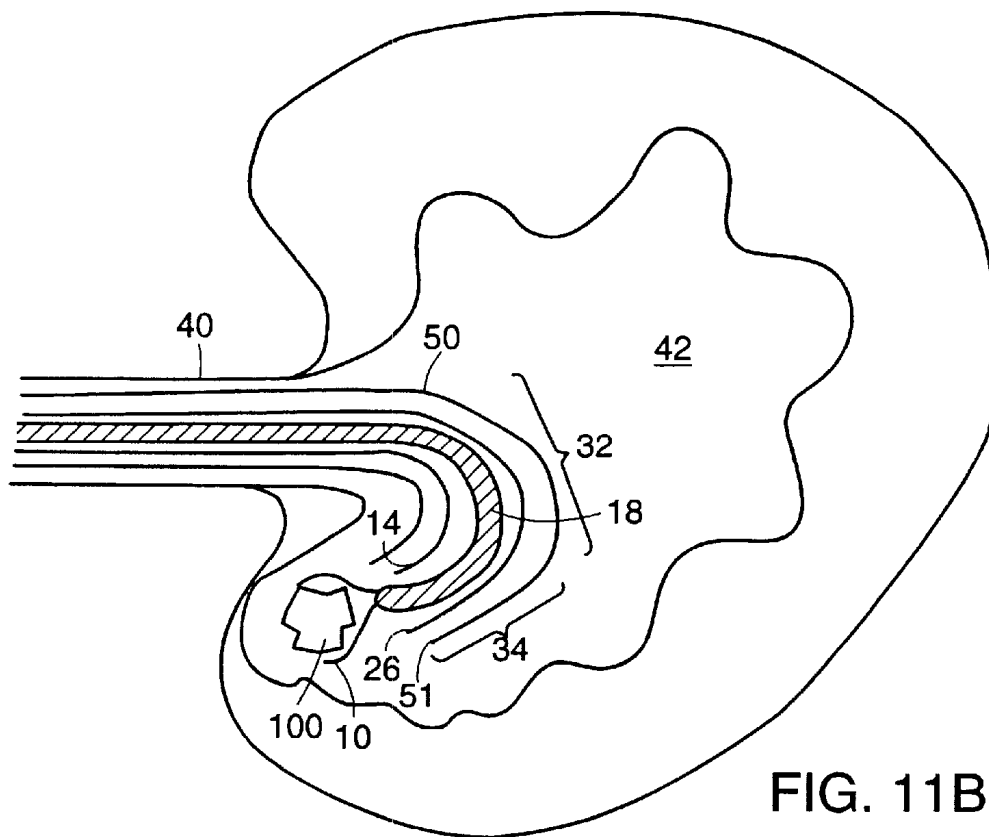


FIG. 11A



VARIABLE COMPOSITE SHEATH WITH INTERRUPTED SECTIONS

CROSS-REFERENCE TO RELATED APPLICATIONS

This is a continuation-in-part of U.S. application Ser. No. 09/478,609, filed Dec. 30, 1999 which is based on and claims priority to provisional U.S. patent application Ser. No. 60/138,950, filed on Jun. 11, 1999.

TECHNICAL FIELD

This invention generally relates to medical devices for manipulating matter in a body. More particularly, the invention relates to a medical device including an object-engaging unit, such as a retrieval device or a surgical blade, and a sheath for introduction of the object-engaging unit directly into a body opening or cavity or into a body through an endoscope or a laparoscope channel, for example.

BACKGROUND INFORMATION

Medical devices can be used in a body opening, cavity, or tract to manipulate material within the body. Such medical devices may be used through an endoscope or a laparoscope. When inserted into a flexible endoscope, medical devices impair the ability of the flexible endoscope to achieve the desired flexion needed to engage material at a remote body site.

One such medical device has a sheath and an object-engaging unit, such as a basket, that is moveable relative to the sheath from a collapsed state within the sheath to another state in which the unit extends past the distal end of the sheath. Typically, the object-engaging unit is in an operational mode when the object-engaging unit is extended beyond the distal end of the sheath. The sheath typically extends from a handle, located at the proximal end (i.e., the end away from the patient) of the sheath, to the object-engaging unit, which is located at the distal end of the sheath (i.e., the end near the patient and that goes into the patient).

One purpose of the sheath is to collapse and release the object-engaging unit by sliding the sheath over (to collapse) or away from (to release) the object-engaging unit, or by moving the object-engaging unit into (to collapse) and out of (to release) the sheath. The object-engaging unit is, for example, a grasping forcep-like assembly, a basket assembly, or any type of tissue and/or object manipulating, capturing, and/or retrieving assembly. When the object-engaging unit is enclosed within the sheath, the object-engaging unit is inoperative and in its collapsed or withdrawn state. For example, object-engaging units, such as baskets, assume a collapsed, reduced diameter profile when the basket is enclosed within the distal end of the sheath. When the sheath is retracted relative to the basket or the basket is extended beyond the distal end of the sheath, the basket expands to a relatively larger diameter than when the basket is enclosed and collapsed within the sheath. In the expanded position, the basket is positioned and is operable at least to capture material in the body, such as kidney stones. If the object-engaging unit is, for example, a blade, it would be withdrawn when not needed to cut, and then extended at least partially out beyond the distal end of the sheath to allow cutting with the blade. The sheath also serves other purposes. For example, the sheath serves to encompass and protect the object-engaging unit as it is inserted into the body cavity or channel of an endoscope. The sheath also serves to protect the body cavity from damage that may be

introduced by the object-engaging unit itself if it were released, expanded, or extended during passage of the sheath into the body. Also, the sheath must provide sufficient strength and rigidity to allow its insertion into the body or endoscope channel while also providing sufficient flexibility to permit the sheath to navigate through the tortuous channels of the body cavity, opening, or tract.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a medical device comprising a sheath with sufficient flexibility to locate and engage material at a site in a body, such as the renal pelvis. That is, the sheath is sufficiently flexible to navigate the turns and curves of the body tract into which the medical device is introduced in order to manipulate target material at the remote body site. The sheath is also sufficiently flexible to allow a flexible endoscope, into which the sheath is inserted, to achieve the desired flexion.

It is another object of the invention to provide a medical device including a sheath that has sufficient strength at the proximal and distal end portions of the sheath to locate, engage, and retrieve target material at a remote body site, and to actuate an object-engaging unit without distorting or deforming the distal end portion of the sheath.

It is yet another object of the invention to provide a method of using medical devices including such sheaths to retrieve material at a remote site in a body.

In one aspect, the invention relates to a device for use in manipulating material at a site within a body. The device includes a handle and a sheath extending from the handle. The sheath includes a lumen, a proximal end, a distal end, a proximal portion, an intermediate portion, and a distal portion. The intermediate portion of the sheath is more flexible than both the proximal portion and the distal portion of the sheath. The device also includes an object-engaging unit. The object-engaging unit and the sheath are moveable relative to each other to achieve a collapsed state of the object-engaging unit in which the object-engaging unit is collapsed within the lumen of the distal portion of the sheath, and another state in which the object-engaging unit extends from the distal end of the sheath.

In one embodiment of the device according to this aspect of the invention, the outside diameter of the intermediate sheath portion is more narrow than the outside diameter of the proximal and distal sheath portions. The intermediate sheath portion, in another embodiment, has one or more fewer layers than the proximal and distal sheath portions, and in this case the outside diameter of the intermediate sheath portion may or may not have the same outside diameter as the proximal and distal sheath portions.

Also in accordance with the invention, the intermediate sheath portion has at least two sections, and at least one of the sections has a different number of layers of material than at least one other of the sections. The sections can be arranged in a variety of different patterns such as circumferential, longitudinal, spiral, helical, and/or criss-cross patterns.

Also, in accordance with this aspect of the invention, the layers of the sheath in all portions of the sheath comprise various materials, such as fluorinated ethylenepropylene (FEP), polytetrafluoroethylene (PTFE), stainless steel braid, or polyimide. Regardless of the materials or the number of layers of material used to make the proximal, intermediate, and distal sheath portions, the diameter of the sheath lumen is the same or different in the proximal, intermediate, and distal sheath portions.

In another aspect, the invention relates to a sheath for a medical device, wherein the sheath comprises a wall extending from a proximal end of the sheath to a distal end of the sheath. The wall defines a lumen extending from the proximal sheath end to the distal sheath end. The wall includes a proximal portion, an intermediate portion, and a distal portion. The intermediate portion is more flexible than the proximal and distal portions. The lumen in the distal portion of the sheath wall is adapted for receiving an object-engaging unit.

In still other aspects of the invention, methods of manipulating material in a body include inserting into a body (either directly or through some other mechanism such as an endoscope channel) a medical device including a sheath of the type described above. The steps of the methods include moving the object-engaging unit from a collapsed state to another state in which the object-engaging unit is extended beyond the distal end of the sheath, engaging the material in the body, and ultimately withdrawing the device from the body.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, like reference characters generally refer to the same parts throughout the different views. Also, the drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention.

FIG. 1 illustrates a stone lodged in a remote body site.

FIG. 2A illustrates a plan view of an embodiment of a medical device including a sheath according to the invention with an object-engaging unit in a fully extended or open position.

FIG. 2B illustrates the device illustrated in FIG. 2A with the object-engaging unit in a collapsed or retracted position within the distal end of the sheath.

FIG. 3A illustrates a plan view of another embodiment of a medical device including a sheath according to the invention with an object-engaging unit in a fully-extended, open position.

FIG. 3B illustrates the device illustrated in FIG. 3A with the object-engaging unit in a collapsed or retracted position within the distal end of the sheath.

FIG. 4A illustrates a plan view of an embodiment of the sheath according to the invention.

FIG. 4B illustrates a plan view of a sheath when the intermediate sheath portion is flexed.

FIG. 5A illustrates a cross-section of an embodiment of the distal portion of a sheath according to the invention.

FIG. 5B illustrates a cross-section of an embodiment of the intermediate portion of the sheath illustrated in FIG. 5A according to the invention.

FIG. 6A illustrates a cross-section of another embodiment of a proximal portion of the sheath according to the invention.

FIG. 6B illustrates a cross-section of an embodiment of the intermediate portion of the sheath illustrated in FIG. 6A according to the invention.

FIG. 7A illustrates a plan view of an embodiment of the sheath according to the invention, the intermediate portion including sections having different numbers of layers of material.

FIG. 7B illustrates a cross-section of the sheath illustrated in FIG. 7A taken at line 7B—7B.

FIG. 7C illustrates a cross-section of the sheath illustrated in FIG. 7A taken at line 7C—7C.

FIG. 7D illustrates a plan view of another embodiment of the sheath according to the invention, the intermediate portion including sections having different numbers of layers of material.

FIG. 7E illustrates a plan view of another embodiment of the sheath according to the invention, the intermediate portion including sections having different numbers of layers of material.

FIG. 7F illustrates a plan view of another embodiment of the sheath according to the invention, the intermediate portion including sections having different numbers of layers of material.

FIG. 8A is a plan view of an embodiment of a sheath according to the invention including an attenuated sheath wall in the intermediate portion of the sheath.

FIG. 8B illustrates a cross-section of the embodiment of the proximal sheath portion illustrated in FIG. 8A taken at line 8b—8b.

FIG. 8C illustrates a cross-section of the embodiment of the intermediate sheath portion illustrated in FIG. 8A taken at line 8c—8c.

FIG. 8D illustrates a cross-section of the embodiment of the distal sheath portion illustrated in FIG. 8A taken at line 8d—8d.

FIG. 9A shows another embodiment of a sheath according to the invention including an attenuated wall in the intermediate portion of the sheath.

FIG. 9B shows another embodiment of a sheath according to the invention including an attenuated wall in the intermediate portion of the sheath.

FIG. 9C shows another embodiment of a sheath according to the invention including an attenuated wall in the intermediate portion of the sheath.

FIG. 9D shows another embodiment of a sheath according to the invention including an attenuated wall in the intermediate portion of the sheath.

FIG. 10A illustrates a plan view of the long axis of a sheath according to the invention, the intermediate portion of the sheath including numerous slits in the external wall of the sheath.

FIG. 10B shows a cross-section in perspective of the embodiment of the intermediate portion of the sheath illustrated in FIG. 9A at 9b—9b.

FIG. 10C shows a cross-section in perspective of another embodiment of the intermediate portion of a sheath according to the invention including numerous depressions in the external wall of the sheath.

FIG. 11A illustrates a first step in a method for retrieving material located in a body cavity using a medical device including a sheath according to the invention.

FIG. 11B illustrates a second step in a method for retrieving material from a body cavity using a medical device including a sheath according to the invention.

FIG. 11C shows a third step in a method for retrieving material from a body cavity using a medical device including a sheath according to the invention.

DESCRIPTION

One of the problems encountered when an elongated medical device, such as a retrieval device in a sheath, is used to reach a remote location in the body, is the turns and curves in the body tract that must be negotiated in order to reach the remote body location. As illustrated in FIG. 1, by way of example, a stone 100 lodged in the renal calyx 42 can not be

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approached via the ureter **40** without encountering at least one curve **102** illustrated by arrow **104**. The rigid elongate member of a medical device can not effectively negotiate curves, such as the one illustrated, without causing tissue trauma in order to reach the remote tissue location.

According to the invention, positioning a flexible sheath portion near the distal end of the sheath, addresses this problem. The embodiments of the invention described below, all have the common feature of a flexible sheath portion positioned near the distal end of the elongated sheath.

All of the following embodiments of the invention have at least one thing in common, the sheath of the invention, on one hand, has sufficient flexibility in an area adjacent the distal end portion (at the "intermediate portion" of the sheath) to allow engagement of a stone, tissue, or other material. On the other hand, the sheath has sufficient strength or rigidity at the most distal end portion of the sheath to enclose the object engaging unit in the inoperative or collapsed state and to permit the object-engaging unit to move in and out of the distal end portion of the sheath without the distal end portion of the sheath deforming or failing.

Referring to FIGS. **2A**, **2B**, **3A**, and **3B**, one embodiment of a medical device, according to the invention, includes a handle portion **16**, an actuator **20**, a sheath **14**, a sheath lumen **15**, an elongated member **18** that passes within the sheath lumen **15**, and an object-engaging unit **10**, such as the grasping forceps illustrated in FIGS. **2A** and **2B**. The handle **16**, the sheath **14**, and the object-engaging unit **10** are not shown in their correct size or proportion to each other. The sheath **14** typically is much longer and narrower than the handle **16** or the grasping forceps **10** to allow insertion into a body cavity or tract.

Referring to FIG. **4A**, a sheath **14** according to the invention comprises at least three segments: a proximal segment **30**, an intermediate segment **32**, and a distal segment **34**. The proximal segment **30** of the sheath is located nearest to the handle **16**. The distal portion of the sheath **34** is that region of the sheath at the distal end of the medical device opposite to the handle **16**. The intermediate portion **32** of the sheath is positioned distal to the proximal portion **30** of the sheath and proximal to the distal portion **34** of the sheath. The proximal end of the intermediate portion **32** of the sheath is located about 3 inches to 7 inches, preferably 4.75 inches, from the distal end **26** of the sheath.

The object-engaging unit **10** is collapsed within the distal portion of the sheath **34** for direct entry into the body or for entry into the body via the operating channel of an endoscope or laparoscope. The object-engaging unit **10** can be a grasping-type device, as illustrated in FIGS. **2A** and **2B**. Such grasping type object-engaging units are described in U.S. Ser. No. 09/064,704, the disclosure of which is expressly incorporated by reference herein. Other types of object-engaging units that can be used with the sheath of the invention are retrieval basket-type devices, as illustrated in FIGS. **3A** and **3B**, such as those described in U.S. Ser. No. 09/065,158, U.S. Ser. No. 09/027,534, U.S. Ser. No. 09/084,135, U.S. Ser. No. 09/296,327, U.S. Ser. No. 09/268,484, and U.S. Ser. No. 09/369,226, the disclosures of which are expressly incorporated by reference herein. Other suitable object-engaging units are forceps, probes, retractors, elevators, blades, needles, and the like.

Referring now to FIGS. **2A**, **2B**, **3A** and **3B**, the sheath **14**, according to the invention, has at least one lumen **15** therein, and it extends from the handle **16** to a distal sheath end **26**.

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In one embodiment, an elongated member **18**, such as a cable, coil, shaft, guidewire, or mandril wire, extends within the lumen **15** from the actuating mechanism **20** in the handle portion **16** to a base **13** of the object engaging unit **10** where the elongated member **18** is joined to the object-engaging unit base **13**. Operation of the actuating mechanism **20** by an operator causes the object-engaging unit **10** to move relative to the sheath **14** between a collapsed state within the distal sheath portion **34**, as illustrated in FIG. **3B**, to an extended state outside of the distal end **26** of the sheath **14** where the object-engaging unit **10** is open and extending beyond the distal end **26** of the sheath, as shown in FIG. **3A**.

Alternatively, in another embodiment of the invention, the actuating mechanism is joined to the sheath. Operation of the actuating mechanism **20** by an operator in this embodiment causes the sheath **14** to move relative to the object-engaging unit **10** and the elongated member **18**, such that the object-engaging unit **10** is moved between a collapsed position within the distal sheath portion **34**, illustrated in FIG. **2B**, to an extended position outside of the sheath **14** where the object-engaging unit **10** is open and extended beyond the distal end of the sheath **26** as illustrated in FIG. **2A**.

With the object-engaging unit **10** withdrawn into and collapsed within the distal sheath portion **34**, as shown in FIGS. **2B** and **3B**, the object-engaging unit **10** is inserted into the body directly, or via an endoscope channel, to a remote internal site in the body where the target material is located. The object-engaging unit **10** is then moved relative to the sheath **14** and placed in the extended position illustrated in FIGS. **2A** and **3A**, such that the object-engaging unit **10**, in its operative position, is manipulated by the operator to engage the target material or tissue in the remote body site. The object-engaging unit **10** can then be used to manipulate the material in the body. Following manipulation of the material by the object-engaging unit **10**, the object-engaging unit **10** is at least partially withdrawn into the lumen **15** of the distal sheath portion **34**, as illustrated in FIG. **3B**, by moving the elongated member **18** axially relative to the sheath **14** with the object-engaging unit **10** attached to its distal end, or by moving the sheath **14** axially relative to the object-engaging unit **10**, as illustrated in FIG. **2B**. The medical device, including the object-engaging unit **10** and the sheath **14**, are withdrawn from the body cavity.

The overall length of the sheath **14**, according to the invention, can range between 40 inches to 75 inches, preferably about 49.5 inches to 52.5 inches. The proximal portion **30** of the sheath is 35 inches to 55 inches in length, preferably 44.75 inches to 48.25 inches in length, the intermediate portion **32** of the sheath is 3 inches to 6 inches in length, preferably 3.5 to 4.0 inches, and the distal portion **34** of the sheath is 0.10 inches to 1.0 inch in length, preferably 0.75 inches.

The outside diameter **11** of the sheath, indicated between the arrows **11** in FIG. **4A**, may or may not be uniform from the proximal end of the sheath **24** to the distal end of the sheath **26**. In general, the outside diameter **11** of the proximal sheath portion **30** may range from 0.0315 inches to 0.0414 inches, the outside diameter **11** of the intermediate sheath portion **32** may range from 0.03 inches to 0.0445 inches, and the outside diameter **11** of the distal sheath portion **34** may range from 0.0315 inches to 0.0445 inches.

Sheath flexibility varies along the sheath's long axis from the proximal end **24** of the sheath to the distal end **26** of the sheath. In one embodiment, according to the invention, the intermediate portion **32** of the sheath **14** is more flexible than

either the proximal sheath portion **30** or the distal sheath portion **34**. That is, the proximal sheath portion **30** and the distal sheath portion **34** are more rigid than the intermediate sheath portion **32**. The flexibility of the proximal sheath portion **30** and the distal sheath portion **34** can be the same or can differ. However, the proximal sheath portion **30** and the distal sheath portion **34** are less flexible, i.e., more rigid, than the intermediate sheath portion **32**. The intermediate portion **32** is highly flexible, as illustrated in FIG. 4B, and can be flexed to as much as 360 degrees from the long axis of the sheath (indicated as reference line **100**). After the sheath of the invention is inserted into a channel of a flexible endoscope, the flexible endoscope with the sheath may flex as much as 180 degrees to 190 degrees.

Enhanced flexibility of the intermediate portion **32** of the sheath **14** is achieved in several ways. Referring to FIGS. 4A, 4B, 5A, 5B, 6A and 6B, in one embodiment of a sheath **14**, according to the invention, the sheath **14** is constructed with layers of material extending from the luminal side **19** of the sheath wall **12** to the outside **17** of the sheath wall **12**. The wall **12** of the sheath, according to the invention, includes multiple concentric layers of the same or different materials. The intermediate sheath portion **32**, like the proximal sheath portion **30** and the distal sheath portion **34**, includes multiple concentric layers, however, the intermediate sheath portion **32** has at least one fewer layer or at least one different layer of material than the layers of material in the proximal sheath portion **30** and the distal sheath portion **34**.

For example, as illustrated by a cross-section of distal sheath **34** in FIG. 5A, in one embodiment of the sheath, according to the invention, the distal sheath portion **34** and the proximal sheath portion **30** (not shown) are manufactured from four layers of material including, from inside **19** of the sheath wall **12** to outside **17** of the sheath wall **12**, a first layer (a) of polytetrafluoroethylene (PTFE), a second layer (b), of 304 braided stainless steel, a third layer (c) of polyimide, and a fourth layer (d) of fluorinated ethylenepropylene (FEP). Each material is arranged in a concentric layer around the circumference of the sheath wall **12**. In the same sheath, the intermediate sheath portion **34**, illustrated in FIG. 5B, has one fewer of the layers a-d than the proximal and distal sheath portions. The materials in intermediate sheath portion **32**, from the inside **19** of the sheath wall **12** to the outside **17** of the sheath wall **12**, include a first inner layer (a) of PTFE, a second layer (b) of stainless steel braid, no third layer, and a fourth layer (d) of FEP, each material arranged in a concentric layer around the circumference of the sheath wall **12**. The relative thickness of each layer, illustrated in FIGS. 5A and 5B, is merely intended to be illustrative and is not limited to that illustrated. The thickness of one or more of the layers of the sheath wall **12** may be greater or lesser than the thickness of one or more of the other layers. Thus, the outer diameter **11** of the intermediate sheath portion **32** may be less than or the same as the outer diameter **11** of proximal sheath portion **30** and distal sheath portion **34**. However, the internal diameter **13** of the intermediate sheath portion **32** is the same as the internal diameter **13** of proximal sheath portion **30** and distal sheath portion **34**. That is, the diameter of the lumen **15** of the sheath **14** is uniform from the proximal end **24** of the sheath to the distal end **26** of the sheath. By maintaining a constant luminal internal diameter **13** throughout the length of the sheath **14**, the object-engaging unit **10** and the elongated member **18** may move in the lumen **15** relative to the sheath **14** without becoming snagged.

In an alternate embodiment, the proximal sheath portion **30** and the distal sheath portion **34** are manufactured from a

different combination of materials. For example, the first or inner layer is FEP, followed by a second layer of stainless steel braid, followed by a third layer of polyimide, and followed by a fourth, outer layer of PTFE. The intermediate sheath portion **32** of this embodiment of the sheath includes a first inner layer (a) of FEP, a second layer (b) of stainless steel braid, no third layer, and a fourth, outer layer (d) of PTFE.

In yet another embodiment of the sheath of the invention, the proximal sheath portion **30**, illustrated in FIG. 6A, and the distal sheath portion **34** each have five layers, each layer made from the same material. In this embodiment of the sheath, the intermediate sheath portion **32**, illustrated in FIG. 6B, has four layers of material identical to the material used in the five layers of the proximal **30** and distal **34** sheath portions.

Other materials and different number of layers of the sheath are also contemplated by the invention and are not limited to those illustrated in FIGS. 5A, 5B, 6A and 6B. Whatever the combination of materials and numbers of layers, the intermediate sheath portion **32** is always more flexible than the proximal sheath portion **30** and distal sheath portion **34**, and the internal diameter **13** of the sheath is uniform from the proximal end **24** of the sheath to the distal end **26** of the sheath.

In another embodiment of the sheath, the intermediate sheath portion **32** has at least two sections **33**, **35**, and at least one of the sections has a different number of layers of material than at least one other of the sections. A section of the sheath is a region of the sheath wall having a different number of layers than an adjacent region of the sheath wall. For example, as illustrated in FIG. 7A, the wall of the intermediate portion **32** of the sheath **17** can have a section of three layers **35** of material followed by a section of four layers **33** of material, followed by a section of three layers **35** of material, and so on. Alternatively, the wall of the intermediate portion **32** of the sheath can have a section of four layers of material, followed by a section of three layers of material, followed by a section of two layers of material, followed by a section of four layers of material, and so on. This pattern may be repeated along the entire length of the intermediate sheath portion **32** or the pattern may be limited to a portion of the intermediate sheath portion **32**. The number and type of sections can be varied and different than the specific arrangements shown. The sections in the intermediate sheath portion **32** can be arranged circumferentially, spirally in a lattice-like or criss-cross pattern, or longitudinally, as illustrated in FIGS. 7A, 7D, 7E and 7F, respectively.

In one particular embodiment, the wall of the intermediate sheath portion **32** has a repeating pattern of four layer and three layer sections along its entire length, although other embodiments can have other layers in the sections. In a particular embodiment of the wall of the intermediate portion of the sheath having four layers, one of the four layers is polyimide while the other layers are selected from materials, such as FEP, stainless steel braid, PTFE, polyetheretherketone (PEEK), or Nitinol. In this embodiment, the polyimide layer is absent in the sections of the wall of the sheath having three layers. In other embodiments, a layer of a different material is absent in the wall of the intermediate sheath portion.

A sheath, according to the invention, has the advantage of enhanced flexibility while maintaining sheath column and compression strength. For example, in one embodiment of the sheath of the invention, the proximal sheath portion **30**

and the distal sheath portion **34** have four layers in the sheath wall while the intermediate sheath portion **32**, has a repeating pattern of a three layer section **35** followed by a four layer section **33**. Alternatively, sections **33** have two, four, or more layers and sections **35** have a different number of layers than sections **33**.

In one embodiment of the invention, the arrangement of sections in the intermediate sheath portion **32** may be circumferential as illustrated in FIGS. 7A, 7B and 7C. In this embodiment, each section **33**, **35** is a band that wraps 360° around the circumference of the sheath wall. At least one of the sections **35** has fewer layers of material than an adjacent section **33**.

In another embodiment, as illustrated in FIG. 7D, adjacent sections **33**, **35** in the intermediate sheath portion **32** are spirally arranged. Rather than the sections being circumferentially arranged as illustrated in FIG. 7A, the sections in this embodiment spiral along all or a portion of the length of the wall of the intermediate sheath portion.

In yet another embodiment of the invention, as illustrated in FIG. 7E, the sections in the intermediate sheath portion **32** are arranged as two intersecting spirals along all or a portion of the intermediate sheath portion **32**. In this embodiment of the intermediate sheath portion **32**, looking at the side of the sheath **17**, spiral sections **33**, **33'** appear as a plurality of "Xs" along all or a portion of the intermediate sheath portion. Sections **35** have a different number of layers of material than sections **33**.

In still another embodiment of the invention, as illustrated in FIG. 7F, adjacent sections **33**, **35** in the intermediate sheath portion **32** are arranged longitudinally, paralleling the long axis of the sheath. In this embodiment of the intermediate sheath portion **32**, one or more longitudinal sections **33**, **35** are distributed around the circumference of the sheath along all or a portion of the intermediate sheath portion **32**.

The embodiments illustrated in FIGS. 7A–7F are meant to be illustrative. Other arrangements of sections in the intermediate sheath portion are possible.

In another embodiment of the sheath, according to the invention, a first polymer having a certain characteristic stiffness is used to manufacture the sheath wall in the intermediate sheath portion **32** and a second polymer having a different characteristic stiffness than the first polymer can be used in the proximal sheath portion **30** and the distal sheath portion **34** (not shown). For example, a polymer-metal composition may be used in the intermediate sheath portion **32** whereas a more rigid or stiff type of polymer can be used in the proximal sheath portion **30** and the distal sheath portion **34**. In general, any type of material may be used in the intermediate sheath portion **32** that is a suitable material having the appropriate strength, flexibility and biocompatibility characteristics.

Other materials that can be included in one or more layers of the sheath are polyetheretherketone. (PEEK), or nickel-titanium (Nitinol) braid.

Referring now to FIG. 8A, in another embodiment, according to the invention, the outer diameter **11** of the sheath wall in the intermediate portion **32**, is less than the thickness of the sheath wall at the proximal portion **30** and the thickness of the sheath wall at the distal sheath portion **34**. As illustrated by cross-sections of proximal sheath portion **30** in FIG. 8B, and distal sheath portion **34** in FIG. 8D, the thickness of sheath wall **12** is the same in the proximal sheath portion **30** and distal sheath portion **34**. As illustrated by cross-section of intermediate sheath portion **32** in FIG. 8C, the thickness of the intermediate sheath portion

32 is less than either the proximal sheath portion **30** illustrated in FIG. 8B and the distal sheath portion **34** illustrated in FIG. 8D. The inside diameter **13** of the sheath in the intermediate portion **32** of the sheath, illustrated in FIG. 8C, is unchanged relative to the inside diameter **13** of proximal sheath portion **30**, illustrated in FIG. 8B, and distal sheath portion **34**, illustrated in FIG. 8D. By maintaining a uniform inside diameter **13** from the proximal end **24** of the sheath to the distal end **26** of the sheath, illustrated in FIG. 8A, an object-engaging unit can slide smoothly in the lumen **15** of the sheath without risk of snagging in dilated or constricted regions of the inner wall **13** of the sheath.

In one embodiment, illustrated in FIG. 8A, the transition in wall **12** thickness along the intermediate portion **32** of the sheath is gradual. In an alternate embodiment, the transition in wall thickness of the intermediate sheath portion **32**, relative to the wall thickness of proximal sheath portion **30** and distal sheath portion **34**, is incremental, i.e., occurs in multiple stages, segments, or steps as illustrated in FIG. 9A. The number of possible incremental steps is without limit. The increments in wall thickness can be non-uniformly distributed along the long axis of intermediate sheath portion **32** as illustrated in FIGS. 9B and 9C. The inside diameter **13** of the sheath wall **12** is uniform from the proximal sheath portion **30**, the intermediate sheath portion **32**, to the distal sheath portion **34**. As a result, the diameter of the sheath lumen **15** is unchanged throughout the length of the sheath from the proximal end **24** to the distal end **26** of the sheath **14**.

Referring to FIG. 9D, in another embodiment of the sheath of the invention, the external sheath wall **17** of the intermediate sheath portion **32** is thrown into circumferential folds to achieve an accordion-like effect. This accordion-like effect enhances the flexibility of the intermediate sheath portion **32** relative to the rest of the sheath **14**. The inner diameter of the sheath in the intermediate sheath portion **32** is unchanged relative to the inner diameter of proximal sheath portion **30** and distal sheath portion **34**. The diameter of the lumen **15** of the sheath, therefore, is constant from the proximal end **24** of the sheath to the distal end **26** of the sheath.

Referring to FIGS. 10A–10C, in another embodiment of the invention, flexibility may be added to the intermediate portion **32** of the sheath by modification of the external sheath wall **17** with slits, grooves, or other depressions. Slits, grooves, or depressions can be distributed completely or partially around the circumference of the sheath wall **12** in the intermediate sheath portion **32** as illustrated in FIG. 10A. As illustrated by a cross-section in perspective of intermediate sheath portion **32** in FIG. 10B, the modifications in the external sheath wall **17** of the intermediate sheath portion **32** extend part way through the full thickness of the sheath wall **12** and not through the inner sheath wall **19**. Sheath all modifications, such as slits or grooves, are oriented with their long axis anywhere from parallel to perpendicular to the long axis of the sheath.

As illustrated in FIG. 10C, in yet another embodiment of the sheath of the invention, scattered dimples or other shapes are introduced into the outer sheath wall **17** of the intermediate sheath portion **32**. Like the grooves or slits illustrated in FIG. 10B, dimples extend from the outer wall **17** partially into the sheath wall **12** but not through the inner sheath wall **19**. Thus, as illustrated in FIGS. 10B and 10C, the inner diameter **13** of the sheath and, therefore, the sheath lumen **15**, is uniform throughout the length of the sheath beginning at the proximal end **24** of the sheath, extending through the intermediate portion **32** of the sheath, to the distal end **26** of sheath **14**.

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The surface of the sheath **14**, from the proximal portion **24** to the distal portion **26**, is made or coated with any suitable material with a low friction coefficient, such as a polymeric material, a polyethylene glycol, a photopolyacrylamide-heparin complex, hyaluronic acid, polyvinylpyrrolidone material, and others. These low-friction materials are materials included in the composition of the sheath wall during manufacturing or applied to the surface of the sheath after the sheath is manufactured.

The sheath of the invention provides numerous advantages. For example, the flexible intermediate portion **32** of the sheath allows an increase in the deflection capability of the sheath **14**. When inserted into a flexible scope, for example, the flexible intermediate portion **32** of the sheath **14** overcomes the rigidity of the distal end **26** of the sheath that is necessary for the proper actuation of the object-engaging unit **10**. The flexible intermediate portion **32** coincides and deflects with a bending portion of the flexible scope without substantially impairing the capacity of the endoscope to flex.

The distal portion **34** of the sheath holds and surrounds the object-engaging unit **10** when it is in the collapsed state or partially collapsed state, without radial deformation of the sheath **14**. The flexible intermediate portion **32** of the sheath allows more steerability than possible with conventional sheaths.

In another aspect, the invention relates to a method for manipulating material or tissue in a body, such as a body tract or body canal, with a medical device including a sheath. The sheath, as part of the medical device, may be introduced directly into the body cavity or may be introduced through a channel in an endoscope or laparoscope. Sheaths, according to the invention, provide the requisite rigidity at the proximal sheath portion **30** for effective manipulation by an operator for locating, engaging, and retrieving stones, and the requisite rigidity at the distal sheath portion **34** to enclose the object-engaging unit **10** in the collapsed or partially collapsed state without deformation or distortion of the distal end of the sheath. Sheaths of the invention can be introduced into an endoscope or laparoscope without the need for introducers or other means. When the sheath is inserted into a flexible endoscope, the flexible intermediate portion **32** of the sheath allows the endoscope to flex to reach a remote body site. With the sheath inserted into a channel of the endoscope, the endoscope can flex about 180 to 190 degrees. Sheaths of variable strengths, according to the invention, are used with medical retrieval devices or a variety of other medical devices. Also, the sheaths of the invention can be used in urology, endoscopy, laparoscopy, biliary, and lithotripsy procedures as well as a variety of other applications.

Referring to FIGS. 11A–11C, a method for retrieving material from a patient includes inserting a medical device including a sheath according to the invention into the patient. The medical device including the sheath according to the invention may be directly introduced into the patient or may be introduced via a channel **50** of an endoscope or laparoscope as illustrated in FIG. 11A. For example, the endoscope **50** is advanced by an operator via the lumen of the ureter **40** until the distal end of the endoscope **50** enters the patient's body site, such as the renal pelvis **42**, where the target material **100** is located. The medical device, including the object-engaging unit **10** collapsed within the distal end portion **34** of the sheath, is passed into the endoscope **50**, until the distal end **26** of the sheath approaches the distal end **51** of the endoscope **50**. As shown in FIG. 11B, the flexible intermediate portion **32** of the sheath coincides and deflects

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with the bending portion of the flexible endoscope **50**. The object-engaging unit **10** is extended from the distal end **26** of the sheath **14** to manipulate the material or tissue **100** within the remote body site **42**. The distal end portion **34** of the sheath is of sufficient strength and rigidity to resist deformation of the sheath as the object-engaging unit **10** is moved relative to the sheath.

As shown in FIG. 11C, after the material or tissue **100** within the remote body site **42** is manipulated, the object-engaging unit **10** is withdrawn partially or completely into the distal end portion **34** of the sheath either by axial movement of the elongated member **18**, attached to the base **13** of the object-engaging unit **10**, or by movement of the sheath **14** over the stationary object-engaging unit **10**.

The medical device including the sheath according to the invention can be directly inserted (not shown) into a body cavity without an endoscope or an introducer. The steps are similar to those described above for use of the medical device in an endoscope. The flexible intermediate portion of the sheath **32** deflects against the wall of the body tract as the sheath housing the object-engaging unit is advanced in the body tract. The object-engaging unit extends from the distal end of the sheath in the manner described above for using the medical device in an endoscope. After the material in the body site is manipulated, the object-engaging unit is withdrawn partially or completely into the distal sheath portion. The medical device including the sheath is withdrawn from the body tract.

Variations, modifications, and other instrumentations of what is described herein will occur to those of ordinary skill in the art without departing from the spirit and scope of the invention as claimed. Accordingly, the invention is to be defined not by the preceding illustrative description but instead by the spirit and scope of the following claims.

What is claimed is:

1. A device for manipulation of material in a body, comprising:
 - a handle;
 - a sheath extending from the handle and comprising a lumen, a distal end, a proximal portion, a distal portion, and an intermediate portion, the proximal portion being substantially longer than the intermediate portion, the intermediate portion of the sheath being more flexible than the proximal and distal portions of the sheath, the intermediate portion of the sheath comprising a plurality of sections, wherein at least one of the sections comprises a different number of layers than at least one of the other sections; and
 - an object-engaging unit, the object-engaging unit and sheath moveable relative to each other to achieve a collapsed state of the object-engaging unit in which the object-engaging unit is collapsed within the lumen of the distal portion of the sheath and another state in which the object-engaging unit extends from the distal end of the sheath.
2. The device of claim 1 wherein the sections comprise circumferential bands positioned along the intermediate sheath portion.
3. The device of claim 1 wherein the sections comprise a spiral arrangement positioned along at least a portion of the length of the intermediate sheath portion.
4. The device of claim 1 wherein the sections comprise a criss-cross arrangement positioned along at least a portion of the length of the intermediate sheath portion.
5. The device of claim 1 wherein the sections comprise a longitudinal arrangement positioned along at least a portion of the length of the intermediate sheath portion.

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6. The device of claim 1 wherein said lumen is adapted for receiving an object-engaging unit.

7. The device of claim 1 wherein the outside diameter of said intermediate sheath portion is more narrow than the outside diameter of said proximal and said distal sheath portions.

8. The device of claim 1 where said sheath layers are selected from a group of materials consisting of fluorinated ethylenepropylene (FEP), polytetrafluoroethylene (PTFE), stainless steel braid, and polyamide.

9. The device of claim 1 wherein said proximal sheath and said distal sheath portion comprises four layers, each layer including one of FEP, PTFE, stainless steel braid, and polyamide, and said intermediate sheath portion comprises three of said four layers of said proximal and distal sheath portions.

10. The device of claim 1 wherein the dimensions of said lumen of said intermediate sheath portion, said proximal sheath portion, and said distal sheath portion are the same.

11. The device of claim 1 wherein the proximal portion is substantially longer than the lengths of the intermediate and distal portions combined.

12. The device claim 1 wherein said object engaging unit is selected from the group consisting of forceps, a retrieval basket, a probe, a retractor, an elevator, a blade and a needle.

13. The device of claim 1 wherein said device is sized for insertion via the operating channel of a laparoscope.

14. The device of claim 1 wherein said object-engaging unit comprises an elongated member selected from the group consisting of a cable, a coil, a shaft, a guidewire, and a mandril.

15. The device of claim 1 wherein said sheath comprises a plurality of sheath layers, said intermediate sheath portion comprising at least one fewer layers than said proximal and said distal sheath portion.

16. The device of claim 15 wherein said layers in said proximal and distal sheath portions comprise a first layer of polytetrafluoroethylene (PTFE), a second layer of stainless steel braid, a third layer of polyamide and a fourth layer of fluorinated ethylenepropylene (FEP) arranged in concentric layers around the circumference of the proximal and distal sheath portions and wherein said layers comprise a first layer of polytetrafluoroethylene (PTFE), a second layer of stainless steel braid, and a third layer of fluorinated ethylenepropylene (FEP) arranged in concentric layers around the circumference of the intermediate portion of said sheath.

17. The device of claim 15 wherein said layers in said proximal and distal sheath portions comprise a first layer of fluorinated ethylenepropylene (FEP), a second layer of stainless steel braid, a third layer of polyamide and a fourth layer of polytetrafluoroethylene (PTFE), arranged in concentric layers around the circumference of the proximal and distal sheath portions and wherein said layers comprise a first layer of FEP, a second layer of stainless steel braid, and a third layer of PTFE, arranged in concentric layers around the circumference of the intermediate portion of said sheath.

18. The device of claim 15 wherein said layers comprise five layers of the same material.

19. The device of claim 1 wherein the inside diameter of said sheath is uniform.

20. The device of claim 1 wherein the intermediate sheath comprises circumferential folds.

21. The device of claim 1 wherein the intermediate sheath comprises slits, grooves, depressions or dimples.

22. The device of claim 1 wherein said sheath is made of, or coated with, a material with a low friction coefficient.

23. The device of claim 22 wherein the material is selected from the group consisting of a polymeric material,

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a polyethylene glycol, a photopolycrylamide-heparin complex, hyaluronic acid and polyvinylpyrrolidone.

24. A sheath for a medical device, comprising:

a proximal sheath end;

a distal sheath end; and

a wall extending from the proximal sheath end to the distal sheath end, the wall defining at least one lumen extending from the proximal sheath end to the distal sheath end, the wall including a proximal portion, an intermediate portion, and a distal portion, the proximal portion being substantially longer than the intermediate portion, the intermediate portion being more flexible than the proximal and distal portions, the intermediate portion comprising a plurality of sections, wherein at least one of the sections comprises a different number of layers than at least one of the other sections.

25. The sheath of claim 24 wherein the sections comprise circumferential bands arranged along at least a portion of the length of along the intermediate portion.

26. The sheath of claim 24 wherein the sections comprise a spiral arrangement positioned along at least a portion of the length of the intermediate portion.

27. The sheath of claim 24 wherein the sections comprise a criss-cross pattern positioned along at least a portion of the length of the intermediate portion.

28. The sheath of claim 24 wherein the sections comprise a longitudinal arrangement positioned along at least a portion of the length of the intermediate portion.

29. The sheath of claim 24 wherein the lumen in the distal portion of the sheath is adapted for receiving an object-engaging unit.

30. The sheath of claim 24 wherein said layers of said proximal and said distal portions are selected from a group of materials consisting of fluorinated ethylenepropylene (FEP), polytetrafluoroethylene (PTFE), polyamide and stainless steel braid.

31. The sheath of claim 24 wherein each of said proximal and distal portions comprises four layers, each layer including one of fluorinated ethylenepropylene (FEP), polytetrafluoroethylene (PTFE), polyamide, and stainless steel braid and said intermediate portion comprises three of said four layers of said proximal and distal portions.

32. The sheath of claim 24 wherein the dimensions of said lumen of said intermediate, proximal, and distal portions are the same.

33. The sheath of claim 24 wherein the proximal portion is substantially longer than the lengths of the intermediate and distal portions combined.

34. The sheath of claim 24 wherein the inside diameter of said sheath is uniform.

35. The sheath of claim 24 wherein the intermediate sheath comprises circumferential folds.

36. The sheath of claim 24 wherein the intermediate sheath comprises slits, grooves, depressions or dimples.

37. The sheath of claim 24 wherein said sheath is made of, or coated with, a material with a low friction coefficient.

38. The sheath of claim 37 wherein the material is selected from the group consisting of a polymeric material, a polyethylene glycol, a photopolycrylamide-heparin complex, hyaluronic acid and polyvinylpyrrolidone.

39. A method of manipulating a material in a body, comprising:

inserting into a body tract a medical device comprising a handle, a sheath extending from the handle, the sheath comprising at least one lumen and a proximal portion, a distal portion, and an intermediate portion, the proximal portion being substantially longer than the inter-

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mediate portion, the intermediate portion of the sheath being more flexible than the proximal and distal portions of the sheath, the intermediate portion of the sheath comprising a plurality of sections, wherein at least one of the sections comprises a different number of layers than at least one of the other sections, and an object-engaging unit, the object-engaging unit and sheath movable relative to each other to achieve a collapsed state of the object-engaging unit in which the object-engaging unit is collapsed within the lumen of the distal portion of the sheath, and another state in which the object-engaging unit extends from the distal end of the sheath;

moving the object-engaging unit relative to the sheath from the collapsed state within the distal end of the sheath, to another state in which the object-engaging unit is extended beyond the distal end of the sheath;

engaging the material to be manipulated in the body tract;

moving the object-engaging unit relative to the sheath to at least partially enclose the object engaging unit within the lumen of the distal end of the sheath; and

withdrawing the medical device from the body.

40. The method of claim **39** wherein the proximal portion is substantially longer than the lengths of the intermediate and distal portions combined.

41. The sheath of claim **39** wherein said device is inserted via the operating channel of a laparoscope.

42. A method of manipulating a material in a body, comprising:

inserting into an endoscope channel a medical device comprising a handle, a sheath extending from a handle,

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the sheath comprising a lumen and a proximal portion, a distal portion, and an intermediate portion, the proximal portion being substantially longer than the intermediate portion, the intermediate portion of the sheath being more flexible than the proximal and distal portions of the sheath, the intermediate portion of the sheath comprising a plurality of sections, wherein at least one of the sections comprises a different number of layers than at least one of the other sections, and an object-engaging unit, the object-engaging unit and sheath movable relative to each other to achieve a collapsed position of the object-engaging unit in which the object-engaging unit is within the lumen of the distal portion of the sheath, and an extended position in which the object-engaging unit extends from the distal end of the sheath;

moving the object-engaging unit relative to the sheath from the collapsed state within the distal end of the sheath, to another state in which the object-engaging unit is extended position beyond the distal end of the sheath;

engaging the material to be manipulated in the body tract;

moving the object-engaging unit relative to the sheath to at least partially enclose the object engaging unit within the lumen of the distal end of the sheath; and

withdrawing the medical device from the body.

43. The method of claim **42** wherein the proximal portion is substantially longer than the lengths of the intermediate and distal portions combined.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 6,398,791 B1
DATED : June 4, 2002
INVENTOR(S) : Que et al.

Page 1 of 1

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

Title page.

Item [73], should read, -- Assignee: **SCIMED LIFE SYSTEMS, INC.**
One SCIMED Place
Maple Grove, Minnesta 55311-1566 --

Column 14.

Line 2, "hyaluroic" should be replaced with -- hyaluronic --.
Line 21, "sprial" should be replaced with -- spiral --.

Column 15.

Line 26, "sheath" should be replaced with -- method --.

Signed and Sealed this

Fifth Day of November, 2002

Attest:

A handwritten signature in black ink, appearing to read "James E. Rogan", with a long horizontal flourish extending to the right.

Attesting Officer

JAMES E. ROGAN
Director of the United States Patent and Trademark Office

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 6,398,791 B1
DATED : June 4, 2002
INVENTOR(S) : Que et al.

Page 1 of 1

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

Column 13,

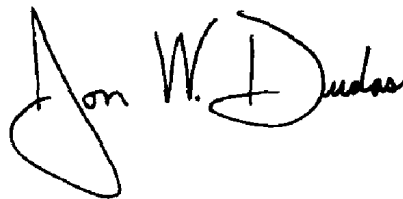
Lines 10, 13, 38 and 49, delete "polyamide" and insert -- polyimide --.

Column 14,

Lines 35 and 40, delete "polyamide" and insert -- polyimide --.

Signed and Sealed this

Twenty-seventh Day of April, 2004

A handwritten signature in black ink, reading "Jon W. Dudas". The signature is stylized, with a large loop for the "J" and a cursive "Dudas".

JON W. DUDAS
Acting Director of the United States Patent and Trademark Office

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 6,398,791 B1
DATED : June 4, 2002
INVENTOR(S) : Que et al.

Page 1 of 1

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

Column 13,

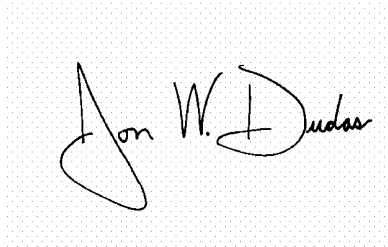
Lines 10, 13, 38 and 49, "polyamide" should be replaced with -- polyimide --.

Column 14,

Lines 35 and 40, "polyamide" should be replaced with -- polyimide --.

Signed and Sealed this

Thirteenth Day of December, 2005

A handwritten signature in black ink on a light gray dotted background. The signature is written in a cursive style and reads "Jon W. Dudas".

JON W. DUDAS
Director of the United States Patent and Trademark Office

专利名称(译)	具有间断截面的可变复合护套		
公开(公告)号	US6398791	公开(公告)日	2002-06-04
申请号	US09/548405	申请日	2000-04-12
[标]申请(专利权)人(译)	QUE LIKE 伯恩GEORGE CURTIS巨力		
申请(专利权)人(译)	QUE LIKE 伯恩GEORGE CURTIS巨力		
当前申请(专利权)人(译)	BOSTON SCIENTIFIC SCIMED , INC.		
[标]发明人	QUE LIKE BOURNE GEORGE CURTIS JULI		
发明人	QUE, LIKE BOURNE, GEORGE CURTIS, JULI		
IPC分类号	A61B17/22 A61B17/28 A61M25/00 A61B1/00 A61B17/00 A61B17/221 A61B17/32		
CPC分类号	A61B17/221 A61B2017/00867 A61B2017/2212 A61B2017/2215 A61M2025/0681 A61B2017/2905 A61M25/0045 A61M25/0054 A61B2017/2901		
优先权	60/138950 1999-06-11 US		
外部链接	Espacenet USPTO		

摘要(译)

医疗装置包括手柄，护套和物体接合单元。护套的远端部分足够坚固以抵抗物体接合单元的变形，护套的另一部分足够柔韧以充分弯曲。

