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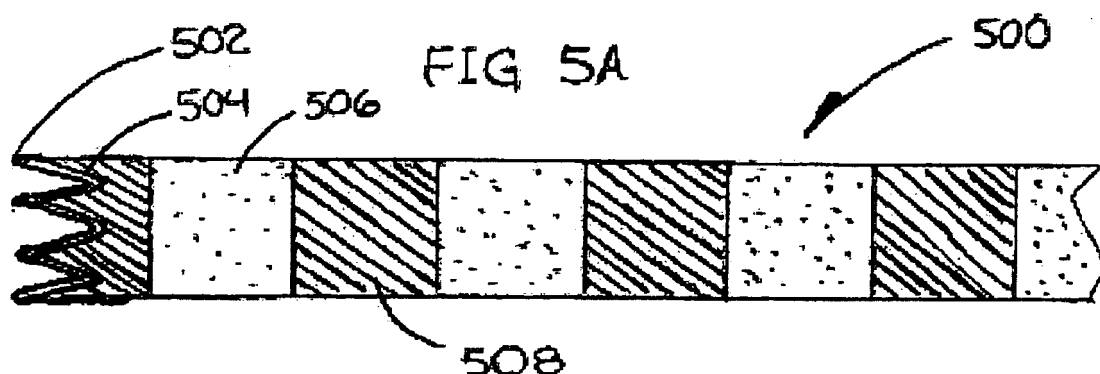
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(54) **MEDICAL APPARATUS**

(57) Disclosed is an implantable apparatus for placement in a gastrointestinal tract. The apparatus has at least one anchoring component attached to a sleeve at-

tached. The sleeve can include a first region having a first porosity and a second region having a second porosity which is different from the first porosity.



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## Description

### BACKGROUND OF THE INVENTION

#### Field of the Invention

[0001] The invention relates to a medical apparatus including a device used in the treatment of obesity and potentially other associated health problems, e.g., type II diabetes. More specifically, the apparatus is used to impede absorption of nutrients within the gastrointestinal tract, i.e., substantially isolating nutrients from a portion of the gastrointestinal tract.

#### Discussion of the Related Art

[0002] Currently, obesity and related health problems are on the rise in the United States and in other industrialized countries. For example, the latest data from the National Center for Health Statistics show that 30 percent of U.S. adults 20 years of age and older-over 60 million people-are obese. Unfortunately, the increase in obesity rates is not limited to adults and the percentage of young people who are overweight has more than tripled since 1980. For example, among children and teens aged 6-19 years, 16 percent (over 9 million young people) are considered overweight.

[0003] Obesity may lead to a number of health problems including, for example, hypertension, dyslipidemia (e.g., high total cholesterol or high levels of triglycerides), diabetes (e.g., Type 2 diabetes), coronary heart disease, stroke, gallbladder disease, osteoarthritis, sleep apnea and respiratory problems, cancers (e.g., endometrial and breast), and other ill-health effects. See e.g., Kanders, B.S., et al., Weight loss outcome and health benefits associated with the Optifast program in the treatment of obesity. *Int J Obes*, 1989. 13: p. 131-134.

[0004] Currently, there are a number of devices and methods for treating obesity, including such surgical procedures as biliopancreatic diversion, silastic ring gastroplasty, jejunioileal bypass, gastric bypass, Roux-en-Y gastric bypass, gastroplasty, gastric banding, vertical banded gastroplasty, and staged procedures. Unfortunately, these procedures have a number of drawbacks including the possibility of severe complications associated with invasive and complicated procedures such as organ failure and even death.

[0005] Other less severe complications may include dumping syndrome. Dumping syndrome occurs when the contents of the stomach empty too quickly into the small intestine. The partially digested food draws excess fluid into the small intestine causing nausea, cramping, diarrhea, sweating, faintness, and/or palpitations. Dumping syndrome usually occurs after the consumption of too much simple or refined sugar by people who have had surgery to modify or remove part of the stomach.

### SUMMARY OF THE INVENTION

[0006] The present invention is directed to an apparatus and method of making the same.

5 [0007] An advantage of the invention is to provide an apparatus having a sleeve that has at least two regions of different properties, e.g., porosity, thickness, pore size and the like.

[0008] Another advantage of the present invention is to provide a sleeve that is releasable from an anchoring component via a releasable component.

[0009] Still another advantage of the invention is to provide a sleeve that is releasable from itself with a releasable component.

10 [0010] Additional features and advantages of the invention will be set forth in the description or may be learned by practice of the invention. These features and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

[0011] To achieve these and other advantages and in accordance with the purpose of the invention, as embodied and broadly described, an apparatus for placement in a portion of the gastrointestinal tract includes a sleeve and at least one anchoring component attached to the sleeve with a releasable component.

20 [0012] In another aspect of the invention, the apparatus for placement in a gastrointestinal tract includes at least one anchoring component and a sleeve attached to at least one anchoring component. The sleeve includes at least a first region and a second region attached to each other with a releasable component. The first and second regions may have different properties, e.g., porosities, pore size, thickness, and the like. In addition, the properties may change in-situ after a predetermined time.

25 [0013] In another aspect of the invention, the apparatus includes a sleeve having a proximal end, a distal end, an inner surface, an outer surface, and a wall thickness. The sleeve also includes at least one portion that is detachable from the remainder of the tube. The anchoring component is attached to a proximal end of the tube with a releasable component.

30 [0014] In another aspect of the present invention, the apparatus includes a sleeve having a proximal end, a distal end, an inner surface, an outer surface, and a wall thickness. An anchoring component is attached to the proximal end of the sleeve with a releasable component, such that the sleeve decouples from the anchoring component when the releasable component weakens after a predetermined time.

35 [0015] In another aspect of the invention, the apparatus includes a first anchoring component sized to be located in a patient's duodenum. A first sleeve is attached to and extends from the first anchoring component. The first sleeve has a proximal end, a distal end, an inner surface, an outer surface, a wall portion extending from

the proximal end to the distal end, and at least one opening in the wall portion. The apparatus also includes a second anchoring component sized to be located in the patient's biliary duct and a second sleeve attached to and extending from the second anchoring component. The second sleeve is sized to fit through at least one opening in the wall portion of the first sleeve.

**[0016]** It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

**[0017]** The accompanying drawings are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention, and together with the description serve to explain the principles of the invention.

**[0018]** In the drawings:

FIG. 1A illustrates an apparatus according to an embodiment of the invention;

FIG. 1B illustrates the apparatus of FIG. 1A having component separation;

FIG. 1C illustrates an expanded view of a portion of FIG. 1A;

FIG. 2A illustrates an apparatus according to another embodiment of the invention;

FIG. 2B illustrates the apparatus of FIG. 2A having component separation;

FIG. 2C illustrates an apparatus according to FIG. 2A having sections of different properties;

FIG. 3A illustrates an apparatus according to another embodiment of the invention;

FIG. 3B illustrates a cross-sectional end view of the apparatus shown in FIG. 3A cut along line A to A' prior to release;

FIG. 3C illustrates a cross-sectional end view of the apparatus shown in FIG. 3A cut along line A to A' after release;

FIG. 4A illustrates an apparatus according to another embodiment of the invention;

FIG. 4B illustrates an apparatus according to another embodiment of the invention;

FIG. 5A illustrates an apparatus according to another embodiment of the invention;

FIG. 5B illustrates an apparatus according to FIG. 5A after a predetermined time; and

FIG. 6 illustrates an apparatus according to another embodiment of the invention.

### **DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS**

**[0019]** The invention relates to a novel medical apparatus for treatment of obesity, diabetes, weight loss

and/or other obesity-associated health problems. The apparatus is used to impede absorption of nutrients within the gastrointestinal tract, i.e., substantially isolating nutrients from a portion of the gastrointestinal tract. The apparatus can be implanted using minimally invasive techniques, such as a transesophageal approach under visualization and others as known in the art.

**[0020]** In one embodiment, the apparatus includes a sleeve and at least one anchoring component. The anchoring component is attached to at least a portion of the sleeve with a releasable component or a coupling agent as known in the art. The coupling agent may include a starch, cyanoacrylates, silicone, urethane, and/or thermoplastics, e.g., nylon, perfluoroalkoxy (PFA), polyurethane (PU), fluorinated ethylene propylene (FEP), and others as known in the art. Preferably, the coupling agent has acceptable biocompatibility and is formed from copolymers, such as a tetrafluoroethylene perfluoroalkylvinylether copolymer (TFE/PAVE), a tetrafluoroethylene perfluoromethylvinylether copolymer (TFE/PMVE), and combinations thereof. Of course, bioabsorbable materials may also be used such as polyglycolic acid and trimethylene carbonate monomer (PGA/TMC), polyglycolic acid and polylactic acid (PGA/PLA), and combinations thereof.

**[0021]** The anchoring component is optional and the sleeve may be attached to a patient via other attachment mechanisms. For example, the sleeve may be directly attached to a patient's anatomy by a variety of attachment mechanisms as known in the art, e.g., sutures, staples, adhesives, anchors, hooks, or combinations thereof and the like.

**[0022]** The anchoring component may be attached to an inner or outer surface of the sleeve. The releasable component may be an active, passive component, and combinations of the same. An active releasable component is one that requires some outside intervention to facilitate its release. For example, a pull mechanism, such as string, tab, and the like other mechanisms may include an external source, such as an energy source, chemical source, thermal source, combinations thereof and the like. Energy sources may include ultrasonic energy, electromechanical energy, magnetic energy and the like. Chemical sources may include different solutions, e.g., a solution at least temporarily changing the pH of the gastrointestinal tract or others. A passive releasable component is one that releases over time without any outside intervention. For example, a passive releasable component may include a degradable material that has a predetermined decay cycle in the given anatomy. In some embodiments, the degradable material includes a bioabsorbable material, biodigestible material, and/or combinations thereof discussed herein.

**[0023]** The sleeve is a conduit for transporting ingested materials, e.g., pre-digested food, chyme, gastrointestinal material and fluids found in the stomach, and the like. The sleeve is designed to permit at least partial isolation of ingested and/or gastrointestinal fluids, such as, bile

and pancreatic juices, from at least portions of the gastrointestinal tract. For example, the sleeve may permit at least partial isolation of chyme from at least portions of villi in the gastrointestinal tract. Preferably, the sleeve is at least a partially compressible conduit that does not substantially inhibit peristaltic mechanisms of the gastrointestinal tract and/or other mechanisms of transport, thereby permitting transport of ingested materials throughout the conduit.

**[0024]** The sleeve may include a plurality of different materials attached together with a releasable component. More specifically, the sleeve may include a first region and a second region attached to each other with a releasable component. Again, the releasable component may be either a passive or active releasable component as previously described. In a preferred embodiment, the release component includes sutures.

**[0025]** The sleeve may include a plurality of different materials, thereby forming regions of different properties, e.g., porosity, pore size, thickness, and the like. Porosity is expressed in percent porosity and may be determined by calculating the quotient of the density of the article and that of the bulk density of PTFE and multiplying that quotient by 100%. For the purposes of this calculation, the bulk density of PTFE was taken to be 2.2 g/cc.

**[0026]** When it is desired to completely isolate ingested materials from the gastrointestinal tract the preferred porosity is about 0%. When it is desired to change the degree of isolation over time it is preferred to fill the pores of the sleeve with a degradable material, e.g., bioabsorbable material that will be absorbed over a predetermined time. In this case, the starting sleeve may be porous, that is possessing a pore size large enough to pass nutrients and/or gastrointestinal fluids through the sleeve wall. For example, the porosity of sleeve may be in the range of about 0% to about 85% or more.

**[0027]** Pore size can be estimated to be an average of the largest dimension of the pore. In porous expanded ePTFE materials pore size may be estimated by an average length of the fibrils. Fibril lengths on the order of 20 microns may allow the passage of nutrients to the gastrointestinal tract. Pore size of the sleeve may be in the range from about 0 microns to 6 mm or more. The pore size may be substantially uniform or non-uniform and may vary throughout the sleeve. For example, the sleeve may be rendered macro-porous to have 6 mm holes throughout at least a portion of the sleeve. The rendering may be conducted by any known means in the art, for example, the sleeve may be hole punched, laser treated, etched, combinations thereof and the like. The pore size may be designed to allow preferential passage of targeted nutrients and/or gastrointestinal fluids through the sleeve wall or a portion of the sleeve wall.

**[0028]** The properties of the different regions of the sleeve may degrade over time or be fixed throughout the implant life of the life sleeve. For example, when utilizing a bioabsorbable material over a portion of the porous sleeve, as the bioabsorbable material degrades, the po-

rosity of the sleeve will change. In one embodiment, various sleeve segments having different porosity maybe attached together with a releasable component. More specifically, the sleeve may include a first region and a second region attached to each other with a releasable component. Again, the releasable component may be either a passive or active releasable component as previously described. In a preferred embodiment, the release component includes sutures.

**[0029]** In another embodiment, the sleeve was constructed to have a releasable component attaching at least a portion of the sleeve together. For example, the sleeve may be formed with a longitudinal seam being attached together with a releasable component.

**[0030]** In another embodiment, the apparatus includes a first anchoring component sized to be located in a patient's duodenum and a first sleeve attached to and extending from the first anchoring component. The first sleeve has a proximal end, a distal end, an inner surface, an outer surface, a wall portion extending from the proximal end to the distal end, and at least one opening in the wall portion. A second anchoring component is sized to be located in the patient's biliary duct. The second sleeve is attached to and extending from the second anchoring component.

**[0031]** The sleeve may also include markings to allow a physician to determine the appropriate deployment, e.g., orientation, location, etc., of the sleeve or alternatively to allow tailoring the sleeve to the desired length. The markings may also include a radiopaque material to aid in non-invasive visualization or other suitable visualization materials as known in the art. For example, the sleeve may have at least one longitudinal strip of radiopaque material incorporated into at least a portion of the length of the sleeve.

**[0032]** A physician may tailor the sleeve into any length suitable for treatment of obesity and/or diabetes as determined necessary. For example, the sleeve may have a length ranging from about 2 cm to 1000 cm. Preferably, the length of the sleeve ranges from about 50 cm to 200 cm.

**[0033]** The sleeve may be designed to have any number of different geometrically shaped cross-sections, such as circular, oval, elliptical, diamond, square, combinations thereof and the like. In addition, the sleeve may narrow along its length, e.g., having a tapered shape. More specifically, a cross-section at one end of sleeve may be larger than a cross-section at an opposite end of the sleeve. Preferably, the sleeve is designed to have a circular cross-section. In addition, the sleeve may include localized regions of restricted or enlarged cross-sections.

**[0034]** The outside dimension of the sleeve is preferably sized to permit the sleeve to fit within a patient's internal gastrointestinal tract. The outside dimension of the sleeve may also be oversized or undersized within a patient's gastrointestinal tract, that is, the outermost dimension, e.g., the outside diameter may be greater or less than the diameter of the gastrointestinal tract. Pref-

erably, when utilizing a sleeve with a circular cross-section the outside diameter may be in the range from about 15 mm to about 50 mm, and more preferably, the outside diameter ranges from about 20 mm to 30 mm.

**[0035]** The sleeve is preferably sized and designed to be suitably flexible enough to permit peristaltic mechanisms of the gastrointestinal tract and/or other mechanisms of transport down the length of the sleeve. The thickness is chosen to permit transport of ingested materials throughout the conduit via peristaltic or other mechanisms. Preferably, the thickness of the sleeve ranges from about 0.003 mm to about 2.6 mm, and more preferably, it ranges from about 0.02 mm to about 0.7 mm thick. The thickness of the sleeve may also vary along the length of the sleeve, for example, the sleeve may be thicker at one end and thinner at an opposite end.

**[0036]** Multiple manufacturing techniques may be used to form the sleeve as known in the art. For example, these techniques can take the form of an extruded or otherwise formed sleeve of a composition that provides mechanical and physical properties that allow at least partial isolation of material exiting the stomach from the small intestine. For example, the sleeve provides at least partial isolation of ingested materials within the sleeve from the digestive tract environment. This isolation may be complete, incomplete, and may vary over time the sleeve is in the patient, vary down the length of the sleeve, and combinations of the same. Preferably, the isolation is designed to provide at least partially impaired absorption of nutrients down a portion of the small intestine, thereby promoting weight loss in the patient.

**[0037]** The sleeve can be constructed, in whole or in part, utilizing a variety of degradable materials, polymeric materials, synthetic or natural, and combinations thereof. In some embodiments, the sleeve may be composed of multiple components that are mixed as a blend, such as a plasticized system, and/or as a microphase immiscible system. If suitable reactive groups are introduced into the formed sleeve, what is commonly known as a thermoset or chemically cross-linked system can be generated under appropriate curing conditions. The formed sleeve can also be composed in the form of a laminate or a fibrous reinforced composite. Of course, the properties of the selected composition, e.g., molecular weight, glass transition temperature(s), crystallinity, and/or the extent of cross-linking will dictate the desired properties of the sleeve. The sleeve may also be coated with a variety of therapeutic agents such as vitamin coatings, drug coatings, and the like. The vitamin coatings may be designed to mimic or supplement therapeutic vitamin therapies implemented to patients of traditional weight loss therapies.

**[0038]** In a preferred embodiment, the sleeve is constructed from a composite of ePTFE and FEP materials. The composite has FEP layer on one side of the laminate and ePTFE on the opposite side. The composite film possesses the following properties: a thickness ranging from about 0.002 mm to about 0.7 mm, and more preferably,

it ranges from about 0.02 mm to about 0.3 mm thick. An IPA bubble point of greater than about 0.6 MPa, and a tensile strength of at least about 75 MPa in the weakest direction. More preferably, also having a tensile strength of about 309 MPa in the strongest direction. In a preferred embodiment, the resultant sleeve is impermeable to gastrointestinal fluids, e.g., chyme, biliopancreatic fluids, digested foods, stomach acids and the like.

**[0039]** The sleeve may be fabricated in a continuous or batch process as known in the art. In one embodiment, a plurality of film strips may be arranged in the longitudinal direction along the length of a mandrel. The strips may be evenly or non-evenly spaced along the length of mandrel, that is, the strips may overlap or not overlap with each other. In a preferred embodiment, the strips are a composite film of FEP and ePTFE, however, other sleeve materials as described herein may be utilized. In this embodiment, an adhesive FEP side of the film may be arranged such that it is up or away from the mandrel.

**[0040]** The mandrel with the longitudinal oriented film may then be helically wrapped with another composite film. The helically wrapped film may be the same or different type material as the previously used composite film. The FEP adhesive may be oriented down towards the mandrel and against the longitudinal film. A helical wrapper may be used to apply the film at a predetermined pitch. Pitch is defined as the amount of advance per revolution of the mandrel. The longitudinal and helical wrapping processes may be repeated one or more times.

**[0041]** The film layered mandrel may then be placed into an oven, e.g., air convection oven set to a temperature ranging from about 250 to 400°C, and more preferably to a temperature ranging from about 300 to 340°C. It may be heated in the oven for time ranging from about 15 to 60 minutes, and more preferably for a time ranging from about 25 to 35 minutes. Upon removal from the oven the resultant sleeve is cooled to room temperature. Alternatively, other suitable techniques as known in the art may be utilized in fabrication of the sleeve.

**[0042]** The anchoring component may be a self-expandable, balloon-expandable or a combination of self-expandable and balloon-expandable anchoring components. In some embodiments, the anchoring component is used to at least partially fix the device inside a portion of the gastrointestinal tract, e.g., before, across, or after the pylorus. Other anchoring locations are also possible, for example it may be arranged in the esophagus; at the gastroesophageal interface; in the stomach such as prior to the pylorus, e.g., in the stomach antrum; across the pylorus; in the duodenum bulb; in the small intestine or at another suitable site.

**[0043]** The anchoring component is preferably constructed from materials that are flexible and strong. The anchoring component may be formed from degradable bioabsorbable materials, biodigestible materials, polymeric materials, metallic materials and combinations thereof. In addition, these materials may be reinforced and/or coated with other materials, such as polymeric materials

and the like. The coating may be chosen to reduce acidic or basic effects of the gastrointestinal tract, e.g., with a thermoplastic coating such as ePTFE and the like.

**[0044]** The anchoring component may be formed into a variety of different geometric configurations having constant and/or varied thickness as known in the art. The geometric configurations may include many conventional stent configurations such as a helical wrapped stent, z-shape stent, tapered stent, coil stent, combinations and the like. Moreover, the anchoring component may be designed to have a flange on one side and a coil shape on the opposite side. Preferably, the anchoring component has a tapered configuration, that is, where one end of the component has a larger dimension than the opposite end. This tapered configuration is thought to provide better anchoring proximally or distally to the pylorus.

**[0045]** The anchoring component may be designed to degrade or decompose over time. For example, the anchoring component may be designed to degrade with exposure to the acidic or basic environment of the anatomy. In these configurations, the anchoring component may be constructed from biodigestible materials and/or bioabsorbable materials. Biodigestible materials include acidic or basic degradable metals and alloys, such as, iron, aluminum, chromalloy, and the like. Of course, other materials that degrade over time as known in the art may also be utilized in the fabrication of the anchoring component.

**[0046]** By way of example, bioabsorbable self-expanding anchoring components may be manufactured as taught in U.S. Patent Application Publication 2006/0025852. For example, an integral framework in a substantially tubular shape can be utilized. The integral framework elements include bioabsorbable materials such as these described herein. In one embodiment, the materials include non-blended hydrolysable polymer material in a tri-block co-polymer of poly(glycolide) and poly(trimethylenecarbonate).

**[0047]** In another embodiment, the anchoring component is constructed from a super-elastic material such as nitinol. The material may be formed from a cut tube material or wire material. The material is sized to have a thickness ranging from about 0.01 to 0.5 mm or more. The material may have any cross-sectional geometry, e.g., a circle, oval, square, triangle, ribbon and the like.

**[0048]** The anchoring component may be manufactured as known in the art, e.g., laser cutting a tube. In one embodiment, the anchoring component is formed from a wire, e.g., nitinol wire. The wire is arranged around variously spaced pins on a jig. The pins are spaced on the jig into a desired geometric pattern. The pins act to hold the wire in a desired shape during a subsequent thermal setting process. In addition, the jig may be tapered or straight along a longitudinal axis. Preferably, the jig is constructed from a stainless steel cylinder. The wire is wrapped around the various pins to form the anchoring component. Each end of the wire is terminated under a termination unit, e.g., screw head that hold an

end of the wire.

**[0049]** The wire and jig are placed into a heat source, e.g., a convection oven, at a shape setting temperature. Preferably, when utilizing super-elastic nitinol wire the shape setting temperature ranges from about 440°C to 500°C, and more preferably from about 460°C to 480°C. The super-elastic nitinol wire is placed into the heat source for time ranging from about 10 to 40 minutes, and more preferably for time from about 15 to 20 minutes. Upon removal, the jig and wire are submersed in a water bath at room temperature. After the jig has cooled and dried the anchor component is removed and any excess wire may be trimmed.

**[0050]** Degradable materials include bioabsorbable materials and biodigestible materials as discussed herein. Biodigestible includes a material that is capable of being converted into assimilable condition in the alimentary canal or capable of being at least partially decayed to allow passing of the material. Bioabsorbable materials include bioabsorbable polymers and copolymers composed from varying amounts of one or more of the following monomer examples, glycolide, d,l-lactide, l-lactide, d-lactide, p-dioxanone (1,4-dioxane-2-one), trimethylene carbonate (1,3-dioxane-2-one),  $\epsilon$ -caprolactone,  $\gamma$ -butyrolactone,  $\delta$ -valerolactone, 1,4-dioxepan-2-one, and 1,5-dioxepan-2-one. Polymers that are either introduced as or can be degraded to segment lengths that can be excreted from the body can also be considered as bioabsorbable, and may include polyethylene glycol, polypropylene glycol, amino acids, anhydrides, orthoesters, phosphazines, amides, urethanes, and phosphoesters. Alternative copolymers may possess, in whole or in part, block, segmented, random, alternating, or statistical polymeric construction characteristics. Animal derived products such as elastin or collagen, either absorbable, e.g., enzymatically degraded, within the body or rendered non-absorbable through chemical treatment, e.g., glutaraldehyde cross-linked bovine pericardium, may alternatively be utilized as or within the sleeve construct. Additional potential components of the sleeve may include naturally derived or modified polysaccharides such as chitosan, alginate, and/or hyaluronic acid.

**[0051]** Reference will now be made in detail to embodiments of the invention, examples of which are illustrated in the accompanying drawings.

**[0052]** FIG. 1A illustrates a sleeve according to an embodiment of the invention. FIG. 1B illustrates a sleeve detached from an anchoring component according to FIG. 1A. FIG. 1C illustrates an expanded view of FIG. 1A.

**[0053]** Referring to FIGS. 1A-1C, an implantable apparatus is generally depicted as reference number 100. The apparatus 100 includes a sleeve 102 and an anchoring component 104. The anchoring component 104 is attached to the sleeve 102 with a releasable component 106.

**[0054]** The releasable component 106 may be active or passive. In this embodiment the releasable component 106 includes a material applied in a pattern to a portion

of the anchoring component 104. For example, the adhesive may be applied as a narrow strip of material to join a portion of the anchoring component to the sleeve. Preferably, the pattern is utilized on both sides of the anchoring component 104 as shown in FIG. 1C. However, the releasable component 106 may be arranged in any geometric pattern such as a circle, square, diamond, ring, line, and the like. The thickness and type of pattern utilized may be a factor in its release time.

**[0055]** In this embodiment, the releasable component is selected from a material that may decay over time such as a degradable material including at least one of the bioabsorbable materials and biodegradable materials as discussed herein. The material is preferably a bioabsorbable material, such as PGA/PLA or other materials as known in the art. In practice, the bioabsorbable material decays at a predetermined time such that the sleeve 102 is released from the anchoring component 104. The sleeve is then free to travel through the rest of the gastrointestinal tract. After the sleeve is released there is no longer isolation of the chyme from gastrointestinal juices over at least a partial length of the sleeve and gastrointestinal tract.

**[0056]** FIG. 2A illustrates an implantable apparatus according to another embodiment of the invention. FIG. 2B illustrates the implantable apparatus of FIG. 2A having component separation. FIG. 2C illustrates an implantable apparatus according to FIG. 2A having sections of different properties.

**[0057]** Referring to FIGS. 2A-2C an implantable apparatus is generally depicted as reference number 200. The apparatus 200 includes a sleeve and an anchoring component 202. The anchoring component 202 is attached to the sleeve with an adhesive 204 as known in the art. The adhesive 204 may be attached to any portion of the anchoring component 202 or a fully covered portion of the anchoring component 202. For example, the adhesive may be applied in a pattern, e.g., a narrow strip of material to join a portion of the anchoring component 202 to the sleeve. Preferably, the pattern is utilized on both sides of the anchoring component 202. Again, the adhesive 204 may be arranged in any geometric pattern such as a circle, ring, line, and the like. The thickness and type of pattern utilized may be a factor in its strength. Alternatively, the anchoring component may be attached to the sleeve with a releasable component as described herein, e.g., as shown in FIGS. 1A-1C.

**[0058]** The sleeve includes a first portion 206 and a second portion 208 arranged together with a releasable component 210. In this embodiment, the first 206 and second 208 portions of the sleeve are circumferentially attached with an active releasable component 210. The active releasable component 210 is a filament arranged in a pattern such as a chain stitch. Preferably, the filament is a fluoropolymer suture, e.g., ePTFE suture. The filament 210 includes a free portion (not shown) to facilitate grasping and application of tension, thereby releasing the stitch as known in the art. The first 206 and second

208 portions of the sleeve may be constructed from the same material. Alternatively, the first and second portions of the sleeve may be constructed from different materials. The different sleeve materials may have different properties, e.g., different porosity, thereby permitting different absorption rates through the sleeve as illustrated in FIG. 2C. Alternatively, the first and second portions may be permanently attached to each other, e.g., with an adhesive.

**[0059]** There could also be a plurality of sleeve portions attached together to permit in-situ length adjustability. For example, there may be six equal or non-equal sleeve segments arranged together each having a releasable component. This would allow a physician to release a portion of the sleeve thereby permitting in-situ length adjustment. Any combination of releasable components may be utilized, e.g., active and/or passive components as described herein.

**[0060]** In another embodiment, the sleeve portions are attached with a passive releasable component. The passive releasable components are designed to permit sequential release of the sleeve portions. For example, the most distal sleeve portion may be released first and its adjacent portion released next, and so on. This is designed to permit automatic staged adjustment of the length of the sleeve.

**[0061]** FIG. 3A illustrates an implantable apparatus according to another embodiment of the invention. FIG. 3B illustrates a cross-sectional end view of the apparatus shown in FIG. 3A cut along line A to A' prior to release. FIG. 3C illustrates a cross-sectional end view of the apparatus shown in FIG. 3A cut along line A to A' after release.

**[0062]** Referring to FIGS. 3A-3C an implantable apparatus is generally depicted as reference number 300. The anchoring component 302 is attached to the sleeve with an adhesive 304. The adhesive 304 may be attached to any portion of the anchoring component 302 as well as a fully covered portion of the anchoring component 302. For example, the adhesive 304 may be applied in a fillet pattern to a portion of the anchoring component 302. Preferably, the fillet pattern is utilized on both sides of the anchoring component 302. Again, the adhesive 304 may be arranged in any geometric pattern such as a circle, ring, line, and the like. The thickness and type of pattern utilized may be a factor in its strength. Alternatively, the anchoring component may be attached to the sleeve with a releasable component as described herein, e.g., as shown in FIGS. 1A-1C.

**[0063]** In this embodiment, the releasable component 306 is a passive releasable component, such as a degradable adhesive that may decay over time. The degradable material is preferably a bioabsorbable adhesive material such as PGA/PLA or other materials as known in the art. FIG. 3C, illustrates a time after the adhesive 306 has decayed and the sleeve opens along the longitudinal seam. This embodiment permits automatic restoration of absorption of the villi in the gastrointestinal tract at a pre-

determined time, e.g., after 3 months or more.

**[0064]** FIG. 4A illustrates an implantable apparatus according to another embodiment of the invention. FIG. 4B illustrates an implantable apparatus according to another embodiment of the invention.

**[0065]** Referring to FIG. 4A an apparatus is generally depicted as reference number 400. The anchoring component 402 is attached to the sleeve with an adhesive 404. The adhesive 404 may be attached to any portion of the anchoring component 402 as well as a fully covered portion of the anchoring component 402. For example, the adhesive 404 may be applied in a fillet pattern to a portion of the anchoring component 402. Preferably, the fillet pattern is utilized on both sides of the anchoring component 402. Again, the adhesive 404 may be arranged in any geometric pattern such as a circle, ring, line, and the like. The thickness and type of pattern utilized may be a factor in its strength. Alternatively, the anchoring component may be attached to the sleeve with a releasable component as described herein, e.g., as shown in FIGS. 1A-1C.

**[0066]** In this embodiment, the sleeve includes areas of different porosities that change over time. For example, the sleeve includes a plurality of first porosity regions 406 and second porosity regions 408. The first set of porosity regions 406 permit nutrient absorption after a predetermined period of time. That is, these regions are designed to allow chyme and other gastrointestinal juices to reach the villi of the small intestine after a predetermined period of time.

**[0067]** The second set of porosity regions 408 substantially minimizes or prevents nutrient absorption, e.g., prevents or minimizes chyme and other gastrointestinal juices from reaching the villi of the small intestine. In this embodiment, the second set of porosity regions 408 includes a helical wrapped film with an underlying sleeve. The helical wrapped film 408 may have a constant pitch angle or variable pitch angle. The variable pitch angle is depicted in FIG. 4B. Preferably, the pitch angle ranges from about 1 to 45 degrees and more preferably, it ranges from about 20 to 30 degrees. Obviously, the width of the helical film may also be adjusted to achieve similar results. Alternatively, the second set of porosity regions 408 could be applied as individual rings, rather than as a helical wrap. The helically wrapped film is preferably selected to have a minimum or no porosity, e.g., a FEP film.

**[0068]** FIG. 5A illustrates an implantable apparatus according to another embodiment of the invention. FIG. 5B illustrates an implantable apparatus according to another embodiment of the invention.

**[0069]** Referring to FIG. 5A, an apparatus is generally depicted as reference number 500. The anchoring component 502 is attached to the sleeve with an adhesive 504. The adhesive 504 may be attached to any portion of the anchoring component 502 or as a fully covered portion of the anchoring component 502. For example, the adhesive 504 may be applied in a fillet pattern to a

portion of the anchoring component 502. Preferably, the fillet pattern is utilized on both sides of the anchoring component 502. Again, the adhesive 504 may be arranged in any geometric pattern such as a circle, ring, line, and the like. The thickness and type of pattern utilized may be a factor in its strength. Alternatively, the anchoring component may be attached to the sleeve with a releasable component as described herein, e.g., as shown in FIGS. 1A-1C.

**[0070]** In this embodiment, the sleeve includes areas of different porosities. For example, the sleeve includes a plurality of first regions 506 and second regions 508 having different porosities. The first set of regions 506 permit nutrient absorption after a predetermined amount of time, e.g., it allows chyme and other gastrointestinal juices to reach the villi of the small intestine, allowing absorption of nutrients along that region. More specifically, the first set of porosity regions include a degradable cover material that degrades after a predetermined time. The degradable material may be a bioabsorbable or biodegradable material as discussed herein. Preferably, the degradable material is a bioabsorbable material such as PGA/PLA or other materials as known in the art. This coating may be applied to the entire sleeve or selected portions such as discrete rings or helical wrapped materials.

**[0071]** The second set of porosity regions 508 substantially minimizes or prevents nutrient absorption, e.g., it prevents or minimizes chyme and other gastrointestinal fluids from reaching the villi of the small intestine. In this embodiment, the second set of porosity regions 508 is a helical wrapped film over the underlying sleeve. The helical wrapped sleeve 508 may have a constant pitch angle or variable pitch angle. Preferably, the pitch angle ranges from about 1 to 45 degrees and more preferably, it ranges from about 20 to 30 degrees. Obviously, the width of the helical film may also be adjusted to achieve similar results. In this embodiment, as shown in FIGS. 5A and 5B, the second set of porosity regions 508 are applied as individual rings, rather than as a helical wrap. The helically wrapped film is preferably selected to have a minimum or no porosity, e.g., a FEP film.

**[0072]** FIG. 6 illustrates an implantable apparatus according to another embodiment of the invention.

**[0073]** Referring to FIG. 6, an implantable apparatus is generally depicted as reference number 600. The anchoring component 602 is attached to the sleeve with an adhesive 604 as described herein. Alternatively, the anchoring component may be attached to the sleeve with a releasable component as also described herein, e.g., as shown in FIGS. 1A-1C. The apparatus also includes a side branch portion 606 that may include another anchoring component 608. In this embodiment, the side portion 606 may be inserted into the common bile duct (not shown), thereby allowing bile duct drainage while excluding the chyme and other gastrointestinal fluids from the small intestine. The sleeve may be constructed to have regions of different porosities as described here-



in.

## EXAMPLES:

**[0074]** Without intending to limit the scope of the invention, the following examples illustrate how various embodiments of the invention may be made and/or used.

### Example 1:

**[0075]** In this example, a sleeve was fabricated and attached to an anchoring component with a releasable component, e.g., a bioabsorbable material. A stainless steel mandrel and having an outer diameter of about 26 mm and a length of about 46 cm was obtained. An ePTFE sacrificial tube was pulled over the mandrel. The sacrificial tube had a wall thickness of about 0.01 mm, a length of about 40 cm, and an inner diameter of about 20 mm. This sacrificial tube was used in construction of the sleeve and would later be discarded.

**[0076]** Next, a substantially non-porous ePTFE film with a thermal adhesive layer FEP on one side was obtained. The composite film had a width of about 150 mm, a thickness of about 0.0025 mm, an isopropyl alcohol bubble point (IBP) of greater than about 0.6 MPa, and a tensile strength of about 309 MPa in the length direction (the strongest direction).

**[0077]** This first film was cut to be about 40 cm long. The first film with the thermal adhesive side up was longitudinally arranged on top of the sacrificial tube. The first film was arranged and cut to have about a 3 mm overlap, thereby creating a two-layer seam. The first film was applied so that its strongest direction was oriented in a direction that was substantially parallel to the longitudinal axis of the mandrel.

**[0078]** A second film including a substantially non-porous ePTFE film on one side and a thermal adhesive layer FEP on the opposite side was obtained. The second film had a width of about 25.4 mm, a thickness of about 0.0025 mm, an IBP of greater than about 0.6 MPa, and a tensile strength of about 309 MPa in the length direction (the strongest direction).

**[0079]** Two layers of the second film having the adhesive side down were then helically wrapped on top of the longitudinally wrapped film. The exposed film ends of the helically-wrapped film were heat-bonded (Weller Soldering Iron, Model EC2002 available from McMaster Carr, Santa Fe Springs, CA).

**[0080]** This fabricated assembly, i.e., the mandrel, sacrificial tube, and first and second film layers, were placed into a forced air oven (model NT-1000, Grieve Corporation, Round Lake, IL) set to about 320 °C for about 15 minutes in order to bond the first and second film layers together, thereby forming a sleeve on the sacrificial tube. The assembly was removed from the oven and allowed to cool to ambient temperature.

**[0081]** An anchoring component having about a 25.4 mm inner diameter self-expanding z-stent was constructed

using nitinol wire having about a 0.51 mm diameter (part number SE508, Nitinol Devices and Components, Fremont, CA). The nitinol wire was wrapped onto an about 25.4 mm diameter stainless steel pin jig. The pin jig had about 1.52 mm diameter pins that were arranged to provide a single-ring, i.e., six-apex zig-zag pattern. The vertical distance between two adjacent apices from a center radius of the first apex to a center radius of an adjacent apex was about 19.1 mm. The ends of the wire were secured to the pin jig with screws. The jig was placed in a forced air oven (model HRF, Carbolite oven, Sheffield, England) set at about 450 °C for about 12 minutes. The jig was removed from the oven and quenched in water to cool it to an ambient temperature. The formed anchoring component was removed from the jig and the wire ends were trimmed as desired.

**[0082]** The anchoring component was placed over one end of the sleeve, which was still arranged on the sacrificial tube on the mandrel. The anchoring component portion was helically wrapped with one layer of an about 0.51 mm diameter copper wire to temporarily hold the anchoring component in place. Next, PLA/PGA resin at 85 weight percent PLA and 15 weight percent PGA (Durect® Corporation of Pelham, Alabama) was obtained and was dissolved in acetone (part no. 12271 from Ace Hardware of Oakbrook, IL). In this example, a sleeve was fabricated and attached to an anchoring component with a releasable component, e.g., bioabsorbable material. A solution of about sixty weight percent acetone and about forty weight percent PLA/PGA (85/15) was applied to the anchoring component and the underlying sleeve material with a brush. The solution was allowed to air dry. The copper wire was removed and discarded and the sleeve attached to an anchoring component with a releasable component was removed from the mandrel. Finally, the sacrificial tube was removed from an internal surface of the finished device.

### Example 2:

**[0083]** In this example, a sleeve was fabricated to include a releasable component along a longitudinal a portion of the length of the sleeve. The releasable component enables disruption of the sleeve after a predetermined time, allowing for increased contact between the villi and chyme.

**[0084]** A stainless steel mandrel having an outer diameter of about 26 mm and a length of about 46 cm long was obtained. An ePTFE sacrificial tube was pulled over the mandrel. The sacrificial tube had a wall thickness of about 0.01 mm, a length of about 40 cm, and an inner diameter of about 20 mm. This sacrificial tube was used in construction of the sleeve and would later be discarded.

**[0085]** Next, a substantially non-porous ePTFE film with a thermal adhesive layer FEP on one side was obtained. The composite film had a width of about 15.2 cm, a thickness of about 0.0025 mm, an IBP of greater than

about 0.6 MPa, and a tensile strength of about 309 MPa in the length direction (the strongest direction).

**[0086]** The film was cut to be about 40 cm long. This film with the thermal adhesive side up was then longitudinally arranged on top of the sacrificial sleeve. The film was arranged and cut to have a 3 mm overlap, thereby creating a two-layer seam. The film was applied so that the strongest direction of the film was oriented in a direction that was substantially parallel to the longitudinal axis of the mandrel. Subsequently, the seam was heat-bonded with a soldering iron. (Weller Soldering Iron, Model EC2002 available from McMaster Carr, Santa Fe Springs, CA).

**[0087]** The fabricated assembly, i.e., the mandrel, sacrificial sleeve, and film, was placed in a forced air oven (model NT-1000, Grieve Corporation, Round Lake, IL) set to about 320 °C for about 15 minutes in order to bond the film together, thereby forming a sleeve on a sacrificial tube. The assembly was removed from the oven and allowed to cool to ambient temperature.

**[0088]** An anchoring component having about a 25.4 mm inner diameter self-expanding z-stent was constructed using nitinol wire having about a 0.51 mm diameter (part number SE508, Nitinol Devices and Components, Fremont, CA). The nitinol wire was arranged onto an about 25.4 mm diameter stainless steel pin jig. The pin jig had about 1.52 mm diameter pins that were arranged to provide a single-ring, i.e., six-apex zig-zag pattern. The vertical distance between two adjacent apices from a center radius of the first apice to a center radius of an adjacent apice was about 19.1 mm. The ends of the wire were secured to the pin jig with screws. The jig was placed in a forced air oven (model HRF, Carbolite oven, Sheffield, England) set at about 450 °C for about 12 minutes. The jig was removed from the oven and quenched in water to cool to ambient temperature. The formed anchoring component was removed from the jig and the wire ends were trimmed as desired.

**[0089]** The anchoring component was placed over one end of the sleeve, which was still arranged on the sacrificial tube on the mandrel. The anchoring component portion was covered with two wraps of the afore-mentioned film. The strength direction of the film was oriented perpendicular to the longitudinal axis of the mandrel and the adhesive side of the film faced down. The edges of the film were heated with a soldering iron (Weller Soldering Iron, Model EC2002 available from McMaster Carr, Santa Fe Springs, CA) to tack them in place.

**[0090]** A second sacrificial tube having a width of about 25.4 mm, thickness of about 0.013 mm, a methanol bubble point (MBP) of about 7 KPa, and a tensile strength of about 77 MPa in the length direction (the strongest direction) was arranged over the anchoring component and sleeve. Seven to ten layers of a sacrificial ePTFE film were then helically wrapped over the second sacrificial sleeve. The purpose of these seven layers of film and the second sacrificial sleeve was to impose a compression force on the underlying elements during a sub-

sequent heating process, thereby bonding the non-porous ePTFE film to the stent.

**[0091]** The entire assembly was heated in a Grieve oven set to about 320 °C for about 15 minutes after which it was removed from the oven and allowed to air cool. The second sacrificial tube and seven to ten layers of a sacrificial ePTFE film helically wrapped over the sacrificial tube were removed and discarded. The remainder of the assembly was then removed from the mandrel and the first sacrificial sleeve was removed, thereby separating it from the anchoring component and sleeve. The ends of the sleeve were trimmed to have a total length of about 32.9 cm, that is, the anchoring component portion had a length of about 1.9 cm and the unanchored portion was about 31 cm in length.

**[0092]** The sleeve had a releasable component, e.g., a seam along the portion not attached to the anchoring component. The releasable component could be released, e.g., disrupted by applying internal pressure, such as through the use of a balloon catheter or similar device as known in the art.

**[0093]** This feature was tested with a release tool constructed from stainless steel tubing having a length of about 25.4 cm and an outer diameter of about 4.7 mm (Small Parts Inc, Miami Lakes, FL). In addition, silicone tubing (Jamak Corp, Weatherford, TX) having an outer diameter of about 6.35 mm and a length of about 7.62 cm was utilized in constructing the release tool.

**[0094]** The stainless steel tubing was closed at one end by inserting and adhering a water-tight plug machined from PVC barstock. The machined PVC barstock had a diameter that was similar to an inner diameter of the stainless steel tubing. A hole was drilled through one wall of the steel tubing at a location about 5.1 cm from the end with the water-tight plug. The drilled hole had a diameter of about 3.18 mm.

**[0095]** The silicone tube was arranged over the stainless steel tube and centered at the drilled hole. The silicone tube was tied down at each end with a glued linen thread. That is, a thread having a diameter of about 0.254 mm was attached to each end by wrapping the thread about thirty times around the silicone tube to attach the silicone tube to the stainless steel tube. Next, a cyanoacrylate glue was applied to the thread to further hold it in place. A luer fitting was then attached to the open end of the stainless steel tubing, thereby permitting a later connection to an inflation tool.

**[0096]** The release tool was inserted into the resultant sleeve of this example and inflated with an inflation tool (part number 622510, B. Braun, Bethlehem, PA), thereby applying a radial force to the sleeve. The pressure was increased at a rate of about 4 atm/min and the sleeve seam released, that is, it disrupted, at about 4 atm pressure.

### Example 3:

**[0097]** In this example, a sleeve was fabricated to have

a porosity that changed after a predetermined time. More specifically, a sleeve was constructed to include porous and non-porous regions. The porous regions were coated with a bioabsorbable material that degraded after a predetermined period of time.

**[0098]** A stainless steel mandrel had an outer diameter of about 26 mm and a length of about 46 cm was obtained. An ePTFE sacrificial tube was pulled over the mandrel. The sacrificial sleeve had a wall thickness of about 0.01 mm, a length of about 40 cm, and an inner diameter of about 20 mm. This sacrificial tube was used in construction of the sleeve and would later be discarded.

**[0099]** Next, a substantially porous ePTFE film with a thermal adhesive layer FEP on one side was obtained. The composite film had a width of about 15.2 cm, a thickness of about 0.01 mm, an MBP of about 7 KPa, and a tensile strength of about 77 MPa in the length direction (the strongest direction). Two layers of the film, with the thermal adhesive side up were longitudinally wrapped on top of the sacrificial sleeve with a 3 mm overlap thereby creating a four-layer seam. The film was applied so that the strongest direction of the film was oriented in a direction substantially parallel to the longitudinal axis of the mandrel.

**[0100]** Next, four layers of film having the same properties as the film above, except that they were about 1.3 cm wide, were helically arranged at about a 30° angle, up and back along the length of the longitudinally-applied film. The seam was heat bonded in place (Weller Soldering Iron, Model EC2002, McMaster Carr, Santa Fe Springs, CA). Black ink dots were applied to the film at about 2 cm intervals.

**[0101]** A substantially non-porous ePTFE film with a thermal adhesive layer of FEP on one side was obtained. This composite film had a width of about 2 cm, a thickness of about 0.0025 mm, an IBP of greater than about 0.6 MPa, and a tensile strength of about 309 MPa in the length direction (the strongest direction). One layer of this film was wrapped circumferentially around the previously-applied helically-wrapped film between every other ink mark and heat-bonded in place with the local heat source described above.

**[0102]** Next, the entire assembly was placed in a forced air oven (Grieve Oven, model NT-1000, Grieve Corporation, Round Lake, IL) set to about 320°C for about 15 minutes. The assembly was removed from the oven and allowed to cool to ambient temperature. The assembly was then removed from the mandrel and the sacrificial tube was removed from the resultant film-tube. The resulting ePTFE film-tube possessed alternating porous and non-porous bands of equal width along the length of the tube. That is, regions of the film-tube were devoid of the non-porous film; such regions retained their porosity through the thickness of the wall.

**[0103]** A PLA/PGA resin at 85 weight percent PLA and 15 weight percent PGA (Durect® Corporation of Pelham, Alabama) was obtained and was dissolved in acetone (part no. 12271 from Ace Hardware of Oakbrook, IL). More

specifically, a solution of about sixty weight percent acetone and about forty weight percent PLA/PGA resin (85/15) and was applied to the porous areas of the underlying ePTFE film tube using a brush. In this way, the pores of the film-tube sleeve were covered with a bioabsorbable material.

#### Example 4:

**[0104]** In this example, a sleeve was fabricated to include varied pore size along its length. A stainless steel mandrel having an outer diameter of about 26 mm and a length of about 46 cm was obtained. An ePTFE sacrificial tube was pulled over the mandrel. The sacrificial tube had a wall thickness of about 0.01 mm, a length of about 40 cm, and an inner diameter of about 20 mm. This sacrificial tube was used in construction of the sleeve and it would later be discarded.

**[0105]** A porous ePTFE film with a thermal adhesive layer (FEP) on one side was obtained. The composite film had a width of about 150 mm, a thickness of about 0.01 mm, an MBP of about 7 KPa, and a tensile strength of about 77 MPa in the length direction (the strongest direction).

**[0106]** Starting at one end of the mandrel two layers of the film with the adhesive side up were longitudinally arranged and trimmed on top of half of the length of the sacrificial tube to have a 3 mm overlap, thereby creating a four-layer seam. The film was applied so that the strongest direction of the film was arranged to be substantially parallel to the longitudinal axis of the mandrel.

**[0107]** A substantially non-porous ePTFE film with a thermal adhesive layer FEP on one side was obtained. The composite film had a width of about 150 mm, a thickness of about 0.0025 mm, an IBP of greater than about 0.6 MPa, and a tensile strength of about 309 MPa in the length direction (the strongest direction). One 20 cm long layer of film with the adhesive side up was longitudinally wrapped and trimmed around the other half the length of the sacrificial tube to have a 3 mm overlap creating a two-layer seam. This film was extended about 13 mm over the previously-applied film. The film was applied so that the strongest direction of the film was arranged to be substantially parallel to the longitudinal axis of the mandrel. The seams were heat-bonded (Weller Soldering Iron, Model EC2002, McMaster Carr, Santa Fe Springs, CA).

**[0108]** The entire assembly was then placed in a forced air oven (Grieve Oven, model NT-1000, Grieve Corporation, Round Lake, IL) set to a temperature of about 320 °C for about 15 minutes. The assembly was removed from the oven and allowed to cool to ambient temperature. The assembly was removed from the mandrel, and the sacrificial tube was removed from the resulting sleeve. The resulting sleeve comprised a porous section and a substantially non-porous section.

## Test Methods:

**[0109]** This section describes measuring the tensile strength of the film. The tensile peak force was measured and averaged for ten samples using an Instron Model No. 5560 tensile testing machine (Canton, MA) equipped with Series 2714 Cord and Yarn grips. The jaw separation was 10.2 cm and the cross-head speed was 200 mm/min. The average of ten maximum load peak force measurements was used. The average of ten sample widths was calculated. Thickness was measured with Mitutoyo Snap Gage Model No. 547-400 (Nakatsugawa, Japan). The average of ten thickness measurements was used. Tensile strength was calculated as the quotient of tensile peak force and cross-sectional area of the tested samples.

**[0110]** Bubble point measurements were performed in accordance with the general teachings of ASTM E128-99. Isopropyl alcohol (Univar, Kirkland, WA) or methyl alcohol (Fisher Chemical, Fair Lawn, NJ) was used as the test liquid. The tests were performed using about a 2.54 cm diameter test fixture. During the test pressure was increased at about 1.4 KPa/sec. The pressure corresponding to the appearance of the first stream of bubbles was identified as the bubble point. Tests performed using isopropyl alcohol yielded isopropyl alcohol bubble points (IBP) and tests performed with methyl alcohol yielded methyl alcohol bubble points (MBP). IBP measurements above 0.6 MPa could not be measured due to test equipment limitations. Bubble point values represent the average of 5 measurements.

**[0111]** It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended clauses and their equivalents.

**[0112]** The invention can also be described in terms of the following numbered clauses:

Clause 1: An implantable apparatus for placement in a gastrointestinal tract, comprising: a sleeve; and at least one anchoring component attached to the sleeve with a releasable component.

Clause 2. The apparatus of clause 1, wherein the releasable component is selected from the group consisting of an active releasable component, a passive releasable component, and combinations thereof.

Clause 3. The apparatus of clause 2, wherein the releasable component is a passive releasable component that includes at least one of a bioabsorbable material and a biodigestible material.

Clause 4. The apparatus of clause 1, wherein the releasable component is a bioabsorbable material used to attach the anchoring component to the sleeve.

Clause 5. The apparatus of clause 4, wherein the bioabsorbable material comprises PLA/PGA.

Clause 6. The apparatus of clause 1, wherein the releasable component comprises at least one suture attaching the anchoring component.

Clause 7. The apparatus of clause 1, wherein the sleeve comprises a fluoropolymer.

Clause 8. The apparatus of clause 7, wherein the fluoropolymer comprises expanded polytetrafluoroethylene.

Clause 9. The apparatus of clause 7, wherein the anchoring component comprises nitinol.

Clause 10. An implantable apparatus for placement in a gastrointestinal tract, comprising: at least one anchoring component; and a sleeve attached to the at least one anchoring component, wherein the sleeve includes a first region and a second region attached to each other with a releasable component.

Clause 11. The apparatus of clause 10, wherein the releasable component is a passive releasable component.

Clause 12. The apparatus of clause 10, wherein the releasable component includes at least one of a bioabsorbable material and a biodigestible material.

Clause 13. The apparatus of clause 12, wherein the bioabsorbable material comprises PLA/PGA.

Clause 14. The apparatus of clause 10, wherein the releasable component are sutures anchoring the anchoring component.

Clause 15. The apparatus of clause 10, wherein the sleeve comprises an expanded polytetrafluoroethylene.

Clause 16. An implantable apparatus for placement in a gastrointestinal tract, comprising: at least one anchoring component; and a sleeve attached to the at least one anchoring component, wherein the sleeve includes a first region and a second region, wherein the first region and second region have different properties.

Clause 17. The apparatus of clause 16, wherein the properties of the second region change over time.

Clause 18. The apparatus of clause 16, wherein the properties comprises a first porosity of the first region and a second porosity of the second region.

Clause 19. The apparatus of clause 16, wherein the properties comprise a first pore size of the first region and a second pore size of the second region.

Clause 20. The apparatus of clause 16, wherein the first and second region are attached together with a releasable component.

Clause 21. The apparatus of clause 16, wherein the releasable component includes at least one of a bioabsorbable material and a biodigestible material

Clause 22. The apparatus of clause 21, wherein the bioabsorbable material comprises PLA/PGA.

Clause 23. The apparatus of clause 20, wherein the releasable component comprise sutures attaching the first and second region of the sleeve.

Clause 24. The apparatus of clause 16, wherein the first region of the sleeve comprises a fluoropolymer.  
 Clause 25. The apparatus of clause 24, wherein the fluoropolymer comprises expanded polytetrafluoroethylene.

Clause 26. The apparatus of clause 16, wherein the anchoring component comprises nitinol.

Clause 27. The apparatus of clause 16, wherein the second region comprises FEP.

Clause 28. The apparatus of clause 16, wherein the anchoring component is self-expanding stent.

Clause 29. The apparatus of clause 16, wherein the anchoring component is a balloon expandable stent.

Clause 30. An apparatus, comprising: a longitudinal sleeve having a proximal end, a distal end, an inner surface, an outer surface, and a wall thickness; an anchoring component is attached to the proximal end of the sleeve with a releasable component, wherein the sleeve decouples from the anchoring component upon weakening of the releasable component after a predetermined time.

Clause 31. The apparatus of clause 30, wherein the anchoring component is attached to at least the outer surface of the sleeve.

Clause 32. The apparatus of clause 30, wherein the releasable component comprises at least one of a bioabsorbable material, a digestible material, and a corrodible material.

Clause 33. The apparatus of clause 30, wherein the anchoring component is self-expanding stent.

Clause 34. The apparatus of clause 30, wherein the anchoring component is a balloon expandable stent.

Clause 35. The apparatus of clause 30, wherein the sleeve comprises a thermoplastic material.

Clause 36. The apparatus of clause 35, wherein the thermoplastic comprises a fluoropolymer.

Clause 37. The apparatus of clause 36, wherein the polytetrafluoroethylene polymer is an expanded polytetrafluoroethylene.

Clause 38. The apparatus of clause 30, wherein the anchoring component comprises nitinol.

Clause 39. The apparatus of clause 30, wherein the sleeve has a wall thickness ranging about 0.5 microns to about 6.0 microns.

Clause 40. The apparatus of clause 39, wherein the wall thickness ranges from about 1.0 microns to about 2.0 microns.

Clause 41. The apparatus of clause 8, wherein the expanded polytetrafluoroethylene further comprises a coating material.

Clause 42. The apparatus of clause 30, further comprising a FEP layer on at least a portion of the sleeve.

Clause 43. The apparatus of clause 30, wherein the expanded polytetrafluoroethylene is substantially non-porous.

Clause 44. The apparatus of clause 30, wherein the anchoring component is bonded to an inner surface of the sleeve.

Clause 45. The apparatus of clause 30, wherein the sleeve has a first diameter at the proximal end and a second diameter at the distal end, and wherein the first diameter is greater than the second diameter.

Clause 46. The apparatus of clause 30, wherein the sleeve comprises a film material.

Clause 47. The apparatus of clause 48, wherein the tape is a helically wrapped film material.

Clause 48. An intestinal device, comprising: a sleeve having a proximal end, a distal end, an inner surface, an outer surface, and a wall thickness, wherein the sleeve further comprises at least one portion that is detachable from the remainder of the sleeve; and an anchoring component is attached to the proximal end of the sleeve with a releasable component.

Clause 49. The apparatus of clause 48, wherein the sleeve will decouple from the anchoring component upon weakening of the releasable component.

Clause 50. The apparatus of clause 48, wherein the anchoring component is expandable.

Clause 51. The apparatus of clause 48, wherein the at least one portion of the sleeve is detachable by inflating a balloon inside the sleeve.

Clause 52. The apparatus of clause 48, wherein the at least one portion of the sleeve is detachable by removing the releasable component, wherein the releasable component is a suture.

Clause 53. An implantable apparatus for placement in a gastrointestinal tract, comprising: a first anchoring component sized to be located in a patient's duodenum; a first sleeve attached to and extending from the first anchoring component, the first sleeve having a proximal end, a distal end, an inner surface, an outer surface, a wall portion extending from the proximal end to the distal end, and at least one opening in the wall portion; a second anchoring component sized to be located in the patient's biliary duct; and a second sleeve attached to and extending from the second anchoring component, the second sleeve being sized to fit through the at least one opening in the wall portion of the first sleeve.

Clause 54. The apparatus of clause 53, wherein the first and second sleeve comprise a fluoropolymer.

## Claims

1. An implantable apparatus (400, 500) for placement in a gastrointestinal tract, comprising: at least one anchoring component (402, 502); and a sleeve attached to the at least one anchoring component, wherein the sleeve includes a first region (406, 506) having a first porosity and a second region (408, 508) having a second porosity which is different from the first porosity.
2. The apparatus (400, 500) of claim 1, wherein the porosity of the first and/or second region changes

over time.

3. The apparatus of claim 2, wherein the pores of the first and/or second region are filled with a degradable material, such as a biodegradable material. 5
4. The apparatus (500) according to claim 2, wherein the first region (506) comprises a degradable cover region and/or wherein the second region (508) comprises a wrapped film over the sleeve, such as an FEP film. 10
5. The apparatus (400, 500) of claim 1, wherein the first region (406, 506) comprises a first pore size and the second region (408, 508) comprises a second pore size. 15
6. The apparatus (400, 500) of claim 1, wherein the first region (406, 506) of the sleeve comprises a fluoropolymer. 20
7. The apparatus (400, 500) of claim 6, wherein the fluoropolymer comprises expanded polytetrafluoroethylene. 25
8. The apparatus (400, 500) of claim 1, wherein the anchoring component (402, 502) comprises nitinol.
9. The apparatus (400, 500) of claim 1, wherein the second region (408, 508) comprises FEP. 30
10. The apparatus (400, 500) of claim 1, wherein the anchoring component (402, 502) is a self-expanding stent. 35
11. The apparatus (400, 500) of claim 1, wherein the anchoring component is a balloon expandable stent.
12. The apparatus (400, 500) of any preceding claim, comprising a plurality of first and second regions. 40
13. The apparatus (400, 500) according to claim 1, wherein the anchoring component (402, 502) is designed to degrade or decompose over time. 45
14. An implantable apparatus (600) according to claim 1, for placement in a gastrointestinal tract, comprising:

a first anchoring component (602) sized to be located in a patient's duodenum; a first sleeve attached to and extending from the first anchoring component, the first sleeve having;

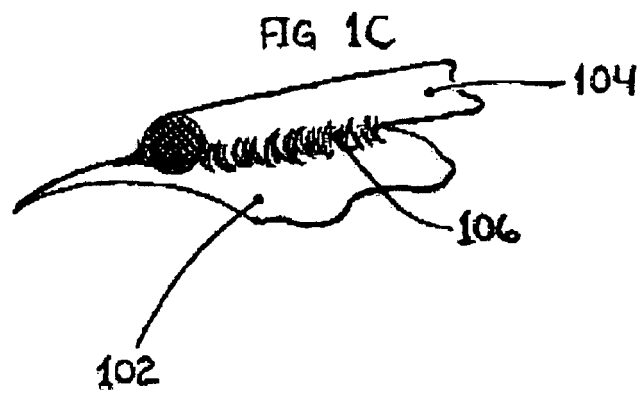
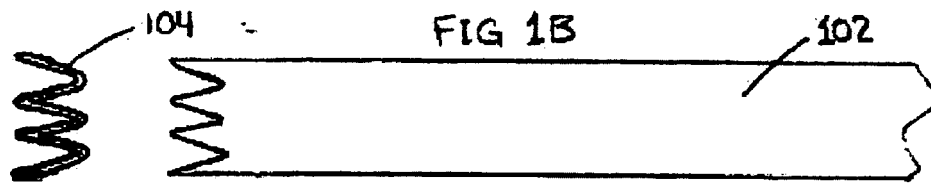
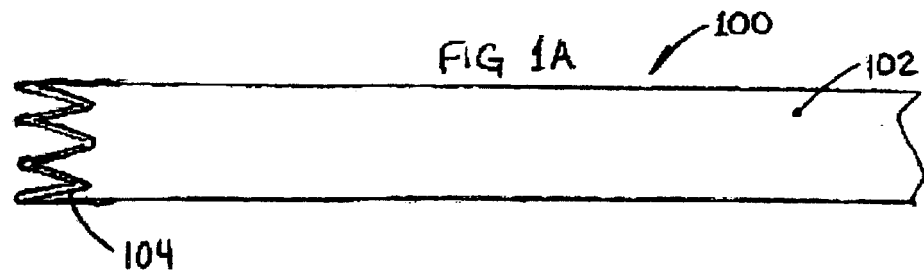
a proximal end, a distal end, an inner surface, an outer surface, a wall portion extending from the proximal end to the distal end, and at least one opening in the wall portion;

and

wherein the first sleeve includes a first region having a first porosity and a second region having a second porosity which is different from the first porosity;

a second anchoring component (608) sized to be located in the patient's biliary duct; and a second sleeve attached to and extending from the second anchoring component, the second sleeve being sized to fit through the at least one opening in the wall portion of the first sleeve.

15. The apparatus (600) of claim 14, wherein the first and second sleeve comprise a fluoropolymer.



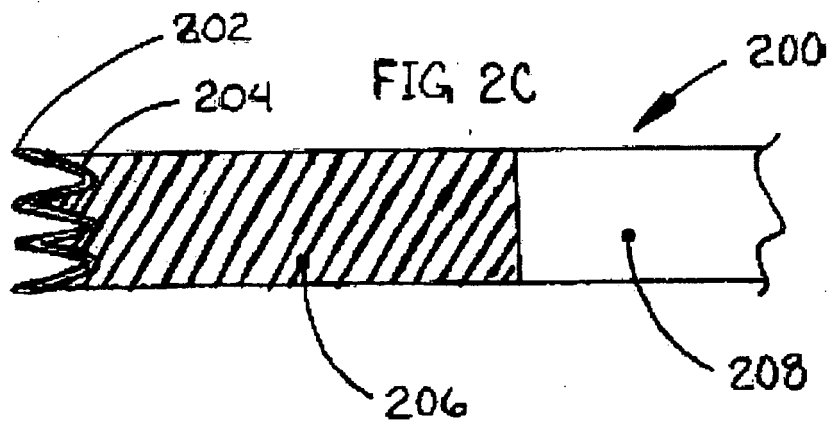
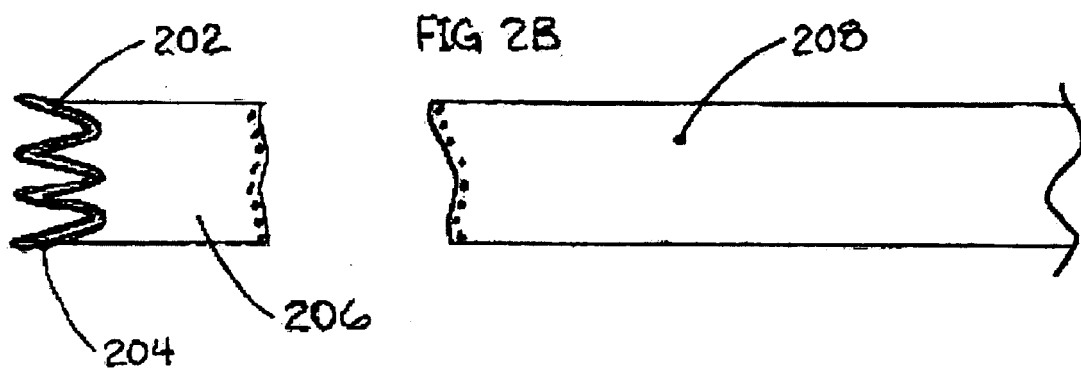
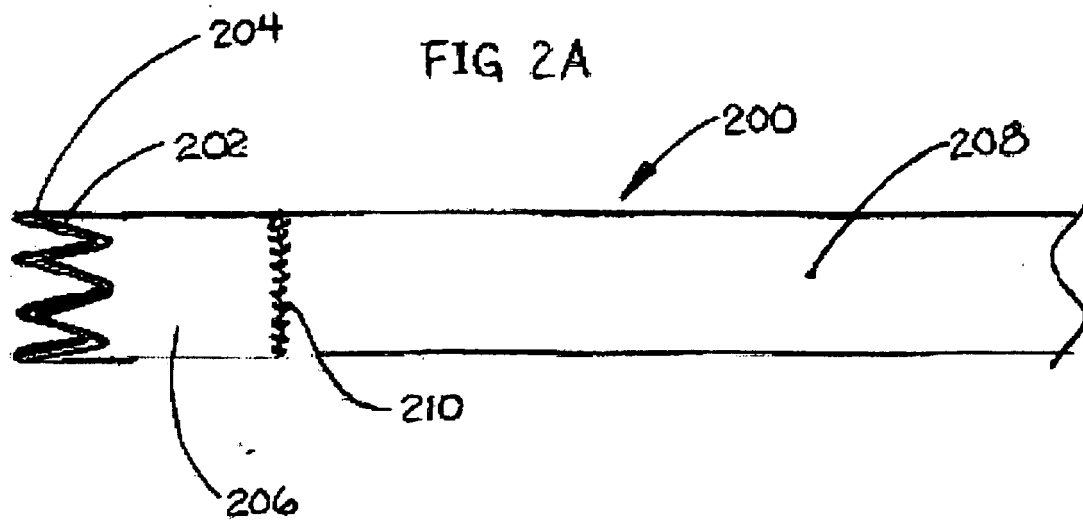




FIG 3A

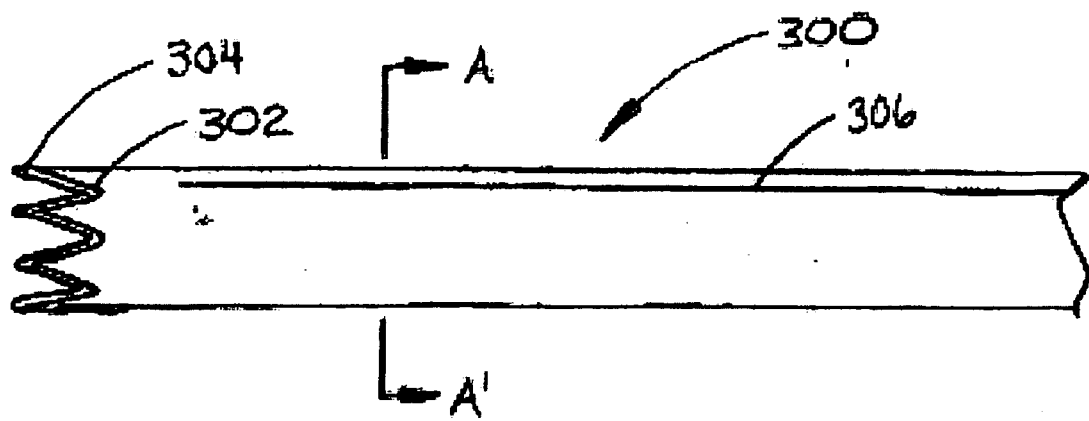


FIG 3B

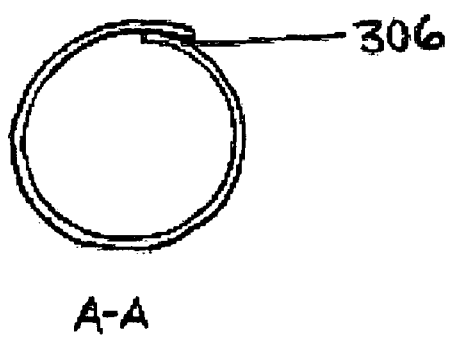
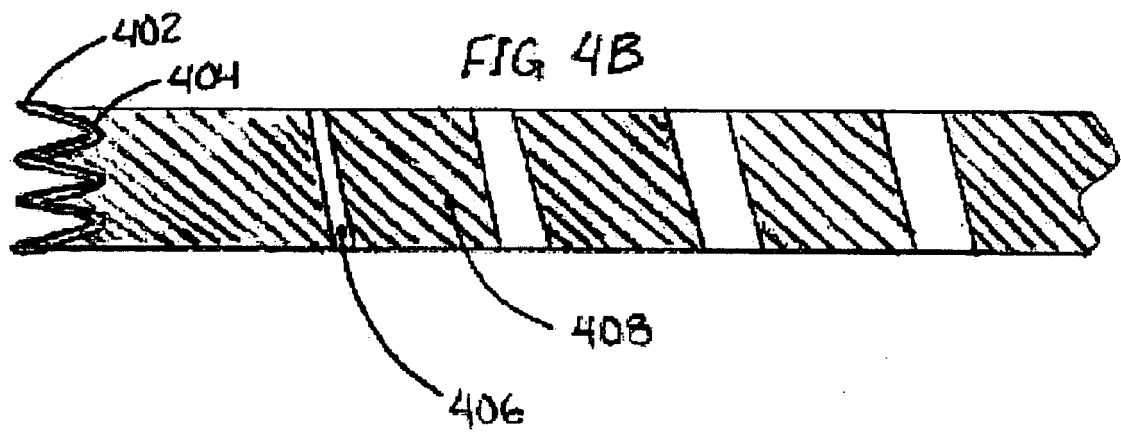
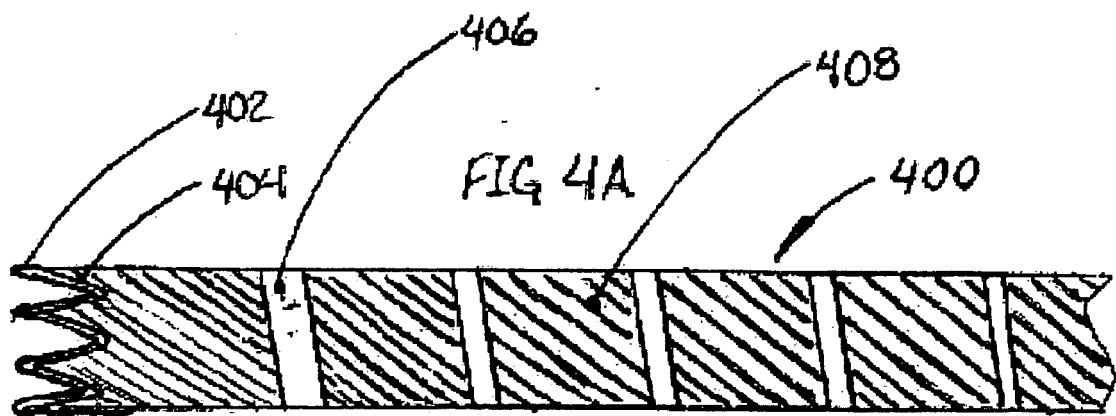
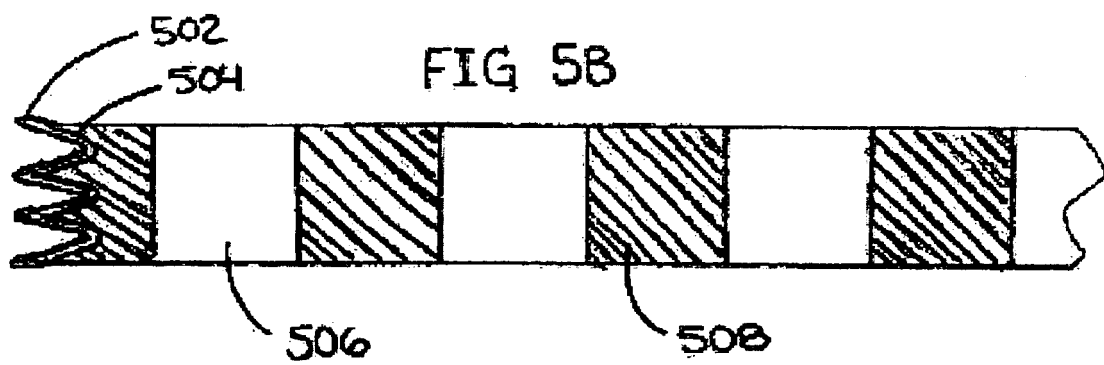
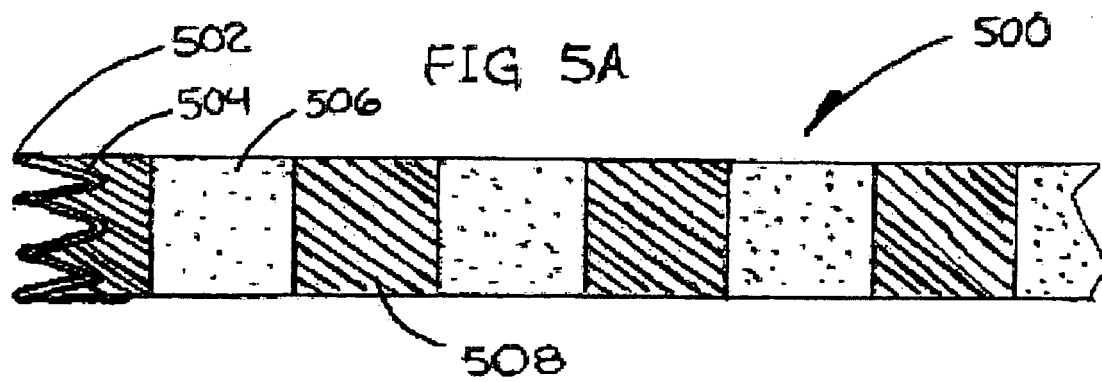
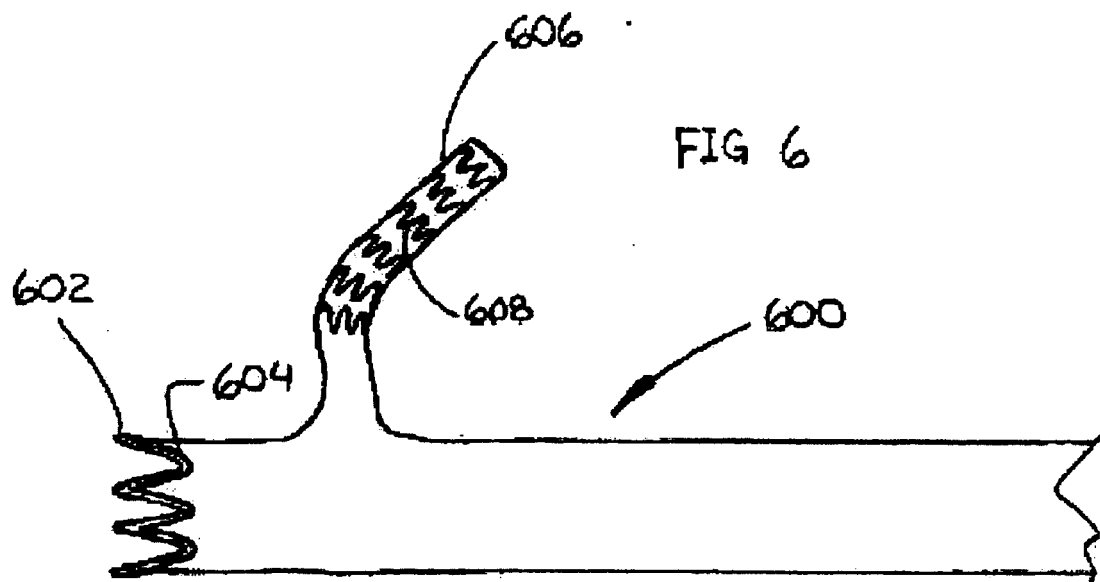


FIG 3C











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## 摘要

本申请公开了一种用于在胃肠道中放置的可植入式器械。该器械具有附接至附设的套管的至少一个锚定部件。该套管可包括具有第一孔隙率的第一区域和具有与第一孔隙率不同的第二孔隙率的第二区域。