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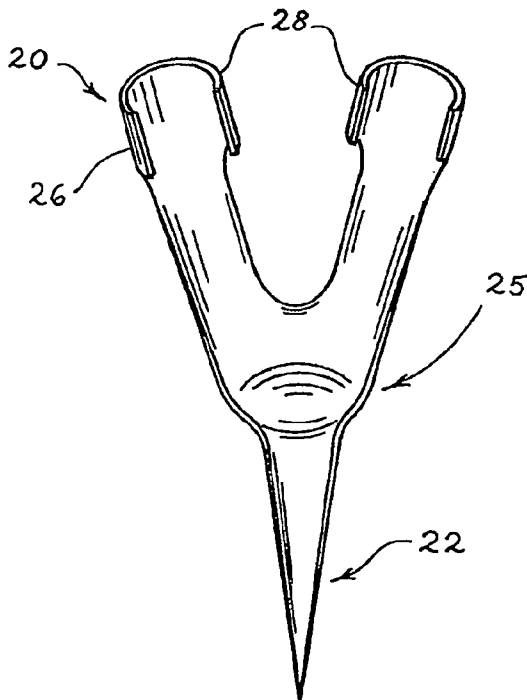
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[Continued on next page]

(54) Title: BARBED ANCHORS FOR IMPLANTABLE MEDICAL DEVICE

*Fig. 4*



(57) Abstract: An endoluminal prosthesis includes a support structure comprising a curvilinear portion having a first strut and a second strut that meet at an apex. Disposed on the support structure is an anchor (25) with an anchor body and one or more barbs (21) extending outwardly from the anchor body. The anchor body fits at least partially about, and conforms to the first strut, second strut, and the apex.

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## BARBED ANCHORS FOR IMPLANTABLE MEDICAL DEVICE

### Description

#### Technical Field

5 The present invention relates to attachable anchors with barbs for use on an implantable medical device such as a stent, methods of attaching the anchors onto implantable medical devices, and to an implantable medical device including one or more of such barbed anchors.

#### Background Art

10 Barbs attached to stents help secure placement of a stent graft in a treated vasculature. Proper stent attachment and placement of the barb ensures that the stent graft will stay in place for the lifespan of the stent graft. Some stent designs limit the barb attachment location and method of attachment due to the material used in the barb and stent and due to the material used to attach the two. Other factors may also limit the barb attachment location, including strut crossover during crimping or potential stent fatigue failure due to weld location near a region on the wire stent of high stress or strain.

15 Some methods of attaching barbs to wire stents include silver soldering the barb to the wire stent, laser cutting the barb directly into a cannula-cut stent design, and laser welding a barb to the strut of the wire stent. Each of these methods may present particular limitations to barb placement and barb fatigue life depending on the stent design. Structure and the materials used in the manufacture thereof.

#### Disclosure of the Invention

25 The present invention seeks to provide an improved implantable medical device, to attachable anchors with barbs for use on an implantable medical device such as a stent, and methods of attaching the anchors onto implantable medical devices.

According to an aspect of the present invention, there is provided an endoluminal prosthesis as specified in claim 1.

30 According to another aspect of the present invention, there is provided a method of attaching an anchor to an endoluminal support structure as specified in claim 15.

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According to another aspect of the present invention, there is provided an anchor for an endoluminal prosthesis as specified in claim 18.

According to another aspect of the present invention, there is provided an endoluminal prosthesis as specified in claim 20.

5       According to another aspect of the present invention, there is provided an anchor for an endoluminal prosthesis as specified in claim 27.

According to another aspect of the present invention, there is provided an anchoring device for an endoluminal prosthesis as specified in claim 28.

10       Described herein is an endoluminal prosthesis that comprises a support structure having a curvilinear portion and an elongate portion. The curvilinear portion can have a first strut and a second strut that meet at an apex. There is an anchor that has an anchor body and one or more barbs extending outwardly from the anchor body. The anchor body fits at least partially about and conforms to the first strut, the second strut, and the apex.

15       An anchor can be positioned at or near the apex of the stent. The anchor monolithically can comprise a first end having a barb and a second end. The second end can comprise two or more substantially curved portions configured to fit about a strut of the stent. The second end also can be bifurcated. The bifurcated end can comprise a first substantially curved clamping portion  
20       configured to fit about the first strut and a second substantially curved clamping portion configured to fit about the second strut.

25       An anchor of this type can be securely fixed to a strut in such a manner that there is virtually no risk of migration of the anchor during use, for instance as a result of forces applied to the medical device when in situ. Moreover, the secure attachment of the anchor to the supporting stent can enhance the effective  
piercing strength of the barb. Moreover, there is no risk of rotation of the anchor relative to the stent, with the consequence that the anchor can in some  
embodiments be fitted by a simple snap-fit with no additional fixation being  
necessary.

30       The anchor can also be made of a plurality of wires that are arranged in a multi-filar tube. The tube has a first end that is disposed, at least in part, about the

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first strut and a second end that is disposed, at least in part, about the second strut. The multi-filar tube can conform to a first strut, second strut, or an apex.

The anchor can include a monolithic longitudinal body having a barb at one end and two or more substantially opposing curved portions perpendicular to that longitudinal body. Each curved portion can be configured to fit about and conform to one of the struts of the stent.

Disclosed herein is also an endoluminal prosthesis that has a stent comprising a curvilinear portion and an elongate portion, with the curvilinear portion having at least two struts meeting at an apex, and an anchor on the stent comprising a longitudinal body having a barb at one end and first and second substantially opposing curved portions disposed along the length of, and perpendicular to, the longitudinal body. The first curved portion can be longitudinally offset from the second curved portion and each curved portion can be configured to fit about and conform to a strut.

There is also disclosed a method of attaching an anchor to an endoluminal support structure comprising a curvilinear portion having a first strut and a second strut that meet at an apex. The method comprises the steps of arranging a first end of the anchor so that it fits at least partially about, and conforms to, the first strut; arranging a second end of the anchor so that it fits at least partially about, and conforms to, the second strut; and arranging the anchor so that it fits at least partially about, and conforms to, the apex.

An anchor device for an endoluminal prosthesis can include a plurality of independent wires arranged to form a multi-filar tube having a first end, a second end, and a longitudinal axis. One of the wires has an end that forms a first barb that extends outwardly from the anchoring device and acts to contact another prosthesis or a vessel wall. The multi-filar tube can also comprise a second wire with an end that forms a second barb that extends outwardly from the anchoring device.

#### Brief Description of the Drawings

Embodiments of the present invention are described below, by way of example only, with reference to the accompanying drawings, in which:

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Figure 1a is a top view of a stamped out sheet of biocompatible material for use as an anchor with two winged portions;

Figure 1b is a perspective view of an anchor made from a stamped out sheet shown in Figure 1a;

5 Figure 1c is a top view of a stamped out sheet of biocompatible material with opposing and off-setting winged segments;

Figure 1d is a perspective view of an anchor made from the stamped out sheet shown in Figure 1c;

10 Figure 1e is a top view of a stamped out sheet of biocompatible material with two winged segments opposed to one winged segment;

Figure 1f is a perspective view of an anchor made from the stamped out sheet shown in Figure 1e;

Figure 2 is a perspective view of an anchor fastened to a stent strut;

15 Figures 3a and 3b depict the steps to fasten a monolithic anchor to a stent strut;

Figure 4 is a perspective view of a monolithic anchor with a bifurcated end;

Figure 5a is a perspective view of a monolithic anchor with a bifurcated attachment end fastened to a curvilinear portion of a stent strut;

20 Figure 5b is a profile view of a monolithic anchor with a bifurcated attachment end fastened to a curvilinear portion of a stent strut;

Figure 6 is a perspective view of a monolithic anchor with a bifurcated attachment end fastened to a curvilinear portion of a stent strut with support sutures;

25 Figure 7 is a profile view of an anchor fastened to a stent strut with support sutures;

Figure 8a is a profile view of a multi-filar anchor attached to a curvilinear stent strut;

Figure 8b are profile view of a multi-filar anchor attached to an elongate strut.

### 30 Description of the Preferred Embodiments

The term "prosthesis" means any replacement for a body part or for a function of that body part or any device that enhances or adds functionality to a

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physiological system. The term "prosthesis" as used herein is intended to encompass all implantable medical devices of all forms and in particular endoluminally implantable medical devices. The specific embodiments are described with reference to stents and stent grafts but the anchors and teachings herein can equally be used on other devices such as vena cava filters, occlusion devices and so on.

The term "support structure" means any device that is attached to a prosthesis. For example, a support structure can encompass stents, radiopaque markers, anchoring stents, barbs, and lateral support rings for supporting a fenestration. The structural components can be attached to the exterior of the graft, the interior of the graft, and/or can be sandwiched between two or more layers of graft material.

The support structure can be made from numerous base materials, such as: biocompatible metals or other metallic materials; polymers including bioabsorbable or biostable polymers; stainless steels; nickel-titanium alloys including shape memory or superelastic types (e.g., Nitinol or elastinite); noble metals including platinum, gold, or palladium; refractory metals including tantalum, tungsten, molybdenum, or rhenium; stainless steels alloyed with noble and/or refractory metals; silver; rhodium; inconel; iridium; niobium; titanium; magnesium; amorphous metals; plastically deformable metals (e.g., tantalum); nickel-based alloys (e.g., including platinum, gold, and/or tantalum alloys); iron-based alloys (e.g., including platinum, gold, and/or tantalum alloys); cobalt-based alloys (e.g., including platinum, gold, and/or tantalum alloys); cobalt-chrome alloys (e.g., elgiloy); cobalt-chromium-nickel alloys (e.g., phynox); alloys of cobalt, nickel, chromium, and molybdenum; cobalt-chromium-vanadium alloys; cobalt-chromium-tungsten alloys; platinum-iridium alloys; platinum-tungsten alloys; magnesium alloys; titanium alloys (e.g., TiC, TiN); tantalum alloys (e.g., TaC, TaN); L605; magnetic ferrite; nonmetallic biocompatible materials including polyamides, polyolefins (e.g., polypropylene or polyethylene), nonabsorbable polyesters (e.g., polyethylene terephthalate), or bioabsorbable aliphatic polyesters (e.g., homopolymers or copolymers of lactic acid, glycolic acid, lactide, glycolide, para-dioxanone, trimethylene carbonate or  $\epsilon$ -caprolactone); polymeric materials (e.g., poly-L-lactic

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acid, polycarbonate, polyethylene terephthalate, or engineering plastics such as thermotropic liquid crystal polymers (LCPs)); biocompatible polymeric materials (e.g., cellulose acetate, cellulose nitrate, silicone, polyethylene terephthalate, polyurethane, polyamide, polyester, polyorthoester, polyanhydride, polyether sulfone, polycarbonate, polypropylene, high molecular weight polyethylene, or polytetrafluoroethylene); degradable or biodegradable polymers, plastics, natural (e.g., animal, plant, or microbial) or recombinant material (e.g., polylactic acid, polyglycolic acid, polyanhydride, polycaprolactone, polyhydroxybutyrate valerate, polydepsipeptides, nylon copolyamides, conventional poly(amino acid) synthetic polymers, pseudo-poly(amino acids), or aliphatic polyesters (e.g., polyglycolic acid (PGA), polylactic acid (PLA), polyalkylene succinates, polyhydroxybutyrate (PHB), polybutylene diglycolate, poly epsilon-caprolactone (PCL), polydihdropyrans, polyphosphazenes, polyorthoesters, polycyanoacrylates, polyanhydrides, polyketals, polyacetals, poly(.alpha.-hydroxy-esters), poly(carbonates), poly(imino-carbonates), poly(.beta.-hydroxy-esters), or polypeptides)); polyethylene terephthalate (e.g., Dacron® or Mylar®); expanded fluoropolymers (e.g., polytetrafluoroethylene (PTFE)); fluorinated ethylene propylene (FEP); copolymers of tetrafluoroethylene (TFE) and per fluoro(propyl vinyl ether) (PFA)); homopolymers of polychlorotrifluoroethylene (PCTFE) and copolymers with TFE; ethylene-chlorotrifluoroethylene (ECTFE); copolymers of ethylene-tetrafluoroethylene (ETFE); polyvinylidene fluoride (PVDF); polyvinyl fluoride (PVF); polyaramids (e.g., Kevlar®); polyfluorocarbons including polytetrafluoroethylene with and without copolymerized hexafluoropropylene (e.g., Teflon® or Goretex®); expanded fluorocarbon polymers; polyglycolides; polylactides; polyglycerol sebacate; polyethylene oxide; polybutylene terephthalate; polydioxanones; proteoglymays; glycosaminoglymays; poly(alkylene oxalates); polyalkanotes; polyamides; polyaspartimic acid; polyglutarunic acid polymer; poly-p-dioxanone (e.g., PDS); polyphosphazene; polyurethane including porous or nonporous polyurethanes; poly(glycolide-trimethylene carbonate); terpolymer (copolymers of glycolide, lactide, or dimethyltrimethylene carbonate); polyhydroxyalkanoates (PHA); polyhydroxybutyrate (PHB) or poly(hydroxybutyrate-co-valerate) (PHB-co-HV); poly(epsilon-caprolactone) (e.g., lactide or glycolide); poly(epsilon-

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caprolactone-dimethyltrimethylene carbonate); polyglycolic acid (PGA); poly-L and poly-D(lactic acid) (e.g., calcium phosphate glass); lactic acid/ethylene glycol copolymers; polyarylates (L-tyrosine-derived) or free acid polyarylates; polycarbonates (tyrosine or L-tyrosine-derived); poly(ester-amides); poly(propylene fumarate-co-ethylene glycol) copolymer (e.g., fumarate anhydrides); polyanhydride esters; polyanhydrides; polyorthoesters; prolactin or silk-elastin polymers (SELP); calcium phosphate (bioglass); compositions of PLA, PCL, PGA ester; polyphosphazenes; polyamino acids; polysaccharides; polyhydroxyalkanoate polymers; various plastic materials; Teflon®; nylon; block polymers or copolymers; Leica RM2165; Leica RM2155; organic fabrics; biologic agents (e.g., protein, extracellular matrix component, collagen, fibrin); small intestinal submucosa (SIS) (e.g., vacuum formed SIS); collagen or collagen matrices with growth modulators; aliginate; cellulose and ester; dextran; elastin; fibrin; gelatin; hyaluronic acid; hydroxyapatite; polypeptides; proteins; ceramics (e.g., silicon nitride, silicon carbide, zirconia or alumina); bioactive silica-based materials; carbon or carbon fiber; cotton; silk; spider silk; chitin; chitosan (NOCC or NOOC-G); urethanes; glass; silica; sapphire; composites; any mixture, blend, alloy, copolymer or combination of any of these; or various other materials not limited by these examples.

20           The term "stent" means any device that provides rigidity, expansion force, or support to a prosthesis, such as a stent graft. In one configuration, the stent can represent a plurality of discontinuous devices. In another configuration, the stent can represent one device. Stents can have a wide variety of configurations and can be balloon-expandable or self-expanding. Typically, stents have a circular cross-section when fully expanded, so as to conform to the generally circular cross-section of a body lumen. In one example, a stent can comprise struts (elongate portions) and acute bends (curvilinear portions) that are arranged in a zig-zag configuration, as exemplified in a Z-stent, in which the struts are set at angles to each other and are connected by the acute bends.

30           A variety of biocompatible materials can be employed to construct the stent, or portions of the stent, including metals and/or alloys, medically-acceptable polymers and/or bioabsorbable polymers, or materials. The metals and/or alloys

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may, among other things, include stainless steel, tantalum, Nitinol, gold, silver, tungsten, platinum, inconel, cobalt-chromium alloys, and iridium, all of which are commercially available metals or alloys used in the fabrication of medical devices. In a preferred configuration, the stent is constructed from Nitinol, stainless steel,  
5 and/or cobalt-chromium alloys.

The anchors having barbs described herein can be in one piece, or monolithic, or have multiple wires in a multi-filar configuration to form a tube. The monolithic anchors can be stamped, machined, or laser cut out of a sheet of biocompatible material. The multi-filar anchors can be provided with wires having  
10 circular or polygonal cross-sections by methods used in the art.

In Figures 1a, to 1f, the anchor is monolithically constructed (that is formed as a single piece). The anchor 10 can include a longitudinal body 13 having a barb 11 at one end and first and second substantially opposing curved portions 15 disposed along at least a part of the length of, and substantially perpendicular to  
15 the longitudinal body 13. In Figure 1a, the anchor 10 has two substantially opposing portions 15 perpendicular to the longitudinal body 13. These portions 15 are shaped to fit about and to conform to a strut. In Figure 1c, an anchor is shown having more than two opposing portions, where there is a first curved portion 14 that is longitudinally offset from the second curved portion 18.

The curved portions 15 of the embodiment of Figure 1a are configured for  
20 fastening the anchor 10 to the stent by snap fitting the portions 15 around a strut or, if necessary, soldering the portion 15 to the strut. The anchor also can include a longitudinal body 13 with more than one barb 11. The barb can be forked at the end to provide two or three separate prongs.

More particularly, the straight portions 15 shown in Figure 1a are bent in the  
25 direction shown by the arrows to provide the two curved portions 15 shown in Figure 1b. It is envisaged that the anchor 1a would be pre-curved prior to fitting to a stent, such that the anchor 10 is provided in the form shown in Figure 1b. It will be seen that in the preferred embodiment the longitudinal body is also radially  
30 curved, which provides rigidity and enhanced strength to the barb. In other embodiments, the elongate body 13 may be radially straight, with the curvature being imparted solely to the arm portions 15. It is envisaged in some

embodiments that the anchor 10 may be curved onto the strut of a stent, that is applied to a stent a flat configuration as shown in Figure 1a and then deformed around the stent strut into the shape shown in Figure 1b. These features of the anchor 10 can apply equally to the other embodiments disclosed herein and to all other embodiments falling within the scope of the claims.

Figure 1c shows a monolithic anchor 10 with two substantially opposing portions 14, 18 that are longitudinally offset to one another. As shown in Figure 1d, these portions 14, 18 are manipulated (deformed) in the direction shown by the arrows to provide two curved portions 14, 18 that in use conform to the tubular elongate portion of a stent strut.

Figure 1e shows an anchor 10 also formed from a sheet of biocompatible material. Three arm portions 14, 16, 18 are bent in the direction shown by the arrows to provide the curved portions 14, 16, 18 shown in Figure 1f. Curved portions 14, 16, 18 are disposed along the length of and are substantially perpendicular to the longitudinal body 13. Curved portion 18 is longitudinally offset from and lies longitudinally between curved portions 14, 16 which extend from the other side of the elongate body portion 13. An anchor can be made having more than one, two, or even three curved portions where some of the curved portions are opposed to the remainder. The number of curved portions and their configuration can vary. Positioning the curved portions in opposing configurations facilitates the stable attachment of the anchor to the strut of the stent.

Furthermore, even though the arms of the various embodiments of anchor disclosed herein and shown in the drawings extend perpendicularly from the elongate body portion 13 this may not be necessary. The arms may extend substantially perpendicularly thereto or at any other angle to the body portion. It is preferred that the arms, when wrapped in the curved configuration shown, do not overlap one another, either by way of their length (as shown for instance in Figures 1a and 1b) or by their shape or placement (as shown for instance in Figures 1c to 1f).

The anchor 10 also includes a barb 11 that, when the prosthesis is implanted into a vasculature, assists in securing the anchor and the stent graft to the vessel wall or to the wall of a mating graft. The barb 11 can be parallel to the

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elongate portion of a stent strut 80, extend from the elongate portion at an angle away from the strut 80, as shown in Figure 2, or bend towards the strut 80. The barb 11 in Figure 3b is in line with the stent elongate portion 80.

The anchor 10 can have geometries permitting press-fit or snap-on  
5 placement of the anchor 10 onto a stent strut at either an elongate 80 portion or at the curvilinear 85, or apex, portion of a Z-stent, as shown in Figure 5a. A sheet of an appropriate material, such as an alloy, can be stamped to incorporate curved and linear segments that act to fasten the anchor 10 around the stent strut 80 and hold the anchor 10 in place. Figure 2 shows an anchor 10 fastened to the  
10 elongate portion 80 of a stent. Figure 5a shows an anchor 20 fastened to the curvilinear portion 85 of a stent. As shown in Figure 5a, the two clamping portions 26, 28 of the anchor substantially mimic and conform to the curvilinear portion 85 of the stent. The clamping portions 26, 28 of the anchor 10 then can support the resultant forces and moments through the points of contact between the stent and  
15 the anchor 10 without the need for solder, welding, glue, or epoxy.

The design of anchor also provides an advantageous method of attaching the anchor 10 to an endoluminal support structure that has an elongate strut 80. Figures 3a and 3b are illustrations of steps that can be taken to fasten a monolithic anchor 10 having two offset curved portions 14, 18 to the elongate strut 80. The  
20 two curved portions 14, 18 are offset and opposed to one another and are bent to fit around the stent elongate portion 80. To fasten the anchor 10 onto the stent elongate portion 80 the, the longitudinal body 13 part of the anchor 10 is initially placed substantially perpendicular to the stent elongate portion 80 such that the elongate portion 80 lies between the curved portions 14, 18. The anchor 10 can  
25 then be rotated in a clockwise direction as shown by the arrows in Figure 3a to fasten the anchor 10 to the elongate portion 80. As shown in Figure 3b, rotating the anchor 10 so that the longitudinal body 13 is in line with the elongate portion 80 of the stent strut can snap the curved portions 14, 18 around the stent strut, thus attaching the anchor 10 to the stent. The length of the arms 14 and 18, as  
30 well as the curvature of the elongate body portion 13, can provide a reliable fastening of the anchor to the stent strut 80.

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An anchor can be provided such that it is fastened to the elongate portion 80 by turning the anchor 10 in a counterclockwise or clockwise direction (depending upon the relative positions of the arms 14, 18). The curved portions 14, 18 also can be provided such that the longitudinal body 13 of the anchor 10 contacts the elongate portion and then turned 45 degrees or so to fit onto the elongate portion 80.

In embodiments where there are provided arms 15 longitudinally aligned with one another (as in Figures 1a and 1b) or sets of arms which encompass overlapping longitudinal extents of the elongate body (for example as with the embodiment of Figures 1e and 1f) these may be snap-fitted to the strut 80 by pressing the anchor 10 towards the strut 80. The curvature of the strut 80 will assist in splaying the arms outwardly until they pass the centre point (widest point) of the strut, beyond which they will snap back into position and fix the anchor around the strut 80.

As shown in Figure 5a, an endoluminal prosthesis can include a support structure comprising a curvilinear portion 85 having a first strut 82 and a second strut 88 meeting at an apex 83. The prosthesis also can include an anchor 20 comprising an anchor body and one or more barbs 21 extending outwardly from the anchor body. The anchor body fits at least partially about, and conforms to, the first strut 82, the second strut 88, and the apex 83. As can be seen in Figure 4, the anchor has a longitudinal structure with a first end 22 with a barb 21 and a second, bifurcated end 25. The second end 25 includes a first substantially curved clamping portion 26 configured to fit about the first strut 82 and a second substantially curved clamping portion 28 configured to fit about the second strut 88.

Figure 5a shows a stent curvilinear portion 85 in dashed lines along with the first 82 and second 88 struts meeting at an apex 83. The apex 83 points in one direction and when an anchor 20 is attached, the barb 21 can extend in that one direction. The barb 21 also can be bent at an angle or in a different direction than the apex 83.

The second, bifurcated end 25 includes two substantially curved clamping portions 26, 28 that can be configured to fit about the two struts found on the

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curvilinear portion of a stent. The two substantially curved clamping portions 26, 28 can be designed for press-fit or snap-on placement onto the stent. The two substantially curved clamping portions 26, 28 also can be soldered onto the stent struts.

5           Figures 5a and 5b show the anchor 20 fastened to the curvilinear portion 85 from the front (Figure 5a) and from a profile view (Figure 5b). The barb 21 can contact and embed into an endoluminal wall when implanted into a vessel. The anchor 20 in Figure 5b has a barb 21 that is bent at an angle such that the barb 21 would point away from where the stent graft (not shown) is positioned. The barb  
10           21 also can be in line with the apex 83 as seen in Figure 5a or be bent laterally in a variety of directions.

          An anchor can be attached to the endoluminal support structure that has a curvilinear portion with a first strut and a second strut meeting at an apex. The method of attachment can include arranging a first end of the anchor so that it fits  
15           at least partially about, and conforms to, the first strut. A second end of the anchor is arranged so that it fits at least partially about, and conforms to, the second strut. The anchor can also be arranged so that it fits at least partially about, and conforms to, the apex. The anchor can be arranged such that it is snapped to the first strut, the second strut, and the apex of the curvilinear portion of a stent.

20           Additionally, support sutures 60 can be used to fasten the anchor 20 to a stent. Figure 6 shows an anchor 20 with a second bifurcated end 25 with one or more openings 62 in each substantially curved clamping portion 26, 28, through which support sutures 60 can be threaded. Figure 7 is a profile view of an anchor 20 having support sutures 60 threaded around the curvilinear portion 85, through  
25           the openings 62, and around the second curved portion 28. The support sutures 60 can be threaded at least partially around the first 26 and second 28 substantially curved clamping portion.

          Figures 8a and 8b show anchors 102 and 92 attached to curvilinear 104 and elongate 94 stent struts. Anchors 102 and 92 are made of a plurality of  
30           independent wires arranged in a multi-filar tube having a first end, a second end and a longitudinal axis. In such a multi-filar anchor, at least one of the wires has an end that extends out of the multi-filar tube and forms a first barb that extends

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outwardly from the anchoring device. In Figures 8a and 8b, the wires are coiled around stent struts 104, 94 to form the multi-filar tubes. The anchors 102, 92 resemble a coil or barbed wire configuration. The wires can have a circular cross-section or a polygonal cross-section. In Figure 8a, the tube has a first end 101 disposed, at least in part, about the first strut 71 and a second end 103 disposed, at least in part, about the second strut 72. The tube is also disposed around the apex 79 of the curvilinear stent 104 strut. In Figure 8b, the multi-filar anchor 92 is disposed on an elongate stent strut 94 from the first end 73 to the second end 74 of the stent. The multi-filar anchors have wires wherein each of the wires have a first end disposed at or near the first end of the multi-filar tube and a second end disposed at or near the second end of the multi-filar tube.

At least one wire in the multi-filar anchor has an end that forms at least one barb. In Figures 8a and 8b, the multi-filar anchors 102, 92 have barbs 108, 109, 98, 99 formed from the sharpened ends of corresponding wires. Barb 108, which extends outwardly from the anchor 102, is formed from a first wire having an end. There is also a second wire that has an end that forms a second barb 108 that extends outwardly from anchor 102. Similarly, in Figure 8b, the anchor 92 attached to the elongate strut 94 has a first end 91 that has a barb 99 disposed thereon and a second end 93 with a barb 98 disposed thereon. It is appreciated that a multi-filar anchor similar to that shown in Figure 8a can be attached to a Z-stent. A multi-filar anchor similar to that shown in Figure 8b can be attached to other interconnected support structures or stents.

When attaching the multi-filar anchor 102, at least a portion of the anchor can be threaded around the first strut 71, the second strut 72, and the apex 79 of the curvilinear stent 104 strut. Similarly, as shown in Figure 8b, anchor 94 can be threaded around an elongate stent strut 94.

An anchor can be attached to the support structure in a position fixed longitudinally and rotationally. Although some incidental movement can be allowed, the anchor can be attached and fixed such that it will not move substantially longitudinally along a stent or rotate about the stent. The attachment is such that there can be little or no movement by the anchor independent of the stent structure. With monolithic anchors having bifurcated attachment ends, there

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can be little or no longitudinal or rotational movement. The anchor can be fastened to the stent by laser weld, adhesive, soldering, or friction fit. The anchor can also include Nitinol. The substantially curved clamping portions can include Nitinol. The Nitinol clamping portions can be configured to constrict around a stent  
5 strut and provide a secure attachment between the anchor and the stent.

It will be appreciated that in the case of anchors made from a shape memory material, the anchors could be provided in a substantially flat form and then made to wrap around a stent strut by heating through the transition temperature. Alternatively, the anchors could be configured to the curved shape  
10 shown, for example, in Figures 1b, 1d and 1f while in their martensitic phase, fitted to a stent strut and then heated through their transition temperature (when implanted with the medical device into a patient for instance), upon which the return to the memory shape will press the anchor onto the stent strut to tighten the fit.

15 It will be appreciated that there may be provided more than one barb on each anchor.

It is therefore intended that the foregoing detailed description be regarded as illustrative rather than limiting, and that it be understood that it is the following claims, including all equivalents, that are intended to define the scope of the  
20 claims.

The disclosures in United States patent application numbers 61/093,172 and 12/360,638, from which this patent application claims priority, and in the abstract accompanying this application are incorporated herein by reference.

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Claims

1. An endoluminal prosthesis including:
  - a support structure including a curvilinear portion provided with a first strut and a second strut meeting at an apex;
  - 5 an anchor including an anchor body and one or more barbs extending outwardly from the anchor body;
  - wherein the anchor body fits at least partially about, and conforms to, the first strut, the second strut, and the apex.
2. A prosthesis according to claim 1, wherein:
  - 10 the anchor includes a longitudinal structure with a first end and a second, bifurcated, end;
  - the first end of the structure includes one or more barbs; and
  - the second end of the structure includes a first substantially curved clamping portion that fits about the first strut and a second substantially curved
  - 15 clamping portion that fits about the second strut.
3. A prosthesis according to claim 2, wherein the apex points in one direction and the or a said barb extends in the one direction.
4. A prosthesis according to claim 2 or 3, wherein the or a said barb extends from the longitudinal structure at an angle.
- 20 5. A prosthesis according to claim 2, 3 or 4, including one or more support sutures disposed at least partially around one or both of the first substantially curved clamping portion and the second substantially curved clamping portion.
6. A prosthesis according to claim 5, wherein the or each support suture is threaded through one or more openings in the first substantially curved clamping
- 25 portion and/or the second substantially curved clamping portion.
7. A prosthesis according to claim 6, wherein the or each support suture is threaded around the stent and around the first substantially curved clamping portion and the second substantially curved clamping portion.
8. A prosthesis according to claim 1, wherein the anchor comprises a coil.
- 30 9. A prosthesis according to claim 1 or 2, wherein the anchor comprises a plurality of wires arranged in a multi-filar tube, and wherein a first end of the tube is

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disposed, at least in part, about the first strut and a second end of the tube is disposed, at least in part, about the second strut.

10. A prosthesis according to claim 9, wherein the multi-filar tube includes a coil.

5 11. A prosthesis according to claim 9, 10 or 11, wherein each of the wires has a polygonal cross-section.

12. A prosthesis according to any one of claims 9 to 11, wherein one of the wires has an end that forms at least a first barb.

10 13. A prosthesis according to claim 12, wherein another one of the wires has an end that forms at least a second barb.

14. A prosthesis according to claim 13, wherein the first barb is disposed on the first strut and the second barb is disposed on the second strut.

15 15. A method of attaching an anchor to an endoluminal support structure provided with a curvilinear portion having a first strut and a second strut meeting at an apex, the method including the steps of:

arranging a first end of the anchor so that it fits at least partially about, and conforms to, the first strut;

arranging a second end of the anchor so that it fits at least partially about, and conforms to, the second strut; and

20 arranging the anchor so that it fits at least partially about, and conforms to, the apex.

16. A method according to claim 15, wherein the arranging steps include snapping the anchor to the first strut, the second strut, and the apex.

25 17. A method according to claim 15 or 16, wherein the arranging steps include threading at least a portion of the anchor around the first strut, the second strut, and the apex.

30 18. An anchor for an endoluminal prosthesis provided with a support structure including a curvilinear portion provided with a first strut and a second strut meeting at an apex; the anchor including an anchor body and one or more barbs extending outwardly from the anchor body; wherein the anchor body is shaped so as to fit at least partially about and to conform to the first strut, the second strut, and the apex.

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19. An anchor according to claim 18, including a longitudinal structure with a first end and a second, bifurcated, end; the first end of the structure including one or more barbs; and the second end including a first substantially curved clamping portion operable to fit about the first strut and a second substantially curved clamping portion operable to fit about the second strut.
20. An endoluminal prosthesis including:  
a stent provided with a curvilinear portion and an elongate portion, the curvilinear portion including at least two struts meeting at an apex; and  
an anchor on the stent including a longitudinal body provided with at least one barb at one end and first and second substantially opposing curved portions disposed along the length of and extending at an angle to the longitudinal body;  
wherein the first curved portion is longitudinally offset from the second curved portion; and  
wherein each curved portion is configured to fit about and conform to a strut.
21. A prosthesis according to claim 20, wherein the first and second substantially curved portions extend substantially perpendicularly relative to the longitudinal body.
22. A prosthesis according to claim 20 or 21, wherein the anchor is fastened to the elongate portion of the support structure.
23. A prosthesis according to claim 20, 21 or 22, wherein the or a said barb extends substantially parallel to the elongate portion.
24. A prosthesis according to any one of claims 20 to 23, wherein the or a said barb extends from the elongate portion at an angle.
25. A prosthesis according to any one of claims 20 to 24, wherein the anchor includes a third curved portion disposed along the length of and extending substantially transversely to the longitudinal body.
26. A prosthesis according to claim 25, wherein the third curved portion is longitudinally offset relative to the first curved portion and the second curved portion.

27. An anchor for an endoluminal prosthesis provided with a stent including a curvilinear portion and an elongate portion, the curvilinear portion including at least two struts meeting at an apex; the anchor including a longitudinal body provided with at least one barb at one end and first and second substantially opposing curved portions disposed along the length of and extending substantially transversely to, the longitudinal body; wherein the first curved portion is longitudinally offset from the second curved portion; and wherein each curved portion is configured to fit about and conform to a strut.

28. An anchoring device for an endoluminal prosthesis including:

a plurality of independent wires arranged to form a multi-filar tube including a first end, a second end, and a longitudinal axis;

wherein at least one of the wires has an end that forms a first barb that extends outwardly from the anchoring device.

29. A device according to claim 28, wherein the wires are arranged in a coil.

30. A device according to claim 28 or 29, wherein a second wire has an end that forms a second barb that extends outwardly from the multi-filar tube.

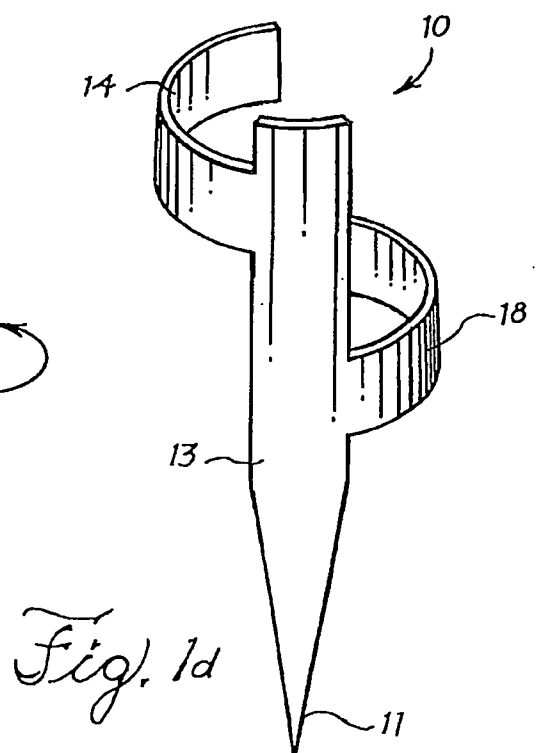
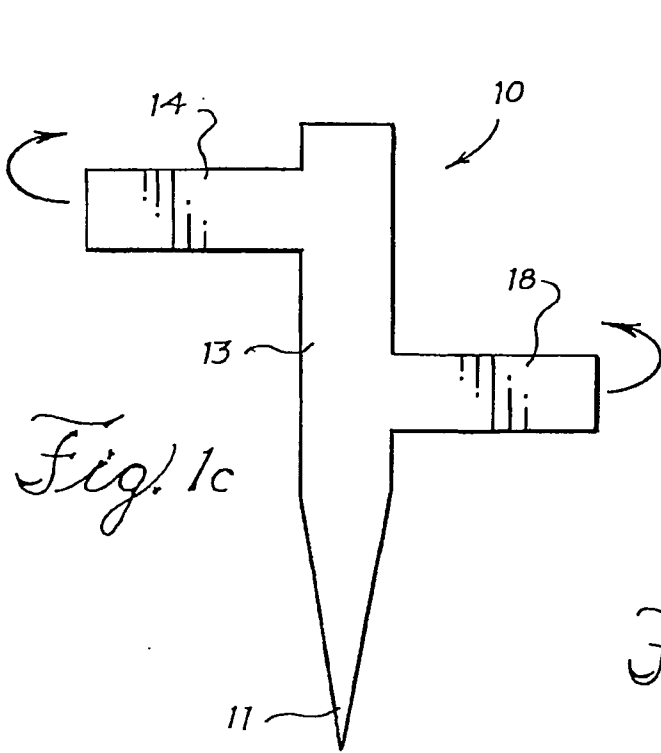
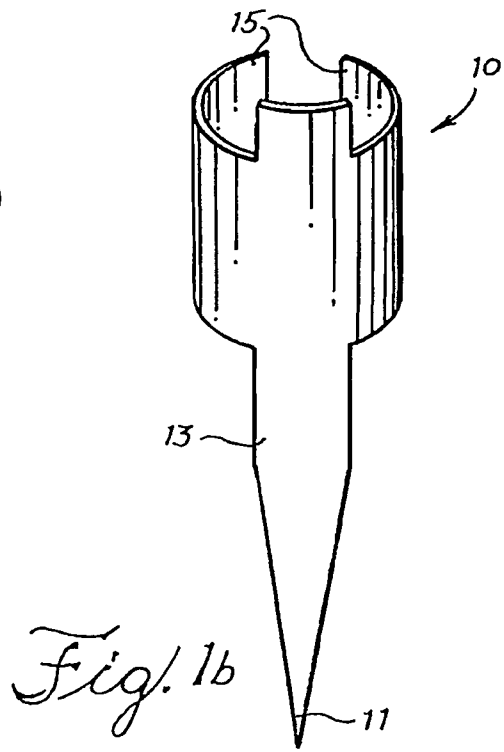
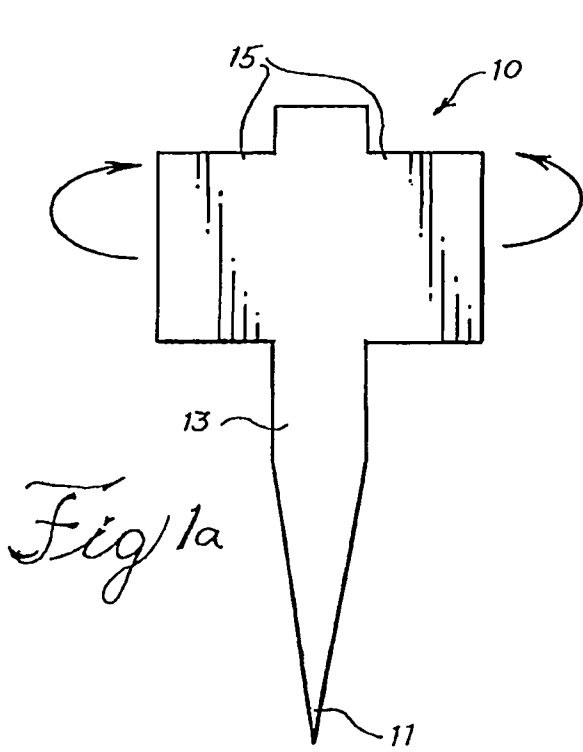
31. A device according to any one of claims 28 to 30, wherein each of the wires includes a first end disposed at or near the first end of the multi-filar tube and a second end disposed at or near the second end of the multi-filar tube.

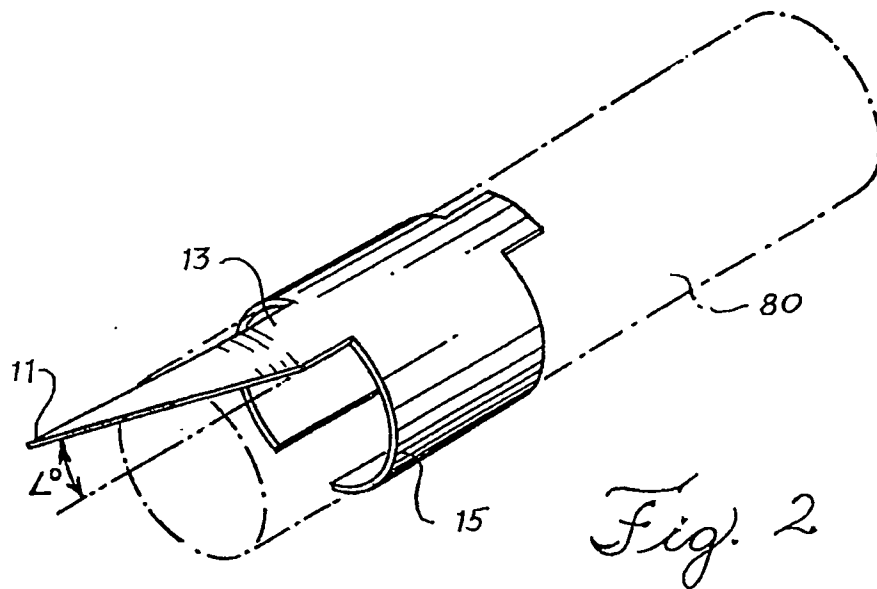
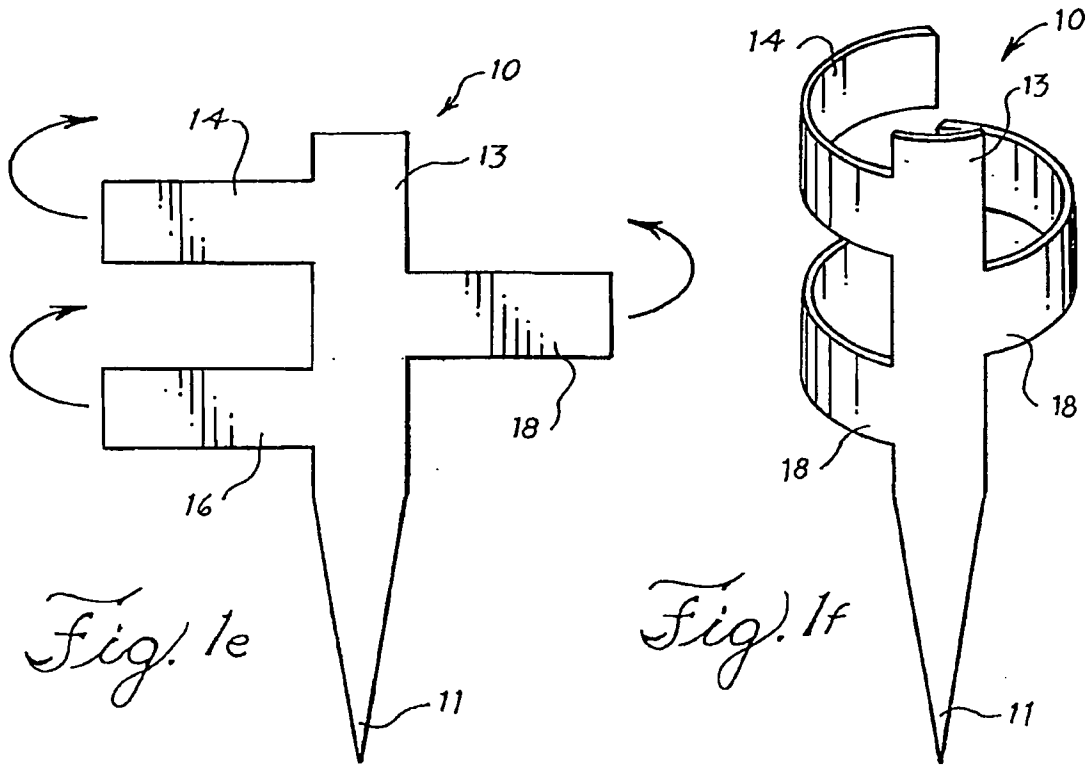
32. A device according to claim 30, wherein a second wire includes an end that forms a second barb that extends outwardly from the multi-filar tube.

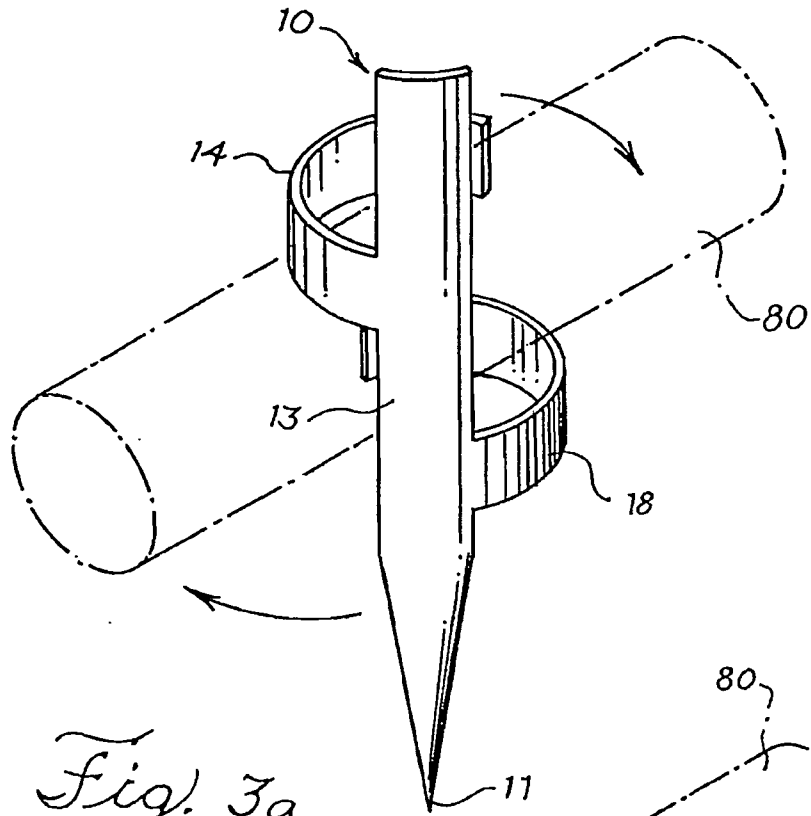
33. A device according to claim 31, wherein the first barb is disposed at or near the first end of the multi-filar tube and the second barb is disposed at or near the second end of the multi-filar tube.

34. A device according to claim 33, wherein the wires are arranged in a coil.

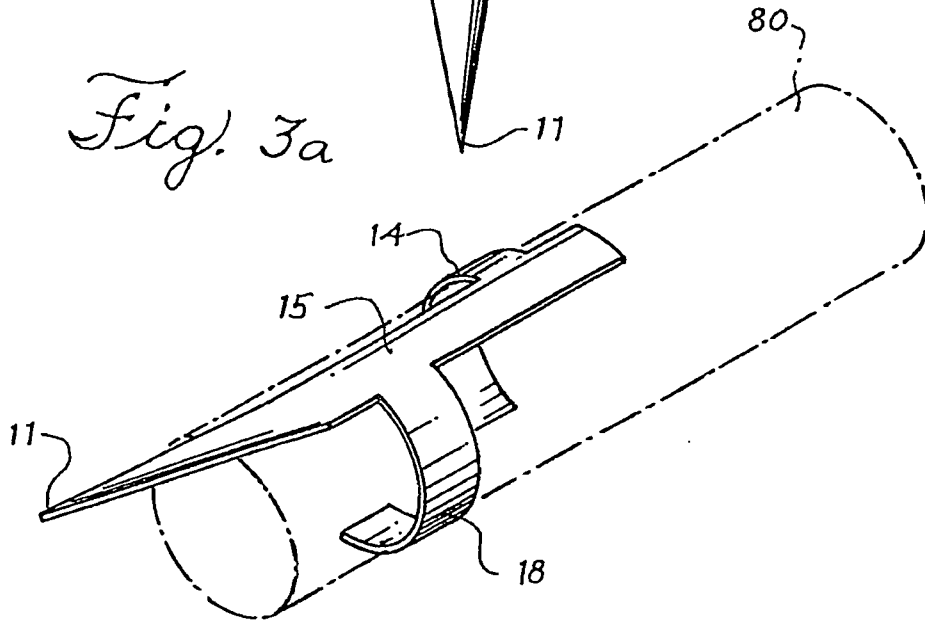
35. A device according to any one of claims 28 to 34, wherein each of the wires has a polygonal cross-section.





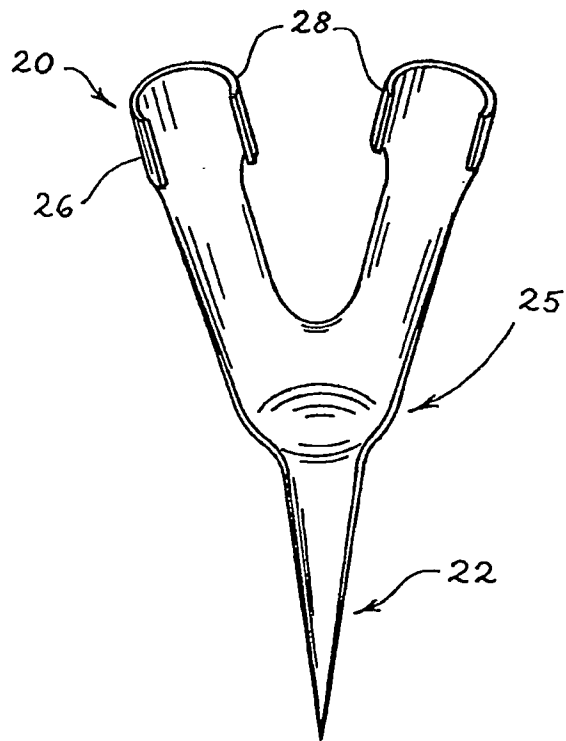


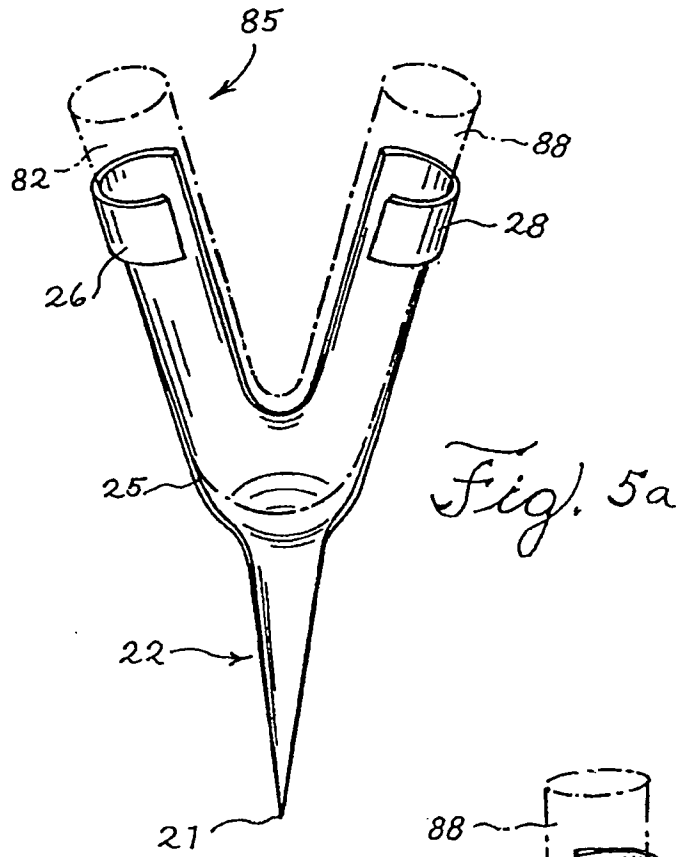
*Fig. 3a*



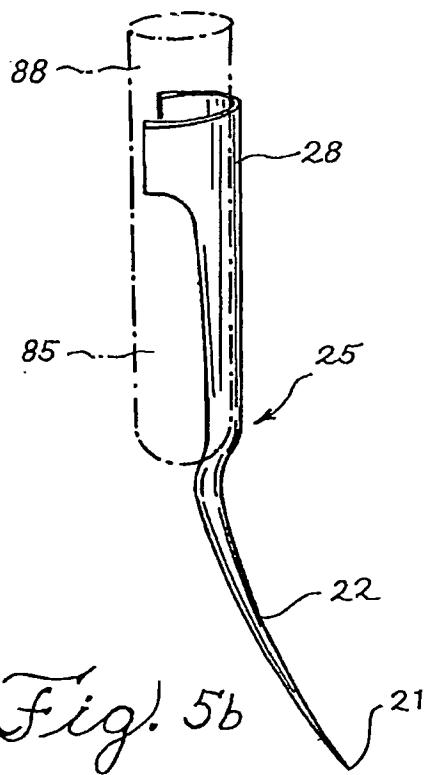
*Fig. 3b*

*Fig. 4*

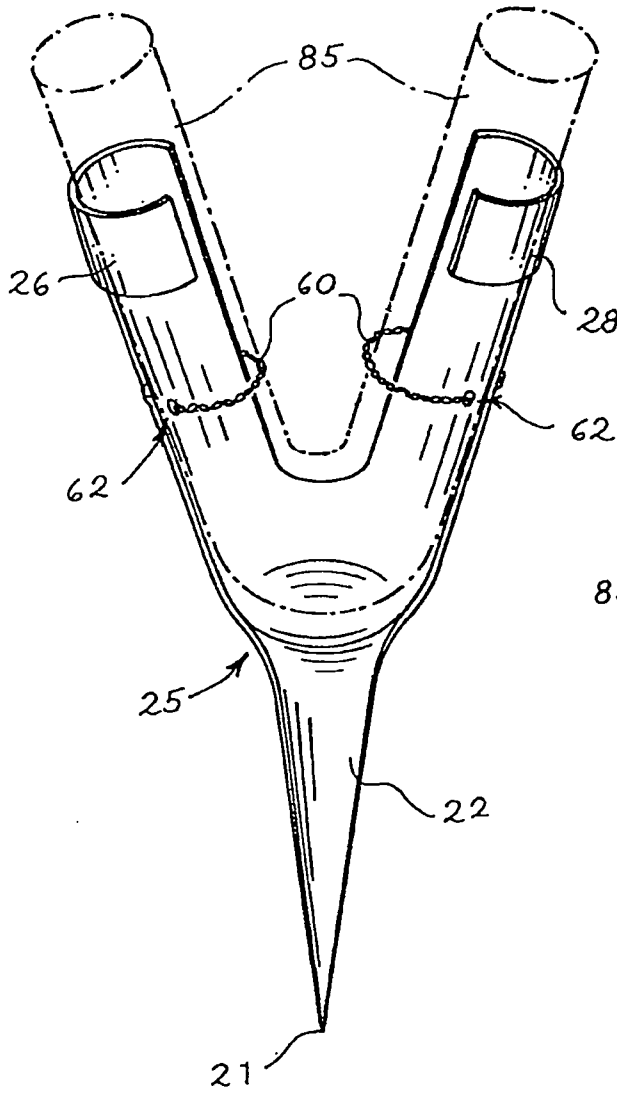




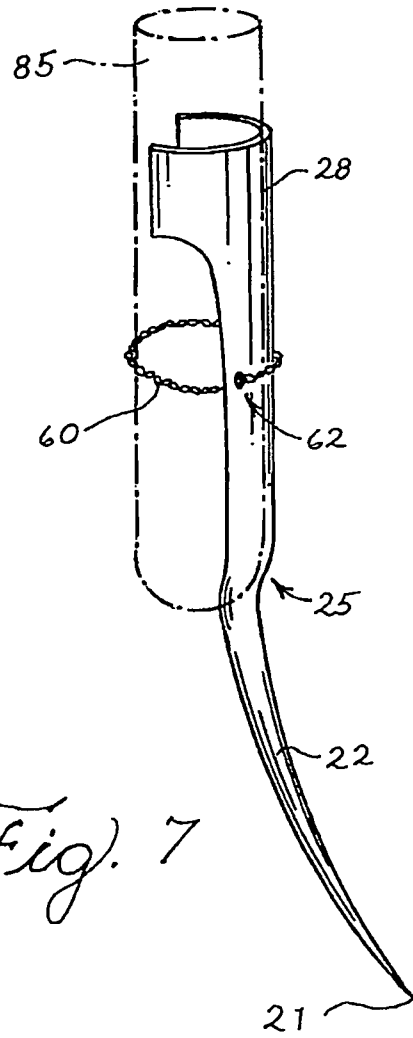
*Fig. 5a*



*Fig. 5b*



*Fig. 6*



*Fig. 7*

Fig. 8A

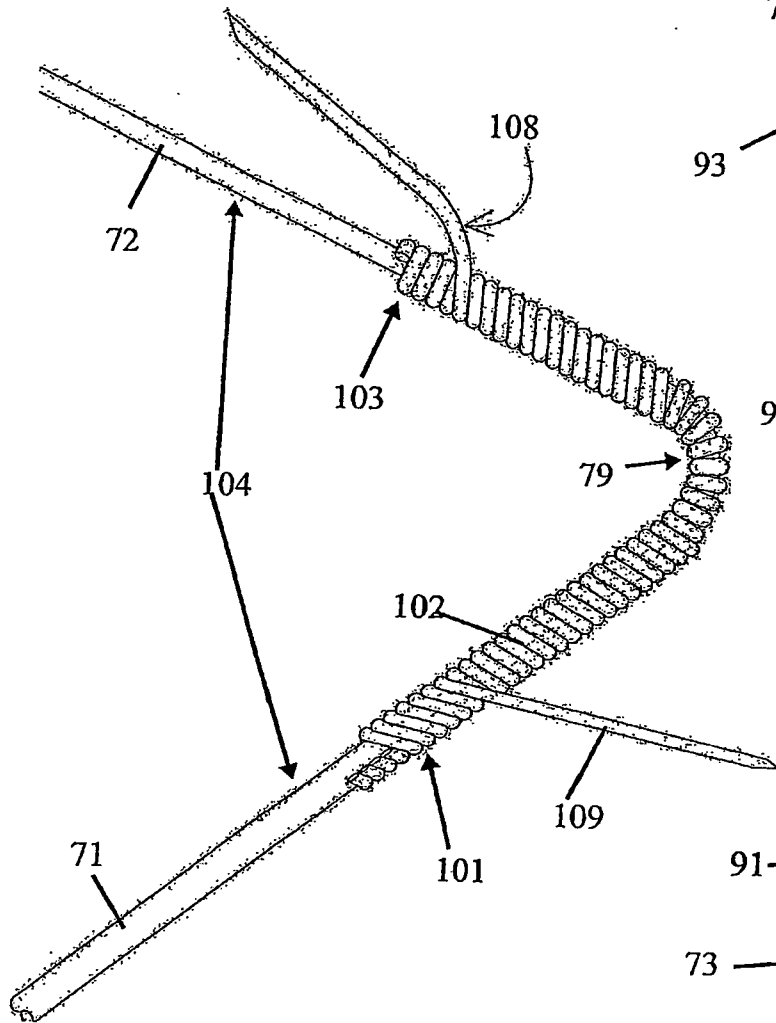
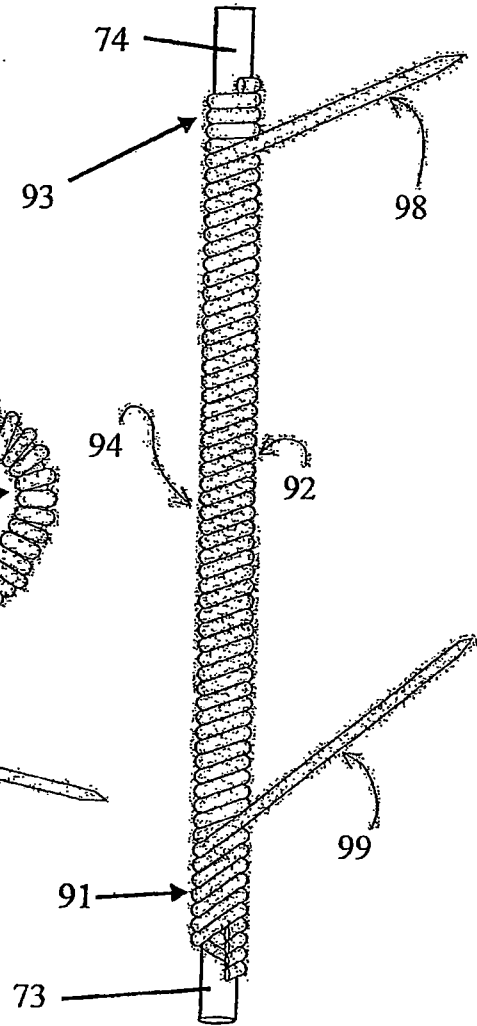


Fig. 8B



**INTERNATIONAL SEARCH REPORT**

International application No  
PCT/US2009/004830

**A. CLASSIFICATION OF SUBJECT MATTER**  
INV. A61F2/82

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
A61F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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X	WO 00/35352 A (SCIMED LIFE SYSTEMS INC [US]) 22 June 2000 (2000-06-22) page 14, line 13 - page 16, line 19 figures 14,15	1,15-18
Y		2-7, 19-27
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Further documents are listed in the continuation of Box C.

See patent family annex.

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Date of the actual completion of the international search

15 December 2009

Date of mailing of the international search report

29/12/2009

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Chevalot, Nicolas

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2009/004830

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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