(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 755 491 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
10.08.2011 Bulletin 2011/32

(21) Application number: **05779920.7**

(22) Date of filing: **10.05.2005**

(51) Int Cl.:
A61F 2/90 *(2006.01)*

(86) International application number:
PCT/US2005/016145

(87) International publication number:
WO 2005/110286 (24.11.2005 Gazette 2005/47)

(54) **METHOD FOR REDUCING STENT WELD PROFILES AND A STENT HAVING REDUCED WELD PROFILES AND A CLOSED-END WIRE CONFIGURATION**

VERFAHREN ZUR VERRINGERUNG VON STENTNAHTPROFILEN UND STENT MIT VERRINGERTEN NAHTPROFILEN SOWIE GESCHLOSSENER DRAHTKONFIGURATION

MÉTHODE DE RÉDUCTION DES PROFILS DE SOUDURE DES STENTS; STENT MUNI DE PROFILS DE SOUDURE RÉDUITS ET CONFIGURATION D'UN CÂBLE FERMÉ

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU MC NL PL PT RO SE SI SK TR

(30) Priority: **14.05.2004 US 845844**

(43) Date of publication of application:
28.02.2007 Bulletin 2007/09

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Description

FIELD OF THE INVENTION:

[0001] The present invention relates to stents having welded portions and atraumatic looped ends. The present invention also relates to such stents having their welded portions electro-chemically polished to reduce their profile and/or having a suture loop threaded at one or both extremities and/or being manufactured with a wire having a radiopaque core, and/or being fully or partially covered with a polymer such as silicone.

BACKGROUND OF THE INVENTION:

[0002] Stents made from interconnecting, often braiding, elongate wires may be made less traumatic, i.e., atraumatic, by closing the loose wire ends at the ends of the stents. The loose wire ends have typically been closed by mechanical means, such as by clamps, for example clamped microtubes, or by welding. Such mechanical means, however, provide regions of high profile as compared to the other regions of the stents, see e.g., U.S. Patent 6,083,257, which represents the closest prior art. The high profile regions are undesirable, often leading to deployment concerns, including higher deployment forces.

[0003] Electropolishing or electro-chemical polishing of laser cut nitinol stents to improve surface finishes has been previously mentioned, see e.g. U.S. Patent No. 6,325,825 B1 and U.S. Patent Application Publication No. 2003/0024534 A1. Further, electro-polishing or electro-chemical polishing services are available, see e.g. from Admedes Schuessler GmbH. Such polishing, however, has not been attempted to alleviate the above-discussed deployment concerns.

[0004] WO 01/35864 A discloses a multi-section filamentary stent comprising a braided section, which is a cylindrical mesh of a first set of filaments, connected to at least one wound section comprising a second set of one or more filaments having a repeating configuration with a bent portion.

[0005] The present invention provides a stent made from elongate wires in a closed-end design while avoiding the disadvantages of the prior art. More particularly, the present invention is directed to certain advantageous closed-end stent loop designs having reduced profiles to lower deployment forces and ease deployment of the stent.

SUMMARY OF THE INVENTION:

[0006] In one aspect of the present invention is a method for making an implantable stent as specified in claim 1 The method comprises the steps of (i) providing a plurality of elongate stent wires; (ii) forming the wires into a hollow tubular structure having opposed first and second open ends; (iii) terminating the wires at the second end; (iv) aligning the wires at the second end into a plurality of mated adjacent wires to define a plurality of abutting regions; (v) welding the mated adjacent wires to one and the other at the abutting regions to define a plurality of welds; and, optionally, (vi) chemically or electro-chemically removing a portion of the welding material from the plurality of welds. Desirably, the mated adjacent wires are substantially parallel to one and the other at the abutting regions.

[0007] In this aspect of the present invention, the step of welding may include the step of providing an inert gas proximal to the weld areas. Further, the step of welding includes laser welding, electron beam welding, resistance welding, tungsten inert gas welding, metal inert gas welding, and combinations thereof.

[0008] Desirably, the step of forming the tubular structure comprises braiding the wires, winding the wires, knitting the wires, and combinations thereof, preferably braiding the wires. The material of the wires and the material of the welds may be the same type of material.

[0009] Further, the stent wire may include a radiopaque material.

[0010] The step of chemically or electro-chemically removing the portion of the welding material may include chemical polishing or etching, chemical deburring, electro-chemical polishing or etching, jet-electropolishing and combinations thereof. The step of electro-chemically removing the portion of the welding material further includes the step of providing an electrolyte, where the electrolyte is selected from the group consisting of $NaClO_3$ electrolyte, $NaNO_3$ electrolyte, NaCl electrolyte, $Na_2Cr_2O_7$ electrolyte, $HOCH_2CH_2OH$ electrolyte, and combinations thereof.

[0011] In further detail, the step of electro-chemically removing the portion of the welding material may further include the step of (i) providing an electrolyte; (ii) placing a cathode into the electrolyte; (iii) placing a portion of the stent having the welding material into the electrolyte; (iv) providing an electrical voltage or current so that the cathode is negatively charged and the stent portion is positively charged; and (v) partially dissolving the portion of the stent exposed to the electrolyte.

[0012] In another aspect of the present invention, the method of making the stent may further include the steps of (i) extending at least one of the mated stent wires to provide an extended stent wire; (ii) looping the extended stent wire so the extended end abuts a proximal pair of stent wires; and (iii) welding extended and looped wire to the proximal pair of wires. Desirably, the step of looping includes forming the wire into an arch with equilateral sides, having an apex, but not having other sharp bends. Desirably, the step of looping includes forming the wire into an equilateral arch having one vertex having similar curvatures on either side of the one vertex, where the equilateral arch does not contain a second vertex having dissimilar curvatures on either side of the second vertex.

[0013] In another aspect of the present invention, the method of making the stent may further include the steps

of (i) extending at least one of the mated stent wires past the abutting regions to provide an extended stent wire; and (ii) looping the extended stent wire at its extended end to form a coil thereat. A plurality of extended wires may also be formed into one coil or pig tail.

[0014] Desirably, the elongate wires comprise biocompatible materials selected from the group consisting of nitinol, stainless steel, cobalt-based alloy such as Elgiloy, platinum, gold, titanium, tantalum, niobium, and combinations thereof, preferably nitinol. The elongate wires may be composite wires for improved radiopacity, such as having an inner core of tantalum, gold, platinum, iridium or combination of thereof and an outer layer or member of nitinol.

[0015] In another aspect of the present invention, an implantable stent is provided as as specified in claim 24. The stent of this aspect of the present invention may include a plurality of wires arranged to form a hollow tubular structure having a tubular wall to define an interior surface and an exterior surface and having opposed open first and second ends, where the wires terminate at the second open end ends and adjacently abutting wires are welded at the second open end with a welding material to provide welds, and further where at least a portion of the welded material has been removed to reduce the profile of the welds. The portion of welded material has been removed by chemical or electro-chemical polishing. At least 25 to 50 % by weight of the stent material at or around the weld location has been removed. The reduced profile of the welds are from about 5 to about 50 linear percent of a diameter of the stent wires.

[0016] The stent includes wires made from biocompatible materials, such as nitinol, stainless steel, cobalt-based alloy such as Elgiloy, platinum, gold, titanium, tantalum, niobium, and combinations thereof. The weld material and the wire material may also be the same, for example nitinol. Further, the elongate wires have an inner core of tantalum gold, platinum, iridium or combination of thereof and an outer member of nitinol.

[0017] In another aspect of the present invention, at least one some of the adjacently abutting stent wires are extended past the welds and looped into an arch with equilateral sides having an apex, but not having other sharp bends, or in other words at least some of the adjacently abutting stent wires are extended past the welds and looped into an arch with equilateral sides having one vertex having similar curvatures on either side of the one vertex, where the arch design does not contain a second vertex having dissimilar curvatures on either side of the second vertex. Alternatively, at least some of the adjacently abutting stent wires are extended past the welds and looped to form a coil thereat in the shape of a pig tail. Still alternatively, at least some of the adjacently abutting stent wires are extended past the welds and looped to form one coil thereat.

[0018] The stent wires may be coated, for example coated with silicone. Further, the stent may be fully or partially covered with a polymeric covering, such as silicone, in order to prevent tissue or tumor ingrowth.

[0019] The stent may further include a hollow tubular graft disposed over the interior or the exterior surface. The graft may be a polymeric material, for example, a polyester, a polypropylene, a polyethylene, a polyurethane, a polynaphthalene, a polytetrafluoroethylene, an expanded polytetrafluoroethylene, a silicone, and combinations thereof.

[0020] Desirably, the stent is a braided stent.

[0021] The stent may further include a polymeric ring disposed over the exterior surface at the second open end. Additionally, the stent may further include a suture secured to one of the open ends. Such suture or sutures are useful for positioning, repositioning, and/or removing the stent. The suture can be a metallic, polymeric or textile suture loop threaded through the stent loops at one or both extremities of the stent. The suture loop may include a protruding part to help facilitate the capture or grabbing of the stent end.

[0022] In another aspect of the present invention, an implantable stent includes a plurality of wires arranged to form a hollow tubular structure having a tubular wall to defme an interior surface and an exterior surface and having opposed open first and second ends, where the wires terminate at the second open end ends and adjacently abutting wires are welded at the second open end with a welding material to provide welds, and further where at least a portion of the welded material has been removed by chemical or electro-chemical polishing to reduce the profile of the welds.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0023]

FIG. 1 is a perspective view of a hollow, tubular stent according to the present invention.

FIG. 2 is an expanded view of a wall portion of the stent of FIG. 1 taken along the 2-2 axis showing a plurality of stent wires.

FIG. 3 depicts a braided stent with a closed-end loop design having a plurality of welds at the closed end according to the present invention.

FIG. 4 is an expanded view of a weld of FIG. 3.

FIG. 5 depicts a weld adjoining two stent wires according to the present invention.

FIG. 5A depicts a weld adjoining two stent wires having an insulator or photoresist on selected stent wire portions according to the present invention.

FIG. 6 is a cross-sectional view of the adjoining stent wires of FIG. 5 taken along the 6-6 axis.

FIG. 7 is a cross-sectional view of the welded stent wires of FIG. 5 taken along the 7-7 axis.

FIG. 8 is a cross-sectional view of the welded stent wires of FIG. 7 after chemical or electro-chemical polishing.

FIG. 9 is a schematic depiction of an electro-chemical polishing cell according to the present invention.

FIGS. 10-14 depict an arch with equilateral sides and an apex in a closed-end loop design according to the present invention.

FIG. 15 depicts another embodiment according to the present invention of a closed-end loop design of the present invention having a plurality of coils at the closed end.

FIG. 16 depicts yet another embodiment according to the present invention of a closed-end loop design of the present invention having one coil or pigtail at the closed end.

FIGS. 17-18 depict yet another embodiment according to the present invention of a closed-end design having a band disposed over the stent wires at the closed end.

FIG. 19 depicts a mandrel having shaped pins for forming the closed loops of FIGS. 10-14.

FIG. 20 depicts a stent having a covering of silicone according to the present invention.

FIG. 21 is a cross-sectional view if the stent of FIG. 20 showing an outer covering of silicone about the stent.

FIG. 22 is a cross-sectional view if the stent of FIG. 20 showing an inner covering of silicone about the stent.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT:

[0024] The present invention overcomes the deficiencies of the prior art by providing, among other things, low profile stent welds that reduce stent deployment forces. FIG. 1 depicts stent **10** of the present invention. Stent **10** is a hollow tubular structure having opposed open ends **12, 14** and having a tubular wall **16** therebetween. A portion of the tubular wall **16** is depicted in FIG. 2 as having a plurality of elongate wires **18** formed into the tubular wall **16.** The elongate wires **18** traverse the length of the stent **10** in a direction traverse to the longitudinal length of the stent **10.** The elongate wires **18** may be formed into the tubular wall **16** by braiding the wires **18,** winding the wires **18,** knitting the wires **18,** and combinations. Preferably, the wires **18** are braided to form the tubular wall **16.**

[0025] A welded stent **10'** according to the present invention is depicted in FIG. 3. The elongate wires **18** terminating at open end **12** are mated and adjacently mated wires are secured to one and the other by welds **20.** The joining of three adjacently mated wires **18** and the welding thereat is depicted in further detailed in FIG. 4. The positioning of adjacently mated wires to form closed-loop end designs, excluding the closed-end arch loop design of the present invention which is described below, is further described in U.S. Application No. 60/472,929, filed May 23, 2003, which represents U.S. Application No. 10/852,495 and which published as US 2005/0049682 A1. The weld **20** may be a low profile weld, i.e., a weld with a reduced welding zone as compared to stent welds of the prior art. The stent **10'** depicted in FIG. 3 includes 24 wires **18** of nitinol or nitinol-containing material. The wires are relatively thin at a diameter of about 0,028 centimetres (0.011 inches). The number of wires and the diameters of the wires, which may be the same or different, depicted in FIG. 3 are not limiting, and other numbers of wires and other wire diameters may suitably be used.

[0026] A pair of adjacently welded wires according to the present invention is depicted in FIGS. 5-8. Weld **24** securably joins adjacently mated stent wires **22.** As compared to the prior art, the weld **24** of the present invention has a significant reduction in the amount of welding material in weld **24.** Weld **24** has at least about 25% or less welding material than prior art welds, for example from about 25% to about 50% less welding material. The weld **24** has a profile, i.e., a depth d_3 and/or a width d_4, that is less than the diameter, d_1, of the wire **22.** Yet alternatively, or in addition to, the welds **24** of the present invention have a profile of about 150 micrometres (150 microns) or less, preferably from about, 50 micrometres (50 microns) to about 150 micrometres (150 microns). Yet alternatively, or in addition to, the weld **24'** of the present invention and portions of the stent wires **22'** proximal to the welds **24'** have a reduced profile where the profile of weld **24'** is lower than the profile of weld **24** and where the diameter, d_2, of the proximal stent portions **22'** is less than the diameter, d_1, of stent wire portions **22.** The mass and volume of the weld **24'** and/or stent portions **22'** is suitably reduced by chemical or electrochemical polishing. Reduced profile welds **24, 24'** of the present invention overcome the difficulty of constraining the stent **10,10'** on a delivery device (not shown) by removing excess weld material that would otherwise increase localized constraining forces at the weld locations as compared to other portions of the stent **10, 10'.**

[0027] Useful welding methods include, but are not limited to, laser welding, electron beam welding, resistance welding, tungsten inert gas welding, metal inert gas welding and combinations thereof. In laser and electron beam welding the wires are partially melted by the energy provided by the laser or electron beam. In gas tungsten arc

welding (GTAW or TIG welding), an arc is formed between an electrode, typically tungsten, and the metal being welded. In metal inert gas (MIG) welding, an arc is generated between a filler electrode and the metal being welded with metal melted from the filler electrode being added to the metal being welded. Resistance welding uses the application of electric current and sometimes mechanical pressure to create a weld between two pieces of metal. The weld areas may be shielded with an inert gas. Suitable, but non-limiting, inert gasses include argon and argon/gas admixtures, such as argon/hydrogen or argon/helium.

[0028] FIG. 9 depicts an electro-chemical cell **30** for removing weld material to thereby form the low profile weld **24, 24'** of the present invention. The cell **30** includes an electrolyte **32** contained within a container **34.** The stent **10** with welds **24, 24'** at stent end **12** is placed within the electrolyte **32.** A cathode **36** is also placed within the electrolyte **32.** A wire **38** connects the cathode **36** to the negative terminal **40** of voltage or current source **46.** A wire **42** connects the stent **10** to the positive terminal **44** of the voltage or current source **46.** Upon application of voltage or current from the source **46** the cell **30** becomes operational. Material, such as weld material, is dissolved from the stent **10** into the electrolyte **32.** Useful electrolytes include $NaClO_3$ electrolyte, $NaNO_3$ electrolyte, NaCl electrolyte, $Na_2Cr_2O_7$ electrolyte, $HOCH_2CH_2OH$ electrolyte and combinations thereof. Typical, but non-limiting, current densities are in the magnitude of about 50 to about 150 amps/cm^2. The electrolyte **32** may be in motion at low velocities or unstirred. As the anode metal is dissolved electrochemically, the dissolution rate is not influenced by the hardness or other physical characteristics of the metal.

[0029] Desirably, the wires **22** are made from nitinol, stainless steel, cobalt-based alloy such as Elgiloy, platinum, gold, titanium, tantalum, niobium, and combinations thereof. Further, the wires **22** have an inner core of tantalum gold, platinum, iridium or combination of thereof and an outer member or layer of nitinol to provide a composite wire for improved radiocapicity or visibility. Further details of such composite wires may be found in U.S. Patent Application Publication 2002/0035396 A1. Preferably, the wires **22** are made from nitinol. Further, the filling weld material, if required by welding processes such as MIG, may also be made from nitinol, stainless steel, cobalt-based alloy such as Elgiloy, platinum, gold, titanium, tantalum, niobium, and combinations thereof, preferably nitinol. The material of the cathode is no critical and can be made out of any suitable metal. The filling weld material and the wire **22** may be made of the same material, for example nitinol.

[0030] As the chemical electro-chemical polishing **30** removes material from portions of the stent **10** that are disposed within the electrolyte **32,** there are several means to selectively remove material from the stent **10,** such as welds **24, 24',** burrs or other imperfections (not shown), and the like. One technique for selectively removing material is through the use of a photoresist or insulator, which is an organic polymer or resin that can be applied to selective areas of the stent **10** to avoid the electro-chemical polishing of covered parts **30** as the photoresist insulates the selected from the action of the electrolyte. For example, as depicted in FIG. 5A, portions of the stent wires **22** may be coated with a photoresist prior to placement in the cell **30.** After chemical or electro-chemical polishing is completed the photoresist may be removed by application of a suitable solvent. Alternatively, jet electro-chemical polishing or etching could be used to specifically etch weld regions. Jet etching includes the localized application of electrolyte at moderate velocity, such as about 3 to about 30 m/s, to selectively polish desired areas, such as stent welds.

[0031] Alternatively, chemical polishing, chemical etching and the like may be used to remove portions of the weld **24, 24'** and optionally portions of the stent wire **22.** Chemical polishing or etching is similar to the above described electro-chemical methods, expect an oxidizing acid is added to the electrolyte and associated equipment (current or voltage source, cathode, etc.) is optionally not necessary. Useful, but not limiting, oxidizing acid-containing electrolytes include electrolytes having hydrofluoric acid, nitric acid, and combinations thereof.

[0032] The present invention, however, is not limited to low profile welds just at terminatingly adjacent wires, such as wires **22** of FIGS. 5 or 5A. As depicted in FIGS. 10-14, certain stent wires **56, 62** may be extended beyond adjacent wires **50, 64,** and then looped back to proximal wires **52, 60** and **58, 64,** respectively. Adjacent portions of wires **50** and **56** are abuttingly disposed at abutting region **68.** Similarly, adjacent portions of wires **52** and **60** and the adjacent portion of the extended loop portion **66** are abuttingly disposed at abutting region **70;** adjacent portions of wires **54** and **62** are abuttingly disposed at abutting region **72;** and adjacent portions of wires **58** and **64** and the adjacent portion of the extended loop portion **67** are abuttingly disposed at abutting region **74.** Desirably, the abuttingly disposed wire portions in the abutting regions are substantially parallel to one and the other, for example, but not limited to, being within about plus or minus 10 degrees of parallelism to one and the other, preferably, but not limited to within about plus or minus 5 degrees of parallelism.

[0033] As depicted in FIG. 11, the wires at the abutting regions **68, 70, 72, 74** may be secured by welds **76.** Desirably, welds **76** are low profile welds having low profiles from electro-chemical polishing according to the present invention.

[0034] Desirably, the extended loop portions **66, 67** are of an arch with equilateral sides design, which can be referred to as a cathedral type of arch or loop. As depicted in FIG. 12, the equilaterally arched loop **78** has an apex or vertex **80.** As used herein, the term "vertex" and its variants refer to the intersection of two geometric lines or curves. As used herein, the term "apex" and its variants refer to a vertex at the top or summit of a loop.

Desirably, the equilaterally arched loop **78** does not have any bends, which are defined as areas having dissimilar curvatures on either side of a point, except for the apex **80.** In other words, the equilaterally arched loop **78** has an apex, but not other sharp bends. Desirably, the equilaterally arched loop **78** has one vertex (or apex **80**) having similar curvatures on either side of the one vertex (or apex **80**), but does not contain a second vertex having dissimilar curvatures on either side of the second vertex.

[0035] The equilaterally arched loop design offers several advantages, including reduced deployment force, as compared to prior art loop designs having a plurality of vertices or sharp bends. When a stent is constrained on or in a delivery system (not shown) the multiple sharp bends in the end loops of the stent typically impinge on the wall of the delivery system and become slightly imbedded thereat, thereby distorting the outer sheath of the delivery system. This results in significantly greater deployment force values. Further, as the equilaterally arched loop has only one sharp bend, i.e., its apex, and is defined otherwise by a gradual curvature, the gradual curvature portions do not become imbedded in the wall of the delivery system, thereby significantly reducing the resultant deployment force.

[0036] In another aspect of the present invention as depicted in FIG. 13, an equilaterally arched loop **82** may have an apex **84** and vertices **86** having substantially straight line portions **88.** In such a case, the vertices **86** and the straight line portions **88** have low profile welds **90** thereover to adjoin other adjacently abutting stent wires (not shown). The equilaterally arched loops **66, 67, 78, 82** of the present invention may be suitably formed by winding their stent wires about shaped pins **98** on a mandrel **100** as depicted in FIG. 19. Further, either or both of the ends **12, 14** of the stent **10,10',** including end **12** with equilaterally arched loops **66, 67, 78, 82,** may have a suture or sutures (not shown) attached thereto. Such sutures are useful for positioning, repositioning, and/or removing the stent **10, 10'.**

[0037] In still a further aspect of the present invention, the stent **10** may have other designs at open end **12** that are useful for positioning, repositioning, and/or removing stent **10.** As depicted in FIG. 15, wires may be extended from all or some of the adjacent wire engaging portions **92.** The ends of the extended wires may be formed into coils **90.** As depicted in FIG. 16, wires may be extended from all or some of the adjacent wire engaging portions **92.** The ends of the extended wires may be formed into a coil **94,** which is in the shape of a hook and commonly referred to as a pigtail. Still further, the open end **12** of stent **10** may be of reduced diameter as compared to the other portions of the stent **10.** The reduced diameter portion facilitates access to the stent end **12** for positioning, repositioning, and/or removing stent **10.** The stent end **12** of the stent **10** of FIG. 17 may include any of the previously described loops or coils thereat. Alternatively, or in addition to, the stent end **12,** as depicted in FIG. 18, may have a band **96** disposed thereover, which is also useful for positioning, repositioning, and/or removing stent **10.** Band **96** may be made of any biocompatible material, including polymers, plastics and metals. The band **96** may be attached to the stent end **12** by adhesive, mechanical or physical means, such as adhesive bonding, welding, suturing, fusing, and the like.

[0038] As depicted in FIG. 20, the stent **10** may be fully, substantially or partially covered with silicone **102** in also the form of a tubular structure. The silicone **102** may be disposed on external surfaces **104** of the stent **10,** as depicted in FIG. 21, or disposed on the internal surfaces **106** of the stent **10,** as depicted in FIG. 22, or combinations thereof.

[0039] With any embodiment of the stent **10, 10'** is usable to maintain patency of a bodily vessel, such as in the coronary or peripheral vasculature, esophagus, trachea, bronchi colon, biliary tract, urinary tract, prostate, brain, and the like. Also, the stent **10, 10'** may be treated with any of the following: anti-thrombogenic agents (such as heparin, heparin derivatives, urokinase, and PPack (dextrophenylalanine proline arginine chloromethylketone); antiproliferative agents (such as enoxaprin, angiopeptin, or monoclonal antibodies capable of blocking smooth muscle cell proliferation, hirudin, and acetylsalicylic acid); antiinflammatory agents (such as dexamethasone, prednisolone, corticosterone, budesonide, estrogen, sulfasalazine, and mesalamine); antineoplastic/antiproliferative/anti-miotic agents (such as paclitaxel, 5-fluorouracil, cisplatin, vinblastine, vincristine, epothilones, endostatin, angiostatin and thymidine kinase inhibitors); anesthetic agents (such as lidocaine, bupivacaine, and ropivacaine); anti-coagulants (such as D-Phe-Pro-Arg chloromethyl keton, an RGD peptide-containing compound, heparin, antithrombin compounds, platelet receptor antagonists, anti-thrombin antibodies, anti-platelet receptor antibodies, aspirin, prostaglandin inhibitors, platelet inhibitors and tick antiplatelet peptides); vascular cell growth promotors (such as growth factor inhibitors, growth factor receptor antagonists, transcriptional activators, and translational promotors); vascular cell growth inhibitors (such as growth factor inhibitors, growth factor receptor antagonists, transcriptional repressors, translational repressors, replication inhibitors, inhibitory antibodies, antibodies directed against growth factors, bifunctional molecules consisting of a growth factor and a cytotoxin, bifunctional molecules consisting of an antibody and a cytotoxin); cholesterol-lowering agents; vasodilating agents; and agents which interfere with endogenous vascoactive mechanisms.

[0040] The invention being thus described, it will now be evident to those skilled in the art that the same may be varied in many ways. Such variations are not to be regarded as a departure from the scope of the invention and all such modifications are intended to be included within the scope of the following claims.

Claims

1. A method for making an implantable stent (10, 10') comprising:

   providing a plurality of elongate stent wires (18) having a diameter;
   forming said wires into a hollow tubular structure having opposed first (14) and second (12) open ends;
   terminating said wires at said second end (12);
   aligning said wires (18) at said second end (12) into a plurality of mated adjacent wires (22, 22') to define a plurality of abutting regions;
   welding said mated adjacent wires (22, 22') to one and the other at said abutting regions to define a plurality of welds (24, 24');
   characterized in that the method further comprises:
   chemically or electro-chemically removing from about 25 % to about 50 % by weight of welding material of said welds (24, 24') in a selective manner to reduce weld profiles to less than the diameter of the stent wires (18).

2. The method of claim 1, wherein
   the chemically or electro-chemically removing a portion of said welds (24, 24') reduces a depth and/or a width of the welds (24, 24') to about 150 micrometres (150 microns) or less.

3. The method of claim 1, further comprising:

   chemically or electro-chemically removing a portion of said mated adjacent wires (22, 22') in a selective manner, wherein said portion is proximal to said welds (24, 24').

4. The method of any of the preceding claims, wherein said step of chemically or electro-chemically removing includes chemical or electro-chemical polishing.

5. The method of any of the preceding claims, wherein said mated adjacent wires (22, 22') are substantially parallel to one and the other at said abutting regions.

6. The method of any of the preceding claims, wherein the step of welding comprises the step of providing an inert gas proximal to the weld areas.

7. The method of any of the preceding claims, wherein the step of welding includes welding selected from the group consisting of laser welding, electron beam welding resistance welding, tungsten inert gas welding, metal inert gas welding and combinations thereof.

8. The method of any of the preceding claims, wherein the step of forming said tubular structure comprises braiding said wires, winding said wires, knitting said wires, and combinations thereof.

9. The method of any of the preceding claims, wherein said wires comprise a wire material and further wherein said welding step further comprises providing a filling material, wherein said wire material and said filling material are the same type of material.

10. The method of any of the preceding claims, wherein said wire comprises a radiopaque material.

11. The method of any of claims 1 to 4, wherein the step of chemically or electro-chemically removing said portion of said welds includes chemical polishing or etching, electro-chemical polishing or etching, jet-electrochemical polishing and combinations thereof.

12. The method of claim 11, wherein the step of electro-chemical polishing or jet-electrochemical polishing further includes the step of providing an electrolyte, wherein the electrolyte is selected from the group consisting of $NaClO_3$ electrolyte, $NaNO_3$ electrolyte, NaCl electrolyte, $Na_2Cr_2O_7$ electrolyte, $HOCH_2CH_2OH$ electrolyte, and combinations thereof.

13. The method of claim 11, wherein the step of chemical polishing or chemical etching further includes the step of providing an oxidizing acid.

14. The method of claim 1, wherein the step of electro-chemically removing said portion of said welds (24, 24') further includes the step of providing an electrolyte (32);
    placing a cathode into said electrolyte (32);
    placing a portion of said stent (10, 10') having said welds (24, 24') into said electrolyte (32); and
    providing an electrical voltage or current so that a portion of said welds (24, 24') dissolves into the electrolyte (32).

15. The method of claim 1, further comprising the steps of:

    extending at least one of the mated stent wires to provide an extended stent wire (56, 62);
    looping said extended stent wire (56, 62) so the extended end abuts a proximal pair of stent wires (52, 60 & 58, 64); and
    welding the extended and looped wire (56, 62) to said proximal pair of wires (52, 60 & 58, 64).

16. The method of claim 15, wherein the step of looping includes forming the wire (56, 62) into an equilaterally arched loop (66, 67, 78, 82) having an apex (80, 84), but not having other sharp bends.

17. The method of claim 15, the step of looping includes forming the wire into an equilaterally arched loop (66, 67, 78, 82) having one vertex (80, 84) having similar curvatures on either side of said one vertex (80, 84), wherein said equilaterally arched loop (66, 67, 78, 82) does not contain a second vertex having dissimilar curvatures on either side of the second vertex.

18. The method of claim 1, further comprising the steps of:

extending at least one of the mated stent wires past the abutting regions to provide an extended stent wire; and
looping said extended stent wire at its extended end to form a coil (94) thereat.

19. The method of claim 18, wherein a plurality of extended wires are formed into one coil (94).

20. The method of claim 1, wherein the elongate wires (18) comprise biocompatible materials selected from the group consisting of nitinol, cobalt-based alloy, stainless steel, platinum, gold, titanium, tantalum, niobium, and combinations thereof.

21. The method of claim 20, wherein the elongate wires (18) comprise nitinol.

22. The method of claim 1, wherein the elongate wires (18) are composite wires for improved radiopacity.

23. The method of claim 23, wherein the elongate wires (18) have an inner core of tantalum, gold, platinum, iridium or combination of thereof and an outer portion of nitinol.

24. An implantable stent (10, 10') comprising:

a plurality of wires (18) having a diameter arranged to form a hollow tubular structure having a tubular wall to define an interior surface and an exterior surface and having opposed open first (14) and second (12) ends,
wherein the wires (18) terminate at said second open end (12) ends and adjacently abutting wires (22, 22') are welded at said second open end (12) with a welding material to provide welds (24, 24'), and
characterized in that at least about 25 % to about 50 % by weight of the welded material has been selectively removed to reduce the profile of the welds (24, 24') to less than the diameter of the stent wires (18).

25. The stent (10, 10') of claim 24, wherein said welding material formed from said adjacently abutting wires (22, 22').

26. The stent (10, 10') of claim 24, wherein said welding material is a filling material.

27. The stent (10, 10') of claim 24, where the portion of welded material has been removed by chemical or electro-chemical polishing.

28. The stent (10, 10') of claim 24 or claim 27, wherein a portion of the adjacently abutting wires (22, 22') proximal to said welds (24, 24') has been removed by chemical or electro-chemical polishing.

29. The stent (10, 10') of claim 28, wherein the reduced profile of the welds (24, 24') are reduced to a depth and/or to a width of the welds (24, 24') to about 150 micrometres (150 microns) or less.

30. The stent (10, 10') of claim 24, wherein the reduced profile of the welds (24, 24') are from about 5 to about 50 linear percent of a diameter of the stent wires (18).

31. The stent (10, 10') of claim 24, wherein the wires (18) comprise a biocompatible material selected from the group consisting of nitinol, stainless steel, cobalt-based alloy, platinum, gold, titanium, tantalum, niobium, and combinations thereof.

32. The stent (10, 10') of claim 31, wherein the weld material and the wire material are the same.

33. The stent (10, 10') of claim 31, wherein the weld material and the wire material are nitinol.

34. The stent (10, 10') of claim 31, wherein the elongate wires (18) have an inner core of tantalum gold, platinum, iridium or combination of thereof and an outer portion of nitinol.

35. The stent (10, 10') of claim 24, wherein at least one some of the adjacently abutting stent wires (56, 62) are extended past the welds (24, 24') and looped into an equilaterally arched loop (66, 67, 78, 82) having an apex (80, 84), but not having other sharp bends.

36. The stent (10, 10') of claim 24, wherein at least some of the adjacently abutting stent wires (56, 62) are extended past the welds (24, 24') and looped into an equilaterally arched loop (66, 67, 78, 82) having one vertex (80, 84) having similar curvatures on either side of said one vertex (80, 84), wherein said equilaterally arched loop (66, 67, 78, 82) does not contain a second vertex having dissimilar curvatures on either side of the second vertex.

37. The stent (10, 10') of claim 24, wherein at least some of the adjacently abutting stent wires are extended past the welds and looped to form a coil (94) thereat.

38. The stent (10, 10') of claim 24, wherein the stent is coated with silicone (102).

39. The stent (10, 10') of claim 24, wherein the stent is partially or fully covered with silicone (102).

40. The stent (10, 10') of claim 24, further comprising a hollow tubular graft disposed over the interior (106) or the exterior (104) surface.

41. The stent (10, 10') of claim 40, wherein the graft is a polymeric material.

42. The stent (10, 10') of claim 41, wherein the polymeric material is selected from the group consisting of polyester, polypropylene, polyethylene, polyurethane, polynaphthalene, polytetrafluoroethylene, expanded polytetrafluoroethylene, silicone, and combinations thereof.

43. The stent (10, 10') of claim 24, wherein the stent is a braided stent.

44. The stent (10, 10') of claim 24, further including a polymeric ring (96) disposed over the exterior surface (104) at said second open end (12).

45. The stent (10, 10') of claim 24, further including a metal or suture loop secured to one of said open ends.

Patentansprüche

1. Verfahren zur Herstellung eines implantierbaren Stents (10, 10'), umfassend:

Bereitstellen einer Vielzahl gestreckter Stent-Drähte (18) mit einem Durchmesser;
Formen der Drähte in eine hohle röhrenförmige Struktur mit gegenüberliegenden ersten (14) und zweiten (12) offenen Enden;
Abschließen der Drähte an dem zweiten Ende (12);
Ausrichten der Drähte (18) an dem zweiten Ende (12) in eine Vielzahl zusammengefügter benachbarter Drähte (22, 22'), um eine Vielzahl aneinanderstoßender Bereiche zu definieren;
aneinander Schweißen der zusammengefügten benachbarten Drähte (22, 22') an den aneinanderstoßenden Bereichen, um eine Vielzahl von Verschweißungen (24, 24') zu definieren;
dadurch gekennzeichnet, dass das Verfahren weiterhin umfasst: chemisches oder elektrochemisches Entfernen von ungefähr 25 bis ungefähr 50 Gewichts-% des Schweißmaterials der Verschweißungen (24, 24') in einer selektiven Weise, um die Schweißprofile auf weniger als den Durchmesser der Stent-Drähte (18) zu reduzieren.

2. Verfahren nach Anspruch 1, wobei das chemische oder elektrochemische Entfernen eines Abschnitts der Verschweißungen (24, 24') eine Tiefe und/oder eine Breite der Verschweißungen (24, 24') auf ungefähr 150 Mikrometer (150 microns) oder weniger reduziert.

3. Verfahren nach Anspruch 1, weiterhin umfassend: chemisches oder elektro-chemisches Entfernen eines Abschnitts der zusammengefügten benachbarten Drähte (22, 22') in einer selektiven Weise, wobei der Abschnitt proximal zu den Verschweißungen (24, 24') ist.

4. Verfahren nach irgendeinem der vorigen Ansprüche, wobei der Schritt des chemischen oder elektro-chemischen Entfernens chemisches oder elektro-chemisches Polieren einschließt.

5. Verfahren nach irgendeinem der vorigen Ansprüche, wobei die zusammengefügten benachbarten Drähte (22, 22') an den aneinanderstoßenden Bereichen im wesentlichen parallel zueinander sind.

6. Verfahren nach irgendeinem der vorigen Ansprüche, wobei der Schritt des Schweißens den Schritt des Bereitstellens eines Inertgases proximal zu den Verschweißungsgebieten umfasst.

7. Verfahren nach irgendeinem der vorigen Ansprüche, wobei der Schritt des Verschweißens ein Schweißen einschließt, welches ausgewählt ist aus der Gruppe, die aus Laser-Schweißen, Elektronenstrahlschweißen, Widerstandsschweißen, Wolfram-Inertgas-Schweißen, Metall-Inertgas-Schweißen und Kombinationen davon besteht.

8. Verfahren nach irgendeinem der vorigen Ansprüche, wobei der Schritt des Bildens der röhrenförmigen Struktur ein Flechten der Drähte, ein Wickeln der Drähte, ein Stricken der Drähte und Kombinationen davon umfasst.

9. Verfahren nach irgendeinem der vorigen Ansprüche, wobei die Drähte ein Drahtmaterial umfassen und wobei weiterhin der Schweißschritt weiter das Bereitstellen eines Füllmaterials umfasst, wobei das Drahtmaterial und das Füllmaterial dieselbe Art von Material sind.

10. Verfahren nach irgendeinem der vorigen Ansprüche, wobei der Draht ein radio-opakes Material umfasst.

11. Verfahren nach irgendeinem der Ansprüche 1-4, wobei der Schritt des chemischen oder elektro-chemi-

schen Entfernens des Abschnitts der Verschweißungen ein chemisches Polieren oder Ätzen, elektrochemisches Polieren oder Ätzen, elektro-chemisches Strahl-Polieren und Kombinationen davon umfasst.

12. Verfahren nach Anspruch 11, wobei der Schritt des elektro-chemischen Polierens oder elektro-chemischen Strahl-Polierens weiterhin den Schritt des Bereitstellens eines Elektrolyts einschließt, wobei der Elektrolyt ausgewählt ist aus der Gruppe, die aus $NaClO_3$ Elektrolyt, $NaNO_3$ Elektrolyt, NaCl Elektrolyt, $Na2Cr2O_7$ Elektrolyt, $HOCH_2CH_2OH$ Elektrolyt und Kombinationen davon besteht.

13. Verfahren nach Anspruch 11, wobei der Schritt des chemischen Polierens oder chemischen Ätzens weiterhin den Schritt des Bereitstellens einer oxydierenden Säure einschließt.

14. Verfahren nach Anspruch 1, wobei der Schritt des elektro-chemischen Entfernens des Abschnitts der Verschweißungen (24, 24') weiterhin den Schritt einschließt:

Bereitstellen eines Elektrolyts (32);
Anordnen einer Kathode in dem Elektrolyt (32);
Anordnen eines Abschnitts des Stents (10, 10') mit den Verschweißungen (24, 24') in dem Elektrolyt (32); und
Bereitstellen einer elektrischen Spannung oder eines Stroms, so dass ein Abschnitt der Verschweißungen (24, 24') in dem Elektrolyt (32) gelöst wird.

15. Verfahren nach Anspruch 1, weiterhin umfassend die Schritte:

Ausdehnen von zumindest einem der zusammengefügten Stent-Drähte, um einen verlängerten Stent-Draht (56, 62) bereitzustellen;
Wickeln des verlängerten Stent-Drahtes (56, 62), so dass das verlängerte Ende an ein proximales Paar von Stent-Drähten (52, 60 & 58, 64) anstößt; und
Schweißen des verlängerten und gewickelten Drahtes (56, 62) an das proximale Paar von Drähten (52, 60 & 58, 64).

16. Verfahren nach Anspruch 15, wobei der Schritt des Wickelns ein Formen des Drahtes (56, 62) in eine gleichseitig gekrümmte Schlaufe (66, 67, 78, 82) mit einem Scheitel (80, 84), aber ohne andere scharfe Biegungen, einschließt.

17. Verfahren nach Anspruch 15, wobei der Schritt des Wickelns ein Formen des Drahtes in eine gleichseitig gekrümmte Schlaufe (66, 67, 78, 82) mit einem Scheitel (80, 84) mit gleichen Krümmungen auf jeder Seite des Scheitels (80, 84) einschließt, wobei die gleichseitig gekrümmte Schlaufe (66, 67, 78, 82) keinen zweiten Scheitel mit ungleichen Krümmungen auf jeder Seite des zweiten Scheitels beinhaltet.

18. Verfahren nach Anspruch 1, weiterhin umfassend die Schritte:

Ausdehnen von zumindest einem der zusammengefügten Stent-Drähte über die anstoßenden Bereiche hinaus, um einen verlängerten Stent-Draht bereitzustellen; und
Wickeln des verlängerten Stent-Drahtes an seinem verlängerten Ende, um dort eine Spule (94) zu bilden.

19. Verfahren nach Anspruch 18, wobei eine Vielzahl von verlängerten Drähten in einer Spule (94) gebildet sind.

20. Verfahren nach Anspruch 1, wobei die verlängerten Drähte (18) biokompatible Materialien umfassen, die ausgewählt sind aus der Gruppe, die aus Nitinol, Kobalt-basierten Legierungen, rostfreiem Stahl, Platin, Gold, Titan, Tantal, Niob und Kombinationen davon besteht.

21. Verfahren nach Anspruch 20, wobei die verlängerten Drähte (18) Nitinol umfassen.

22. Verfahren nach Anspruch 1, wobei die verlängerten Drähte (18) Verbunddrähte für eine verbesserte Radio-Opakizität sind.

23. Verfahren nach Anspruch 22, wobei die verlängerten Drähte (18) einen inneren Kern aus Tantal, Gold, Platin, Iridium oder einer Kombination davon aufweisen, und einen äußeren Abschnitt aus Nitinol.

24. Ein implantierbarer Stent (10, 10'), umfassend:

eine Vielzahl von Drähten (18) mit einem Durchmesser, die angeordnet sind, um eine hohle röhrenförmige Struktur mit einer röhrenförmigen Wand zu bilden, um eine innere Oberfläche und eine äußere Oberfläche zu definieren, und gegenüberliegenden offenen ersten (14) und zweiten (12) Enden,
wobei die Drähte (18) an dem zweiten offenen Ende (12) enden und benachbarte anstoßende Drähte (22, 22') an das zweite offene Ende (12) mit einem Schweißmaterial geschweißt sind, um Verschweißungen (24, 24') bereitzustellen, und
dadurch gekennzeichnet, dass zumindest ungefähr 25 bis ungefähr 50 Gewichts-% des geschweißten Materials selektiv entfernt wurde,

um das Profil der Verschweißungen (24, 24') auf weniger als den Durchmesser der Stent-Drähte (18) zu reduzieren.

25. Stent (10, 10') nach Anspruch 24, wobei das Schweißmaterial aus benachbarten aneinanderstoßenden Drähten (22, 22') gebildet ist.

26. Stent (10, 10') nach Anspruch 24, wobei das Schweißmaterial ein Füllmaterial ist.

27. Stent (10, 10') nach Anspruch 24, wobei der Abschnitt des geschweißten Materials durch chemisches oder elektro-chemisches Polieren entfernt wurde.

28. Stent (10, 10') nach Anspruch 24 oder 27, wobei ein Abschnitt der benachbarten aneinanderstoßenden Drähte (22, 22') proximal zu den Verschweißungen (24, 24') durch chemisches oder elektro-chemisches Polieren entfernt wurde.

29. Stent (10, 10') nach Anspruch 28, wobei das reduzierte Profil der Verschweißungen (24, 24') auf eine Tiefe und/oder eine Breite der Verschweißungen (24, 24') von ungefähr 150 Mikrometern (150 microns) oder weniger reduziert wird.

30. Stent (10, 10') nach Anspruch 24, wobei das reduzierte Profil der Verschweißungen (24, 24') ungefähr 5 bis ungefähr 50 Linear-Prozent eines Durchmessers des Stent-Drahtes (18) beträgt.

31. Stent (10, 10') nach Anspruch 24, wobei die Drähte (18) ein biokompatibles Material umfassen, welches ausgewählt ist aus der Gruppe, die aus Nitinol, rostfreiem Stahl, einer Kobalt-basierten Legierung, Platin, Gold, Titan, Tantal, Niob und Kombinationen davon besteht.

32. Stent (10, 10') nach Anspruch 31, wobei das Schweißmaterial und das Drahtmaterial dasselbe sind.

33. Stent (10, 10') nach Anspruch 31, wobei das Schweißmaterial und das Drahtmaterial Nitinol sind.

34. Stent (10, 10') nach Anspruch 31, wobei die verlängerten Drähte (18) einen inneren Kern aus Tantal, Gold, Platin, Iridium oder einer Kombination davon aufweisen, und einen äußeren Abschnitt aus Nitinol.

35. Stent (10, 10') nach Anspruch 24, wobei zumindest einige von einigen der benachbarten aneinanderstoßenden Stent-Drähte (56, 62) sich über die Verschweißungen (24, 24') hinaus erstrecken, und in eine gleichseitig gekrümmte Schlaufe (66, 67, 78, 82) gewickelt sind, die einen Scheitel (80, 84), aber keine weiteren scharfen Biegungen aufweist.

36. Stent (10, 10') nach Anspruch 24, wobei zumindest einige der benachbarten aneinanderstoßenden Stent-Drähte (56, 62) sich über die Verschweißungen (24, 24') hinaus erstrecken und in eine gleichseitig gekrümmte Schlaufe (66, 67, 78, 82) mit einem Scheitel (80, 84) mit gleichen Krümmungen auf jeder Seite des einen Scheitels (80, 84) gewickelt sind, wobei die gleichseitig gekrümmte Schlaufe (66, 67, 78, 82) keinen zweiten Scheitel mit unterschiedlichen Krümmungen auf jeder Seite des zweiten Scheitels aufweist.

37. Stent (10, 10') nach Anspruch 24, wobei zumindest einige der benachbarten aneinanderstoßenden Stent-Drähte sich über die Verschweißungen hinaus erstrekken und gewickelt sind, um dort eine Spule (94) zu bilden.

38. Stent (10, 10') nach Anspruch 24, wobei der Stent mit Silikon (102) beschichtet ist.

39. Stent (10, 10') nach Anspruch 24, wobei der Stent teilweise oder vollständig mit Silikon (102) bedeckt ist.

40. Stent (10, 10') nach Anspruch 24, weiterhin umfassend ein hohles röhrenförmiges Transplantat, welches über der inneren (106) oder der äußeren (104) Oberfläche angeordnet ist.

41. Stent (10, 10') nach Anspruch 24, wobei das Transplantat ein polymeres Material ist.

42. Stent (10, 10') nach Anspruch 41, wobei das polymere Material ausgewählt ist aus der Gruppe, die aus Polyester, Polypropylen, Polyethylen, Polyurethan, Polynaphtalen, Polytetrafluorethylen, ausgedehntem Polytetrafluorethylen, Silikon und Kombinationen davon besteht.

43. Stent (10, 10') nach Anspruch 24, wobei der Stent ein geflochtener Stent ist.

44. Stent (10, 10') nach Anspruch 24, weiterhin einen polymeren Ring (96) einschließend, der über der äußeren Oberfläche (104) und dem zweiten offenen Ende (12) angeordnet ist.

45. Stent (10, 10') nach Anspruch 24, weiterhin eine Metall- oder Nahtschlaufe aufweisend, die an eines der offenen Enden gesichert ist.

Revendications

1. Un procédé de fabrication d'un stent implantable (10,

10') comprenant :

l'apport d'une pluralité de fils de stent allongés (18) présentant un diamètre ;
la formation desdits fils en une structure tubulaire creuse possédant une première (14) et une seconde (12) extrémités ouvertes ;
la terminaison desdits fils à ladite seconde extrémité (12) ;
l'alignement desdits fils (18) à ladite seconde extrémité (12) en une pluralité de fils adjacents associés (22, 22') pour définir une pluralité de régions en aboutement ;
le soudage desdits fils adjacents associés (22, 22') à l'un et à l'autre à l'endroit desdites régions d'aboutement pour définir une pluralité de soudures (24, 24') ;
caractérisé en ce que le procédé comprend en outre :

l'élimination chimique ou électrochimique d'environ 25 % à environ 50 % en poids du matériau de soudage desdites soudures (24, 24') de manière sélective pour réduire les profils de soudure à moins que le diamètre des fils de stent (18).

2. Le procédé de la revendication 1, dans lequel :

l'élimination chimique ou électrochimique d'une partie desdites soudures (24, 24') réduit une profondeur et/ou une largeur des soudures (24, 24') à environ 150 micromètres (150 microns) ou moins.

3. Le procédé de la revendication 1, comprenant en outre :

l'élimination chimique ou électrochimique d'une partie desdits fils adjacents associés (22, 22') de manière sélective, ladite partie étant proximale auxdites soudures (24, 24').

4. Le procédé de l'une des revendications précédentes, dans lequel ladite étape d'élimination chimique ou électrochimique comprend un polissage chimique ou électrochimique.

5. Le procédé de l'une des revendications précédentes, dans lequel lesdits fils adjacents associés (22, 22') sont substantiellement parallèles l'un à l'autre à l'endroit desdites régions d'aboutement.

6. Le procédé de l'une des revendications précédentes, dans lequel l'étape de soudage comprend l'étape consistant à apporter un gaz inerte proximalement aux zones de soudure.

7. Le procédé de l'une des revendications précédentes, dans lequel l'étape de soudage comprend un soudage choisi dans le groupe constitué par le soudage laser, le soudage par faisceau électronique, le soudage par résistance, le soudage sous gaz inerte tungstène, le soudage sous gaz inerte métal et les combinaisons des précédents.

8. Le procédé de l'une des revendications précédentes, dans lequel l'étape de formation de ladite structure tubulaire comprend le tissage desdits fils, l'enroulement desdits fils, le tricotage desdits fils et les combinaisons des précédents.

9. Le procédé de l'une des revendications précédentes, dans lequel lesdits fils comprennent un matériau de fil et dans lequel en outre ladite étape de soudage comprend en outre l'apport d'un matériau de remplissage, ledit matériau de fil et ledit matériau de remplissage étant des matériaux du même type.

10. Le procédé de l'une des revendications précédentes, dans lequel ledit fil comprend un matériau radio-opaque.

11. Le procédé de l'une des revendications 1 à 4, dans lequel l'étape d'élimination chimique ou électrochimique de ladite partie desdites soudures comprend un polissage ou une gravure chimique, un polissage ou une gravure électrochimique, un polissage électrochimique par jet et les combinaisons des précédents.

12. Le procédé de la revendication 11, dans lequel l'étape de polissage électrochimique ou de polissage électrochimique par jet comprend en outre l'étape d'apport d'un électrolyte, dans lequel l'électrolyte est choisi dans le groupe formé par l'électrolyte $NaClO_3$, l'électrolyte $NaNO_3$, l'électrolyte NaCl, l'électrolyte $Na_2Cr_2O_7$, l'électrolyte $HOCH_2CH_2OH$ et les combinaisons des précédents.

13. Le procédé de la revendication 11, dans lequel l'étape de polissage chimique ou de gravure chimique comprend en outre l'étape d'apport d'un acide oxydant.

14. Le procédé de la revendication 1, dans lequel l'étape d'élimination électrochimique de ladite partie desdites soudures (24, 24') comprend en outre l'étape de :

apport d'un électrolyte (32) ;
placement d'une cathode dans ledit électrolyte (32) ;
placement d'une partie dudit stent (10, 10') comportant lesdites soudures (24, 24') dans ledit électrolyte (32) ; et
apport d'une tension ou d'un courant électrique

de sorte qu'une partie desdites soudures (24, 24') se dissolve dans l'électrolyte (32).

15. Le procédé de la revendication 1, comprenant en outre les étapes de :

allongement d'au moins l'un des fils de stent associés pour obtenir un fil de stent allongé (56, 62) ;
formation d'une boucle avec ledit fil de stent allongé (56, 62) de sorte que l'extrémité allongée vienne en butée contre une paire proximale de fils de stent (52, 60 & 58, 64) ; et
soudage du fil allongé et bouclé (56, 62) à ladite paire proximale de fils (52, 60 et 58, 64).

16. Le procédé de la revendication 15, dans lequel l'étape de formation d'une boucle comprend le formage du fil (56, 62) en une boucle courbée équilatéralement (66, 67, 78, 82) possédant un sommet (80, 84) mais ne possédant pas d'autre courbure serrée.

17. Le procédé de la revendication 15, dans lequel l'étape de formation d'une boucle comprend le formage du fil en une boucle courbée équilatéralement (66, 67, 78, 82) possédant un sommet (80, 84) avec des courbures similaires de chaque côté dudit sommet (80, 84), ladite boucle courbée équilatéralement (66, 67, 78, 82) ne contenant pas de second sommet présentant des courbures dissemblables de part et d'autre du second sommet.

18. Le procédé de la revendication 1, comprenant en outre l'étape suivante :

allongement d'au moins l'un des fils de stent associés au-delà des régions d'aboutement pour obtenir un fil de stent allongé ; et
formation d'une boucle dudit fil de stent allongé à son extrémité allongée pour former un enroulement (84) à cet endroit.

19. Le procédé de la revendication 18, dans lequel une pluralité de fils allongés sont formés en un seul enroulement (94).

20. Le procédé de la revendication 1, dans lequel les fils allongés (18) comprennent des matériaux biocompatibles choisis dans le groupe formé par le nitinol, les alliages à base de cobalt, l'acier inoxydable, le platine, l'or, le titane, le tantale, le niobium et les combinaisons des précédents.

21. Le procédé de la revendication 20, dans lequel les fils allongés comprennent du nitinol.

22. Le procédé de la revendication 1, dans lequel les fils allongés (18) sont des fils composites pour une radio-opacité accrue.

23. Le procédé de la revendication 22, dans lequel les fils allongés possèdent un coeur interne en tantale, en or, en platine, en iridium ou en une combinaison des précédents et une partie externe en nitinol.

24. Un stent implantable (10, 10') comprenant :

une pluralité de fils (18) présentant un diamètre, configurés pour former une structure tubulaire creuse présentant une paroi tubulaire pour définir une surface intérieure et une surface extérieure et possédant des première (14) et seconde (12) extrémités ouvertes opposées,
dans lequel les fils (18) se terminent à ladite seconde extrémité ouverte (12) et des fils en aboutement adjacent (22, 22') sont soudés à l'endroit de la seconde extrémité ouverte (12) avec un matériau de soudage pour obtenir des soudures (24, 24'), et
caractérisé en ce qu'au moins environ 25 % à environ 50 % en poids du matériau soudé a été sélectivement éliminé pour réduire le profil des soudures (24, 24') à moins que le diamètre des fils de stent (18).

25. Le stent (10, 10') de la revendication 24, dans lequel ledit matériau de soudage est formé à partir desdits fils en aboutement adjacents (22, 22').

26. Le stent (10, 10') de la revendication 24, dans lequel ledit matériau de soudage est un matériau de remplissage.

27. Le stent (10, 10') de la revendication 24, dans lequel la partie de matériau soudé a été éliminée par polissage chimique ou électrochimique.

28. Le stent (10, 10') de la revendication 24 ou la revendication 27, dans lequel une partie des fils en aboutement adjacent (22, 22') proximaux desdites soudures (24, 24') a été éliminée par polissage chimique ou électrochimique.

29. Le stent (10, 10') de la revendication 28, dans lequel le profil réduit des soudures (24, 24') est réduit à une profondeur et/ou à une largeur des soudures (24, 24') d'environ 150 micromètres (150 microns) ou moins.

30. Le stent (10, 10') de la revendication 24, dans lequel le profil réduit des soudures (24, 24') est d'environ 5 à environ 50 pourcents linéaires d'un diamètre des fils de stent (18).

31. Le stent (10, 10') de la revendication 24, dans lequel les fils (18) comprennent un matériau biocompatible

choisi dans le groupe formé par le nitinol, l'acier inoxydable, les alliages à base de cobalt, le platine, l'or, le titane, le tantale, le niobium et les combinaisons des précédents.

32. Le stent (10, 10') de la revendication 31, dans lequel le matériau de la soudure et le matériau du fil sont les mêmes.

33. Le stent (10, 10') de la revendication 31, dans lequel le matériau de la soudure et le matériau du fil sont du nitinol.

34. Le stent (10, 10') de la revendication 31, dans lequel les fils allongés (18) possèdent un coeur interne en tantale, en or, en platine, en iridium ou en une combinaison des précédents et une partie extérieure en nitinol.

35. Le stent (10, 10') de la revendication 24, dans lequel au moins certains des fils de stent en aboutement adjacent (56, 62) sont allongés au-delà des soudures (24, 24') et bouclés en une boucle courbée équilatéralement (66, 67, 78, 82) possédant un sommet (80, 84) mais ne possédant pas d'autre courbure serrée.

36. Le stent (10, 10') de la revendication 24, dans lequel au moins certains des fils de stent en aboutement adjacent (56, 62) sont allongés au-delà des soudures (24, 24') et bouclés en une boucle courbée équilatéralement (66, 67, 78, 82) possédant un sommet (80, 84) avec des courbures semblables de chaque côté dudit sommet (80, 84), ladite boucle courbée équilatéralement (66, 67, 78, 82) ne contenant pas de second sommet présentant des courbures dissemblables de chaque côté du second sommet.

37. Le stent (10, 10') de la revendication 24, dans lequel au moins certains des fils de stent en aboutement adjacent sont allongés au-delà des soudures et bouclés pour former un bobinage (94) à cet endroit.

38. Le stent (10, 10') de la revendication 24, dans lequel le stent est revêtu de silicone (102).

39. Le stent (10, 10') de la revendication 24, dans lequel le stent est partiellement ou totalement recouvert de silicone.

40. Le stent (10, 10') de la revendication 24, comprenant en outre une greffe tubulaire creuse disposée au-dessus de la surface intérieure (106) ou extérieure (104).

41. Le stent (10, 10') de la revendication 40, dans lequel la greffe est un matériau polymère.

42. Le stent (10, 10') de la revendication 41, dans lequel le matériau polymère est choisi dans le groupe formé par le polyester, le polypropylène, le polyéthylène, le polyuréthanne, le polynaphtalène, le polytétrafluoroéthylène, le polytétrafluoroéthylène expansé, le silicone et les combinaisons des précédents.

43. Le stent (10, 10') de la revendication 24, dans lequel le stent est un stent tressé.

44. Le stent (10, 10') de la revendication 24, comprenant en outre un anneau polymère (96) disposé au-dessus de la surface extérieure (104) à ladite seconde extrémité ouverte (12).

45. Le stent (10, 10') de la revendication 24, comprenant en outre une boucle métallique ou de suture assujettie à l'une desdites extrémités ouvertes.

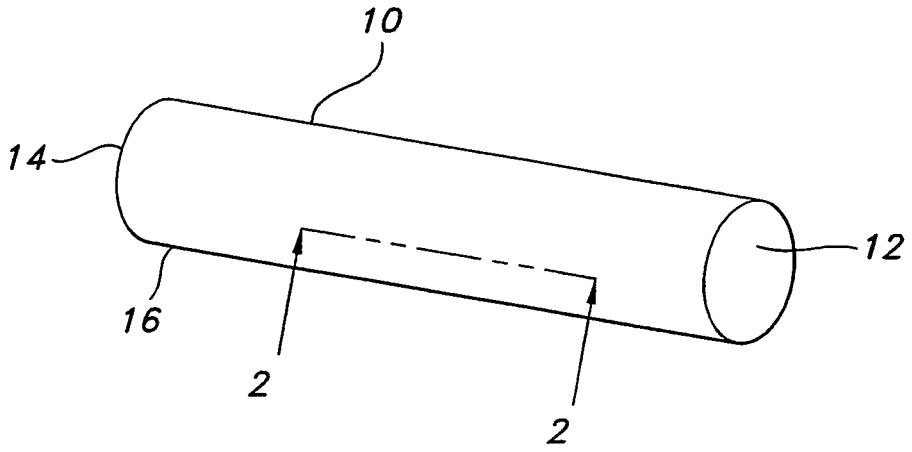

FIG. 1

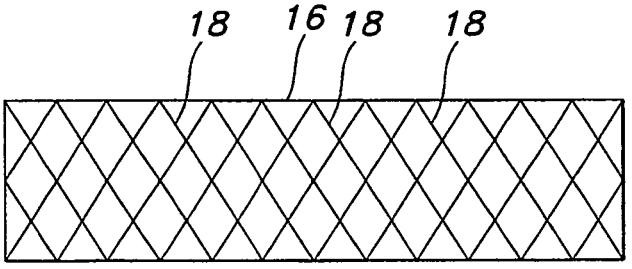

FIG. 2

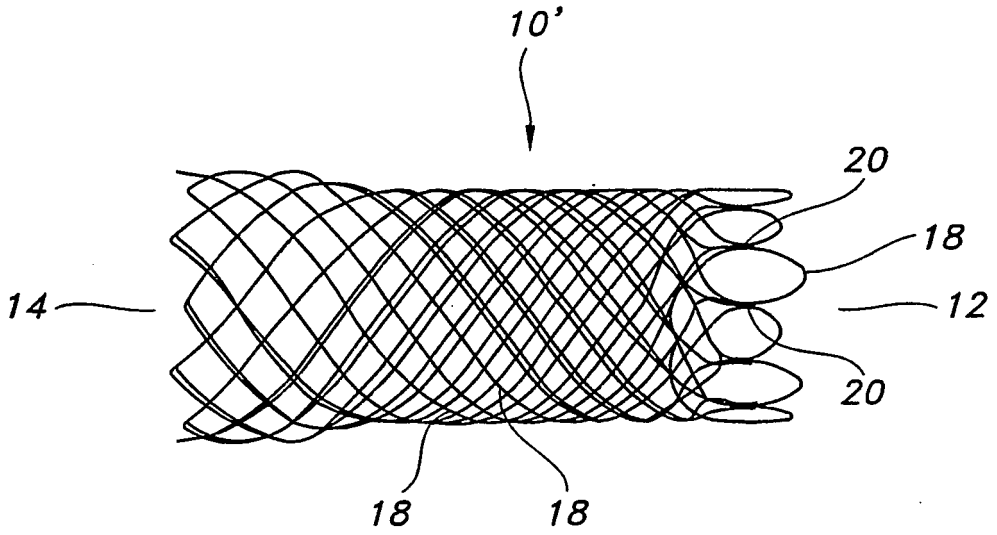

FIG. 3

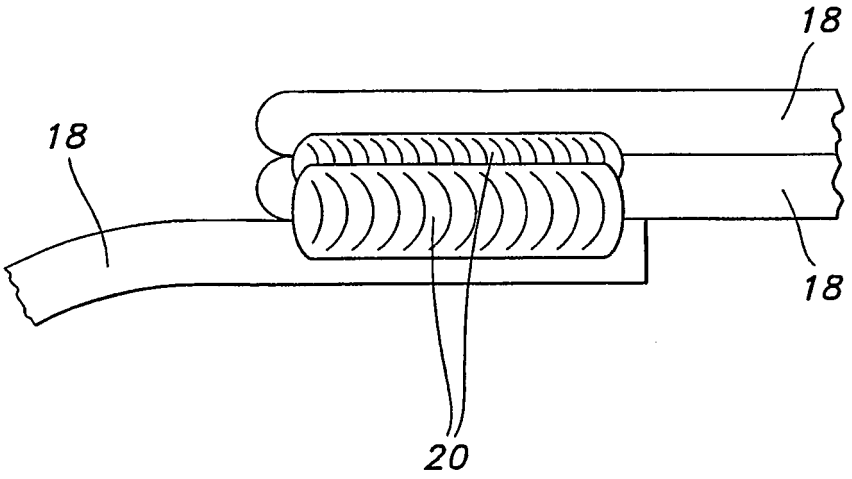

FIG. 4

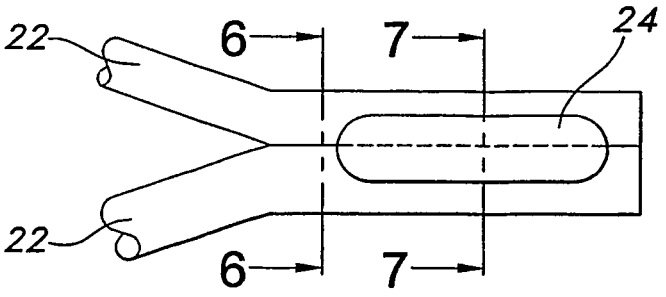

FIG. 5

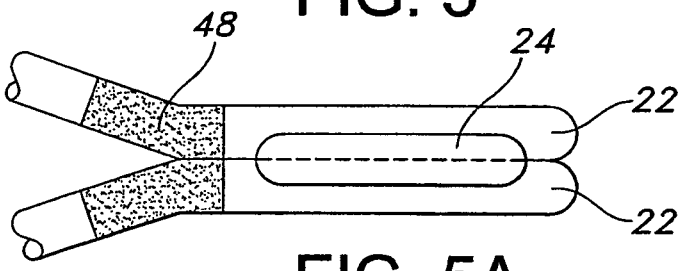

FIG. 5A

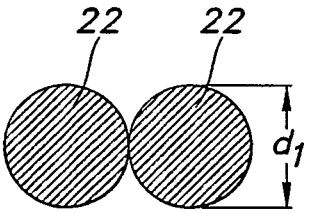

FIG. 6

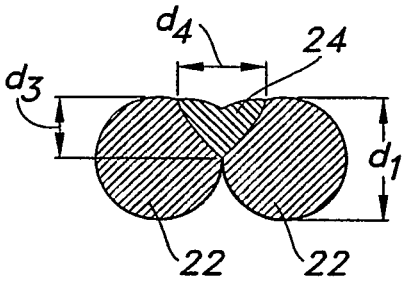

FIG. 7

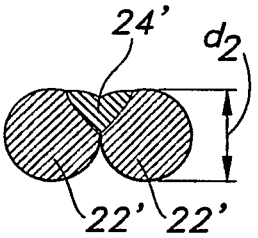

FIG. 8

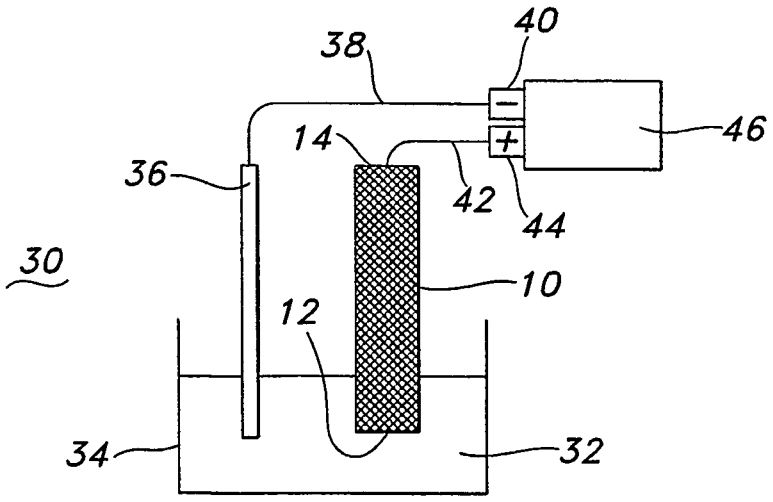

FIG. 9

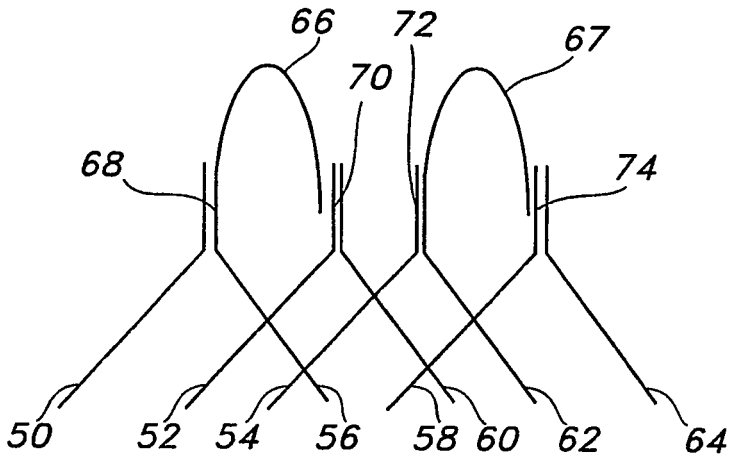

FIG. 10

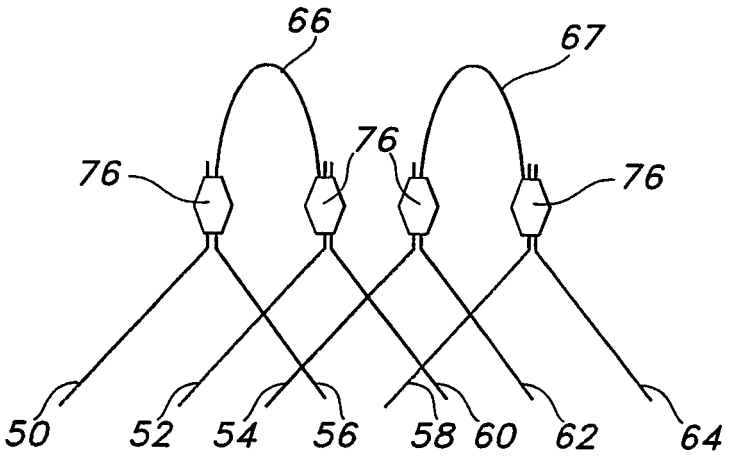

FIG. 11

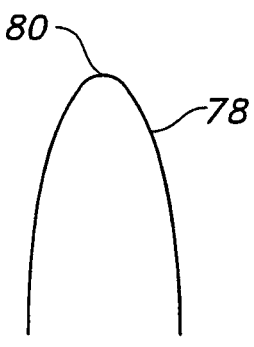

FIG. 12

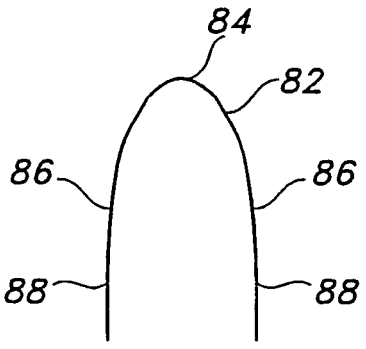

FIG. 13

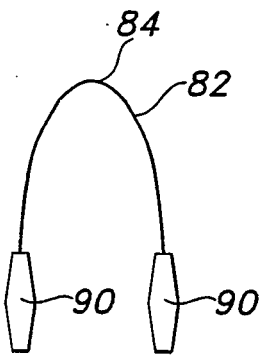

FIG. 14

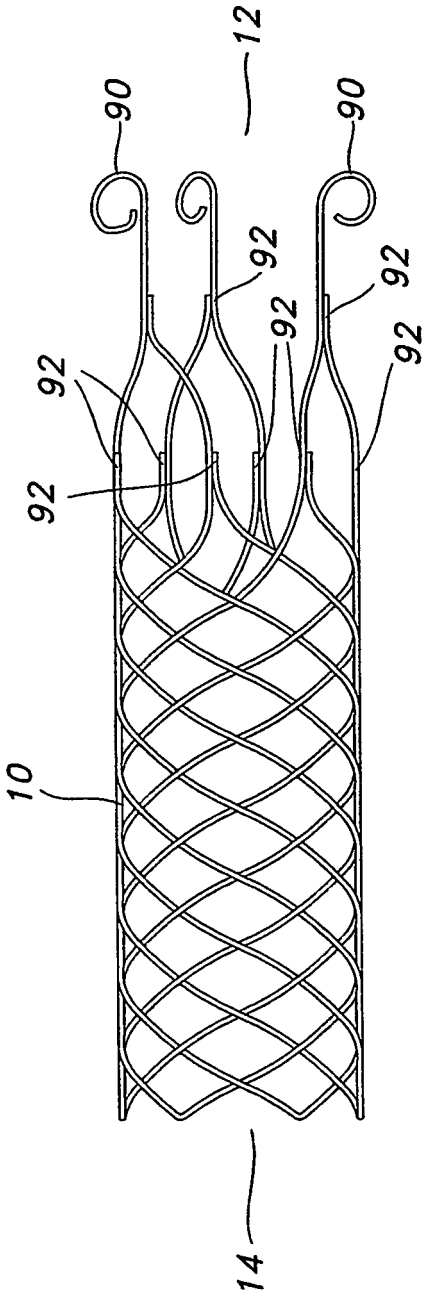

FIG. 15

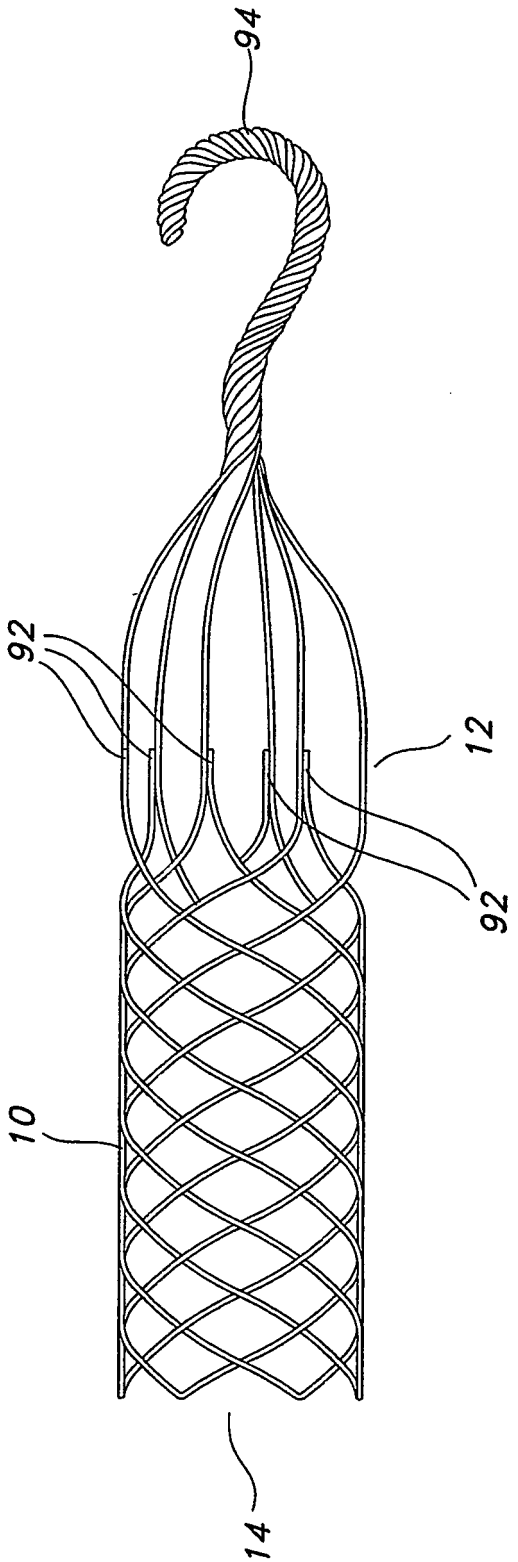

FIG. 16

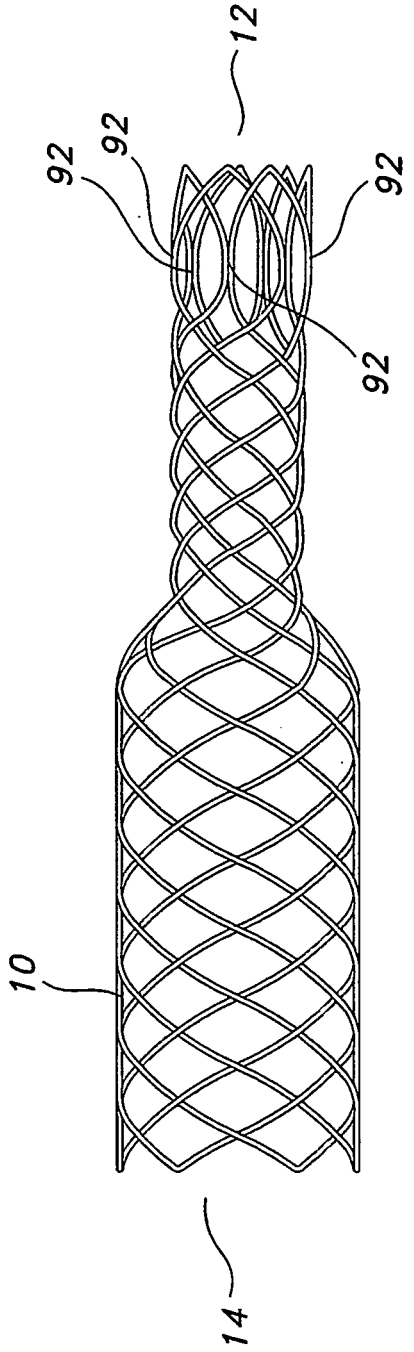

FIG. 17

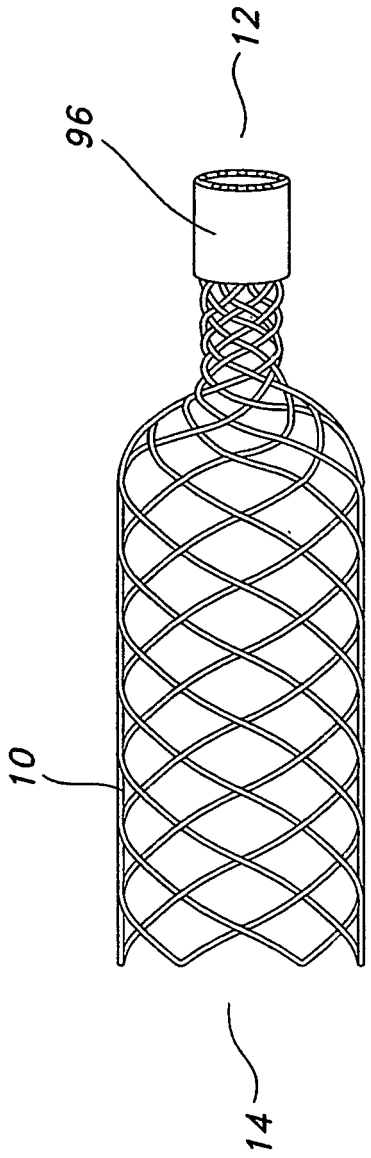

FIG. 18

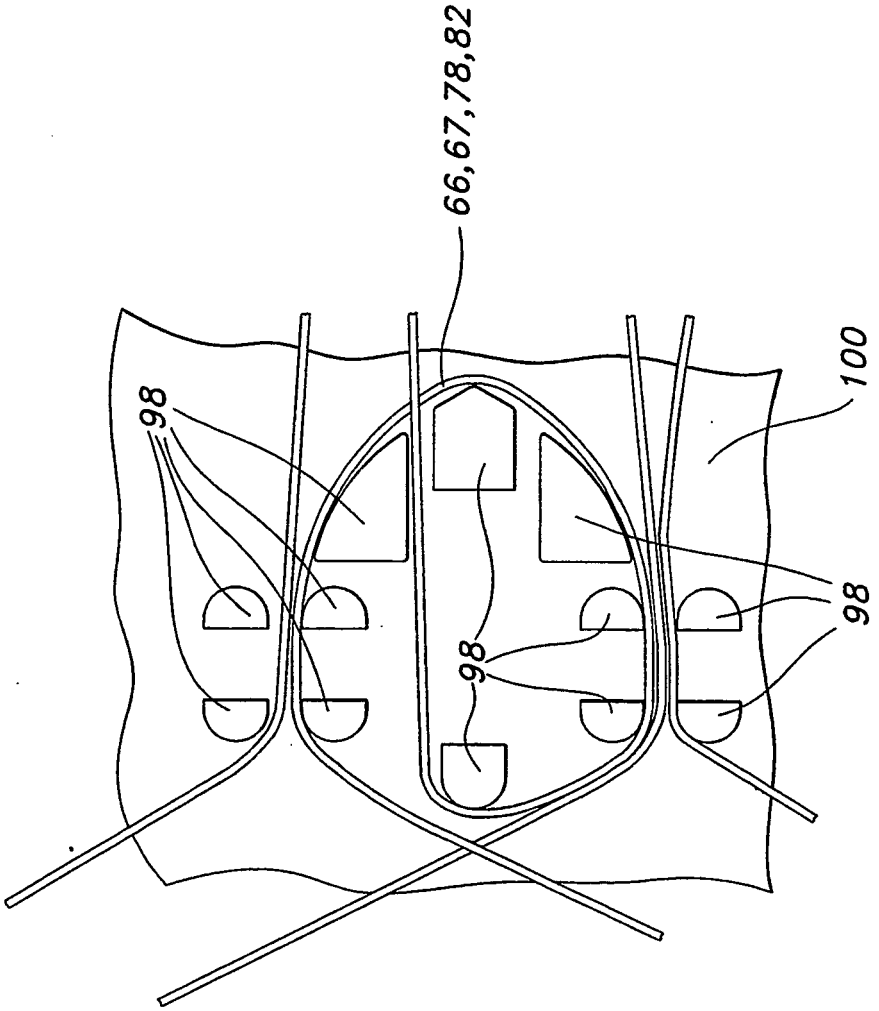

FIG. 19

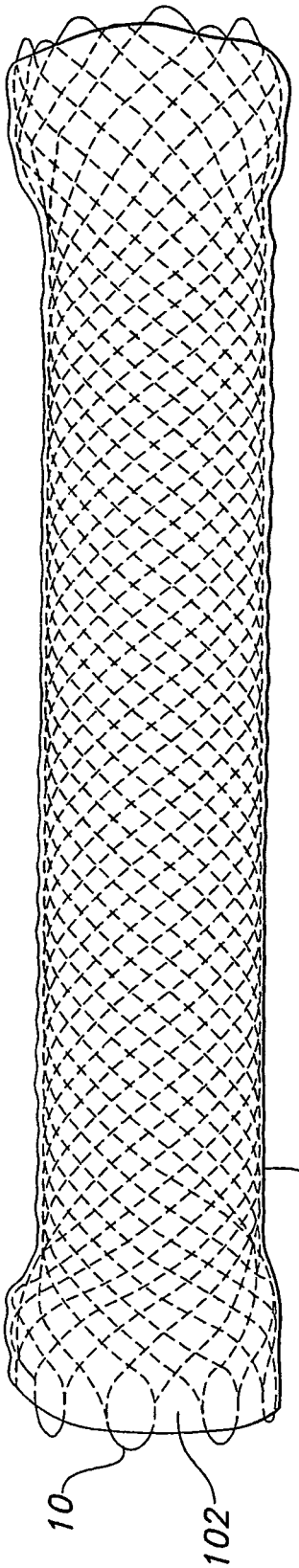

FIG. 20

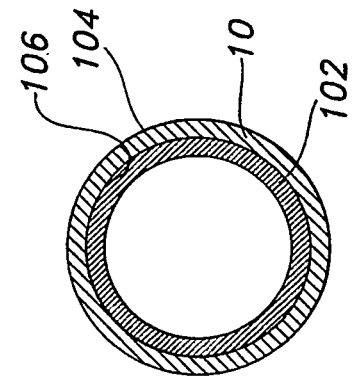

FIG. 22

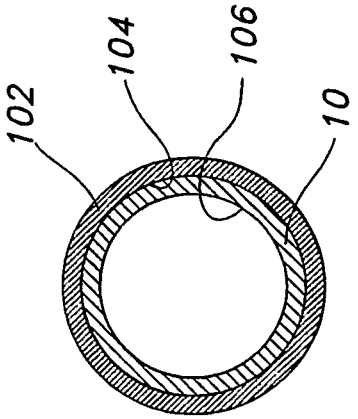

FIG. 21

REFERENCES CITED IN THE DESCRIPTION

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