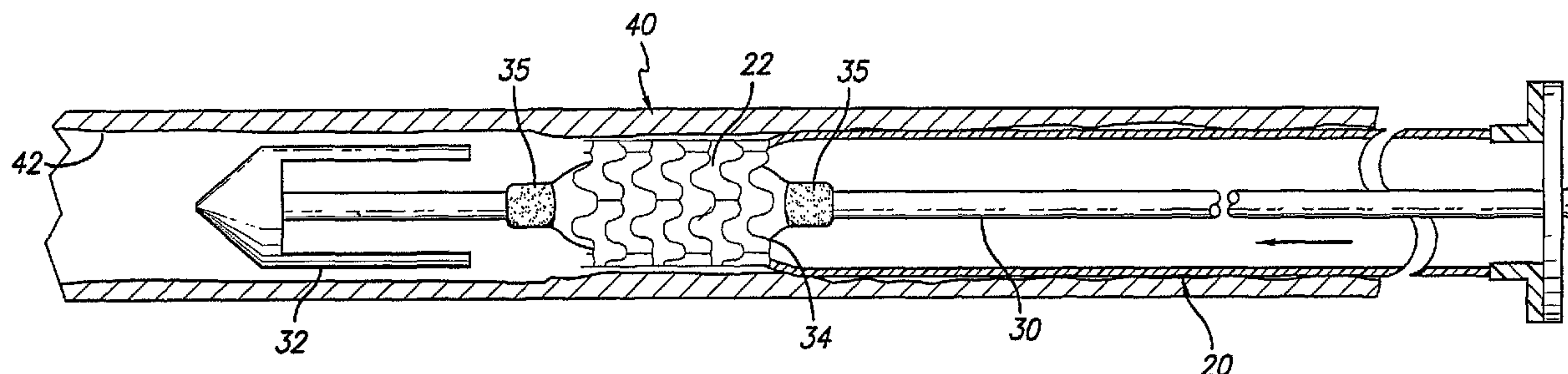




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 (54) Title: ENDOLUMINALLY PLACED VASCULAR GRAFT



(57) Abrégé/Abstract:

A delivery system and device for re-lining bodily vessels. A stent (22) is attached to a distal end of a tubular lining (20) made of biocompatible material and loaded into a hollow atraumatic tip (32). A semi-rigid shaft (30) connects the atraumatic tip to a stopper (36) and runs through the center of the tubular lining (20). The proximal end of the tubular lining (20) is attached to a sliding hub (28). Optionally, a balloon (34) is positioned near the stent in fluid communication with the shaft. The assembled device is introduced into a bodily vessel (40) following an endarterectomy or atherectomy procedure. The atraumatic tip (32) is delivered to a pre-determined location and upon reaching that destination, the stent (22) is released from the tip (32) to expand against the vessel wall. If a balloon (34) is utilized, it is inflated to ensure that the stent (22) is fully deployed within the vessel. The balloon (34) is then deflated and the tip (32) and shaft (30) are pulled through the expanded stent (22) and tubular lining (20). The sliding hub (28) is cut off of the tubular lining and the proximal anastomosis is completed.

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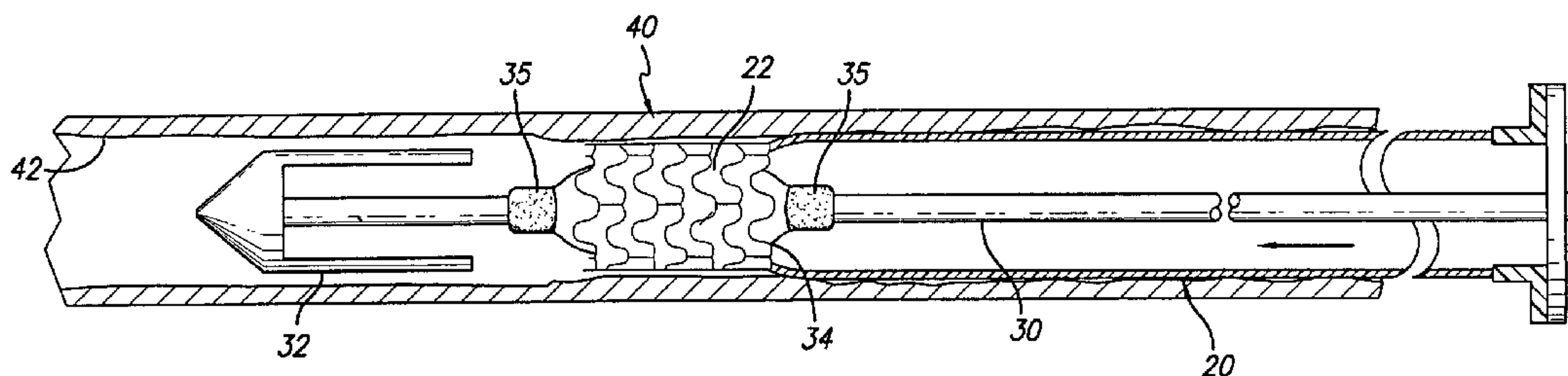
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(57) **Abstract:** A delivery system and device for re-lining bodily vessels. A stent (22) is attached to a distal end of a tubular lining (20) made of biocompatible material and loaded into a hollow atraumatic tip (32). A semi-rigid shaft (30) connects the atraumatic tip to a stopper (36) and runs through the center of the tubular lining (20). The proximal end of the tubular lining (20) is attached to a sliding hub (28). Optionally, a balloon (34) is positioned near the stent in fluid communication with the shaft. The assembled device is introduced into a bodily vessel (40) following an endarterectomy or atherectomy procedure. The atraumatic tip (32) is delivered to a pre-determined location and upon reaching that destination, the stent (22) is released from the tip (32) to expand against the vessel wall. If a balloon (34) is utilized, it is inflated to ensure that the stent (22) is fully deployed within the vessel. The balloon (34) is then deflated and the tip (32) and shaft (30) are pulled through the expanded stent (22) and tubular lining (20). The sliding hub (28) is cut off of the tubular lining and the proximal anastomosis is completed.



WO 02/028316 A3

## ENDOLUMINALLY PLACED VASCULAR GRAFT

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

The present invention relates generally to the field of medical devices, and  
5 more particularly, to a graft to re-line a debulked vessel.

#### 2. Description of Related Art

Arterial stenosis is a disease of the artery wherein a portion of the vessel  
becomes occluded, primarily with plaque (atheroma) containing cholesterol, lipid  
material, macrophages and proliferating smooth muscle cells, consequently  
10 restricting blood flow and causing further complications. Traditionally, arterial  
stenosis has been treated by surgical construction of a bypass channel to connect  
healthy parts of the vessel around the atheroma. While the bypass method may  
produce good results, a major disadvantage is the invasiveness of the surgery  
because the procedure requires general anesthesia and a substantial post-surgical  
15 healing period.

Another, less invasive method of treatment includes balloon catheter  
angioplasty, where a balloon catheter is inserted into the diseased portion of the  
vessel and inflated, pushing the atheroma outward and opening the vessel. While  
balloon catheter angioplasty is much less invasive than bypass surgery, it does not  
20 enjoy similar success rates due to frequent restenosis of the vessel. To overcome  
this problem, stents and other similar endoluminal devices may be inserted to  
keep the vessel open following angioplasty. Cellular infiltration through the  
stents' mesh-like structure makes the use of bare stents less than optimal,  
particularly in longer (>5 cm) legions. Consequently, the stent may be covered  
25 with a biocompatible material such as polytetrafluoroethylene (PTFE) to prevent  
cellular infiltration.

Endarterectomy is a method for treating occluded portions of a vessel  
where the atheroma is surgically removed, along with the inner two layers (intima  
and media) of the three-layered artery. Following the endarterectomy, only the



adventitia layer remains, thus the vessel can be prone to cellular accumulation and thrombosis.

Artherectomy is a method for treating occluded blood vessels where a mechanical device is inserted into the vessel, removing atheroma by cutting or grinding the plaque and creating an open channel. Similar to endarterectomy, this procedure can trigger a cellular response that leads to thrombosis and/or restenosis of the vessel.

Another term for endarterectomy and artherectomy is "debulking." Debulking is simply the removal of atheroma, plaque and other tissue to restore blood flow in a vessel. To prevent the cellular response that leads to thrombosis and/or restenosis following a debulking procedure, the vessel can be re-lined with PTFE or other biocompatible materials.

Many delivery systems have been used for introducing stents, grafts, and other endoluminal devices into bodily vessels with minimum invasiveness. One problem with a number of these systems, however, is that they require multiple components and procedural steps to deliver and deploy the device against the vessel wall. In addition, grafts and other endoluminal devices used to currently re-line vessels are not optimal due to problems with effectively anchoring the device within the vessel.

The present invention overcomes these stated drawbacks by providing a simple delivery system and device to re-line a vessel following debulking.

#### SUMMARY OF THE INVENTION

The present invention is directed to a delivery system and device for re-lining blood vessels. In particular, following debulking procedures, a graft containing a stent or other fixation device is deployed slightly distal to the debulked section of the vessel. A small balloon on the shaft of the delivery catheter is inflated to ensure good opposition of the graft to the vessel wall. Next, the delivery system is removed through the newly implanted graft, which is sutured proximally to the debulked vessel.

It is an object of this invention to provide an endoluminal vascular graft device to re-line a debulked vessel as a less invasive alternative to traditional surgical bypass.

5 It is another object of this invention to provide an endoluminal vascular graft device that has a minimal profile when loaded into an insertion system, can be seen with fluoroscopic imaging and can be deployed quickly and easily.

It is yet another object of this invention to provide a delivery system to introduce the endoluminal vascular graft device quickly, easily and effectively within the debulked vessel.

10 These and additional objects are accomplished by delivering a graft with an attached stent or other support structure to a debulked vessel. The replacement lining is delivered to the desired site by using a delivery system, including an atraumatic tip to house the stent, a sliding hub attached to the graft lining material, and an inner shaft connected to the tip.

15 To prepare the replacement lining for delivery, the distal stent is bonded, attached or encapsulated to the graft material. The graft material can either be supported, unsupported, or a combination of the two to resist compression. The distal portion is compressed into the atraumatic tip for delivery to the desired site within the treated vessel. Ideally, a self-expanding stent is used for this purpose so  
20 that the deployment of the stent occurs quickly, as soon as it is released from the atraumatic tip, thus ensuring that the stent can be deployed at the pre-selected location without migration in either direction within the vessel.

The atraumatic tip is connected to an inner shaft that extends through the compressed stent and graft material to the proximal end of the delivery device.  
25 The connection between the tip and the shaft allows the device to be maneuvered as it is being inserted into the vessel. Optionally coupled to the shaft, proximal to the loaded stent, is a balloon that is positioned to be inside of the stent after the stent is removed from the atraumatic tip. Once the stent is removed from the atraumatic tip and expands to come into contact with the vessel wall, the balloon  
30 can be inflated to ensure a good fit to the vessel wall. A sliding hub is attached to the proximal end of the graft lining material so that the distal stent can be pulled

out of the atraumatic tip. After the delivery system is removed from the vessel and the graft lining material is pulled taut, the sliding hub is cut off of the graft lining material and the lining material is sutured to the treated vessel.

5 A more complete understanding of the endoluminally placed vascular graft and delivery system will be afforded to those skilled in the art, as well as a realization of additional advantages and objects thereof, by a consideration of the following detailed description of the preferred embodiment. Reference will be made to the appended sheets of drawings, which will first be described briefly.

#### BRIEF DESCRIPTION OF THE DRAWINGS

10 Fig. 1 is a perspective view of a distal end of the vascular graft device after it has been deployed from the catheter.

Fig. 2 is a cross-sectional view of a preferred embodiment of the vascular graft device and delivery system of the present invention.

15 Fig. 3A is a cross-sectional view of the present invention being delivered *in vivo*.

Fig. 3B is cross-sectional view of the present invention after the stent has been deployed from the atraumatic tip.

Fig. 3C is a cross-sectional view of the present invention as the stent is tightly fit to the vessel wall.

20 Fig. 3D is a cross-sectional view of the present invention as the delivery system is being removed from inside the replacement lining.

Fig. 4 is a cross-sectional view of an alternate embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE INVENTION

25 The present invention satisfies the need for a replacement lining for a vessel and a method of delivering the lining to a desired location. This is accomplished by bonding, attaching or encapsulating a stent at one end of a biocompatible plastic lining material and loading the stent and lining into a delivery system including an atraumatic tip, a sliding hub and an inner shaft with  
30 a balloon.



Referring now to the drawings, in which like reference numbers represent similar or identical structures throughout, Fig. 1 illustrates a preferred embodiment of the replacement lining of the present invention. A distal end of a replacement lining **20** is shown with a shadow view of a stent **22** attached thereto. The stent **22** may be attached to the lining **20** at its distal end in any number of ways including, but not limited to, direct bonding, bonding with the use of an adhesive material, and encapsulation with the use of an additional tubular portion of ePTFE. The stent **22** can be attached to the luminal or abluminal surface of the lining, or in the case of encapsulation, the stent can have the lining as its luminal or abluminal surface. The lining is a biocompatible graft material, which in the preferred embodiment is expanded polytetrafluoroethylene (ePTFE). The preferred ePTFE is one optimized for bond strength as described in U.S. Patent 5,749,880, incorporated by reference herein. In Fig. 1, the stent **22** is self-expanding, thus not requiring any external force to conform to the sides of the vessel wall in which it is placed. However, many other stent configurations are possible, including various self-expanding and balloon-expandable stents.

Fig. 1 shows encapsulation of the stent **22** as the attachment method to the lining **20**. The stent **22** is encapsulated between two layers of ePTFE **24** and **26** by utilizing a mandrel assembly. Once the appropriate ePTFE coverings are placed onto the luminal and abluminal surfaces, the stent **22** is encapsulated within the replacement lining **20** at the lining's distal end by connecting or bonding the luminal covering **26** to the abluminal covering **24**. The replacement lining **20** represents the continuation of the ePTFE covering whether it be a continuation of the abluminal covering **24** from the stent to the proximal end of the device **10** (see Fig. 2), the luminal covering **26**, or both luminal and abluminal coverings **24** and **26**. Encapsulation can be accomplished by a number of methods as is well-known in the art.

Fig 2 illustrates a cross-section of the delivery system **10** containing the replacement lining **20** before introduction into the vessel of a patient. The delivery system **10** contains an atraumatic tip **32** that encloses the stent **22** in a small-diameter state, after it has been reduced in size by any of the known loading

methods, including the method disclosed in U.S. Serial No. 09/310,763, which is incorporated by reference herein. Attached to the atraumatic tip **32**, extending the length of the delivery system **10**, is a shaft **30** that connects the tip **32** to a stopper **36**. Built into the stopper **36** is a hub **38** for the inflation of an optional balloon **34** located proximally a short distance from the loaded stent **22** along the shaft **30**. The optional balloon **34** has radiopaque markers **35** situated at both ends to reveal the proximal and distal ends of the balloon **34** to assist in the positioning of the balloon **34** with respect to the stent **22**. The stent **22** is attached to the biocompatible replacement lining **20** at the distal end thereof. At the proximal end of the replacement lining **20**, a sliding hub **28** is attached to the lining **20** to pull back the replacement lining **20** from the atraumatic tip **32** and deploy the stent **22** and replacement lining **20** within a vessel.

Figs. 3A through 3D illustrate the replacement lining **20** as it is deployed within a vessel **40**. In Fig. 3A, the delivery system **10** is introduced into the vessel **40** through a single entry point (not shown), distal to the end of the endarterectomy or atherectomy, in which the replacement lining **20** is to be implanted. The delivery system **10** can be manipulated through the vessel **40** by the stopper **36** due to the rigidity of the shaft **30**, which is connected proximally to the stopper **36** and distally to the atraumatic tip **32** (shown in Fig. 2). In order to monitor the device **10** as it is guided through the treated vessel **40**, markers can be placed on or encapsulated within the replacement liner **20**, on the stent **22**, and/or on the optional balloon **34** (as shown in Figs. 2-4) when included as a part of the device **10**. Once the device **10** has reached the desired location within the vessel **40**, the stent **22** is removed from the atraumatic tip **32** and deployed within the vessel **40** as shown in Fig. 3B.

Referring again to Fig. 2, the deployment of the stent **22** is preferably accomplished by holding the stopper **36** steady while pulling the sliding hub **28**, attached to lining **20**, toward the stopper **36**. This action pulls the stent **22** attached to a distal end of the lining **20** out of the atraumatic tip **32**, allowing the stent **22** to self-expand to its pre-loaded diameter to bring it and the attached lining **20** in close proximity to the vessel wall **42**. Alternatively, the stopper **36** can be pushed



toward the sliding hub 28 while the hub is held steady, thereby pushing the atraumatic tip 32 off of the stent 22. The optional balloon 34, when present, is positioned proximal to the stent 22 so that removal of the stent 22 from the atraumatic tip 32 places the expanding stent 22 over the top of the balloon 34 as shown in Fig. 3B. The balloon 34, which is then within the lumen created by the stent 22 as the stent 22 expands close to the vessel wall 42, can be inflated to come into contact with the stent 22 as shown in Fig. 3C, thus ensuring a tight fit to the vessel wall 42.

Referring to Fig. 3D, once the replacement lining 20 has been implanted within the vessel 40, the delivery system 10 is withdrawn from the vessel 40 through the replacement lining 20. The stopper 36, with atraumatic tip 32 in tow, is pulled through the lining 20 and out of the single incision site (not shown). Prior to removing the delivery system 10, the sliding hub 28 is detached from the lining 20 by cutting the lining material near the hub 28. The remaining lining material is then surgically attached to the vessel 40 wall through suturing or other accepted medical procedures, thus completing the proximal anastomosis.

Fig. 4 illustrates an alternate embodiment of the vascular graft device and delivery system of the present invention. In this embodiment, a delivery system 100 contains many of the same features as those of the delivery system 10 shown in Fig. 2, including the atraumatic tip 32, the shaft 30 that connects the atraumatic tip 32 to the stopper 36, and the balloon 34. In this embodiment, however, in addition to the stent 22 that is initially constrained within the atraumatic tip 32, there are several small balloon-expandable stents 42, 52, and 62 located at axially spaced apart intervals along the replacement lining 20. These stents can be expanded by the balloon 34 as it is withdrawn in a proximal direction. Only those areas requiring such support need to have a stent expanded in the corresponding location in the replacement lining 20. Thus, any vessel irregularity can be tailored according to stents that are expanded. It should be appreciated that any number of stents can be placed along the replacement lining 20. By having numerous stents placed at spaced apart intervals, the physician is permitted great flexibility in tailoring the present invention to each individual procedure.

Having thus described a preferred embodiment of the endoluminally placed vascular graft, it will be apparent by those skilled in the art how certain advantages of the present invention have been achieved. It should also be appreciated that various modifications, adaptations, and alternative embodiments thereof may be made. For example, while replacement linings with ePTFE have been illustrated, it should be apparent that the inventive concepts described herein would be equally applicable to other types of biocompatible covering materials. Moreover, the words used in this specification to describe the invention and its various embodiments are to be understood not only in the sense of their commonly defined meanings, but to include by special definition in this specification structure, material or acts beyond the scope of the commonly defined meanings. The definitions of the words or elements of the following claims are, therefore, defined in this specification to include not only the combination of elements which are literally set forth, but all equivalent structure, material or acts for performing substantially the same function in substantially the same way to obtain substantially the same result. The described embodiments are to be considered illustrative rather than restrictive. The invention is further defined by the following claims.

## CLAIMS

**I Claim:**

1. A device for implantation within a tubular body vessel comprising:  
a stent;  
5 a tubular lining made from a biocompatible material, wherein the stent is attached at a distal end of the tubular lining;  
a sliding hub, wherein the hub is coupled to a proximal end of the tubular lining; and  
a delivery system for placing the tubular lining into the body vessel,  
10 including a hollow atraumatic tip, wherein the stent is retained within the tip upon delivery to the body vessel.
2. The implantation device of Claim 1, wherein the delivery system further comprises a semi-rigid shaft and a stopper, wherein the shaft is coupled at a proximal end to the stopper and at a distal end to the atraumatic tip.
- 15 3. The implantation device of Claim 2, wherein the shaft is hollow.
4. The implantation device of Claim 3, wherein the delivery system further comprises a balloon and a hub, wherein the balloon is positioned over the shaft in fluidic communication with the shaft, near the stent, and wherein the hub is in fluid communication with the shaft.
- 20 5. The implantation device of Claim 1, wherein the biocompatible material is expanded polytetrafluoroethylene.
6. The implantation device of Claim 1, wherein one or more portions of the tubular lining includes a location marking means.



7. The implantation device of Claim 1, wherein one or more portions of the stent includes a location marking means.
8. The implantation device of Claim 6 or Claim 7, wherein the location marking means comprises a radiopaque material.
- 5 9. The implantation device of Claim 1, wherein the stent is self-expanding.
10. The implantation device of Claim 1, wherein the stent is encapsulated within a tubular layer of biocompatible material at the distal end of the tubular lining.

11. A method for implanting a biocompatible lining material, with a self-expanding stent attached to a distal end thereof and a sliding hub attached to a proximal end thereof, within a tubular body vessel using a delivery device having an atraumatic tip, wherein the stent is retained within the tip upon delivery to the  
5 body vessel, and wherein the delivery device includes a semi-rigid shaft coupled to the tip at a distal end and coupled to a gripping device at a proximal end, comprising the steps of:

introducing the atraumatic tip into the vessel and guiding the tip to a  
desired location with the use of the gripping device;  
10 pulling the sliding hub toward the gripping device while the gripping device remains stationary, thereby pulling the stent from the atraumatic tip whereupon the stent expands into close proximity with the vessel;  
removing the tip and the shaft from the vessel through the lining material;  
15 removing the sliding hub from the lining material; and attaching the second end of the lining material to the vessel.

12. The method of Claim 11, wherein the delivery device further includes a balloon in fluid communication with the shaft, disposed proximally to the stent upon delivery to the body vessel, further comprising the step of inflating  
20 the balloon to press the stent against the wall of said vessel.

1/3

FIG. 1

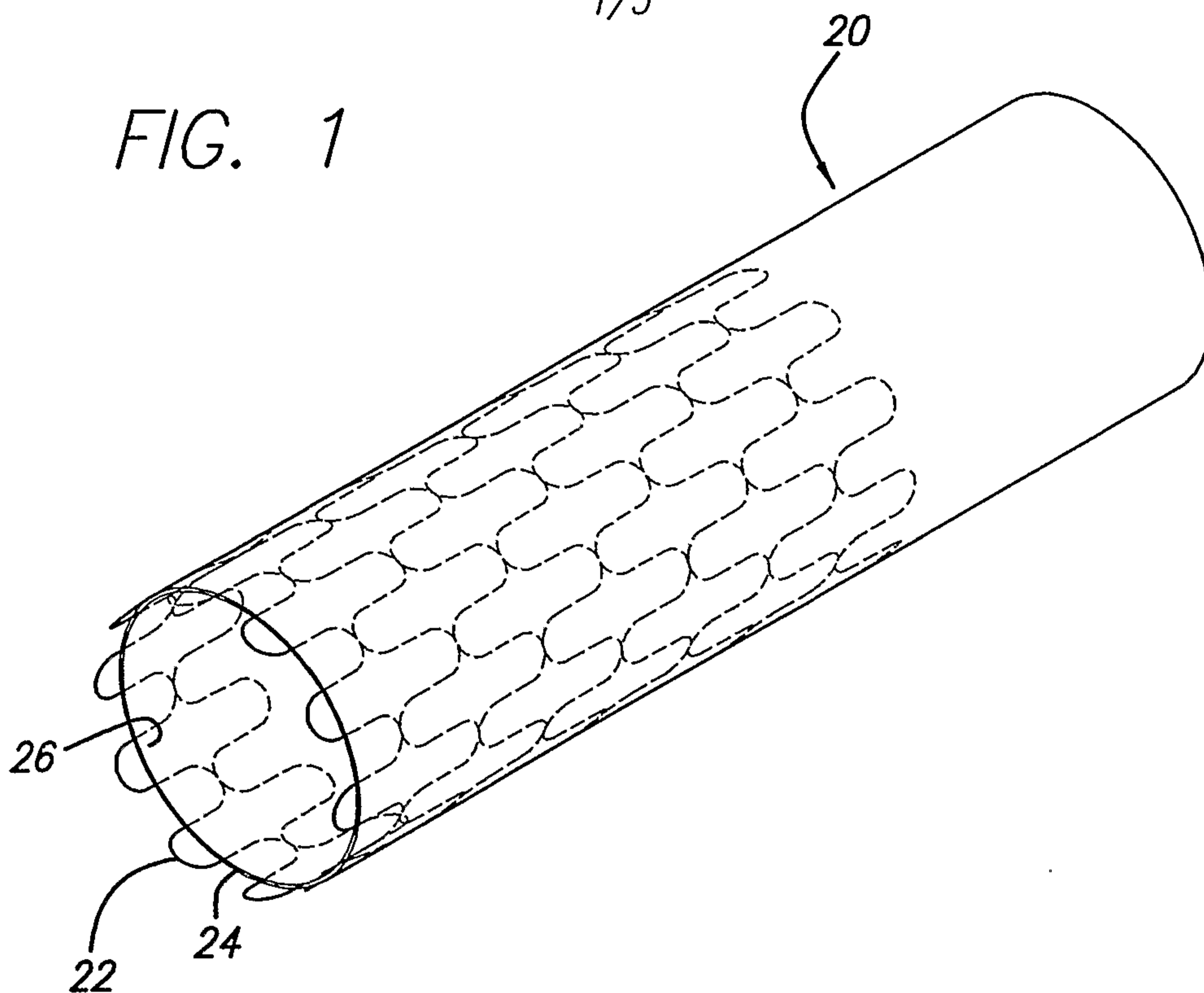


FIG. 2

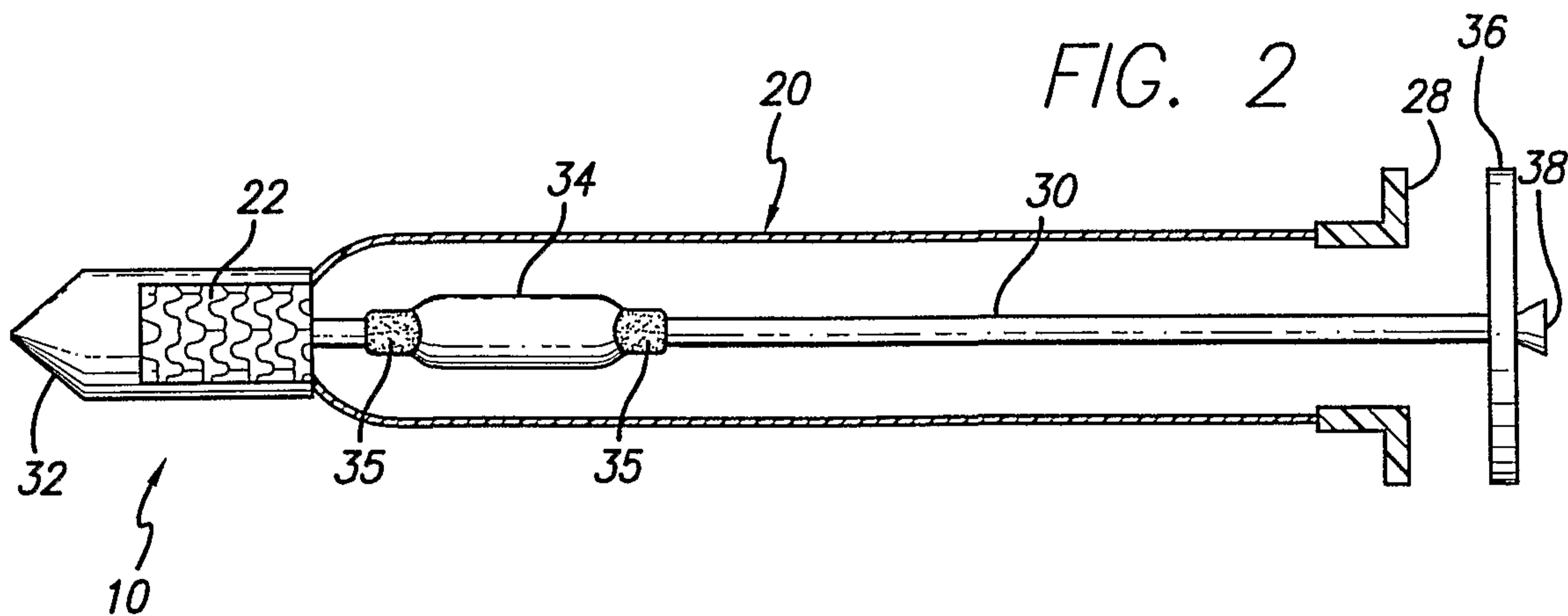
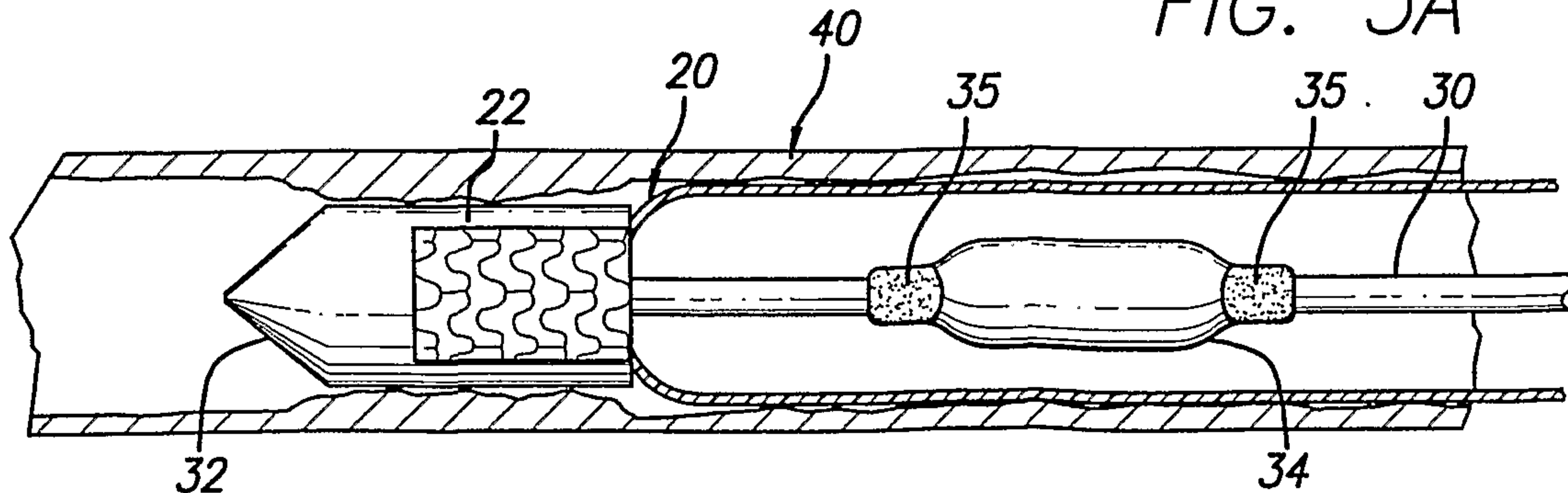
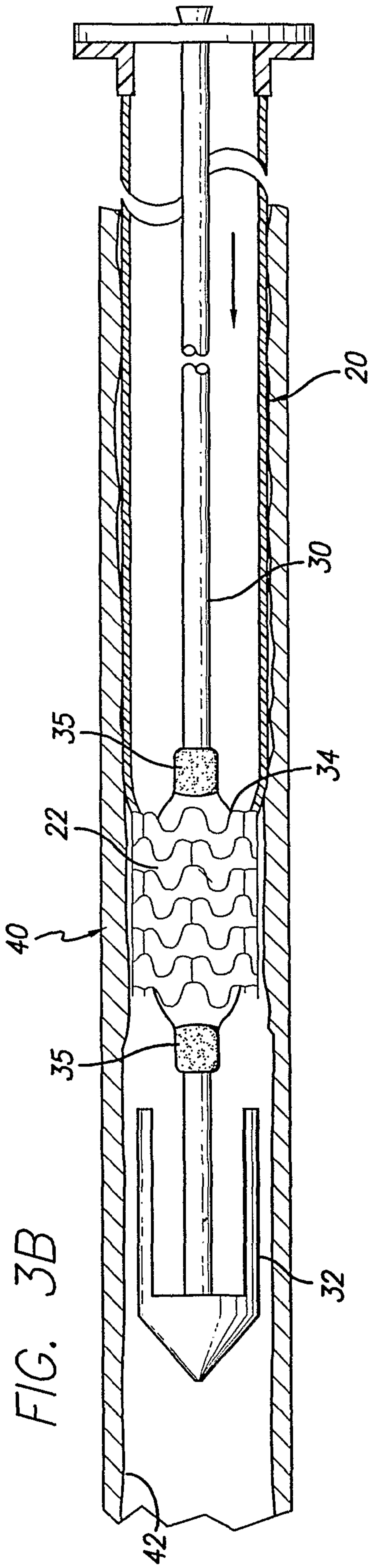


FIG. 3A







2/3

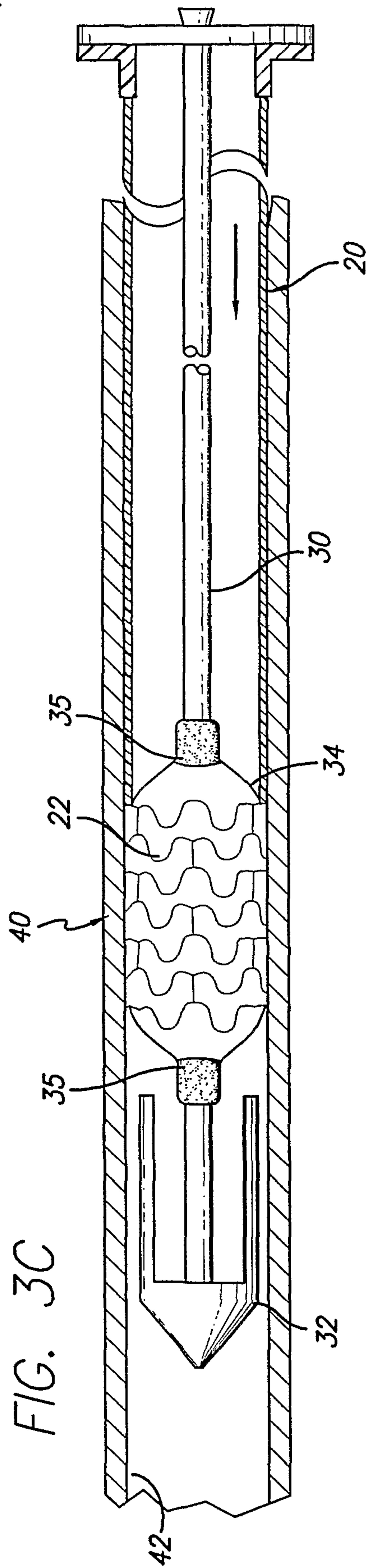
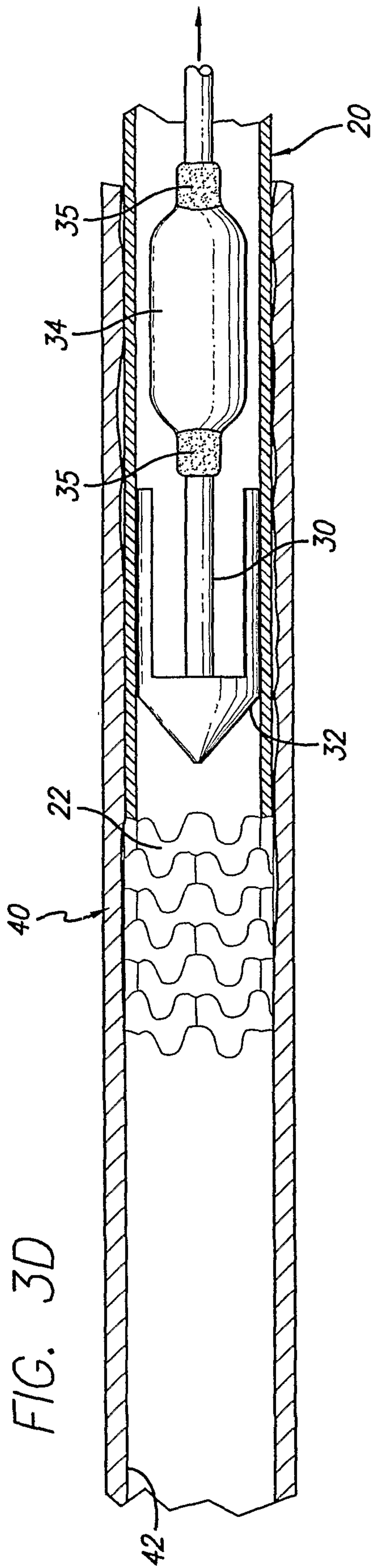


FIG. 3C



3/3

