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(71) Applicant: **SCIMED LIFE SYSTEMS, INC.** [—/US]; One Scimed Place, Maple Grove, MN 55311-1566 (US).

(72) Inventors: **WEBER, Jan**; 18112 89th Place W., Maple Grove, MN 55311 (US). **SPENCER, Steven, M.**; 2529 33rd Avenue South, Minneapolis, MN 55406 (US).

(74) Agents: **BROOKS, Edward, J., III** et al.; E.J. Brooks & Associates, PLLC, 1221 Nicollet Avenue, Suite 500, Minneapolis, MN 55403 (US).

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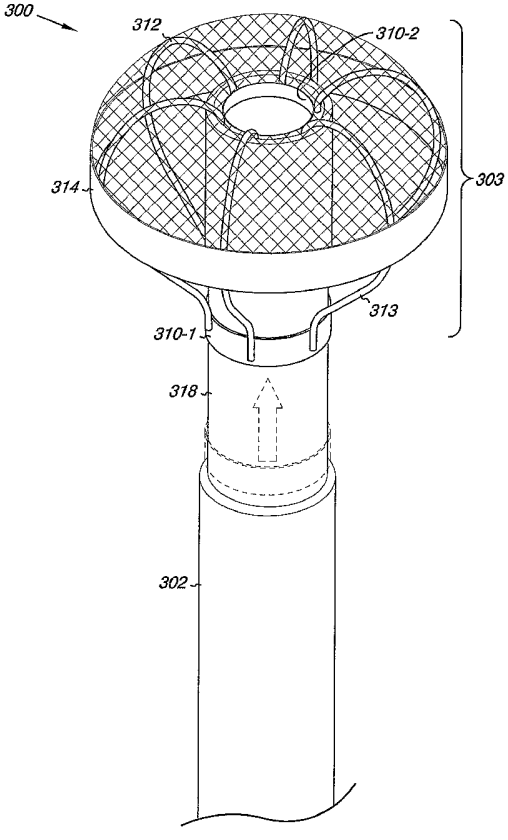

(57) Abstract: Methods, devices, and systems for extracting vessel occluding material are provided. An embodiment of a vessel occluding material extractor includes a host structure, a plurality of expandable members, a slide mechanism, and a circumferential member. The host structure has an elongate axis. The expandable members are connected to the host structure arrayed radially around the elongate axis. The slide mechanism is connected to the expandable members and adjacent the host structure, and is slidable in the direction of the elongate axis. The circumferential member is connected to the expandable members between the connection of the slide mechanism and the host structure to the expandable members.

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VESSEL OCCLUDING MATERIAL EXTRACTOR

Introduction

Intravascular devices are used in various medical procedures. For example, certain intravascular devices, such as catheters and guidewires are generally used to deliver fluids or other medical devices to specific locations within a patient's body, such as within the vascular system. Various devices are also used in treating specific conditions, such as vessel occlusion. Such treatment devices include devices for extracting vessel occluding material whether the material is connected to the vessel or floating in the stream of fluid within the vessel. Needles, burrs, and blades, for example, are sometimes used in removing occluding material from a lumen forming a vessel. Additionally, filtering devices are utilized to remove material that is entrained within the flow of fluid in the vessel. These devices, either singly or in combination, operate to extract vessel occluding material.

Further, in some cases it is desirable to work at the center of the occluded region because it can be less occluded and can also be easier to remove, since the material at the center of the occlusion is likely newer material. Additionally, in some situations it is necessary to pass a treatment device through an occluded region. For example, when utilizing a filter, guidewire, or other device delivered from an upstream position, it is necessary to pass the device through the occluded region so that the filter or other device can be deployed downstream. In either of the above cases, the centering of the treatment device can be difficult to achieve and therefore these procedures can take a significant amount of time and require significant maneuverability of the treatment device before the objectives of the treatment are obtained.

Brief Description of the Drawings

Figure 1A illustrates an embodiment of the present invention in its unexpanded state.

Figure 1B illustrates the embodiment of Figure 1A in its expanded state.

Figure 1C illustrates an end view of the embodiment of Figure 1B.

Figure 2A illustrates an embodiment of the present invention being positioned in a vessel.

Figure 2B illustrates the embodiment of Figure 2A in a deployed state.

Figure 3A illustrates another embodiment of the present invention in its unexpanded state.

Figure 3B illustrates the embodiment of Figure 3A in its expanded state.

Figure 4A illustrates an embodiment of the present invention being positioned in a vessel.

Figure 4B illustrates the embodiment of Figure 4A in a deployed state.

Figure 5A illustrates an embodiment of the present invention being positioned in a vessel.

Figure 5B illustrates the embodiment of Figure 5A in a deployed state.

Figure 5C illustrates another embodiment of the present invention in a deployed state.

Figure 5D illustrates an end view of the embodiment of Figure 5C.

Figure 5E illustrates another embodiment of the present invention in a deployed state.

Figure 6A illustrates an embodiment of the present invention being positioned in a vessel.

Figure 6B illustrates the embodiment of Figure 6A in a deployed state.

Figure 7A illustrates an embodiment of the present invention being positioned in a vessel.

Figure 7B illustrates the embodiment of Figure 7A in a deployed state.

Figure 8A illustrates another embodiment of the present invention.

Figure 8B illustrates a cross-section of the embodiment of Figure 8A taken along line 8B-8B

Figure 8C illustrates the embodiment of Figure 8A in a deployed state.

Figure 9A illustrates another embodiment of the present invention in its expanded state.

Figure 9B illustrates area 9B of the embodiment of Figure 9A in detail.

Figure 9C illustrates an embodiment of a hinge such as that utilized in the embodiment of Figure 9B.

Figure 10 illustrates a method embodiment of the present invention.

Figure 11 illustrates another method embodiment of the present invention.

Detailed Description

The present invention relates to methods, systems, and devices for extracting vessel occluding material, such as emboli and thrombi, from a vessel. The following description is presented to enable one of ordinary skill in the art to make and use the invention and is provided in the context of a patent application and its requirements. Various modifications to the embodiments shown will be readily apparent to those skilled in the art and are intended to be within the scope of the present invention. Thus, the present invention is not intended to be limited to the embodiments shown, but is to be accorded the widest scope consistent with the claims.

Those skilled in the art will appreciate from this disclosure that vessel occluding material, such as thrombi and emboli, can include any material that is to be removed or filtered, including, but not limited to blood clots, and plaque, among others. Additionally, those skilled in the art will appreciate that the term "occlusion" as used herein includes partial or complete blockage of a vessel by vessel occluding material.

As described herein, the embodiments of the vessel occluding material extractor can serve many different purposes. For example, various embodiments of the device can be utilized as a filter or trap, to break up or capture emboli flowing in

the fluid stream within a vessel. The embodiments shown in Figures 1A-4B are such embodiments and are discussed in detail below. Various embodiments of the device can be utilized in various positioning embodiments such as shown in Figures 5A-5E illustrates. Various embodiments of the device can also be utilized to hold the host device in place within the vessel to allow a treatment device to be advanced along its length as the embodiment shown in Figures 6A and 6B illustrate. Embodiments of the device can also be utilized to score the surface of occluding material, blocking the fluid flow in a vessel, as shown in Figures 7A and 7B. Additionally, in embodiments having a catheter, the catheter can be used to, for example, to deliver drugs or treatment devices such as in the embodiment of Figures 8A-8C, can be utilized to remove the vessel occluding material, such as by a suction applied through the catheter, or for other suitable functions, the invention is not so limited. Additionally, Figures 9A-9C illustrate another embodiment of the invention having hinged expandable members. However, the invention is not so limited.

Figures 1A-1C illustrate a device embodiment of the present invention. Figure 1A illustrates the embodiment in its unexpanded state, while Figure 1B illustrates the embodiment in its expanded state. Figure 1C illustrates an end view of the embodiment shown in Figures 1A and 1B.

As shown in the embodiment of Figure 1A, a vessel occluding material extracting device 100 includes a host structure 102, having an elongate axis, and an expandable portion 103. Those skilled in the art will appreciate that a host structure can be a catheter, a wire, or the like. The invention is not so limited. As shown in the embodiments of Figures 1A-1C, the expandable portion 103 includes a plurality of expandable members 112, a first collar 110-1, a second collar 110-2, and a circumferential member 114.

In various embodiments, the expandable members 112 are connected to the host structure and arrayed radially around the elongate axis in an axially aligned manner. Those skilled in the art will appreciate that the expandable members can be constructed from any suitable material known in the art. Some suitable examples include metals, such as spring steel, super-elastic materials, such as Nitinol, polymers, or fabrics, among others.

Additionally, those skilled in the art will appreciate from reading this disclosure that the expandable members can be connected to the host structure in any manner that allows the extracting device to expand. For example, in the embodiment

shown in Figures 1A-1C, the expandable members 112 are connected to first collar 110-1 at one end and second collar 110-2 at another end. The first and second collars 110-1 and 110-2 are connected to the host device 102. In various embodiments, one or both ends of the expandable members 112 are moveable with respect to each other.

In the embodiment shown in Figures 1A-1C, first collar 110-1 is slidably connected to the host structure 102 and can move from one position on the host structure 102 to another. The second collar 110-2 is fixedly attached to a distal end of the host device 102. In this embodiment, the slidable movement of the first collar 110-1 causes the expandable members 112 to bend when the ends of the expandable members 112 move toward one another. The bending results in the expansion of the diameter of the expandable portion 103. This is illustrated in the difference in diameter of the expandable portion 103 in Figures 1A and 1B. One of ordinary skill in the art will recognize numerous manners in which collar 110-1 and/or collar 110-2 can be actuated.

The second collar 110-2, in this embodiment, is affixed inside the host structure 102 with one end of the expandable members 112 bent around the end of the host structure 102. However, the invention is not so limited. For example, in various embodiments where an extraction device is connected to a host wire, both ends of the expandable members will be connected, either fixedly or movably, to the exterior of the host wire.

In various embodiments, the expandable portion 103 includes a circumferential member 114. In various embodiments, as shown in Figures 1A-1C, the circumferential member 114 can be utilized to maintain a generally uniform lateral spacing between the expandable members 112. In various embodiments, the circumferential member 114 can be constructed to limit the expansion of the expandable members 112. In various embodiments, the circumferential member 114 is non-elastic and connected generally mid way between the ends of the expandable members. In these embodiments, circumferential member 114 can retract to an unexpanded state, shown in Figure 1A, to reduce its diameter. In various embodiments, circumferential member 114 is elastic and expands when the expandable portion 103 is moved from the unexpanded state in Figure 1A to the expanded state in figure 1B.

Those skilled in the art will appreciate that the circumferential member can be constructed from any suitable material known in the art and can be either elastic or

inelastic. Some suitable examples include metals, such as spring steel or Nitinol, polymers, or fabrics, among others. Those skilled in the art will also appreciate that the circumferential member 114 can be connected to the expandable members in any manner, for example soldering, gluing, and tying, among others. The invention is not so limited.

In Figure 1C, the device 100 is shown in an expanded state having twelve (12) expandable members 112, although the invention is not limited to 12 expandable members. In the embodiment shown, the circumferential member 114 can be connected to each expandable member 112 and when expanded, as shown, can operate to serve as a filter or vessel occluding material trap.

In various embodiments, the device can be utilized wherein substantial force could be applied to the expandable members. In these embodiments, the device can be constructed from a material that can be deformed and substantially returned to its original shape. Examples of such materials include plastics, polymers, stainless steel, and the like. However, the invention is not so limited.

Figures 2A and 2B illustrates an embodiment of the present invention being positioned in a vessel. In these Figures, the device is utilized downstream from an occlusion. The device operates to filter and/or trap emboli, for example emboli broken loose from an occlusion by a treatment device and entrained in the fluid flowing within a vessel.

In Figure 2A, the device 200 is inserted into a vessel 220 from a location upstream of an occluded region 230. Those skilled in the art will appreciate that in some situations, such as when vessel occluding material completely occludes a vessel, such as with a total occlusion or chronic total occlusion (CTO), the device 200 can be inserted at a point downstream from the occlusion 230. In the embodiment shown in Figure 2A, the device 200 is guided through the occluded region 230 along guidewire 206 and is positioned downstream of the occlusion 230.

As shown in Figure 2B, once the device 200 is positioned at a desired location in the vessel 220, it can be expanded by expanding the expandable portion 203. The expanded device 200 can operate as a filter/trap device by allowing fluid to flow between the expandable members 212, while restricting the space through which emboli can pass, thereby catching or filtering emboli with the expandable members 212. The device 200 can then be retracted and the emboli removed therewith.

In various embodiments, the device 200 can have an expanded diameter large enough to engage the walls of the vessel 220 such that the force between the device and the wall of the vessel 202 holds the device 200 in position. However, those skilled in the art will appreciate that the device 200 can also have an expanded diameter smaller than the diameter of the vessel 220 thereby allowing the device 200 to be movable within the vessel 220 while in its expanded state. This allows for adjustment of the positioning of the device 200 and allows for the device 200 to be utilized in situations when the positioning of the occlusion 230 is such that engaging the walls of the vessel 220 is impractical.

Figures 3A and 3B illustrate another embodiment of a vessel occluding material extractor that can be utilized as a filter and/or trap for the straining and/or capturing of emboli therein. In this embodiment, the device 300 has a filtering material 316 connected thereon to aid in filtering and trapping emboli entrained in the fluid flowing through the vessel 320. In Figure 3A, an embodiment of a device 300 is illustrated in its unexpanded state prior to reaching its destination within the vessel 320, while in Figure 3B, the device 300 is illustrated in its expanded state.

In the embodiment shown in Figures 3A and 3B, the device 300 has a host structure 302, and an expandable portion 303 having two collars 310-1 and 310-2, a plurality of expandable members 312, a circumferential member 314, filtering material 316, and a recessed section 318. The device 300 has a filtering material 316 connected to the distal end of the expandable members 312.

In various embodiments, the filtering material 316 has a plurality of pores formed therein. As one of ordinary skill in the art will appreciate, the plurality of pores on the filtering material 316 allow for the passing of fluid there-through and provide for the filtering of emboli. The pores in the filtering material 316 can be of any size suitable to implement the various aspects of the present invention. The invention is not so limited.

Those skilled in the art will also appreciate from reading this disclosure that the filtering material 316 can be constructed of any suitable material. The invention is not so limited. For example, the material can be a plurality of wires, such as stainless steel or Nitinol, can be a fabric, or can be a sheet of material, among others. Additionally, those skilled in the art will appreciate from reading this disclosure that the circumferential member 314 and the filter material 316 can be connected, and/or can be formed as a single unit.

In the embodiment shown in Figures 3A and 3B, the device 300 also has a stop mechanism therein that can restrict the expansion and/or the retraction of the device 300. For example, in the embodiment shown, the device 300 has a recessed section 318 formed in the exterior surface of the host structure 302. A collar 310-1 is slidably connected to the host structure 302 within the recessed section 318. In the embodiment shown, the collar 310-1 and recessed section 318 are constructed and arranged such that the ends of the recessed section 318 form stops that impede the movement of the collar 310-1 in both the distal and proximal directions, the invention, however, is not so limited. In various embodiments, the collar 310-1 can be designed such that its exterior diameter, including the expandable members 312 connected thereto, is the same or smaller than the larger exterior diameter of the host device 302. The invention, however, is not so limited.

Those skilled in the art will appreciate that one or more stop mechanisms other than that shown in Figures 3A and 3B can be provided to arrest directional movement of a collar, e.g. 310-1, or the expandable portion 303. The invention is not so limited. For example, a stop mechanism can be one or more areas on the host device having a larger or smaller diameter than the general diameter of the host device. Those areas can extend around the entire circumference of the host device or around a portion of the circumference, the invention is not so limited.

Those skilled in the art will also appreciate from reading this disclosure that one or more of the expandable members 312 can have a hollow interior, e.g. 313, formed therein for the communication of drugs or medication to a treatment site, such as occluded region 330. Additionally, the hollow interior 313 within the one or more expandable members 312 can connect with a reservoir located on the device 300 to retain drugs or medication therein. Those skilled in the art will understand that the delivery of the drug to the hollow interior 313 can be by any manner and that a reservoir can be formed in any manner, such as a reservoir demonstrated in Figures 8A-8C, among others. The invention is not so limited.

Figures 4A and 4B illustrate a procedure in which an extraction device, such as that shown in Figures 3A and 3B could be utilized. In these Figures, the device is utilized downstream from an occlusion and operates to filter and/or trap emboli, for example emboli broken loose from an occlusion by a treatment device and entrained in the fluid flowing within the vessel. In Figure 4A, an embodiment of a device 400

is illustrated in its unexpanded state prior to reaching its destination within the vessel 420. In Figure 4B, the device 400 is illustrated in its expanded state.

In Figure 4A, the device 400 is inserted into the vessel 420 from a location upstream of the occluded region 430. In various embodiments, such as when vessel occluding material completely occludes a vessel, e.g. CTO, the device 402 can be inserted at a point downstream from the occlusion 430. In the embodiment shown in Figure 4A, the device 400 is guided through the occluded region 430 and is positioned downstream of the occlusion 430.

In this embodiment, the pore size of the filter material 416 is smaller than the space between the expandable members 412. Accordingly, this embodiment allows for the filtration and/or capture of smaller emboli than the device 300 of Figures 3A and 3B. Those skilled in the art will appreciate that one or more filters having varying pore sizes, such as those shown in Figures 1A-4B, can be utilized in combination to break up large emboli with a filter having large pores before they reach the pores of a filter having smaller pores.

Figures 5A-5E illustrate several embodiments of the present invention being positioned in a vessel. In Figures 5A and 5B, illustrate another embodiment of the present invention being positioned in a vessel. Figures 5A and 5B illustrate the device 500 being positioned and deployed in a vessel 520 for centering and/or stabilization of a host structure 502. The centering and/or stabilization of a host structure can allow for better navigation and stability for passing a treatment device into an opening in an occlusion as well as for breaking through a full occlusion, such as a CTO.

In Figure 5A, an embodiment of a device 500 is illustrated in its unexpanded state prior to reaching its destination within a vessel 520. In Figure 5B, the device 500 has reached its destination and has been deployed into its expanded state.

As shown in Figure 5A, the device 500 includes a host structure 502 having an expandable portion 503 connected thereto. In the embodiments of Figures 5A and 5B, the expandable portion 503 includes collars 510-1 and 510-2, expandable members 512, and circumferential member 514. In various embodiments, the device 500 travels through vessel 520 along a guide catheter or guidewire 506. In the embodiment shown in Figure 5A, the extracting or centering device 500 is positioned proximal to an occluded region 530 in need of treatment. In this embodiment, a

guidewire 506 is utilized to penetrate and cross the occluded region 530. In various embodiments, other treatment devices can be utilized.

As shown in Figure 5B, the device 500 can be expanded to provide centralized positioning and/or stability to the delivery of a treatment device, e.g. guidewire 506. For example, in the embodiment shown in Figure 5B, the device 500 is also expanded to engage the walls of the vessel 520 to hold it in place. In this way, the device 500 can provide a stable platform proximate to the treatment area 530 from which to launch a treatment device, e.g. guidewire 506. This can be accomplished by expanding the expandable portion 503 to restrict the amount of space in which the device 500 can move and, thereby, restrict the movement of the host structure 502. In this way, the device 500 can allow for a treatment device, such as a guidewire 506, to be generally centered in the vessel 520 at a position that is proximal to a region 530 needing treatment.

By having a stable structure proximate to the treatment site, there can be less risk of buckling the treatment device when it is in contact with the occluded region and can allow for more push force to be applied to the treatment device. This increased push-ability can allow for smaller diameter and more flexible guidewires and host wires to be utilized. Additionally, when an embodiment of the present invention is utilized such that it is held in place within a vessel, the device allows for a guidewire to be withdrawn without losing the advanced position.

Figures 5C and 5D, illustrate another embodiment of the present invention being positioned in a vessel. As shown in Figure 5C, the device 500 includes a host structure 502 having an expandable portion 503 connected thereto. In the embodiment of Figures 5C, the expandable portion 503 includes collars 510-1 and 510-2, expandable members 512, and circumferential member 514. In this embodiment, a guidewire 506 can be utilized to penetrate and cross the occluded region 530. However, other treatment devices can be utilized. The invention is not so limited.

As shown in Figure 5C, the device 500 can be expanded to provide decentralized positioning and/or stability to the delivery of a treatment device, in this case guidewire 506 as has been described previously herein. Those skilled in the art will appreciate from reading this disclosure that a decentralized position can be accomplished in any manner.

For example, Figure 5D, illustrates an end view of the embodiment shown in Figure 5C. As shown in Figure 5D, in this embodiment, one or more of the expandable members have different spring strengths such that some expandable members bend more readily than others. In the embodiment shown, in Figures 5C and 5D, the expandable members 512-1 have a first spring strength and the expandable members 512-2 have a second spring strength that is less than the first spring strength of members 512-1.

A decentralized position can be accomplished by utilizing irregular spacing between the expandable members 512. For example, as shown in Figure 5D, since the expandable members 512-2 have a greater spring strength, they expand the circumferential member 514 out more. This changes the centering of the host structure 502, thereby, moving the host structure 502 to a decentralized position. Examples, of other manners in which decentralizing can be accomplished include, shortening some of the expandable members 512 and arraying the expandable members 512 in a non-uniform manner about the host structure 502, among others. The invention is not so limited.

In Figure 5E, illustrate another embodiment of the present invention being positioned in a vessel. In Figure 5E, the device 500 includes a host structure 502 having two or more expandable portions 503 connected thereto. In the embodiment of Figure 5E, the expandable portions 503 include collars 510-1 and 510-2, expandable members 512, and circumferential member 514. In the embodiment shown in Figure 5A, the extracting device 500 is positioned proximal to an occluded region 530 in need of treatment. In this embodiment, a guidewire 506 is utilized to penetrate and cross the occluded region 530. In various embodiments, other treatment devices can be utilized.

As shown in Figure 5E, the device 500 can be expanded to provide centralized positioning and additional stability to the delivery of a treatment device, e.g. guidewire 506. For example, in the embodiment shown in Figure 5E, the expandable portions 503 of the device 500 expanded to engage the walls of the vessel 520 to hold the device 500 in place. In this way, the device 500 can provide a stable platform proximate to the treatment area 530 from which to launch a treatment device, e.g. guidewire 506 as has been described previously herein.

In various embodiments, the expandable portions 503 can be covered in a non-porous material and, thereby, once the portions 503 are expanded, the portions 503

can act to isolate a section of vessel 520 that is located between the portions 503 from the flow of fluid through the vessel 520. In such embodiments, a number of fluid lumens, such as are shown in the embodiment of Figures 8A-8C at 824 can be formed in the host structure 502 of the embodiment shown in Figure 5E. In this way, fluid flowing in the vessel 520 can continue to flow while the device 500 is isolating a section for treatment between portions 503. Additionally, in such an embodiment, the drug delivery can be provided through apertures formed in the host structure 502 between the two expandable portions 503.

Figures 6A and 6B illustrate an embodiment of the present invention being positioned in a vessel. The figures illustrate a vessel occluding material extractor being inserted and deployed in a vessel to aid in the delivery of a treatment device. In Figure 6A, an embodiment of a device 600 is illustrated in its unexpanded state, while in Figure 6B, the device 600 is illustrated, in its expanded state, deployed within a vessel 620.

As with Figures 5A and 5B, the embodiment illustrated in Figures 6A and 6B is shown being utilized as a centering device to center a host structure 602, in this case a catheter, within the vessel 620. This function can allow for a treatment device 608. In the embodiment shown in Figure 6B, the treatment device is a needle. However, the invention is not so limited. Those skilled in the art will appreciate that a host structure can be a catheter or wire, among others. The invention is not so limited.

In the embodiments of Figures 6A and 6B, a device 600 has a host structure 602 and an expandable portion 603. The expandable portion 603 includes collars 610-1 and 610-2, expandable members 612, and circumferential member 614. In various embodiments, the device 600 travels through vessel 620 along a guide catheter or guidewire 606. In the embodiment shown in Figure 6A, the extracting device 600 is positioned proximal to an occluded region 630 in need of treatment. In this embodiment, a needle 608 is utilized to penetrate and cross the occluded region 630.

A treatment device such as needle 608 can be operable to provide several functions. The invention is not so limited. For example, needle 608 can be utilized to take a sample of the occluding material from the occluded region 630. In this way, for example, the type of material, its fibrosity, and general internal makeup can be determined.

The needle 608 can also aid in treating an occlusion by loosening or extracting some of the occluded material at the region 630. For example, the needle 608 can be utilized to push through the occluded region 630, in cases of total occlusion or chronic total occlusion (CTO).

In various embodiments, the needle 608 can be utilized to measure the length of the occluded region 630, through use of a radiopaque needle tip or by examination of the length of a core sample taken from the occluded region. The measurement can, for example, be used to help determine the types of treatment options that are available. By way of example and not by way of limitation, information on the length of the occlusion can be used to determine the size and the length of stent to be utilized to recanalize the vessel.

Additionally, the needle 608 can also be utilized to administer anti-thrombogenic or anti-embolic drugs to an area in need of treatment such as for example, region 630. Those skilled in the art will appreciate from this disclosure that any treatment device can be utilized with various embodiments of the invention and that the invention can be utilized for any suitable treatment application in any area of the body, including but not limited to vascular, renal, esophageal, and stomach, among others. Some examples of treatment devices include, but are not limited to radiation sources, burrs, blades, filters, drug delivery devices, needles, optical fibers, guidewires, and catheters, among others.

In the embodiments of Figures 7A and 7B, a device 700 has a host structure 702 and an expandable portion 703. In various embodiments, the expandable portion 703 includes a plurality of expandable members 712, a first collar 710-1, a second collar 710-2, and a circumferential member 714. In various embodiments, the device 700 travels through vessel 720 along a guide catheter or guidewire 706.

In the embodiment shown in Figure 7A, the device 700 is positioned proximal to an occluded region 730 in need of treatment.. In this technique, the device 700 is placed proximal to the surface of the occluded region 730, and the end surface of the device 700 is utilized to score, loosen, and/or remove vessel occluding material. In various techniques, the extended ends of the expandable members 712 are movable as has been described in detail herein.

In this embodiment, shown in Fig. 7B for example, expandable members 712 can be operable to score and/or loosen occluded material from the occluded region 730. Those skilled in the art will appreciate that the expandable members 712 can be

sharpened to provide better scoring of the occluding material, whether distal to the device 700 or between the device and the walls of the vessel 720.

In various techniques for example, first collar 710-1 can be moved away from the expandable portion 703 to bend the expandable members outward, near second collar 710-2 and can be accomplished either before or after contact with the occluding material. In various embodiments, the first collar 710-1 can be moved away and toward the expandable portion 703 repeatedly, thereby moving the expandable members 712. Additionally, once the device 700 is positioned, it can be expanded, as the same has been described herein. These movements can aid in loosening and scoring the occluded material of the occluded region 730.

Figures 8A-8C, illustrate another embodiment of the present invention being positioned in a vessel. In the embodiment of Figures 8A, 8B, and 8C, a device 800 has a host structure 802 and an expandable portion 803. In various embodiments, the expandable portion 803 includes a collar 810, expandable members 812, and reservoir material 814. In various embodiments the host structure includes a delivery lumen 822 terminating in an aperture at 826. This lumen 822 can be utilized for the delivery of materials, such as drugs or medications, among others. Additionally, in various embodiments, the host structure 802 can include a fluid flow lumen 824. The blood flow lumen has one or more access ports 828 that allow fluid flowing through the vessel to be diverted into the lumen 824 and then out the distal end of the device 800.

Figure 8B illustrates a cross-section of the host structure 802. This Figure illustrates the two lumens 822 and 824 formed therein. Although shown in a side-by-side relation, those skilled in the art will appreciate that the two lumens can be substantially co-axial and that the sizes of the respective lumens 822 and 824 can be any suitable sizes. The invention is not so limited.

In various embodiments, as shown in Figure 8C, the device 800 is deployed within a vessel 820. In the embodiment shown in Figure 8C, the device 800 is positioned over an occluded region 830 in need of treatment. In various embodiments, when the device 500 is expanded, the expandable members 812 bend outward and expand reservoir material 814 to create a reservoir therein. The reservoir is connected through aperture 826 to lumen 822, thereby allowing the reservoir to house material provided through the lumen 822. In various embodiments, the reservoir material 814 has one or more holes 816 therein. The holes 816 allow one or more fluids, such as liquids, housed within the reservoir to be dispensed into the

vessel 820. As shown in Figure 8C, the device 800 can be sized such that when expanded, a part of the expandable portion 803 isolates a section of the vessel 820. In the case shown in Figure 8C, the isolated section of the vessel 820 contains occluding material 830 thereon. By isolating this section of the vessel 820, the device 800 can be utilized to provide drugs or medications, among others, to the occluding material 830 through use of lumen 822 in communication with the reservoir and the holes 816 formed in the reservoir material 816. In the embodiment shown in Figure 8C, the device 800 also includes a fluid lumen 824 to allow the fluid flowing through the vessel 820 to continue to pass through the vessel 820 while the device 800 is deployed.

In the embodiments of Figures 9A-9C, a device 900 has a host structure 902 and an expandable portion 903. In various embodiments, the expandable portion 903 includes a plurality of expandable members 912, a first collar 910-1, a second collar 910-2, and a circumferential member 914. In various embodiments, the expandable members 912 are formed from a number of sections. In various embodiments, the number of sections of an expandable member 912 are hinged together to allow the expandable member to expand.

For example, in the embodiment of Figure 9A a hinge structure as shown in detail in Figures 9B and 9C includes a first section 920 and a second section 922 movably engaged by a pin 924. The engagement allows one or both sections 920 and 922 to move with respect to each other. In various embodiments, as shown in Figure 9B, the hinging mechanism includes one or more arresting structures 926. In the embodiment shown in Figure 9B, the arresting structure 926 contacts the surface 928 of section 922 to arrest the counterclockwise movement of the section 922. However, the invention is not so limited.

Figures 10 and 11 are block diagrams illustrating method embodiments of the invention. As those skilled in the art will appreciate from reading this disclosure, unless explicitly stated, the methods described herein are not constrained to a particular order or sequence. Additionally, some of the so described methods or parts of a single method can occur or be performed at the same point in time.

Figure 10 illustrates a method of extracting vessel occluding material. In the embodiment of Figure 10, the method includes advancing vessel occluding material extractor, having longitudinally aligned expandable members at block 1010. In various embodiments, advancing a vessel occluding material extractor, includes

advancing a vessel occluding material extractor having material spanning between a distal half of the plurality of expandable members to form a filter. In various embodiments, advancing a vessel occluding material extractor, includes advancing a vessel occluding material extractor having a circumferential member connected to the expandable members.

The method of Figure 10 also includes actuating the members to an expanded state to serve as a clot filter at block 1020. In various embodiments, actuating the members includes bending the expandable members to expand the extractor to an expanded state to form a filtering device.

Figure 11 illustrates a method embodiment for extracting vessel occluding material. In the embodiment of Figure 11, the method includes advancing a centering device, having a plurality of expandable members and an elongate central axis, to a predetermined position within a lumen, the centering device having a first diameter at block 1110. In various embodiments, the centering device includes a catheter centered along the central axis.

The method of the embodiment of Figure 11 also includes expanding the expandable members to expand the centering device to have a second diameter larger than the first diameter at block 1120. In various embodiments, expanding the expandable members includes manually expanding the expandable members. However, the invention is not so limited.

The method of Figure 11 further includes advancing a treatment device generally parallel to the elongate central axis of the centering device at block 1130. In various embodiments, advancing a centering device includes advancing the centering device along a guidewire. In various embodiments, advancing a treatment device includes advancing a treatment device through the catheter of the centering device. In various embodiments, advancing a treatment device includes advancing a treatment device along the central axis of the centering device.

The method of the embodiment illustrated in Figure 11 includes positioning the treatment device proximate the centering device at block 1140. In various embodiments, positioning the treatment device proximate the centering device includes positioning the treatment device on the proximal side of the centering device with respect to the direction the treatment device is advanced. And, in various embodiments, positioning the treatment device proximate the centering device

includes positioning the treatment device on the distal side of the centering device with respect to the direction the treatment device is advanced.

Although specific embodiments have been illustrated and described herein, those of ordinary skill in the art will appreciate that any arrangement calculated to achieve the same techniques can be substituted for the specific embodiments shown. This disclosure is intended to cover any and all adaptations or variations of various embodiments of the invention. It is to be understood that the above description has been made in an illustrative fashion, and not a restrictive one. Combination of the above embodiments, and other embodiments not specifically described herein will be apparent to those of skill in the art upon reviewing the above description. The scope of the various embodiments of the invention includes any other applications in which the above structures and methods are used. Therefore, the scope of various embodiments of the invention should be determined with reference to the appended claims, along with the full range of equivalents to which such claims are entitled.

It is emphasized that the Abstract is provided to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to limit the scope of the claims.

In the foregoing Detailed Description, various features are grouped together in a single embodiment for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the embodiments of the invention require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus, the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separate embodiment.

Claims

What is claimed:

1. An extractor comprising;
a host structure having an elongate axis;
a plurality of expandable members connected to the host structure arrayed radially around the elongate axis;
a slide mechanism, connected to the expandable members and adjacent the host structure, and slidable in the direction of the elongate axis; and
a circumferential member connected to the expandable members between the connection of the slide mechanism and the host structure.

2. The extractor of claim 1, wherein the plurality of expandable members includes filtering material spanning between at least two adjacent expandable members.

3. The extractor of claim 1, wherein the plurality of expandable members includes one or more elongate metal members.

4. The extractor of claim 1, wherein the plurality of expandable members includes one or more elongate polymer members.

5. The extractor of claim 1, wherein the circumferential member is operable to provide generally uniform radial spacing of the plurality of expandable members.

6. The extractor of claim 1, wherein the circumferential member is connected to the expandable members mid way between the connection of the slide mechanism and the host structure to the expandable members.

7. An extractor comprising;
a host structure having an elongate axis;

a plurality of expandable members, connected to the host structure, having an unexpanded state and an expanded state, and when in their expanded state, are operable to filter vessel occluding material;

a slide mechanism, connected to the expandable members and adjacent the host structure, and slidable in the direction of the elongate axis; and

a circumferential member connected to the expandable members between the connection of the slide mechanism and the host structure to the expandable members.

8. The extractor of claims 1 and 7, wherein the extractor includes a stop structure operable to stop the slidable movement of the slide mechanism in one direction.

9. The extractor of claim 8, wherein the stop structure includes a stop structure formed on the host structure.

10. The extractor of claim 8, wherein the stop structure includes a first stop structure connected to the host structure.

11. The extractor of claim 8, wherein the stop structure includes a first stop structure operable to stop the slidable movement of the slide mechanism in a first direction.

12. The extractor of claim 11, wherein the stop structure includes a second stop structure operable to stop the slidable movement of the slide mechanism in a second direction.

13. The extractor of claim 12, wherein the stop structure includes a recessed section, formed in an exterior surface of the host structure, the recessed section having a first end acting as the first stop structure and a second end acting as the second stop structure.

14. A vessel occluding material extractor, comprising;

a host structure having an elongate axis;

a plurality of expandable members connected to the host structure;

means for expanding the plurality of expandable members, connected to the expandable members and adjacent the host structure; and

a circumferential member connected to the expandable members between the connection of the slide mechanism and the host structure to the expandable members.

15. The extractor of claims 1, 7 and 14, wherein a circumferential member connected to the expandable members includes one or more reservoirs connected thereto for housing a drug therein.

16. The extractor of claim 15, wherein the plurality of expandable members includes at least one expandable member having a hollow lumen formed therein and wherein the hollow lumen is connected to one or more of the reservoirs.

17. The extractor of claim 14, wherein means for expanding the expandable members includes a slide mechanism slidable in the direction of the elongate axis.

18. The extractor of claim 17, wherein the extractor includes means for arresting directional movement of the slide mechanism.

19. The extractor of claim 17, wherein the host structure has an exterior surface and wherein the means for arresting directional movement of the slide mechanism includes means for arresting directional movement of the slide mechanism that are external to the exterior surface of the host.

20. The extractor of claim 17, wherein the host structure includes an recessed section in which the slide mechanism slides.

21. The extractor of claim 20, wherein the recessed section includes a predetermined length that serves as a member for arresting the directional movement of the slide mechanism.

22. A positioning device, comprising;

a host structure having an elongate axis;

a plurality of expandable members connected to the host structure arrayed radially around the elongate axis, the expandable members having a unexpanded state and an expanded state, when in the expanded state the expandable members are operable to position the elongate axis of the positioning device within a lumen;

a slide mechanism, connected to the expandable members and adjacent the host structure, and slidable in the direction of the elongate axis; and

a circumferential member connected to the expandable members between the connection of the slide mechanism and the host structure.

23. A vessel occluding extractor, comprising;

a host structure having an elongate axis;

a plurality of expandable members connected to the host structure arrayed radially around the elongate axis;

a filtering material spanning between each adjacent expandable member to form a filter;

a slide mechanism, connected to the expandable members and adjacent the host structure, and slidable in the direction of the elongate axis; and

a circumferential member connected to the expandable members between the connection of the slide mechanism and the host structure to the expandable members.

24. The extractor of claims 2 and 23, wherein a plurality of expandable members connected to the host structure arrayed radially around the elongate axis includes expandable members having a unexpanded state and an expanded state.

25. The device of claim 24, wherein filtering material spanning between each adjacent expandable member includes filtering material spanning between all adjacent expandable members and has a diameter when in an expanded state that is greater than a lumen diameter within which the device is to be placed.

26. A method, comprising;

advancing a vessel occluding material extractor, having a plurality of expandable members connected to a host structure having an elongate

axis, and longitudinally aligned and arrayed radially around the elongate axis, to a predetermined position, wherein the expandable members have an unexpanded state for advancing the extractor; and

bending the expandable members to expand the extractor to an expanded state, having a second diameter larger than the first diameter.

27. The method of claim 26, wherein advancing a vessel occluding material extractor, includes advancing a vessel occluding material extractor having material spanning between a distal half of the plurality of expandable members to form a filter.

28. The method of claim 26, wherein advancing a vessel occluding material extractor, includes advancing a vessel occluding material extractor having a circumferential member connected to the expandable members.

29. The method of claim 26, wherein bending the expandable members to expand the extractor to an expanded state includes bending the expandable members to form a filtering device.

30. A method, comprising;

advancing a positioning device, having a plurality of expandable members and an elongate central axis, to a predetermined position, the positioning device having a first diameter;

expanding the expandable members to expand the positioning device to have a second diameter larger than the first diameter;

advancing a treatment device generally parallel to the elongate central axis of the positioning device; and

positioning the treatment device proximate the positioning device.

31. The method of claim 30, wherein the positioning device includes a catheter centered along the central axis.

32. The method of claim 31, wherein advancing a positioning device includes advancing the positioning device along a guidewire.

33. The method of claim 31, wherein advancing a treatment device includes advancing a treatment device through the catheter of the positioning device.

34. The method of claim 30, wherein advancing a treatment device includes advancing a treatment device along the central axis of the positioning device.

35. The method of claim 30, wherein expanding the expandable members includes manually expanding the expandable members.

36. The method of claim 30, wherein positioning the treatment device proximate the positioning device includes positioning the treatment device on the proximal side of the positioning device with respect to the direction the treatment device is advanced.

37. The method of claim 30, wherein positioning the treatment device proximate the positioning device includes positioning the treatment device on the distal side of the positioning device with respect to the direction the treatment device is advanced.

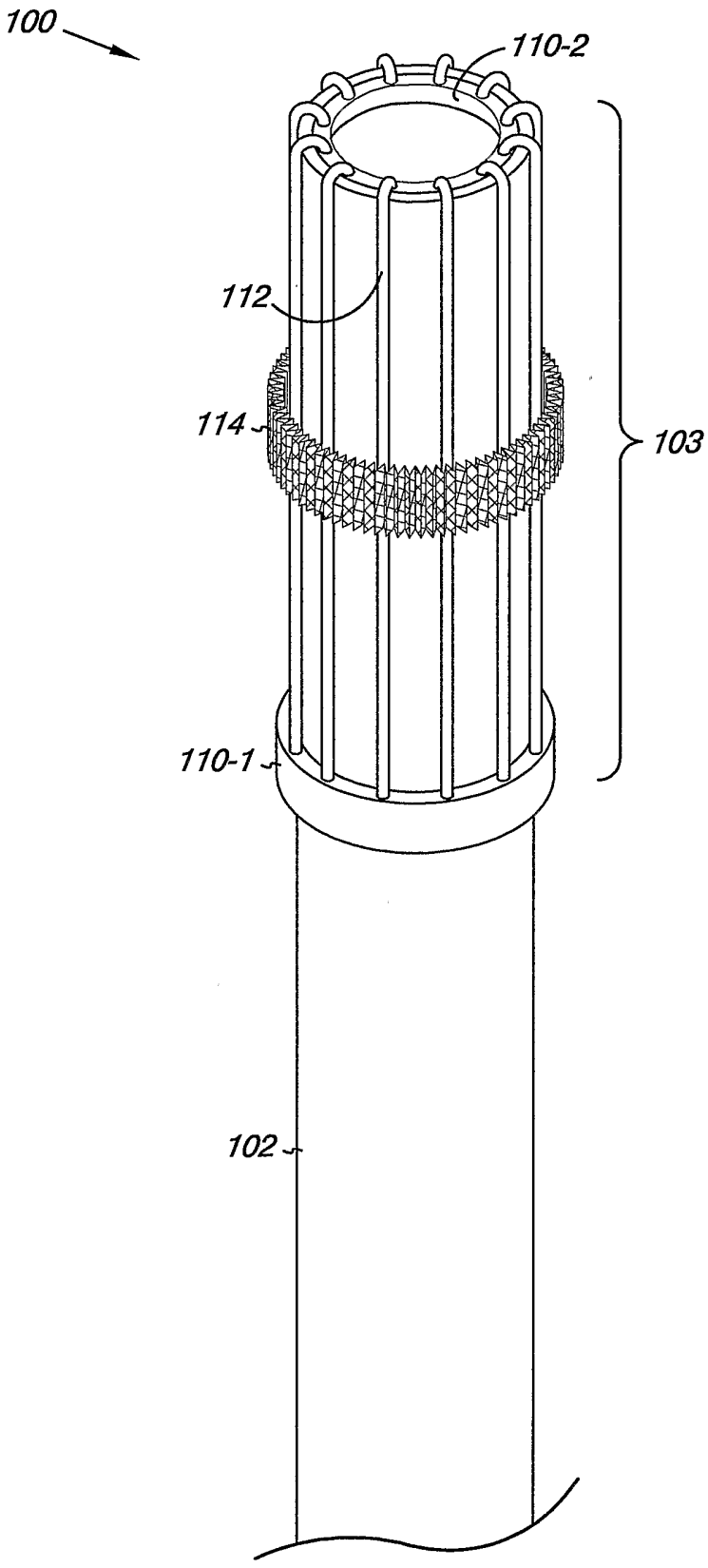

Fig. 1A

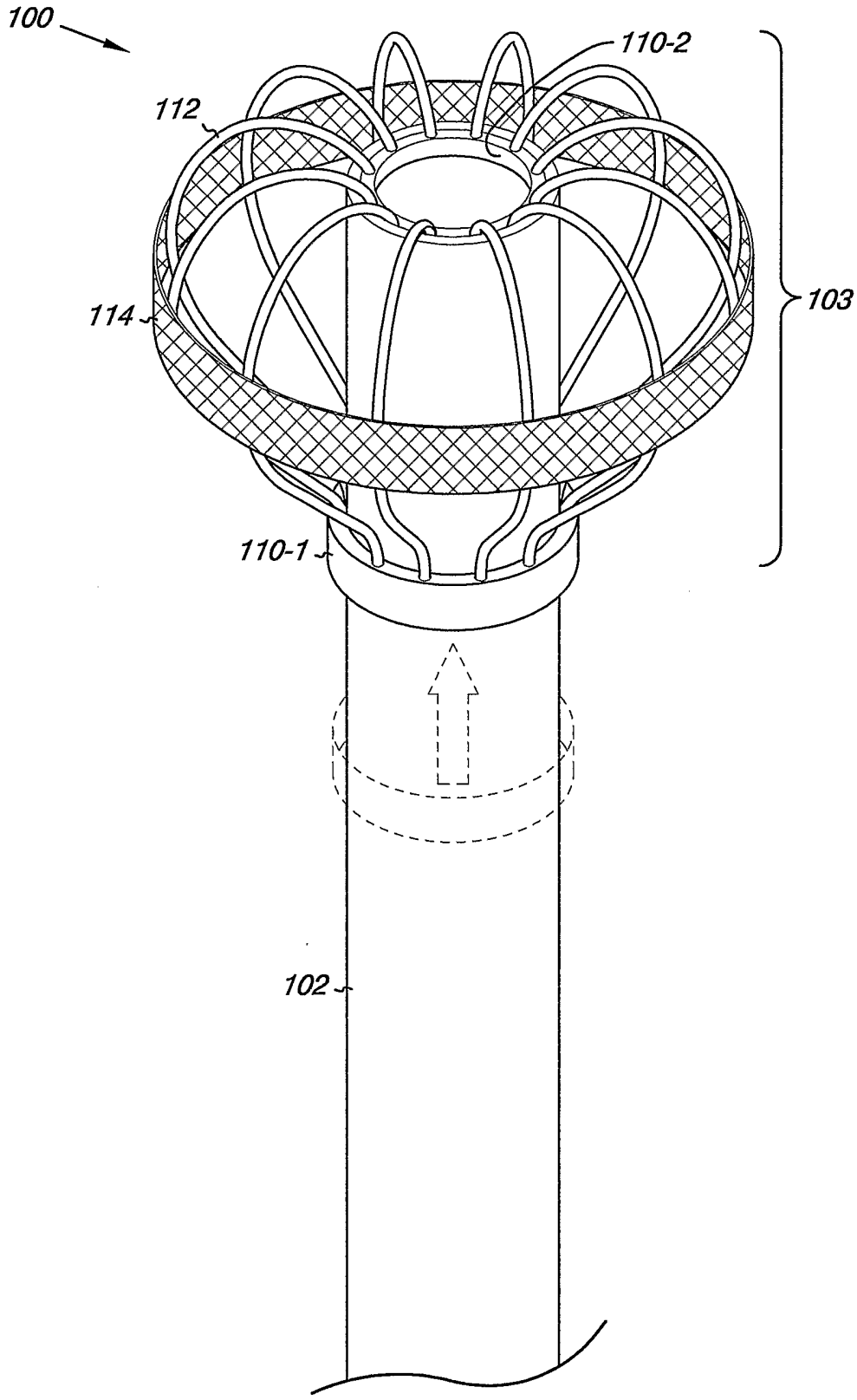

Fig. 1B

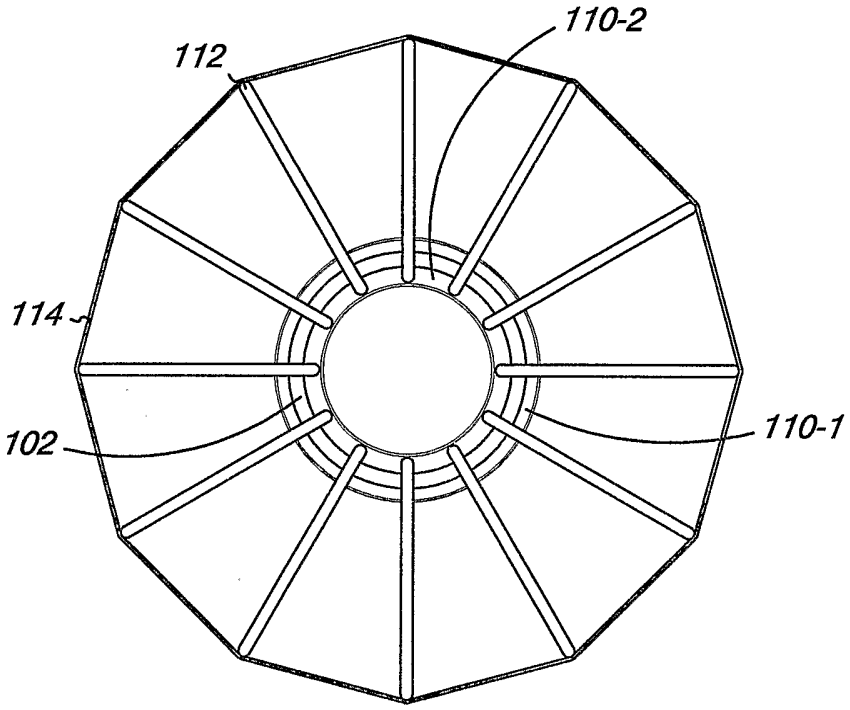

Fig. 1C

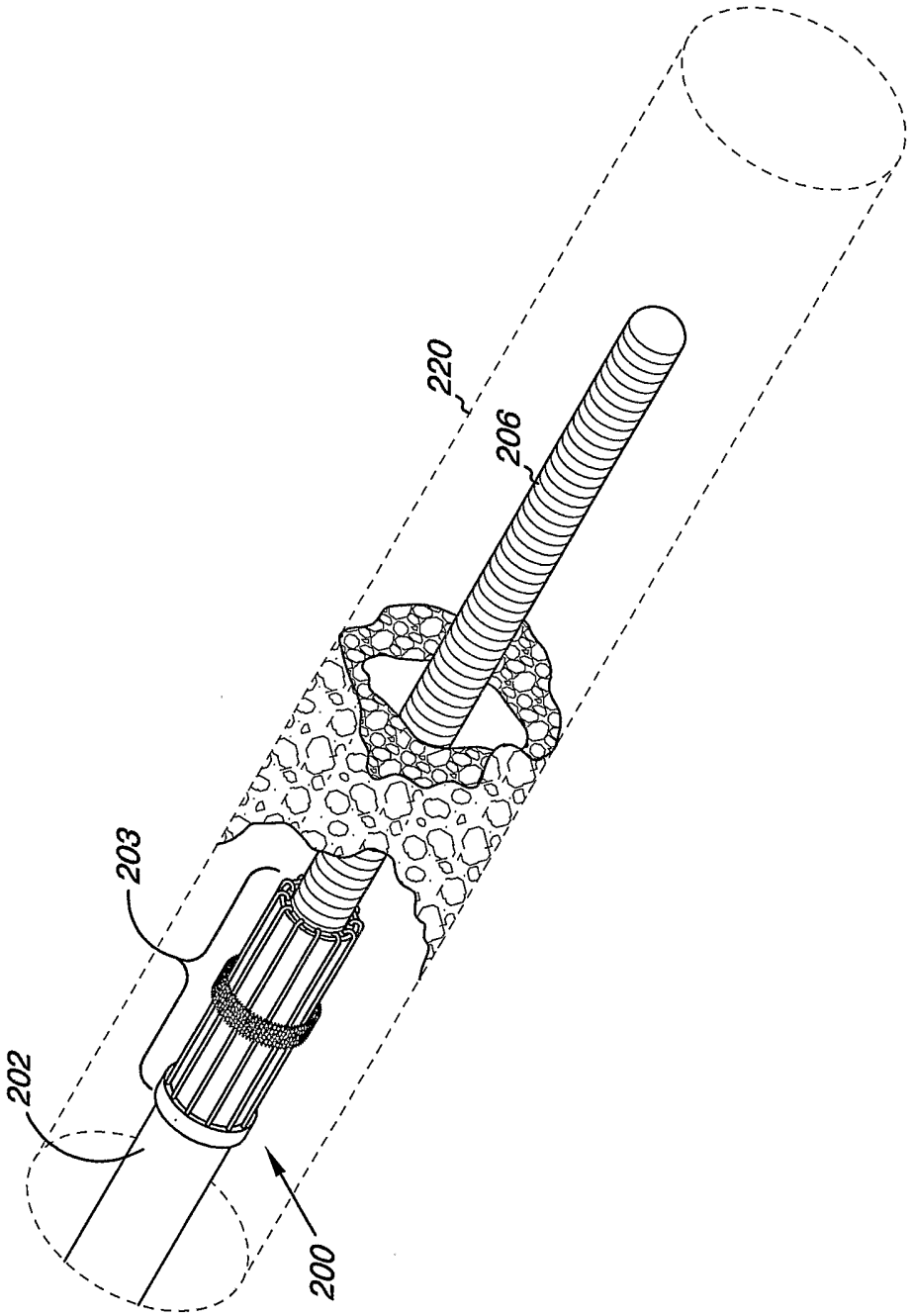

Fig. 2A

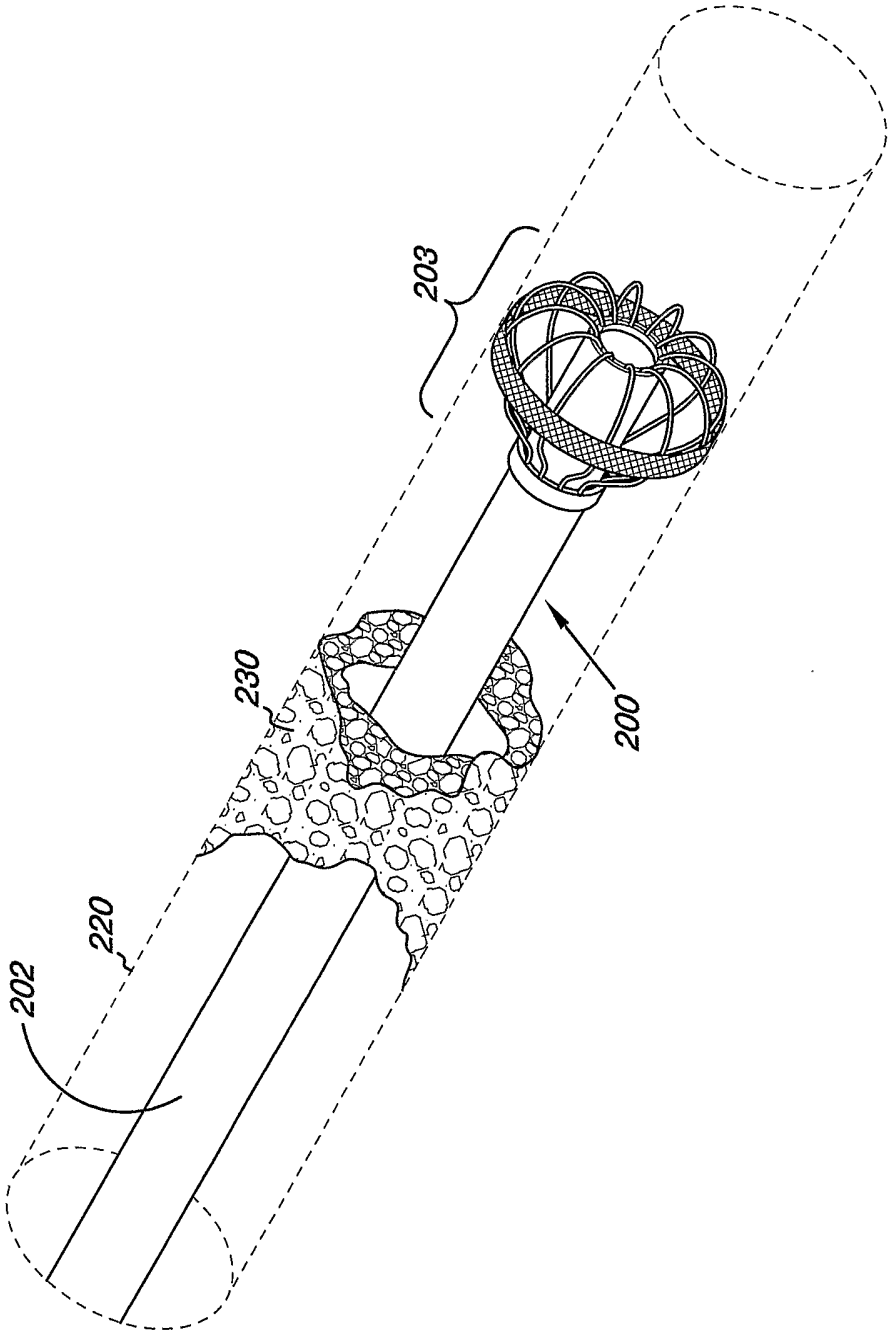

Fig. 2B

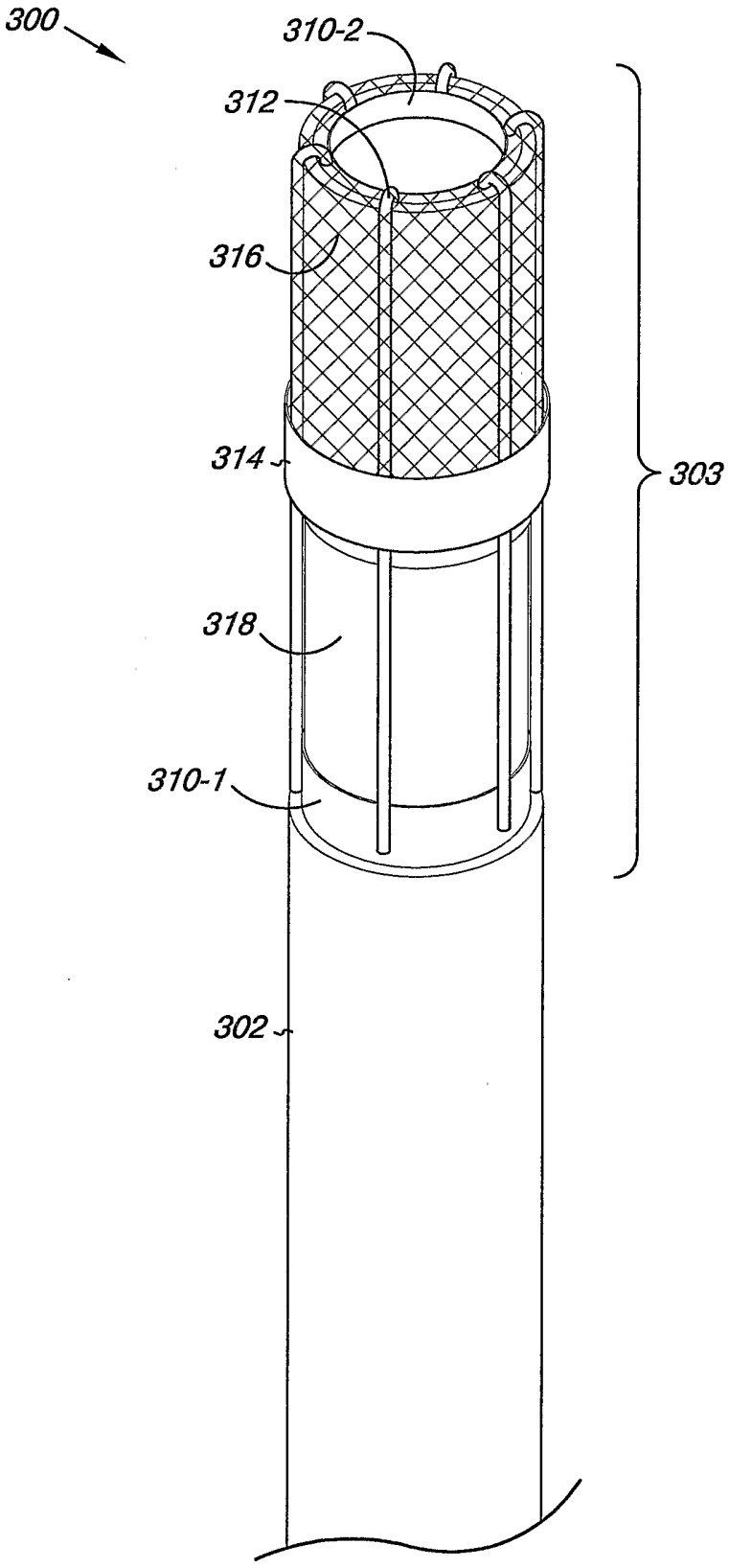

Fig. 3A

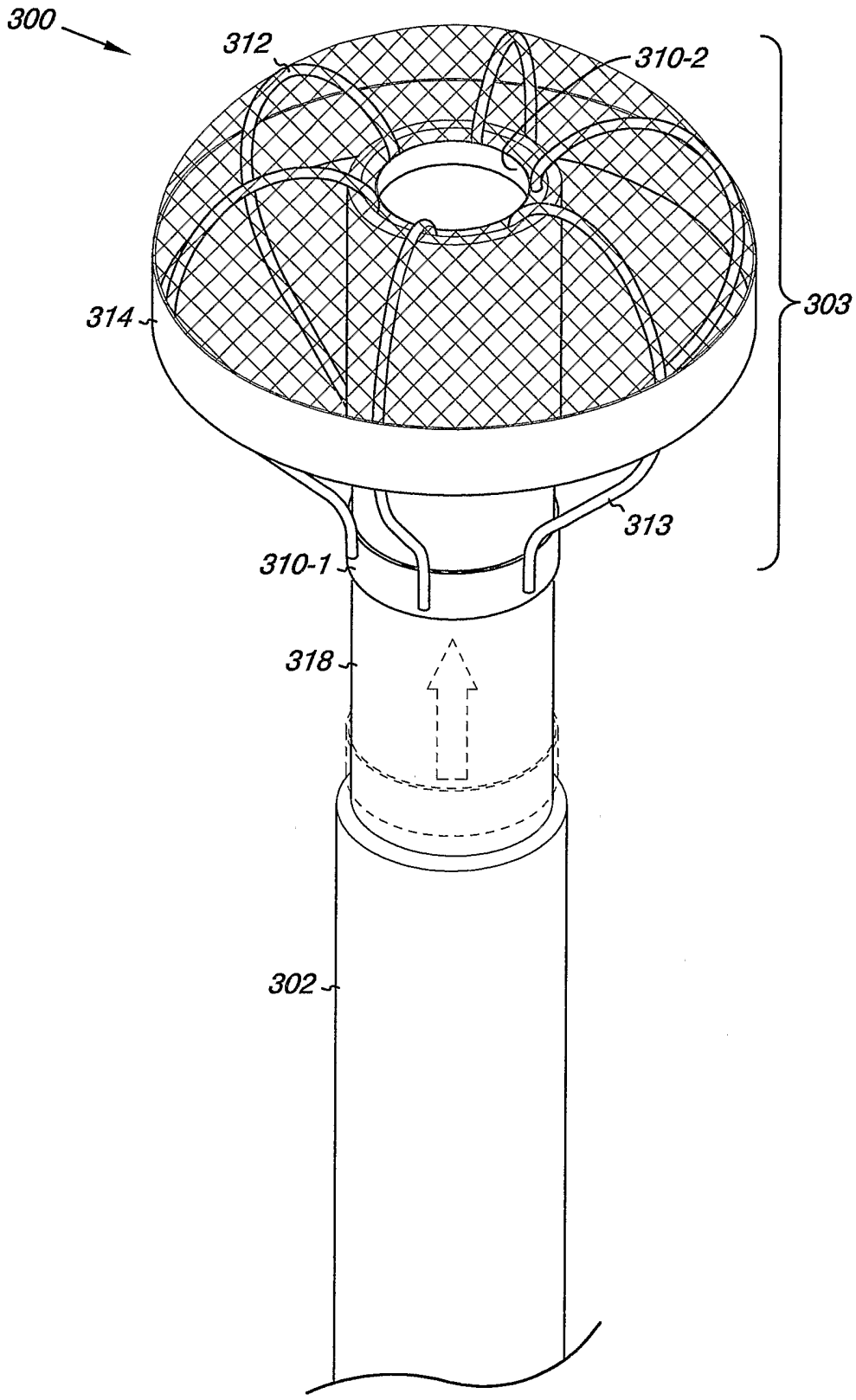

Fig. 3B

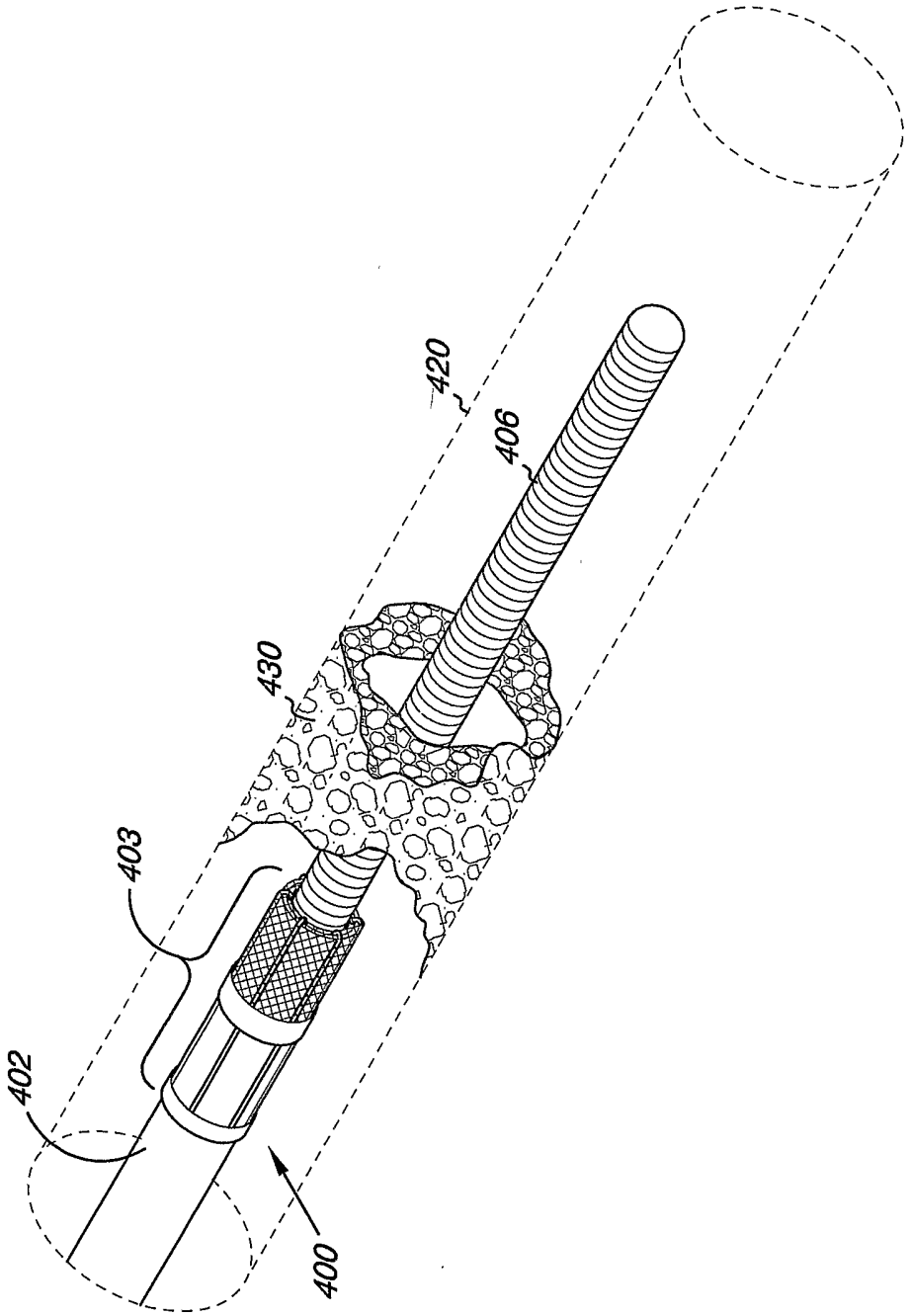

Fig. 4A

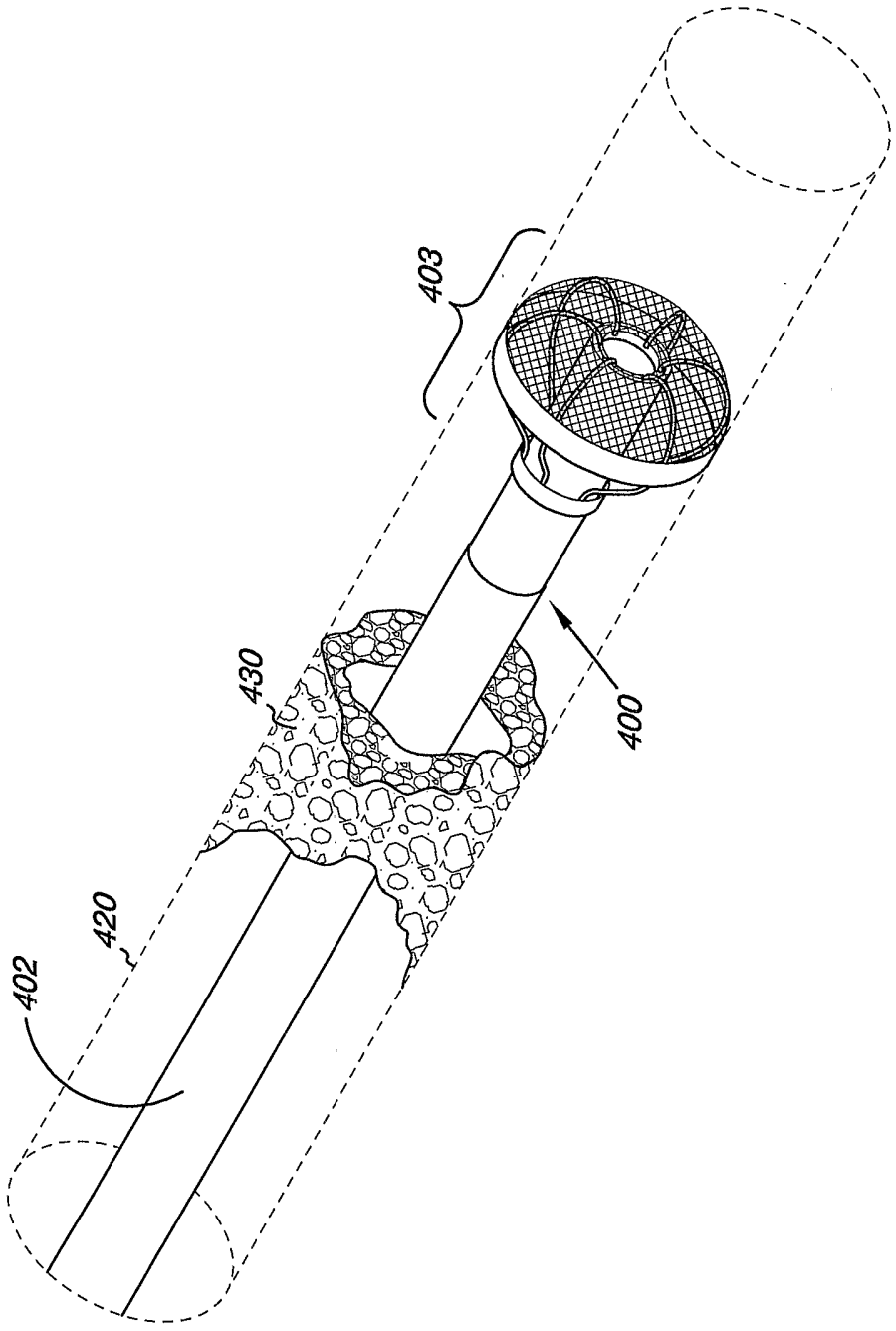

Fig. 4B

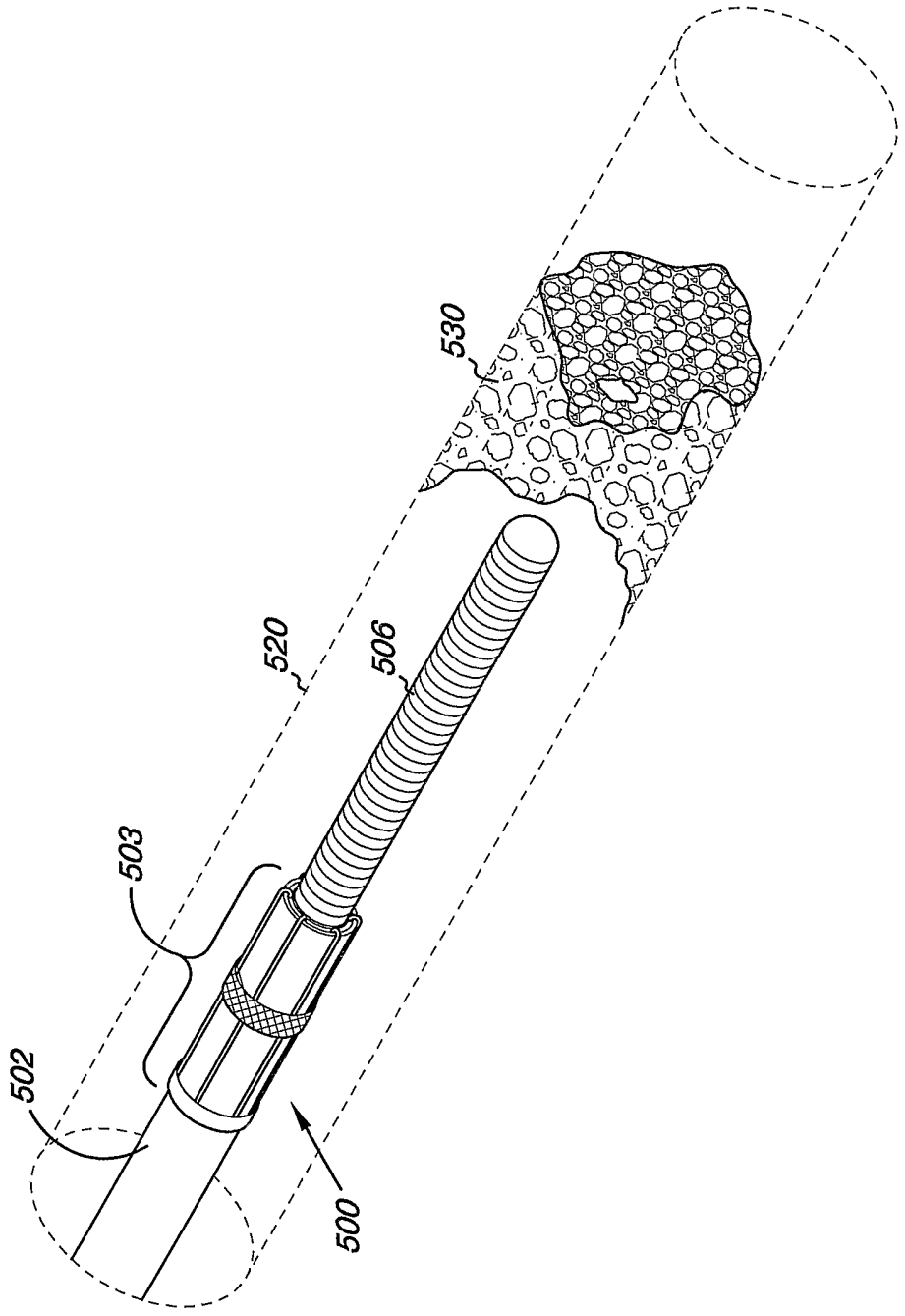

Fig. 5A

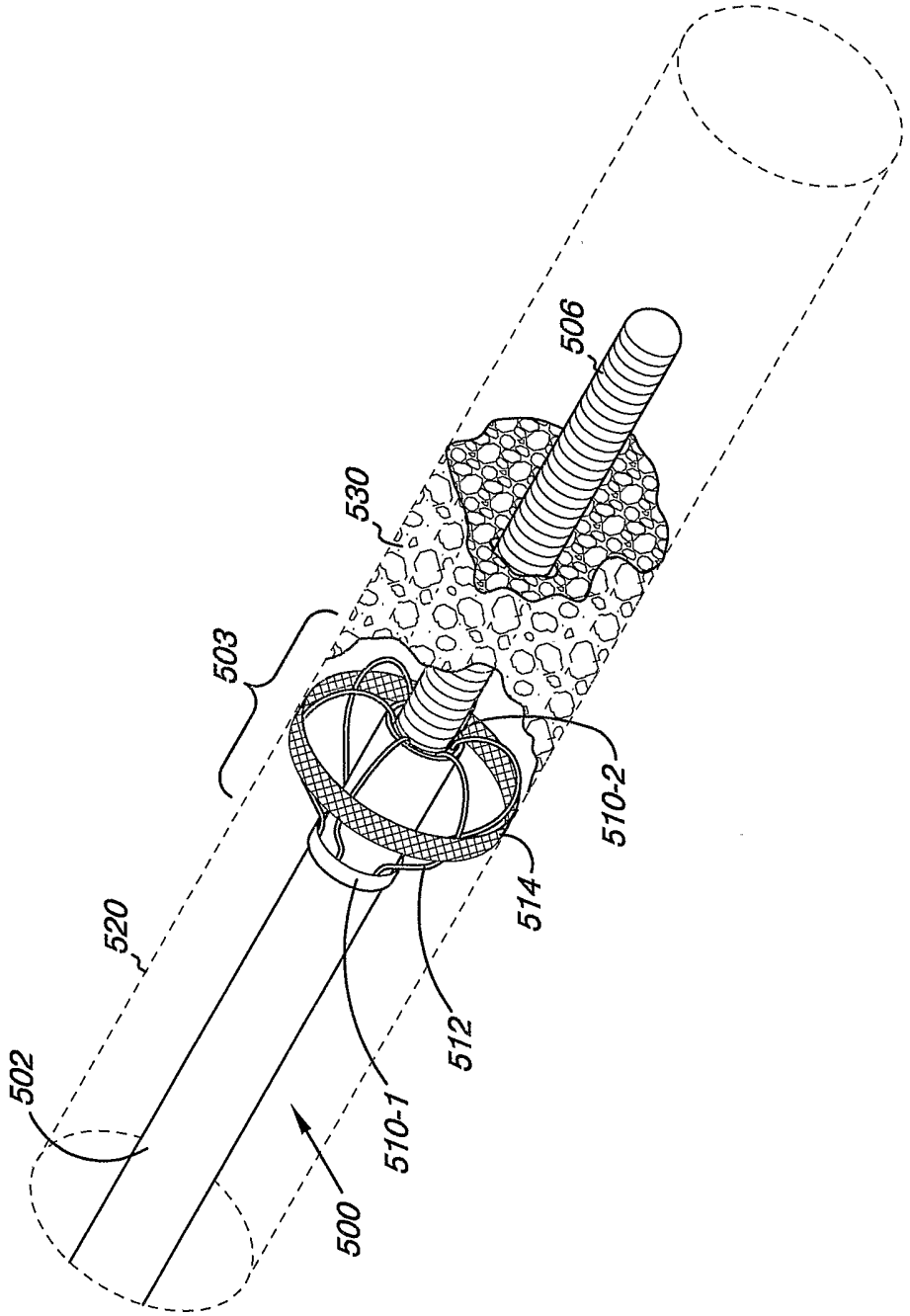

Fig. 5B

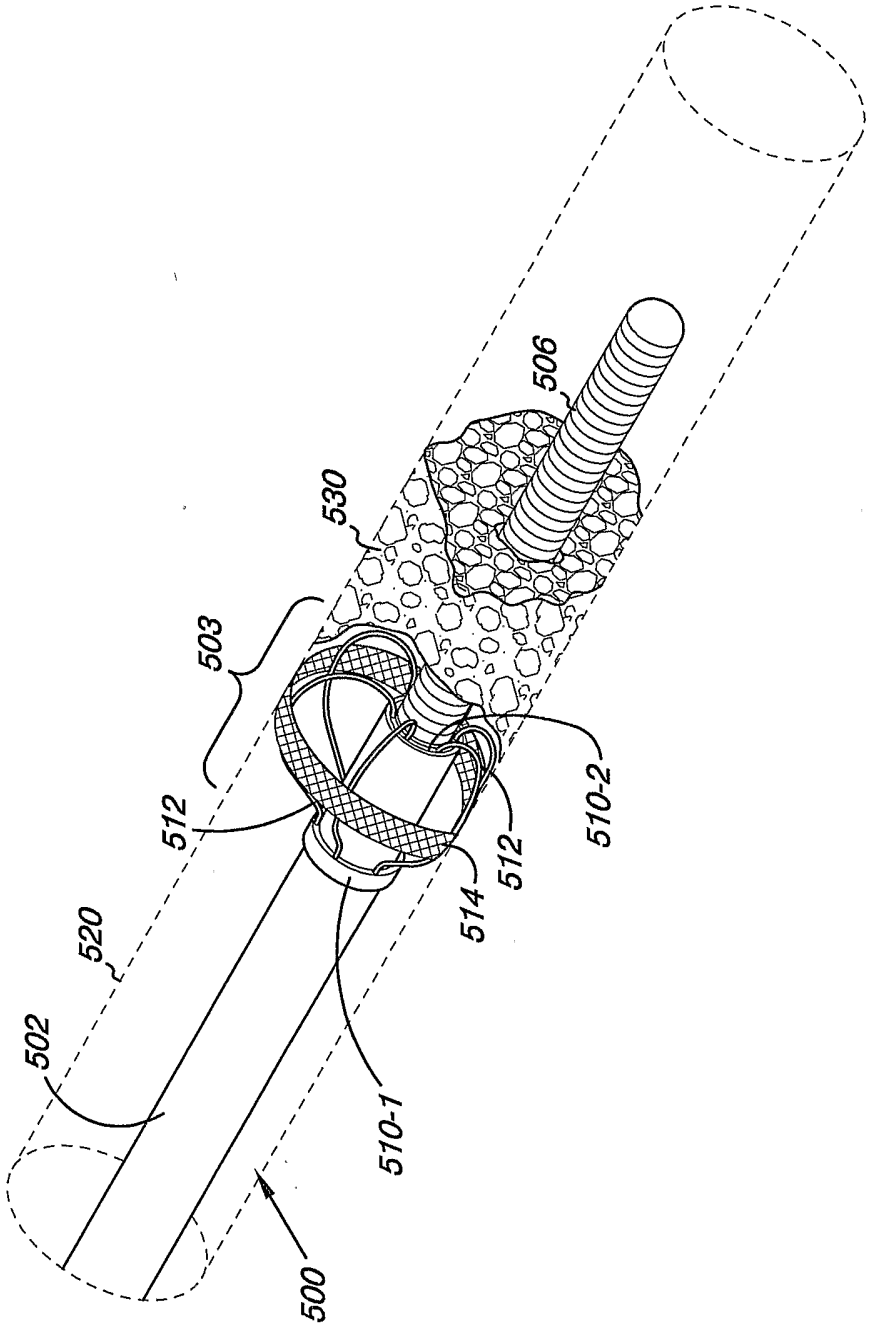

Fig. 5C

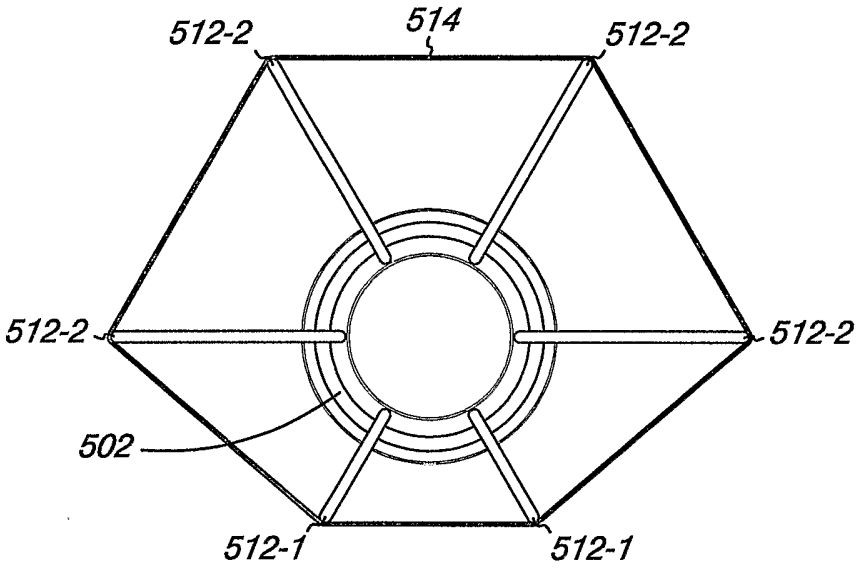

Fig. 5D

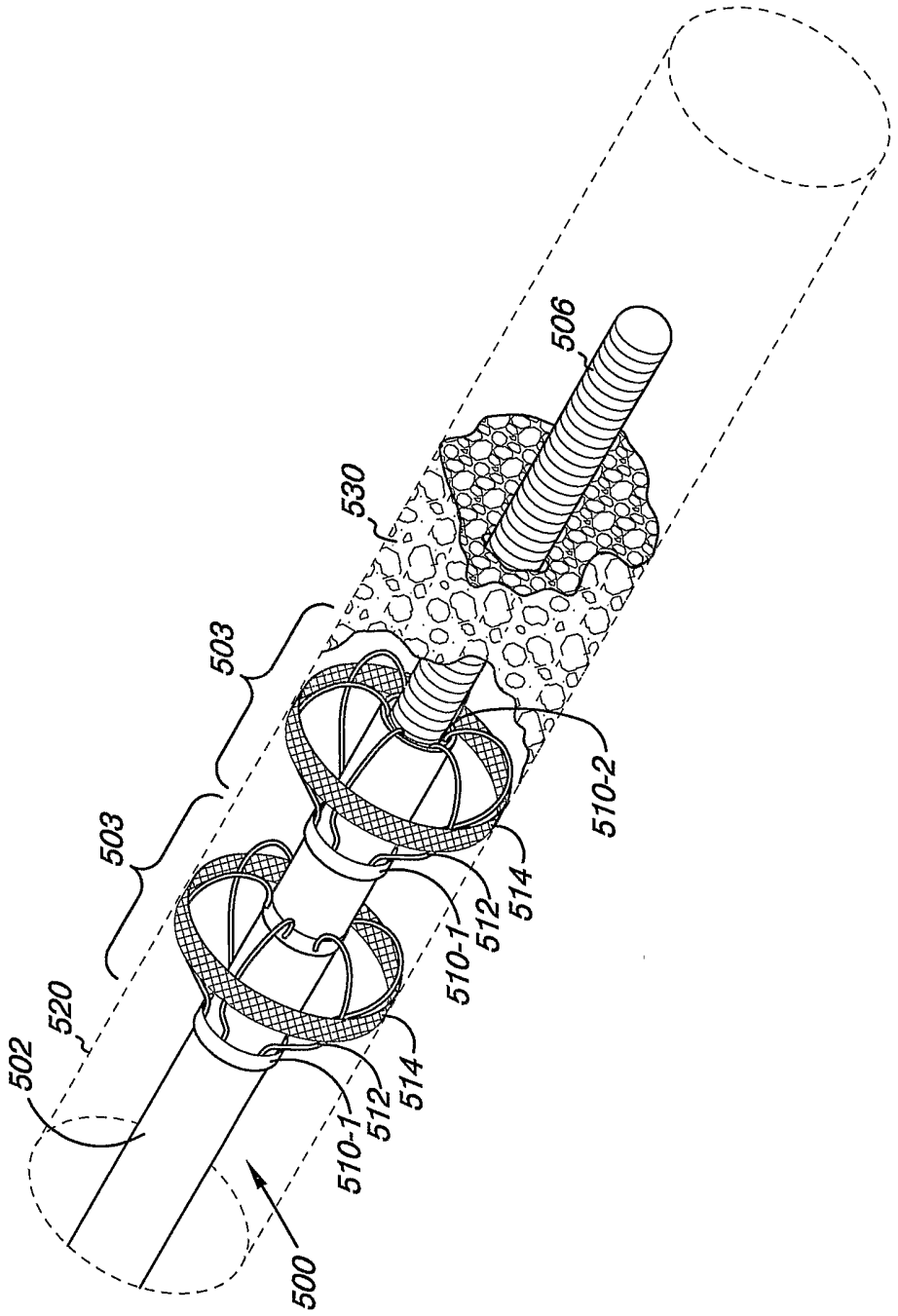

Fig. 5E

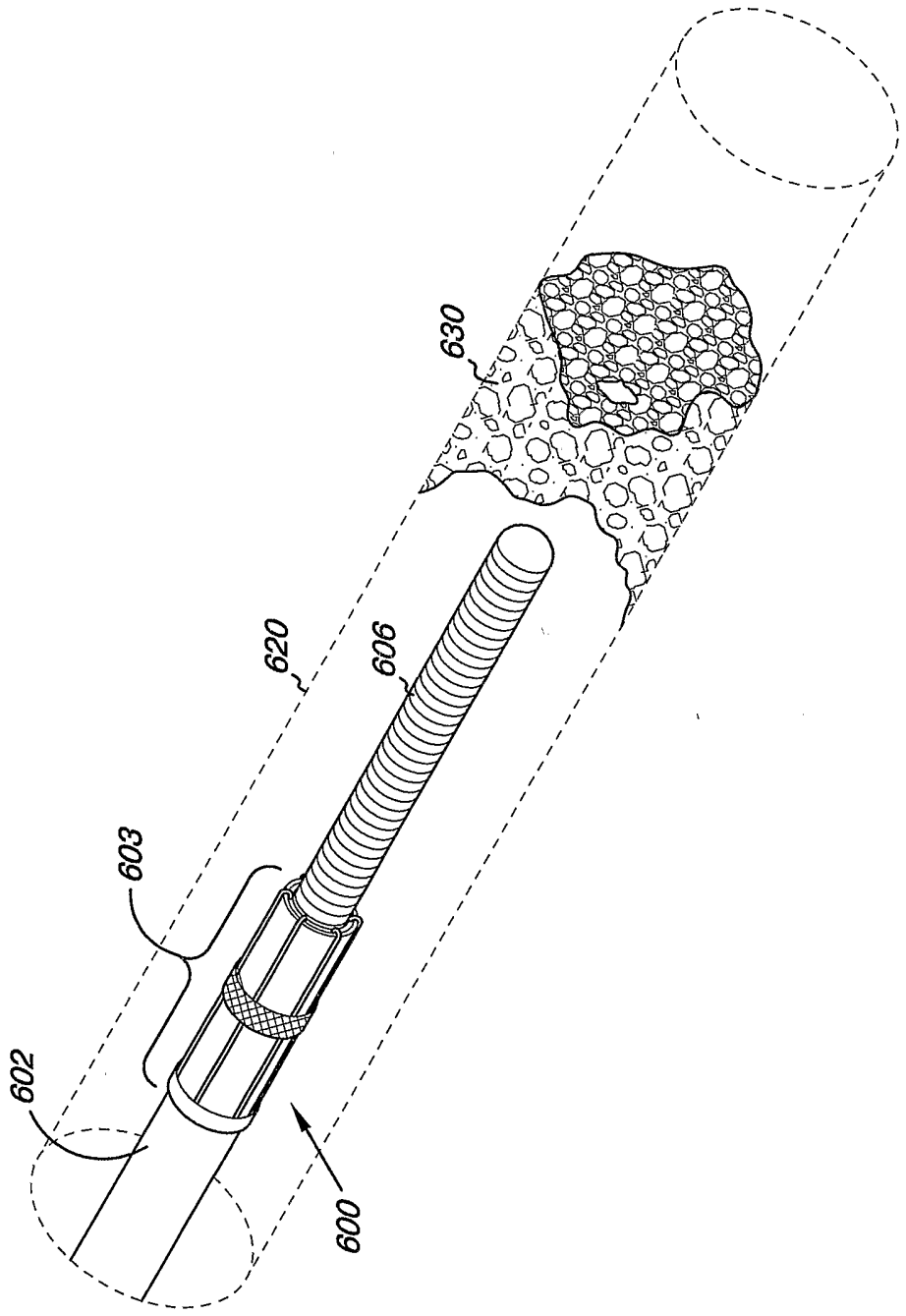

Fig. 6A

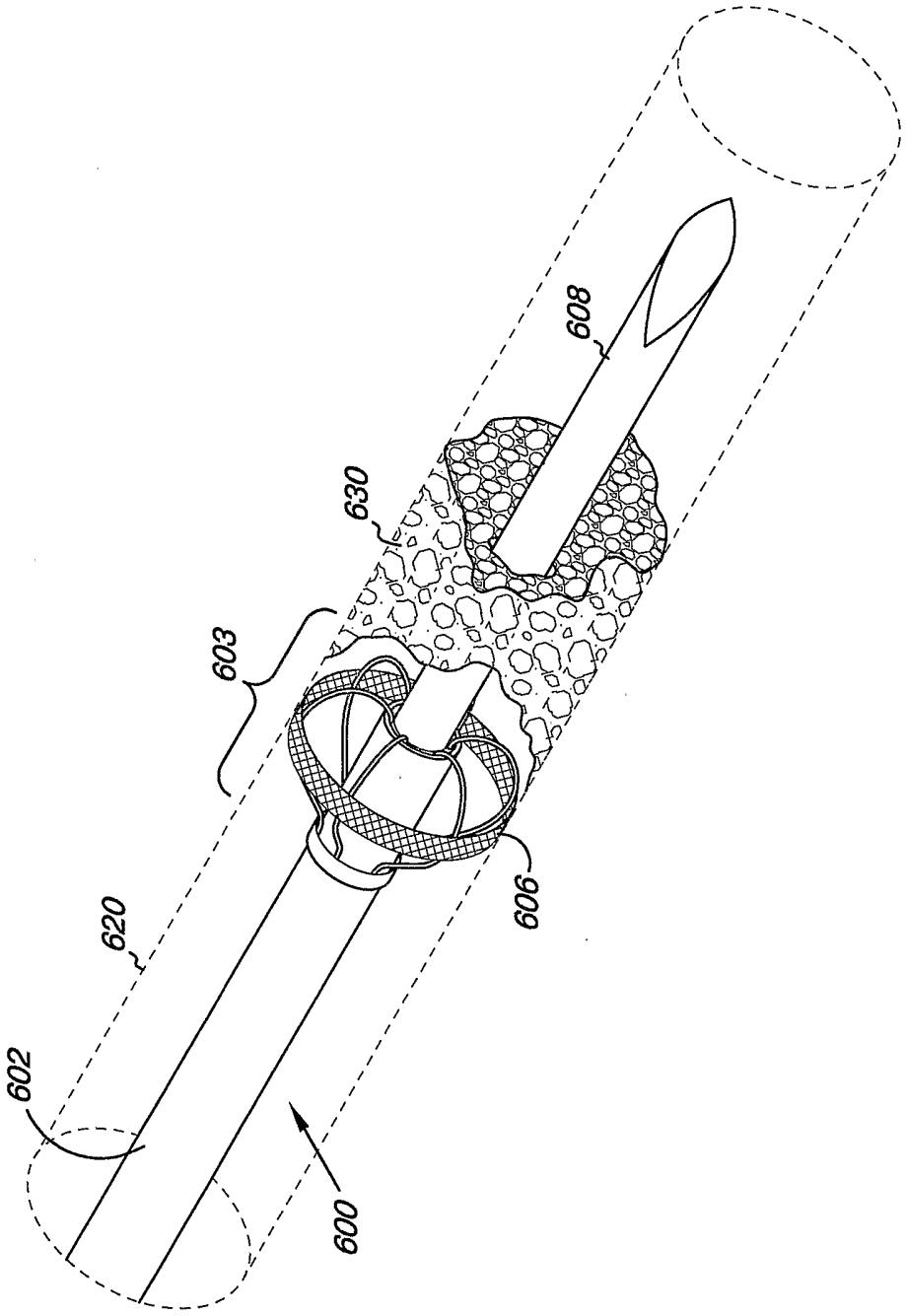

Fig. 6B

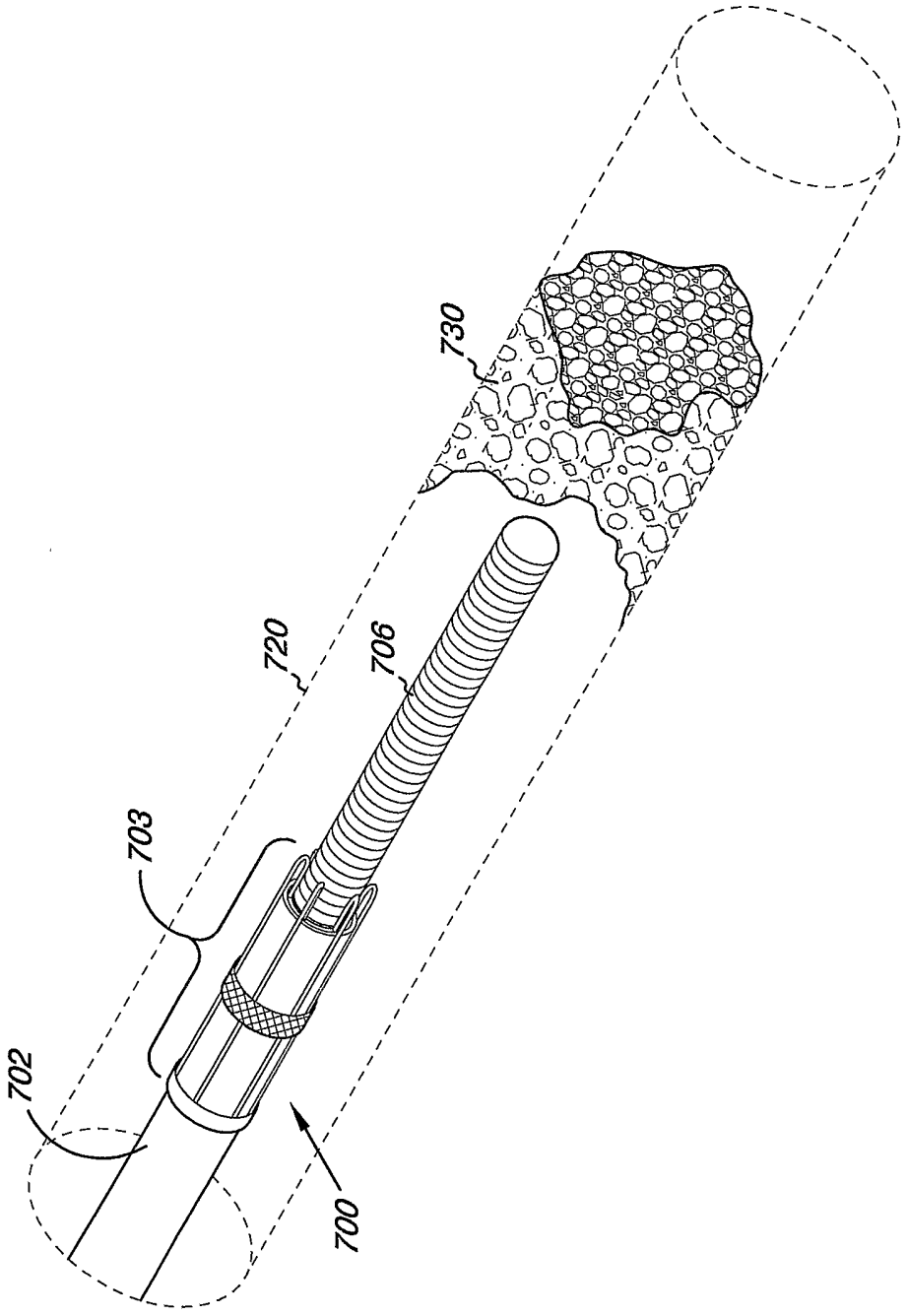

Fig. 7A

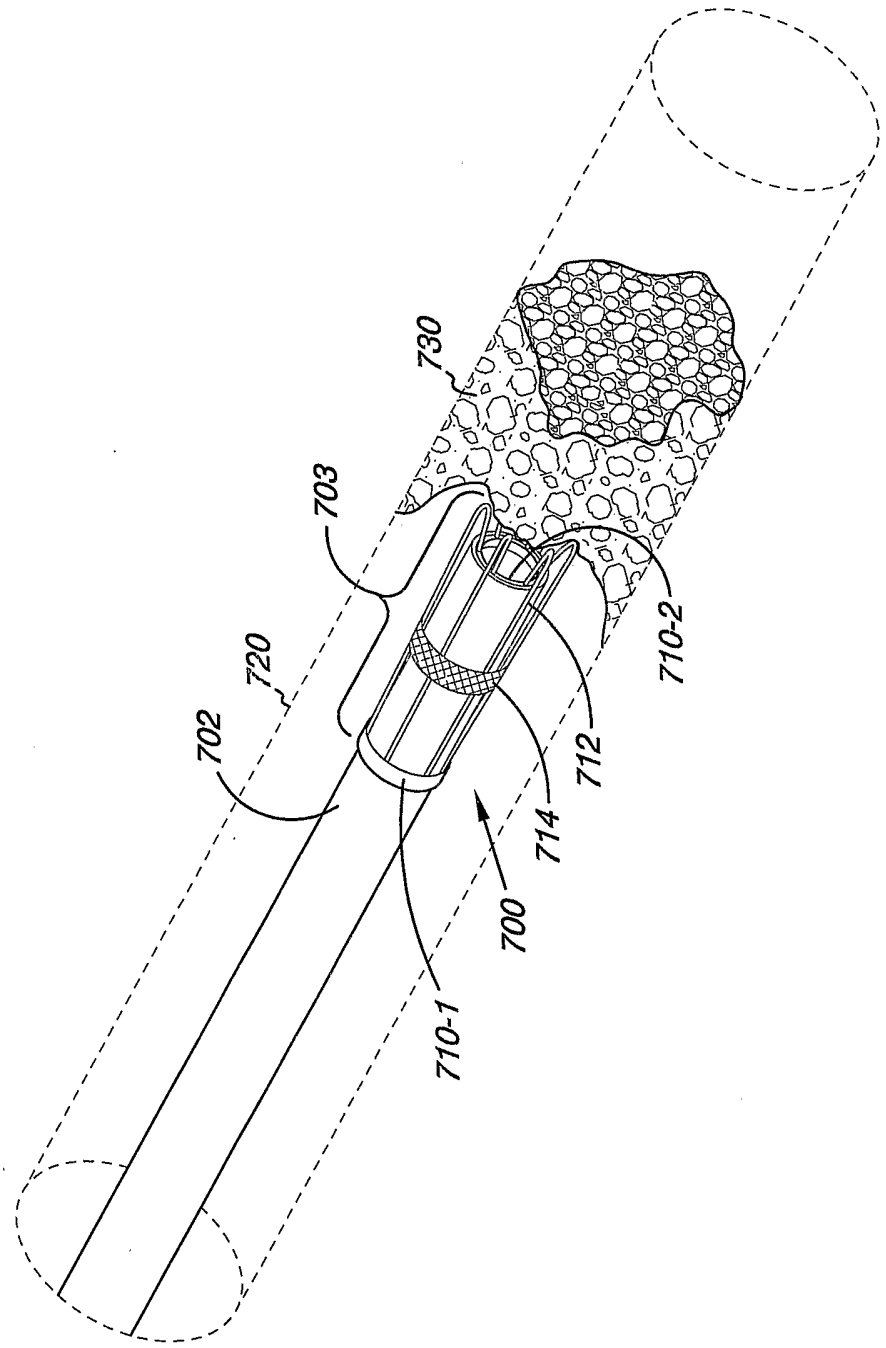

Fig. 7B

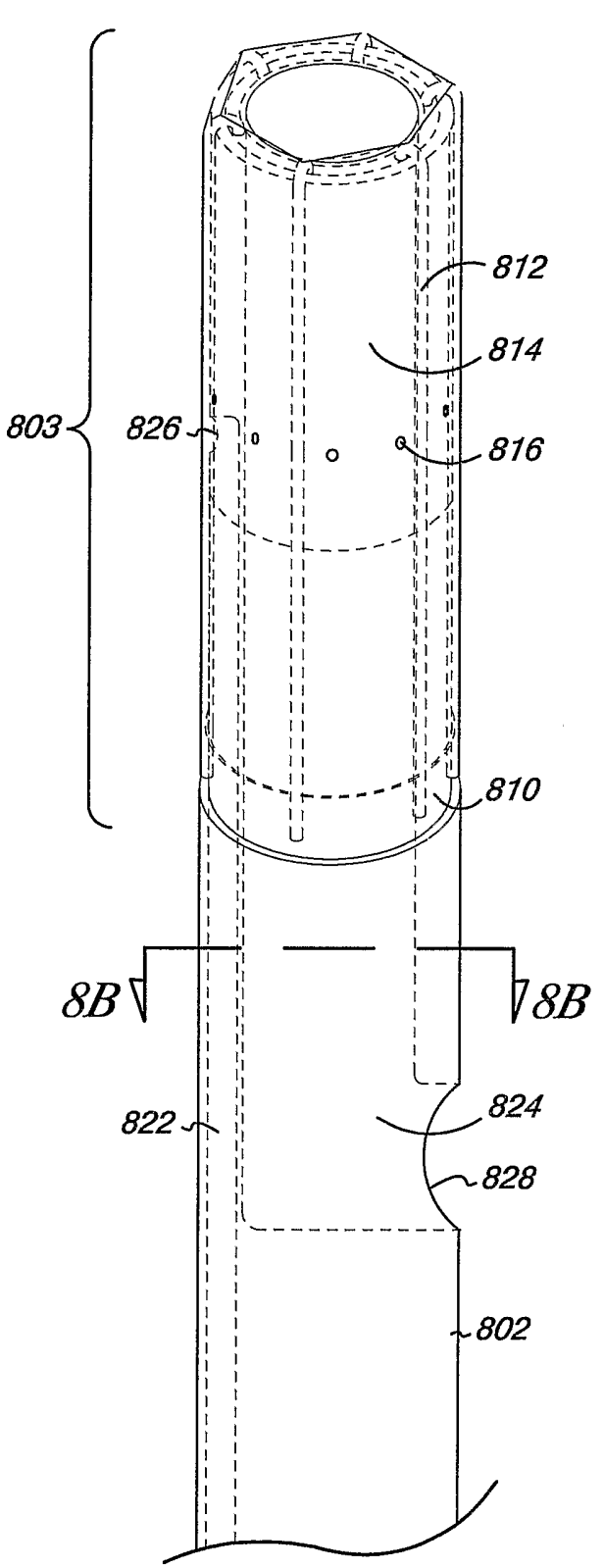

Fig. 8A

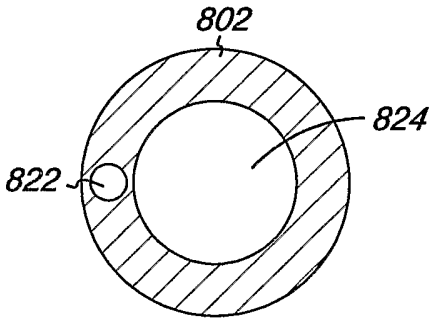

Fig. 8B

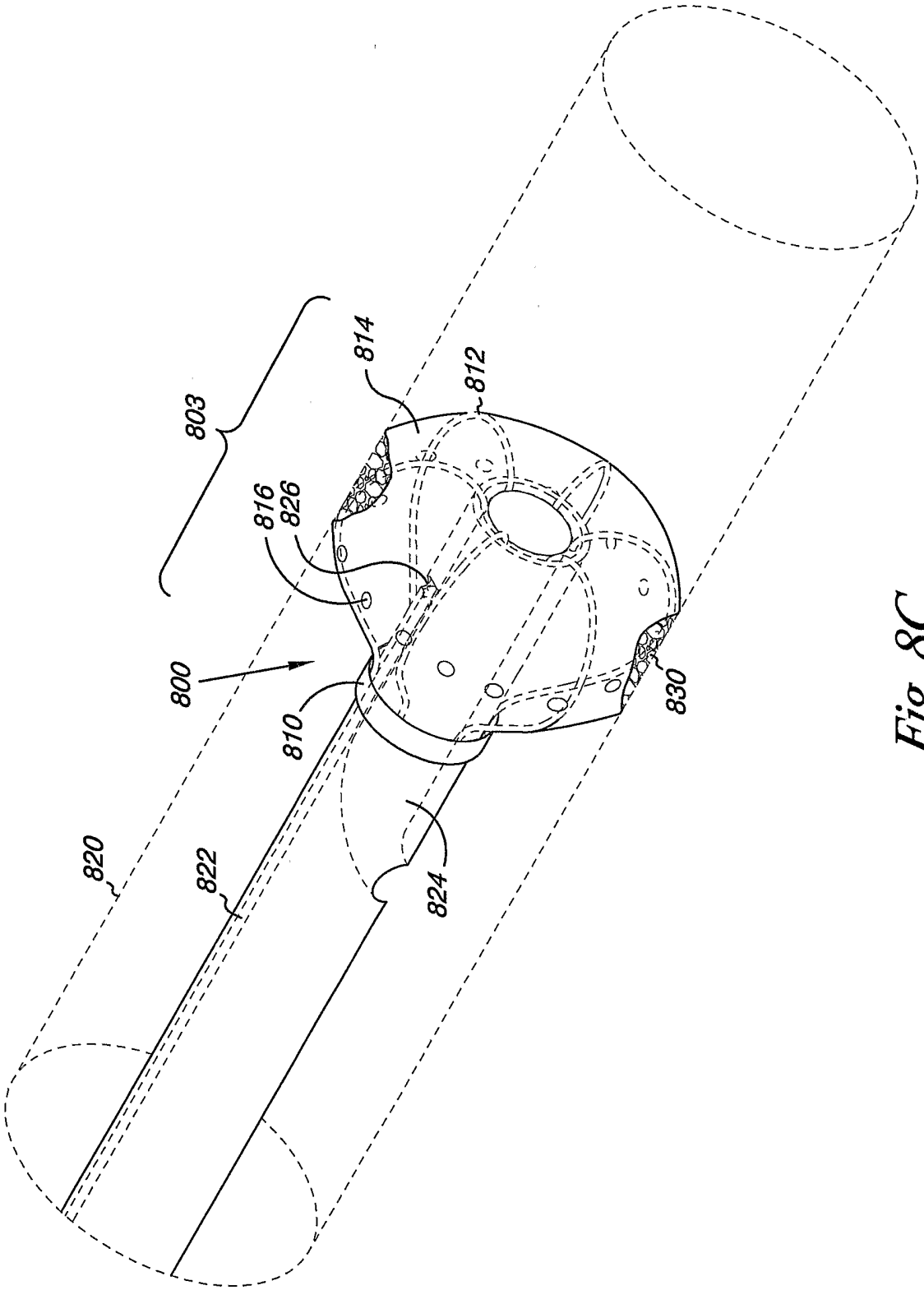

Fig. 8C

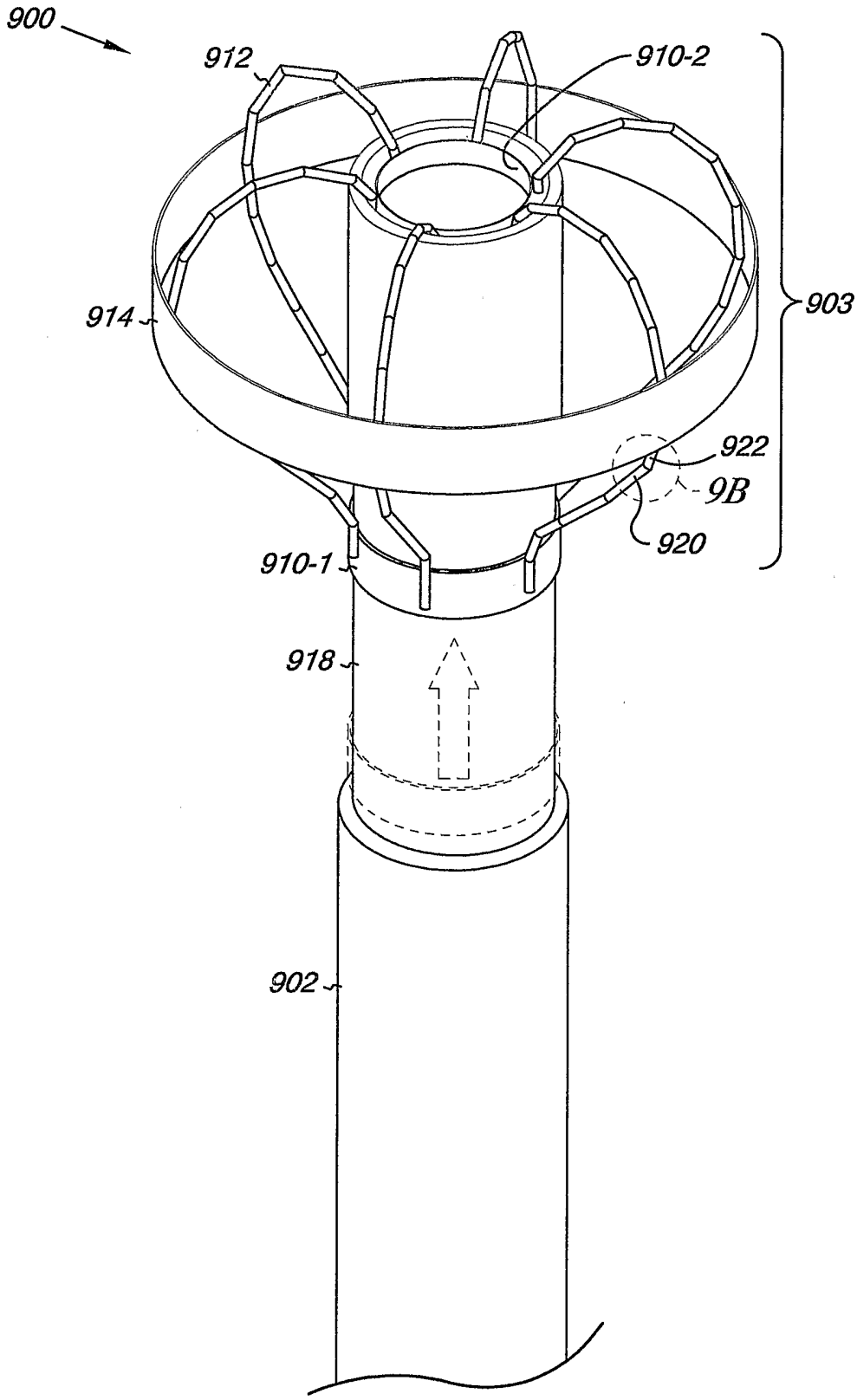

Fig. 9A

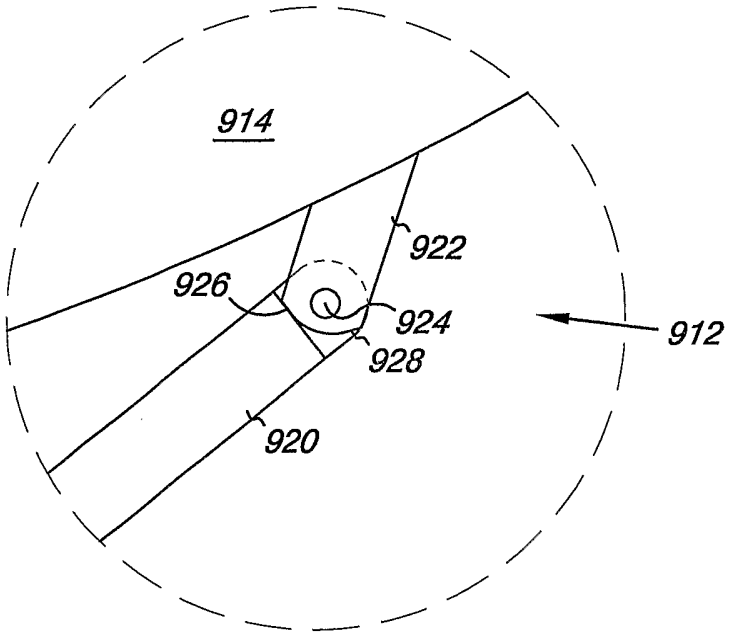

Fig. 9B

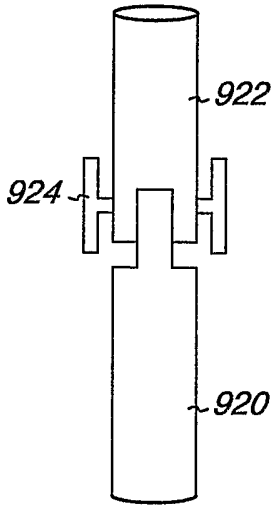

Fig. 9C

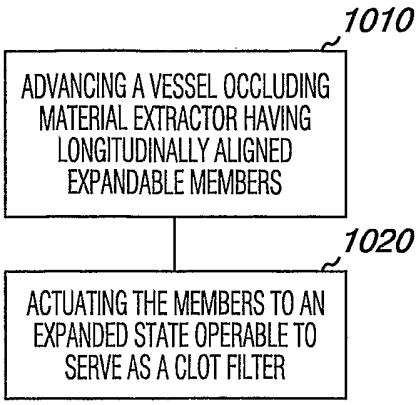
1010
ADVANCING A VESSEL OCCLUDING MATERIAL EXTRACTOR HAVING LONGITUDINALLY ALIGNED EXPANDABLE MEMBERS
1020
ACTUATING THE MEMBERS TO AN EXPANDED STATE OPERABLE TO SERVE AS A CLOT FILTER

Fig. 10

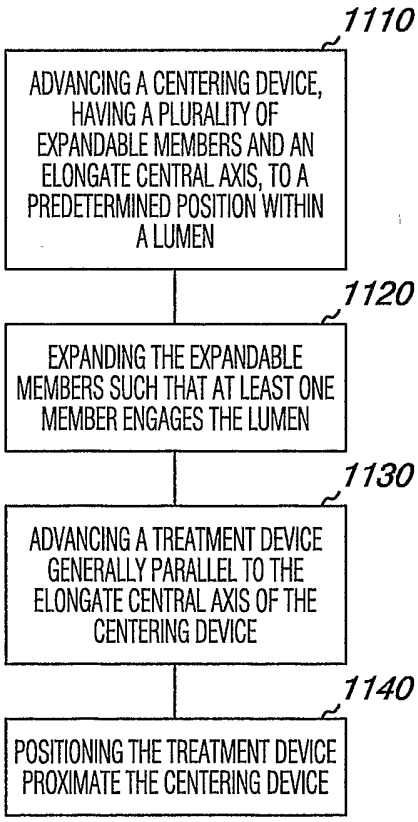
1110
ADVANCING A CENTERING DEVICE, HAVING A PLURALITY OF EXPANDABLE MEMBERS AND AN ELONGATE CENTRAL AXIS, TO A PREDETERMINED POSITION WITHIN A LUMEN
1120
EXPANDING THE EXPANDABLE MEMBERS SUCH THAT AT LEAST ONE MEMBER ENGAGES THE LUMEN
1130
ADVANCING A TREATMENT DEVICE GENERALLY PARALLEL TO THE ELONGATE CENTRAL AXIS OF THE CENTERING DEVICE
1140
POSITIONING THE TREATMENT DEVICE PROXIMATE THE CENTERING DEVICE

Fig. 11