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(54) **TOOLS FOR SHEATHING TREATMENT DEVICES AND ASSOCIATED SYSTEMS AND METHODS**

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(57) **ABSTRACT**

Devices for loading intravascular treatment devices into a sheath and associated systems and methods are disclosed herein. A sheathing tool may include, for example, a first channel extending to a first opening, the first channel configured to receive a treatment device in a constrained state therethrough. The treatment device may include an elongated member and a first element and a second element at a distal region of the elongated member. The second channel may extend to a second opening, the second opening surrounded by a sidewall and configured to receive the treatment device in the constrained state therethrough, wherein the second opening is spaced apart from the first opening by a gap, and wherein a length of the gap is great enough to allow the first element to self-expand over the sidewall while
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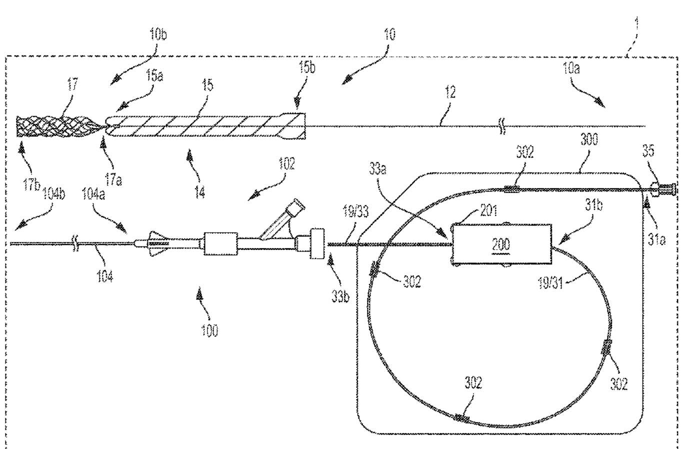

the second element generally maintains its diameter in the constrained state while crossing the gap.

5 Claims, 14 Drawing Sheets

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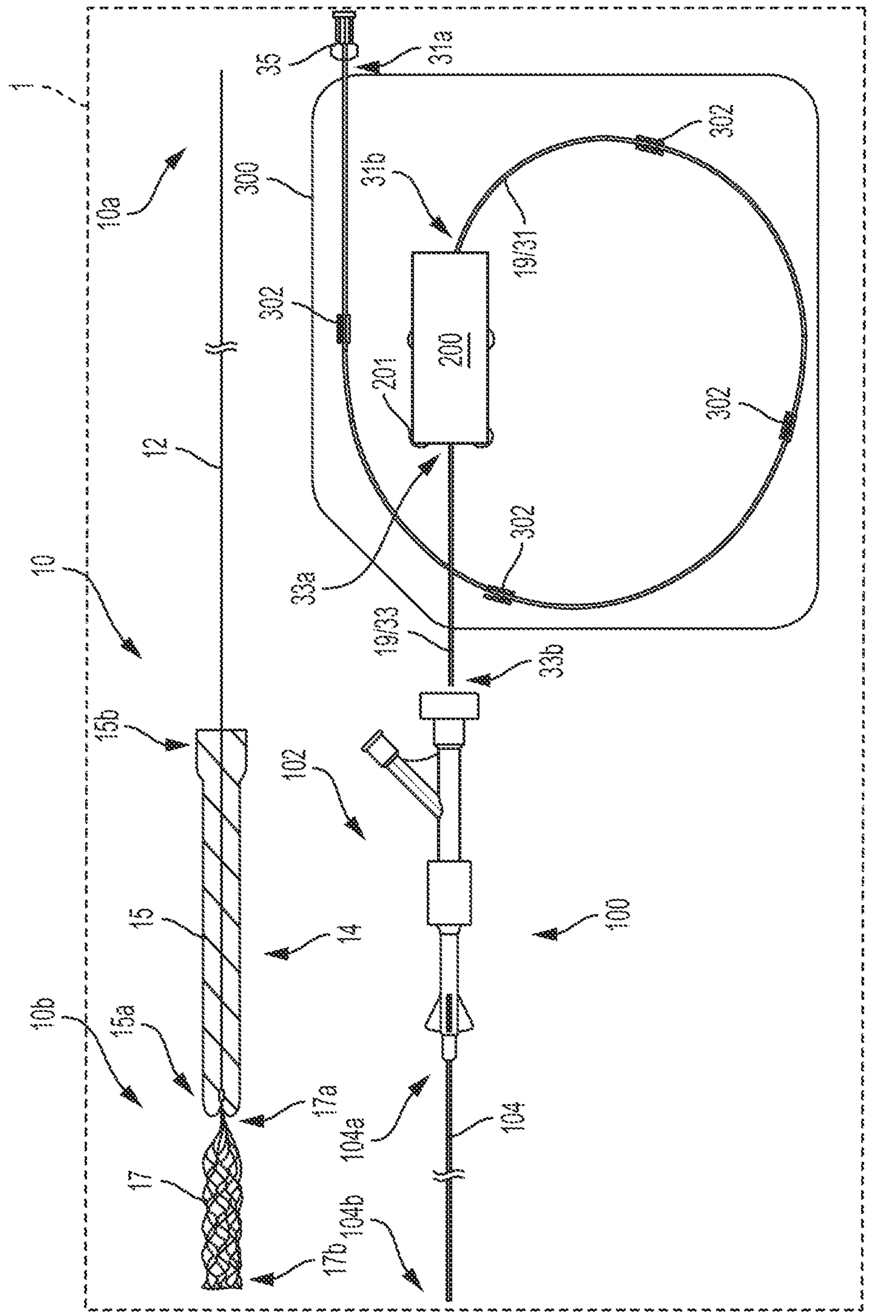
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104b

FIG. 1

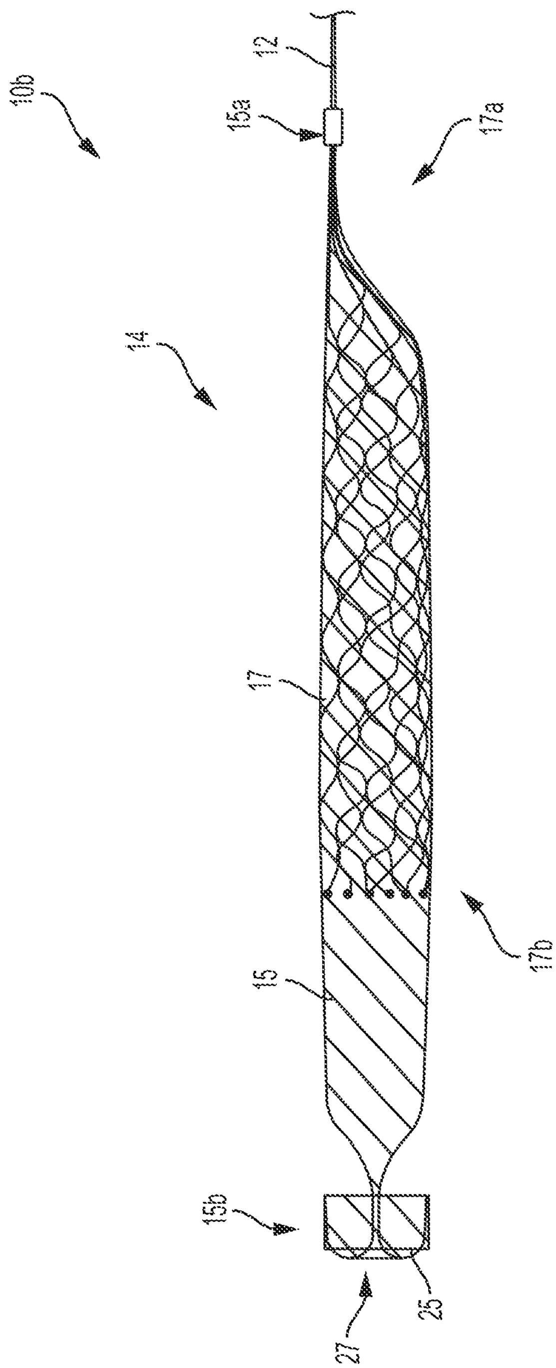

FIG. 2

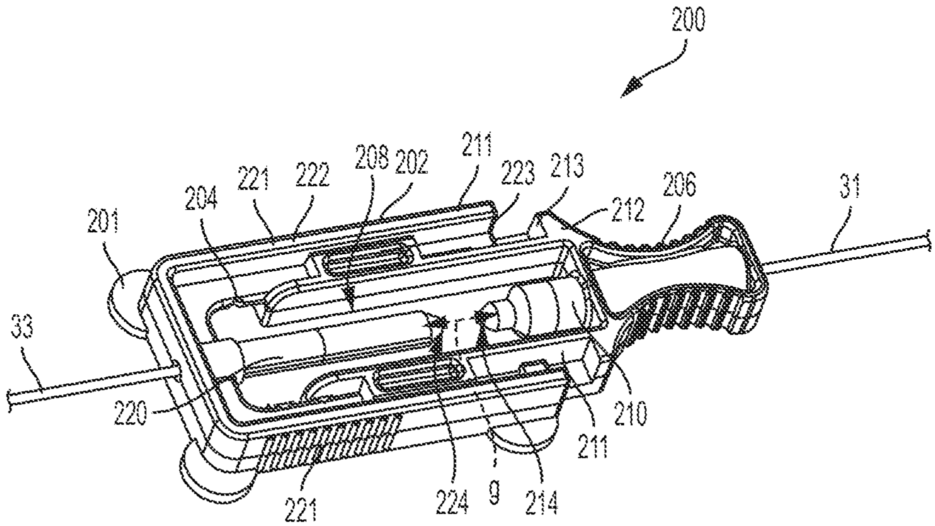
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FIG. 3A

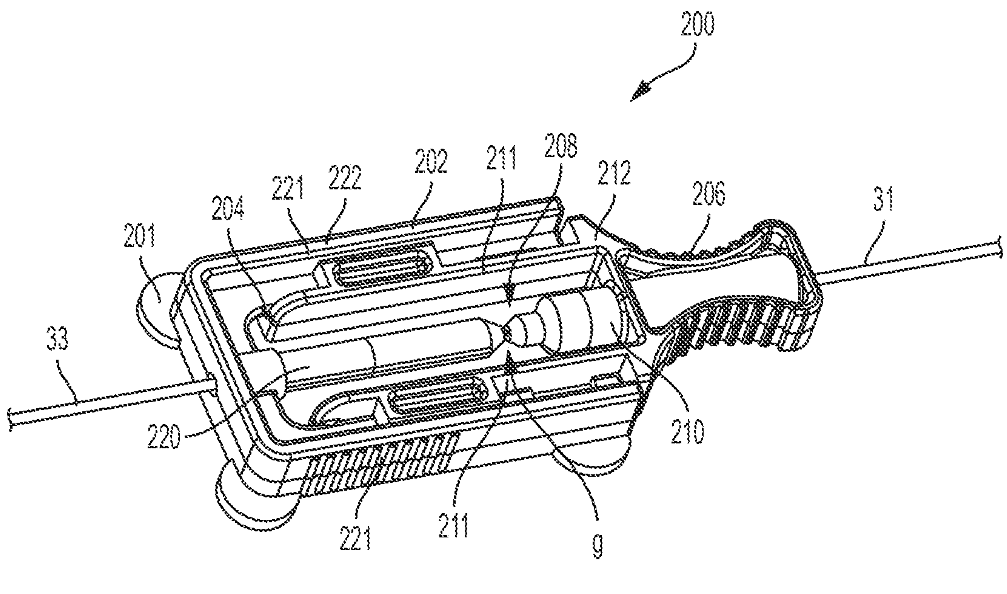
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FIG. 3B

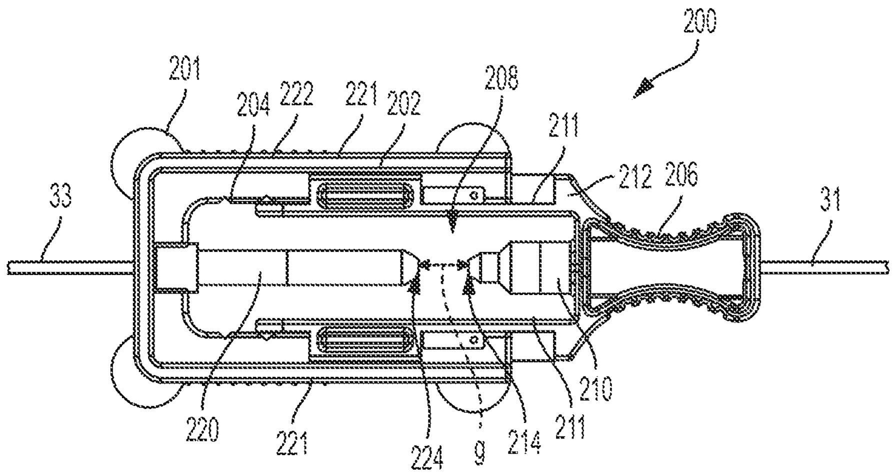

FIG. 3C

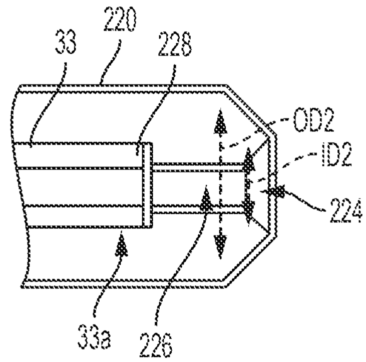

FIG. 3F

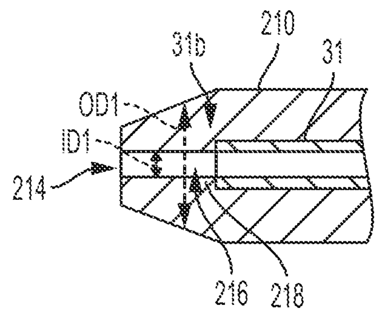

FIG. 3E

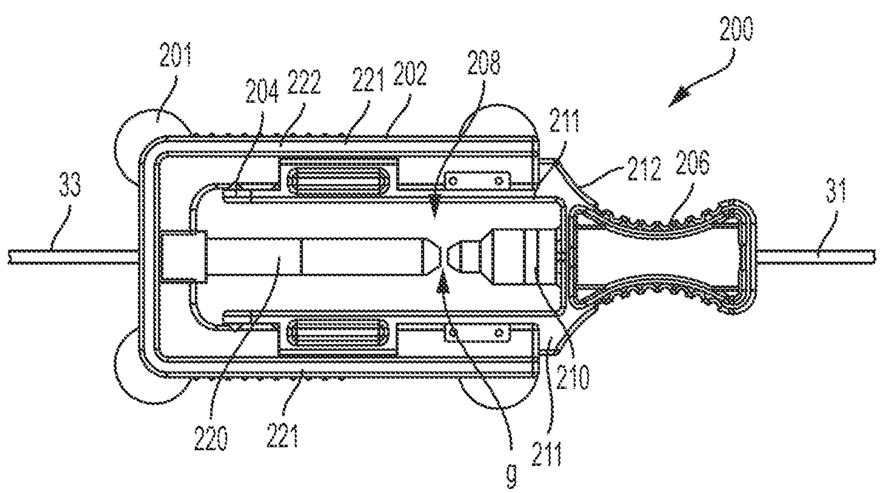

FIG. 3D

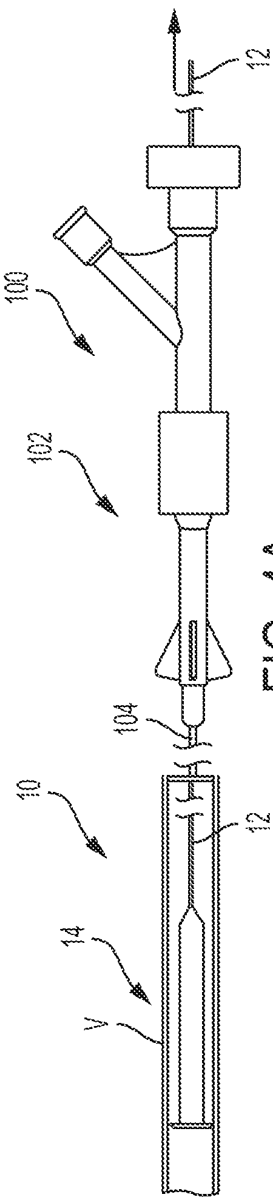
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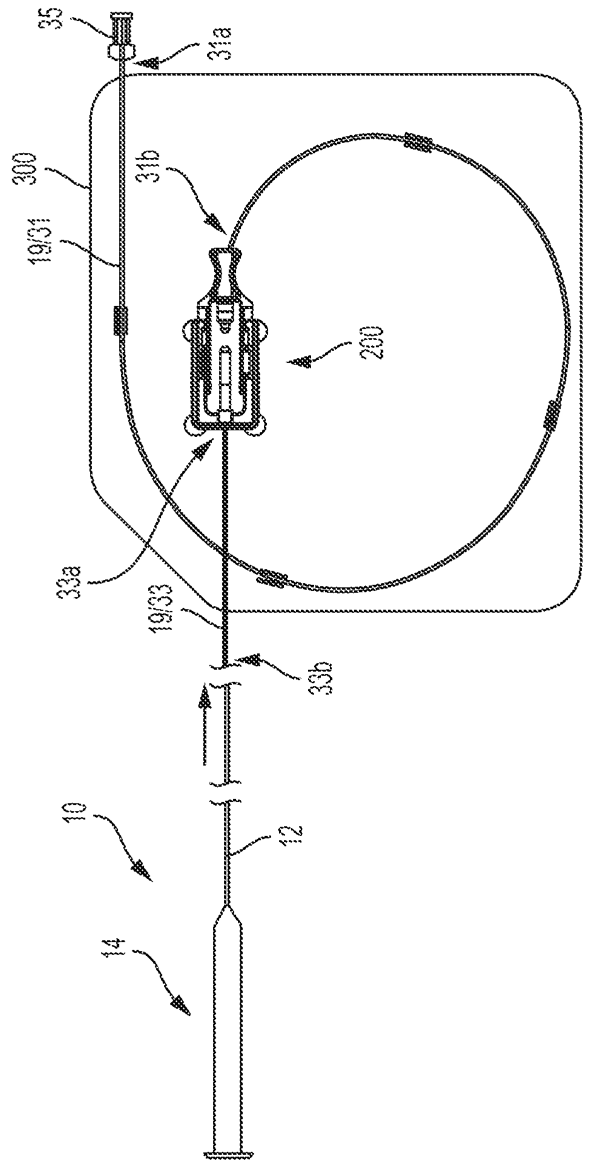
FIG. 4A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33b
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FIG. 4B

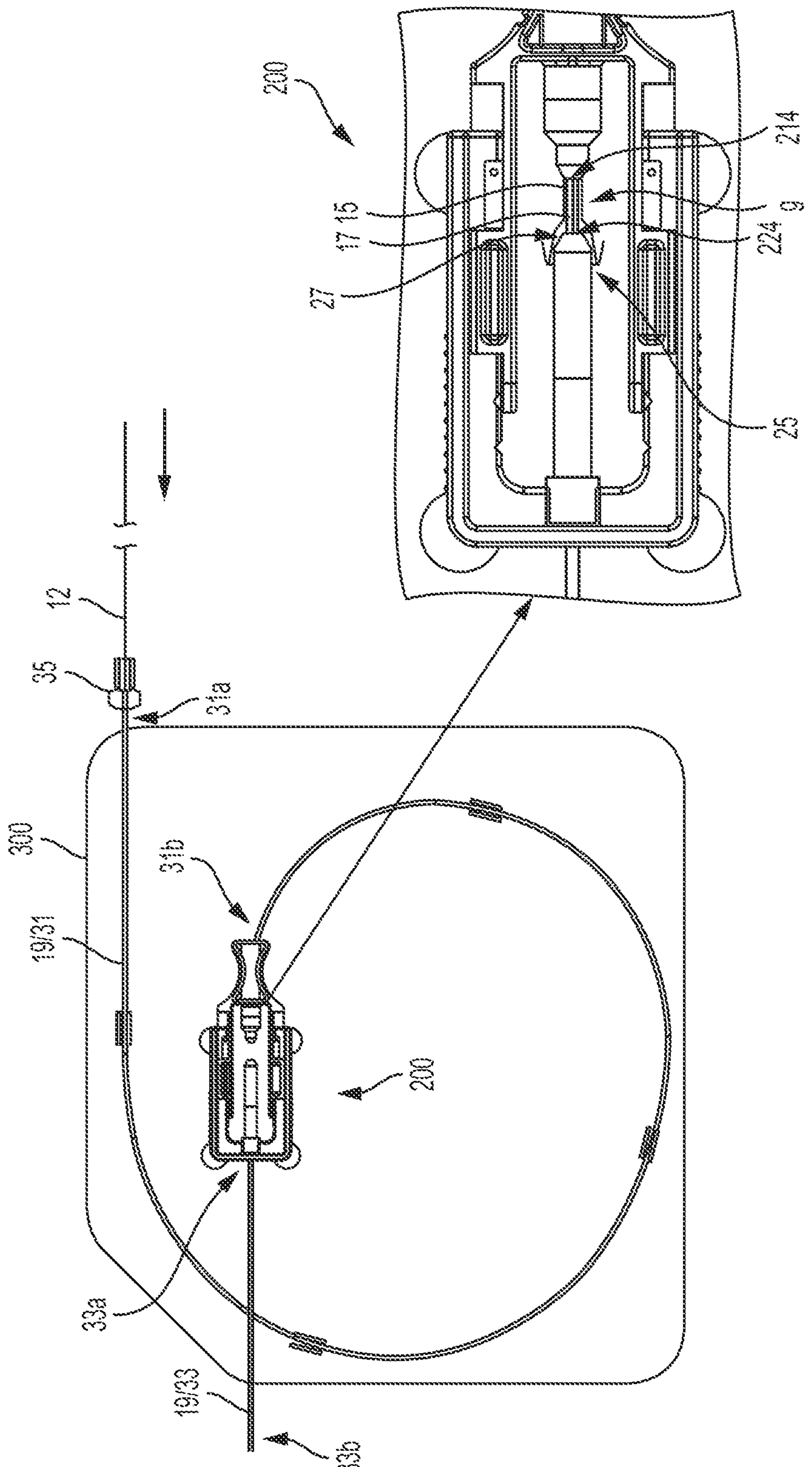

FIG. 4C

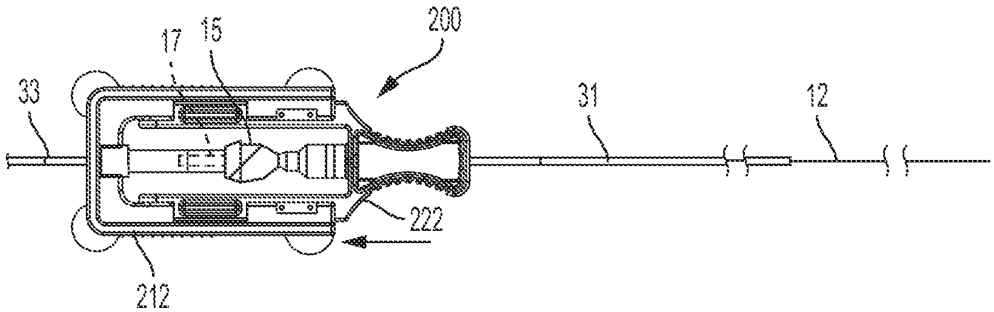

FIG. 4D

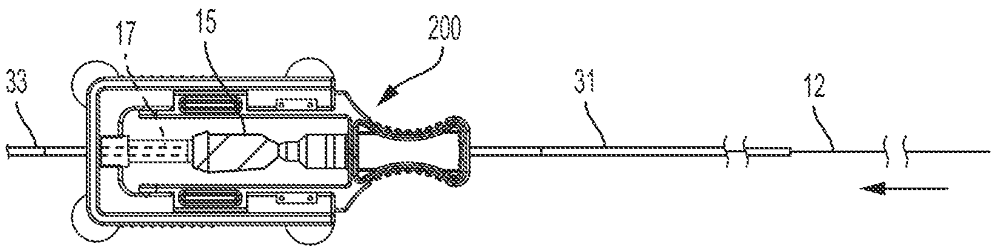

FIG. 4E

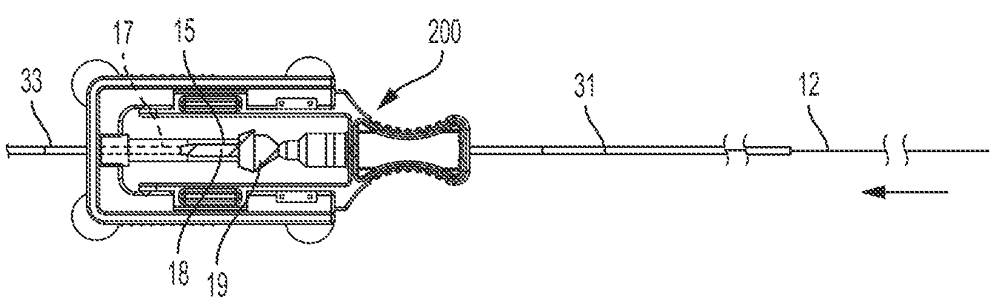

FIG. 4F

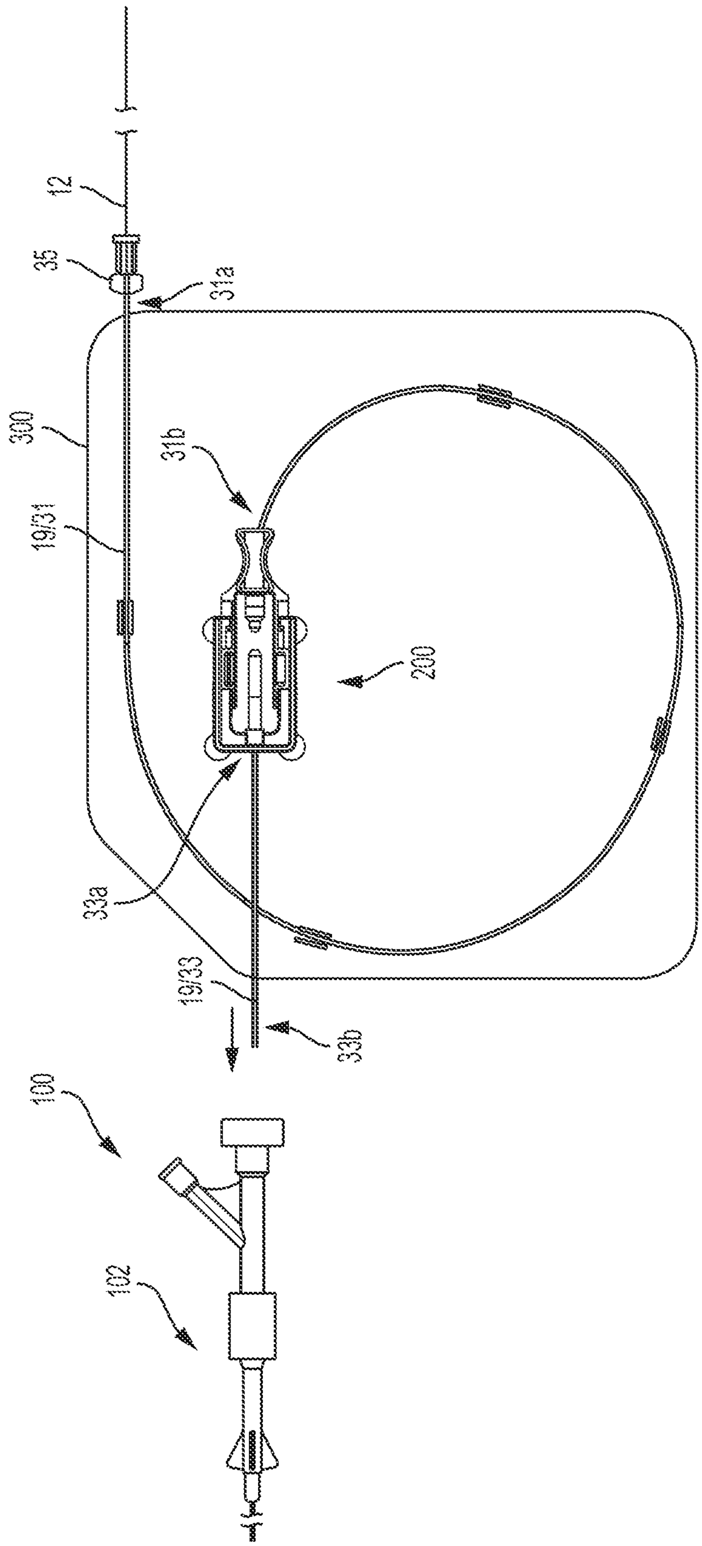

FIG. 4G

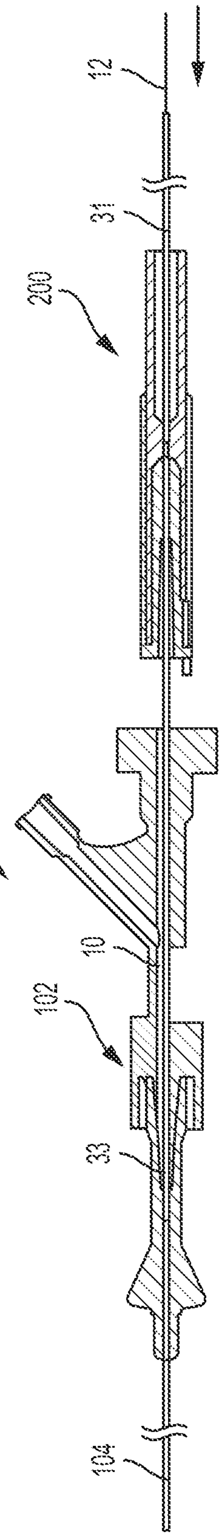

FIG. 4H

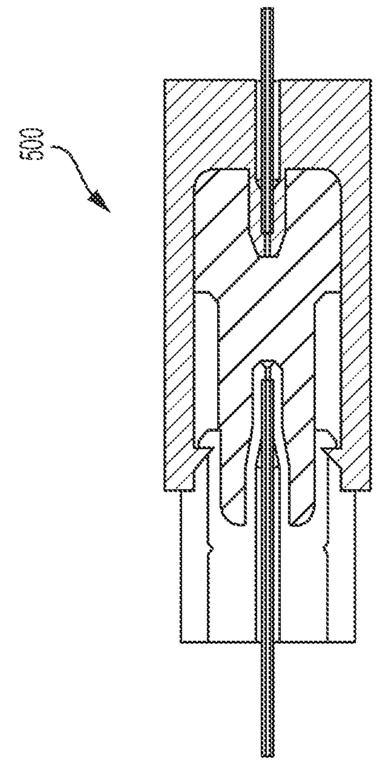

FIG. 5B

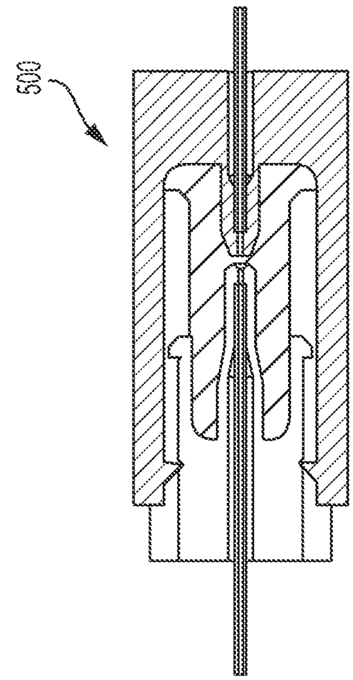

FIG. 5D

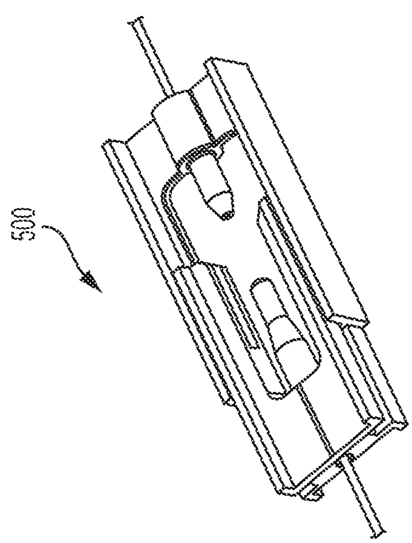

FIG. 5A

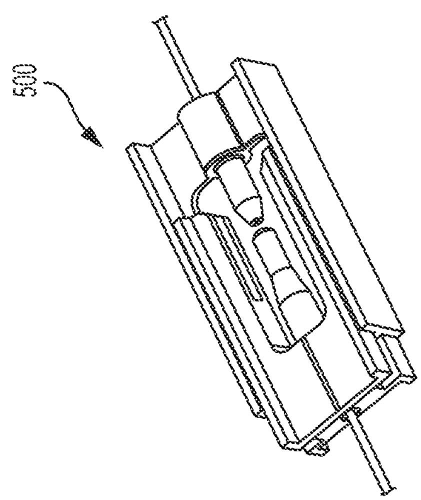

FIG. 5C

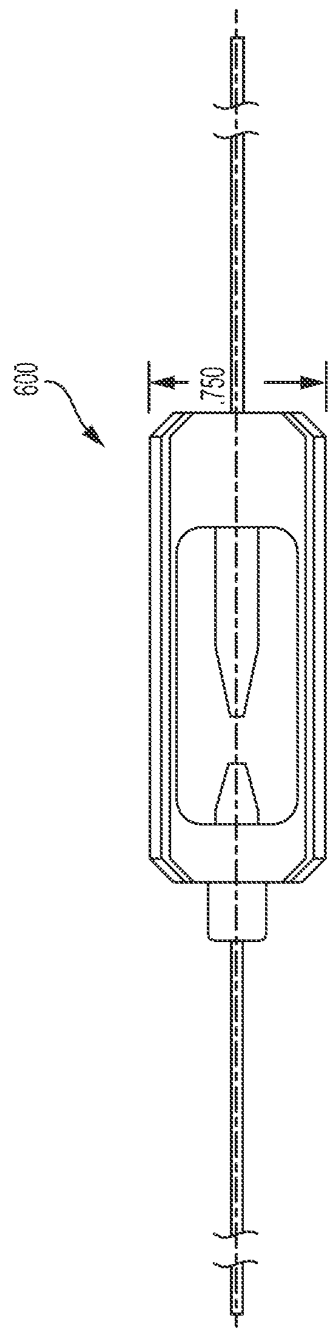

FIG. 6A

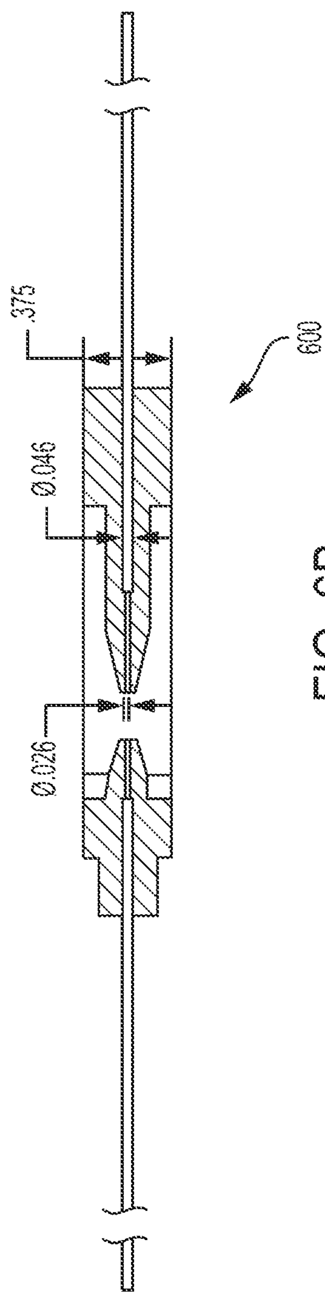

FIG. 6B

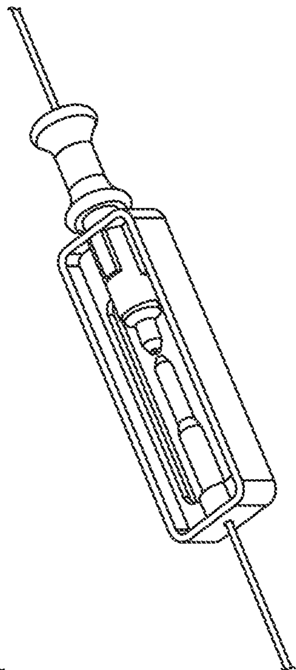

FIG. 7B

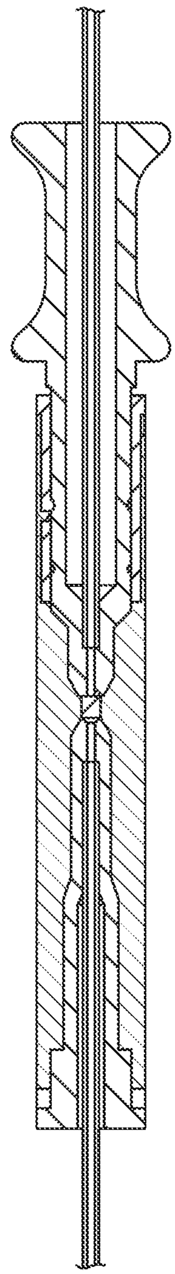

FIG. 7C

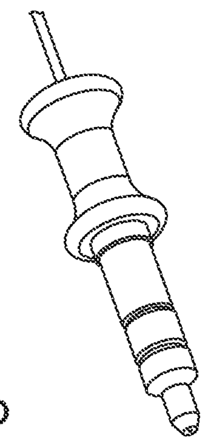

FIG. 7D

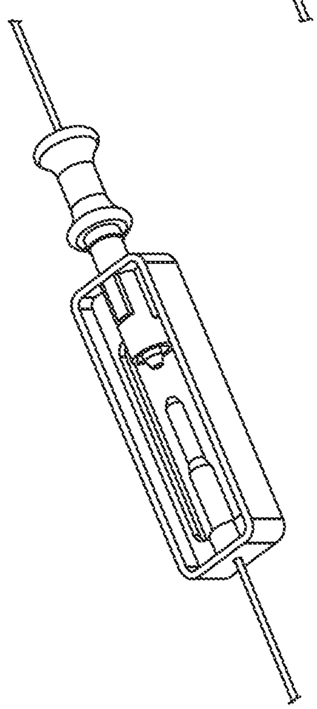

FIG. 7A

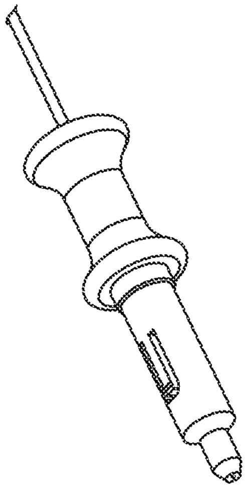

FIG. 8C

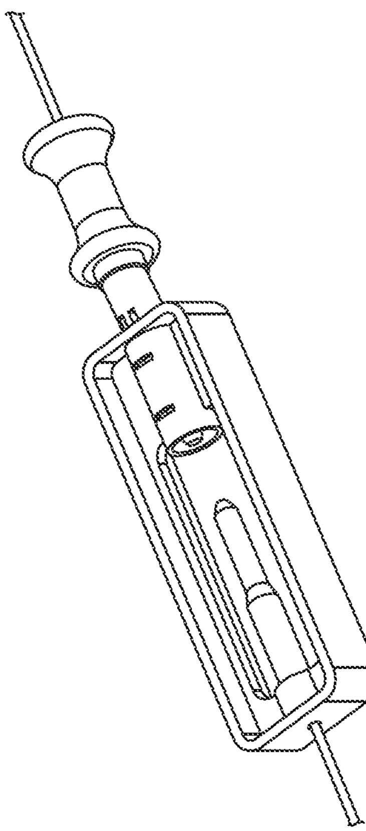

FIG. 8A

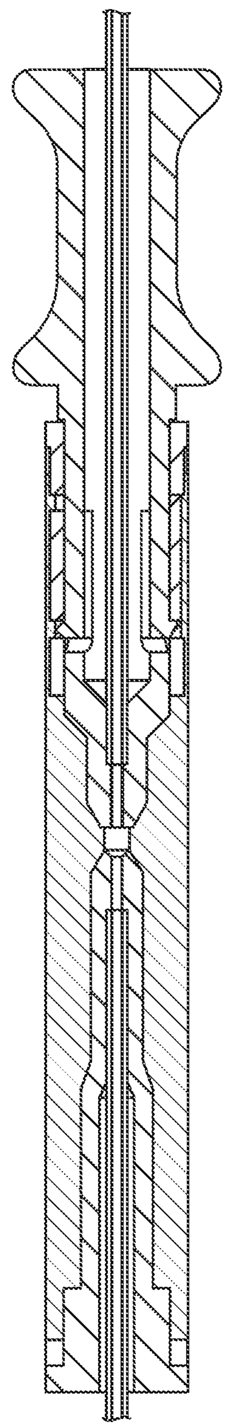

FIG. 8B

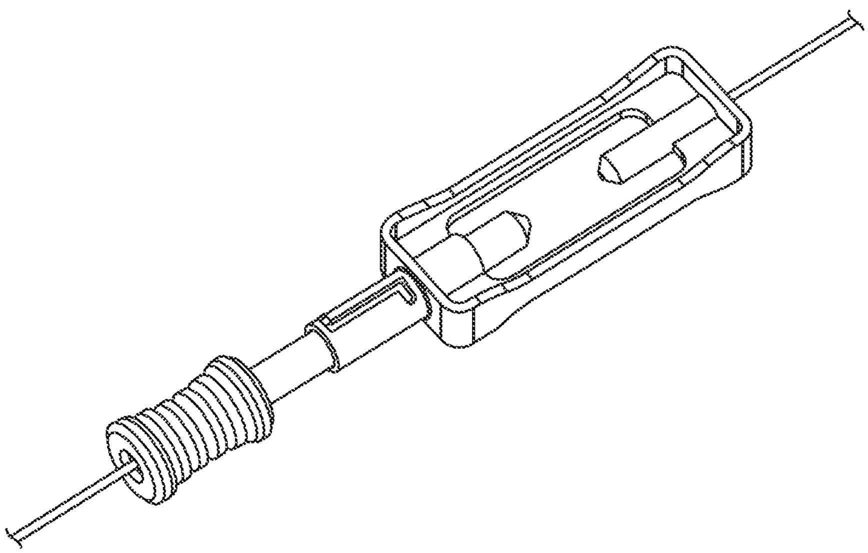

FIG. 9A

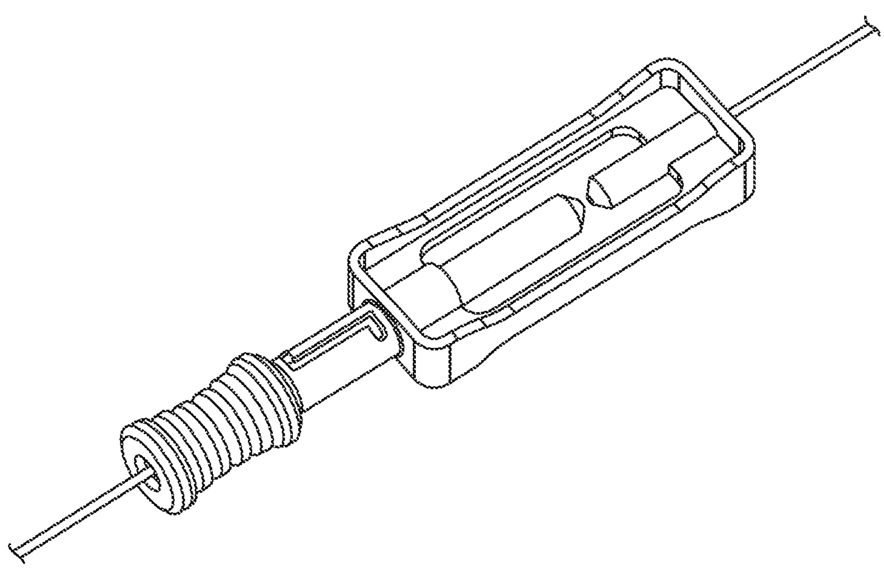

FIG. 9B

TOOLS FOR SHEATHING TREATMENT DEVICES AND ASSOCIATED SYSTEMS AND METHODS

CROSS-REFERENCE TO RELATED APPLICATION(S)

The present application is a divisional of U.S. application Ser. No. 16/007,961, filed Jun. 13, 2018, which claims the benefit of U.S. Patent Application No. 62/518,586, filed Jun. 12, 2017, each of which are incorporated herein by reference in their entirety.

TECHNICAL FIELD

The present technology relates generally to sheathing tools and associated systems and methods. Some embodiments of the present technology relate to devices for loading an intravascular treatment device into a sheath.

BACKGROUND

Many medical procedures use medical device(s) to remove an obstruction (such as clot material) from a body lumen, vessel, or other organ. An inherent risk in such procedures is that mobilizing or otherwise disturbing the obstruction can potentially create further harm if the obstruction or a fragment thereof dislodges from the retrieval device. If all or a portion of the obstruction breaks free from the device and flows downstream, it is highly likely that the free material will become trapped in smaller and more tortuous anatomy. In many cases, the physician will no longer be able to use the same retrieval device to again remove the obstruction because the device may be too large and/or immobile to move the device to the site of the new obstruction.

Even in successful procedures, a physician must be cautious to prevent the walls of the vessel or body lumen from imparting undesired forces to shear or dislodge the obstruction as it passes through the vasculature during removal. These forces have the potential of fragmenting the obstruction. In some cases, the obstruction can simply break free from the retrieval device and can lodge in a new area causing more concern than the original blockage.

Procedures for treating ischemic stroke by restoring flow within the cerebral vasculature are subject to the above concerns. The brain relies on its arteries and veins to supply oxygenated blood from the heart and lungs and to remove carbon dioxide and cellular waste from brain tissue. Blockages that interfere with this blood supply eventually cause the brain tissue to stop functioning. If the disruption in blood occurs for a sufficient amount of time, the continued lack of nutrients and oxygen causes irreversible cell death (infarction). Accordingly, it is desirable to provide immediate medical treatment of an ischemic stroke. To access the cerebral vasculature, a physician typically advances a catheter from a remote part of the body (typically a leg) through the abdominal vasculature and into the cerebral region of the vasculature. Once within the cerebral vasculature, the physician deploys a device for retrieval of the obstruction causing the blockage. Concerns about dislodged obstructions or the migration of dislodged fragments increases the duration of the procedure at time when restoration of blood flow is paramount. Furthermore, a physician might be unaware of one or more fragments that dislodge from the initial obstruction and cause blockage of smaller more distal vessels.

Many physicians currently perform thrombectomies (i.e. clot removal) with stents to resolve ischemic stroke. Typically, the physician deploys a stent into the clot in an attempt to push the clot to the side of the vessel and re-establish blood flow. Tissue plasminogen activator ("tPA") is often injected into the bloodstream through an intravenous line to break down a clot. However, it takes for the tPA to reach the clot because the tPA must travel through the vasculature and only begins to break up the clot once it reaches the clot material. tPA is also often administered to supplement the effectiveness of the stent. Yet, if attempts at clot dissolution are ineffective or incomplete, the physician can attempt to remove the stent while it is expanded against or enmeshed within the clot. In doing so, the physician must effectively drag the clot through the vasculature, in a proximal direction, into a guide catheter located within vessels in the patient's neck (typically the carotid artery). While this procedure has been shown to be effective in the clinic and easy for the physician to perform, there remain some distinct disadvantages using this approach.

For example, one disadvantage is that the stent may not sufficiently retain the clot as it pulls the clot to the catheter. In such a case, some or all of the clot might remain the vasculature. Another risk is that as the stent mobilizes the clot from the original blockage site, the clot might not adhere to the stent as the stent is withdrawn toward the catheter. This is a particular risk when passing through bifurcations and tortuous anatomy. Furthermore, blood flow can carry the clot (or fragments of the clot) into a branching vessel at a bifurcation. If the clot is successfully brought to the end of the guide catheter in the carotid artery, yet another risk is that the clot may be "stripped" or "sheared" from the stent as the stent enters the guide catheter. Regardless, simply dragging an expanded stent (either fully or partially expanded) can result in undesired trauma to the vessel. In most cases, since the stent is oversized compared to the vessel, dragging a fixed metallic (or other) structure can pull the arteries and/or strip the cellular lining from the vessel, causing further trauma such as a hemorrhagic stroke (leakage of blood from a cerebral vessel). Also, the stent can become lodged on plaque on the vessel walls resulting in further vascular damage.

In view of the above, there remains a need for improved devices and methods that can remove occlusions from body lumens and/or vessels.

SUMMARY

At least some of the embodiments disclosed herein are devices, systems, and methods for facilitating a user in positioning an expandable, intravascular treatment device within a lumen of a catheter and/or sheath. For example, certain medical procedures may require multiple passes of the same treatment device in order to effectively treat the patient. Between passes, the treatment device is often completely removed from the catheter and/or patient and must be re-loaded into the catheter for the next pass. For instance, removing clot material from a blood vessel of a patient may include advancing a clot retrieving device to a treatment site within the blood vessel lumen, capturing at least a portion of the clot material with the clot retrieving device, removing the clot material and clot retrieving device from the patient, then repeating the foregoing process until a sufficient amount of clot material is removed.

Some embodiments of the present technology include a device for sheathing (and/or re-sheathing) a treatment device, such as a clot retrieving device. In some embodi-

ments, the device includes a first channel and a second channel, each of which are configured to receive the treatment device in a constrained state therethrough. In some embodiments, the first channel may extend to a first opening and the second channel may extend to a second opening that is surrounded by a sidewall. The second opening may be spaced apart from the first opening by a gap, and the length of the gap may be great enough to allow a first portion of the treatment device to self-expand over the sidewall while a second portion of the treatment device generally maintains its diameter in the constrained state while crossing the gap.

The subject technology is illustrated, for example, according to various aspects described below. Various examples of aspects of the subject technology are described as numbered clauses (1, 2, 3, etc.) for convenience. These are provided as examples and do not limit the subject technology. It is noted that any of the dependent clauses may be combined in any combination, and placed into a respective independent clause, e.g., clause (1, 16, 20, 23, etc.). The other clauses can be presented in a similar manner.

1. A device for sheathing a treatment device having an elongated member and a first element and a second element at a distal region of the elongated member, wherein the device comprises:
   a first channel extending to a first opening, the first channel configured to receive the treatment device in a constrained state therethrough; and
   a second channel extending to a second opening, the second opening surrounded by a sidewall and configured to receive the treatment device in the constrained state therethrough, wherein the second opening is spaced apart from the first opening by a gap, and wherein a length of the gap is great enough to allow the first element to self-expand over the sidewall while the second element generally maintains its diameter in the constrained state while crossing the gap.
2. The device of Clause 1, wherein an inner diameter of the second channel tapers distally from the second opening.
3. The device of Clause 1 or Clause 2, wherein an outer diameter of the sidewall increases distally from the second opening.
4. The device of any one of Clauses 1-3, wherein the first and second openings are fixed relative to one another such that the length of the gap is fixed.
5. The device of any one of Clauses 1-4, wherein the first and second openings are movable relative to one another such that the length of the gap is adjustable.
6. The device of any one of Clauses 1-5, wherein the first channel is within a first housing and the second channel is within a second housing movable relative to the first housing, and wherein the first housing has a detent configured to receive a protrusion of the second housing, or vice versa, such that the first housing is locked in place relative to the second housing.
7. The device of any one of Clauses 1-6, wherein the first channel is configured to receive a sheath therethrough, wherein the sheath is configured to slidably receive the treatment device therein in the constrained state.
8. The device of any one of Clauses 1-7, wherein the second channel is configured to receive a sheath therethrough, and wherein the sheath is configured to slidably receive the treatment device therein in the constrained state.
9. The device of any one of Clauses 1-8, wherein the first element is a self-expanding element.
10. The device of any one of Clauses 1-9, wherein the second element is a self-expanding element.
11. The device of any one of Clauses 1-10, wherein the first element is a mesh.
12. The device of any one of Clauses 1-11, wherein the second element is a stent.
13. The device of any one of Clauses 1-12, wherein, in an expanded state, the first element has a flared distal region with a lumen therethrough, and wherein the lumen of the flared distal region is configured to receive the sidewall therein as the treatment device is moved through the across the gap.
14. The device of any one of Clauses 1-13, wherein the treatment device is a clot retrieving device.
15. The device of any one of Clauses 1-14, wherein the device is configured to be detachably coupled to a handle of a catheter, thereby placing the second channel in fluid communication with a lumen of the catheter.
16. A system for sheathing a treatment device having an elongated member and a first element and a second element at a distal region of the elongated member, wherein the device comprises:
   a sheath configured to receive the treatment device in a constrained state therethrough;
   a first channel extending to a first opening and configured to receive at least a portion of the sheath; and
   a second channel extending to a second opening, the second opening surrounded by a sidewall and configured to receive the treatment device in the constrained state therethrough, wherein the second opening is spaced apart from the first opening by a gap, and wherein a length of the gap is great enough to allow the first element to self-expand over the sidewall while the second element generally maintains its diameter in the constrained state while crossing the gap.
17. The system of Clause 16, further comprising a fluid port coupled to a proximal end portion of the sheath.
18. The system of Clause 16 or Clause 17, wherein the sheath is a first sheath and the system further comprises a second sheath configured to receive the treatment device in a constrained state therethrough, and wherein the second channel is configured to receive at least a portion of the second sheath therein.
19. The system of Clause 18, further comprising a catheter, and wherein the second sheath is configured to be coupled to the catheter.
20. A system for sheathing a treatment device having an elongated member and a first element and a second element at a distal region of the elongated member, wherein the device comprises:
   a sheath configured to receive the treatment device in a constrained state therethrough;
   a sheathing tool comprising:
      a first channel extending to a first opening and configured to receive at least a portion of the sheath, and
      a second channel extending to a second opening, the second opening surrounded by a sidewall and configured to receive the treatment device in the constrained state therethrough, wherein the second opening is spaced apart from the first opening by a gap, and wherein a length of the gap is great enough to allow the first element to self-expand over the sidewall while the second element generally maintains its diameter in the constrained state while crossing the gap;

a housing configured to be detachably coupled to the sheath and the sheathing tool, wherein a majority of the length of the sheath is contained within a perimeter of the housing such that a user may position manipulate both ends of the sheath and/or treatment device without taking a step.

21. The system of Clause 20, wherein the sheath is a first sheath and the system further comprises a second sheath configured to receive the treatment device in a constrained state therethrough, and wherein the second channel is configured to receive at least a portion of the second sheath therein.

22. The system of Clause 21, further comprising a catheter, and wherein the second sheath is configured to be coupled to the catheter.

23. A method for sheathing a treatment device having an elongated member and a first element and a second element at a distal region of the elongated member, the method comprising:

positioning the treatment device in a first channel with the first and second elements in a constrained state;

moving the treatment device from a first opening of the first channel through a second opening of a second channel spaced apart from the first opening by a gap; and

while moving the treatment device across the gap, generally maintaining a cross-sectional dimension of the first element at its cross-sectional dimension in the constrained state while allowing the second element to expand over a sidewall surrounding the second opening.

24. The method of Clause 23, further comprising moving a portion of the second element in a first direction through the second channel while moving a second portion of the second element in a second direction opposite the first direction outside of the channel.

25. The method of Clause 23 or Clause 24, further comprising moving the treatment device along the first channel in a first direction, and wherein moving the treatment device from the first opening and through the second opening is in a second direction opposite the first direction.

26. The method of any one of Clauses 23-25, wherein moving the treatment device from the first opening and through the second opening in the second direction occurs after moving the treatment device along the first channel in the first direction.

27. The method of any one of Clauses 23-26, further comprising moving the treatment device along the second channel in a first direction, and wherein moving the treatment device from the first opening and through the second opening is in a second direction opposite the first direction.

28. The method of Clause 27, wherein moving the treatment device from the first opening and through the second opening in the second direction occurs after moving the treatment device along the second channel in the first direction.

29. The method of any one of Clauses 23-28, wherein the constrained state is a first constrained state and the treatment device is movable to a second constrained state in which the second element is inverted relative to its position when the treatment device is in a first constrained state.

30. The method of Clause 29, further comprising inverting the second element by moving the first element through the second channel while the second element surrounds the sidewall.

31. The method of Clause 29 or Clause 30, further comprising moving the treatment device in the second constrained state through the second channel.

32. The method of any one of Clauses 29-31, further comprising moving the treatment device in the second constrained state through the second channel and into a catheter.

33. The method of any one of Clauses 23-32, further comprising decreasing a length of the gap before moving the treatment device through the first opening.

34. The method of any one of Clauses 23-33, further comprising decreasing a length of the gap after moving the treatment device across a portion of the gap.

35. The method of any one of Clauses 23-34, further comprising removing the treatment device from a catheter before positioning the first and second elements in the first channel.

36. The method of Clause 35, further comprising removing clot material from the treatment device before positioning the first and second elements in the first channel.

37 The method of Clause 36, wherein removing clot material includes rinsing clot material from the treatment device.

38. The method of Clause 35, further comprising removing clot material from the treatment device while at least a portion of the elongated member is positioned within the first channel but before positioning the first and second elements in the first channel.

39. The method of Clause 38, wherein removing clot material includes rinsing clot material from the treatment device.

40. A device for transferring an intravascular treatment device from a first sheath to a second sheath, the treatment device including first and second self-expanding elements, wherein each of the first and second sheaths is sized such that the treatment device is constrained in a compressed state when positioned within each of the first and second sheaths, and wherein the device comprises:

a first channel configured to receive at least a portion of the first sheath therein, the first channel having a first proximal opening configured to receive the first sheath therethrough and a first distal opening; and

a second channel configured to receive at least a portion of the second sheath therein, the second channel having a second proximal opening and a second distal opening configured to receive the second sheath therethrough,

wherein the device is configured to securely position the first and second channels relative to one another such that the first distal opening is aligned with the second proximal opening and spaced apart from the second proximal opening by a gap, the gap having a length such that, when the first and second sheaths are positioned within the first and second channels, respectively, and the treatment device is moved from the first sheath to the second sheath across the gap, a distal region of the first element expands from the compressed state within the gap while the second element generally maintains its diameter in the compressed state while crossing the gap.

41. The device of Clause 40, wherein the second channel is surrounded by a sidewall having an outer diameter, and wherein the distal region of the first element expands over the outer diameter of the sidewall as it crosses the gap.
42. The device of Clause 40 or Clause 41, wherein an inner diameter of the second channel tapers distally from the second proximal opening.
43. The device of any one of Clauses 40-42, wherein the second channel is surrounded by a sidewall having an outer diameter that increases distally from the second proximal opening.
44. The device of any one of Clauses 40-43, wherein the first and second channels are fixed relative to one another.
45. The device of any one of Clauses 40-44, wherein the first and second channels are movable relative to one another.
46. The device of any one of Clauses 40-45, wherein the length is a first length, and wherein the device is configured to securely position the first and second channels relative to one another such that the gap has a second length greater than the first length.
47. A sheathing tool, comprising:
   a support;
   a loading member coupled to the support and having a first distal opening, a first proximal opening, and a first channel extending therebetween, wherein the first proximal opening is configured to receive a first sheath therethrough; and
   a receiving member coupled to the support and having a second distal opening, a second proximal opening, and a second channel extending therebetween, wherein the second distal opening is configured to receive a second sheath therethrough,
   wherein the support is configured to securely position the loading member and the receiving member relative to one another such that the first distal opening is aligned with the second proximal opening and spaced apart from the second proximal opening by a gap, the gap having a length such that, when the first and second sheaths are positioned within the first and second channels, respectively, and a self-expanding treatment device is moved in a compressed state from a lumen of the first sheath to a lumen of the second sheath across the gap, a distal portion of the treatment device maintains its diameter in the compressed state between the first distal opening and the second proximal opening.

Additional features and advantages of the subject technology are described below, and in part will be apparent from the description, or may be learned by practice of the subject technology. The advantages of the subject technology will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Many aspects of the present technology can be better understood with reference to the following drawings. The components in the drawings are not necessarily to scale Instead, emphasis is placed on illustrating clearly the principles of the present disclosure.

FIG. **1** is a schematic overview of a treatment system configured in accordance with the present technology.

FIG. **2** is a side view of a distal portion of the treatment device shown in FIG. **1** in a second position in accordance with embodiments of the present technology.

FIG. **3**A is an isometric view of a sheathing tool in a first position configured in accordance with the present technology.

FIG. **3**B is an isometric view of the sheathing tool of FIG. **3**A in a second position configured in accordance with the present technology.

FIG. **3**C is a top view of the sheathing tool in the first position, as shown in FIG. **3**A.

FIG. **3**D is a top view of the sheathing tool in the second position, as shown in FIG. **3**B.

FIG. **3**E is an enlarged, isolated, cross-sectional view of the first channel shown in FIGS. **3**A-**3**D.

FIG. **3**F is an enlarged, isolated view, cross-sectional view of the second channel shown in FIGS. **3**A-**3**D.

FIGS. **4**A-**4**H illustrate a method of using a sheathing tool to sheath a treatment device.

FIGS. **5**A and **5**B are an isometric view and a top cross-sectional view, respectively, of a sheathing tool shown in a first position configured in accordance with some embodiments of the present technology.

FIGS. **5**C and **5**D are an isometric view and a top cross-sectional view, respectively, of the sheathing tool shown in FIGS. **5**A and **5**B in a second position configured in accordance with some embodiments of the present technology.

FIGS. **6**A and **6**B are a top view and a side cross-sectional view, respectively, of a sheathing tool shown in a first position configured in accordance with some embodiments of the present technology.

FIG. **7**A is an isometric view of a sheathing tool in a first position configured in accordance with the present technology.

FIG. **7**B is an isometric view of the sheathing tool of FIG. **7**A in a second position configured in accordance with the present technology.

FIG. **7**C is a side cross-sectional view of the sheathing tool as shown in FIG. **7**B.

FIG. **7**D is an isometric view of the connector of the sheathing tool shown in FIGS. **7**A-**7**C.

FIG. **8**A is an isometric view of a sheathing tool in a first position configured in accordance with the present technology.

FIG. **8**B is a side cross-sectional view of the sheathing tool of FIG. **8**A in a second position configured in accordance with the present technology.

FIG. **8**C is an isometric view of the connector of the sheathing tool shown in FIGS. **8**A and **8**B.

FIG. **9**A is an isometric view of a sheathing tool in a first position configured in accordance with the present technology.

FIG. **9**B is an isometric view of the sheathing tool of FIG. **7**A in a second position configured in accordance with the present technology.

DETAILED DESCRIPTION

The present technology provides devices, systems, and methods for sheathing and/or re-sheathing an intravascularly deliverable treatment device. Although many of the embodiments are described below with respect to devices, systems, and methods for removing clot material/treating embolism (such as a cerebral embolism), the sheathing tools of the present technology may be used to re-sheath any intravascularly deliverable, expandable treatment device. Other applications and other embodiments in addition to those described herein are within the scope of the technology. For example, the sheathing tools of the present technology may be used with devices for removing emboli from body lumens other than blood vessels (e.g., the digestive tract, etc.) and/or may be used to remove emboli from blood vessels outside of the brain (e.g., pulmonary blood vessels, blood vessels within the legs, etc.). In addition, the sheathing tools of the present technology may be used with devices for removing luminal obstructions other than clot material (e.g., plaque, resected tissue, etc.).

1. System Overview

FIG. **1** is a schematic representation of a system **1** ("system **1**") configured in accordance with the present technology. As shown in FIG. **1**, the system **1** may include a treatment device **10** (shown in an expanded, unconstrained state), a catheter **100** (e.g., a microcatheter), a sheathing tool **200** (shown schematically), a support **300**, and a sheath **19** for facilitating introduction of the treatment device **10** to the catheter **100** and/or sheathing tool **200**. The catheter **100** may include a handle **102** and an elongated shaft **104** having a proximal portion **104***a* coupled to the handle **102** and a distal portion **104***b* configured to be positioned at a treatment site within a blood vessel lumen (e.g., a cerebral blood vessel lumen). The elongated shaft **104** is configured to slidably receive the treatment device **10** in a low-profile, constrained state (not shown) therethrough.

The sheath **19** may be configured to be detachably coupled to the catheter **100**, the sheathing tool **200**, and/or the support **300** and is configured to slidably receive the treatment device **10** in a low-profile, constrained state (not shown) therethrough. In some embodiments, such as the embodiment shown in FIG. **1**, the sheath **19** may include a first segment **31** and a second segment **33**. The first segment **31** may have a proximal portion **31***a* and a distal portion **31***b* configured to be detachably coupled to the sheathing tool **200**, and the second segment **33** may have a proximal portion **33***a* configured to be detachably coupled to the sheathing tool **200** and a distal portion **33***b* configured to be detachably coupled to the handle **108** of the catheter **100**, thereby creating a pathway between the lumen of the second segment and the lumen of the elongated shaft **104**.

As shown in FIG. **1**, the sheathing tool **200** and/or one or more portions of the sheath **19** may be configured to be detachably or permanently coupled to the support **300**. For example, to secure the sheathing tool **200** and/or the sheath **19** to the support **300**, the support **300** may include one or more tabs, slots, protrusions or other means **302** for engaging the sheath **19** and/or the sheathing tool **200** and/or one or more corresponding tabs, protrusions, slots, etc. on the sheath **19** and/or the sheathing tool **200**. In some embodiments, the system **1** may be packaged with one or both of the sheathing tool **200** and the sheath **31** detachably or permanently mounted on the support **300**.

In some embodiments, the treatment device **10** includes an elongated member **12** and a treatment assembly **14** coupled to a distal region of the elongated member **12**. The treatment assembly **14** may be configured to be intravascularly positioned at or adjacent clot material within a blood vessel lumen and includes a first element **17** and a second element **15**. In some embodiments, the first element **17** may be a self-expanding stent **17** (e.g., a laser-cut stent) and the second element **15** may be a self-expanding mesh (e.g., a braid, a weave, a lattice structure, a fabric, etc.). In some embodiments, the first and second elements **17**, **15** may have other suitable configurations.

The first element **17** may have a proximal portion **17***a* coupled to the elongated member **12** and a distal portion **17***b*, and the second element **15** may have a free end portion **15***b* and a fixed end portion **15***a* coupled to the elongated member **12**. The second element **15** may be flexible such that it is movable between a first position (FIG. **1**) in which its free end portion **15***b* is proximal of its fixed end portion **15***a*, and a second position (see FIG. **2**) in which the second element **15** is inverted over the first element **17** such that a distal terminus of the second element **15** is at or distal to the distal terminus of the first element **17**. As shown in FIG. **2**, when the second element **15** is in the second position, the free end portion **15***b* is distal of the fixed end portion **15***a* and distal of the distal terminus of the first element **17**. In the second position, the second element **15** may have a flared distal region **25** that surround a lumen **27** therethrough.

Examples of suitable treatment devices **10** for use with the system **1** can be found in U.S. patent application Ser. No. 15/594,410, filed May 12, 2017, which is incorporated by reference herein in its entirety. Although the sheathing tools discussed below are described with reference to the treatment device **10** shown in FIGS. **1** and **2**, the sheathing tools disclosed herein may be utilized to sheath or re-sheath any expandable treatment device deliverable through a catheter.

2. Selected Embodiments of Sheathing Tools and Associated Methods of Use

FIGS. **3**A and **3**C are an isometric view and a top view of a sheathing tool **200**, respectively, in a first position configured in accordance with embodiments of the present technology. FIGS. **3**B and **3**D are an isometric view and a top view of the sheathing tool **200**, respectively, in a second position configured in accordance with embodiments of the present technology. Referring to FIGS. **3**A-**3**D together, the sheathing tool **200** may include a housing **202** having a first portion **212** and a second portion **222** slidably coupled to the first portion **212**. The first portion **212** may include a first protrusion **210** and first arms **211** extending distally beyond the first protrusion **210**, and the second portion **222** may include a second protrusion **220** and second arms **221** extending proximally beyond the second protrusion **220**. The first and second arms **211**, **221** can be coupled along at least a portion of their lengths and together surround an open interior region **208** of the housing **202** into which the first and second protrusions **210**, **220** extend. As such, the first and second protrusions **210**, **220** are spaced apart from the adjacent first and second arms **211**, **221**. In some embodiments, the first protrusion **210** is not spaced apart from the adjacent first arms **211**.

FIG. **3**E is an enlarged, isolated, cross-sectional view of a distal region of the first protrusion **210**. As shown in FIG. **3**E, the first protrusion **210** may include a first channel **216** extending distally from a proximal region of the proximal portion **212** of the housing **202** to a first opening **214**. In some embodiments the first channel **216** may be configured to receive the treatment device **10** in a constrained state therethrough, and in some embodiments the first channel **216** may be configured to receive the sheath **19**. In FIG. **3**E, for example, the first sheath segment **31** is shown positioned within the first channel **216**. The first channel **216** may be surrounded by a generally tubular sidewall having an outer diameter OD1 that tapers in a distal direction. An inner diameter ID1 of the first channel **216** may taper distally to help guide the first element **17** in a generally constrained state towards the second opening **224**.

FIG. **3**F is an enlarged, isolated, cross-sectional view of a proximal region of the second protrusion **220**. As shown in FIG. **3**E, the second protrusion **220** may include a second channel **226** extending proximally from a distal region of the distal portion **222** of the housing **202** to a second opening **224**. In some embodiments the second channel **226** may be configured to receive the treatment device **10** in a constrained state therethrough, and in some embodiments the second channel **226** may be configured to receive the sheath **19**. In FIG. **3**F, for example, the second sheath segment **33** is shown positioned within the second channel **226**. The second channel **226** may be surrounded by a generally tubular sidewall having an outer diameter OD**2** that tapers in a proximal direction to facilitate positioning the second element **15** over the second protrusion **220**. In some embodiments, an inner diameter ID**2** of the second channel **216** may taper distally to help guide and/or deflect the first element **17** into the second channel **226** and/or the second sheath segment **33**.

When the sheathing tool **200** is in a first position, the first and second openings **214**, **224** are spaced apart by a gap g having a first length, and when the sheathing tool **200** is in a second position, the first and second openings **214**, **224** are spaced apart by a gap g having a second length less than the first length. The second length may be great enough to allow the second element **15** to self-expand such that the second element **15** is positioned over the sidewall while the first element **17** generally maintains its diameter in the constrained state while crossing the gap g. In other words, because the first element **17** does not have enough space between the first and second openings **214**, **224** to expand, the first element **17** crosses the gap g in a constrained state which allows the first element **17** to enter through the second opening **224**. If the gap g is too long, the distal ends of the first element **17** may begin to expand/splay outwardly and prevent the first element **17** from entering the second channel **226**. Likewise, if the gap g is too short, the second element **15** may not have enough room for the distal portion **15***b* to flare radially outwardly to an extent that allows the second element **15** to extend over the second protrusion **222** and/or receive the second protrusion **222** within the lumen **27** (FIG. **2**) of the distal region **15***b*.

FIGS. **4**A-**4**H illustrate a method of using the sheathing tool **200** to sheath and/or re-sheath the treatment device **10**. As shown in FIG. **4**A, in some embodiments the treatment device **10** may first be withdrawn proximally from a treatment site through the blood vessel V lumen and catheter **100**. Once removed from the catheter **100**, the treatment device **10** may be in an expanded, unconstrained state in the second position such that the second element **15** is inverted over the first element **17**. As shown in FIG. **4**B, the treatment device **10** in the second position may then be pulled proximally through the second sheath segment **33**, then the sheathing tool **200**, and into the first sheath segment **31**. For example, a proximal end of the elongated member **12** may be inserted into an opening at the distal portion **33***b* of the second segment **33**, and the rest of the elongated member **12** may be pushed proximally through the second sheath segment **33**, the sheathing tool **200**, and at least a portion of the first sheath segment **31** (and/or pulled once the proximal end of the elongated member **12** exits a proximal portion **31***a* of the first sheath segment **31**). Once a distal portion of the treatment device **10** is aligned with or proximal of the first opening **214**, the elongated member **12** may then be pushed distally, thereby advancing the first and second elements **17**, **15** across the gap g, as shown in FIG. **4**C. While moving the treatment device **10** across the gap, the first element **17** may maintain its cross-sectional dimension in the constrained state while the second element **15** expands over the sidewall surrounding the second opening **224**. (In FIG. **4**C, the first and second elements **17**, **15** are shown in cross-section for ease of viewing the treatment device **10** within the gap g.) In some embodiments, the first element **17** may be advanced across the gap g and into the second opening **224** while the sheathing tool **200** is in the first position. In some embodiments, the first element **17** may only be advanced across a portion of the gap g (and not into the second opening **224**) while the sheathing tool **200** remains in the first position.

As shown in FIG. **4**D, the first portion **212** of the housing **202** may be moved towards the second portion **222** of the housing **202** and secured in place by one or more detents and/or other securement features of the housing **202**. Moving the first and second openings towards one another forces the second protrusion **220** further within the lumen of the second element **15**. As shown in FIGS. **4**E and **4**F, the elongated member **12** can be pushed proximally while the sheathing tool **200** is in the second position, thereby advancing the first element **17** further within the second channel **126** and/or second sheath segment **33**. As the elongated member **12** is advanced distally, the second element **15** extends further distally along the second protrusion **220** until it's fixed end portion pulls the second element **15** into the second channel **226**. As such, a portion of the second element may move in a first direction through the second channel while a second portion of the second element moves in a second direction opposite the first direction outside of the second channel **226**. As shown in FIG. **4**G, the second sheath segment **33** may then be coupled to the catheter **100**. As shown in FIG. **4**H, the elongated member **12** may be pushed proximally to transfer the treatment device **10** in the first position from the second sheath segment **33** to the catheter **100**.

FIGS. **5**A and **5**B are an isometric view and a top cross-sectional view, respectively, of a sheathing tool shown in a first position configured in accordance with some embodiments of the present technology. FIGS. **5**C and **5**D are an isometric view and a top cross-sectional view, respectively, of the sheathing tool shown in FIGS. **5**A and **5**B in a second position configured in accordance with some embodiments of the present technology.

FIGS. **6**A and **6**B are a top view and a side cross-sectional view, respectively, of a sheathing tool **600** shown in a first position configured in accordance with some embodiments of the present technology. In some embodiments, such as that shown in FIGS. **6**A and **6**B, the housing **202** may be a single component and/or the first and second openings are spaced apart by a fixed distance.

FIG. **7**A is an isometric view of a sheathing tool in a first position configured in accordance with the present technology. FIG. **7**B is an isometric view of the sheathing tool of FIG. **7**A in a second position configured in accordance with the present technology FIG. **7**C is a side cross-sectional view of the sheathing tool as shown in FIG. **7**B. FIG. **7**D is an isometric view of the connector of the sheathing tool shown in FIGS. **7**A-**7**C.

FIG. **8**A is an isometric view of a sheathing tool in a first position configured in accordance with the present technology. FIG. **8**B is a side cross-sectional view of the sheathing tool of FIG. **8**A in a second position configured in accordance with the present technology. FIG. **8**C is an isometric view of the connector of the sheathing tool shown in FIGS. **8**A and **8**B.

FIG. 9A is an isometric view of a sheathing tool in a first position configured in accordance with the present technology. FIG. 9B is an isometric view of the sheathing tool of FIG. 7A in a second position configured in accordance with the present technology.

3. Conclusion

This disclosure is not intended to be exhaustive or to limit the present technology to the precise forms disclosed herein. Although specific embodiments are disclosed herein for illustrative purposes, various equivalent modifications are possible without deviating from the present technology, as those of ordinary skill in the relevant art will recognize. In some cases, well-known structures and functions have not been shown and/or described in detail to avoid unnecessarily obscuring the description of the embodiments of the present technology. Although steps of methods may be presented herein in a particular order, in alternative embodiments the steps may have another suitable order. Similarly, certain aspects of the present technology disclosed in the context of particular embodiments can be combined or eliminated in other embodiments. Furthermore, while advantages associated with certain embodiments may have been disclosed in the context of those embodiments, other embodiments can also exhibit such advantages, and not all embodiments need necessarily exhibit such advantages or other advantages disclosed herein to fall within the scope of the present technology. Accordingly, this disclosure and associated technology can encompass other embodiments not expressly shown and/or described herein.

Throughout this disclosure, the singular terms "a," "an," and "the" include plural referents unless the context clearly indicates otherwise. Similarly, unless the word "or" is expressly limited to mean only a single item exclusive from the other items in reference to a list of two or more items, then the use of "or" in such a list is to be interpreted as including (a) any single item in the list, (b) all of the items in the list, or (c) any combination of the items in the list. Additionally, the terms "comprising" and the like are used throughout this disclosure to mean including at least the recited feature(s) such that any greater number of the same feature(s) and/or one or more additional types of features are not precluded. Directional terms, such as "upper," "lower," "front," "back," "vertical," and "horizontal," may be used herein to express and clarify the relationship between various elements. It should be understood that such terms do not denote absolute orientation. Reference herein to "one embodiment," "an embodiment," or similar formulations means that a particular feature, structure, operation, or characteristic described in connection with the embodiment can be included in at least one embodiment of the present technology. Thus, the appearances of such phrases or formulations herein are not necessarily all referring to the same embodiment. Furthermore, various particular features, structures, operations, or characteristics may be combined in any suitable manner in one or more embodiments.

We claim:

1. A system for sheathing a treatment device, the system comprising: the treatment device having an elongated member and a first element and a second element at a distal region of the elongated member, a sheath configured to receive the treatment device in a constrained state therethrough; a first channel extending to a first opening and configured to receive at least a portion of the sheath; and a second channel extending to a second opening, the second opening surrounded by a sidewall and configured to receive the treatment device in the constrained state therethrough, wherein the second opening is spaced apart from the first opening by a gap, and wherein a length of the gap allows the first element to self-expand over the sidewall while the second element generally maintains its diameter in the constrained state while crossing the gap.

2. The system of claim **1**, further comprising a fluid port coupled to a proximal end portion of the sheath.

3. The system of claim **1**, wherein the sheath is a first sheath and the system further comprises a second sheath configured to receive the treatment device in a constrained state therethrough, and wherein the second channel is configured to receive at least a portion of the second sheath therein.

4. The system of claim **3**, further comprising a catheter, and wherein the second sheath is configured to be coupled to the catheter.

5. A system for sheathing a treatment device, the system comprising: the treatment device having an elongated member and a first element and a second element at a distal region of the elongated member, a sheath configured to receive the treatment device in a constrained state therethrough; a sheathing tool comprising: a first channel extending to a first opening and configured to receive at least a portion of the sheath, and a second channel extending to a second opening, the second opening surrounded by a sidewall and configured to receive the treatment device in the constrained state therethrough, wherein the second opening is spaced apart from the first opening by a gap, and wherein a length of the gap allows the first element to self-expand over the sidewall while the second element generally maintains its diameter in the constrained state while crossing the gap; a housing configured to be detachably coupled to the sheath and the sheathing tool, wherein a majority of the length of the sheath is contained within a perimeter of the housing such that a user may manipulate both ends of the sheath and/or treatment device.

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