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(54) **CATHETER WITH RETRACTABLE SHEATH AND METHODS THEREOF**

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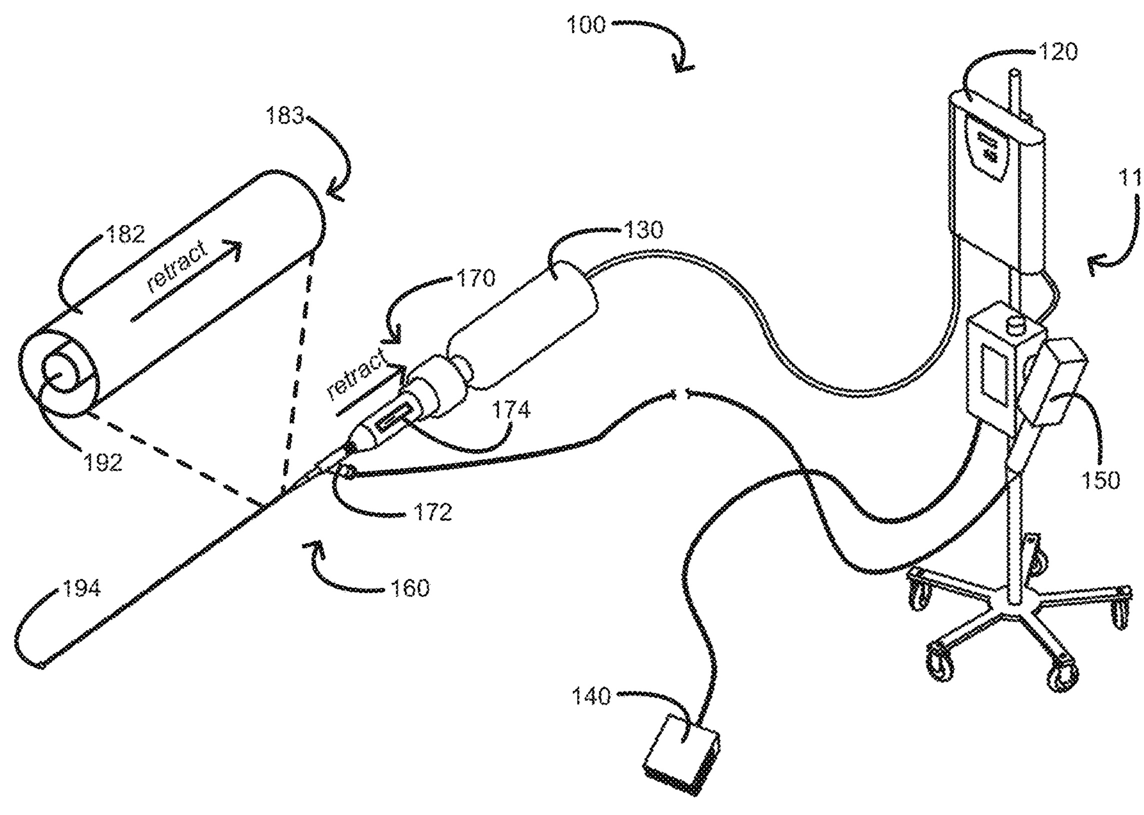
(57) **ABSTRACT**

A system including a catheter assembly, which can include a housing, a sheath, and a core wire disposed within a sheath lumen. The housing can include a retraction-extension mechanism configured to retract the sheath from a first, fully extended position of the sheath, in which position a distal portion of the core wire can be wholly disposed within the sheath lumen. The housing can accommodate a proximal length of the sheath, and the retraction-extension mechanism can be configured to retract the proximal length of the sheath into the housing and expose a working length of a distal portion of the core wire. The core wire can include a sonic connector at a proximal end of the core wire configured to connect to an ultrasound-producing mechanism for ultrasound-based modification of one or more intravascular lesions with the working length of the core wire.



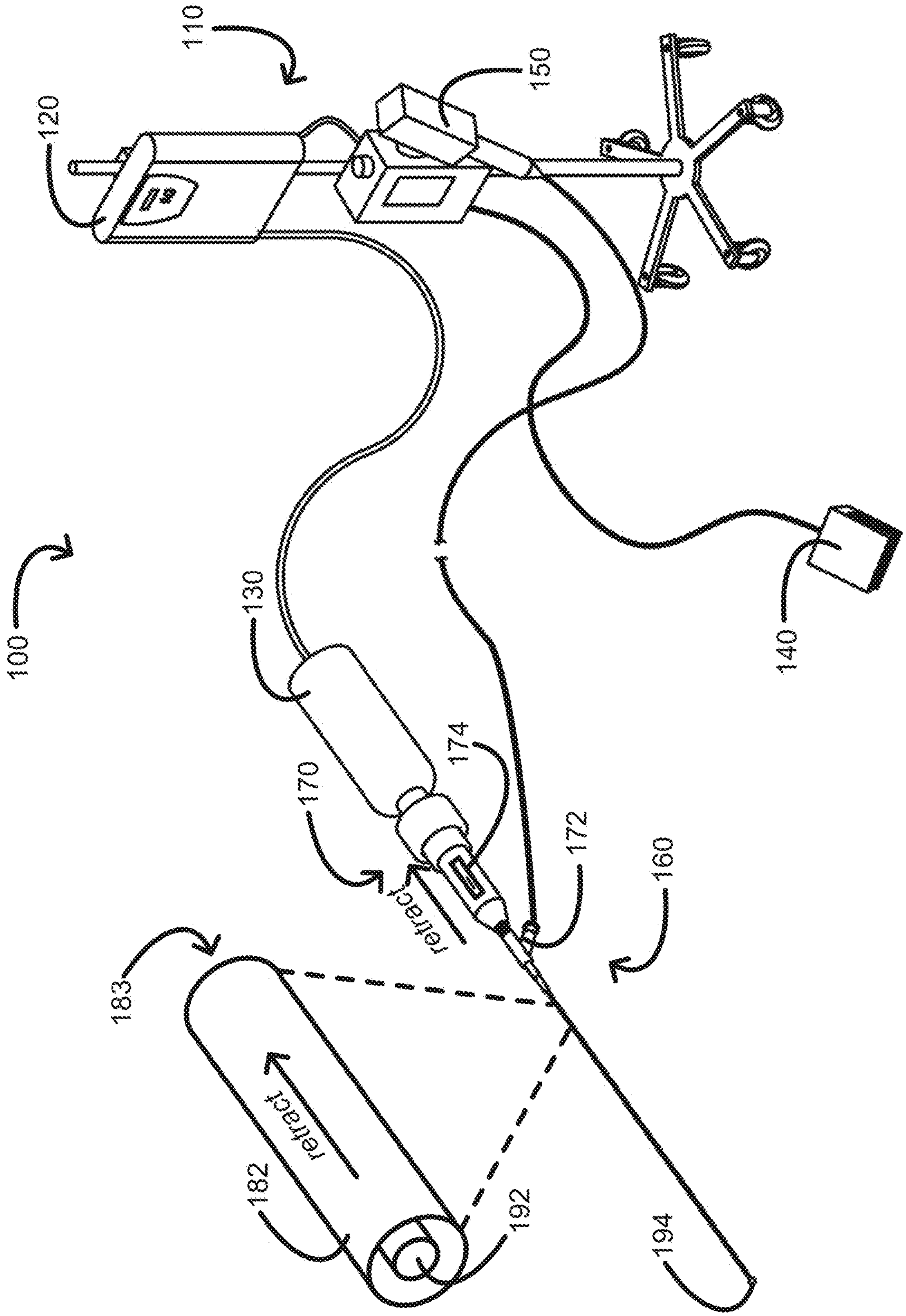

100
110
120
130
140
150
160
170
172
174
retract
183
retract
182
192
194

FIG. 1

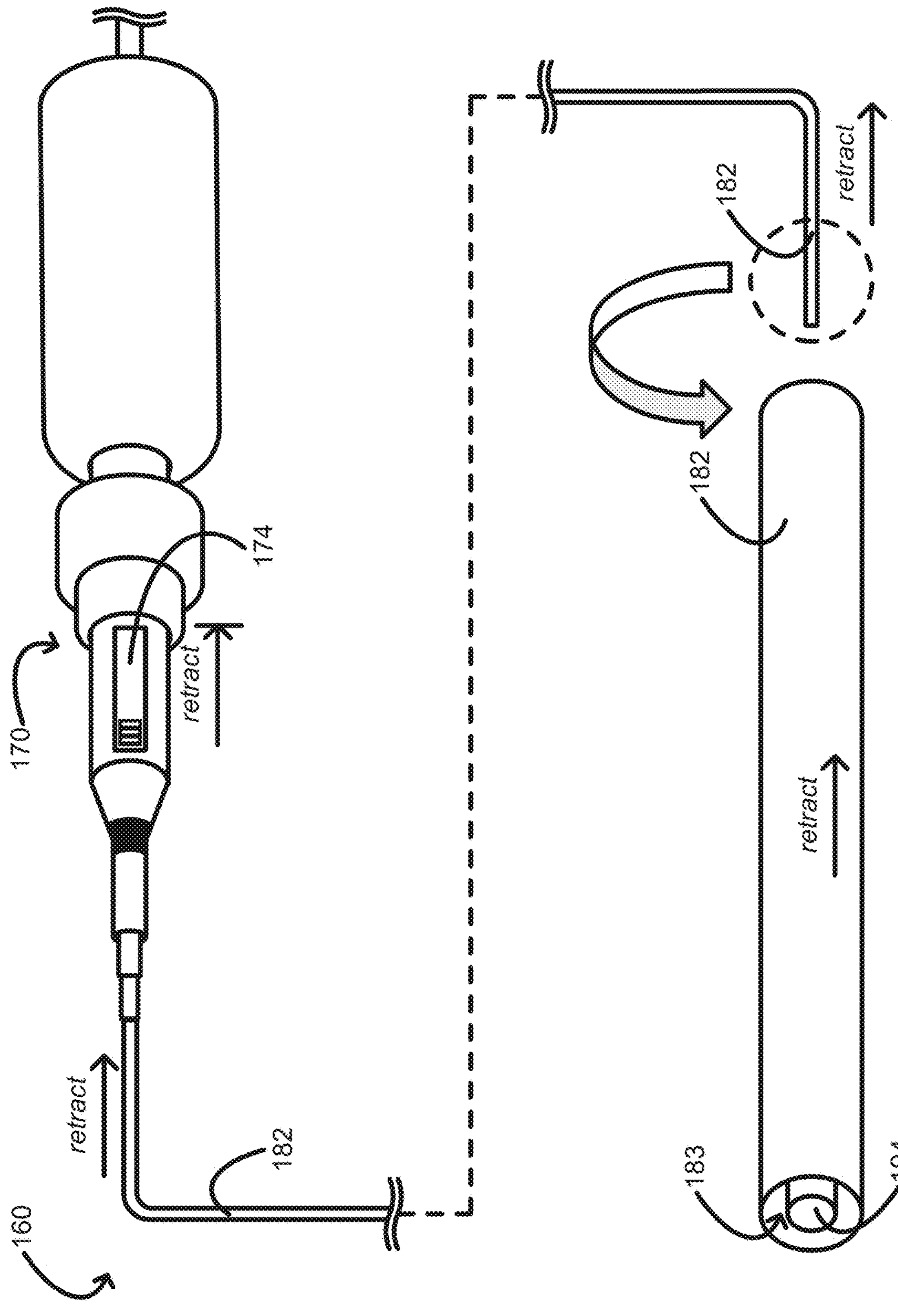

160
170
174
retract
retract
182
182
retract
182
retract
183
194

FIG. 2A

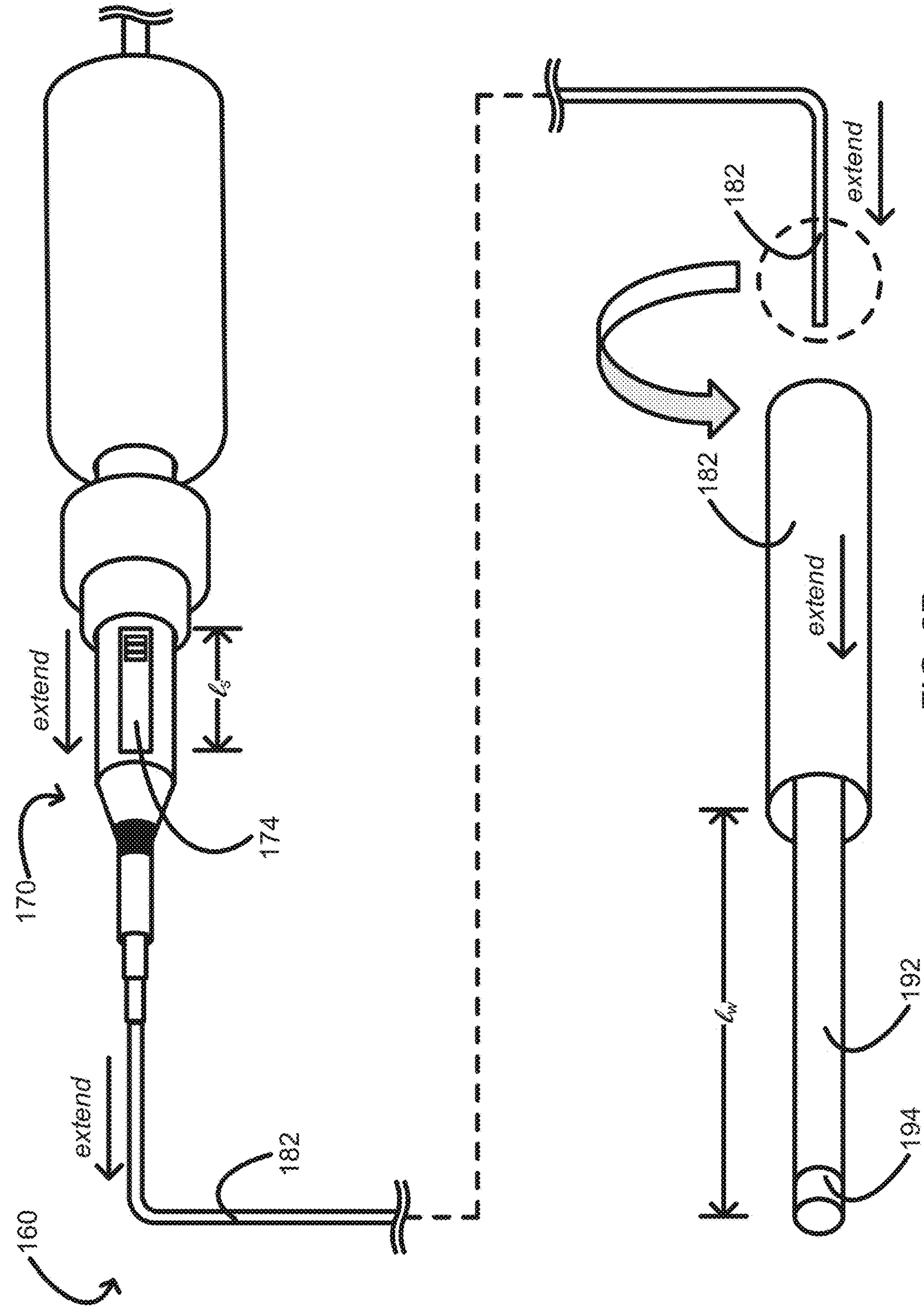

160
170
174
182
182
182
192
194
extend
extend
extend
extend
ℓ_s
ℓ_w

FIG. 2B

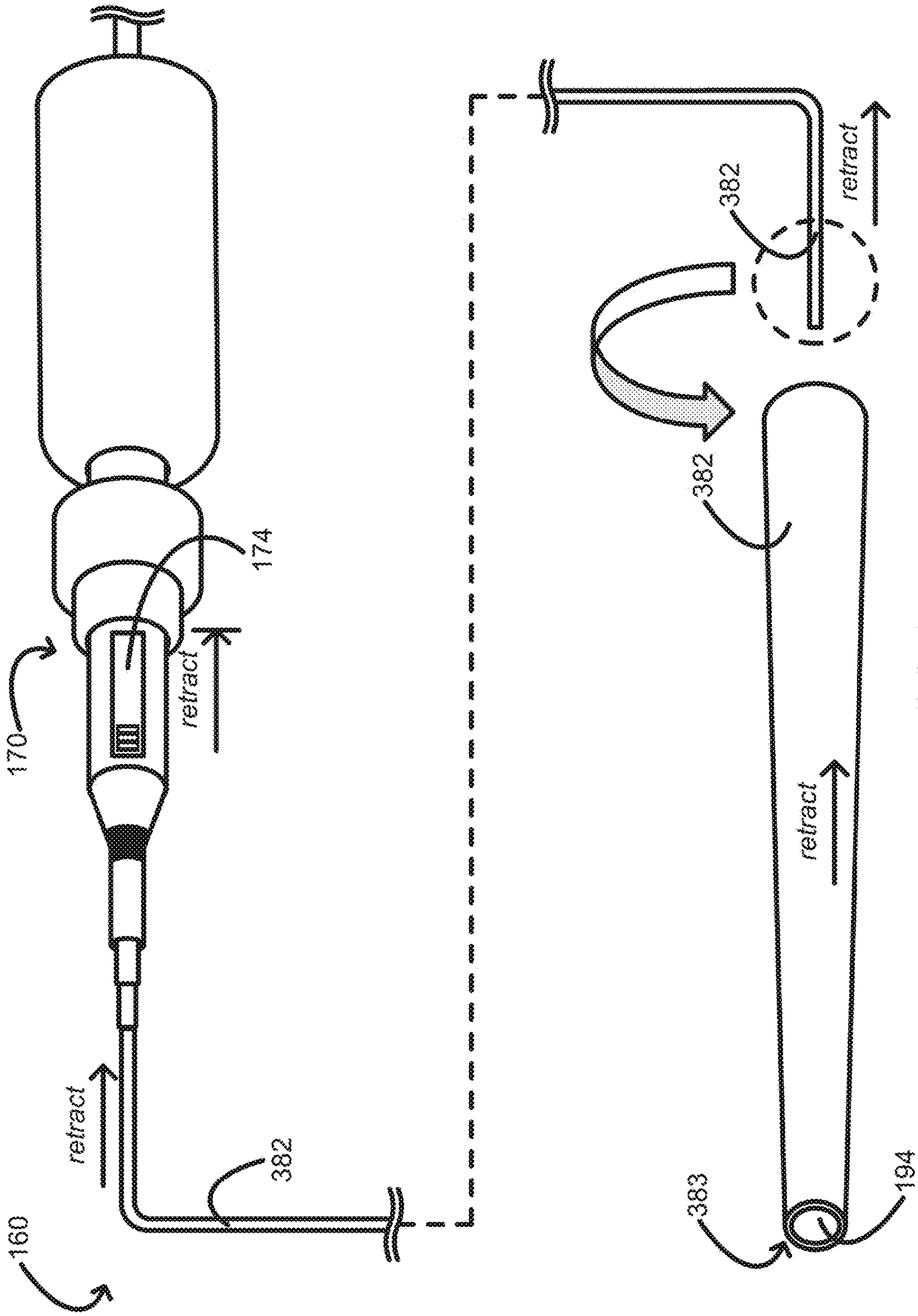

160
170
174
retract
retract
382
382
retract
382
retract
383
194

FIG. 3A

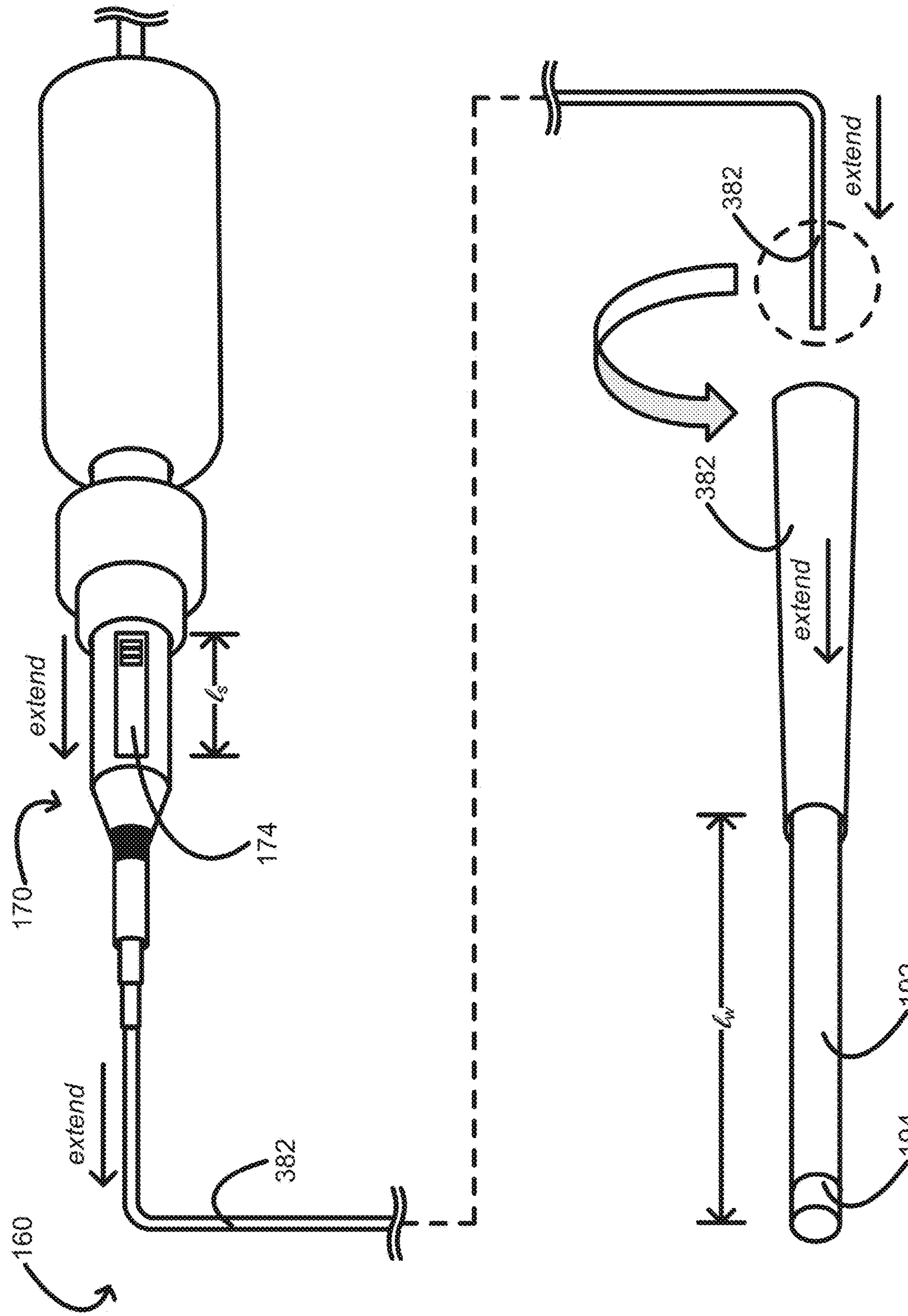

160
170
174
extend
extend
extend
extend
382
382
382
192
194
ℓ_s
ℓ_w

FIG. 3B

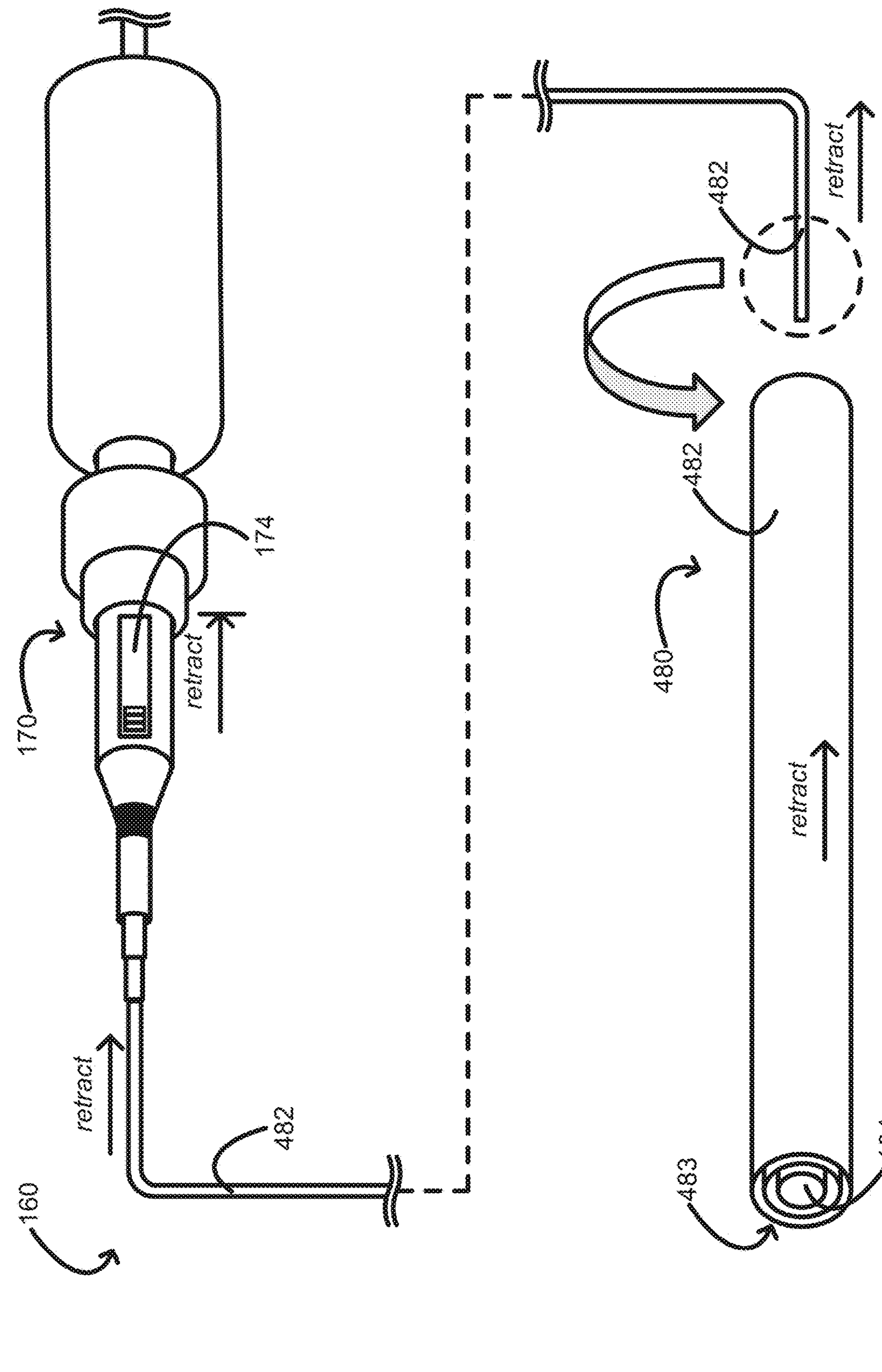

174
170
retract
retract
482
160
482
retract
482
480
retract
483
194

FIG. 4A

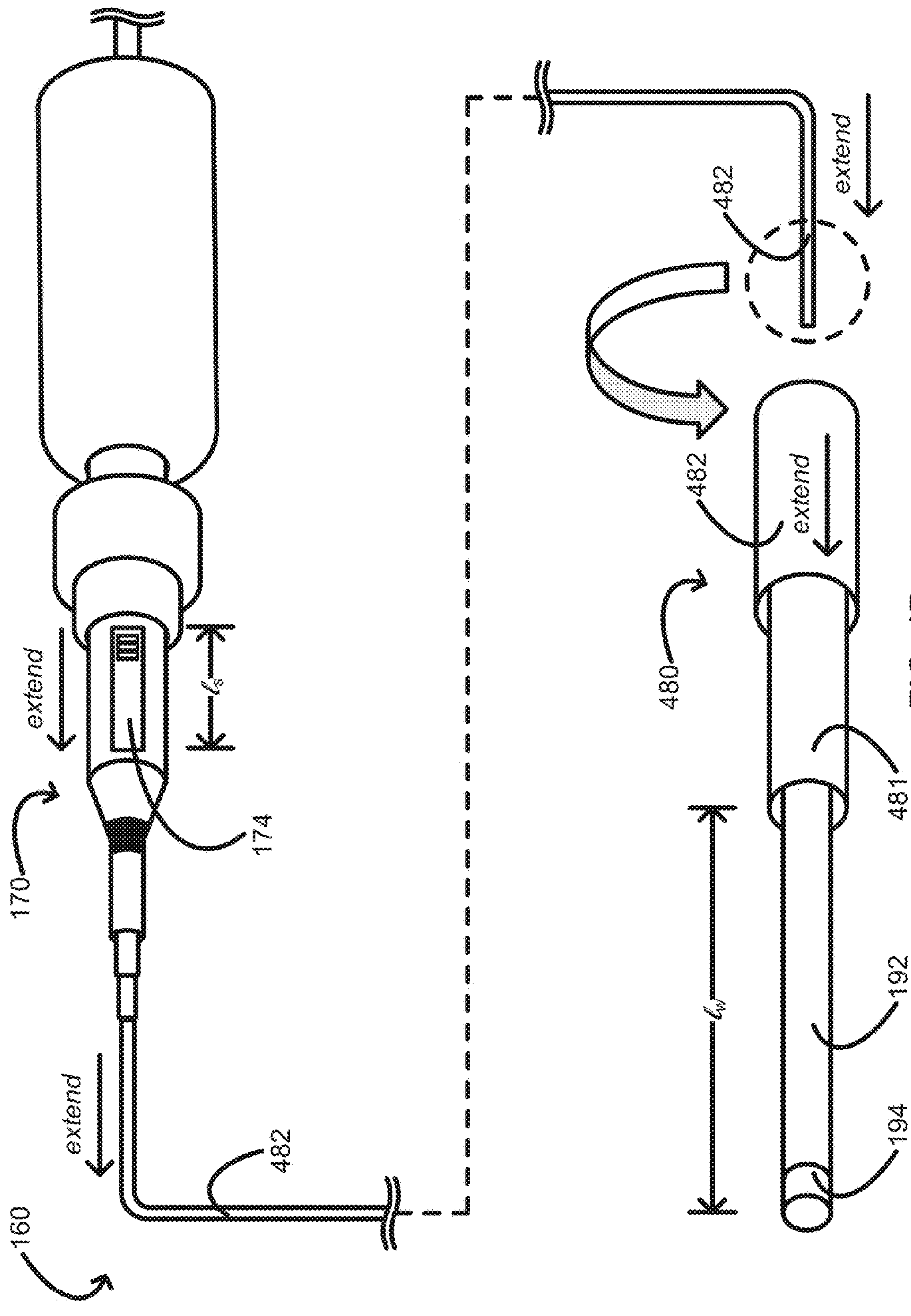

160
170
174
extend
extend
ℓ_s
482
480
481
482
extend
482
extend
ℓ_w
192
194

FIG. 4B

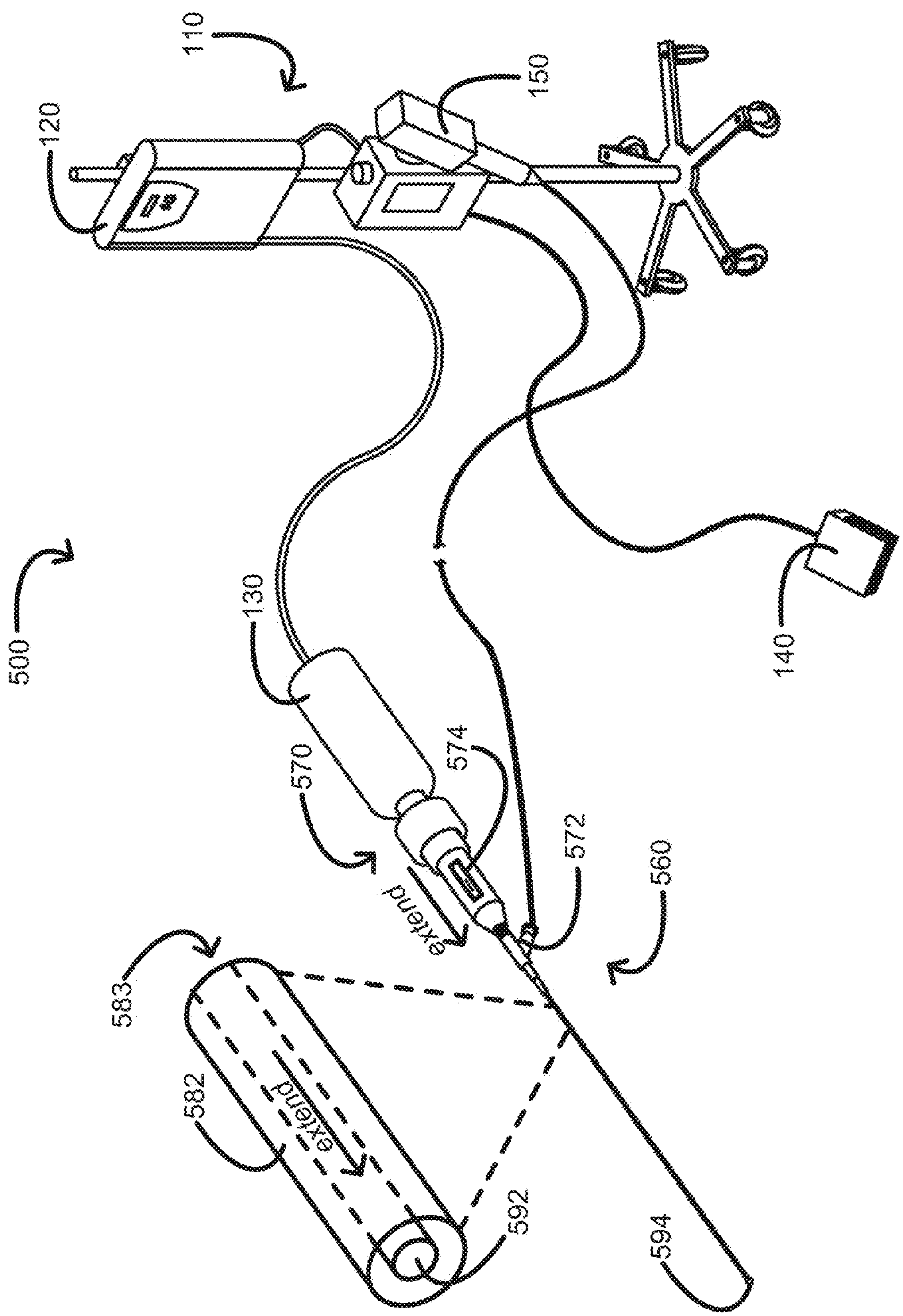

500
110
120
150
130
140
570
574
572
560
extend
583
582
extend
592
594

FIG. 5

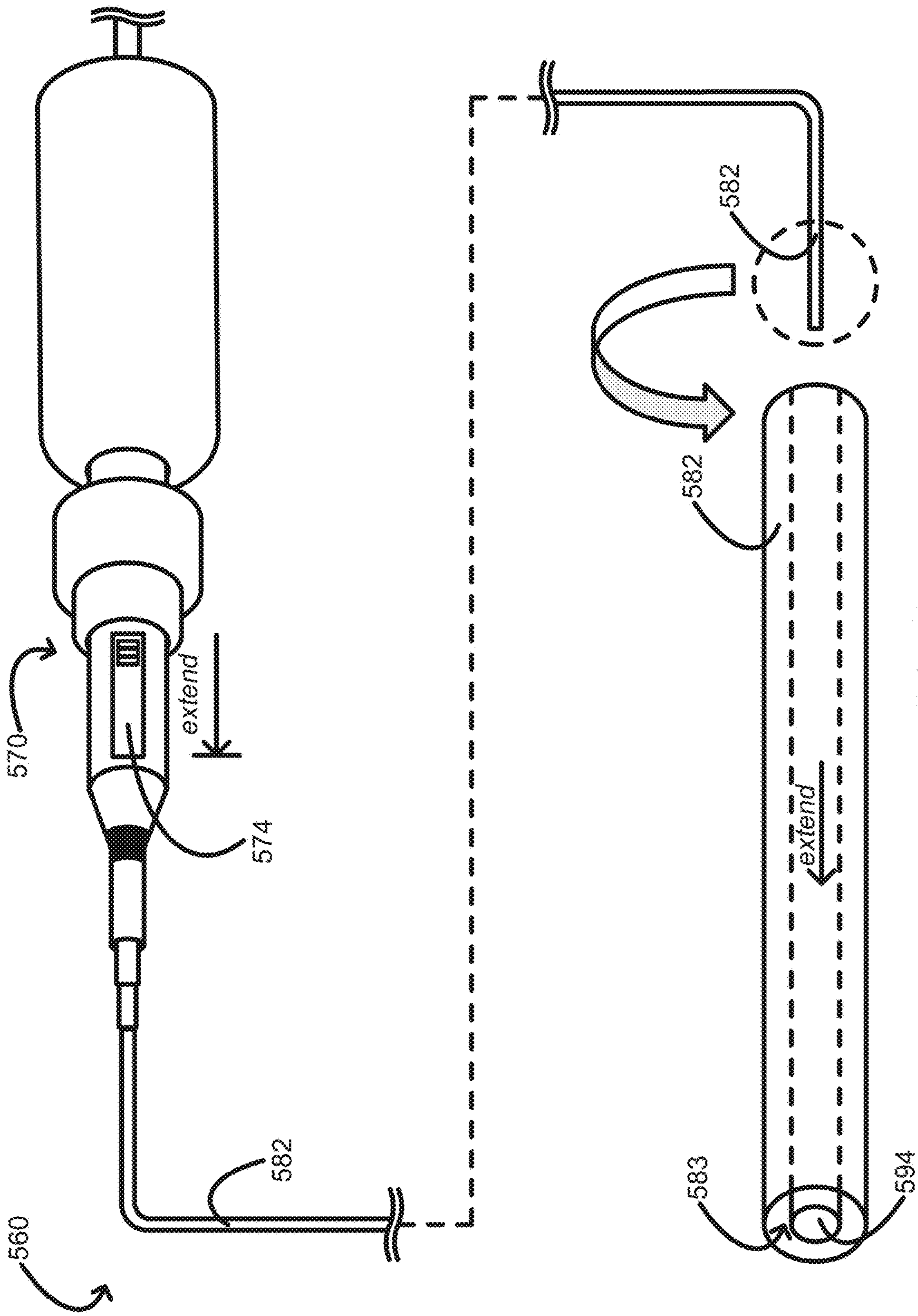


FIG. 6A

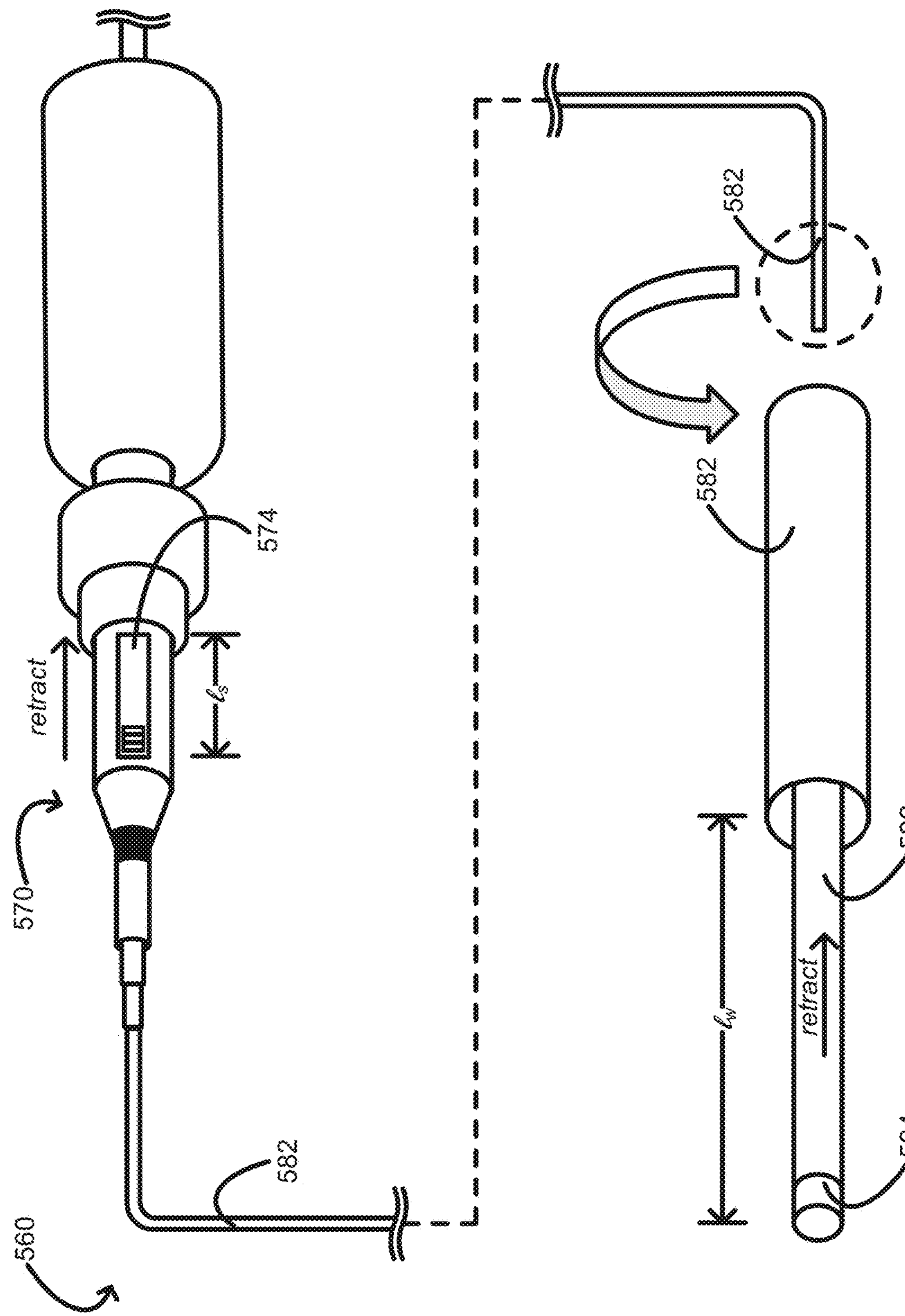


FIG. 6B

CATHETER WITH RETRACTABLE SHEATH AND METHODS THEREOF

FIELD

[0001] This application generally relates to catheters with retractable sheaths. In some embodiments, for example, the catheters are for modification of one or more intravascular lesions associated with atherosclerosis.

BACKGROUND

[0002] Atherosclerosis is characterized by one or more intravascular lesions formed in part of plaque including blood-borne substances such as fat, cholesterol, and calcium. An intravascular lesion such as an arterial lesion can form on a wall of an arterial lumen and build out across the lumen to an opposite wall thereof. A last point of patency often occurs at a boundary between the arterial lesion and the opposite wall of the arterial lumen.

[0003] Surgical procedures for atherosclerosis such as angioplasty or atherectomy can be used to restore patency and blood flow lost to the one or more intravascular lesions. To effect such surgical procedures, one or more endoluminal devices are advanced to an intravascular lesion to modify the intravascular lesion. For example, atherectomy can involve placing a guidewire through an intravascular lesion with a first, lesion-crossing device and subsequently advancing a second, atherectomy device to the intravascular lesion for ablation thereof. However, advancing an endoluminal device to an intravascular lesion can lead to device complications, surgical complications, or a combination thereof—especially when a lesion-modifying tip of the endoluminal device is exposed before needed for a surgical procedure. Accordingly, there is a need to conceal lesion-modifying tips of endoluminal devices until needed for surgical procedures. Provided herein in some embodiments are systems and methods that address the foregoing.

SUMMARY

[0004] Provided herein in some embodiments is a system including a catheter assembly. The catheter assembly can include a housing, a sheath, and a core wire disposed within a sheath lumen. The housing can include a retraction-extension mechanism configured to retract the sheath from a first, fully extended position of the sheath, in which position a distal portion of the core wire can be wholly disposed within the sheath lumen. The housing can accommodate a proximal length of the sheath, and the retraction-extension mechanism can be configured to retract the proximal length of the sheath into the housing and expose a working length of a distal portion of the core wire. The core wire can include a sonic connector at a proximal end of the core wire configured to connect to an ultrasound-producing mechanism for ultrasound-based modification of one or more intravascular lesions with the working length of the core wire.

[0005] These and other features of the concepts provided herein may be better understood with reference to the drawings, description, and appended claims.

DRAWINGS

[0006] FIG. **1** provides a schematic illustrating a system in accordance with some embodiments.

[0007] FIG. **2**A provides a schematic illustrating a catheter assembly with a retraction-extension mechanism configured to retract a sheath from a first, fully extended position of the sheath in accordance with some embodiments.

[0008] FIG. **2**B provides a schematic illustrating a catheter assembly with a retraction-extension mechanism configured to extend a sheath from a second, fully retracted position of the sheath in accordance with some embodiments.

[0009] FIG. **3**A provides a schematic illustrating a catheter assembly with a retraction-extension mechanism configured to retract a tapered sheath from a first, fully extended position of the sheath in accordance with some embodiments.

[0010] FIG. **3**B provides a schematic illustrating a catheter assembly with a retraction-extension mechanism configured to extend a tapered sheath from a second, fully retracted position of the sheath in accordance with some embodiments.

[0011] FIG. **4**A provides a schematic illustrating a catheter assembly with a retraction-extension mechanism configured to retract a sheath of a telescopic system from a first, fully extended position of the sheath in accordance with some embodiments.

[0012] FIG. **4**B provides a schematic illustrating a catheter assembly with a retraction-extension mechanism configured to extend a sheath of a telescopic system from a second, fully retracted position of the sheath in accordance with some embodiments.

[0013] FIG. **5** provides a schematic illustrating an alternative system in accordance with some embodiments.

[0014] FIG. **6**A provides a schematic illustrating a catheter assembly with an extension-retraction mechanism configured to extend a core wire from a first, fully retracted position of the core wire in accordance with some embodiments.

[0015] FIG. **6**B provides a schematic illustrating a catheter assembly with an extension-retraction mechanism configured to retract a core wire from a second, fully extended position of the core wire in accordance with some embodiments.

DESCRIPTION

[0016] Before some particular embodiments are provided in greater detail, it should be understood that the particular embodiments provided herein do not limit the scope of the concepts provided herein. It should also be understood that a particular embodiment provided herein can have features that can be readily separated from the particular embodiment and optionally combined with or substituted for features of any of a number of other embodiments provided herein.

[0017] Regarding terminology used herein, it should also be understood the terminology is for the purpose of describing some particular embodiments, and the terminology does not limit the scope of the concepts provided herein. Unless indicated otherwise, ordinal numbers (e.g., first, second, third, etc.) are used to distinguish or identify different features or steps in a group of features or steps, and do not supply a serial or numerical limitation. For example, “first,” “second,” and “third” features or steps need not necessarily appear in that order, and the particular embodiments including such features or steps need not necessarily be limited to the three features or steps. It should also be understood that, unless indicated otherwise, any labels such as “left,” “right,” “front,” “back,” “top,” “bottom,” “forward,” “reverse,” "clockwise," "counter clockwise," "up," "down," or other similar terms such as "upper," "lower," "aft," "fore," "vertical," "horizontal," "proximal," "distal," and the like are used for convenience and are not intended to imply, for example, any particular fixed location, orientation, or direction. Instead, such labels are used to reflect, for example, relative location, orientation, or directions. It should also be understood that the singular forms of "a," "an," and "the" include plural references unless the context clearly dictates otherwise.

[0018] With respect to "proximal," a "proximal portion" of, for example, a sheath or a core wire respectively includes a portion of the sheath or the core wire proximate to a system operator when the system is used as intended. Likewise, a "proximal length" of, for example, the sheath or the core wire respectively includes a length of the sheath or the core wire proximate to the system operator when the system is used as intended. A "proximal end" of, for example, the sheath or the core wire respectively includes an end of the sheath or the core wire proximate to the system operator when the system is used as intended. The proximal portion or the proximal length of the sheath or the core wire can respectively include the proximal end of the sheath or the core wire; however, the proximal portion or the proximal length of the sheath or the core wire need not respectively include the proximal end of the sheath or the core wire. That is, unless context suggests otherwise, the proximal portion or the proximal length of the sheath or the core wire is respectively not a terminal portion or a terminal length of the sheath of the core wire.

[0019] With respect to "distal," a "distal portion" of, for example, a sheath or a core wire respectively includes a portion of the sheath or the core wire proximate to a patient when the system is used as intended. Likewise, a "distal length" of, for example, the sheath or the core wire respectively includes a length of the sheath or the core wire proximate to the patient when the system is used as intended. A "distal end" of, for example, the sheath or the core wire respectively includes an end of the sheath or the core wire proximate to the patient when the system is used as intended. The distal portion or the distal length of the sheath or the core wire can respectively include the distal end of the sheath or the core wire; however, the distal portion or the distal length of the sheath or the core wire need not respectively include the distal end of the sheath or the core wire. That is, unless context suggests otherwise, the distal portion or the distal length of the sheath or the core wire is respectively not a terminal portion or a terminal length of the sheath of the core wire.

[0020] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood those of ordinary skill in the art.

[0021] Surgical procedures for atherosclerosis such as angioplasty or atherectomy can be used to restore patency and blood flow lost to the one or more intravascular lesions. To effect such surgical procedures, one or more endoluminal devices are advanced to an intravascular lesion to modify the intravascular lesion. For example, atherectomy can involve placing a guidewire through an intravascular lesion with a first, lesion-crossing device and subsequently advancing a second, atherectomy device to the intravascular lesion for ablation thereof. However, advancing an endoluminal device to an intravascular lesion can lead to device complications, surgical complications, or a combination thereof—especially when a lesion-modifying tip of the endoluminal device is exposed before needed for a surgical procedure. Accordingly, there is a need to conceal lesion-modifying tips of endoluminal devices until needed for surgical procedures. Provided herein in some embodiments are systems and methods that address the foregoing.

[0022] For example, provided herein in some embodiments is a system including a catheter assembly. The catheter assembly can include a housing, a sheath, and a core wire disposed within a sheath lumen. The housing can include a retraction-extension mechanism configured to retract the sheath from a first, fully extended position of the sheath, in which position a distal portion of the core wire can be wholly disposed within the sheath lumen. The housing can accommodate a proximal length of the sheath, and the retraction-extension mechanism can be configured to retract the proximal length of the sheath into the housing and expose a working length of a distal portion of the core wire. The core wire can include a sonic connector at a proximal end of the core wire configured to connect to an ultrasound-producing mechanism for ultrasound-based modification of one or more intravascular lesions with the working length of the core wire.

[0023] FIG. **1** provides a schematic illustrating a system **100** in accordance with some embodiments. The system **100** can be configured for crossing one or more intravascular lesions, ablating one or more intravascular lesions, or a combination thereof.

[0024] As shown in FIG. **1**, the system **100** can include a console **110**. The console **110** provides a system operator an instrument for monitoring and controlling the system **100** and various sub-systems and functions thereof. The console **110** can include an ultrasound-producing mechanism including an ultrasound generator **120** and an ultrasound transducer **130**. The ultrasound-producing mechanism can be configured to convert an electric current into a vibrational energy. For example, the ultrasound generator **120** can be configured to convert an alternating electric current (e.g., a current associated with mains electricity) into a high-frequency current (e.g., a current with a frequency commensurate with the operating frequency of the ultrasound transducer **130**), and the ultrasound transducer **130**, in turn, can be configured to convert the high-frequency current into the vibrational energy (e.g., >20 kHz such as 20.5 kHz±500 Hz).

[0025] In some embodiments, the console **110** can further include a foot switch **140** configured to activate and deactivate the system **100** such as activate and deactivate a core wire **192** of a catheter assembly **160**. For example, when the system **100** is powered on but not activated, the foot switch **140** can be used to activate the system **100**, thereby activating the core wire **192** of the catheter assembly **160**. When the system **100** is powered on and activated, the foot switch **140** can be used to deactivate the system **100**, thereby deactivating the core wire **192** of the catheter assembly **160**. In some embodiments, the console **110** can further include an injector **150** configured to inject an irrigant into an optional irrigation lumen **172** of the catheter assembly **160**. The irrigant can be, for example, sterile saline for irrigating an anatomical area undergoing an intravascular lesion-modification procedure (e.g., crossing an intravascular lesion, ablating an intravascular lesion, etc.), for cooling the core wire **192** of the catheter assembly **160**, or a combination thereof. In some embodiments, the console **110** can further include the foot switch **140** and the injector **150**. In such embodiments, the foot switch **140** can be further configured to activate and deactivate the injector **150** when the system **100** is respectively activated and deactivated with the foot switch **140**.

[0026] As shown in FIG. **1**, the system **100** can also include the aforementioned catheter assembly **160**. The catheter assembly **160** can include a housing **170**, a sheath **182**, and the aforementioned core wire **192** disposed within a sheath lumen **183**. The housing **170** can include a retraction-extension mechanism **174** configured to retract the sheath **182** from a first, fully extended position of the sheath **182**. In the fully extended position of the sheath, a distal portion of the core wire **192** including i) a lesion-modifying tip **194** of the core wire **192**, or ii) a lesion-modifying tip member **194** coupled to the core wire **192**, can be wholly disposed within the sheath lumen **183**. (See FIG. **2**A for more detail.) The retraction-extension mechanism **174** can be further configured to extend the sheath **182** from a second, fully retracted position of the sheath **182**. In the fully retracted position, a maximum working length $l_{w(max)}$ (see FIG. **2**B for l_w) of the core wire **192** including i) the lesion-modifying tip **194** of the core wire **192** or ii) the lesion-modifying tip member **194** coupled to the core wire **192** can be exposed outside the sheath lumen **183**. (See FIG. **2**B for more detail.)

[0027] FIG. **2**A provides a schematic illustrating the catheter assembly **160** with the retraction-extension mechanism **174** configured to retract the sheath **182** from the first, fully extended position of the sheath **182** in accordance with some embodiments. As shown in FIG. **2**A, the housing **170** of the catheter assembly **160** can include the retraction-extension mechanism **174** configured to retract the sheath **182** from the first, fully extended position of the sheath **182**. The distal portion of the core wire **192**—exemplified at least in part by the blown-up portion of the sheath **182** and the core wire **192** in FIG. **2**A—can be wholly disposed with the lesion-modifying tip or tip member **194** within the sheath lumen **183** in the fully extended position of the sheath **182**.

[0028] FIG. **2**B provides a schematic illustrating the catheter assembly **160** with the retraction-extension mechanism **174** configured to extend the sheath **182** from the second, fully retracted position of the sheath **182** in accordance with some embodiments. As shown in FIG. **2**B, the housing **170** of the catheter assembly **160** can include the retraction-extension mechanism **174** also configured to extend the sheath **182** from the second, fully retracted position of the sheath **182**. The maximum working length $l_{w(max)}$ of the core wire **192** can be exposed with the lesion-modifying tip or tip member **194** outside the sheath lumen **183** in the fully retracted position of the sheath **182**.

[0029] As shown in FIGS. **2**A and **2**B, the housing **170** can accommodate a proximal length of the sheath **182**, and the retraction-extension mechanism **174** can be configured to retract the proximal length of the sheath **182** into the housing **170** and expose the working length l_w of the distal portion of the core wire **192** for ultrasound-based modification of one or more intravascular lesions with the working length l_w of the core wire **192**. A maximum working length $l_{w(max)}$ of the core wire **192** can be defined by a retraction distance over which a point on the sheath retracts from the first position to the second position. The maximum working length $l_{w(max)}$ of the core wire **192** can also be defined by a slot length in the housing **170** configured to accommodate the proximal length of the sheath **182** in the second position. The working length l_w of the core wire **192** can range between about 5 and 200 mm, including between about 5 and 100 mm or between about 100 and 200 mm; however the working length l_w of the core wire **192** is not limited thereto.

[0030] The retraction-extension mechanism **174** can be a hand-actuated retraction-extension mechanism, or the retraction-extension mechanism **174** can be a motor-actuated retraction-extension mechanism. Whether hand-actuated or motor-actuated, the retraction-extension mechanism **174** can be configured to i) retract the sheath **182** from the first, fully extended position of the sheath **182**, ii) extend the sheath **182** from the second, fully retracted position of the sheath **182**, iii) retract or extend the sheath **182** into intermediate positions between the first position and the second position, or iv) any combination thereof. Retraction and extension of the sheath **182** into the foregoing intermediate positions provides customizability as needed for different anatomy and intravascular lesions.

[0031] The core wire **192** can include a sonic connector (not shown) at a proximal end of the core wire **192** configured to connect to an ultrasound-producing mechanism for ultrasound-based modification of one or more intravascular lesions with the working length l_w of the core wire **192**. The sonic connector can be configured to connect to the ultrasound-producing mechanism by the ultrasound transducer **130** or an intervening ultrasonic horn (not shown). A distal end of the core wire **192** can include the lesion-modifying tip **194** of the core wire **192**, or the distal end of the core wire **192** can be coupled to the lesion-modifying tip member **194**.

[0032] The working length l_w of the distal portion of the core wire **192** beyond the sheath **182** or the sheath lumen **183** thereof can be configured for displacement to effect intravascular lesion modification. The displacement can be longitudinal, transverse, or longitudinal and transverse in accordance with a profile of the core wire **192** and the vibrational energy (e.g., >20 kHz such as 20.5 kHz±500 Hz). Longitudinal displacement of the working length l_w of the core wire **192** can result in micromotion such as cavitation, and transverse displacement of the working length l_w of the core wire **192** can result in macromotion. The micromotion can be used to cross intravascular lesions. The macromotion coupled with the micromotion can be used to ablate intravascular lesions, thereby breaking the lesions into minute fragments and restoring patency and blood flow.

[0033] FIGS. **3**A, **3**B, **4**A and **4**B provide schematics illustrating catheter assemblies with sheath alternatives to the sheath of FIGS. **2**A and **2**B in accordance with some embodiments.

[0034] FIG. **3**A provides a schematic illustrating a catheter assembly **160** with a tapered sheath **382** and a retraction-extension mechanism **174** configured to retract the tapered sheath **382** from a first, fully extended position of the sheath **382** in accordance with some embodiments. FIG. **3**B provides a schematic illustrating the catheter assembly **160** with the retraction-extension mechanism **174** configured to extend the tapered sheath **382** from a second, fully retracted position of the sheath **382** in accordance with some embodiments. The descriptions set forth above with respect to the features of FIGS. **2**A and **2**B are incorporated herein by reference to describe the features of FIGS. **3**A and **3**B, which use the same reference numerals as FIGS. **2**A and **2**B; however, as shown in FIGS. **3**A and **3**B, a distal portion of the sheath **382** can be tapered proximate to the working length l_w of the core wire **192**. A sheath lumen **383** of the tapered sheath **382** can have a constant diameter to accommodate the core wire **192** and the profile thereof.

[0035] FIG. **4**A provides a schematic illustrating a catheter assembly **160** with a sheath **482** of a telescopic system **480** and a retraction-extension mechanism **174** configured to retract the sheath **482** of the telescopic system **480** from a first, fully extended position of the sheath **482** in accordance with some embodiments. FIG. **4**B provides a schematic illustrating the catheter assembly **160** with the retraction-extension mechanism **174** configured to extend the sheath **482** of the telescopic system **480** from a second, fully retracted position of the sheath **482** in accordance with some embodiments. The descriptions set forth above with respect to the features of FIGS. **2**A and **2**B are incorporated herein by reference to describe the features of FIGS. **4**A and **4**B, which use the same reference numerals as FIGS. **2**A and **2**B; however, the catheter assembly **160** can further include a telescopic system **480** including two or more nested telescopic members such as a first telescopic member **481** and a second telescopic member **482**. At least one telescopic member of the two or more telescopic members can be the sheath **482**. As shown, the second telescopic member **482** can be the sheath **482**. Alternatively, the two or more nested telescopic members such as the first telescopic member **481** and the second telescopic member **482**, together, form the sheath **482**. A sheath lumen **483** of the sheath **482** such as the foregoing sheath **482** formed of the first telescopic member **481** and the second telescopic member **482** can have a constant diameter to accommodate the core wire **192** and the profile thereof.

[0036] In an alternative to the foregoing telescopic system **480**, the two or more nested telescopic members can be located in a proximal portion of the catheter assembly **160** proximate to the retraction-extension mechanism **174**.

[0037] FIG. **5** provides a schematic illustrating an alternative system **500** in accordance with some embodiments. The system **500** can be configured for crossing one or more intravascular lesions, ablating one or more intravascular lesions, or a combination thereof.

[0038] The descriptions set forth above with respect to the features of FIG. **1** in common with the features of FIG. **5** are incorporated herein by reference, which features are readily identified by common reference numerals; however, as shown in FIG. **5**, the system **500** is configured to extend and retract a core wire **592** of a catheter assembly **560** instead of retract and extend a sheath **582**.

[0039] As shown in FIG. **5**, the system **500** can include the aforementioned catheter assembly **560**. The catheter assembly **560** can include a housing **570**, the aforementioned sheath **582**, the aforementioned core wire **592** disposed within a sheath lumen **583**, and an optional irrigation lumen **572** for use with the injector **150**. The housing **570** can include an extension-retraction mechanism **574** configured to extend the core wire **592** from a first, fully retracted position of the core wire **592**. In the fully retracted position of the core wire **592**, a distal portion of the core wire **592** including i) a lesion-modifying tip **594** of the core wire **592**, or ii) a lesion-modifying tip member **594** coupled to the core wire **592**, can be wholly disposed within the sheath lumen **583**. (See FIG. **6**A for more detail.) The extension-retraction mechanism **574** can be further configured to retract the core wire **592** from a second, fully extended position of the core wire **592**. In the fully extended position, a maximum working length $l_{w(max)}$ (see FIG. **6**B for l_w) of the core wire **592** including i) the lesion-modifying tip **594** of the core wire **592** or ii) the lesion-modifying tip member **594** coupled to the core wire **592** can be exposed outside the sheath lumen **583**. (See FIG. **6**B for more detail.)

[0040] FIG. **6**A provides a schematic illustrating the catheter assembly **560** with the extension-retraction mechanism **574** configured to extend the core wire **592** from the first, fully retracted position of the core wire **592** in accordance with some embodiments. As shown in FIG. **6**A, the housing **570** of the catheter assembly **560** can include the extension-retraction mechanism **574** configured to extend the core wire **592** from the first, fully retracted position of the core wire **592**. The distal portion of the core wire **592**—exemplified at least in part by the blown-up portion of the sheath **582** and the core wire **592** in FIG. **6**A—can be wholly disposed with the lesion-modifying tip or tip member **594** within the sheath lumen **583** in the fully retracted position of the core wire **592**.

[0041] FIG. **6**B provides a schematic illustrating the catheter assembly **560** with the extension-retraction mechanism **574** configured to retract the core wire **592** from the second, fully extended position of the core wire **592** in accordance with some embodiments. As shown in FIG. **6**B, the housing **570** of the catheter assembly **560** can include the extension-retraction mechanism **574** also configured to retract the core wire **592** from the second, fully extended position of the core wire **592**. The maximum working length $l_{w(max)}$ of the core wire **592** can be exposed with the lesion-modifying tip or tip member **594** outside the sheath lumen **583** in the fully extended position of the core wire **592**.

[0042] As shown in FIGS. **6**A and **6**B, the housing **570** can accommodate a proximal length of the core wire **592**, and the extension-retraction mechanism **574** can be configured to extend the proximal length of the core wire **592** from the housing **570** and expose the working length l_w of the distal portion of the core wire **592** for ultrasound-based modification of one or more intravascular lesions with the working length l_w of the core wire **592**. A maximum working length $l_{w(max)}$ of the core wire **592** can be defined by an extension distance over which a point on the core wire **592** extends from the first position to the second position. The maximum working length $l_{w(max)}$ of the core wire **592** can also be defined by a slot length l_s in the housing **570** configured to accommodate the proximal length of the core wire **592** in the first position. The working length l_w of the core wire **592** can range between about 5 and 200 mm, including between about 5 and 100 mm or between about 100 and 200 mm; however the working length l_w of the core wire **592** is not limited thereto.

[0043] The extension-retraction mechanism **574** can be a hand-actuated extension-retraction mechanism, or the extension-retraction mechanism **574** can be a motor-actuated extension-retraction mechanism. Whether hand-actuated or motor-actuated, the extension-retraction mechanism **574** can be configured to i) extend the core wire **592** from the first, fully retracted position of the core wire **592**, ii) retract the core wire **592** from the second, fully extended position of the core wire **592**, iii) extend or retract the core wire **592** into intermediate positions between the first position and the second position, or iv) any combination thereof. Extension and retraction of the core wire **592** into the foregoing intermediate positions provides customizability as needed for different anatomy and intravascular lesions.

[0044] The core wire **592** can include a sonic connector (not shown) at a proximal end of the core wire **592** configured to connect to an ultrasound-producing mechanism for ultrasound-based modification of one or more intravascular lesions with the working length l_w of the core wire **592**. The sonic connector can be configured to connect to the ultrasound-producing mechanism by the ultrasound transducer **130** or an intervening ultrasonic horn (not shown). A distal end of the core wire **592** can include the lesion-modifying tip **594** of the core wire **592**, or the distal end of the core wire **592** can be coupled to the lesion-modifying tip member **594**.

[0045] The working length l_w of the distal portion of the core wire **592** beyond the sheath **582** or the sheath lumen **583** thereof can be configured for displacement to effect intravascular lesion modification. The displacement can be longitudinal, transverse, or longitudinal and transverse in accordance with a profile of the core wire **592** and the vibrational energy (e.g., >20 kHz such as 20.5 kHz±500 Hz). Longitudinal displacement of the working length l_w of the core wire **592** can result in micromotion such as cavitation, and transverse displacement of the working length l_w of the core wire **592** can result in macromotion. The micromotion can be used to cross intravascular lesions. The macromotion coupled with the micromotion can be used to ablate intravascular lesions, thereby breaking the lesions into minute fragments and restoring patency and blood flow.

[0046] As such, provided herein in some embodiments is a system including a catheter assembly. The catheter assembly can include a housing, a sheath including a sheath lumen, and a core wire disposed within the sheath lumen. The housing can include a retraction-extension mechanism configured to retract the sheath from a first, fully extended position of the sheath and extend the sheath from a second, fully retracted position of the sheath. The retraction-extension mechanism can be further configured to retract a proximal length of the sheath into the housing and expose a working length of a distal portion of the core wire for ultrasound-based modification of one or more intravascular lesions.

[0047] In such embodiments, the distal portion of the core wire can be wholly disposed within the sheath lumen while the sheath is in the first position.

[0048] In such embodiments, a maximum working length of the core wire can be defined by a retraction distance over which a point on the sheath retracts from the first position to the second position. The retraction distance can be defined by a slot length in the housing configured to accommodate the proximal length of the sheath in the second position.

[0049] In such embodiments, a distal portion of the sheath can be tapered proximate to the working length of the core wire.

[0050] In such embodiments, the retraction-extension mechanism can be a hand-actuated or motor actuated retraction-extension mechanism.

[0051] In such embodiments, the catheter assembly can further include a telescopic system including two or more nested telescopic members. At least one telescopic member of the two or more telescopic members can be the sheath.

[0052] In such embodiments, the system can further include a console. The console can include an ultrasound-producing mechanism configured to convert an electric current into a vibrational energy. A sonic connector at a proximal end of the core wire can be configured to connect to the ultrasound-producing mechanism for the ultrasound-based modification of one or more intravascular lesions.

[0053] In such embodiments, the ultrasound-producing mechanism can include an ultrasonic generator, an ultrasonic transducer, and an ultrasonic horn. The ultrasonic generator can be configured to convert an alternating electric current into a high-frequency current. The ultrasonic transducer can be configured to convert the high-frequency current into the vibrational energy. The ultrasonic horn can be configured to augment an amplitude of the vibrational energy. The sonic connector of the core wire can be configured to connect to the ultrasonic horn for the ultrasound-based modification of one or more intravascular lesions.

[0054] Also provided herein in some embodiments is a system including a catheter assembly. The catheter assembly can include a housing, a sheath including a sheath lumen, and a core wire disposed within the sheath lumen. The housing can include a retraction-extension mechanism configured to retract the sheath from a first, fully extended position of the sheath, in which position a distal portion of the core wire can be wholly disposed within the sheath lumen. The retraction-extension mechanism can be further configured to extend the sheath from a second, fully retracted position of the sheath. The housing can accommodate a proximal length of the sheath, and the retraction-extension mechanism can be configured to retract the proximal length of the sheath into the housing and expose a working length of a distal portion of the core wire. The working length can be defined by a slot length in the housing configured to accommodate the proximal length of the sheath in the second position. The core wire can include a sonic connector at a proximal end of the core wire configured to connect to an ultrasound-producing mechanism for ultrasound-based modification of one or more intravascular lesions.

[0055] In such embodiments, a distal portion of the sheath can be tapered proximate to the working length of the core wire.

[0056] In such embodiments, the retraction-extension mechanism can be a hand-actuated or motor-actuated retraction-extension mechanism.

[0057] In such embodiments, the system can further include a console. The console can include an ultrasonic generator, an ultrasonic transducer, and an ultrasonic horn. The ultrasonic generator can be configured to convert an alternating electric current into a high-frequency current. The ultrasonic transducer can be configured to convert the high-frequency current into the vibrational energy. The ultrasonic horn can be configured to augment an amplitude of the vibrational energy. The sonic connector of the core wire can be configured to connect to the ultrasonic horn for the ultrasound-based modification of one or more intravascular lesions.

[0058] Also provided herein in some embodiments is a system including a catheter assembly and a console. The catheter assembly can include a housing, a sheath including a sheath lumen, and a core wire disposed within the sheath lumen. The housing can include a retraction-extension mechanism configured to retract the sheath from a first, fully extended position of the sheath, in which position a distal portion of the core wire can be wholly disposed within the sheath lumen. The retraction-extension mechanism can be further configured to extend the sheath from a second, fully retracted position of the sheath. The housing can accommodate a proximal length of the sheath, and the retraction-extension mechanism can be configured to retract the proximal length of the sheath into the housing and expose a working length of a distal portion of the core wire for ultrasound-based modification of one or more intravascular lesions. The console can include an ultrasound-producing mechanism configured to convert an electric current into a vibrational energy. A sonic connector at a proximal end of the core wire can be configured to connect to the ultrasound-producing mechanism for the ultrasound-based modification of one or more intravascular lesions.

[0059] In such embodiments, a maximum working length of the core wire can be defined by a retraction distance over which a point on the sheath retracts from the first position to the second position.

[0060] In such embodiments, a maximum working length of the core wire can be defined by a slot length in the housing configured to accommodate the proximal length of the sheath in the second position.

[0061] In such embodiments, a distal portion of the sheath can be tapered proximate to the working length of the core wire.

[0062] In such embodiments, the catheter assembly can further include a telescopic system including two or more nested telescopic members. At least one telescopic member of the two or more telescopic members can be the sheath.

[0063] While some particular embodiments have been provided herein, and while the particular embodiments have been provided in some detail, it is not the intention for the particular embodiments to limit the scope of the concepts presented herein. Additional adaptations and/or modifications can appear to those of ordinary skill in the art, and, in broader aspects, these adaptations and/or modifications are encompassed as well. Accordingly, departures may be made from the particular embodiments provided herein without departing from the scope of the concepts provided herein.

What is claimed is:

1. A system, comprising:

a catheter assembly comprising:

a housing including a retraction-extension mechanism;

a sheath including a sheath lumen, wherein the sheath is configured to retract from a first, fully extended position of the sheath and extend from a second, fully retracted position of the sheath; and

a core wire disposed within the sheath lumen, wherein the retraction-extension mechanism is configured to retract a proximal length of the sheath into the housing and expose a working length of a distal portion of the core wire for ultrasound-based modification of one or more intravascular lesions.

2. The system of claim **1**, wherein the distal portion of the core wire is wholly disposed within the sheath lumen while the sheath is in the first position.

3. The system of claim **1**, wherein a maximum working length of the core wire is defined by a retraction distance over which a point on the sheath retracts from the first position to the second position.

4. The system of claim **3**, wherein the retraction distance is defined by a slot length in the housing configured to accommodate the proximal length of the sheath in the second position.

5. The system of claim **1**, wherein a distal portion of the sheath is tapered proximate to the working length of the core wire.

6. The system of claim **1**, wherein the retraction-extension mechanism is a hand-actuated retraction-extension mechanism.

7. The system of claim **1**, wherein the retraction-extension mechanism is a motor-actuated retraction-extension mechanism.

8. The system of claim **1**, the catheter assembly further comprising a telescopic system including two or more nested telescopic members, wherein at least one telescopic member of the two or more telescopic members is the sheath.

9. The system of claim **1**, further comprising a console comprising an ultrasound-producing mechanism configured to convert an electric current into a vibrational energy, wherein a sonic connector at a proximal end of the core wire is configured to connect to the ultrasound-producing mechanism for the ultrasound-based modification of one or more intravascular lesions.

10. The system of claim **9**, wherein the ultrasound-producing mechanism includes:

an ultrasonic generator configured to convert an alternating electric current into a high-frequency current;

an ultrasonic transducer configured to convert the high-frequency current into the vibrational energy; and

an ultrasonic horn configured to augment an amplitude of the vibrational energy, wherein the sonic connector of the core wire is configured to connect to the ultrasonic horn.

11. A system, comprising:

a catheter assembly comprising:

a housing including a retraction-extension mechanism;

a sheath including a sheath lumen, wherein the sheath is configured to retract from a first, fully extended position of the sheath and extend from a second, fully retracted position of the sheath; and

a core wire disposed within the sheath lumen including a sonic connector at a proximal end of the core wire configured to connect to an ultrasound-producing mechanism, wherein:

a distal portion of the core wire is wholly disposed within the sheath lumen while the sheath is in the first position;

the retraction-extension mechanism is configured to retract a proximal length of the sheath into the housing and expose a working length of the distal portion of the core wire for ultrasound-based modification of one or more intravascular lesions; and

the working length is defined by a slot length in the housing configured to accommodate the proximal length of the sheath in the second position.

12. The system of claim **11**, wherein a distal portion of the sheath is tapered proximate to the working length of the core wire.

13. The system of claim **11**, wherein the retraction-extension mechanism is a hand-actuated retraction-extension mechanism.

14. The system of claim **11**, wherein the retraction-extension mechanism is a motor-actuated retraction-extension mechanism.

15. The system of claim **11**, further comprising:

a console comprising:

an ultrasonic generator configured to convert an alternating electric current into a high-frequency current;

an ultrasonic transducer configured to convert the high-frequency current into a vibrational energy; and
an ultrasonic horn configured to augment an amplitude of the vibrational energy, wherein the sonic connector of the core wire is configured to connect to the ultrasonic horn.

16. A system, comprising:
a) a catheter assembly comprising:
a housing including a retraction-extension mechanism;
a sheath including a sheath lumen, wherein the sheath is configured to retract from a first, fully extended position of the sheath and extend from a second, fully retracted position of the sheath; and
a core wire disposed within the sheath lumen, wherein:
a distal portion of the core wire is wholly disposed within the sheath lumen while the sheath is in the first position, and
the retraction-extension mechanism is configured to retract a proximal length of the sheath into the housing and expose a working length of a distal portion of the core wire for ultrasound-based modification of one or more intravascular lesions; and
b) a console comprising:
an ultrasound-producing mechanism configured to convert an electric current into a vibrational energy, wherein a sonic connector at a proximal end of the core wire is configured to connect to the ultrasound-producing mechanism for the ultrasound-based modification of one or more intravascular lesions.

17. The system of claim **16**, wherein a maximum working length of the core wire is defined by a retraction distance over which a point on the sheath retracts from the first position to the second position.

18. The system of claim **16**, wherein a maximum working length of the core wire is defined by a slot length in the housing configured to accommodate the proximal length of the sheath in the second position.

19. The system of claim **16**, wherein a distal portion of the sheath is tapered proximate to the working length of the core wire.

20. The system of claim **16**, the catheter assembly further comprising a telescopic system including two or more nested telescopic members, wherein at least one telescopic member of the two or more telescopic members is the sheath.

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