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(54) **Title:** CONTRACTION OF AN ANNULOPLASTY STRUCTURE

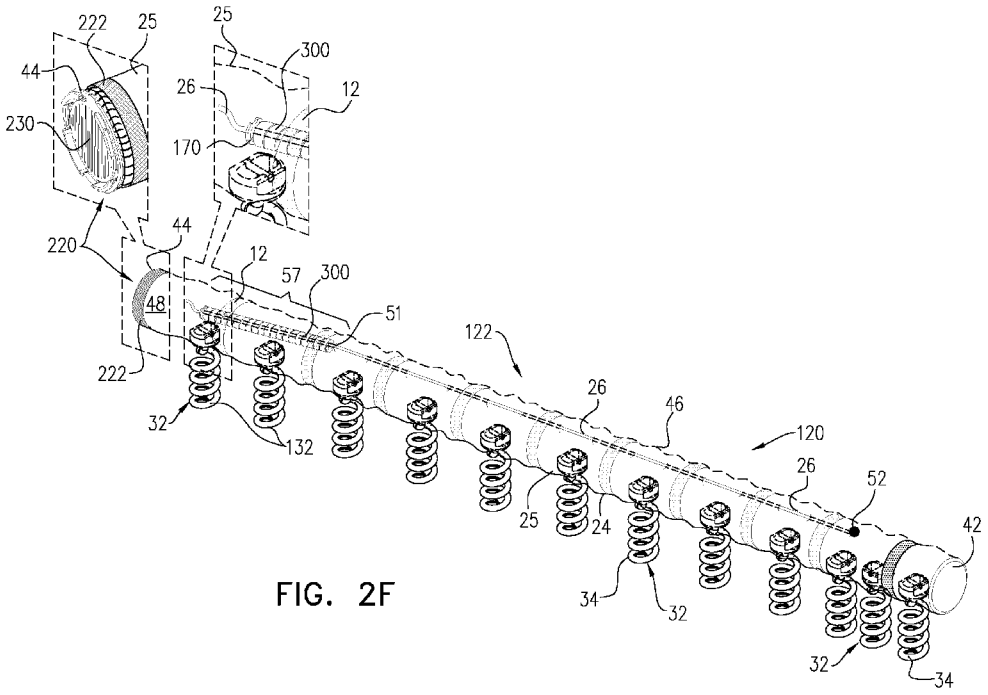

FIG. 2F

(57) **Abstract:** Systems and apparatuses for use at a heart of a subject are described. The systems and apparatuses comprise an annuloplasty structure. The annuloplasty structure can comprise a flexible sleeve and an elongate contraction member and a plurality of tissue anchors configured to extend through a circumferential wall of the sleeve and into tissue of the heart to anchor the sleeve to the tissue. In some applications, the systems and apparatuses include a force-distributing element configured to be disposed within the lumen of the sleeve and to surround the contraction member such that a distal end of the force-distributing element abuts an inner surface of the sleeve so as to distribute a force applied. Pulling the proximal end of the contraction member increases a length of the proximal end portion of the contraction member that is disposed within the lumen so as to longitudinally contract the sleeve.

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CONTRACTION OF AN ANNULOPLASTY STRUCTURE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the benefit of US Provisional Patent Application No. 62/877,776, filed July 23, 2019 and entitled "CONTRACTION OF AN ANNULOPLASTY STRUCTURE", the disclosures of which is incorporated herein by reference in its entirety for all purposes.

BACKGROUND

[0001] Ischemic heart disease can cause atrioventricular valve regurgitation by, for example, the combination of ischemic dysfunction of the papillary muscles, and the dilatation of the ventricle associated with ischemic heart disease, with the subsequent displacement of the papillary muscles and/or the dilatation of the valve annulus.

[0002] Dilation of the annulus of an atrioventricular valve can prevent the valve leaflets from fully coapting when the valve is closed. Regurgitation of blood from the ventricle into the atrium can result in increased total stroke volume and decreased cardiac output, and ultimate weakening of the ventricle secondary to a volume overload and a pressure overload of the atrium.

[0003] Annuloplasty, such as by implantation of an annuloplasty ring, can be used to improve leaflet coaptation by adjusting the shape of the atrioventricular valve annulus. Percutaneous (e.g., transfemoral, transseptal, etc.) annuloplasty devices can be beneficial.

SUMMARY OF THE INVENTION

[0004] This summary is meant to provide some examples and is not intended to be limiting of the scope of the invention in any way. For example, any feature included in an example of this summary is not required by the claims, unless the claims explicitly recite the features. Also, the features described can be combined in a variety of ways. The description herein relates to systems, assemblies, methods, devices, apparatuses, combinations, etc. that can be used for reshaping the heart and/or a portion thereof. Various features and steps as described elsewhere in this disclosure can be included in the examples summarized here.

[0005] An adjustable annuloplasty structure, comprising a sleeve and a contracting member (e.g., a contraction wire, etc.), is contracted by tensioning the contracting member. In an exemplary application, the resulting excess of the contraction member is deposited within the lumen of the sleeve, obviating the need to remove the excess from the implant, e.g., by cutting.

Contraction of the annuloplasty structure can therefore achieved by pulling the contraction member into and/or increasing a longitudinal proportion of the contraction member that is disposed within the lumen. The contraction can be maintained by locking a locking mechanism to the contraction member.

[0006] For some applications, the contraction member is pulled into the lumen from within the lumen.

[0007] There is therefore provided, in accordance with some applications, a system and/or an apparatus for use at a heart of a subject, the system/apparatus including an annuloplasty structure that includes a flexible sleeve having a first sleeve-end-portion, a second sleeve-end-portion, and a circumferential wall that defines a longitudinal lumen between the first and second sleeve-end-portions. The annuloplasty structure can also include an elongate contraction member, such as a contraction wire. The contraction member/wire having a first end (e.g., a first wire-end) and a second end (e.g., a second wire-end). The first end or wire-end can be attached to the sleeve at the first sleeve-end-portion, and the member/wire extending, in association with the circumferential wall, from the first sleeve-end-portion toward the second sleeve-end-portion.

[0008] The system/apparatus can also include a plurality of tissue anchors that are configured to anchor the sleeve to tissue. The plurality of tissue anchors can include at least one second sleeve-end-portion tissue anchor configured to anchor the second sleeve-end-portion to tissue by being driven through the circumferential wall and into the tissue.

[0009] In some implementations, the system/apparatus also includes a force-distributing element configured to surround a second end portion or second wire-end portion of the member/wire that is disposed within the lumen of the sleeve and to distribute a force applied to the at least one second sleeve-end-portion tissue anchor during application of a contraction force to the elongate contraction member/wire.

[0010] In some implementations, the member/wire is arranged with respect to the sleeve such that increasing a longitudinal proportion of the member/wire that is disposed within the lumen longitudinally contracts the sleeve.

[0011] In an application, the force-distributing element includes a tube shaped so as to define a plurality of slits, and the plurality of slits increase flexibility of the force-distributing element.

[0012] In an application, the force-distributing element includes a flexible coil.

[0013] In an application, each tissue anchor of the plurality of tissue anchors is independently advanceable into the lumen of the sleeve and configured to anchor the sleeve to tissue by being driven through the circumferential wall and into the tissue.

[0014] In an application, the at least one second sleeve-end-portion tissue anchor are configured to anchor the second sleeve-end-portion at a portion of the second sleeve-end-portion containing the second end portion or second wire-end portion of the member/wire that is disposed within the lumen of the sleeve.

[0015] In an application, the member/wire extends from the first sleeve-end-portion to the second sleeve-end-portion in association with the circumferential wall, by weaving along the circumferential wall between the first sleeve-end-portion and the second sleeve-end-portion.

[0016] In an application, the second end portion or second wire-end portion of the member/wire enters the lumen of the sleeve such that it is disposed within the second sleeve-end-portion at an entry point, and the at least one second sleeve-end-portion tissue anchor is anchorable proximally to the entry point.

[0017] In an application, the second end or second wire-end is disposed within the lumen of the sleeve, and the member/wire is arranged with respect to the sleeve such that movement of the second end or second wire-end toward the second sleeve-end-portion increases the longitudinal proportion of the member/wire that is disposed within the lumen of the sleeve by drawing the member/wire into the lumen of the sleeve.

[0018] In an application, the member/wire extends from the first sleeve-end-portion to the second sleeve-end-portion in association with the circumferential wall, by weaving along the circumferential wall between the first sleeve-end-portion and the second sleeve-end-portion.

[0019] In an application, the system/apparatus further includes an anchor-delivery tool including an anchor-delivery channel and an anchor driver slidable within the anchor delivery channel.

[0020] In an application, the system/apparatus further includes coupling elements coupled to a distal end of the anchor-delivery tool, and the coupling elements are configured to ensnare a proximal end of the sleeve and have a tendency to flex inwardly toward a central longitudinal axis of the anchor-delivery tool in an absence of force applied thereto.

[0021] In an application, the channel is configured to (a) maintain coupling of the coupling elements to the sleeve by pushing against the coupling elements sleeve of the annuloplasty

structure, and (b) facilitate decoupling of the anchor-delivery tool from the annuloplasty structure by being removed from the lumen of the sleeve and allowing the coupling elements to flex inwardly and become decoupled from the sleeve.

[0022] In an application:

each anchor of the plurality of tissue anchors:

including an anchor head and a tissue-engaging element,

being independently advanceable into the lumen of the sleeve by the anchor driver, and

being configured to anchor the sleeve to tissue by the tissue-engaging element being driven through the circumferential wall and into the tissue while the anchor head remains in the lumen of the sleeve; and

the anchor driver is removable from within a lumen of the channel following anchoring of the sleeve using the plurality of tissue anchors.

[0023] In an application, the system/apparatus further includes a contraction tool that includes a contraction member-engaging element or wire-engaging element, and the engaging element, subsequently to the anchoring of the sleeve using the plurality of tissue anchors:

is movable longitudinally through the lumen of the channel and into the lumen of the sleeve,

includes a snare configured to ensnare the second end of the member or second wire-end of the wire, and

while coupled to the second end or second wire-end, is movable within the lumen of the channel, such that the second end or second wire-end is pulled into the lumen of the channel, thereby drawing the member/wire into the lumen of the sleeve and longitudinally contracting the sleeve.

[0024] In an application, the system/apparatus further includes a loop coupled to the second end of the member or the second wire-end of the wire and disposed within the second sleeve-end-portion, and the loop surrounds an end portion of the channel that is advanceable within the lumen of the sleeve, and the channel is slidable with respect to the loop while the loop remains disposed within the second sleeve-end-portion, in order to facilitate implantation of the plurality of tissue anchors.

[0025] In an application, the snare is configured to ensnare the loop and to pull the loop into the lumen of the channel in order to facilitate application of a contraction force to the

contraction member/wire, and the loop is compressible into the lumen of the channel as the snare pulls the loop and a portion of the contraction member/wire through the lumen of the channel.

[0026] In an application, the system/apparatus further includes a closure mechanism at the second sleeve-end-portion, the closure mechanism being maintainable in an opened state while the channel passes through the closure mechanism.

[0027] In an application, the channel is slidable with respect to the loop to and to the closure mechanism in order to facilitate implantation of the plurality of tissue anchors.

[0028] In an application, the system/apparatus further includes a contraction tool that includes a contraction member-engaging element or wire-engaging element, and the engaging element:

is movable longitudinally into the lumen of the sleeve and through the lumen of the sleeve toward the second wire-end,

is reversibly couplable to the second end or second wire-end, and

while coupled to the second end or second wire-end, is movable longitudinally toward the first sleeve-end-portion, such that the second end or second wire-end is moved toward the first sleeve-end-portion, thereby drawing the member/wire into the lumen and longitudinally contracting the sleeve.

[0029] In an application, the system/apparatus further includes a locking mechanism that has:

an unlocked state in which the locking mechanism allows movement of the member/wire through the locking mechanism, and increasing of the longitudinal proportion of the member/wire that is disposed within the lumen of the sleeve, and

a locked state in which the locking mechanism inhibits movement of the member/wire through the locking mechanism.

[0030] In an application, the locking mechanism is positionable inside the lumen of the sleeve.

[0031] In an application, the system/apparatus further includes a contraction tool that includes a contraction member-engaging element or wire-engaging element, and:

the engaging element:

is movable longitudinally into the lumen of the sleeve and through the lumen of the sleeve toward the second end or second wire-end,

is reversibly couplable, within the lumen of the sleeve, to the second end or second wire-end, and

while coupled to the second end or second wire-end, is movable longitudinally toward the second sleeve-end-portion, such that the second end or second wire-end is moved toward the second sleeve-end-portion, thereby drawing the member/wire into the lumen of the sleeve and longitudinally contracting the sleeve, and

the locking mechanism:

is coupled to the contraction tool, and

is advanceable, using the contraction tool, longitudinally through the lumen of the sleeve toward the second sleeve-end-portion and the member/wire.

[0032] In an application, the system/apparatus further includes a lock tool that engages the locking mechanism and is configured to transition the locking mechanism into the locked state.

[0033] In an application, the locking mechanism is biased to assume the locked state, the lock tool is configured to retain the locking mechanism in the unlocked state while the lock tool is engaged with the locking mechanism, and the lock tool is configured to transition the locking mechanism into the locked state by disengaging from the locking mechanism.

[0034] There is further provided, in accordance with some applications, a method, including using a delivery tool, securing an annuloplasty structure on an annulus of a valve of a subject. The annuloplasty structure can be the same as or similar to other annuloplasty structures herein or otherwise known. In some applications, for example, the annuloplasty structure includes (i) a flexible sleeve that defines a longitudinal lumen therethrough, and (ii) an elongate contraction member (e.g., a contraction wire, etc.).

[0035] The method further includes, subsequently, while the delivery tool is coupled to the annuloplasty structure, longitudinally contracting the sleeve. The sleeve can be contracted in a variety of ways. In some applications, the sleeve is contracted by increasing a longitudinal proportion of the contraction member/wire that is disposed within the lumen or causing the contraction member/wire to enter the lumen, e.g., by drawing the contraction member/wire into the lumen.

[0036] In an application, the delivery tool is coupled to the annuloplasty structure at a proximal end thereof, and longitudinally contracting includes longitudinally pulling the contraction member/wire proximally.

[0037] In an application, the sleeve includes a circumferential wall that defines the lumen, and securing the annuloplasty structure on the annulus includes sequentially, for each anchor of a plurality of anchors:

advancing the anchor into the lumen of the sleeve, and

driving a tissue-engaging element of the anchor through the circumferential wall and into the annulus, such that an anchor head of the anchor remains in the lumen of the sleeve.

[0038] In an application, the method further includes, subsequently to the step of longitudinally contracting the sleeve, maintaining a contraction state of the sleeve by locking a locking mechanism to the contraction member/wire.

[0039] In an application, locking the locking mechanism includes locking the locking mechanism while maintaining coupling of the delivery tool to the annuloplasty structure.

[0040] In an application, the method further includes, prior to the locking, delivering a force-distributing element within the lumen of the sleeve and facilitating distributing of contraction forces along the annuloplasty structure using the force-distributing element.

[0041] In an application, securing the annuloplasty structure includes implanting a plurality of tissue anchors, and delivering the force-distributing element includes distributing the contraction forces along a subset of the plurality of tissue anchors.

[0042] In an application, locking the locking mechanism includes locking in place the force-distributing element.

[0043] In an application, the contraction member/wire is coupled to a loop and the loop surrounds a portion of the delivery tool during the securing of the annuloplasty structure on the annulus.

[0044] In an application, longitudinally contracting includes:

retracting the portion of the delivery tool until the loop does not surround the portion of the delivery tool,

ensnaring the loop; and

subsequently, longitudinally pulling the contraction member/wire by pulling the loop.

[0045] In an application, securing the annuloplasty structure on the annulus includes:

advancing the portion of the delivery tool through the lumen of the sleeve while the loop surrounds the portion of the delivery tool,

delivering a plurality of tissue anchors through the portion of the delivery tool; and

using the delivery tool, while the loop surrounds the portion of the delivery tool, anchoring the annuloplasty structure to the annulus by driving each one of the plurality of tissue anchors through respective portions of the sleeve and into tissue of the annulus.

[0046] In an application, advancing the portion of the delivery tool through the lumen of the sleeve includes moving the portion of the delivery tool with respect to the loop, while the loop remains stationary.

[0047] In an application, advancing the portion of the delivery tool through the lumen of the sleeve includes advancing the portion of the delivery tool distally through the lumen, and driving each one of the plurality of tissue anchors through the respective portions of the sleeve includes retracting the portion of the delivery tool proximally with each successive driving.

[0048] In an application, a portion of the delivery tool slides within the lumen of the sleeve, and the method further includes maintaining coupling of the delivery tool to annuloplasty structure by maintaining the portion of the delivery tool within the lumen.

[0049] In an application, maintaining the coupling of the delivery tool includes pushing outwardly coupling elements of the delivery tool that are coupled to the sleeve of the annuloplasty structure, and the method further includes decoupling the delivery tool from the annuloplasty structure by removing the portion of the delivery tool from within the lumen and allowing the coupling elements to flex inwardly and disengage from the sleeve of the annuloplasty structure.

[0050] In an application, maintaining the coupling of the delivery tool includes maintaining a closure mechanism of the annuloplasty structure in an open state by maintaining the portion of delivery tool within the lumen.

[0051] In an application, the method further includes decoupling the delivery tool from the annuloplasty structure by removing the portion of the delivery tool from within the lumen and transitioning the closure mechanism to a closed state.

[0052] This method can be performed on a living animal or on a simulation, such as on a cadaver, cadaver heart, simulator (e.g. with the body parts, tissue, etc. being simulated), etc.

[0053] There is further provided, in accordance with some applications, a system and/or an apparatus for use at a heart of a subject, the system/apparatus including an annuloplasty structure that includes a flexible sleeve having a first sleeve-end-portion, a second sleeve-end-portion, and a circumferential wall that defines a longitudinal lumen between the first and second sleeve-end-portions. The annuloplasty structure also includes an elongate contraction

member/wire having a first end (e.g., a first wire-end) and a second end (e.g., a second wire-end). The first end or first wire-end can be attached to the sleeve at the first sleeve-end-portion with the member/wire extending, in association with the circumferential wall, from the first sleeve-end-portion toward the second sleeve-end-portion.

[0054] In some applications, the system/apparatus also includes a plurality of tissue anchors configured to anchor the sleeve to tissue. The plurality of tissue anchors can include at least one second sleeve-end-portion tissue anchor configured to anchor the second sleeve-end-portion to tissue by being driven through the circumferential wall and into the tissue.

[0055] In some applications, the system/apparatus also includes an anchor-delivery tool including an anchor-delivery channel and an anchor driver slidable within the anchor delivery channel.

[0056] In some applications a loop is coupled to the second end of the member or the second wire-end of the wire and disposed within the second sleeve-end-portion. The loop can surround an end portion of the channel that is advanceable within the lumen of the sleeve, the channel being slidable with respect to the loop while the loop remains disposed within the second sleeve-end-portion, in order to facilitate implantation of the plurality of tissue anchors.

[0057] In some applications, the member/wire is arranged with respect to the sleeve such that increasing a longitudinal proportion of the member/wire that is disposed within the lumen, or causing the member/wire to enter the lumen, longitudinally contracts the sleeve.

[0058] In an application, the system/apparatus further includes coupling elements coupled to a distal end of the anchor-delivery tool, and the coupling elements are configured to ensnare a proximal end of the sleeve and have a tendency to flex inwardly toward a central longitudinal axis of the anchor-delivery tool in an absence of force applied thereto.

[0059] In an application, the channel is configured to (a) maintain coupling of the coupling elements to the sleeve by pushing against the coupling elements sleeve of the annuloplasty structure, and (b) facilitate decoupling of the anchor-delivery tool from the annuloplasty structure by being removed from the lumen of the sleeve and allowing the coupling elements to flex inwardly and become decoupled from the sleeve.

[0060] In an application:

each anchor of the plurality of tissue anchors:

including an anchor head and a tissue-engaging element,

being independently advanceable into the lumen of the sleeve by the anchor driver, and

being configured to anchor the sleeve to tissue by the tissue-engaging element being driven through the circumferential wall and into the tissue while the anchor head remains in the lumen of the sleeve; and

the anchor driver is removable from within a lumen of the channel following anchoring of the sleeve using the plurality of tissue anchors.

[0061] In an application, the system/apparatus further includes a contraction tool that includes a contraction member-engaging element or wire-engaging element, and the engaging element, subsequently to the anchoring of the sleeve using the plurality of tissue anchors:

is movable longitudinally through the lumen of the channel and into the lumen of the sleeve,

includes a snare configured to ensnare the second end of the member or the second wire-end of the wire, and

while coupled to the second end or second wire-end, is movable within the lumen of the channel, such that the second end or second wire-end is pulled into the lumen of the channel, thereby drawing the member/wire into the lumen of the sleeve and longitudinally contracting the sleeve.

[0062] In an application, the snare is configured to ensnare the loop and to pull the loop into the lumen of the channel in order to facilitate application of a contraction force to the contraction member/wire, and the loop is compressible into the lumen of the channel as the snare pulls the loop and a portion of the contraction member/wire through the lumen of the channel.

[0063] In an application, the system/apparatus further includes a closure mechanism at the second sleeve-end-portion, the closure mechanism being maintainable in an opened state while the channel passes through the closure mechanism.

[0064] In an application, the channel is slidable with respect to the loop to and to the closure mechanism in order to facilitate implantation of the plurality of tissue anchors.

[0065] Other features and components and steps described elsewhere herein can also be used with and/or added to the systems, apparatuses, and methods described above. And the methods herein can be performed on a living animal or on a simulation, such as on a cadaver, cadaver heart, simulator (e.g. with the body parts, tissue, etc. being simulated), etc.

[0066] The present invention will be more fully understood from the following detailed description of applications thereof, taken together with the drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

[0067] Figs. 1A-E are schematic illustrations of an example annuloplasty system for treating a native heart valve; and

[0068] Figs. 2A-F are schematic illustrations of an example annuloplasty system for treating the native heart valve.

DETAILED DESCRIPTION OF EMBODIMENTS

[0069] Reference is made to Figs. 1A-E, which are schematic illustrations of an example annuloplasty system 20 that comprises an implant 22. System 20 is for treating a native valve 10 (e.g., an atrioventricular valve, such as the mitral valve or the tricuspid valve) of a heart 4 of a subject. Any and all of the methods, techniques, steps, etc. described herein using system 20 can be performed on a living animal or on a non-living cadaver, cadaver heart, simulator, anthropomorphic ghost, etc.

[0070] Implant 22 comprises an implant body 24, which can be an annuloplasty structure, such as an annuloplasty band or an annuloplasty ring. Implant body 24 comprises a flexible sleeve 25. Sleeve 25 has a first sleeve-end (i.e., a proximal end of sleeve 25), a first sleeve-end-portion 42 (i.e., a proximal end portion of sleeve 25), a second sleeve-end (i.e., a distal end of sleeve 25), a second sleeve-end-portion 44 (i.e., a distal end portion of sleeve 25), and a circumferential wall 46. It is to be noted that in the context of the specification and claims the term "distal" refers to any part of systems described herein that is further from a point of entry into the body of the subject, and the term "proximal" refers to any part of systems described herein that is closer to a point of entry into the body of the subject.

[0071] Circumferential wall 46 defines a longitudinal lumen 48 between the first and second sleeve-ends. Circumferential wall 46 can be made of a fabric, such as a polyethylene terephthalate fabric, e.g., Dacron (TM). Implant 22 further comprises an elongate contraction member or contraction wire 26. It is to be noted that the term "wire" is not intended to limit wire 26 to being metallic, nor to limit the number of strands that it may comprise. For some applications, the contraction member or contraction wire comprises one or more strands of metal. For some applications, the contraction member or contraction wire 26 comprises one or more strands of polymer. For some applications, contraction member or contraction wire 26 is braided

or woven. For some applications, contraction member or contraction wire 26 is coated with a low-friction coating, such as polytetrafluoroethylene (PTFE).

[0072] Implant body 24 can be configured to be placed partially (e.g., 50%, 60%, 70%, 80%, 90%, 50-99%, etc.) or completely around an annulus of valve 10. Implant body 24 can be attached to tissue (e.g., tissue of a heart valve annulus, etc.) in a variety of ways, such as with anchors, sutures, clips, and/or other attachment means. In some embodiments, the implant body 24 is configured to be anchored in place using a plurality of (e.g., 5-20) tissue anchors 32. In one embodiment, each tissue anchor comprises a tissue-coupling element 34, and a tool-engaging head 36 fastened to an end of the tissue-coupling element. In some embodiments, following introduction of implant body 24 into the subject, each anchor 32 is sequentially (and typically independently) intracorporeally delivered into the lumen of the sleeve, and its tissue-coupling element 34 is driven through the circumferential wall and into tissue of the valve annulus, thereby anchoring the sleeve to the valve annulus. Subsequent to attachment to the tissue, longitudinal contraction of implant body 24 circumferentially tightens the valve annulus, thereby improving coaptation of the valve leaflets, and reducing regurgitation. Tissue anchors 32 can also be shaped differently, such as disclosed in PCT application publication WO 2012/176195 to Gross, which is incorporated herein by reference or as otherwise known in the art.

[0073] For some applications, flexible sleeve 25 comprises a plurality of radiopaque markers 12, which are positioned along the sleeve at respective longitudinal sites. The markers may provide an indication in a radiographic image (such as a fluoroscopy image) of how much of the sleeve has been deployed at any given point during an implantation procedure, in order to enable setting a desired distance between anchors 32 along the sleeve. For some applications, the markers comprise a radiopaque ink.

[0074] For some applications, the annuloplasty structure of implant body 24 is, or shares features with, mutatis mutandis, the annuloplasty structure(s) described in one or more of the following publications, which are incorporated herein by reference. For some applications, implant 22 is implanted as described in one or more of these publications, mutatis mutandis:

PCT application publication WO 2010/128503 to Zipory et al.

PCT application publication WO 2012/176195 to Gross et al.

PCT application publication WO 2013/069019 to Sheps et al.

PCT application publication WO 2014/064694 to Sheps et al.

[0075] Contraction member/wire 26 has a first end or a first wire-end 52 (i.e., a proximal end or a proximal wire-end 52) and a second end or a second wire-end 54 (i.e., a distal end or a distal wire-end 52). In some embodiments, first end or first wire-end 52 is attached (e.g., fixedly attached) to sleeve 25 at first sleeve-end-portion 42, and member/wire 26 extends, in association with the circumferential wall of the sleeve, from the first sleeve-end-portion 42 to second sleeve-end-portion 44. In some embodiments, and as shown, the association between member/wire 26 and circumferential wall 46 is provided by the member/wire being woven along or as part of the circumferential wall between first sleeve-end-portion 42 and second sleeve-end-portion 44.

[0076] As shown, first and second sleeve-end-portions 42 and 44 can include more than just the very ends of sleeve 25, i.e. the first and second sleeve-ends. Similarly, member/wire 26 may not extend all the way to the ends of sleeve 25. As shown, at least one anchor 32 can be placed within at least one of first and second sleeve-end-portions 42 and 44, beyond member/wire 26. First end or first wire-end 52 being attached to sleeve 25 at first sleeve-end-portion 42 means that first end or first wire-end 52 is attached to sleeve 25 at an attachment point. First sleeve-end-portion 42 extends between the attachment point and the first sleeve-end. Member/wire 26 extends from the attachment point of first sleeve-end-portion 42 to an entry point of sleeve 25. Second sleeve-end-portion 44 extends between the entry point and the second sleeve-end.

[0077] As described in more detail hereinbelow, member/wire 26 is arranged with respect to sleeve 25 such that pulling (e.g., proximal pulling from a location proximal to implant 22 in a proximal direction) a longitudinal proportion of the member/wire into the lumen (through the entry point at second sleeve-end-portion 44) and/or increasing the amount that is disposed within the lumen longitudinally contracts the sleeve. Optionally, second end or second wire-end 54 of the member/wire 26 can be positioned inside the lumen.

[0078] Fig. 1A schematically shows implant 22 following its implantation at valve 10, with the tissue-coupling element 34 of each anchor 32 extending through the circumferential wall of sleeve 25 and into the annulus of the valve. Tool-engaging head 36 is located within lumen 48 of sleeve 25. For the sake of clarity, the tissue into which tissue-coupling elements 34 penetrate is not shown. As shown, second end or second wire-end 54 can be disposed within the lumen of sleeve 25 prior to and/or during implantation, or can be disposed outside the lumen but be pullable into the lumen. For some applications, and as shown, system 20 further comprises an elongate guide member 28, reversibly coupled to second end or second wire-end 54, and extending

proximally though the lumen of sleeve 25, and proximally away from implant 22 (e.g., out of the subject).

[0079] Following implantation of implant 22, a contraction tool 60 is used to facilitate contraction of the implant. Contraction tool 60 comprises a contraction member-engaging element or wire-engaging element 62, which is movable longitudinally into lumen 48 (e.g., over guide member 28), and through the lumen to second end or second wire-end 54. Such movement is shown in Fig. 1B. For applications in which implant body 24 is anchored using anchors 32, tool 60 is dimensioned to be advanceable through lumen 48 past anchor heads 36 already disposed within the lumen.

[0080] Engaging element 62 is reversibly couplable, e.g., within lumen 48, to second end or second wire-end 54. Such coupling is shown in Fig. 1C. Implant 22 can comprise an appendage 55 coupled to second end or second wire-end 54 of contraction member/wire 26. Engaging element 62 and appendage 55 are mutually configured to facilitate the reversible coupling of the engaging element to the second end or second wire-end of the contraction member/wire. While coupled to second end or second wire-end 54, engaging element 62 is movable longitudinally toward first sleeve-end-portion 42 (e.g., by being pulled proximally), such that the second end or second wire-end 54 is moved toward the first sleeve-end-portion, thereby drawing contraction member/wire 26 into lumen 48, and longitudinally contracting sleeve 25 (Fig. 1D).

[0081] System 20 further comprises a locking mechanism 70, coupled to contraction tool 60, and advanceable, using the contraction tool, longitudinally through lumen 48 (e.g., over guide member 28) toward second sleeve-end-portion 44 and second end or second wire-end 54 of contraction member/wire 26 (e.g., as shown in Figs. 1B-C). In some embodiments, locking mechanism 70 has (i) an unlocked state in which the locking mechanism allows movement of contraction member/wire 26 through the locking mechanism, and increasing of the longitudinal proportion of the member/wire that is disposed within the lumen, and (ii) a locked state in which the locking mechanism inhibits movement of the member/wire through the locking mechanism.

[0082] Once a desired amount of contraction of sleeve 25 has been achieved by drawing contraction member/wire 26 into lumen 48 (and through locking mechanism 70), locking mechanism 70 is locked, e.g., using tool 60, which thereby also serves as a lock tool 64 that engages locking mechanism 70 within lumen 48. The locking of locking mechanism 70 inhibits the contraction member/wire from moving back out of the lumen, and therefore maintains the

desired amount of contraction of the sleeve. For example, locking mechanism 70, locked to contraction member/wire 26, may be too large to exit lumen 48 via the entry point or hole through which member/wire 26 entered the lumen at second sleeve-end-portion 44. Though optionally, locking mechanism 70 can be configured to be attached to an inner wall of sleeve 25.

[0083] Tool 60 can then be decoupled from member/wire 26 and removed from implant 22 (Fig. 1E). For applications in which system 20 comprises guide member 28, the guide member is also decoupled from implant 22, e.g., facilitated by tool 60.

[0084] It is to be noted that the resulting excess 56 of member/wire 26 (i.e., the part of the member/wire that has passed through locking mechanism 70 and does not serve to maintain the contraction of sleeve 25, e.g., the part of the member/wire that is not under tension) is disposed within lumen 48. The inventors hypothesize that this, in contrast to a hypothetical similar implant in which the excess of the contraction member/wire is disposed outside of sleeve 25, advantageously does not require removal of the excess of the contraction member/wire (e.g., by cutting).

[0085] Reference is now made to Figs. 2A-F, which are schematic illustrations of an annuloplasty system 120 for treating native valve 10, in accordance with some applications. System 120 comprises an implantable annuloplasty structure 122, which comprises implant body 24 (comprising flexible sleeve 25) and contraction member/wire 26, e.g., as described hereinabove, mutatis mutandis. Typically, except where noted, structure 122 and the implantation thereof are as described hereinabove for implant 22 and its implantation, mutatis mutandis.

[0086] As described for implant 22, member/wire 26 of structure 122 can be arranged with respect to sleeve 25 such that pulling member/wire 26 into the lumen and/or increasing a longitudinal proportion of the member/wire that is disposed within the lumen longitudinally contracts the sleeve.

[0087] Figs. 2A-F show system 120 not comprising a guide member such as guide member 28, described hereinabove. Optionally, in some embodiments, system 120 may in fact comprise a guide member, and/or system 20 may not comprise a guide member.

[0088] Contraction member/wire 26 has a first end or first wire-end 52 (i.e., a distal end or distal wire-end of member/wire 26), and a second end or second wire-end 54 (i.e., a proximal end or proximal wire-end of member/wire 26). In some embodiments, first end or first wire-end 52 is attached (e.g., fixedly attached) to sleeve 25 at first sleeve-end-portion 42 (i.e., a distal end portion

of sleeve 25), and member/wire 26 extends, in association with circumferential wall 46 of the sleeve, from the first sleeve-end-portion 42 toward second sleeve-end-portion 44 (i.e., a proximal end portion of sleeve 25). First end or first wire-end 52 being attached to sleeve 25 at first sleeve-end-portion 42 means that first end or first wire-end 52 is attached to sleeve 25 at an attachment point. First sleeve-end-portion 42 extends between the attachment point and a first sleeve-end (i.e., a distal end of sleeve 25). Member/wire 26 extends from the attachment point at first sleeve-end-portion 42 to an entry point 51 of sleeve 25. Second sleeve-end-portion 44 extends between entry point 51 and a second sleeve-end (i.e., a proximal end of sleeve 25). In some embodiments, and as shown, the association between member/wire 26 and circumferential wall 46 is provided by the member/wire being woven along or as part of the circumferential wall between first sleeve-end-portion 42 and second sleeve-end-portion 44.

[0089] First end or first wire-end 52 is attached to sleeve 25 at the attachment point generally in a vicinity that is 0-25 mm from the first sleeve-end. That is, one or two anchors 32 are implanted between first end or first wire-end 52 and the first sleeve-end at first sleeve-end-portion 42. In such a manner, the forces applied to contraction member/wire 26 are distributed between the anchors 32 at portion 42. Member/wire 26 extends along body 24 until member/wire 26 enters lumen 48 of sleeve 25 at entry point 51 and a proximal end portion 57 of member/wire 26 is disposed within lumen 48 between entry point 51 and the second sleeve-end at second sleeve-end-portion 44. Second end or second wire-end 54 of the member/wire 26 can be positioned inside the lumen. Second end or second wire-end 54 is provided with a loop 59. In one embodiment, proximal end portion 57 of member/wire 26 forms a loop 59 and is secured to itself using a fastener 53. In another embodiment, loop 59 is coupled to second end or second wire-end 54. Entry point 51 is generally in a vicinity that is 0-35 mm from the second sleeve-end at second sleeve-end-portion 44.

[0090] Anchors 32 are used to secure annuloplasty structure 122 to tissue of an annulus of a heart valve of the subject. System 120 is for treating a native valve (e.g., an atrioventricular valve, such as the mitral valve or the tricuspid valve) of the heart of the subject. Any and all of the methods, techniques, steps, etc. described herein using system 120 can be performed on a living animal or on a non-living cadaver, cadaver heart, simulator, anthropomorphic ghost, etc.

[0091] As shown, first and second sleeve-end-portions 42 and 44 can include more than just the very ends of sleeve 25, i.e., the first and second sleeve-ends. Similarly, member/wire 26

may not extend all the way to the ends of sleeve 25. As shown, at least one anchor 32 can be placed within at least one of first and second sleeve-end-portions 42 and 44, beyond member/wire 26.

[0092] As described in more detail hereinbelow, member/wire 26 is arranged with respect to sleeve 25 such that pulling (e.g., proximal pulling from a location proximal to structure 122 in a proximal direction) a longitudinal proportion of the member/wire into the lumen and/or increasing the amount that is disposed within the lumen longitudinally contracts the sleeve.

[0093] System 120 comprises an implant-structure-delivery tool 110 and an anchor-delivery tool comprising an anchor driver 17 and a channel or tube 18 (e.g., an anchor-delivery channel, anchor-delivery tube, etc.) which houses anchor driver 17 (Fig. 2A). Anchor driver 17 is slidable within tube/channel 18. For some applications, implant-structure-delivery tool 110 comprises the anchor-delivery tool and a reference-force tube 15. Though optionally, implant-structure-delivery tool 110 and the anchor-delivery tool can be separate devices which can be delivered, introduced and manipulated independently. A distal end 19 of anchor-delivery tube/channel 18 can be introduced into and disposed within lumen 48 of sleeve 25 of structure 122. Tube/channel 18 can slide through and with respect to loop 59 in order to facilitate delivery of anchors 32. As shown, the distal end 19 of anchor-delivery tube/channel 18 begins closest to first sleeve-end-portion 42 and deploys a first anchor 32 through wall 46 of sleeve 25. As each subsequent anchor 32 is delivered, anchor-delivery tube 18 is retracted proximally toward second sleeve-end-portion 44 by sliding with respect to loop 59 while loop 59 remains in place and generally stationary. Techniques for implanting structure 122 and anchoring structure 122 to tissue using anchors 32 may be practiced in combinations with techniques as described in PCT Publication WO 14/064694 to Sheps, which is incorporated herein by reference.

[0094] A force is applied to the second sleeve-end-portion 44 by a distal end of reference-force tube 15 of implant-delivery tool 110 used to deliver structure 122. As shown, anchor-delivery tube 18 is advanceable within a lumen of reference-force tube 15 and through lumen 48 of sleeve 25 such that a portion of anchor-delivery tube 18 that is disposed within the sleeve is coaxial with the sleeve. Distal end 19 of anchor-delivery tube 18 is disposed in contact with an inner wall of sleeve 25 at a distal end thereof. Additionally, a distal end portion of anchor-delivery tube 18 may comprise one or more radiopaque markers. As shown, anchor-delivery tube 18 and sleeve 25 are longitudinally and coaxially disposed with respect to each other.

[0095] In some embodiments, structure 122 comprises a closure mechanism 220 at second sleeve-end-portion 44 for closing an opening at second sleeve-end-portion portion 44 of sleeve 25. Optionally, second sleeve-end-portion 44 may be left open when structure 122 is implanted, or may be closed as described in PCT application publication WO 2012/176195 to Gross, which is incorporated herein by reference. Closure mechanism 220 is coupled to sleeve 25 such as by being sutured to sleeve 25 using one or more sutures. Closure mechanism 220 comprises a flap 230 (e.g., a door) that has an open state and a closed state (e.g., as shown in Fig. 2F), and is configured to be biased toward assuming the closed state, such as described in PCT application publication WO 2014/064694 to Sheps, which is incorporated herein by reference. When flap 230 is in the closed state, the lumen of sleeve 25 is in reduced communication with outside of the sleeve compared to when the flap is in the open state. In some applications, closure mechanism comprises a frame 222 to which flap 230 is articulatably coupled at an articulation point, and flap 230 is elastically biased toward assuming the closed state, e.g., by the frame, the articulation point, and the flap comprising a continuous piece of shape-memory material such as nitinol. In some applications, frame 222 is generally cylindrical, which reinforces the proximal end of sleeve 25. For some applications, closure mechanism 220 comprises (e.g., is coated with) an anti-thrombotic agent.

[0096] When a portion of anchor-delivery tube 18 is disposed within lumen 48 of sleeve 25, flap 230 is held in the open state. Anchor-delivery tube 18 thereby provides a working channel between outside the body of the subject, and lumen 48 of sleeve 25, such as for delivery of anchors 32, as described hereinabove. When anchor-delivery tube 18 is removed from lumen 48 (e.g., slid out of a proximal opening of the sleeve), flap 230 automatically moves toward the closed state.

[0097] Sleeve 25 can be reversibly couplable to reference-force tube 15 via one or more coupling elements 224 (e.g., sleeve-coupling elements) which are coupled to a distal end of the reference-force tube, such as described in PCT application publication WO 2014/064694 to Sheps, which is incorporated herein by reference. Each coupling element 224 is shaped to define a distal projection, which is configured to be disposed within a respective negative space, such as a recess or a hole (not shown) in frame 222, thereby coupling the coupling element to closure mechanism 220, and thereby to sleeve 25. Frame 222 can be generally cylindrical, and the hole can be defined in a lateral portion of the cylindrical shape. Coupling elements 224 can be configured to have a natural tendency (e.g., to be biased) to flex inwardly toward a central longitudinal axis of tube 15.

[0098] That is, when anchor-delivery tube 18 is slid through lumen 48 in order to anchor tissue anchors 32 to tissue of the subject, anchor-delivery tube 18 (1) slides with respect to loop 59, (2) slides with respect to frame 222 of closure mechanism 220 in order to maintain flap 230 in an open state, and (3) maintains coupling of implant-delivery tool 110 comprising tube 15.

[0099] When coupling elements 224 are coupled to closure mechanism 220 and distal end 19 of anchor-delivery tube 18 is disposed within lumen 48 of sleeve 25 and distal to closure mechanism 220, anchor-delivery tube 18 inhibits the coupling elements from decoupling from frame 222 of closure mechanism 220. When distal end 19 of anchor-delivery tube 18 is slid proximally past closure mechanism 220 (and proximally past coupling elements 224), the coupling elements automatically decouple from frame 222 of closure mechanism 220 by flexing inwardly toward the central longitudinal axis of tube 15, thereby allowing tube 15 to become decoupled from sleeve 25. Reference-force tube 15 may then be withdrawn proximally from sleeve 25.

[0100] Thereby, in some applications, system 120 facilitates:

(1) when distal end 19 of anchor-delivery tube 18 is disposed within the lumen of sleeve 25 of implant structure 122 (a) coupling of reference-force tube 15 to sleeve 25, and (b) fluid communication between a proximal end of anchor-delivery tube 18 (e.g., a proximal end of the lumen thereof) and the lumen of the sleeve, and

(2) when the distal end of anchor-delivery tube 18 is withdrawn past closure mechanism 220 (e.g., withdrawn from the lumen of the sleeve), (a) automatic closure of second sleeve-end-portion 44 of sleeve 25 of implant structure 122, and (b) automatic decoupling of reference-force tube 15 from the sleeve of the implant structure.

[0101] Techniques for using anchor-delivery tube 18 and closure mechanism 220 can be practiced in combinations with techniques as described in PCT Publication WO 14/064694 to Sheps, which is incorporated herein by reference.

[0102] Fig. 2A schematically shows structure 122 following its initial implantation at the mitral valve, in which the first three tissue anchors 32 are used to anchor structure 122 to the tissue of the annulus. Tissue-coupling element 34 of each anchor 32 extends through circumferential wall 46 of sleeve 25 and into the annulus of the valve while tool-engaging head 36 of each anchor 32 is located (remains) within the lumen 48 of structure 122. For the sake of clarity, the tissue into which tissue-coupling elements 34 penetrate is not shown.

[0103] In some embodiments, as shown, second end or second wire-end 54 is disposed within the lumen of sleeve 25 prior to and/or during implantation.

[0104] Anchor-delivery tube 18 is used to facilitate delivery of anchor 32. After each anchor 32 is delivered, anchor-delivery tube 18 is retracted proximally, i.e., toward second sleeve-end-portion 44 of sleeve 25. During implantation of anchors 32, loop 59 surrounds a portion of anchor-delivery tube 18. As each subsequent anchor 32 is delivered, anchor-delivery tube 18 is retracted toward second sleeve-end-portion 44 by sliding with respect to loop 59 while loop 59 remains in place and generally stationary. Anchors 32 are implanted using techniques described, for example, with reference to Figs. 10A-I of PCT Publication WO 14/064694 to Sheps, which is incorporated herein by reference.

[0105] Fig. 2B shows structure 122 following implantation thereof. A plurality of anchors 32 is used to anchor structure 122 to the tissue. It is to be noted that the plurality of tissue anchors 32 comprises at least one second sleeve-end-portion tissue anchor 132, e.g., two anchors 132 as shown. It is to be noted that any suitable number of second sleeve-end-portion tissue anchors 132 can be implanted, e.g., between 1 and 4 by way of illustration and not limitation. In some implementations, second sleeve-end-portion tissue anchors 132 are implanted between entry point 51 of contraction member/wire 26 and the second sleeve-end at second sleeve-end-portion 44. That is, anchors 132 are implanted in a vicinity of proximal end portion 57 of member/wire 26. As is described herein below, second sleeve-end-portion tissue anchors 132 help distribute forces between anchors 132 from entry point 51 toward the second sleeve-end at second sleeve-end-portion 44.

[0106] Reference is now made to Figs. 2B-D. Following implantation of structure 122, a contraction tool is used to facilitate contraction of the implant. The contraction tool passes through anchor-delivery tube 18 and comprises an outer tube 160, an inner tube 162 slidably disposed within outer tube 160, and an engaging element or wire-engaging element 163 slidably disposed within inner tube 162. The contraction tool is movable longitudinally into lumen 48, and through lumen 48 of sleeve 25 toward second end or second wire-end 54 provided with loop 59. In Fig. 2B, loop 59 no longer surrounds anchor-delivery tube 18 because anchor-delivery tube 18 has been retracted toward reference-force tube 15 in order to free loop 59 from around anchor-delivery tube 18. That is, distal end 19 of anchor-delivery tube 18 is disposed proximally to loop 59. Distal end 19 of anchor-delivery tube 18 is still within lumen 48 of sleeve 25 and anchor-delivery tube 18 at

this stage still remains within the opening at second sleeve-end-portion 44 such that an external wall of anchor-delivery tube 18 retains closure mechanism 220 in an opened state.

[0107] Engaging element 163 comprises an elongate member, such as a wire, rod, line, suture, tube, a flat Nitinol wire, etc., and, in some implementations, has a distal end portion folded proximally so as to form a curved portion. Worded differently, engaging element 163 can be folded onto itself to define a hairpin-shaped segment defining a U-shaped bend. In some implementations, the pre-shaped distal end portion of engaging element 163 is biased to assume a closed configuration. The curved portion can be shaped so that the distal end of engaging element 163 flexes inwardly toward a longitudinal axis of inner tube 162. In some implementations, the curved portion is contiguous with a distal portion of engagement element 163 located proximal (in the direction of extension of engaging element 163) the distal end of engaging element 163. In the closed configuration, the distal end of engaging element 163 can be biased toward the distal portion of engaging element 163. Thus, in some implementations, in the closed configuration, the distal end of engaging element 163 is radially closer to the distal portion of engaging element 163 (or to inner tube 162) than in the open configuration.

[0108] Fig. 2B shows the contraction tool transitioning from a delivery configuration, in which the distal end portion of engaging element 163 is in its closed configuration, to a gripping configuration shown in Fig. 2C. With further reference to Fig. 2B, when the contraction tool is in the delivery configuration, the distal end of engaging element 163 is disposed within a lumen of outer tube 160. In particular, a distal end of inner tube 162 is positioned proximal the curved portion and the distal end of engaging element 163 is positioned radially between outer tube 160 and inner tube 162.

[0109] Fig. 2C shows the pre-shaped distal end portion of engaging element 163 fully exposed from within a lumen of outer tube 160. In some implementations, in the gripping configuration of the contraction tool shown in Fig. 2C, outer tube 160 is positioned proximal the distal end of engaging element 163 and inner tube 162 extends into the curved portion (i.e., the U-shaped bend) of the distal end portion of engaging element 163 so as to force the distal end of engaging element 163 to flex outwardly and thereby move the distal end portion of engaging element 163 into the open configuration. In some implementations, in the open position of the distal end portion of engaging element 163, a distance between the distal end of engaging element 163 and an outer surface of inner tube 162 is enough to grip loop 59 so as to facilitate coupling

between contraction tool 160 and loop 59. When inner tube 162 is retracted proximally so as to no longer engage the curved portion, the distal end portion of engaging element 163 moves back into the closed configuration. Outer tube 160 can then be advanced distally to cover at least the distal end of engaging element 163, as shown in Fig. 2B.

[0110] While coupled to second end or second wire-end 54, i.e., by ensnaring loop 59 when the distal end portion of engaging element 163 assumes its closed configuration, the contraction tool is movable longitudinally toward the opening at the second sleeve-end 44 (i.e., by being pulled proximally), such that the second end or second wire-end 54 is moved toward the second sleeve-end, thereby drawing additional portions of contraction member/wire 26 into lumen 48 through entry point 51, and longitudinally contracting sleeve 25 initially (Fig. 2D). Distal end 19 of anchor-delivery tube 18 is still within lumen 48 of sleeve 25 and anchor-delivery tube 18 at this stage still remains within the opening at second sleeve-end-portion 44 such that an external wall of anchor-delivery tube 18 retains closure mechanism 220 in an opened state. It is to be noted that the majority of contraction occurs subsequently to this initial step shown in Fig. 2D, as is described hereinbelow with reference to Figs. 2E-F.

[0111] Loop 59 comprises a super-elastic and flexible material, e.g., nitinol. Pulling on loop 59 when the distal end portion of engagement element 163 is in the closed configuration pulls loop 59 toward distal end 19 of anchor-delivery tube 18. Loop 59 is compressed and constrained by the wall of anchor-delivery tube 18 as it is pulled within the lumen of anchor-delivery tube 18 so as to draw a portion of contraction member/wire 26 within the lumen of anchor-delivery tube 18.

[0112] Reference is now made to Fig. 2E. System 120 comprises a force-distributing-element- and lock-delivering-tool 164 which is advanceable within the lumen of anchor-delivery tube 18 and over the contraction tool. Tool 164 is configured to deliver a force-distributing element 300. Force-distributing element 300 can be coupled to a distal end of tool 164. Though in some implementations, force-distributing element 300 can be positioned distal to tool 164 and pushed through anchor-delivery tube 18 by tool 164. Further, optionally, force-distributing element 300 can be slidable with respect to and out of a lumen of a distal end of tool 164, such as by means of a pusher tube (not shown) slidably disposed within tool 164. Force-distributing element 300 is configured to surround proximal end portion 57 of contraction member/wire 26. Tool 164 and force-distributing element 300 slide around the contraction tool. Once tool 164 and

force-distributing element 300 slide beyond the distal end of the contraction tool, tool 164 and force-distributing element 300 slide directly along a portion of contraction member/wire 26, including portion 57, that is now disposed within a lumen of anchor-delivery tube 18.

[0113] Force-distributing element 300 comprises a flexible structure having a lumen which surrounds contraction member/wire 26 at proximal end portion 57. For some applications, force-distributing element 300 comprises a tubular element having a plurality of slits to increase flexibility of element 300. For some applications, force-distributing element 300 comprises a coiled element. During placement of force-distributing element 300, distal end 19 of anchor-delivery tube 18 is still within lumen 48 of sleeve 25 and anchor-delivery tube 18 at this stage still remains within the opening at second sleeve-end-portion 44 such that an external wall of anchor-delivery tube 18 retains closure mechanism 220 in an opened state.

[0114] Once force-distributing element 300 is fully deployed within lumen 48 of sleeve 25 (as shown in Fig. 2F), contraction of sleeve 25 is performed, e.g., by pulling on the contraction tool which pulls on loop 59 that is ensnared by the distal end portion of engagement element 163, and by pushing against force-distributing element 300, such as by means of tool 164 or, as mentioned above, a pusher tube or other. It is to be noted that "fully deployed" refers to a moment in which a distal end of element 300 reaches a distal end of portion 57 of member/wire 26 such that the distal end of element 300 reaches the inner surface of sleeve 25 at entry point 51. Fig. 2F shows contraction of sleeve 25. Contraction of structure 122 occurs from within lumen 48 as member/wire is being pulled, and also from within delivery tool 110 that houses anchor-delivery tube 18, since contracting member/wire 26 is pulled within a lumen of anchor-delivery tube 18.

[0115] During contraction, force-distributing element 300 distributes contraction forces between second sleeve-end-portion tissue anchors 132 from entry point 51 toward the second sleeve-end. That is, contraction is restricted to the portion of implant body 24 that is between entry point 51 of contraction member/wire and first end or first wire-end 52. During contraction of sleeve 25, distal end 19 of anchor-delivery tube 18 is still within lumen 48 of sleeve 25 and anchor-delivery tube 18 at this stage still remains within the opening at second sleeve-end-portion 44 such that an external wall of anchor-delivery tube 18 retains closure mechanism 220 in an opened state.

[0116] Once a desired amount of contraction of sleeve 25 has been achieved by drawing contraction member/wire 26 into lumen 48 and into the lumen of anchor-delivery tube 18, tool 164 delivers toward a proximal end of element 300 a locking mechanism 170, e.g., a lock, in an

unlocked state, e.g., maintained in the unlocked state by lock tool 164. Locking mechanism 170 is delivered around member/wire 26. For some applications, force-distributing element 300 is delivered together with locking mechanism 170 in its unlocked state. Only once contraction of member/wire 26 has been achieved, locking mechanism 170 is transitioned to the locked state to lock member/wire 26 in place with respect to force-distributing element 300, in order to maintain a contraction state of sleeve 25.

[0117] Locking mechanism 170 has an unlocked state in which locking mechanism 170 allows movement of member/wire 26 through locking mechanism 170 and allows increasing of the longitudinal proportion of member/wire 26 that is disposed within lumen 48 of sleeve 25. Locking mechanism 170 has a locked state in which locking mechanism 170 inhibits movement of member/wire 26 through locking mechanism 170.

[0118] Locking mechanism 170 is locked, e.g., using lock tool 164, such as by disengaging the lock tool from the locking mechanism. For some applications, locking mechanism 170 is biased to assume its locked state, and lock tool 164 is configured to retain the locking mechanism in its unlocked state while the lock tool is engaged with the locking mechanism. For such applications, disengagement of lock tool 164 from locking mechanism 170 allows the locking mechanism to transition into its locked state. Other locking mechanisms and lock tools described herein may also operate in this manner, mutatis mutandis. During the locking of member/wire 26, distal end 19 of anchor-delivery tube 18 is still within lumen 48 of sleeve 25 and anchor-delivery tube 18 at this stage still remains within the opening at second sleeve-end-portion 44 such that an external wall of anchor-delivery tube 18 retains closure mechanism 220 in an opened state. Tool 164 can comprise a cutting element which can sever member/wire 26 once locking mechanism 170 is locked in place.

[0119] Locking mechanism or lock 170 locks in place contraction member/wire 26. The contraction tool (e.g., engaging element 163 thereof) can then be decoupled from member/wire 26 and removed from structure 122 (Fig. 2F). The resulting excess of member/wire 26 is cut in order to avoid this loose portion of the member/wire from moving freely within the heart. In some embodiments, after contraction of structure 122, excess member/wire 26 is removed. For example, the delivery tool 110 can comprise a cutter, or a dedicated cutter can be used – e.g., advanced over and along member/wire 26. Optionally, excess member/wire 26 can be pushed back into lumen

48 of sleeve 25, e.g. by means of the contraction tool or tool 164, and can be enclosed within sleeve 25 in order to avoid this loose portion of member/wire 26 from moving freely within the heart.

[0120] Implant-delivery tool 110 (comprising reference-force tube 15 and channel/tube 18, inter alia) is then decoupled from structure 122 by removing anchor-delivery tube 18 from within lumen 48 of sleeve 25 of structure 122. Removing of anchor-delivery tube 18 from within lumen 48 enables closure mechanism 220 to assume its closed state. In the absence of anchor-delivery tube 18 within frame 222, anchor-delivery tube 18 no longer pushes against coupling elements 224 and coupling elements 224 assume their natural tendency to flex inwardly toward the central longitudinal axis of tube 15. As elements 224 flex inwardly, elements 224 are decoupled from frame 222 of structure 122 and tube 15 is disengaged from structure 122. Additionally, anchor-delivery tube 18 no longer holds open flap 230, if present, and flap 230 assumes the natural tendency toward the closed state. In such embodiments, flap 230 also prevents migration of locking mechanism 170 in an event in which locking mechanism 170 were to be decoupled from member/wire 26. Thus, closure mechanism 220 retains locking mechanism 170 within lumen 48 of structure 122.

[0121] Implant-delivery tool 110 (comprising reference-force tube 15, anchor-delivery tube 18, contraction tool 160, force-distributing-element and lock-delivering tool 164, inter alia) used to deliver structure 122, and excess portions of member/wire 26 extending from loop 59 are extracted from the body of the subject. That is, system 120 advantageously provides a system in which implant-delivery tool 110, remains coupled to structure 122 during contraction of structure 122 and during performing of the annuloplasty on the heart valve of the subject.

[0122] Reference is again made to Figs. 2A-F. It is to be noted that the pulling and contracting of contraction member/wire 26 occurs from second sleeve-end-portion 44, i.e., from a proximal portion of structure 122 and the direction of the pulling and contraction is proximal. That is, contraction of structure 122 occurs at the proximal end of structure 122 and from within lumen 48 of structure 122 while implant-delivery tool 110 is coupled to structure 122. Contraction is performed under the guidance of imaging and multiple contractions of member/wire 26 can be performed responsively to feedback, e.g., tactile, pressure gauge, and imaging.

[0123] Reference is again made to Figs. 1A-2F. For some applications, the locking mechanism of a given system can be replaced with a one-way mechanism such as a ratchet, mutatis mutandis. The one-way mechanism can be coupled to the contraction member/wire, and to the

sleeve at the second sleeve-end-portion, and can be configured to allow one-way movement of the member/wire through the one-way mechanism. The system would be arranged such that the one-way mechanism (i) allows increasing the longitudinal proportion of the member/wire that is disposed within the lumen, and (ii) inhibits reducing the longitudinal proportion of the member/wire that is disposed within the lumen.

[0124] Methods involving the systems and devices herein can include any of the steps described above, e.g., to implant, attach, contract, lock, etc. the systems, devices, components, etc. In some embodiments, methods involve transvascularly (e.g., transfemorally, etc.) advancing the system, device, implant, etc. to a target location, such as a heart valve annulus or simulation of a heart valve annulus. The methods involve attaching the system, device, implant, etc. to the target location (e.g., after advancement as described previously). Attaching can involve anchoring, suturing, clipping, and/or using other attachment means to attach the system, device, implant, etc. to the target location. The methods also involve contracting the system, device, implant, etc., which can be done by pulling or otherwise exerting force on a contraction member/wire (which can be attached, configured, and/or arranged as described in any of the embodiments above) to cause the system, device, implant, etc. to contract (e.g., to a contracted configuration with a smaller length, diameter, and/or radius of curvature). The contracting can be done as described with respect to any of the embodiments above. The methods can also include locking a locking mechanism, lock, locking device, etc. to hold the system, device, implant, etc. in the contracted configuration. The locking mechanism, lock, locking device, etc. can be the same and function and/or be operated in the same way as any of those described above.

[0125] It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly shown and described hereinabove. Rather, the scope of the present invention includes both combinations and subcombinations of the various features described hereinabove, as well as variations and modifications thereof that are not in the prior art, which would occur to persons skilled in the art upon reading the foregoing description. For example, a tool described for use with one of the implants described herein can optionally be used with another of the implants described herein, mutatis mutandis. Similarly, an adjustment mechanism or lock described for use in one of the implants described herein can optionally be used in another of the implants described herein, mutatis mutandis. Further, each of the techniques, methods, operations, steps, etc. described herein can be performed on a living animal or on a non-

living simulation, such as on a cadaver, cadaver heart, simulator (e.g. with the body parts, tissue, etc. being simulated), etc.

CLAIMS

1. A system for use at a heart of a subject, the system comprising an annuloplasty structure that comprises:

a flexible sleeve having a proximal sleeve-end, a distal sleeve-end, and a circumferential wall that defines a longitudinal lumen between the proximal and distal sleeve-ends;

an elongate contraction member having a proximal end and a distal end, wherein the distal end of the contraction member is attached to the sleeve at an attachment point of the sleeve, the attachment point and the distal end of the sleeve defining a distal sleeve-end-portion, and a distal end portion of the contraction member extends, in association with the circumferential wall of the sleeve, from the attachment point toward the proximal sleeve-end and enters the lumen of the sleeve at an entry point of the sleeve so that a proximal end portion of the contraction member extends toward the proximal sleeve-end within the lumen, the entry point and the proximal sleeve-end defining a proximal sleeve-end-portion;

a plurality of tissue anchors configured to extend through the circumferential wall and into tissue of the heart to anchor the sleeve to the tissue, wherein at least one tissue anchor is placed within the proximal sleeve-end-portion; and

a force-distributing element configured to be disposed within the lumen of the sleeve and to surround the proximal end portion of the contraction member such that a distal end of the force-distributing element abuts an inner surface of the circumferential wall of the sleeve at the entry point so as to distribute a force applied to the at least one tissue anchor of the proximal sleeve-end-portion during application of a contraction force to the elongate contraction member,

wherein pulling the proximal end of the contraction member proximally increases a length of the proximal end portion of the contraction member that is disposed within the lumen so as to longitudinally contract the sleeve.

2. The system according to claim 1, wherein the force-distributing element comprises a tube shaped so as to define a plurality of slits, wherein the plurality of slits increases flexibility of the force-distributing element.

3. The system according to claim 1, wherein the force-distributing element comprises a flexible coil.

4. The system according to any one of claims 1 to 3, wherein at least one tissue anchor is placed within the distal sleeve-end-portion.

5. The system according to any one of claims 1 to 4, wherein the contraction member is woven along the circumferential wall between the attachment point and the entry point.

6. The system according to any one of claims 1 to 5, further comprising an anchor-delivery tool comprising an anchor-delivery tube and an anchor driver slidable within the anchor delivery tube and configured to drive the plurality of tissue anchors through the circumferential wall and into the tissue.

7. The system according to claim 6, further comprising an implant-structure-delivery tool comprising a reference-force tube configured to reversibly couple and apply a force to the proximal sleeve-end-portion, wherein the anchor-delivery tube is slidable within the reference-force tube.

8. The system according to claim 7, wherein the reference-force tube comprises coupling elements coupled to a distal end of the reference-force tube and configured to couple to the proximal sleeve-end-portion, wherein the coupling elements are biased to flex inwardly toward a central longitudinal axis of the reference-force tube.

9. The system according to claim 8, wherein the anchor-delivery tube is configured to (a) maintain coupling of the coupling elements of the reference-force tube to the sleeve when inserted into the lumen of the sleeve and pushing against the coupling elements so as to allow the coupling elements to flex outwardly and become coupled to the proximal sleeve-end-portion of the annuloplasty structure, and (b) facilitate decoupling of the reference-force tube from the proximal sleeve-end-portion of the sleeve when removed from the lumen of the sleeve so as to allow the coupling elements to flex inwardly and become decoupled from the sleeve.

10. The system according to any one of claims 6 to 9, wherein each tissue anchor of the plurality of tissue anchors comprises an anchor head and a tissue-engaging element, the tissue-engaging element configured to extend through the circumferential wall and into the tissue, and the anchor head configured to reversibly couple to the anchor driver and to be positioned in the lumen of the sleeve.

11. The system according to any one of claims 1 to 10, wherein a loop is provided at the proximal end of the contraction member, wherein the anchor-delivery tube is slidable with respect to the loop while the loop remains disposed within the proximal sleeve-end-portion.

12. The system according to any one of claims 1 to 11, further comprising a loop provided at the proximal end of the contraction member and a contraction tool comprising an

engaging element, wherein the engaging element comprises a distal portion and distal end portion contiguous with the distal portion, the distal end portion of the engaging element having a closed configuration and an open configuration, the distal end portion of the engaging element biased to assume the closed configuration, wherein the distal end portion of the engaging element is folded proximally so as to define a curved portion, wherein in the open configuration, the distal end of the engaging element is spaced further from to the distal portion of the engagement element than in the closed configuration so as to allow the distal end portion of the engaging element to grip the loop.

13. The system according to claim 12, wherein the contraction tool has a delivery configuration and a gripping configuration, wherein in the delivery configuration of the contraction tool, the engagement element is in the closed configuration and in the gripping configuration of the contraction tool, the engagement element is in the open configuration.

14. The system according to claim 13, wherein the contraction tool further comprises an outer tube and an inner tube slidable within the outer tube, the engaging element slidable within the inner tube, wherein in the delivery configuration of the contraction tool, a distal end of the inner tube is positioned proximal the curved portion and the distal end of the engaging element is positioned radially between the inner and outer tubes, and wherein in the gripping configuration of the contraction tool, the outer tube is positioned proximal the distal end of the engaging element and the inner tube extends into the curved portion so as to force the distal end of the engaging element to flex outwardly and thereby move the distal end portion of the engaging element into the open configuration.

15. The system according to any one of claims 12 to 14, when dependent on claim 6, wherein the anchor-delivery tube is slidable through the loop and the distal end portion is configured to grip the loop and the contraction tool is configured to pull the loop into the lumen of the anchor-delivery tube in order to facilitate application of a contraction force to the contraction member, and wherein the loop is compressible into the lumen of the anchor-delivery tube as the contraction tool pulls the loop and a portion of the contraction member through the lumen of the anchor-delivery tube.

16. The system according to any one of claims 1 to 15, when dependent on claim 6, further comprising a closure mechanism at the proximal sleeve-end-portion, the closure

mechanism is maintained in an opened state while the anchor-delivery tube passes through the closure mechanism.

17. The system according to any one of claims 1 to 16, further comprising a locking mechanism that has:

an unlocked state in which the locking mechanism allows movement of the contraction member through the locking mechanism, and increasing of the length of the distal end portion of the contraction member that is disposed within the lumen of the sleeve, and

a locked state in which the locking mechanism inhibits movement of the contraction member through the locking mechanism.

18. A system for use at a heart of a subject, the system comprising an annuloplasty structure that comprises:

a flexible sleeve having a proximal sleeve-end, a distal sleeve-end, and a circumferential wall that defines a longitudinal lumen between the proximal and distal sleeve-ends;

an elongate contraction member having a proximal end and a distal end, wherein the proximal end of the contraction member is attached to the sleeve at an attachment point of the sleeve, the attachment point and the proximal sleeve-end defining a proximal sleeve-end-portion, and a proximal end portion of the contraction member extends, in association with the circumferential wall of the sleeve, from the attachment point toward the distal sleeve-end and enters the lumen of the sleeve at an entry point of the sleeve so that a distal end portion of the contraction member is disposed within the lumen, the entry point and the distal end of the sleeve defining a distal sleeve-end-portion; and

a plurality of tissue anchors configured to extend through the circumferential wall and into tissue to anchor the sleeve to the tissue, wherein at least one tissue anchor is placed within the distal sleeve-end-portion,

wherein pulling the distal end of the contraction member proximally increases a length of the distal end portion of the contraction member that is disposed within the lumen so as to longitudinally contract the sleeve.

19. The system according to claim 18, further comprising a contraction tool comprising an engaging element, wherein the engaging element is movable longitudinally into and through the lumen of the sleeve toward the distal sleeve-end, and reversibly couplable to the distal end of the contraction member, wherein when the engaging element is reversibly coupled the distal end

of the contraction member, pulling the engaging element proximally increases a length of the distal end portion of the contraction member that is disposed within the lumen so as to longitudinally contract the sleeve.

20. The system according to claim 18 or 19, further comprising an elongate guide member reversibly coupled to the distal end of the contraction member, the guide member extending proximally through the lumen of the sleeve.

21. The system according to any one of claims 18 to 20, further comprising a locking mechanism having an unlocked state in which the locking mechanism allows movement of the contraction member through the locking mechanism, and increasing of the length of the distal end portion of the contraction member that is disposed within the lumen of the sleeve, and a locked state in which the locking mechanism inhibits movement of the contraction member through the locking mechanism.

22. The system according to any one of claims 18 to 21, wherein the locking mechanism is coupled to the contraction tool and is advanceable, using the contraction tool, longitudinally through the lumen of the sleeve toward the entry point of the sleeve.

23. The system according to claim 21 or 22, further comprising a lock tool that engages the locking mechanism and is configured to transition the locking mechanism into the locked state.

24. The system according to claim 23, wherein the locking mechanism is biased to assume the locked state, wherein the lock tool is configured to retain the locking mechanism in the unlocked state while the lock tool is engaged with the locking mechanism, and to transition the locking mechanism into the locked state by disengaging from the locking mechanism.

25. A method, comprising:

using a delivery tool, securing an annuloplasty structure on an annulus of a valve of a subject, the annuloplasty structure including (i) a flexible sleeve that defines a longitudinal lumen therethrough, and (ii) an elongate contraction member; and

subsequently, while the delivery tool is coupled to the annuloplasty structure, longitudinally contracting the sleeve by drawing the contraction member into and/or further into the lumen.

26. The method according to claim 25, wherein the delivery tool is coupled to the annuloplasty structure at a proximal end thereof, and wherein longitudinally contracting comprises longitudinally pulling the contraction member proximally.

27. The method according to any one of claims 25 to 26, wherein the sleeve includes a circumferential wall that defines the lumen, and wherein securing the annuloplasty structure on the annulus comprises sequentially, for each anchor of a plurality of anchors:

advancing the anchor into the lumen of the sleeve, and

driving a tissue-engaging element of the anchor through the circumferential wall and into the annulus, such that an anchor head of the anchor remains in the lumen of the sleeve.

28. The method according to any one of claims 25 to 27, further comprising, subsequently to the step of longitudinally contracting the sleeve, maintaining a contraction state of the sleeve by locking a locking mechanism to the contraction member.

29. The method according to claim 28, wherein locking the locking mechanism comprises locking the locking mechanism while maintaining coupling of the delivery tool to the annuloplasty structure.

30. The method according to claim 28, further comprising, prior to the locking, delivering a force-distributing element within the lumen of the sleeve and facilitating distributing of contraction forces along the annuloplasty structure using the force-distributing element.

31. The method according to claim 30, wherein securing the annuloplasty structure comprises implanting a plurality of tissue anchors, and wherein delivering the force-distributing element comprises distributing the contraction forces along a subset of the plurality of tissue anchors.

32. The method according to claim 30, wherein locking the locking mechanism comprises locking in place the force-distributing element.

33. The method according to any one of claims 25 to 32, wherein the contracting member is provided with a loop and wherein the loop surrounds a portion of the delivery tool during the securing of the annuloplasty structure on the annulus.

34. The method according to claim 33, wherein longitudinally contracting comprises:

retracting the portion of the delivery tool until the loop does not surround the portion of the delivery tool,

gripping the loop; and

subsequently, longitudinally pulling the contraction member by pulling the loop.

35. The method according to claim 33, wherein securing the annuloplasty structure on the annulus comprises:

advancing the portion of the delivery tool through the lumen of the sleeve while the loop surrounds the portion of the delivery tool,

delivering a plurality of tissue anchors through the portion of the delivery tool; and

using the delivery tool, while the loop surrounds the portion of the delivery tool, anchoring the annuloplasty structure to the annulus by driving each one of the plurality of tissue anchors through respective portions of the sleeve and into tissue of the annulus.

36. The method according to claim 35, wherein advancing the portion of the delivery tool through the lumen of the sleeve comprises moving the portion of the delivery tool with respect to the loop, while the loop remains stationary.

37. The method according to claim 35, wherein advancing the portion of the delivery tool through the lumen of the sleeve comprises advancing the portion of the delivery tool distally through the lumen, and wherein driving each one of the plurality of tissue anchors through the respective portions of the sleeve comprises retracting the portion of the delivery tool proximally with each successive driving.

38. The method according to any one of claims 25 to 37, wherein a portion of the delivery tool slides within the lumen of the sleeve, and wherein the method further comprises maintaining coupling of the delivery tool to annuloplasty structure by maintaining the portion of the delivery tool within the lumen.

39. The method according to claim 38, wherein maintaining the coupling of the delivery tool comprises pushing outwardly coupling elements of the delivery tool that are coupled to the sleeve of the annuloplasty structure, and wherein the method further comprises decoupling the delivery tool from the annuloplasty structure by removing the portion of the delivery tool from within the lumen and allowing the coupling elements to flex inwardly and disengage from the sleeve of the annuloplasty structure.

40. The method according to claim 38, wherein maintaining the coupling of the delivery tool comprises maintaining a closure mechanism of the annuloplasty structure in an open state by maintaining the portion of delivery tool within the lumen.

41. The method according to claim 40, further comprising decoupling the delivery tool from the annuloplasty structure by removing the portion of the delivery tool from within the lumen and transitioning the closure mechanism to a closed state.

42. An apparatus for use at a heart of a subject, the apparatus comprising an annuloplasty structure that comprises:

a flexible sleeve having a proximal sleeve-end, a distal sleeve-end, and a circumferential wall that defines a longitudinal lumen between the first and second sleeve-ends;

an elongate contraction member having a proximal end and a distal end, wherein the distal end of the contraction member is attached to the sleeve at an attachment point of the sleeve, the attachment point and the distal sleeve-end defining a distal sleeve-end-portion, and a distal end portion of the contraction member extends, in association with the circumferential wall, from the attachment point toward the proximal sleeve-end and enters the lumen of the sleeve at an entry point of the sleeve so that a proximal end portion of the contraction member extends toward the proximal sleeve-end within the lumen, the entry point and the proximal sleeve-end defining a proximal sleeve-end-portion;

a plurality of tissue anchors configured to extend through the circumferential wall and into tissue of the heart to anchor the sleeve to the tissue, wherein at least one tissue anchor is placed within the proximal sleeve-end-portion;

an anchor-delivery tool comprising an anchor-delivery tube slidable within the lumen of the sleeve and an anchor driver slidable within the anchor delivery tube;

a loop provided at the proximal end of the contraction member, the anchor-delivery tube slidable with respect to the loop while the loop remains disposed within the proximal sleeve-end-portion, in order to facilitate implantation of the plurality of tissue anchors,

wherein pulling the proximal end of the contraction member proximally increases a length of the proximal end portion of the contraction member that is disposed within the lumen so as to longitudinally contract the sleeve.

43. The apparatus according to claim 42, further comprising a reference-force tube comprising coupling elements coupled to a distal end of the reference-force tube and are configured to couple to the proximal sleeve-end , wherein the coupling elements are biased to flex inwardly toward a central longitudinal axis of the reference-force tube wherein the anchor-delivery tube is slidable within the reference-force tube.

44. The apparatus according to claim 43, wherein the anchor-delivery tube is configured to (a) maintain coupling of the coupling elements to the sleeve when inserted into the lumen of the sleeve and pushing against the coupling elements so as to allow the coupling elements to flex

outwardly and become coupled to the proximal sleeve-end-portion of the annuloplasty structure, and (b) facilitate decoupling of the reference-force tube from proximal sleeve-end-portion of the annuloplasty structure when removed from the lumen of the sleeve so as to allow the coupling elements to flex inwardly and become decoupled from the sleeve.

45. The apparatus according to any one of claims 42 to 44, wherein:

each tissue anchor of the plurality of tissue anchors comprises an anchor head and a tissue-engaging element, the tissue-engaging element configured to extend through the circumferential wall and into the tissue, and the anchor head configured to reversibly couple to the anchor driver and to be positioned in the lumen of the sleeve.

46. The system according to any one of claims 42 to 45, further comprising a contraction tool comprising an engaging element, wherein the engaging element comprises a distal portion and distal end portion contiguous with the distal portion, the distal end portion of the engaging element having a closed configuration and an open configuration, the distal end portion of the engaging element biased to assume the closed configuration, wherein the distal end portion of the engaging element is folded proximally so as to define a curved portion, wherein in the open configuration, the distal end of the engaging element is spaced further from to the distal portion of the engagement element than in the closed configuration so as to allow the distal end portion of the engaging element to grip the loop.

47. The system according to claim 46, wherein the contraction tool has a delivery configuration and a gripping configuration, wherein in the delivery configuration of the contraction tool, the engagement element is in the closed configuration and in the gripping configuration of the contraction tool, the engagement element is in the open configuration.

48. The system according to claim 47, wherein the contraction tool further comprises an outer tube and an inner tube slidable within the outer tube, the engaging element slidable within the inner tube, wherein in the delivery configuration of the contraction tool, a distal end of the inner tube is positioned proximal the curved portion and the distal end of the engaging element is positioned radially between the inner and outer tubes, and wherein in the gripping configuration of the contraction tool, the outer tube is positioned proximal the distal end of the engaging element and the inner tube extends into the curved portion so as to force the distal end of the engaging element to flex outwardly and thereby move the distal end portion of the engaging element into the open configuration.

49. The system according to any one of claims 48, wherein the contraction tool is configured to pull the loop into the lumen of the anchor-delivery tube in order to facilitate application of a contraction force to the contraction member, and the loop is compressible into the lumen of the anchor-delivery tube as the contraction tool pulls the loop and a portion of the contraction member through the lumen of the anchor-delivery tube.

50. The apparatus according to any one of claims 46 to 49, further comprising a closure mechanism at the proximal sleeve-end-portion, the closure mechanism being maintainable in an opened state while the anchor-delivery tube passes through the closure mechanism.

51. The apparatus according to claim 50, wherein the anchor-delivery tube is slidable with respect to the loop and the closure mechanism in order to facilitate implantation of the plurality of tissue anchors.

52. A system for use at a heart of a subject, the system comprising an annuloplasty structure that comprises:

a flexible sleeve having a proximal sleeve-end, a distal sleeve-end, and a circumferential wall that defines a longitudinal lumen between the proximal and distal sleeve-ends;

an elongate contraction member having a proximal end and a distal end, the distal end of the contraction member being attached to the sleeve at an attachment point, the attachment point and the distal end of the sleeve defining a distal sleeve-end-portion, and a distal end portion of the contraction member extending, in association with the circumferential wall of the sleeve, from the attachment point toward the proximal sleeve-end and entering the lumen of the sleeve at an entry point of the sleeve so that a proximal end portion of the contraction member is disposed within the lumen, the entry point and the proximal sleeve-end defining a proximal sleeve-end-portion; and

a plurality of tissue anchors configured to extend through the circumferential wall and into tissue to anchor the sleeve to the tissue, wherein at least one tissue anchor is disposed at the proximal sleeve-end-portion,

wherein pulling the proximal end of the contraction member proximally increases a length of the proximal end portion of the contraction member that is disposed within the lumen so as to longitudinally contract the sleeve.

53. The system according to claim 52, further comprising a loop provided at the proximal end of the contraction member and a contraction tool comprising an engaging element, wherein the engaging element comprises a distal portion and distal end portion contiguous with

the distal portion, the distal end portion of the engaging element having a closed configuration and an open configuration, the distal end portion of the engaging element biased to assume the closed configuration, wherein the distal end portion of the engaging element is folded proximally so as to define a curved portion, wherein in the open configuration, the distal end of the engaging element is spaced further from to the distal portion of the engagement element than in the closed configuration so as to allow the distal end portion of the engaging element to grip the loop.

54. The system according to claim 53, wherein the contraction tool has a delivery configuration and a gripping configuration, wherein in the delivery configuration of the contraction tool, the engagement element is in the closed configuration and in the gripping configuration of the contraction tool, the engagement element is in the open configuration.

55. The system according to claim 54, wherein the contraction tool further comprises an outer tube and an inner tube slidable within the outer tube, the engaging element slidable within the inner tube, wherein in the delivery configuration of the contraction tool, a distal end of the inner tube is positioned proximal the curved portion and the distal end of the engaging element is positioned radially between the inner and outer tubes, and wherein in the gripping configuration of the contraction tool, the outer tube is positioned proximal the distal end of the engaging element and the inner tube extends into the curved portion so as to force the distal end of the engaging element to flex outwardly and thereby move the distal end portion of the engaging element into the open configuration.

56. The system according to any one of claims 52 to 55, further comprising an anchor-delivery tube, wherein the contraction tool is slidable within the anchor-delivery tube.

57. The system according to any one of claims 52 to 56, further comprising a force-distributing element configured to be disposed within the lumen of the sleeve and to surround the proximal end portion of the contraction member such that a distal end of the force-distributing element abuts an inner surface of the circumferential wall of the sleeve at the entry point so as to distribute a force applied to the at least one tissue anchor of the proximal sleeve-end-portion during application of a contraction force to the elongate contraction member.

58. A contraction tool, comprising

an engaging element comprising a distal portion and distal end portion contiguous with the distal portion, the distal end portion of the engaging element having a closed configuration and an open configuration, the distal end portion of the engaging element biased to assume the closed

configuration, wherein the distal end portion of the engaging element is folded proximally so as to define a curved portion, wherein in the open configuration, the distal end of the engaging element is spaced further from to the distal portion of the engagement element than in the closed configuration so as to allow the distal end portion of the engaging element to grip the loop.

59. The contraction tool according to claim 58, wherein the contraction tool has a delivery configuration and a gripping configuration, wherein in the delivery configuration of the contraction tool, the engagement element is in the closed configuration and in the gripping configuration of the contraction tool, the engagement element is in the open configuration.

60. The contraction tool according to claim 59, further comprising an outer tube and an inner tube slidable within the outer tube, the engaging element slidable within the inner tube, wherein in the delivery configuration of the contraction tool, a distal end of the inner tube is positioned proximal the curved portion and the distal end of the engaging element is positioned radially between the inner and outer tubes, and wherein in the gripping configuration of the contraction tool, the outer tube is positioned proximal the distal end of the engaging element and the inner tube extends into the curved portion so as to force the distal end of the engaging element to flex outwardly and thereby move the distal end portion of the engaging element into the open configuration.

61. A system for use at a heart of a subject, the system comprising an annuloplasty structure that comprises:

a flexible sleeve having a first sleeve-end-portion, a second sleeve-end-portion, and a circumferential wall that defines a longitudinal lumen between the first and second sleeve-end-portions; an elongate contraction member having a first end and a second end, the first end being attached to the sleeve at the first sleeve-end-portion, and the member extending, in association with the circumferential wall, from the first sleeve-end-portion toward the second sleeve-end-portion;

a plurality of tissue anchors and configured to anchor the sleeve to tissue, the plurality of tissue anchors comprising at least one second sleeve-end-portion tissue anchor configured to anchor the second sleeve-end-portion to tissue by being driven through the circumferential wall and into the tissue; and

a force-distributing element configured to surround a second end portion of the member that is disposed within the lumen of the sleeve and to distribute a force applied to the at least one

second sleeve-end-portion tissue anchor during application of a contraction force to the elongate contraction member,

wherein the member is arranged with respect to the sleeve such that increasing a longitudinal proportion of the member that is disposed within the lumen longitudinally contracts the sleeve.

62. The system according to claim 61, wherein the force-distributing element comprises a tube shaped so as to define a plurality of slits, wherein the plurality of slits increases flexibility of the force-distributing element.

63. The system according to any one of claims 61-62, wherein each tissue anchor of the plurality of tissue anchors is independently advanceable into the lumen of the sleeve and is configured to anchor the sleeve to tissue by being driven through the circumferential wall and into the tissue.

64. The system according to any one of claims 61-63, wherein the at least one second sleeve-end-portion tissue anchor are configured to anchor the second sleeve-end-portion at a portion of the second sleeve-end-portion containing the second end portion of the member that is disposed within the lumen of the sleeve.

65. The system according to claim 64, wherein the member extends from the first sleeve-end-portion to the second sleeve-end-portion in association with the circumferential wall, by weaving along the circumferential wall between the first sleeve-end-portion and the second sleeve-end-portion.

66. The system according to claim 65, wherein the second end portion of the member enters the lumen of the sleeve such that it is disposed within the second sleeve-end-portion at an entry point, and wherein the at least one second sleeve-end-portion tissue anchor is anchorable proximally to the entry point.

67. The system according to any one of claims 61-66, wherein the second end is disposed within the lumen of the sleeve, and the member is arranged with respect to the sleeve such that movement of the second end toward the second sleeve-end-portion increases the longitudinal proportion of the member that is disposed within the lumen of the sleeve by drawing the member into the lumen of the sleeve.

68. The system according to claim 67, wherein the member extends from the first sleeve-end-portion to the second sleeve-end-portion in association with the circumferential wall, by

weaving along the circumferential wall between the first sleeve-end-portion and the second sleeve-end-portion.

69. The system according to any one of claims 61-68, further comprising an anchor-delivery tool comprising an anchor-delivery channel and an anchor driver slidable within the anchor delivery channel.

70. The system according to claim 69, further comprising coupling elements coupled to a distal end of the anchor-delivery tool, wherein the coupling elements are configured to ensnare a proximal end of the sleeve and have a tendency to flex inwardly toward a central longitudinal axis of the anchor-delivery tool in an absence of force applied thereto.

71. The system according to claim 70, wherein the channel is configured to (a) maintain coupling of the coupling elements to the sleeve by pushing against the coupling elements sleeve of the annuloplasty structure, and (b) facilitate decoupling of the anchor-delivery tool from the annuloplasty structure by being removed from the lumen of the sleeve and allowing the coupling elements to flex inwardly and become decoupled from the sleeve.

72. The system according to claim 69, wherein:

each anchor of the plurality of tissue anchors:

comprising an anchor head and a tissue-engaging element,

being independently advanceable into the lumen of the sleeve by the anchor driver, and

being configured to anchor the sleeve to tissue by the tissue-engaging element being driven through the circumferential wall and into the tissue while the anchor head remains in the lumen of the sleeve; and

the anchor driver is removable from within a lumen of the channel following anchoring of the sleeve using the plurality of tissue anchors.

73. The system according to claim 72, further comprising a contraction tool that comprises a contraction member-engaging element, wherein the engaging element, subsequently to the anchoring of the sleeve using the plurality of tissue anchors:

is movable longitudinally through the lumen of the channel and into the lumen of the sleeve,

comprises a snare configured to ensnare the second end of the member, and

while coupled to the second end, is movable within the lumen of the channel, such that the second end is pulled into the lumen of the channel, thereby drawing the member into the lumen of the sleeve and longitudinally contracting the sleeve.

74. The system according to claim 73, further comprising a loop coupled to the second end of the member and disposed within the second sleeve-end-portion, wherein the loop surrounds an end portion of the channel that is advanceable within the lumen of the sleeve, and wherein the channel is slidable with respect to the loop while the loop remains disposed within the second sleeve-end-portion, in order to facilitate implantation of the plurality of tissue anchors.

75. The system according to claim 74, wherein the snare is configured to ensnare the loop and to pull the loop into the lumen of the channel in order to facilitate application of a contraction force to the contraction member, and wherein the loop is compressible into the lumen of the channel as the snare pulls the loop and a portion of the contraction member through the lumen of the channel.

76. The system according to claim 74, further comprising a closure mechanism at the second sleeve-end-portion, the closure mechanism being maintainable in an opened state while the channel passes through the closure mechanism.

77. The system according to any one of claims 61-76, further comprising a contraction tool that comprises an engaging element, wherein the engaging element:

is movable longitudinally into the lumen of the sleeve and through the lumen of the sleeve toward the second end,

is reversibly couplable to the second end, and

while coupled to the second end, is movable longitudinally toward the first sleeve-end-portion, such that the second end is moved toward the first sleeve-end-portion, thereby drawing the member into the lumen and longitudinally contracting the sleeve.

78. The system according to any one of claims 61-77, further comprising a locking mechanism that has:

an unlocked state in which the locking mechanism allows movement of the member through the locking mechanism, and increasing of the longitudinal proportion of the member that is disposed within the lumen of the sleeve, and

a locked state in which the locking mechanism inhibits movement of the member through the locking mechanism.

79. The system according to claim 78, further comprising a contraction tool that comprises an engaging element, wherein:

the engaging element:

is movable longitudinally into the lumen of the sleeve and through the lumen of the sleeve toward the second end,

is reversibly couplable, within the lumen of the sleeve, to the second end, and

while coupled to the second end, is movable longitudinally toward the second sleeve-end-portion, such that the second end is moved toward the second sleeve-end-portion, thereby drawing the member into the lumen of the sleeve and longitudinally contracting the sleeve, and

the locking mechanism:

is coupled to the contraction tool, and

is advanceable, using the contraction tool, longitudinally through the lumen of the sleeve toward the second sleeve-end-portion and the member.

80. The system according to claim 79, further comprising a lock tool that engages the locking mechanism and is configured to transition the locking mechanism into the locked state, and wherein the locking mechanism is biased to assume the locked state, the lock tool is configured to retain the locking mechanism in the unlocked state while the lock tool is engaged with the locking mechanism, and the lock tool is configured to transition the locking mechanism into the locked state by disengaging from the locking mechanism.

81. An apparatus for use at a heart of a subject, the apparatus comprising an annuloplasty structure that comprises:

a flexible sleeve having a first sleeve-end-portion, a second sleeve-end-portion, and a circumferential wall that defines a longitudinal lumen between the first and second sleeve-end-portions; an elongate contraction wire having a first wire-end and a second wire-end, the first wire-end being attached to the sleeve at the first sleeve-end-portion, and the wire extending, in association with the circumferential wall, from the first sleeve-end-portion toward the second sleeve-end-portion;

a plurality of tissue anchors and configured to anchor the sleeve to tissue, the plurality of tissue anchors comprising at least one second sleeve-end-portion tissue anchor configured to anchor the second sleeve-end-portion to tissue by being driven through the circumferential wall and into the tissue;

an anchor-delivery tool comprising an anchor-delivery channel and an anchor driver slidable within the anchor delivery channel;

a loop coupled to the second wire-end of the wire and disposed within the second sleeve-end-portion, the loop surrounding an end portion of the channel that is advanceable within the lumen of the sleeve, the channel being slidable with respect to the loop while the loop remains disposed within the second sleeve-end-portion, in order to facilitate implantation of the plurality of tissue anchors,

wherein the wire is arranged with respect to the sleeve such that increasing a longitudinal proportion of the wire that is disposed within the lumen longitudinally contracts the sleeve.

82. The apparatus according to claim 81, further comprising coupling elements coupled to a distal end of the anchor-delivery tool, wherein the coupling elements are configured to ensnare a proximal end of the sleeve and have a tendency to flex inwardly toward a central longitudinal axis of the anchor-delivery tool in an absence of force applied thereto.

83. The apparatus according to claim 82, wherein the channel is configured to (a) maintain coupling of the coupling elements to the sleeve by pushing against the coupling elements sleeve of the annuloplasty structure, and (b) facilitate decoupling of the anchor-delivery tool from the annuloplasty structure by being removed from the lumen of the sleeve and allowing the coupling elements to flex inwardly and become decoupled from the sleeve.

84. The apparatus according to any one of claims 81-83, wherein:

each anchor of the plurality of tissue anchors:

comprising an anchor head and a tissue-engaging element,

being independently advanceable into the lumen of the sleeve by the anchor driver, and

being configured to anchor the sleeve to tissue by the tissue-engaging element being driven through the circumferential wall and into the tissue while the anchor head remains in the lumen of the sleeve; and

the anchor driver is removable from within a lumen of the channel following anchoring of the sleeve using the plurality of tissue anchors.

85. The apparatus according to claim 84, further comprising a contraction tool that comprises a wire-engaging element, wherein the wire-engaging element, subsequently to the anchoring of the sleeve using the plurality of tissue anchors:

is movable longitudinally through the lumen of the channel and into the lumen of the sleeve,

comprises a snare configured to ensnare the second wire-end of the wire, and

while coupled to the second wire-end, is movable within the lumen of the channel, such that the second wire-end is pulled into the lumen of the channel, thereby drawing the wire into the lumen of the sleeve and longitudinally contracting the sleeve.

86. The apparatus according to claim 85, wherein the snare is configured to ensnare the loop and to pull the loop into the lumen of the channel in order to facilitate application of a contraction force to the contraction wire, and wherein the loop is compressible into the lumen of the channel as the snare pulls the loop and a portion of the contraction wire through the lumen of the channel.

87. The apparatus according to claim 85, further comprising a closure mechanism at the second sleeve-end-portion, the closure mechanism being maintainable in an opened state while the channel passes through the closure mechanism.

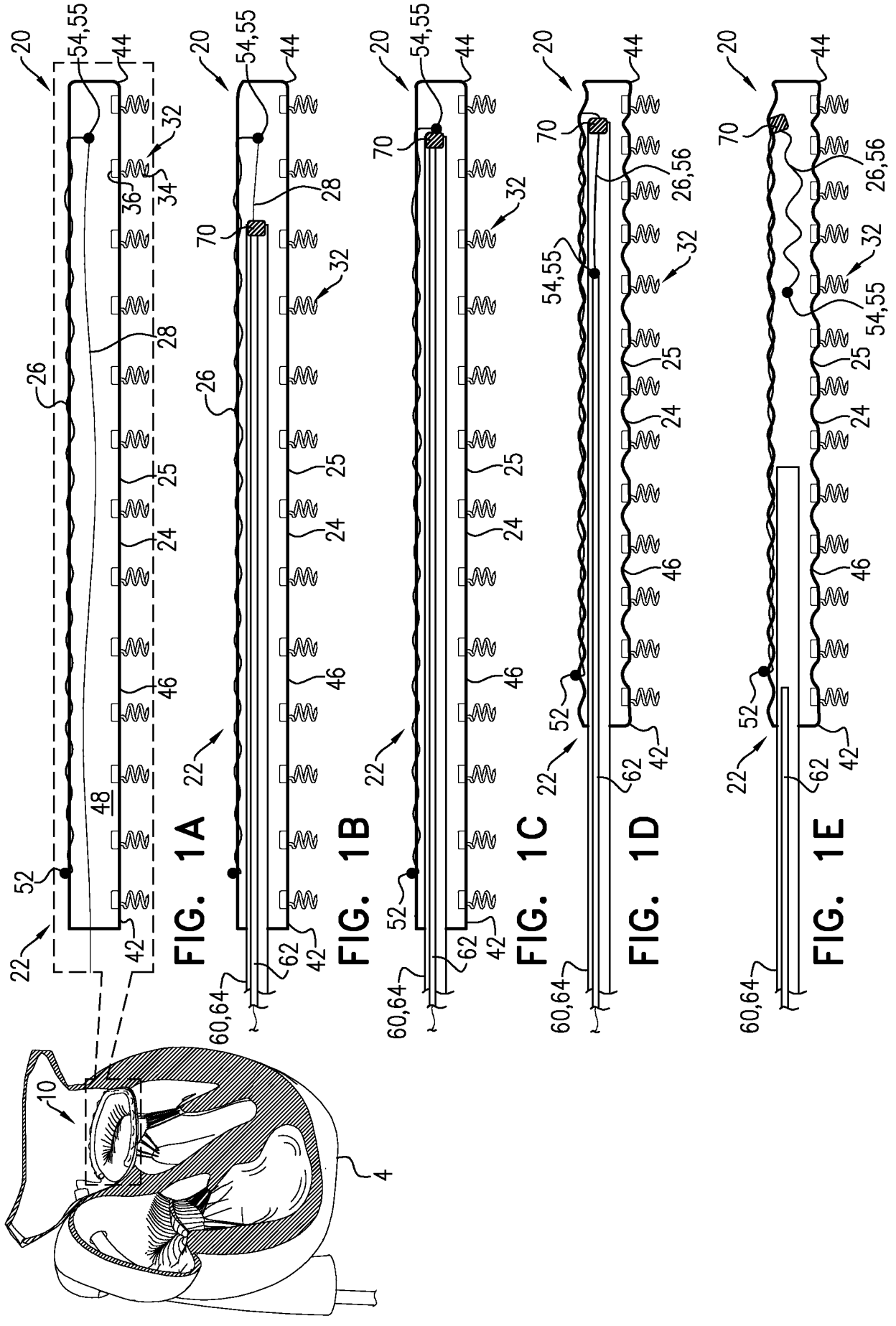

FIG. 1A FIG. 1B FIG. 1C FIG. 1D FIG. 1E

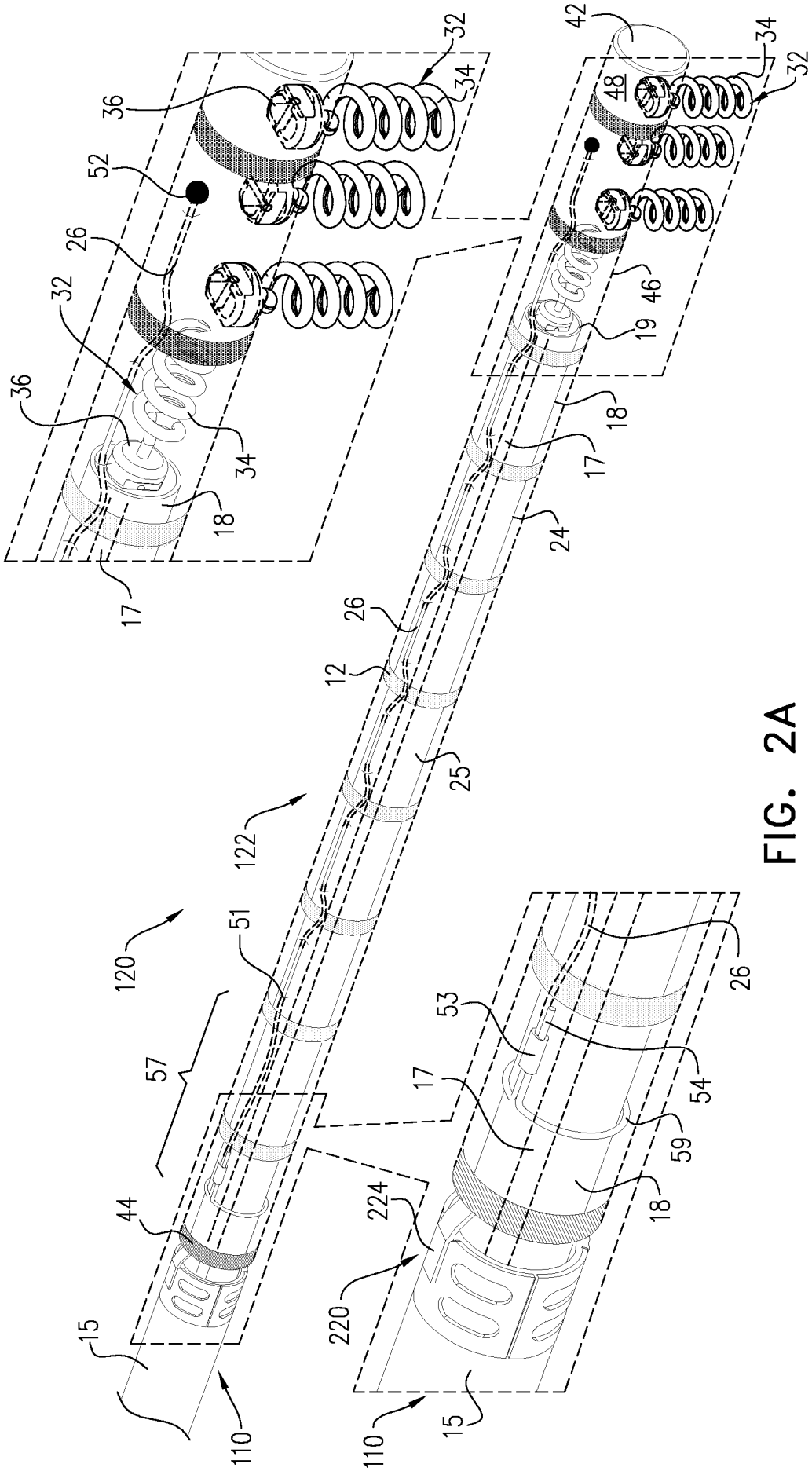
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FIG. 2A

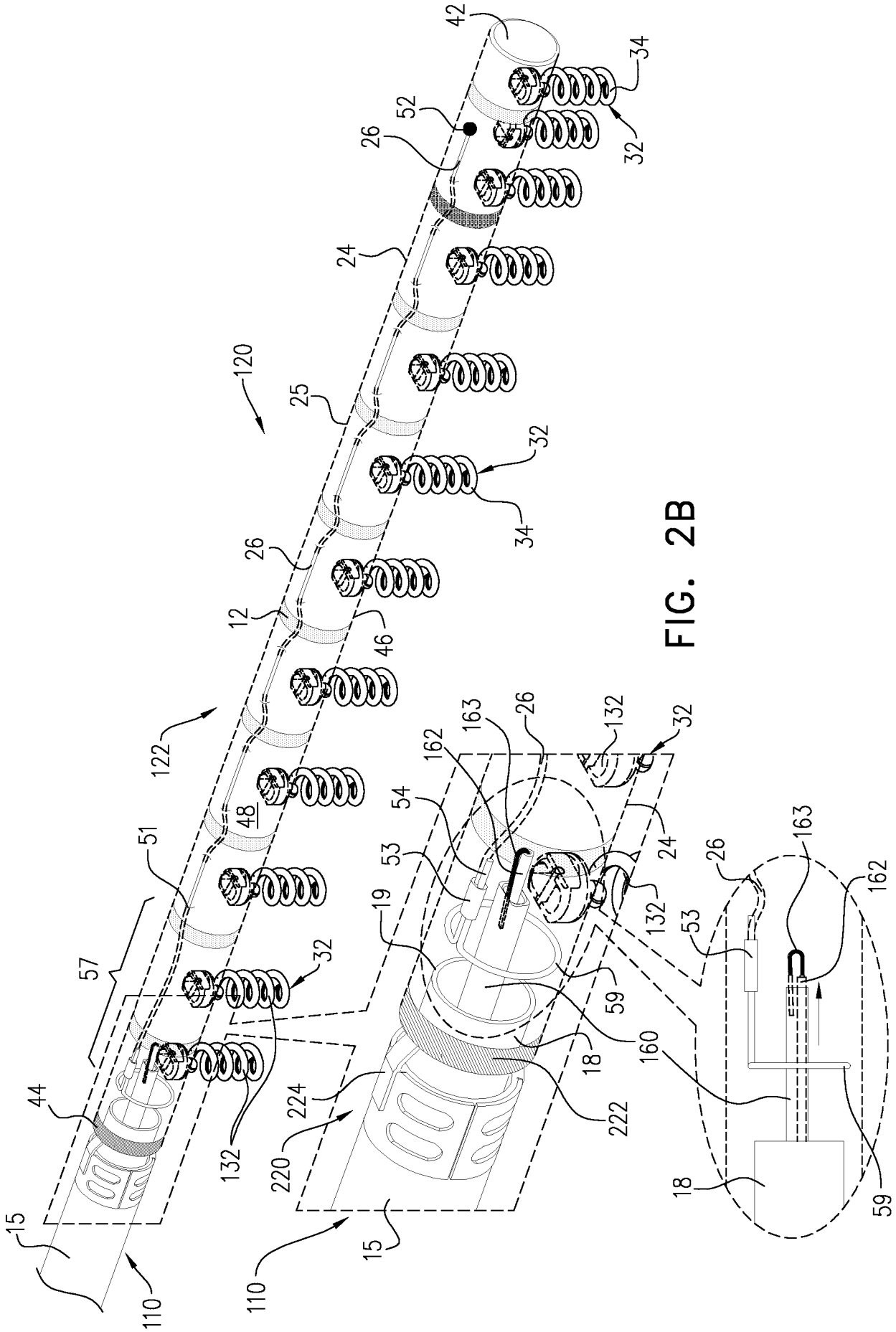
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FIG. 2B

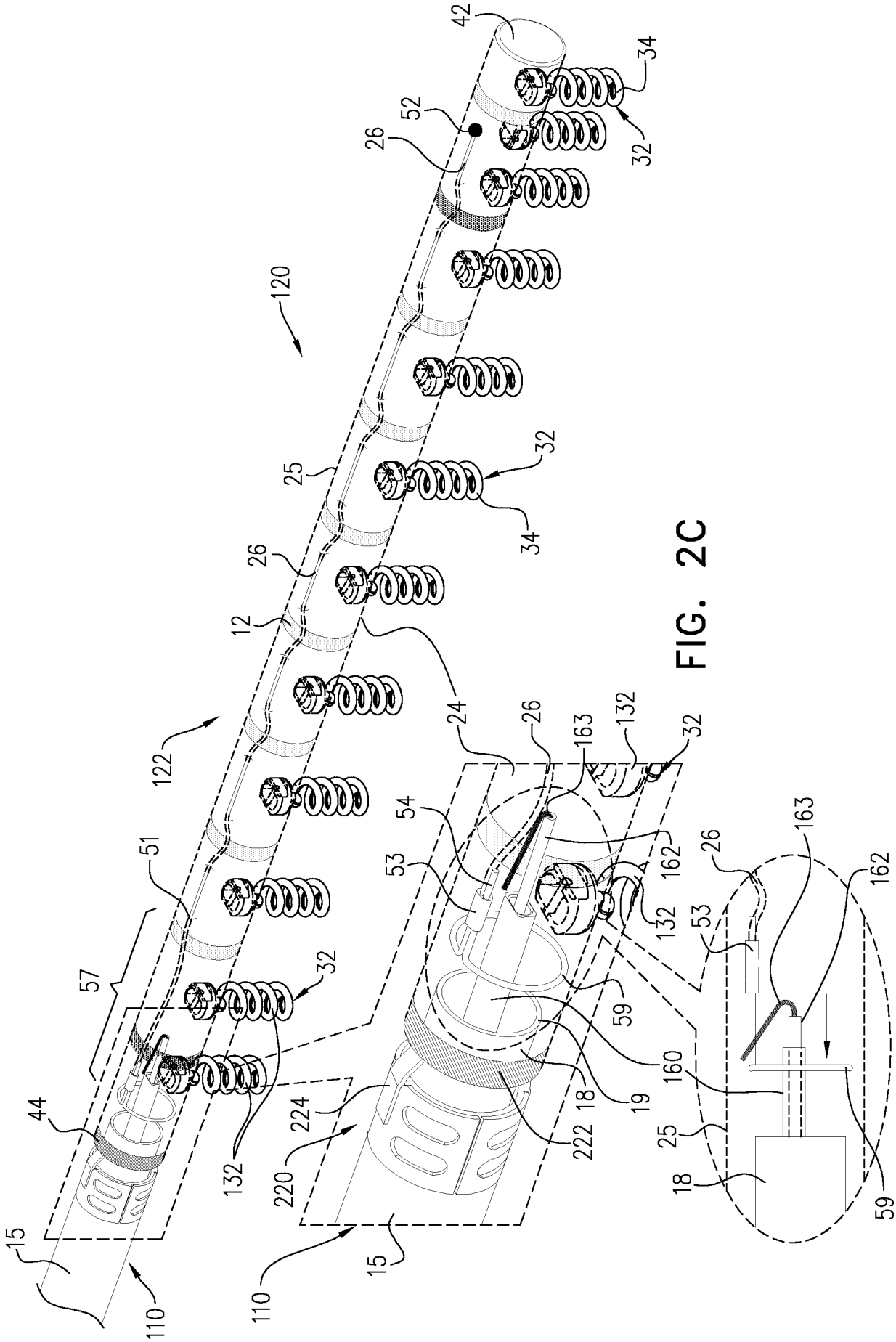
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FIG. 2C

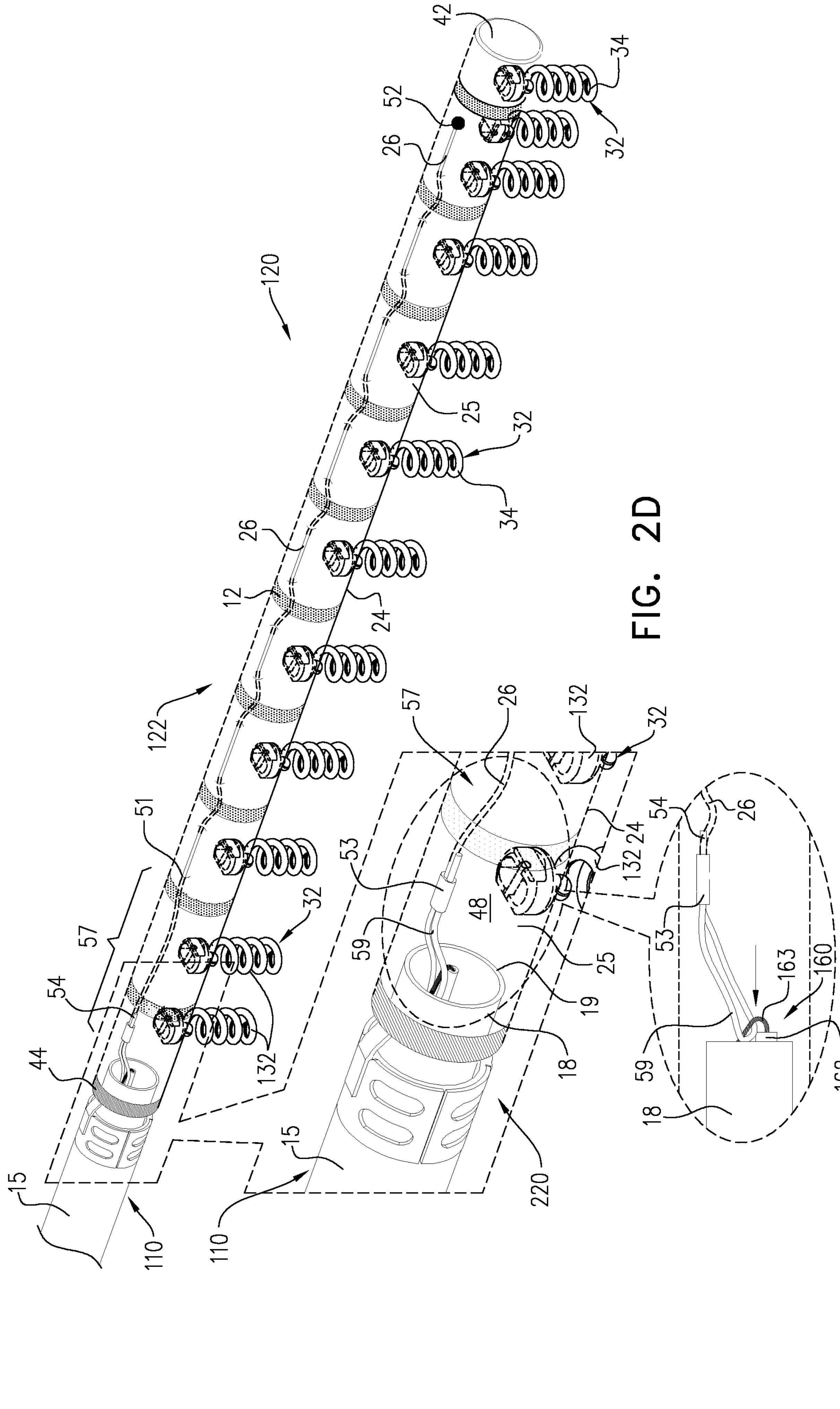
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FIG. 2D

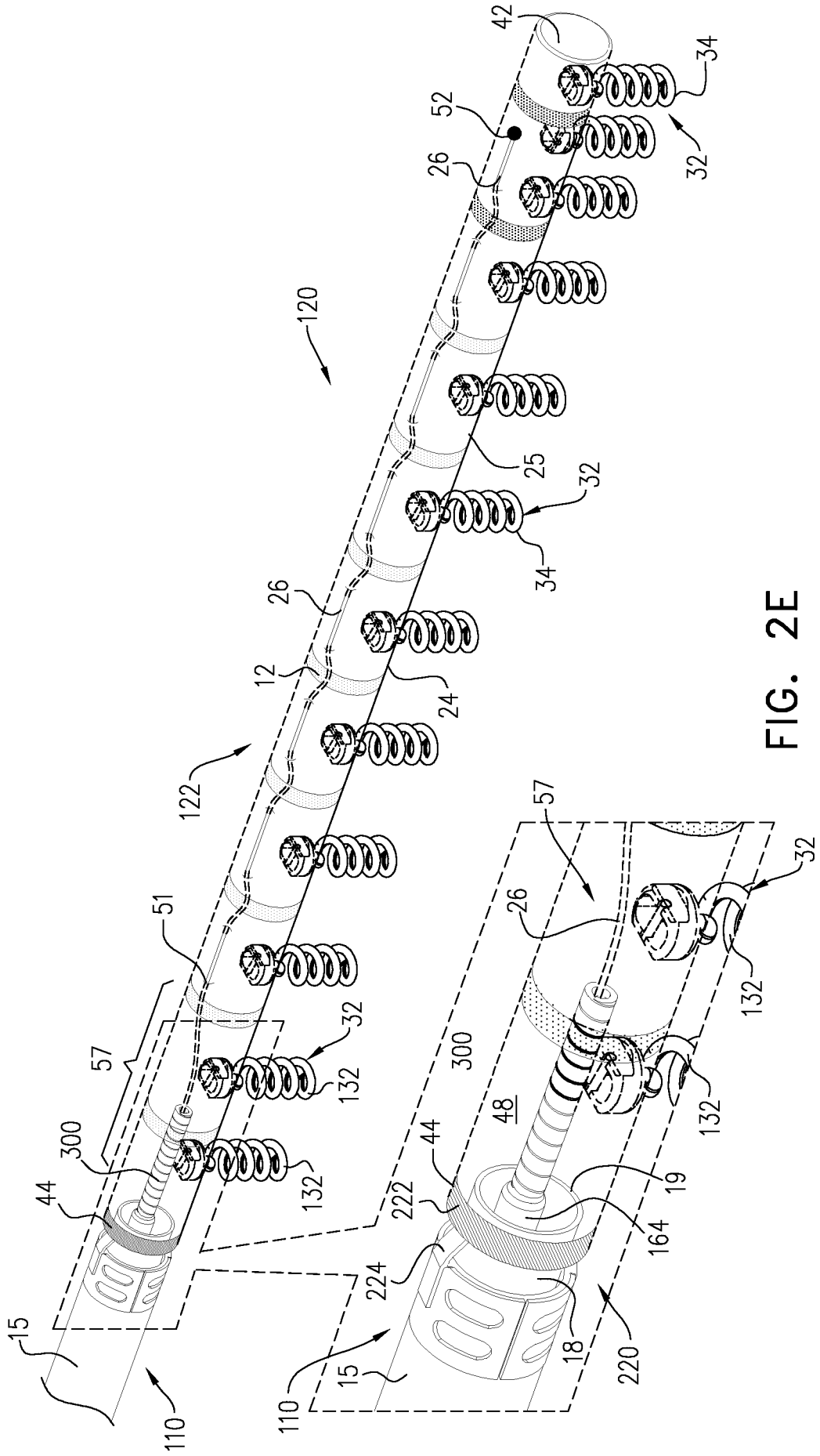
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FIG. 2E

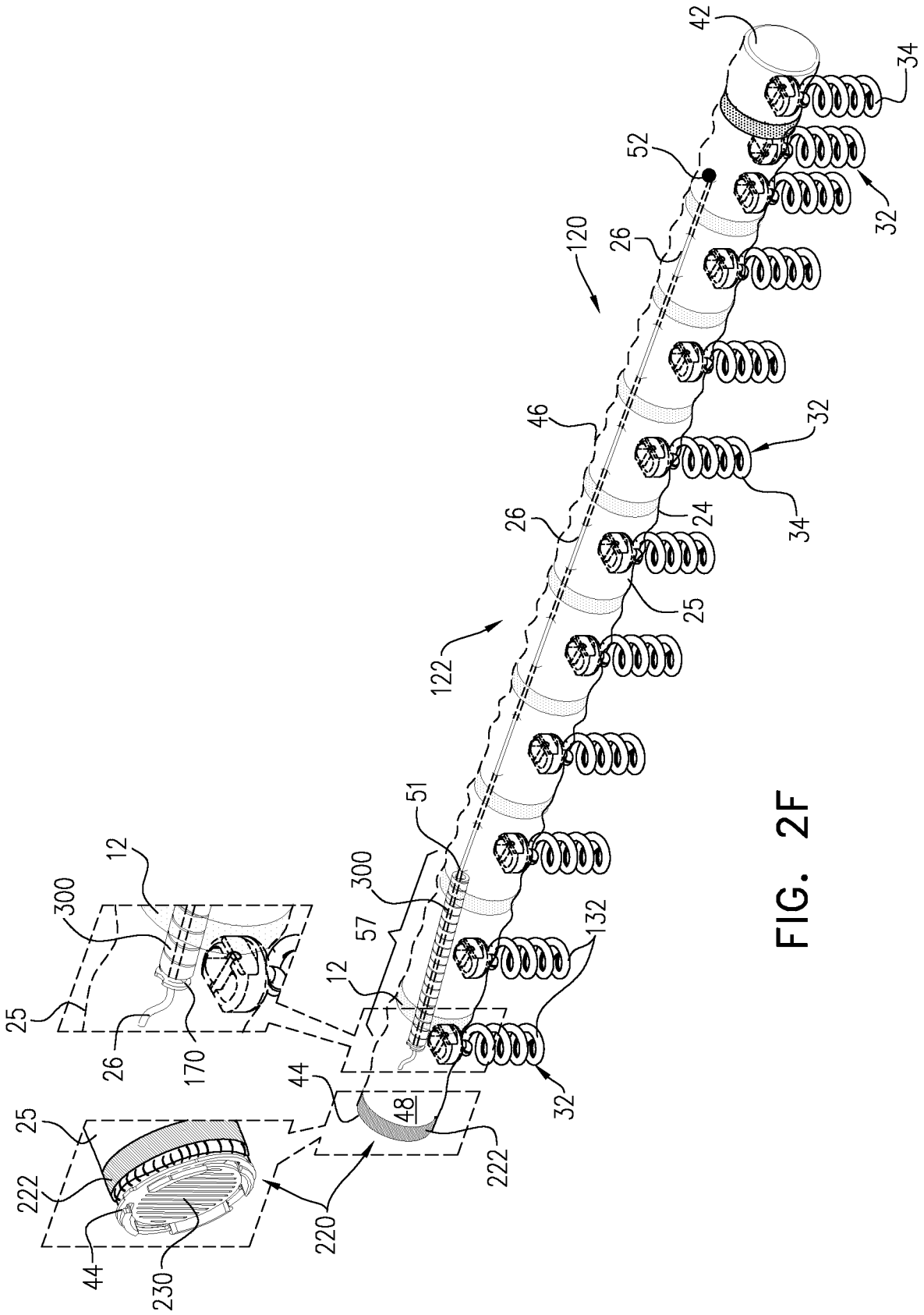
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FIG. 2F