In a system for retrieving an implanted device, a flared inner surface of a catheter tubular sidewall may define a distal-most opening of a device receptacle; the opening has a first diameter equal to that of the receptacle, and a second diameter, coincident with a distal-most edge of the tubular sidewall, and at least 5% greater than the receptacle diameter. Alternately, a retrieval tool in sliding engagement within a lumen of a catheter includes a shaft assembly, through which a snare member passes, and which includes a collapsible spring-biased perimeter sidewall; the sidewall defines a capture member passageway approximately coaxial, and in fluid communication with a lumen of the shaft assembly. A distal-most opening of the passageway has a spring-biased diameter that is greater than that of a distal-most opening of a device receptacle of the catheter, and a collapsed diameter that is less than the receptacle distal-most opening diameter.

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INTERVENTIONAL MEDICAL SYSTEMS

FIELD OF THE DISCLOSURE

The present disclosure pertains to interventional medical systems, and more particularly to systems, catheters and methods that are useful for retrieving medical devices from implant sites.

BACKGROUND

The traditional implantable cardiac pacemaker includes a pulse generator device to which one or more flexible elongate lead wires are coupled. The device is typically implanted in a subcutaneous pocket, remote from the heart, and each of the one or more lead wires extends therefrom to a corresponding electrode, coupled thereto and positioned at a pacing site, either endocardial or epicardial. Mechanical and/or MRI compatibility issues, which are sometimes associated with elongate lead wires and well known to those skilled in the art, have motivated the development of implantable cardiac pacing devices that are wholly contained within a relatively compact package, the entirety of which is configured for implant in close proximity to the pacing site. Figure 1 is a schematic diagram that shows potential cardiac implant sites for such a device, for example, within an appendage 102 of a right atrium RA, within a coronary vein CV (via a coronary sinus ostium CSOS), or in proximity to an apex 103 of a right ventricle RV, for example, as shown in Figure 2.

Figure 2 shows an implantable medical device 300 having been implanted by an operator using a catheter 200, for example, like the tool described in the commonly assigned United States Patent Application US 2015/0094668, wherein the operator advanced tool 200 into the right heart through the inferior vena cava IVC, for example, from a femoral vein access site, and then deployed device 300 from a device receptacle 230 of catheter 200. In some cases, when it may be necessary to retrieve the implanted device, the operator can employ catheter 200 to do so, but new and improved tools and methods would increase the ease and efficiency of retrieval.
SUMMARY

An interventional medical system, according to embodiments disclosed herein, includes features configured to accommodate misalignment between an implanted medical device and a distal-most opening of a device receptacle of a system catheter, when an operator employs the catheter to retrieve the device from the implant site.

In some embodiments, a tubular sidewall of the catheter, which defines the device receptacle, is improved to include a flared inner surface, wherein the inner surface defines the distal-most opening, so that the opening has a first diameter and a second diameter, the first diameter being equal to a diameter of the receptacle, and the second diameter, which is coincident with a distal-most edge of the tubular sidewall, being at least 5% greater than the diameter of the receptacle.

In alternate embodiments, a shaft assembly of a retrieval tool of the system includes a capture member formed by a collapsible spring-biased perimeter sidewall, wherein the perimeter sidewall defines a passageway approximately coaxial, and in fluid communication with a lumen formed by an elongate tubular sidewall of the retrieval tool shaft assembly. The retrieval tool lumen and passageway allow passage of a snare member of the retrieval tool therethrough, and the tool shaft assembly is configured for sliding engagement within the system catheter. A distal-most opening of the capture member passageway has a spring-biased diameter that is greater than a diameter of a distal-most opening of the device receptacle of the catheter, and has a collapsed diameter that is less than that of the device receptacle, when the capture member is received within therein.

In some embodiments, the collapsible spring-biased perimeter sidewall of the aforementioned capture member includes a flexible polymer mesh supported by a plurality of spring-biased ribs, and the system may further include a vacuum source configured for applying suction through the lumen and capture member passageway of the retrieval tool shaft assembly. The spring biased diameter of the distal-most opening of the capture member passageway in these embodiments may be 2 to 5 times greater than the diameter of the device.
receptacle distal-most opening. In some alternate embodiments, the elongate tubular sidewall of the retrieval tool shaft assembly includes a flared distal end, and the collapsible spring-biased perimeter sidewall of the capture member includes a 'serpented' wire loop mounted to the flared distal end. The spring biased diameter of the distal-most opening of the capture member passageway in these alternate embodiments is at least 5% greater than the diameter of the device receptacle distal-most opening.

According to some embodiments, an inner assembly of a catheter is formed by a shaft subassembly that includes the elongate tubular member with the flared distal end and the 'serpented' wire loop of the capture member mounted thereto. And, according to some methods, the catheter may be converted from a deployment configuration, in which a device tether extends through lumens of the tubular member, to a retrieval configuration, by removing the device tether from the lumens and then inserting capture member tethers into the lumens, to couple the collapsible spring-biased perimeter sidewall of the capture member to the tubular sidewall.

According to some additional methods disclosed herein, an operator may employ any of the above-described retrieval tools in retrieving the medical device from an implant site, for example, according to the following steps. The operator first advances the device receptacle of the catheter to the implant site, so that the distal-most opening of the device receptacle is located in proximity to the device, and then either advances the retrieval tool out through the distal-most opening of the device receptacle of the catheter, in some embodiments, or retracts the device receptacle to expose the capture member, in some alternate embodiments, so that the spring-biased sidewall of the capture member of the tool opens to the spring-biased diameter. Then, the operator may maneuver the retrieval tool to snare an attachment feature of the device. Once the device attachment feature is snared, the operator advances the capture member of the retrieval tool over the snared device attachment feature and a proximal end of the device housing, to which the attachment feature is joined, after which, the operator may apply a pull force, to disengage the device fixation member from the implant site. In some cases, the operator advances the capture member of the retrieval tool over the
snared device until a distal edge of the spring-biased sidewall thereof abuts the implant site, and then applies suction through the capture member passageway while applying the pull force.

5 BRIEF DESCRIPTION OF THE DRAWINGS

The following drawings are illustrative of particular embodiments of the present invention and therefore do not limit the scope of the invention. The drawings are not to scale (unless so stated) and are intended for use in conjunction with the explanations in the following detailed description. Embodiments will hereinafter be described in conjunction with the appended drawings wherein like numerals denote like elements, and:

Figure 1 is a schematic diagram showing potential implant sites for a relatively compact implantable medical device;

Figure 2 is a schematic showing an exemplary relatively compact implantable medical device having been delivered from a catheter to an implant site;

Figure 3 is a plan view of the exemplary relatively compact implantable medical device, which may be part of an interventional medical system, according to some embodiments;

Figures 4A-B are schematics depicting a difficulty in retrieving an implanted medical device;

Figure 5A is a plan view of a catheter and an associated retrieval tool of an interventional medical system, according to some embodiments;

Figure 5B is a longitudinal cross-section view of a portion of the catheter, according to some embodiments;

Figure 6A is a schematic depicting the employment of the system of Figures 5A-B, according to some methods;

Figure 6B is a longitudinal cross-section view of the system of Figures 5A-B, according to some embodiments;

Figure 7A is a plan view, with a partial cross-section view, of an interventional medical system, according to some alternate embodiments;
Figure 7B is an enlarged perspective view of a portion of the system, according to some embodiments;

Figures 8A-B are schematics outlining some methods of use corresponding to the system of Figures 7A-B;

Figure 9A is a plan view, with a partial cross-section view, of a catheter of an interventional medical system, according to yet further embodiments;

Figure 9B is a perspective view of a capture member and associated tethers of the system shown in Figure 9A, according to some embodiments;

Figure 9C is a cross-section view per section line C-C of Figure 9A, according to some embodiments;

Figure 9D is a plan view inside a handle of the system shown in Figure 9A, according to some embodiments;

Figure 10A is a schematic depicting the employment of the system of Figure 9A, according to some methods; and

Figure 10B is a longitudinal cross-section view of the system of Figure 9A, according to some embodiments.

DETAILED DESCRIPTION

The following detailed description is exemplary in nature and is not intended to limit the scope, applicability, or configuration of the invention in any way. Rather, the following description provides practical examples, and those skilled in the art will recognize that some of the examples may have suitable alternatives.

Figure 3 is a plan view of exemplary relatively compact implantable medical device 300, which may be part of an interventional medical system, for example, according to some embodiments described below. Figure 3 illustrates device 300 including a hermetically sealed housing 380 extending from a proximal end 381 thereof to a distal end 382 thereof and along a longitudinal axis 3. Device 300 further includes an electrode 320 and a fixation member 350, both mounted in proximity to distal end 382 of housing 380, and an electronic controller (not shown), for example, a pulse generator and an associated power supply, contained in housing 380, wherein electrode 320 is electrically coupled to the
controller via a hermetically sealed feedthrough assembly (not shown) such as is known in the art. Housing 380, for example, formed from a biocompatible and biostable metal such as titanium, may be overlaid with an insulative layer, for example, medical grade polyurethane, parylene, or silicone, and, although not shown, device 300 may include another electrode, for example, formed by removing a portion of the insulative layer to expose the metallic surface of housing 380. The other electrode may function in conjunction with electrode 320 for bipolar pacing and sensing, when fixation member 350 secures electrode 320 in intimate tissue contact at a target implant site. Figure 3 further illustrates device 300 including an attachment feature 310 joined to proximal end 381 of housing 380, wherein feature 310 is configured for snaring, for example, by an elongate snare member 42, which is described below in conjunction with Figure 4A.

With further reference to Figure 3, device fixation member 350 includes a plurality of fingers 35 spaced apart from one another around a perimeter of device housing distal end 382. Although only two fingers 35 of fixation member 350 are shown in Figure 3, fixation member 350 may include as many as eight fingers 35. According to an exemplary embodiment, fixation fingers 35 are integrally formed with one another, having been cut from Nitinol tubing, according to methods known in the art. After cutting the Nitinol tubing, fingers 35 may be shaped by bending and holding fingers 35 in the illustrated curvature while heat treating, according to methods known to those skilled in the art. Fixation member 350 may be mounted to distal end 382 of device housing 380, for example, in a manner similar to that described for a fixation component 102 in co-pending and commonly assigned United States Patent Application 2012/0172690, which description is hereby incorporated by reference. The super-elastic nature of Nitinol allows fingers 35 to elastically deform between a relaxed condition, which is shown, and an extended condition, in which a free end 305 of each finger extends distally away from distal end 382 of device housing 380, for example, as shown in Figures 6B and 10B. Figures 4A-B are schematics depicting a difficulty that may be encountered by an operator when attempting to retrieve medical device 300 from an implant site, for example, the site in proximity to an apex 103 of a right ventricle RV shown
in Figure 2. Figure 4A illustrates device receptacle 230 of catheter 200 having been advanced to the implant site, and a device retrieval tool 40 having been passed out through a distal-most opening 203 of receptacle 230. Retrieval tool 40 includes elongate snare member 42, which extends within a shaft 41 of tool 40, wherein snare member 42 may be a medical grade Nitinol wire that has a diameter of between approximately .020 inch and approximately 0.040 inch, and is slideably engaged within shaft 41 to open and close a loop thereof. Snare member 42 is shown deployed to snare device attachment feature 310, and the operator may deflect, per arrow d, shaft 41, via a steering assembly thereof, to maneuver the deployed snare member 42 into position around attachment feature 310. (Figure 5A illustrates a pull band 14 mounted to shaft 41 of tool 40, and an actuator 454 mounted to a handle 45 of tool 40, both of the steering assembly, wherein those skilled in the art will understand that an elongate pull wire extends within shaft 41 and has a distal end coupled to pull band 14 and a proximal end coupled to actuator 454.)

Once the operator has snared attachment feature 310, the operator may advance catheter 200 over retrieval tool 40 until opening 203 is brought into proximity with device housing proximal end 381, as shown in Figure 4B. Figure 4B illustrates an angle Θ that corresponds to a misalignment of a plane of distal-most opening 203 of receptacle 230 and a plane of proximal end 381 (approximately orthogonal to longitudinal axis 3 of device 300). The misalignment will likely cause a distal-most edge 23 of receptacle 230 to catch on an edge of device proximal end 381, so that the operator may find it difficult to advance receptacle 230 over the snared device 300, or to pull the snared device 300 into receptacle 230. The angle of misalignment Θ encountered in some cardiac implant sites, for example, in appendage 102 of the right atrium RA, or near apex 103 of the right ventricle RV (Figure 1), may be as great as 45 degrees.

Figure 5A is a plan view of a catheter 500 and retrieval tool 40, which may be included in an interventional medical system, according to some embodiments; and Figure 5B is a longitudinal cross-section view of a distal portion of catheter 500, according to some embodiments. Figure 5A illustrates catheter 500 including an elongate shaft 510, a handle 550 joined to a proximal end of shaft 510, and a
tubular sidewall 513 joined to a distal end of shaft 510, wherein tubular sidewall 513 defines a device receptacle 530. With reference to Figure 5B, shaft 510 includes a longitudinally extending lumen 501 configured to receive passage of device retrieval tool 40 therethrough, wherein device receptacle 530 is in fluid communication with lumen 501. Lumen 501 may have a diameter of approximately 0.154 inch (3.9 mm). Catheter 500 and retrieval tool 40 may be employed together to retrieve medical device 300 from an implant site, for example, as described above in conjunction with Figures 4A-B. But, according to the illustrated embodiment, tubular sidewall 513 is improved to include a flared inner surface 535 that defines a distal-most opening 503 of receptacle 530, and thereby alleviates the above-described difficulty associated with angle of misalignment 0, for example, as shown in the schematic of Figure 6A.

With further reference to Figure 5B, distal-most opening has a first diameter D1, which corresponds to that of receptacle 530, and a second diameter D2, which is coincident with a distal-most edge 53 of tubular sidewall 513. Second diameter D2 may be at least 5% greater than first diameter D1, or up to approximately 25% greater than first diameter D1 in some embodiments, wherein a length LF of flared inner surface 535 may be between 0.003 inch and 0.005 inch. The portion of sidewall 513 along length LF may also function as a radiopaque marker, for example, being formed from a medical grade polyamide material with a radiopaque filler, for example, Tungsten-filled Vestamid®, that is bonded to the remainder of sidewall 513, which may be formed from a medical grade polyether block amide (e.g., PEBAX® 7233 SA-01). A thickness of sidewall 513 may be approximately 0.004 inch along length LF, whereas a wall thickness along a length LR of receptacle 530 may be approximately 0.006 inch. According to the illustrated embodiment, the diameter of receptacle 530, which is equal to D1, is uniform along length LR thereof, and is sized to hold fingers 35 of device fixation member 350 in the extended condition, with free ends 305 thereof supported by diameter D1, when device 300 is contained therein, for example, as shown in Figure 6B. In an exemplary embodiment, diameter D1 is approximately 0.3 inch (7.6 mm), and length LR is at least 31 millimeters.
Catheter shaft 510, for example, extending over a length of approximately 100 cm, may be formed by a stainless steel braid-reinforced medical grade polymer, for example, one or more appropriate grades of polyether block amide, which are arranged for decreasing stiffness from handle 550 to shaft distal end (e.g., PEBAX® 3533, 6333, 4033, and 7233). In some preferred embodiments, catheter 500 further includes a steering assembly, which is similar to that described above for tool 40. Figures 5A-B illustrate the steering assembly including a pull band 514, which is mounted to shaft 510 in proximity to the distal end thereof, an actuator 554, which is mounted to handle 550, and an elongate pull wire 54, which extends along a length of shaft 510, and which has a distal end coupled to pull band 514 and a proximal end coupled to actuator 554, so that moving actuator 554 per arrow D causes pull wire 54 to deflect the distal end of shaft 510. Although not shown, catheter shaft 510 may include a pre-formed curvature in proximity to receptacle 530.

Figure 6A illustrates retrieval tool 40 having been passed through the positioned catheter 500 and manipulated to snare attachment feature 310 of the implanted device 300. Device. Like the situation described above in conjunction with Figure 4B, the plane of receptacle distal-most opening 503 is misaligned with that of device proximal end 381, by angle θ. But, due to flared inner surface 535, which defines distal-most opening 503, receptacle 530 can be "funneled" over the snared device 300, after which, the operator may apply a pull force to retrieval tool 40 to disengage device fixation member 350 from the implant site and bring device fixation member 350 into receptacle 530, so that fingers 35 thereof are held in the extended condition, as illustrated in Figure 6B.

Figure 7A is a plan view, with a partial cross-section view, of an interventional medical system 7000, according to some alternate embodiments. Figure 7A illustrates system 7000 including a catheter 700 and a retrieval tool 600, which is in sliding engagement within a lumen (not shown) of an elongate shaft 710 of catheter 700. The partial cross-section view shows the above described elongate snare member 42 of tool 600 and a portion of a shaft assembly of tool 600 extending within a device receptacle 730 of catheter 700, which is joined to a distal end of shaft 710. Device receptacle 730, in some exemplary embodiments,
may be formed from a medical grade polyether block amide (e.g., PEBAX® 7233 SA-01), while shaft 710 for example, extending over a length of approximately 100 cm, may be formed by a stainless steel braid-reinforced medical grade polymer, for example, one or more appropriate grades of polyether block amide, which are arranged for decreasing stiffness from a handle 750 of catheter 700 to shaft distal end (e.g., PEBAX® 3533, 6333, 4033, and 7233).

According to the illustrated embodiment, the shaft assembly of retrieval tool 600 includes an elongate tubular sidewall 610 and a capture member 630 joined thereto. Tubular sidewall 610 is configured for sliding engagement within the lumen of catheter shaft 710, and tubular sidewall 610 defines a lumen (not shown) in fluid communication with a passageway 631 of capture member 630 (Figure 7B). The lumen of tubular sidewall 610 and capture member passageway 631 receive snare member 42 in sliding engagement, so that snare member 42 may be advanced out through capture member passageway 631, in order to retrieve a device, such as device 300, from an implant site, for example, as shown in Figure 8A.

Figure 7B is an enlarged perspective view of capture member 630, according to some embodiments, when capture member 630 is not constrained by device receptacle 730 of catheter 700, for example, having been advanced out through a distal-most opening 703 of receptacle 730. Figure 7B illustrates capture member 630 including a collapsible spring-biased perimeter sidewall 613 that defines passageway 631, wherein passageway 631 is approximately coaxial, and in fluid communication with the lumen of tubular sidewall 610 of the retrieval tool shaft assembly. Perimeter sidewall 613 is shown extending from a proximal end thereof 61 to a distal end thereof 63, wherein proximal end 61 is coupled to tubular sidewall 610, and distal end 63 defines a distal-most opening 603 of passageway 631. Figure 7A shows perimeter sidewall 613 of capture member 630 constrained within device receptacle 730 of catheter 700 so that distal-most opening 603 is at a collapsed diameter, while Figure 7B shows distal-most opening 603 of capture member passageway 631 at a spring-biased diameter that is 2-5 times greater than a diameter of distal-most opening 703 of device receptacle 730. In either instance, capture member passageway 631 is sized to
contain at least attachment member 310 and housing proximal end 381 of device 300. According to some exemplary embodiments, perimeter sidewall 613 includes a flexible polymer mesh 602 supported by a plurality of spring-biased ribs 601, for example, a weave of medical grade polyester fibers supported by Nitinol wires, wherein a proximal end of each rib 601 defines proximal end 61 of perimeter sidewall 613, and the rib proximal ends are spaced apart from one another around a circumference of tubular sidewall 610 of the retrieval tool shaft assembly. Polymer mesh 602 may be sown in place, and/or bonded, at either end of ribs 601, according to methods known to those skilled in the art. According to the illustrated embodiment, collapsible spring-biased perimeter sidewall 613 defines a flared outer surface of capture member 630, and in some preferred embodiments, a length of capture member passageway 631 is approximately equal to an overall length of medical device 300 so that fingers 35 of device fixation member 350 can be held inside passageway 631, when fixation member 350 is disengaged from the implant site in retrieving device 300.

Figures 8A-B are schematics outlining some methods of use corresponding to system 7000. Figure 8A illustrates retrieval tool 600, having been passed through distal-most opening 703 of catheter 700, wherein device receptacle 730 of catheter 700 may be positioned in proximity to an implant site near apex 103 of a right ventricle RV shown in Figure 2, for example, having been advanced through a 23 F introducer sheath that provides vascular access at a femoral vein puncture site (not shown). Device receptacle 730 is shown including a radiopaque marker band 732, which is located in proximity to distal-most opening, according to some preferred embodiments, wherein marker band 732 may be formed a Tungsten filled polymer, for example, 75% Tungsten and 25% Vestamid® L2140, which is heat bonded to receptacle 730, for example, while being secured thereto with a sacrificial heat-shrink tube. Figure 8A further illustrates tool 600 having been maneuvered to snare attachment feature 310 of the implanted device 300. With reference back to Figures 7A-B, retrieval tool 600 further includes a steering assembly similar to that described above for retrieval tool 40. For example, Figure 7A illustrates an actuator 654 of the steering assembly mounted to a handle 650 of tool 600, which is coupled to a proximal end of tubular sidewall 610, and
Figures 7A-B further illustrate a pull band 16 mounted to tubular sidewall 610 in proximity to the distal end thereof, wherein a pull wire (not shown), which extends within tubular sidewall 610, has a proximal end coupled to actuator 654, and a distal end coupled to pull band 16. Thus, the operator can deflect the shaft assembly via the steering assembly, while maneuvering retrieval tool 600, by rotating actuator 654, for example, per arrow R. With further reference to Figure 7A, catheter 700 may also include a similar steering assembly in some embodiments, wherein a pull band 714 is mounted in proximity to the distal end of catheter shaft 710, and an actuator 754 is mounted to handle 750 of catheter 700, being movable, per arrow D, to deflect the distal end of shaft 710 via a pull wire (not shown) that extends along shaft 710 with a proximal end coupled to actuator 754 and a distal end coupled to pull band 714, for example, as described above for catheter 500 of Figure 5A.

With further reference to Figure 8A, similar to the situations described above in conjunction with Figures 4B and 6A, the plane of receptacle distal-most opening 703 is misaligned with that of device proximal end 381. But, due to the expanded distal-most opening 603 of capture member passageway 631, at the spring-biased diameter, the operator can ‘funnel’ attachment feature 310 and proximal end 381 of device housing 380 into passageway 631, after which the operator can more easily advance receptacle 730 over the snared device 300. With reference to Figure 8B, according to some embodiments and methods, the operator may advance capture member 630 over the snared device 300 until distal end 63 of spring-biased sidewall 613 abuts the implant site, and then apply a suction force through the lumen of the retrieval tool shaft assembly while applying a pull force to disengage device fixation member 350 from the implant site. The suction may draw any emboli, for example, released during the disengagement of device 300 from the implant site, into polymer mesh 602 of capture member spring biased perimeter sidewall 613, for containment within catheter 700 when the operator subsequently advances catheter 700 over retrieval tool 600, to bring device 300 and capture member 630 into device receptacle 730, according to some methods. With reference back to Figure 7A, system 7000 is shown including an optional vacuum source 670 in the form of a
syringe, which is coupled to handle 650 of retrieval tool 600 for fluid communication with the lumen defined by tubular sidewall 610. Figure 7A further illustrates a proximal sealing member 642 of handle 650, for example, a Touhy Borst type, through which snare member 42 passes, and which provides an adequate seal for vacuum source 670 to apply suction in capture member passageway 631.

Figure 9A is a plan view, with a partial cross-section view, of a catheter 900 of an interventional medical system, according to yet further embodiments, which has a retrieval tool integrated together therewith, for example, as an inner assembly extending within an outer assembly of catheter 900. It should be noted that, according to some alternate embodiments, the retrieval tool of catheter 900, rather than being an inner assembly of catheter 900, as described below, may be separate from catheter 900 and include a handle like tool 600 of system 7000. Figure 9A illustrates the outer assembly of catheter 900 including a shaft 910 and a receptacle 930 that is coupled to a distal end of shaft 910 and in fluid communication with a longitudinally extending lumen 901 of shaft 910. Catheter shaft 910, for example, extending over a length of approximately 100 cm, may be formed by a stainless steel braid-reinforced medical grade polymer, for example, one or more appropriate grades of polyether block amide, which are arranged for decreasing stiffness from a handle 950 of catheter 900 to shaft distal end (e.g., PEBAX® 3533, 6333, 4033, and 7233). Although not shown, catheter shaft 910 may include a pre-formed curvature in proximity to receptacle 930. Device receptacle 930, in some exemplary embodiments, may be formed from a medical grade polyether block amide (e.g., PEBAX® 7233 SA-01), and preferably includes a radiopaque marker band 932 integrated therein. According to some embodiments, marker band 932 is formed from a Tungsten filled polymer, for example, 75% Tungsten and 25% Vestamid® L2140, which is heat bonded to receptacle 930, for example, while being secured thereto with a sacrificial heat-shrink tube. According to some alternate embodiments, marker band 932 is a gold foil, for example, having a thickness of approximately ten microns, which is secured around receptacle 930 by a reflow of the material thereof thereover. In yet further embodiments, a radiopaque filler, such as Tungsten, may be blended
with the aforementioned PEBAX® material prior to extruding receptacle 930. A
diameter of receptacle 930, is sized to hold fingers 35 of device fixation member 350 in the extended condition, with free ends 305 thereof supported, when device 300 is contained therein, for example, as shown in Figure 10B. In an exemplary
embodiment, the diameter of receptacle 930 is approximately 0.3 inch (7.6 mm),
and a length thereof is at least 31 millimeters. Figure 9A further illustrates a
control member 953 of handle 950, which is coupled to shaft 910 for retraction thereof, per arrow R, relative to the inner assembly/retrieval tool, according to the illustrated embodiment.

With further reference to Figure 9A, a shaft subassembly of the retrieval
tool/inner assembly of catheter 900 includes an elongate tubular sidewall 810,
which may be secured to handle 950, so that shaft 910 may be moved relative thereto by control member 953. A capture member 830 of the retrieval tool/inner assembly is shown mounted to a flared distal end 812 of tubular sidewall 810,
wherein both are contained in receptacle 930. According to the illustrated
embodiment, receptacle 930 has a distal-most opening 903, which allows
passage of implantable medical device 300 therethrough, and receptacle 930 is
sized to contain device 300, along with capture member 830 and flared distal end
812 of tubular sidewall 810, for example, as shown in Figure 10B.

Figure 9B is a perspective view of capture member 830 and an associated
pair of tethers 820, according to some embodiments. Figures 9A-B illustrate
spring-biased perimeter sidewall 832 of capture member 830 defining a
passageway 831 and extending from a proximal end 81 thereof to a distal end 83
thereof, which defines a distal-most opening 803 of passageway 831. Spring-
baised sidewall 832 is shown formed by a 'serpented' wire loop, for example, a
Nitinol wire that has a diameter of approximately 0.01 inch, and has been formed
to undulate in a sinusoidal fashion around a generally circular perimeter. Figure
9A further illustrates perimeter sidewall 832 of capture member 830 constrained
within device receptacle 930 of catheter 900 so that distal-most opening 803 is at
a collapsed diameter, but, when catheter shaft 910 is retracted relative to capture
member 830 and tubular sidewall 810, for example, via control member 953 of
handle 950, so that capture member 830 is exposed outside of receptacle 930,
distal-most opening 803 of capture member passageway 631 expands to a spring-biased diameter that is greater than a diameter of distal-most opening 903 of device receptacle 930, for example, being at least 5% greater, or up to 25% greater in some embodiments. Capture member passageway 831, at both the spring-biased and collapsed diameters, is sized to contain at least attachment member 310 and housing proximal end 381 of device 300.

Figure 9B further illustrates tethers 820 secured to capture member 830 and extending proximally therefrom, for example, to couple proximal end 81 of perimeter sidewall 832 to tubular sidewall 810 by extending within first and second lumens 801, 802 defined by tubular sidewall 810, as shown in Figure 9C, which is a cross-section view per section line C-C of Figure 9A, according to some embodiments. Tethers 820 may be polymer fibers tied to capture member 830 or metal wires/cables welded to capture member 830, according to methods known in the art. With reference to Figure 9D, which is a plan view inside handle 950 of catheter 900, proximal ends of tethers 820 may extend within a tether conduit 956 within handle 950, and be secured therein by a clamping member 958, for example, a stop-cock valve, wherein the operator has access to clamping member 958 via an aperture 951 formed through a sidewall 959 of handle 950, to alternately secure and release tethers 820. (Sidewall 959 is removed from handle 950 to show the inside thereof.)

With further reference to Figure 9A in conjunction with Figure 9C, the retrieval tool/inner assembly of catheter 900 may include a steering subassembly, wherein an elongate pull wire 84 extends within a third lumen 803 of tubular sidewall 810 from a distal end thereof (not shown), which is coupled to a pull band 818 mounted to tubular sidewall 810 in proximity to flared distal end 812, to a proximal end thereof (not shown), which is coupled to an actuator 954 mounted to catheter handle 950. Catheter shaft 910, handle 950, and tubular sidewall 810 may be constructed in a manner similar to that for the tool described in the aforementioned and commonly assigned United States Patent Application US 2015/0094668, according to some embodiments. The retrieval tool/inner assembly of catheter 900 further includes snare member 42, similar to embodiments described above, wherein snare member 42 extends through a
proximal port opening 955 and a snare conduit 952 of catheter handle 950, and within a fourth lumen 804 (Figure 9C) defined by tubular sidewall 810, so that the operator can slide snare member 42 out through capture member passageway 831 (Figure 9B), and open and close the loop of snare member 42 to snare implanted device 300, for example, as shown in Figure 10A.

According to some embodiments, catheter 900 may initially be configured for deploying an implantable medical device, for example, device 300, wherein attachment feature 310 of device 300 is mounted to flared distal end 812 of inner assembly tubular sidewall 810, rather than capture member 830, and a tether that is joined to attachment feature 310 extends within lumens 801, 802 and tether conduit 956, rather than deployment member tethers 820. Thus, according to some methods, after deploying device 300 out through distal-most opening 903 of receptacle 930 to engage device fixation member 350 at the implant site, for example, according to methods described in the aforementioned '668 reference, the operator may reconfigure catheter 900 by removing the device tether from catheter 900, for example, by pulling the device tether out through a proximal opening 957 of tether conduit 956, and then assembling capture member 830 together with inner assembly tubular sidewall 810, as described above, and inserting snare member 42 through proximal port opening 955.

Figure 10A is a schematic depicting an initial step in a method for retrieving implanted device 300 with catheter 900. Figure 10A illustrates device receptacle 930 having been retracted to expose capture member 830 of the inner assembly/retrieval tool out through distal-most opening 903, wherein receptacle 930 of catheter 900 is positioned in proximity to an implant site, for example, near apex 103 of a right ventricle RV shown in Figure 2, having been advanced through a 23 F introducer sheath that provides vascular access at a femoral vein puncture site (not shown). Figure 10 further illustrates snare member 42 having been maneuvered to snare attachment feature 310 of device 300. With further reference to Figure 8A, similar to the situations described above in conjunction with Figures 4B, 6A and 8A, the plane of receptacle distal-most opening 903 is misaligned with that of device proximal end 381. But, due to the expanded distal-most opening 803 of capture member passageway 831, at the spring-biased
diameter, the operator can advance capture member 830 to ‘funnel’ attachment feature 310 and proximal end 381 of device housing 380 into capture member passageway 831, after which the operator can more easily advance receptacle 930 over the snared device 300. According to some methods, after advancing capture member 830 over attachment feature 310 and housing proximal end 381 of the snared device 300, the operator may advance device receptacle 930 over the snared device 300, for example, until distal-most opening 903 abuts the implant site, prior to applying a pull force to disengage device fixation member 350 from the implant site. Figure 10B is a longitudinal cross-section view of receptacle 930 advanced over the snared device 300, after the operator has applied a pull force to disengage device fixation member 350 from the implant site. Figure 10B illustrates spring-biased perimeter sidewall 832 of capture member 830 surrounding proximal end 381 of device housing 380 within receptacle 930, and device receptacle 930 holding fingers 35 of device fixation member 350 in the extended condition.

In the foregoing detailed description, the invention has been described with reference to specific embodiments. However, it may be appreciated that various modifications and changes can be made without departing from the scope of the invention as set forth in the appended claims.

For example, the following Items are illustrative of further embodiments:

Item 1. An interventional medical system comprising an implantable medical device, a catheter, and a retrieval tool; the medical device comprising an electronic controller, a hermetically sealed housing containing the controller, an electrode electrically coupled to the controller and mounted in proximity to a distal end of the housing, an attachment feature joined to a proximal end of the housing, and a fixation member mounted to the distal end of the housing; the catheter comprising an elongate shaft and a device receptacle joined to a distal end of the shaft, the shaft including a longitudinally extending lumen, and the device receptacle being sized to contain the medical device therein and having a distal-most opening that allows passage of the medical device therethrough, and the device receptacle being in fluid communication with the shaft lumen; and the retrieval tool comprising an elongate snare member and a shaft assembly, the
shaft assembly comprising an elongate tubular sidewall that defines a lumen configured to receive passage of the snare member therethrough, the elongate tubular sidewall configured for sliding engagement within the lumen of the catheter shaft; and wherein the shaft assembly of the retrieval tool further comprises:

5 a capture member comprising a collapsible spring-biased perimeter sidewall, the perimeter sidewall defining a passageway that is approximately coaxial, and in fluid communication with the lumen of the tubular sidewall of the retrieval tool shaft assembly, the perimeter sidewall extending from a proximal end thereof to a distal end thereof, the proximal end being coupled to the tubular sidewall of the shaft assembly, and the distal end defining a distal-most opening of the passageway; and

10 wherein the distal-most opening of the capture member passageway has a spring-biased diameter that is greater than a diameter of the distal-most opening of the device receptacle of the catheter; the distal-most opening of the capture member passageway has a collapsed diameter that is less than the diameter of the device receptacle distal-most opening, when the capture member is received within the device receptacle; and the capture member passageway is sized to contain the attachment member of the medical device and the proximal end of the medical device housing.

Item 2. The system of item 1, wherein:

the collapsible spring-biased perimeter sidewall of the capture member of the retrieval tool shaft assembly defines a flared outer surface of the capture member, when the distal-most opening of the passageway defined thereby is at the spring-biased diameter; and

25 a length of the capture member passageway is approximately equal to an overall length of the medical device.

Item 3. The system of any one of items 1-2, wherein the collapsible spring-biased perimeter sidewall comprises a flexible polymer mesh supported by a plurality of spring-biased ribs, a proximal end of each rib defining the proximal end of the
perimeter sidewall, and the rib proximal ends being spaced apart from one another around a circumference of the tubular sidewall of the retrieval tool shaft assembly.

Item 4. The system of any one of items 1-3, wherein:

the spring-biased diameter of the distal-most opening of the capture member passageway of the retrieval tool shaft assembly is 2 to 5 times greater than the diameter of the distal-most opening of the device receptacle of the catheter; and

the collapsible spring-biased perimeter sidewall of the capture member comprises a flexible polymer mesh supported by a plurality of spring-biased ribs, a proximal end of each rib defining the proximal end of the perimeter sidewall, and the rib proximal ends being spaced apart from one another around a circumference of the tubular sidewall of the retrieval tool shaft assembly.

Item 5. The system of any one of items 1-4, further comprising:

a vacuum source adapted for coupling to the retrieval tool shaft assembly, so that suction can be applied through the lumen defined by the tubular sidewall and through the capture member passageway of the retrieval tool shaft assembly; and

wherein a length of the capture member passageway is approximately equal to an overall length of the medical device.
Item 6. The system of any one of items 1-5, wherein:
the tubular sidewall of the retrieval tool shaft assembly includes a flared distal end; and
the collapsible spring-biased perimeter sidewall of the capture member comprises a 'serpentinised' wire loop mounted to the flared distal end of the shaft assembly tubular sidewall.

Item 7. The system of any one of items 1-6, wherein:
the retrieval tool shaft assembly further comprises a pair of elongate tethers extending along a length of the tubular sidewall thereof and on opposite sides of the lumen defined by the sidewall; and
the proximal end of the collapsible spring-biased perimeter sidewall is coupled to the shaft assembly tubular sidewall by the pair of elongate tethers.

Item 8. The system of any one of items 1-7, wherein the retrieval tool shaft assembly further comprises a steering subassembly; and wherein the steering subassembly comprises an elongate pull wire, a pull band, and an actuator, the pull wire extending along a length of the tubular sidewall of the shaft assembly from a proximal end of the wire to a distal end of the wire, the pull band being mounted to a distal end of the tubular sidewall of the shaft assembly, in proximity to the capture member, and being coupled to the distal end of the pull wire, and the actuator being mounted to a handle of the retrieval tool and being coupled to the proximal end of the pull wire.

Item 9. An assembly comprising a snare member and a shaft subassembly, the shaft subassembly comprising a tubular sidewall that defines a lumen configured to receive passage of the snare member therethrough, the tubular sidewall having a flared distal end defining a distal-most opening of the lumen, and the tubular sidewall being configured for sliding engagement within a catheter of an interventional medical system, the catheter including an elongate shaft and a device receptacle coupled to a distal end of the shaft, the device receptacle being in fluid communication with a lumen of the catheter shaft, and being sized to
contain an implantable medical device therein, the device receptacle having a distal-most opening that allows passage of the medical device therethrough; and wherein the shaft subassembly of the assembly further comprises:

- a capture member comprising a collapsible spring-biased perimeter sidewall formed by a 'serpentinized' wire loop mounted to the flared distal end of the tubular sidewall, the perimeter sidewall defining a passageway, the passageway being approximately coaxial, and in fluid communication with the lumen of the tubular sidewall; and wherein the passageway has a spring-biased diameter that is greater than a diameter of the device receptacle of the catheter, and has a collapsed diameter that is less than the diameter of the device receptacle, when the capture member is received within the device receptacle; and the capture member passageway is sized to contain a proximal end of a housing of the medical device and an attachment member of the medical device that is coupled to the proximal end of the housing.

Item 10. The assembly of item 9, wherein:

- the shaft subassembly further comprises a pair of elongate tethers extending along a length of the tubular sidewall thereof and on opposite sides of the lumen defined by the sidewall; and

- the collapsible spring-biased perimeter sidewall of the capture member is coupled to the tubular sidewall by the pair of elongate tethers.

Item 11. The assembly of any one of items 9-10, wherein the shaft subassembly further comprises a handle coupled to the proximal end of the tubular sidewall, the handle including a clamping member through which the pair of elongate tethers extend, the clamping member configured to alternately secure and release the tethers.

Item 12. A method for converting a catheter from a first configuration to a second configuration, the first configuration suitable for deploying an implantable medical
device to an implant site, and the second configuration suitable for retrieving an implantable medical device from an implant site; and the method comprising:

removing a device tether from first and second lumens of an inner assembly of the catheter, the first and second lumens being defined by a tubular sidewall of the inner assembly;

mounting a capture member to a flared distal end of a tubular sidewall of the inner assembly by inserting a pair of capture member tethers into the first and second lumens, after removing the device tether therefrom, the flared distal end defining a distal-most opening for the first and second lumens and for a snare lumen defined by the tubular sidewall;

collapsing a spring-biased sidewall of the mounted capture member within a device receptacle of the catheter, the device receptacle being coupled to a distal end of a shaft of an outer assembly of the catheter, the device receptacle being in fluid communication with a lumen of the shaft and having a distal-most opening that allows passage of a medical device therethrough, and the inner assembly being slideably engaged within the lumen of the outer assembly shaft; and

inserting a snare member through the snare lumen of the inner assembly.

Item 13. The method of item 12, further comprising securing a proximal end of each of the capture member tethers within a clamping member of a handle of the catheter, after mounting the capture member to the inner assembly, the handle being coupled to a proximal end of the inner assembly tubular sidewall and to the outer assembly shaft.

Item 14. A method for retrieving an implantable medical device from an implant site, the medical device comprising an electronic controller, a hermetically sealed housing containing the controller, an electrode electrically coupled to the controller and mounted in proximity to a distal end of the housing, an attachment feature joined to a proximal end of the housing, and a fixation member mounted to the distal end of the housing, the fixation member comprising a plurality of fingers spaced apart from one another around a perimeter of the distal end of the
housing, each finger being elastically deformable between a relaxed condition and an extended condition, a free end of each finger extending distally away from the distal end of the device housing, when the finger is in the extended condition, and the method comprising:

advancing a device receptacle of a catheter of an interventional medical system to the implant site so that a distal-most opening of the device receptacle is located in proximity to the medical device, the device receptacle being coupled to a distal end of a shaft of the catheter, the device receptacle being in fluid communication with a lumen of the shaft and having a distal-most opening that allows passage of the medical device therethrough;

snaring the attachment feature of the medical device with a snare member of a retrieval tool, the retrieval tool being in sliding engagement within the lumen of the catheter shaft, and the snare member being in sliding engagement within a lumen of a shaft assembly of the tool;

causing a spring-biased sidewall of a capture member of the retrieval tool shaft assembly to open to a spring-biased diameter, the spring-biased sidewall defining a passageway in fluid communication and approximately coaxial with the lumen of the shaft assembly of the tool;

advancing the capture member of the retrieval tool shaft assembly, with the spring-biased sidewall opened to the spring-biased diameter, over the snared device attachment feature and the proximal end of the device housing;

applying a pull force, after advancing the capture member over the snared device attachment feature and the proximal end of the device housing, to disengage the device fixation member from the implant site; and

advancing the device receptacle over the advanced capture member and the disengaged device to contain the capture member and the device in the receptacle so that the fingers of the device fixation member are held in the extended condition by the receptacle.
Item 15. The method of item 14, further comprising advancing the device receptacle of the catheter over the snared device with the capture member advanced thereover, prior to applying the pull force.

Item 16. The method of any one of items 14-15, wherein the device receptacle of the catheter is advanced over the snared device until the distal-most opening thereof abuts the implant site.

Item 17. The method of any one of items 14-16, further comprising deflecting the shaft assembly of the retrieval tool after snaring the device attachment feature and prior to advancing the device receptacle of the catheter over the snared device.

Item 18. The method of any one of items 14-17, wherein the capture member of the retrieval tool is advanced over the snared device until a distal end of the spring-biased sidewall thereof abuts the implant site; and further comprising applying a suction force through the lumen of the retrieval tool shaft assembly while applying the pull force.
Item 19. An interventional medical system comprising an implantable medical device, a device retrieval tool, and a catheter; the medical device comprising an electronic controller, a hermetically sealed housing containing the controller, an electrode electrically coupled to the controller and mounted in proximity to a distal end of the housing, an attachment feature joined to a proximal end of the housing, and a fixation member mounted to the distal end of the housing, the fixation member comprising a plurality of fingers spaced apart from one another around a perimeter of the distal end of the housing, each finger being elastically deformable between a relaxed condition and an extended condition, a free end of each finger extending distally away from the distal end of the device housing, when the finger is in the extended condition; the device retrieval tool configured to snare the attachment feature of the medical device; and the catheter comprising an elongate shaft and tubular sidewall that defines a device receptacle, the tubular sidewall being joined to a distal end of the shaft, the shaft including a longitudinally extending lumen configured to receive passage of the device retrieval tool therethrough, the device receptacle being in fluid communication with the shaft lumen, the receptacle having a length and a diameter uniform along the length, to hold the fingers of the device fixation member in the extended condition when the medical device is contained therein; and wherein an improvement to the tubular sidewall of the catheter comprises:

- a flared inner surface defining a distal-most opening into the receptacle, the opening having a first diameter and a second diameter, the first diameter being equal to the diameter of the receptacle and the second diameter being at least 5% greater than the diameter of the receptacle, the second diameter being coincident with a distal-most edge of the tubular sidewall;

and

- wherein a length of the flared inner surface is between 0.003 inch and 0.005 inch.

Item 20. The system of item 19, wherein the improvement further comprises a radiopaque filler blended into the tubular sidewall along the length of the flared inner surface.
We claim:
1. An interventional medical system comprising an implantable medical device, a catheter, and a retrieval tool; the medical device comprising an electronic controller, a hermetically sealed housing containing the controller, an electrode electrically coupled to the controller and mounted in proximity to a distal end of the housing, an attachment feature joined to a proximal end of the housing, and a fixation member mounted to the distal end of the housing; the catheter comprising an elongate shaft and a device receptacle joined to a distal end of the shaft, the shaft including a longitudinally extending lumen, and the device receptacle being sized to contain the medical device therein and having a distal-most opening that allows passage of the medical device therethrough, and the device receptacle being in fluid communication with the shaft lumen; and the retrieval tool comprising an elongate snare member and a shaft assembly, the shaft assembly comprising an elongate tubular sidewall that defines a lumen configured to receive passage of the snare member therethrough, the elongate tubular sidewall configured for sliding engagement within the lumen of the catheter shaft; and wherein the shaft assembly of the retrieval tool further comprises:
   a capture member comprising a collapsible spring-biased perimeter sidewall, the perimeter sidewall defining a passageway that is approximately coaxial, and in fluid communication with the lumen of the tubular sidewall of the retrieval tool shaft assembly, the perimeter sidewall extending from a proximal end thereof to a distal end thereof, the proximal end being coupled to the tubular sidewall of the shaft assembly, and the distal end defining a distal-most opening of the passageway; and
   wherein the distal-most opening of the capture member passageway has a spring-biased diameter that is greater than a diameter of the distal-most opening of the device receptacle of the catheter;
the distal-most opening of the capture member passageway has a collapsed diameter that is less than the diameter of the device receptacle distal-most opening, when the capture member is received within the device receptacle; and
the capture member passageway is sized to contain the attachment member of the medical device and the proximal end of the medical device housing.
2. The system of claim 1, wherein:
   the collapsible spring-biased perimeter sidewall of the capture member of the retrieval tool shaft assembly defines a flared outer surface of the capture member, when the distal-most opening of the passageway defined thereby is at the spring-biased diameter; and
   a length of the capture member passageway is approximately equal to an overall length of the medical device.

3. The system of claim 2, wherein the collapsible spring-biased perimeter sidewall comprises a flexible polymer mesh supported by a plurality of spring-biased ribs, a proximal end of each rib defining the proximal end of the perimeter sidewall, and the rib proximal ends being spaced apart from one another around a circumference of the tubular sidewall of the retrieval tool shaft assembly.

4. The system of any one of claims 1-3, wherein:
   the spring-biased diameter of the distal-most opening of the capture member passageway of the retrieval tool shaft assembly is 2 to 5 times greater than the diameter of the distal-most opening of the device receptacle of the catheter; and
   the collapsible spring-biased perimeter sidewall of the capture member comprises a flexible polymer mesh supported by a plurality of spring-biased ribs, a proximal end of each rib defining the proximal end of the perimeter sidewall, and the rib proximal ends being spaced apart from one another around a circumference of the tubular sidewall of the retrieval tool shaft assembly.

5. The system of claim 4, further comprising:
   a vacuum source adapted for coupling to the retrieval tool shaft assembly, so that suction can be applied through the lumen defined by the tubular sidewall and through the capture member passageway of the retrieval tool shaft assembly; and
   wherein a length of the capture member passageway is approximately equal to an overall length of the medical device.
6. The system of any one of claims 1-5, wherein:
   the tubular sidewall of the retrieval tool shaft assembly includes a flared distal end;
   and
   the collapsible spring-biased perimeter sidewall of the capture member comprises a 'serpentinened' wire loop mounted to the flared distal end of the shaft assembly tubular sidewall.

7. The system of claim 6, wherein:
   the retrieval tool shaft assembly further comprises a pair of elongate tethers extending along a length of the tubular sidewall thereof and on opposite sides of the lumen defined by the sidewall; and
   the proximal end of the collapsible spring-biased perimeter sidewall is coupled to the shaft assembly tubular sidewall by the pair of elongate tethers.

8. The system of any one of claims 1-7, wherein the retrieval tool shaft assembly further comprises a steering subassembly; and wherein the steering subassembly comprises an elongate pull wire, a pull band, and an actuator, the pull wire extending along a length of the tubular sidewall of the shaft assembly from a proximal end of the wire to a distal end of the wire, the pull band being mounted to a distal end of the tubular sidewall of the shaft assembly, in proximity to the capture member, and being coupled to the distal end of the pull wire, and the actuator being mounted to a handle of the retrieval tool and being coupled to the proximal end of the pull wire.
## INTERNATIONAL SEARCH REPORT

**International application No:**
PCT/US2016/038609

### A. CLASSIFICATION OF SUBJECT MATTER

**INV.** A61N1/375 A61N1/05 A61N1/362

According to International Patent Classification (IPC) or to both national classification and IPC

### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A61N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Date of the actual completion of the international search

19 August 2016

Date of mailing of the international search report

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Name and mailing address of the ISA/Authorized officer

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016

Scheffler, Arnaud

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<td>US 2013053921 AI</td>
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<td>WO 2013032624 A2</td>
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<td>EP 2771064 AI</td>
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<td>02-05-2013</td>
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<td>CN 103384546 A</td>
<td>06-11-2013</td>
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<td>CN 103561810 A</td>
<td>05-02-2014</td>
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<td>EP 2658599 AI</td>
<td>06-11-2013</td>
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<td>06-11-2013</td>
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<td>US 2012172690 A</td>
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<td>WO 2012092067 A</td>
<td>05-07-2012</td>
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