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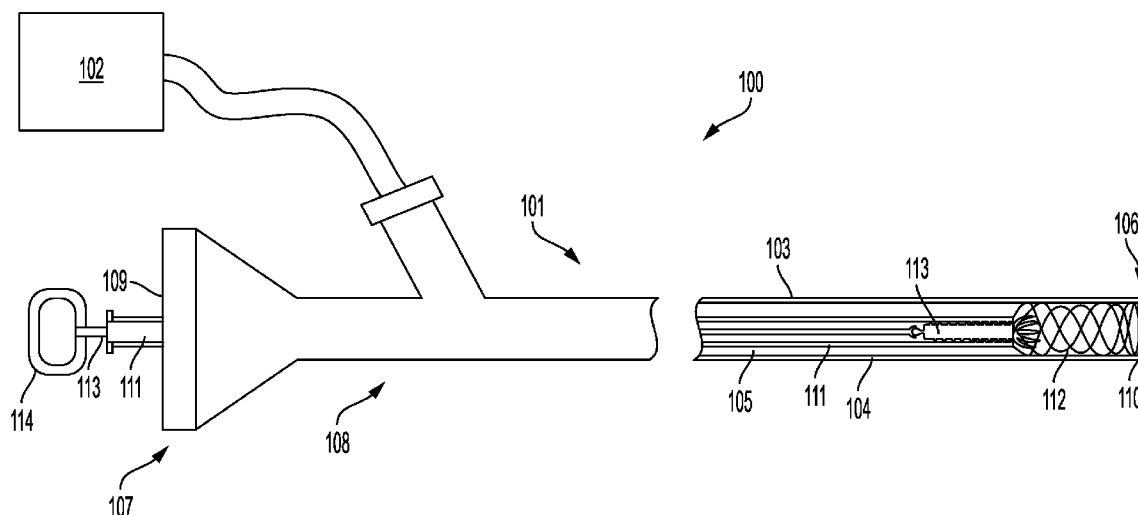


FIG. 1

(57) Abstract: Systems and methods for removing thromboembolic material from blood vessels, including a first, outer catheter, a second, inner catheter disposed inside of the first catheter, an elongate member disposed inside of the second catheter, and a stent arranged adjacent to the distal end of the second catheter. The stent can be expanded to encapsulate at least a portion of a thrombus, and the elongate member can be rotated to break down the thrombus for removal from the blood vessel. In one or more embodiments, the first catheter is provided with aspiration capability to assist in removal of the thrombus.

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SYSTEMS AND METHODS FOR REMOVAL OF CLOT MATERIAL FROM A BLOOD VESSEL

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 63/462,027, filed April 26, 2023 and No. 63/465,559, filed May 11, 2023, which are incorporated by reference as if disclosed herein in their entireties.

BACKGROUND

[0002] An ischemic stroke occurs when a blood clot, or thrombus, prevents the supply of blood to an area of the brain. This lack of blood supply can lead to lasting brain damage, long-term disability, or even death. Over 15 million people worldwide experience a stroke every year, with 87% of these strokes being ischemic.

[0003] Thrombolytics, mechanical thrombectomy, and surgical thrombectomy are the three courses of treatment that are FDA approved for ischemic stroke. There are complications with each of these thrombus removal methods that decrease patients' ability to return to their baseline neurological ability. The complication that produces the most devastating effects is failing to remove the entire thrombus.

[0004] The current standard of care for treating ischemic strokes is the use of IV thrombolytics in conjunction with a mechanical thrombectomy. Thrombolytics are a class of drug that break up and dissolve blood clots. Mechanical thrombectomies are conducted using catheters, aspiration devices, and stent retrievers.

[0005] Current methods of thrombus removal can cause significant problems. In one method, a catheter and wire system is passed through a thrombus and is then withdrawn in an attempt to remove the thrombus. However, if a piece of the thrombus is left behind while the rest of the catheter-wire system and thrombus is removed, another pass of the system is required to retrieve the remaining thrombus. This increases the risk of vessel damage and hemorrhage. The remaining thrombus could also travel into a smaller cerebral vessel that is unreachable by a catheter and cause additional clotting.

[0006] Similarly, an embolus is a clot formed of any foreign material that moves, and could include air, fat, blood clot, and other foreign material. An embolism occurs when an embolus becomes stuck and reduces blood flow.

[0007] What is needed, therefore, is an improved clot removal device that will improve patient outcomes.

SUMMARY

[0008] One or more embodiments of the present technology are directed to systems for removing clot material from a blood vessel. In one or more embodiments, the system includes a device that includes a first, outer catheter having an opening at its distal end, a second, inner catheter disposed within the first catheter and movable relative thereto, a stent, arranged adjacent to a distal end of the second catheter, and an elongate member disposed within the second catheter and movable and rotatable relative to the second catheter. In one or more embodiments, at least a distal end of the elongate member is extendable within an interior volume of the stent and is adapted to break down clot material. In one or more embodiments, the first and second catheters are sized such that a gap exists between an inner surface of the first catheter and an outer surface of the second catheter to permit clot material to be aspirated by the first catheter via the opening. The system further includes an aspiration pump coupled to the device to generate suction at the distal end of the first catheter.

[0009] One or more embodiments of the present technology are directed to devices for removing clot material from a blood vessel, the device comprising a first, outer catheter having an opening at its distal end, a second, inner catheter disposed within the first catheter and movable relative thereto, a stent, arranged adjacent to a distal end of the second catheter, and an elongate member disposed within the second catheter and movable and rotatable relative to the second catheter. In one or more embodiments, at least a distal end of the elongate member is extendable within an interior volume of the stent and is adapted to break down clot material. In one or more embodiments, the distal end of the elongate member includes one or more features for accelerating the break-up of the clot: barbs that extend radially from the member, high-friction surface(s), and/or mesh structures for cutting/slicing the clot.

[0010] One or more embodiments of the present technology are directed to methods for removal of clot material from a blood vessel, the method comprising the steps of advancing a first catheter to the site of a clot in a blood vessel, the first catheter comprising, within its interior volume: a second catheter; a stent, attached to a distal end of the second catheter; and an elongate member, disposed within the second catheter and movable along its elongate axis

and rotatable relative to the second catheter. The first catheter is then pushed through the clot at the site, and then retracted relative to the second catheter so that the stent expands to an expanded state to at least partially encapsulate the clot. The elongate member is then advanced through at least a portion of the clot. A distal portion of the elongate member is rotated, wherein the distal end of the elongate member is adapted to break down clot material via one or more barbs extending radially from the distal end of the elongate member. During this process fragments of the clot are aspirated into a gap formed between an inner surface of the first catheter and an outer surface of the second catheter.

[0011] Various embodiments of the technology will now be described with reference to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The drawings show embodiments of the disclosed subject matter for the purpose of illustrating the invention. However, it should be understood that the present application is not limited to the precise arrangements and instrumentalities shown in the drawings, wherein:

[0013] FIG 1 shows a partial sectional side view of a system according to an embodiment of the disclosure.

[0014] FIG. 2 shows a partial sectional side view of a distal end of the embodiment of FIG. 1.

[0015] FIG. 3 shows a partial sectional side view of a distal end of the embodiment of FIG. 1.

[0016] FIG. 4 shows a partial sectional side view of a distal end of the embodiment of FIG. 1.

[0017] FIG. 5 shows a partial sectional side view of a distal end of the embodiment of FIG. 1.

[0018] FIG. 6 shows a perspective view of an elongate member that is part of one or more embodiments of the present technology.

DETAILED DESCRIPTION

[0019] One or more embodiments of the present technology are directed to a system for removing clot material from a blood vessel. As used herein, “clot material” refers to any material that reduces, restricts, or blocks blood flow in a blood vessel, including thrombi, thromboembolic material, and emboli. A first, exemplary embodiment of such a system is shown in FIG. 1. In this embodiment, the system 100 comprises a device 101 and an aspiration pump 102. The device 101 comprises a first catheter 103 (also referred to as an “outer catheter”), which includes a tubular catheter section 104 having a main lumen 105

extending between a distal end 106 and a proximal end 107. The catheter section 104 can be constructed from any composition having suitable biocompatibility, flexibility, and strength characteristics. In one or more embodiments, viscoelastic materials are preferred due to their high mobility through blood vessels. Examples of suitable materials for the catheter section 104 include polymers, such as silicone or polyurethane, which may be embedded with braided metal components such as stainless steel. In one or more embodiments, at least portions of the catheter section 104 include radiopaque materials so that the catheter can be visualized using X-ray. The first catheter can be sized depending upon the entry point into the vasculature, the location of the clot, variances in patient anatomy, and any extenuating circumstances. In an exemplary embodiment, the catheter section 104 has a length of about 140 cm. Other embodiments may have a length between about 120 cm and 140cm. In an exemplary embodiment, the catheter section 104 has an outer diameter of about 3 mm and a wall thickness between about 0.05 mm and 0.9 mm.

[0020] The first catheter 103 also includes a proximal assembly 108 coupled to the proximal end 107 for the purpose of coupling the lumen 105 to the aspiration pump 102. As described herein, the distal end 106 of the first catheter 103 includes an opening 110 to permit the aspiration of materials into the lumen 105. In the embodiment shown in FIG. 1, the entire distal end 106 is open. In other embodiments, an opening is formed in the wall of the catheter section 104. The aspiration pump 102 supplies the suction force at the opening 110.

[0021] The assembly 108 also includes an access port 109 for allowing the passage of additional device elements into the lumen 105, as will be discussed below. In one or more embodiments, the port 109 is sealed in a leak-free fashion to permit efficient use of the aspiration pump 102 and to prevent material from travelling into or out of the lumen 105 and any associated contamination.

[0022] In the embodiment shown in FIG. 1, the device 101 further comprises a second catheter 111, disposed within the catheter section 104 of the first catheter 103. The second catheter 111 extends through the port 109, and, in one or more embodiments, is fixed in position relative to the first catheter 103 by a friction fit at the seal between the two catheters. In one or more embodiments, the second catheter 111 is constructed using similar or the same materials as the first catheter 103, and specifically the catheter section 104. In an exemplary embodiment, the second catheter has an outer diameter of about 1.5 mm and a wall thickness between about 0.05 mm and 0.9 mm.

[0023] As shown in detail in FIG. 2, the difference in the diameters of the first catheter 103 and the second catheter 111 creates a gap between an inner surface of the first catheter 103

and an outer surface of the second catheter 111 to permit clot material to be aspirated by the first catheter via the opening 110.

[0024] In the embodiment shown in FIG. 1, the device 101 further comprises a stent 112, which is arranged adjacent to the distal end of the second catheter. The stent 112 is constructed as a wire mesh or net structure, as is generally known in the art. In one or more embodiments, the stent 112 is a self-expanding stent, which has a compressed state and an expanded state. In other embodiments, the stent 112 is expanded as the result of an applied force, such as one or more control wires or a balloon. For example, the stent 112 can automatically expand when it is removed from a space that confines it. More specifically for example, the stent 112, in one or more embodiments, is in a compressed state when it is confined within the catheter section 104 of the first catheter 103. Due to spring forces generated by the material of the stent 112, the stent will automatically expand to an expanded state when it is slid out of the distal end 106 of the catheter. This feature will be discussed in further detail in connection with FIGs. 2-5, below. In one or more embodiments, the stent 112 is formed of Nitinol material due to its viscoelastic properties. In other embodiments, the stent is made of other suitably flexible and biocompatible material. In one or more embodiments, the stent 112 includes one or more radiopaque markers made from radiopaque materials so that the stent can be visualized using X-ray during a procedure.

[0025] The device 101 shown in FIG. 1 further comprises an elongate member 113, which is disposed within the second catheter 111 and is movable along its elongate axis relative to the second catheter 111 and is rotatable relative to the second catheter 111. The elongate axis refers to the axis running along the length of the elongate member 113. The elongate member 113, in this embodiment, includes a handle 114 which permits a user of the device to translate the elongate member 113 and rotate the elongate member 113. As described further below, one use of the elongate member is to rotate within the clot material to mechanically break up the clot and allow for easy removal of the clot materials.

[0026] In one or more embodiments, as described below in connection with FIGs. 2-5, the elongate member 113 includes a threaded engagement with the second catheter 111 and a ball-and-socket joint that permits the distal end of the member 113 to rotate when the user pushes or pulls on the handle 114. In other embodiments, the elongate member 113 does not include a ball-and-socket joint but is formed of a sufficiently flexible material such that the distal end will rotate relative to the handle. For example, Nitinol is employed in such embodiments. In other embodiments, for example as shown in FIG. 6, an elongate member 213 comprises a wire section 220 that extends most of the length between the handle 214 on

the proximal end of the member 213 and the distal end of the member 213, where the barbs 215 are located. The wire section is designed to have sufficient stiffness to permit the application of translational force along the elongate axis of the member, as well as torsional stiffness to permit the application of a rotational force along the length of the member. In other words, when a user twists the handle 214, a corresponding twist in the distal end of the member occurs with very little lag in one or more embodiments. Suitable materials for the wire section include stainless steel and other metals.

[0027] In this embodiment, at least a distal end of the elongate member is extendable within an interior volume of the stent and is adapted to break down clot material at the site of a blood clot. A distal portion of the elongate member 113 includes one or more features adapted to break up a blood clot by breaking it into smaller pieces, mashing it into a more flowable state, or combinations of these. In one or more embodiments the distal portion includes a high friction surface, such as ridges or abrasive protrusions like sandpaper. In one or more embodiments, a wire mesh structure is included at the distal end that is adapted for cutting through blood clot material.

[0028] In the embodiment shown in FIGs. 1-5, the elongate member comprises one or more barbs 115 extending radially from its distal end for breaking down clot material. The barbs increase the device's impact on the clot and perform a shredding function. The barbs have a variety of shapes in various embodiments. In the embodiment shown in the figures, the barbs have a blade-like shape. Other shapes also are suitable provided they facilitate a shredding, tearing, slicing, or grinding function to break up a clot. In one or more embodiments, the elongate member 113 includes both a high friction surface and barbs to further increase the mechanical breakdown of the clot.

[0029] FIG. 2 shows a close-up view of the distal end 106 of the device 101. In this view, the second catheter 111 is sufficiently within the catheter section 104 of the first catheter 103 such that the stent 112 is confined within the walls of the catheter section 104 of the first catheter 103 and in a compressed state. In this embodiment, the elongate member 113 further comprises threads 116 on its outer surface for engaging corresponding protrusions 117 on an inner surface of the second catheter 111. This permits the elongate member 113 to rotate about its elongate axis when a translational force along its elongate axis is applied to pull or push the elongate member 113 relative to the second catheter 111. In this embodiment, the elongate member 113 further comprises a ball and socket joint 118 that permits a distal portion 119 of the member to rotate relative to a proximal portion 120 of the elongate member 113 and also permits translational movement of the distal end of the member 113

relative to the second catheter 111. In this embodiment, the distal portion 119 includes the threads 116 and the ball portion 121 of the ball and socket joint 118. In this embodiment, the proximal portion 120 includes the socket portion 122 of the ball and socket joint 118. This arrangement is reversed in other embodiments. Thus, when a user pushes or pulls on the handle 114, the distal portion 119 will rotate as a result of the threads and ball and socket arrangement.

[0030] FIG. 2 also shows the stent 112 attached to the distal end of the second catheter 111. The attached end of the stent 112 is open so that the distal portion 119 of the elongate member 113 can be moved into the interior volume of the stent 112. As mentioned above, in FIG. 2, the stent 112 is shown in a collapsed state because it is confined within the first catheter 103. In this embodiment, the stent 112 is self-expanding and will expand to an expanded state when it is moved outside of the catheter section 104 of the first catheter 103. In other embodiments, a stent is used that is manually expandable, such as through the use of one or more control wires or a balloon. In one or more embodiments, the stent is attached to a distal end of the first catheter, and is manually expandable. In one or more embodiments, FIG. 2 shows the state of the device as it is introduced into a patient's blood vessel and advanced to the site of a blood clot.

[0031] FIG. 3 shows the device in position at the site of a blood clot 123 within a blood vessel 124. The first catheter 103 and/or the second catheter 111 have been moved relative to each other so that the stent 112 is now completely outside of the catheter section 104 of the first catheter 103. The stent 112 is surrounding the clot 123, after having self-expanded through the clot.

[0032] In one or more embodiments, FIG. 3 shows the state of the device after it has been pushed through the clot 123 and then the first catheter 103 has been retracted relative to the second catheter 111 so that the stent 112 expands into the clot.

[0033] FIG. 3 also shows a gap 125 between the outer surface of the second catheter 111 and the inner surface of the catheter section 104. In this embodiment, the catheter section 104 of the first catheter 103 has an inner diameter of about 3 millimeters and the second catheter 111 has a diameter of about 1.5 millimeters so that the gap 125 has a total diameter of about 1.5 millimeters. Here, the total diameter refers to the total distance between the second catheter 111 and the inner surface of the catheter section 104. The shape of the gap can change during use of the device since the second catheter can move radially within the catheter section 104. When the second catheter is located at the center of the catheter section 104, the total distance would be the sum of the gaps 125a and 125b.

[0034] FIG. 4 again shows a close-up view of the distal end 106 of the device 101, in which the distal portion 119 of the elongate member 113 is engaging the clot 123 to break it down for removal. The distal portion with the barbs 115 is rotated while being pushed against the clot 123 to tear, slice, and/or grind the clot into smaller pieces and/or a more liquid, flowable material. In this embodiment, the stent 112 traps the clot and forms a barrier between the distal portion 119 and the blood vessel walls 124 to prevent damage to the blood vessel by the rotation of the distal portion 119. In this embodiment, the stent 112 traps the clot pieces and prevents them from travelling deeper into the blood vessel distally of the device.

[0035] FIG. 5 shows an additional close-up view of the distal end 106 of the device 101, in which the clot 123 has been broken into numerous smaller pieces. The elongate member 113 has been retracted into the second catheter 111, and the second catheter has been partially retracted into the catheter section 104 of the first catheter 103. This is causing the stent 112 to collapse on its proximal end as it is confined within the catheter section 104. The aspiration function of the first catheter is suctioning pieces of the clot 123 into the catheter section 104 so that they can be removed. The aspiration combined with the stent 112, in this embodiment, captures substantially all of the clot material from the clot 123. The stent 112 can be full retracted into the catheter section 104 or partially retracted for removal of the device from the site of the blood clot. In one or more embodiments, the stent 112 is not retracted into the catheter section 104, but the device is simply withdrawn from the blood vessel.

[0036] According to an additional embodiment of the present technology, a method for the removal of clot material from a blood vessel is provided. The method comprises advancing a first catheter 103 to the site of a clot 123 in a blood vessel 124. In this embodiment, the first catheter 103 includes, within its interior volume: a second catheter 111, a stent 112, attached to the distal end of the second catheter 111; and an elongate member 113, disposed within the second catheter 111 and movable along its elongate axis and rotatable relative to the second catheter 111. Once the first catheter reaches the site of the clot, the first catheter is pushed through the clot 123. Then, the first catheter is retracted relative to the second catheter 111 so that the stent 112 self-expands to an expanded state to at least partially encapsulate the clot 123. In an embodiment, the user would hold the second catheter 111 steady while pulling back on the first catheter 103 slowly. The stent 112 would expand through the clot due to the stent 112's inherent spring force causing it to self-expand and push and slice through the clot. In one or more embodiments, the user would then wait a short period of time to allow the clot 123 to obtain some adherence to the stent 112.

[0037] Next, in one or more embodiments, the elongate member 113 is advanced, relative to the second catheter 111, through at least a portion of the clot. In one or more embodiments, the distal portion of the elongate member 113 is rotated, wherein the distal end of the elongate member is adapted to break down clot material via one or more barbs 115 extending radially from the distal end of the elongate member.

[0038] In one or more embodiments, the method includes aspirating fragments of the clot 123 into a gap formed between an inner surface of the first catheter 103 and an outer surface of the second catheter 111. These fragments are the result of either the stent 112 or the barbs 115 slicing through the clot, or both, or are simply smaller clots picked up by the device.

[0039] In one or more embodiments, the method also includes retracting the elongated member 113 into the second catheter 111, and then retracting the second catheter 111 into the first catheter 103 so that the stent 112 is pulled into the first catheter. In other embodiments, the stent 112 remains in its expanded state or a partially expanded state while the device is withdrawn from the body.

[0040] In one or more embodiments, the steps of advancing the elongate member 113 through at least a portion of the clot 123 and rotating a distal portion of the elongate member 113 occur substantially simultaneously. An example of such an embodiment is the embodiment shown in FIGs. 2-5, in which the elongate member 113 includes a ball and socket joint and is in a threaded relationship with the second catheter 111. Thus, in one or more embodiments, the elongate member 113 further comprises threads 116 on its outer surface for engaging corresponding protrusions 117 on an inner surface of the second catheter 111, so that the elongate member rotates about its elongate axis when a translational force along its elongate axis is applied to pull or push the elongate member relative to the second catheter. In other embodiments, the threads are included on both the second catheter and the elongate member and, in still other embodiments the threads are included on the second catheter while the elongate member includes protrusions for engaging the threads.

[0041] In one or more embodiments, the elongate member further comprises a ball and socket joint that permits a distal portion of the member to rotate relative to a proximate portion of the elongate member and also permits translational movement of the distal end relative to the second catheter.

[0042] Although the invention has been described and illustrated with respect to exemplary embodiments thereof, it should be understood by those skilled in the art that the foregoing and various other changes, omissions and additions may be made therein and thereto, without departing from the spirit and scope of the present invention.

CLAIMS

What is claimed is:

1. A system for removing clot material from a blood vessel, the system comprising:
a device comprising:
a first catheter, comprising an opening at a distal end of the first catheter;
a second catheter, disposed within the first catheter;
a stent, arranged adjacent to a distal end of the second catheter; and
an elongate member, disposed within the second catheter and movable along its elongate axis and rotatable relative to the second catheter;
wherein at least a distal end of the elongate member is extendable within an interior volume of the stent and is adapted to break down clot material; and
wherein the first and second catheters are sized such that a gap exists between an inner surface of the first catheter and an outer surface of the second catheter to permit clot material to be aspirated by the first catheter via the opening;
an aspiration pump coupled to the device to generate suction at the distal end of the first catheter.
2. The system of claim 1, wherein the elongate member further comprises one or more barbs extending radially from its distal end.
3. The system of claim 1, wherein the elongate member further comprises threads on its outer surface for engaging corresponding protrusions on an inner surface of the second catheter, so that the elongate member rotates about its elongate axis when a translational force along its elongate axis is applied to pull or push the elongate member relative to the second catheter.
4. The system of claim 3, wherein the elongate member further comprises a ball and socket joint that permits a distal portion of the elongate member to rotate relative to a proximal portion of the elongate member and also permits translational movement of the distal end relative to the second catheter.

5. The system of claim 1, wherein the stent is attached to a distal end of the second catheter.
6. The system of claim 5, wherein the stent has a compressed state and an expanded state, and wherein the stent is in a compressed state when it is confined within the first catheter and wherein the stent expands to the expanded state when it is moved outside of the distal end of the first catheter.
7. The system of claim 1, wherein the first catheter has an inner diameter of about 3 millimeters and the second catheter has a diameter of about 1.5 millimeters so that the gap has a total diameter of about 1.5 millimeters.
8. A device for removing clot material from a blood vessel, the device comprising:
 - a first catheter, comprising an opening at a distal end of the first catheter;
 - a second catheter, disposed within the first catheter;
 - a stent, arranged adjacent to the distal end of the second catheter; and
 - an elongate member, disposed within the second catheter and movable along its elongate axis and rotatable relative to the second catheter;wherein at least a distal end of the elongate member is extendable within an interior volume of the stent and is adapted to break down clot material.
9. The device of claim 8, wherein the elongate member further comprises one or more barbs extending radially from its distal end.
10. The device of claim 8, wherein the elongate member further comprises threads on its outer surface for engaging corresponding protrusions on an inner surface of the second catheter, so that the elongate member rotates about its elongate axis when a translational force along its elongate axis is applied to pull or push the elongate member relative to the second catheter.

11. The device of claim 10, wherein the elongate member further comprises a ball and socket joint that permits a distal portion of the elongate member to rotate relative to a proximal portion of the elongate member and also permits translational movement of the distal end relative to the second catheter.
12. The device of claim 8, wherein the stent is attached to a distal end of the second catheter.
13. The device of claim 12, wherein the stent has a compressed state and an expanded state, and wherein the stent is in a compressed state when it is confined within the first catheter and wherein the stent expands to the expanded state when it is moved outside of the distal end of the first catheter.
14. The device of claim 8, wherein the stent comprises radiopaque material.
15. The device of claim 8, wherein the first and second catheters are sized such that a gap exists between an inner surface of the first catheter and an outer surface of the second catheter to permit clot material to be aspirated by the first catheter via the opening and wherein the first catheter is adapted to apply a suction force at its distal end.
16. A method for removal of clot material from a blood vessel, the method comprising the steps of:
 - advancing a first catheter to a site of a clot in a blood vessel, the first catheter comprising, within its interior volume:
 - a second catheter;
 - a stent, attached to a distal end of the second catheter; and
 - an elongate member, disposed within the second catheter and movable along its elongate axis and rotatable relative to the second catheter;
 - pushing the first catheter through the clot at the site;
 - retracting the first catheter relative to the second catheter so that the stent expands to an expanded state to at least partially encapsulate the clot;
 - advancing the elongate member through at least a portion of the clot;

rotating a distal portion of the elongate member, wherein the distal end of the elongate member is adapted to break down clot material via one or more barbs extending radially from the distal end of the elongate member;

aspirating fragments of the clot into a gap formed between an inner surface of the first catheter and an outer surface of the second catheter.

17. The method of claim 16, further comprising the steps of:

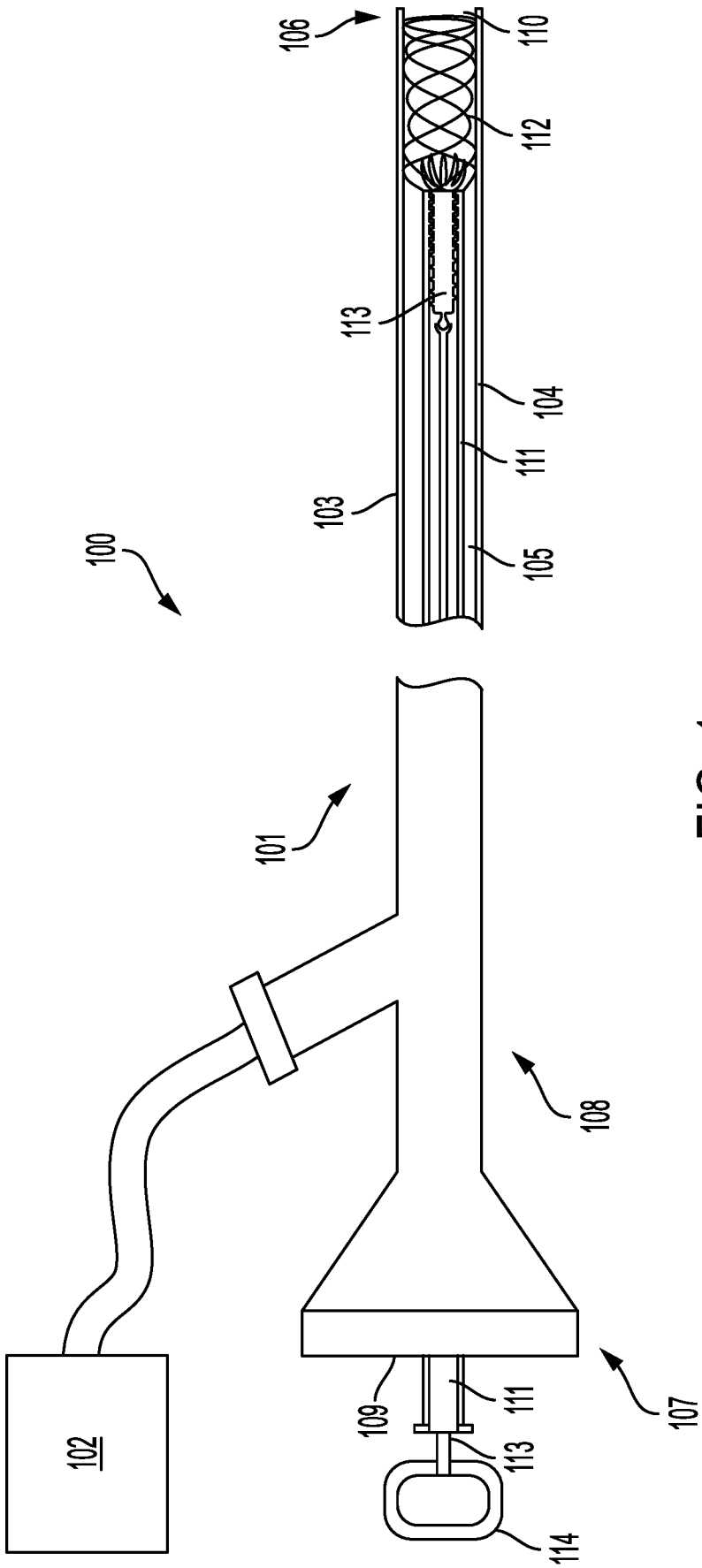
retracting the elongated member into the second catheter; and

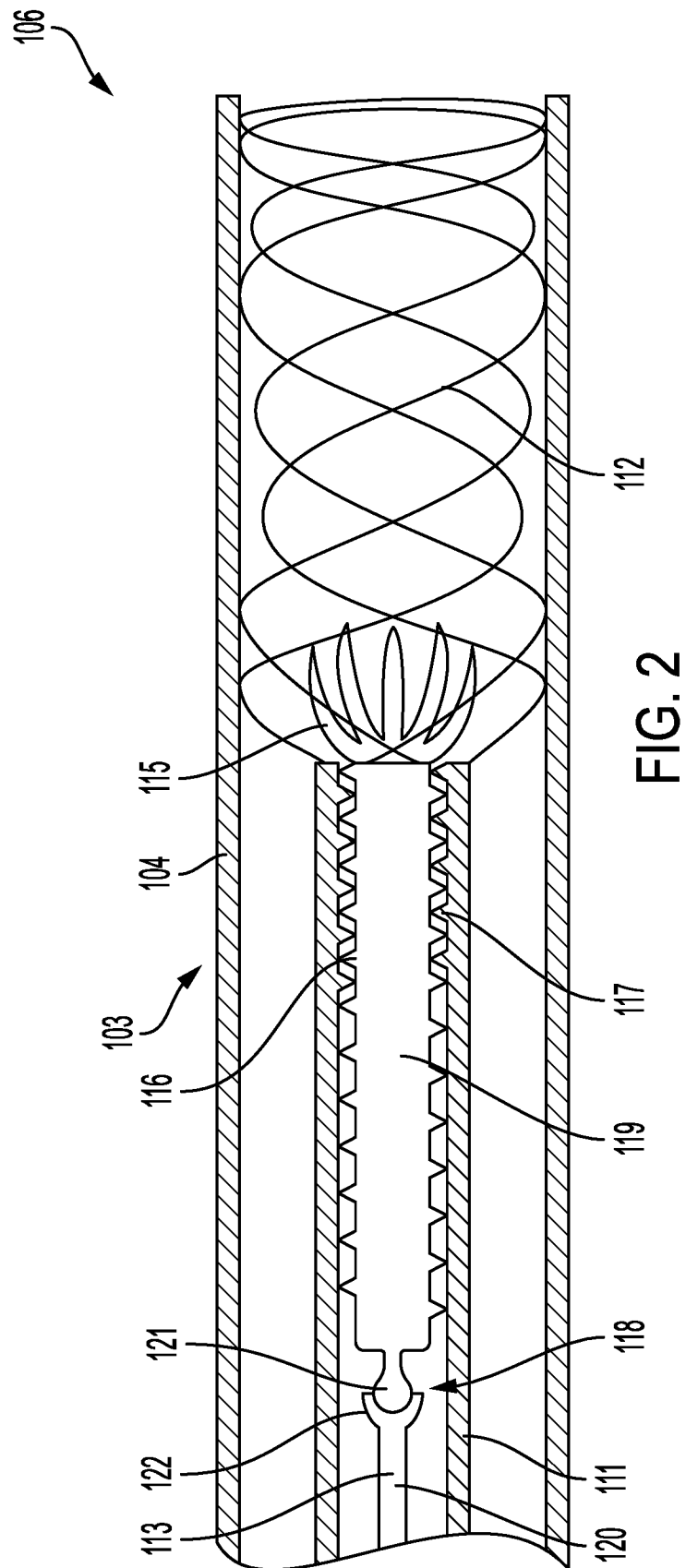
retracting the second catheter into the first catheter so that the stent is pulled into the first catheter.

18. The method of claim 16, wherein the steps of advancing the elongate member through at least a portion of the clot and rotating a distal portion of the elongate member occur substantially simultaneously.

19. The method of claim 18, wherein the elongate member further comprises threads on its outer surface for engaging corresponding protrusions on an inner surface of the second catheter, so that the elongate member rotates about its elongate axis when a translational force along its elongate axis is applied to pull or push the elongate member relative to the second catheter.

20. The method of claim 19, wherein the elongate member further comprises a ball and socket joint that permits a distal portion of the member to rotate relative to a proximate portion of the elongate member and also permits translational movement of the distal end relative to the second catheter.





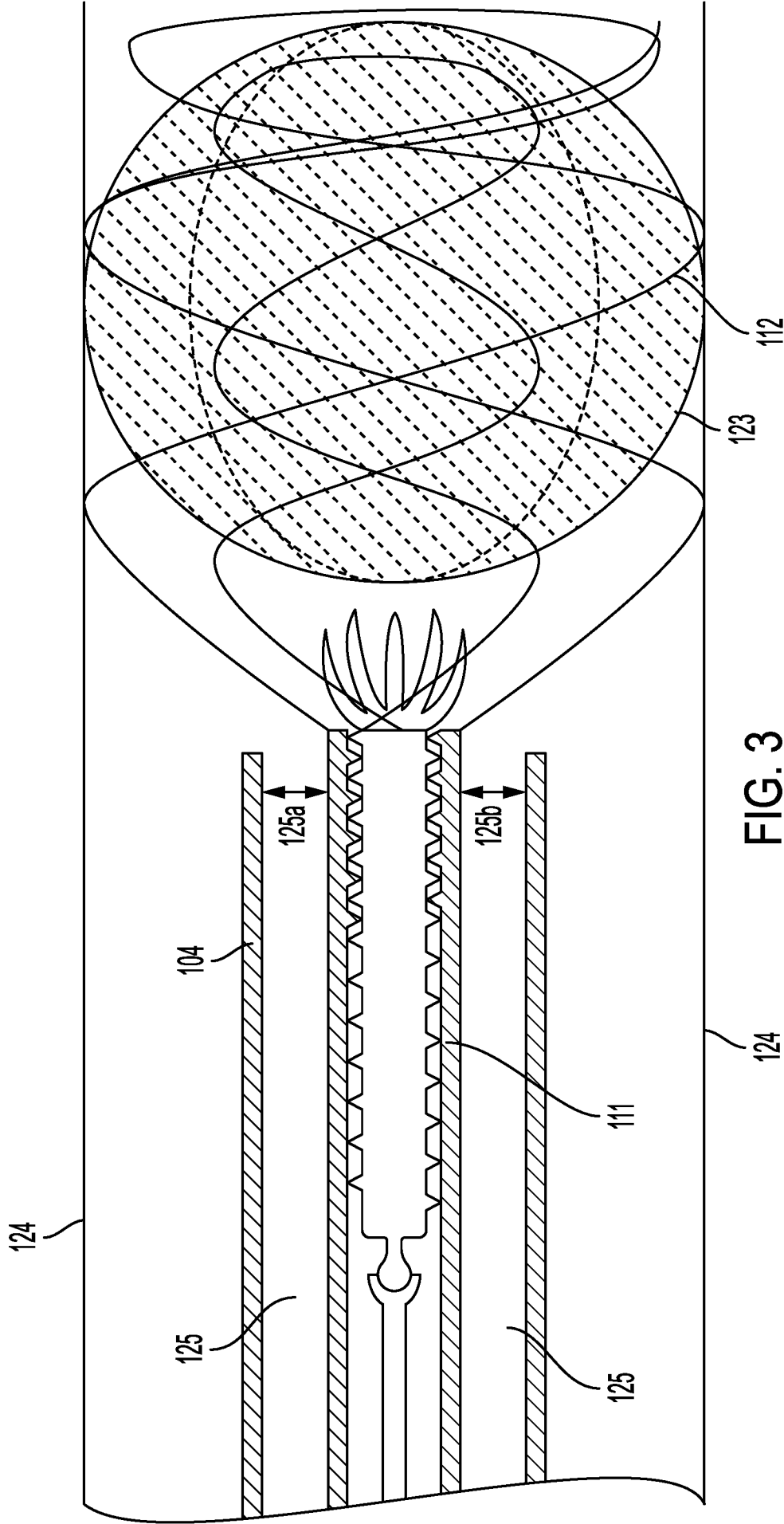


FIG. 3

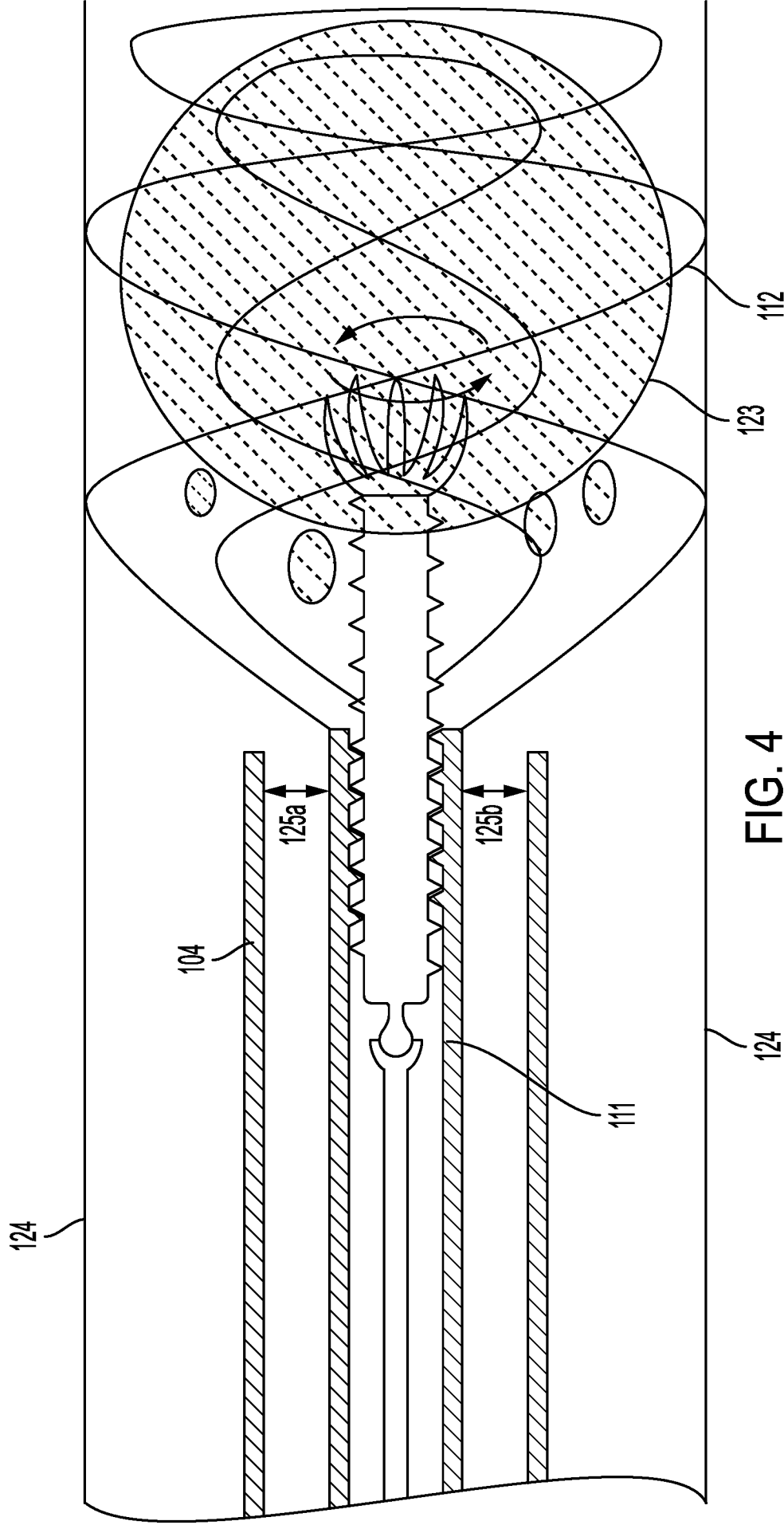


FIG. 4

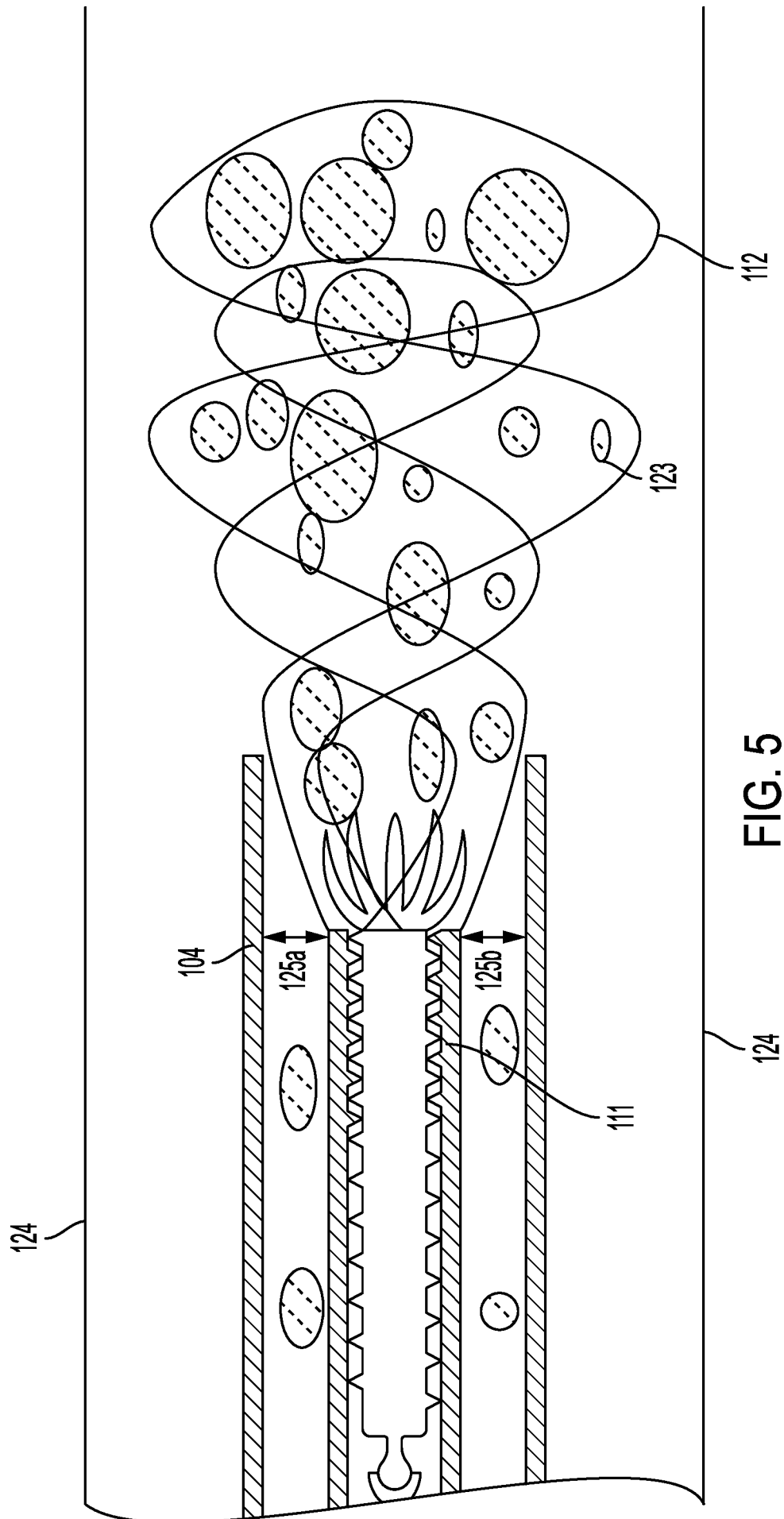


FIG. 5

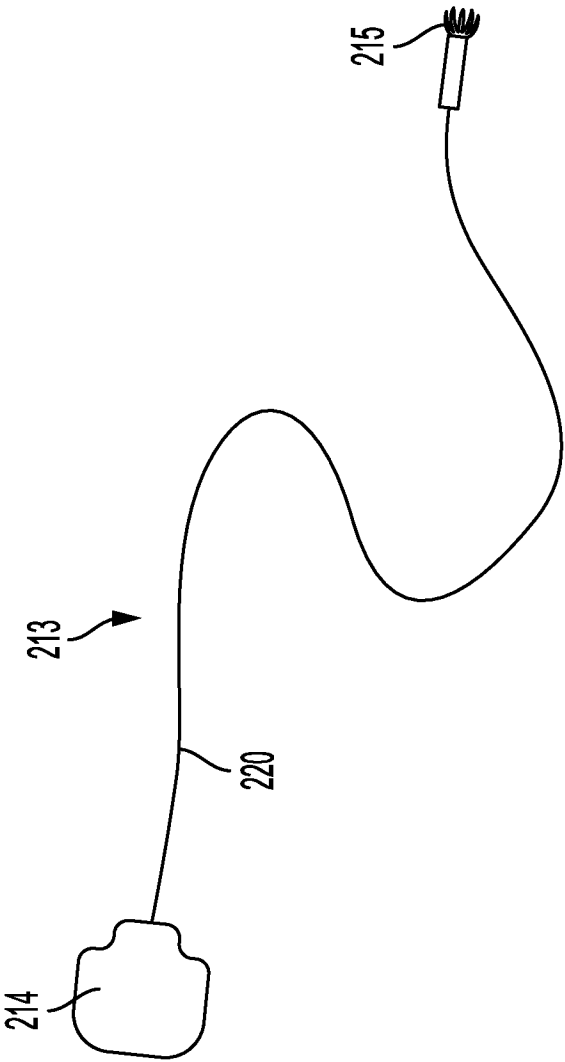


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2024/026417

A. CLASSIFICATION OF SUBJECT MATTERIPC: **A61B 17/22** (2024.01); **A61M 25/00** (2024.01)CPC: **A61B 17/22031**; **A61B 17/00234**; **A61M 25/00**; A61B 2017/00292; A61B 2017/00358; A61B 2017/22034; A61B 2017/22035; A61B 2017/22078; A61B 2017/22079; A61M 2025/0004

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)

See Search History Document

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

See Search History Document

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

See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2022/0000507 A1 (INARI MEDICAL INC.) 06 January 2022 (06.01.2022)	
Y	entire document	1, 5-8, 12, 13, 15
Y	entire document	2, 9, 14, 16, 17
Y	WO 2014/178198 A1 (TERUMO KABUSHIKI KAISHA) 06 November 2014 (06.11.2014)	
	see machine translation	2, 9, 16, 17
Y	US 2022/0233821 A1 (BOLT MEDICAL INC.) 28 July 2022 (28.07.2022)	
	entire document	14
A	US 8,652,193 B2 (DORN) 18 February 2014 (18.02.2014)	
	entire document	1-20
A	US 2007/0179519 A1 (HUISUN) 02 August 2007 (02.08.2007)	
	entire document	1-20



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See patent family annex.

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“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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“&” document member of the same patent family

Date of the actual completion of the international search

24 July 2024 (24.07.2024)

Date of mailing of the international search report

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Name and mailing address of the ISA/US

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