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(54) **DEVICES AND METHODS FOR ENHANCED ASPIRATION-INDUCED THROMBECTOMY**

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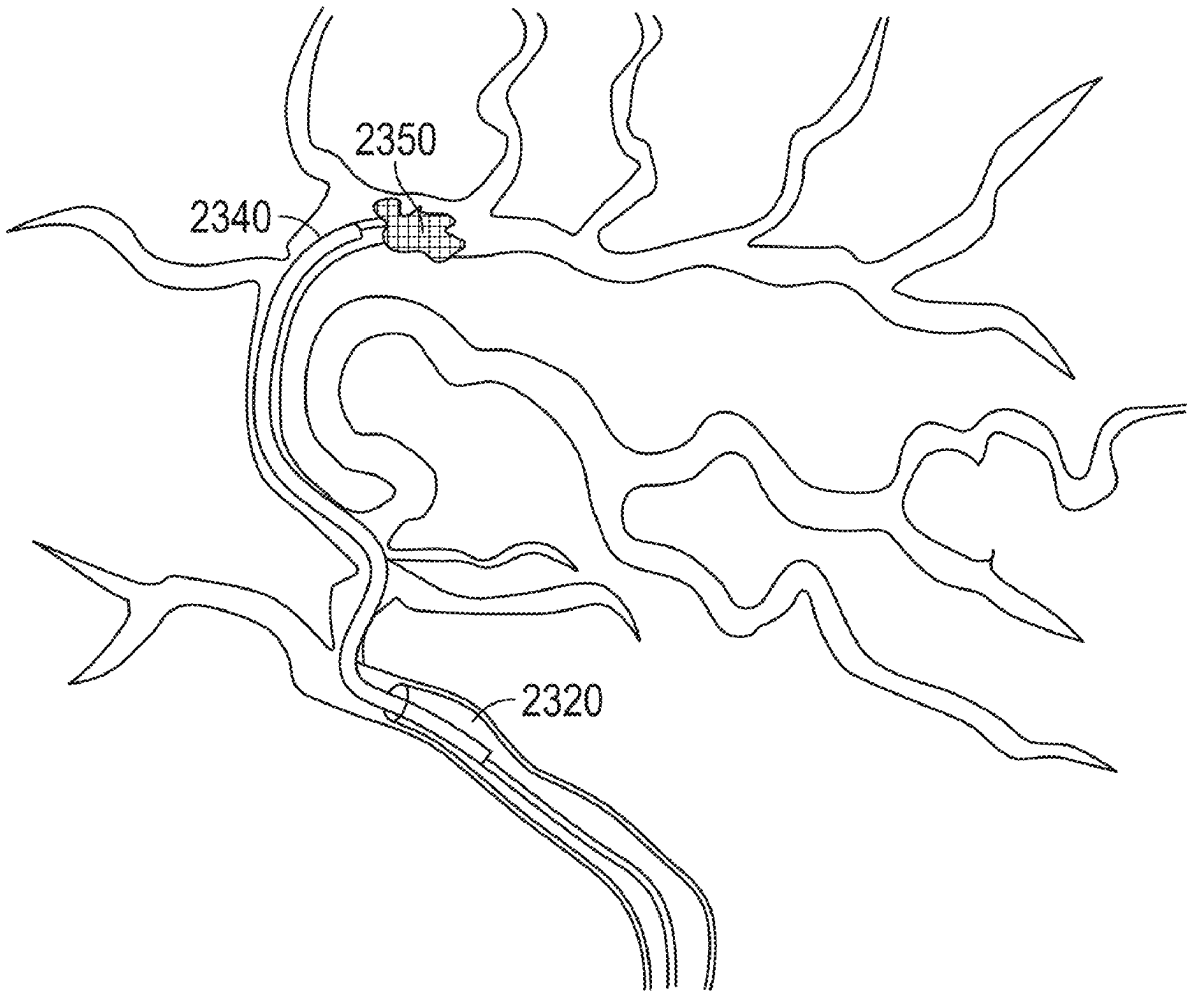
(57) **ABSTRACT**

Described herein are various embodiments of valve systems that comprise a compressible region that is configured to reduce vacuum at a first port of the valve while substantially maintaining vacuum at a second port of the valve. Further described herein is an improved aspiration canister configured to maintain vacuum at a second vacuum line while a first vacuum line is disconnected from the canister.



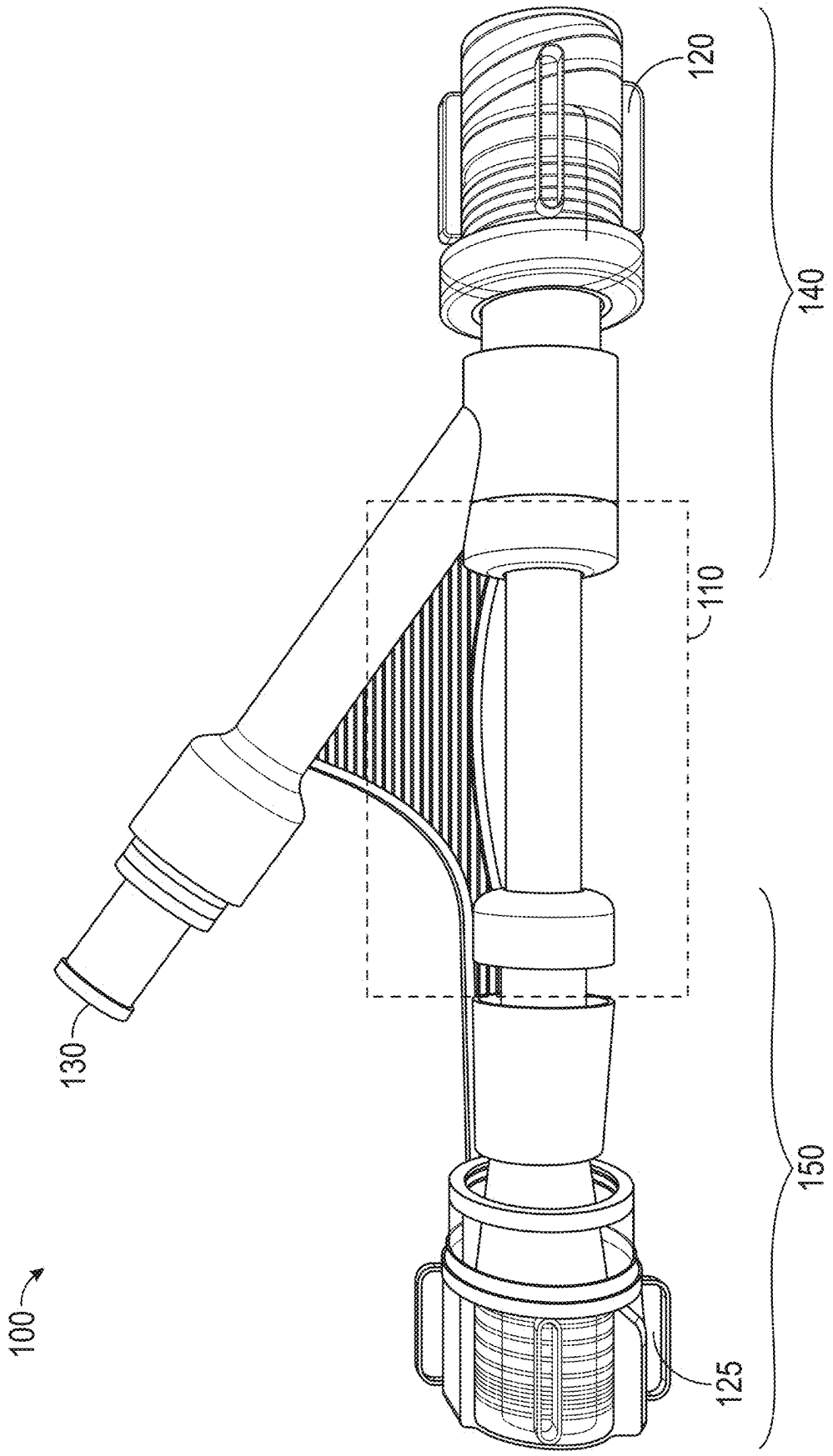


FIG. 1

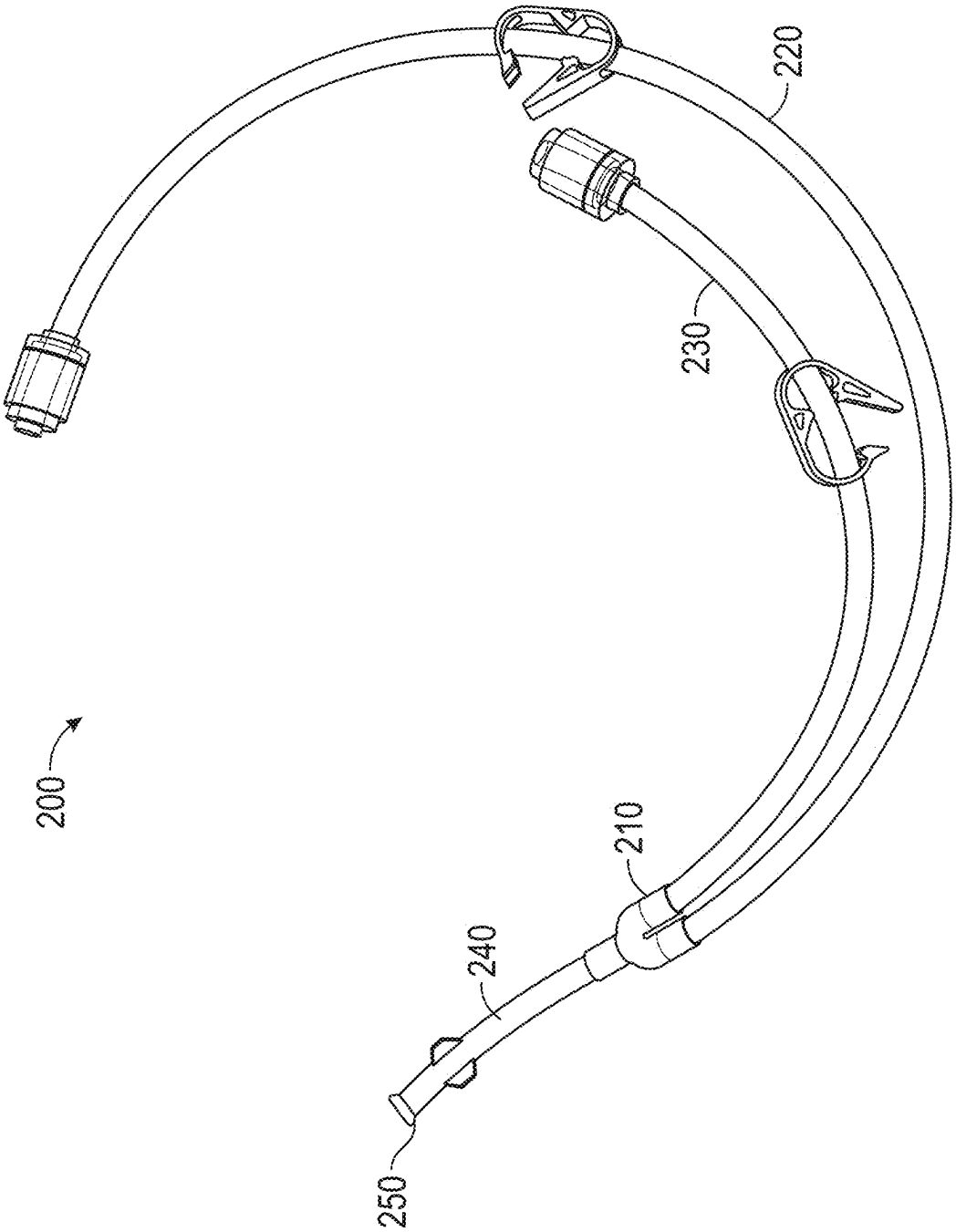


FIG. 2

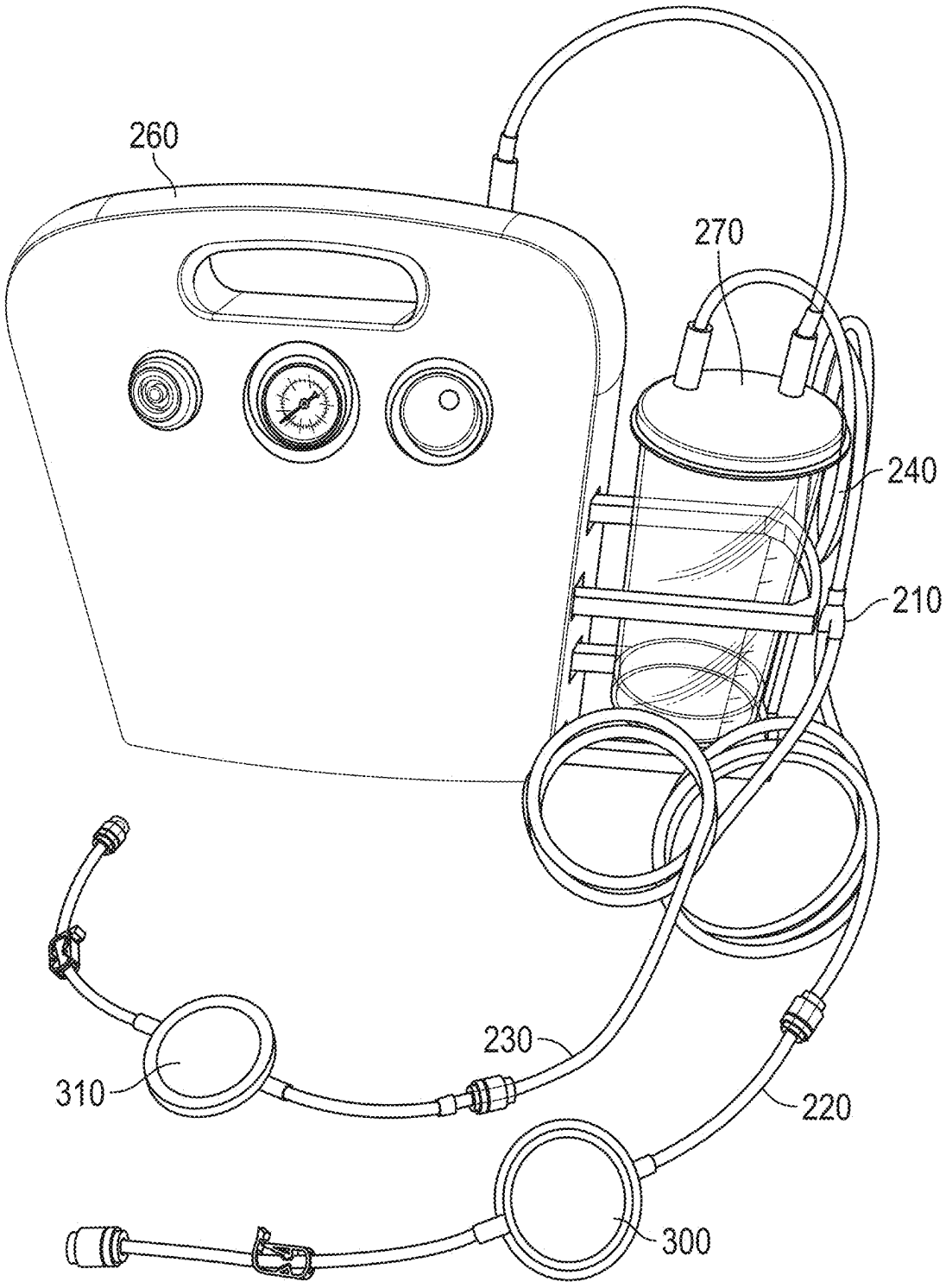


FIG. 3

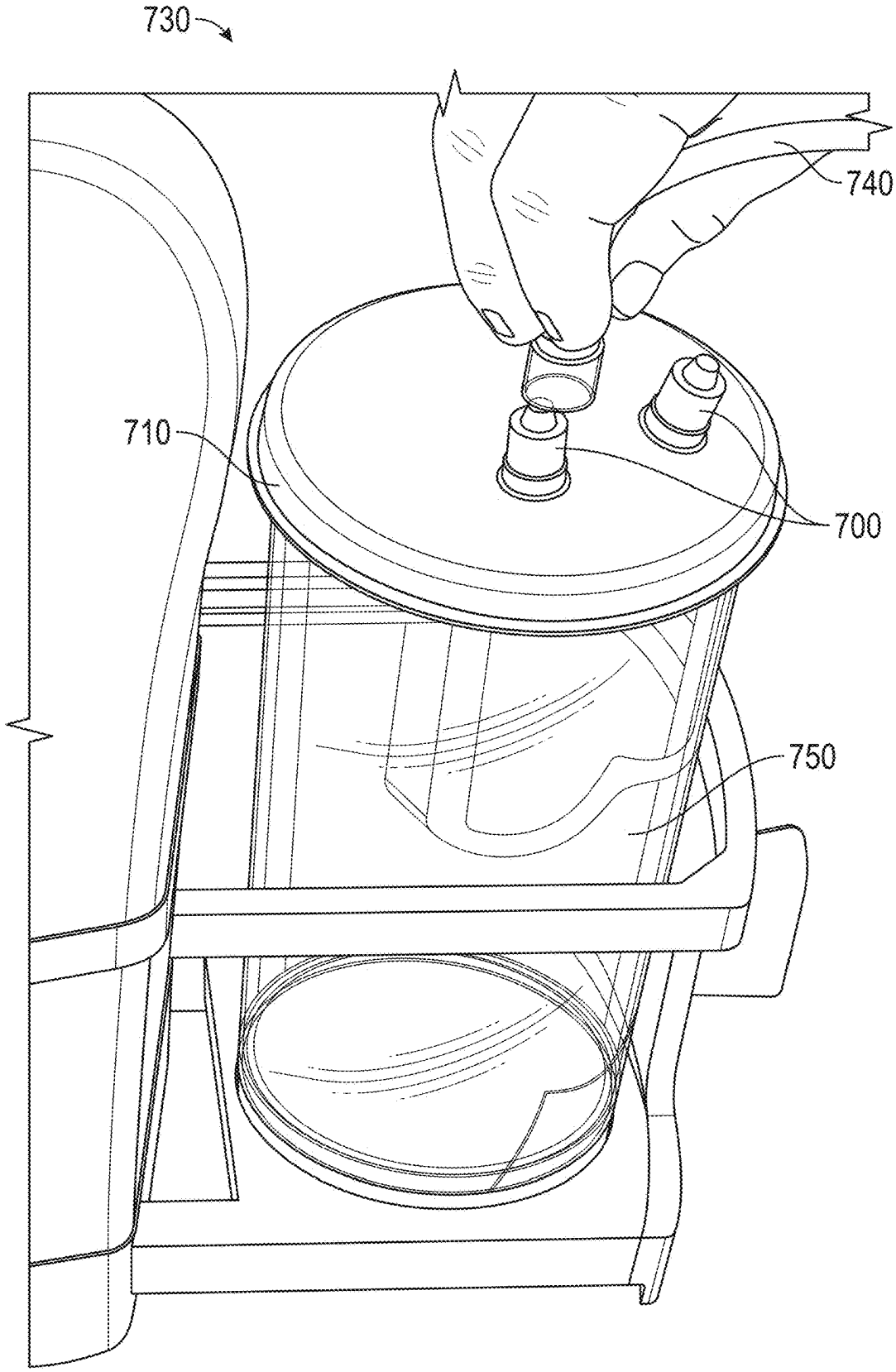


FIG. 4

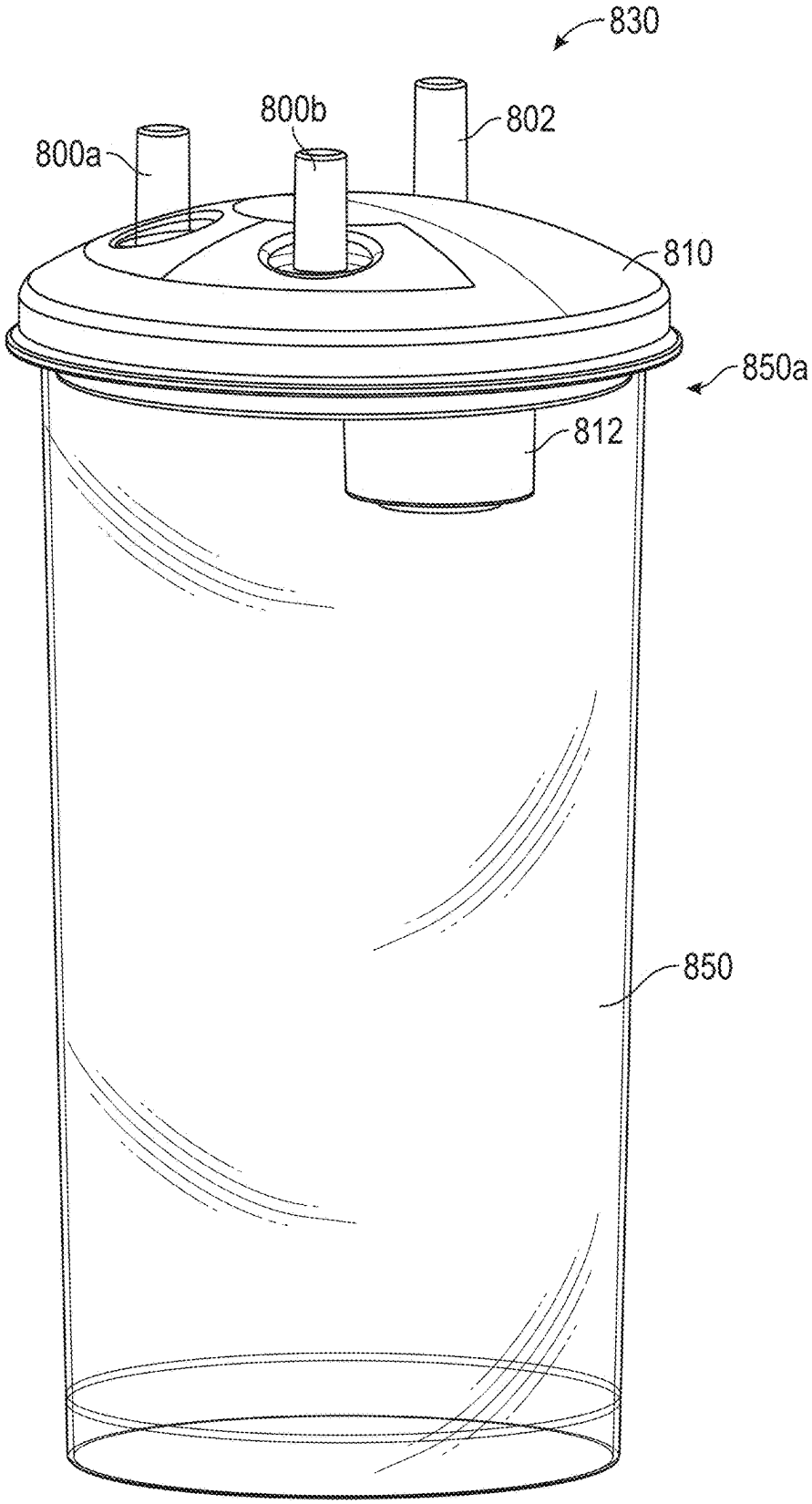


FIG. 5A

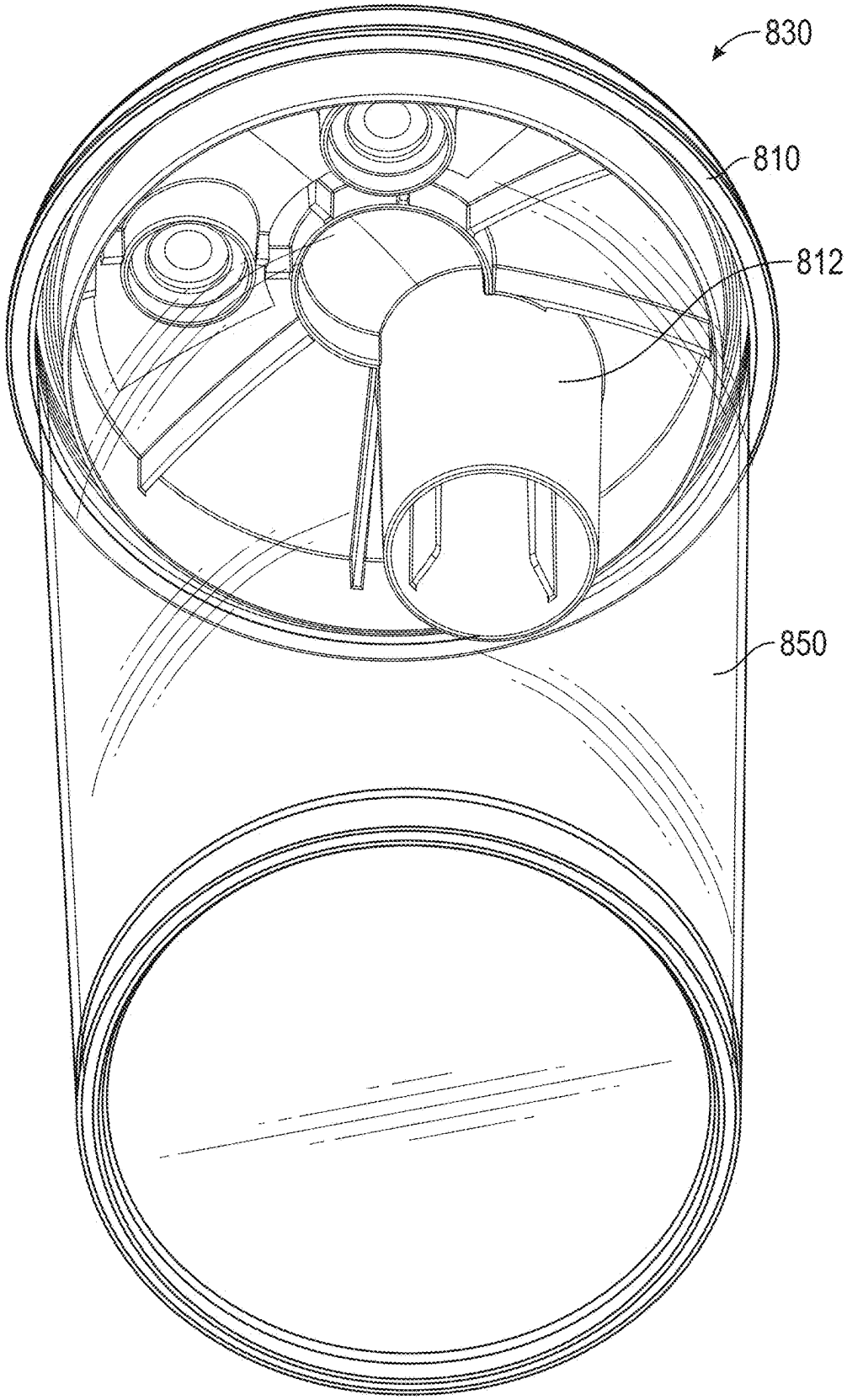


FIG. 5B

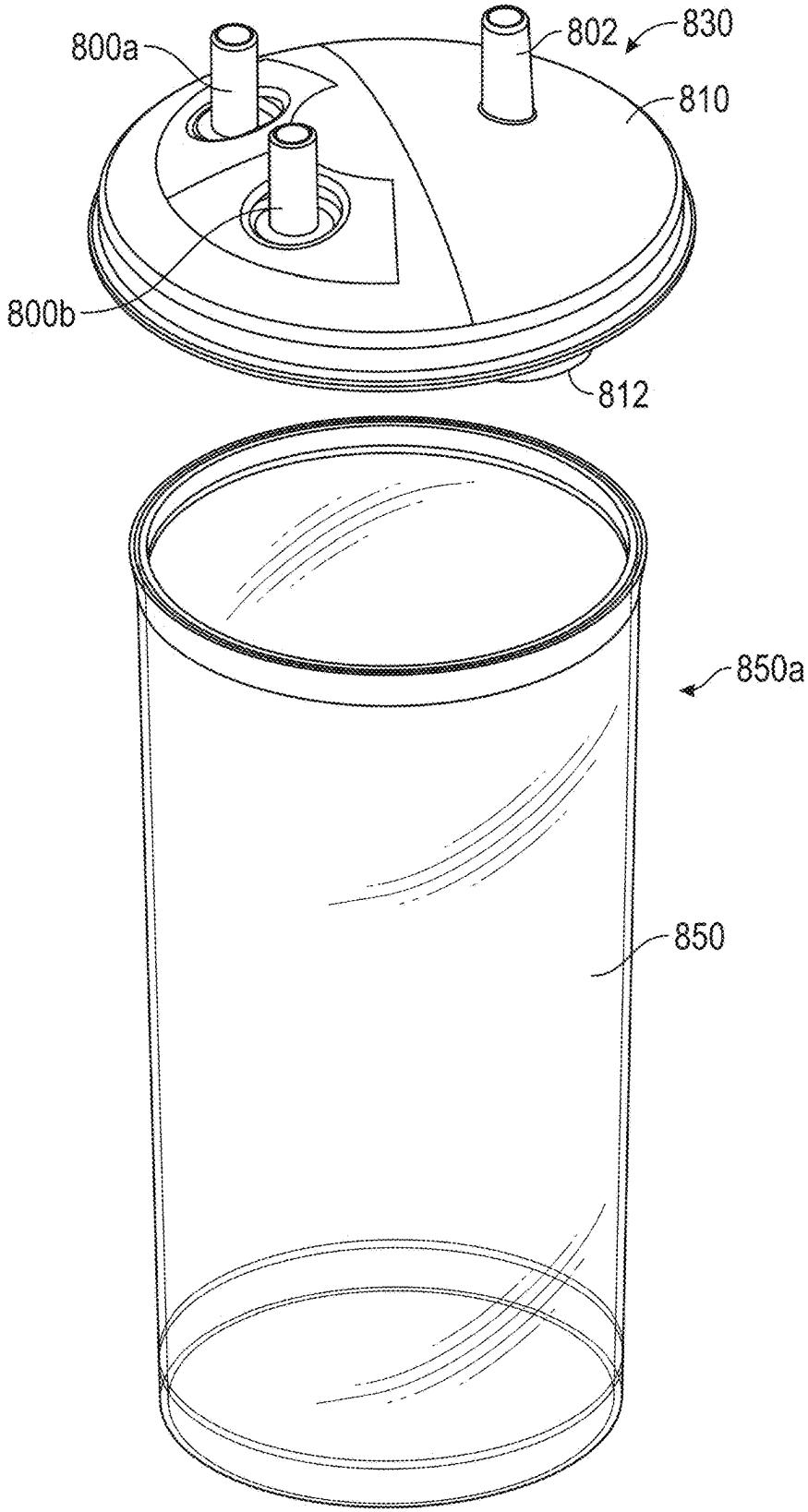


FIG. 5C

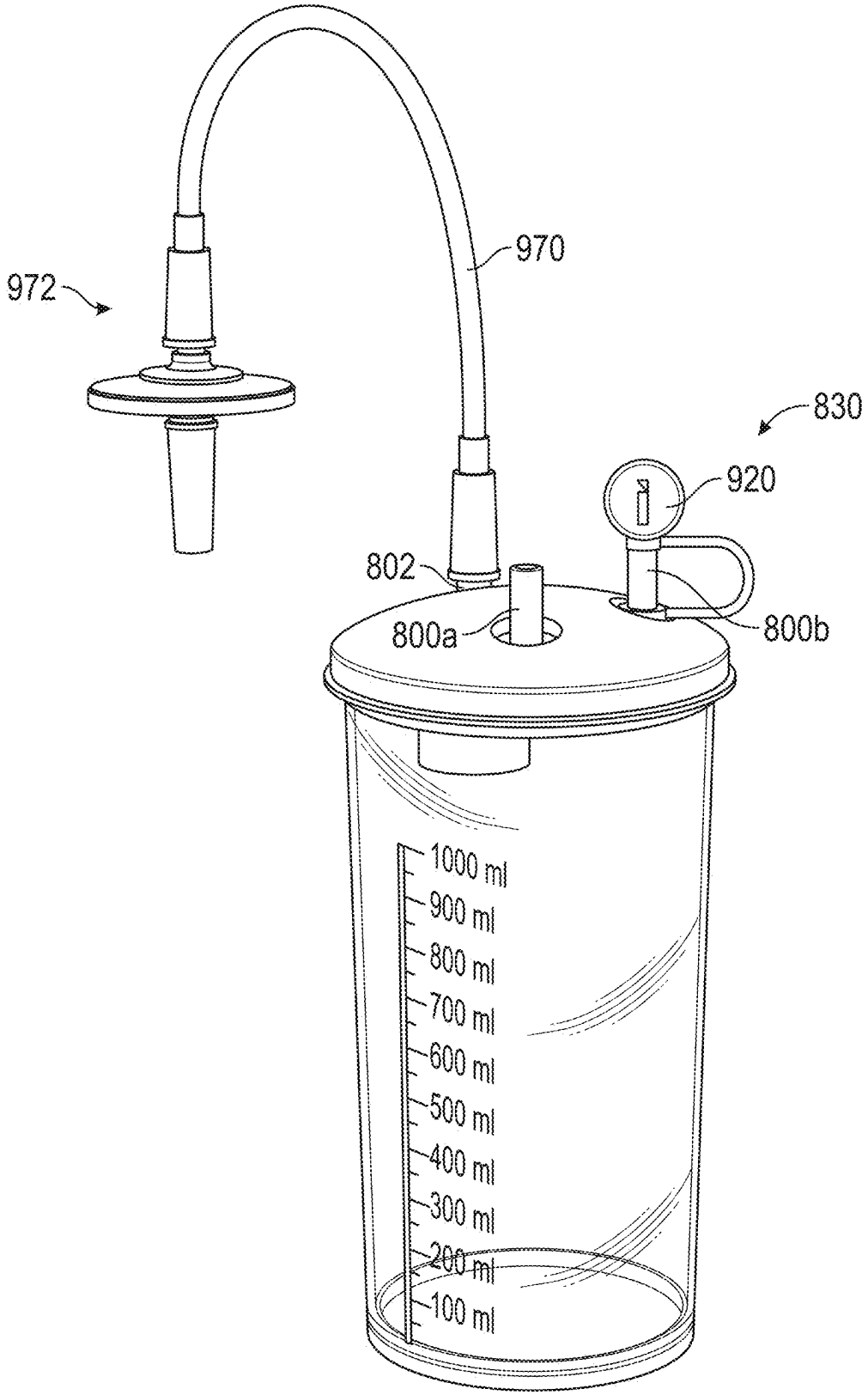

970
972
830
920
802
800a
800b
1000 ml
900 ml
800 ml
700 ml
600 ml
500 ml
400 ml
300 ml
200 ml
100 ml

FIG. 6A

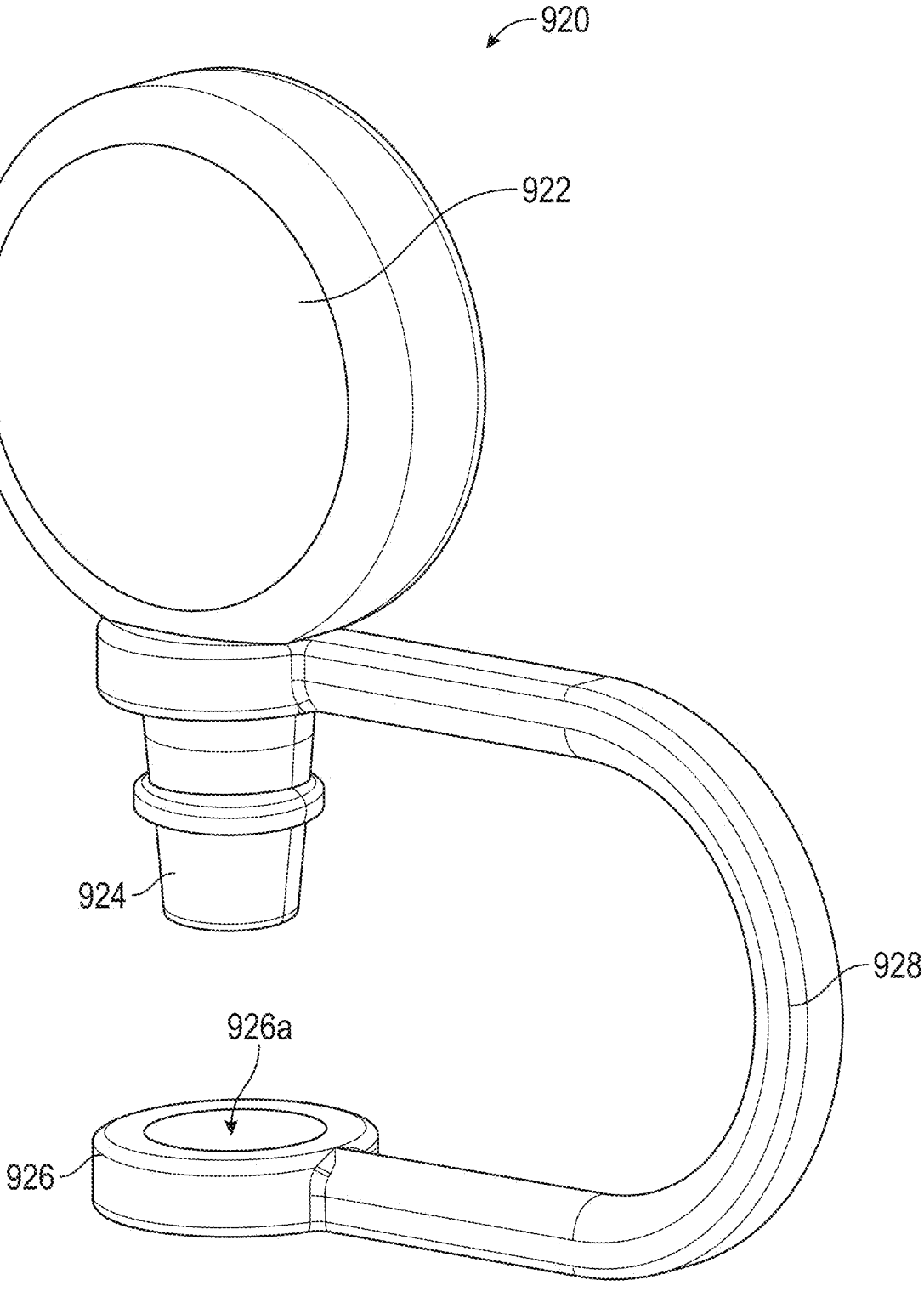


FIG. 6B

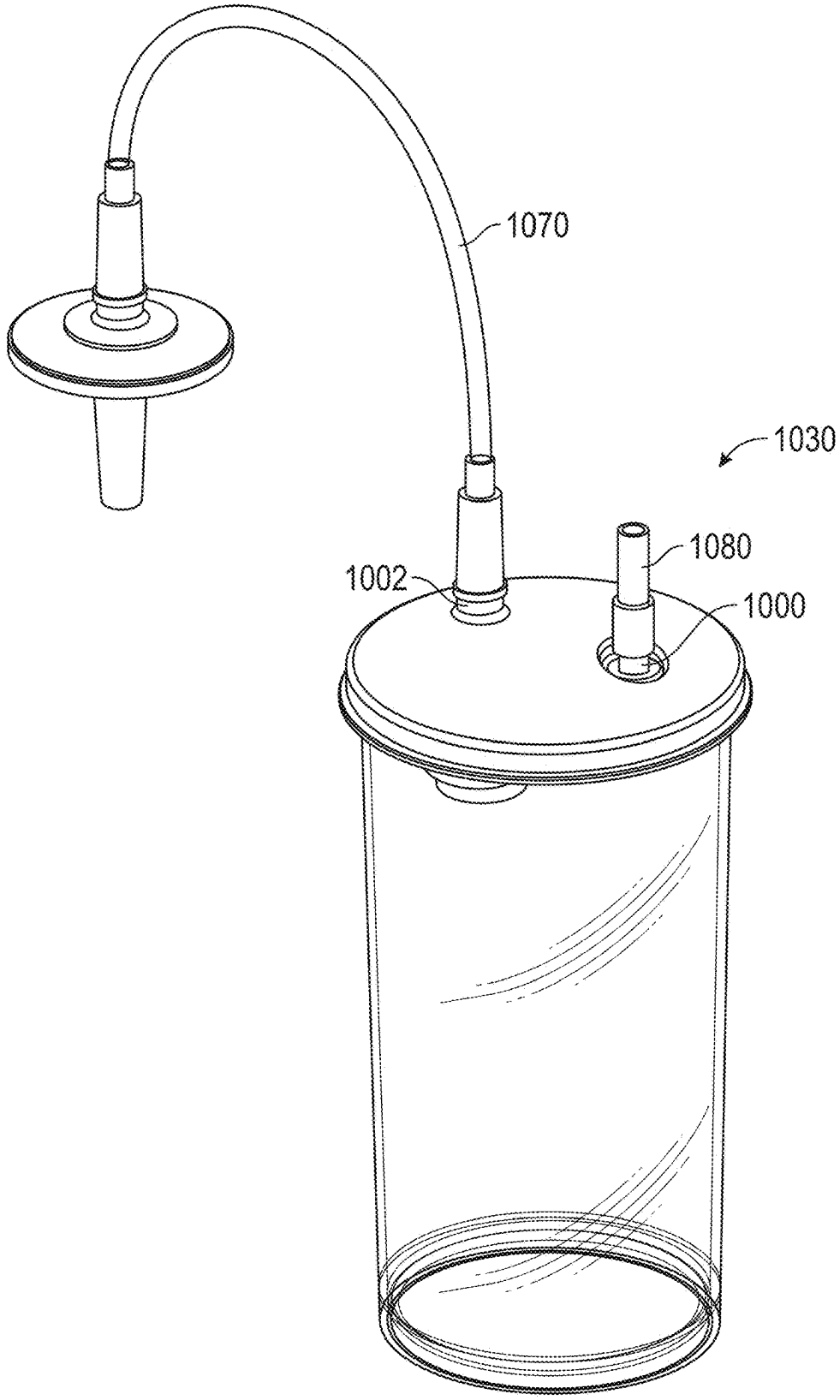


FIG. 7A

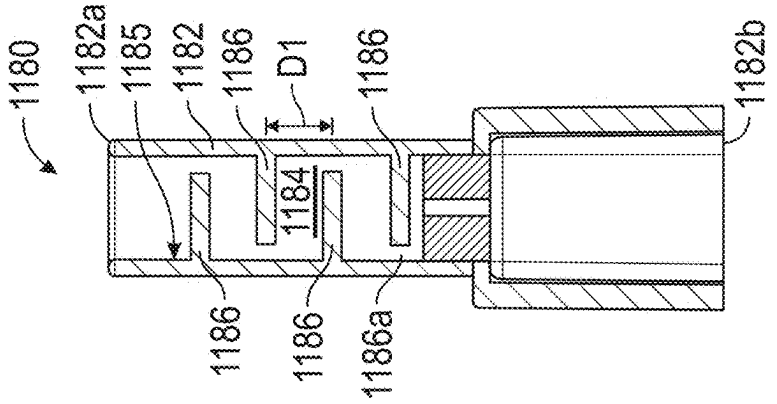


FIG. 7D

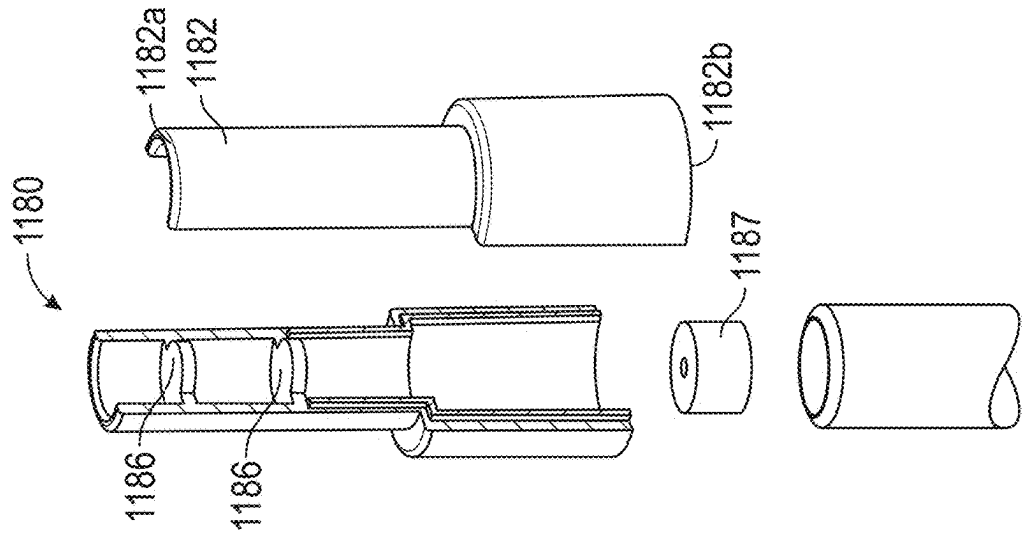


FIG. 7C

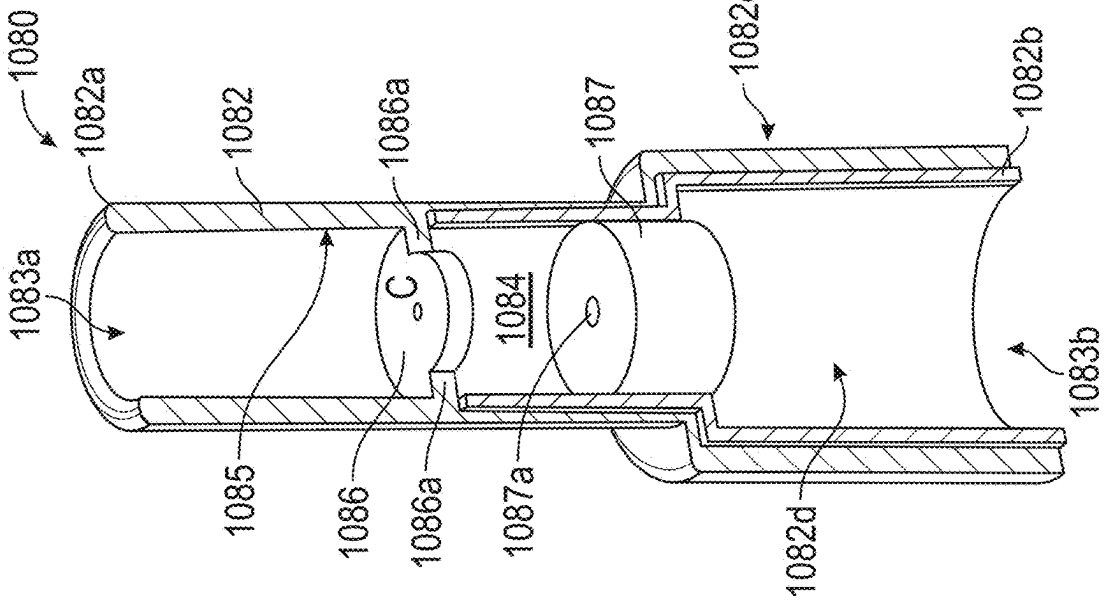
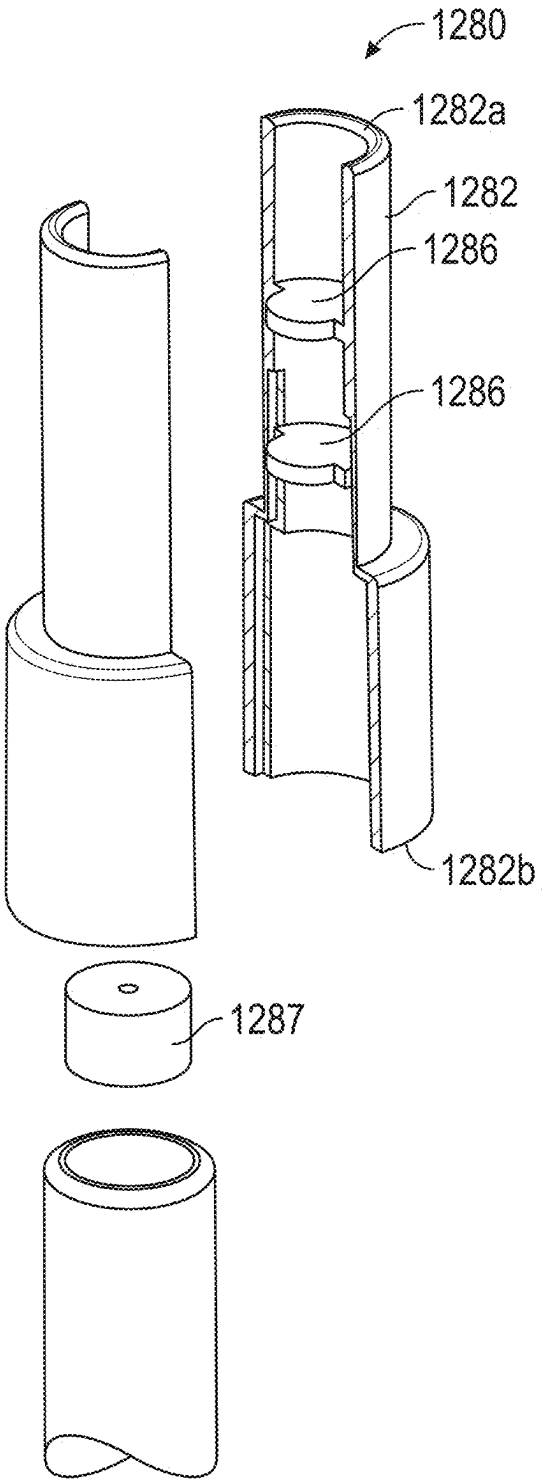


FIG. 7B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1282a
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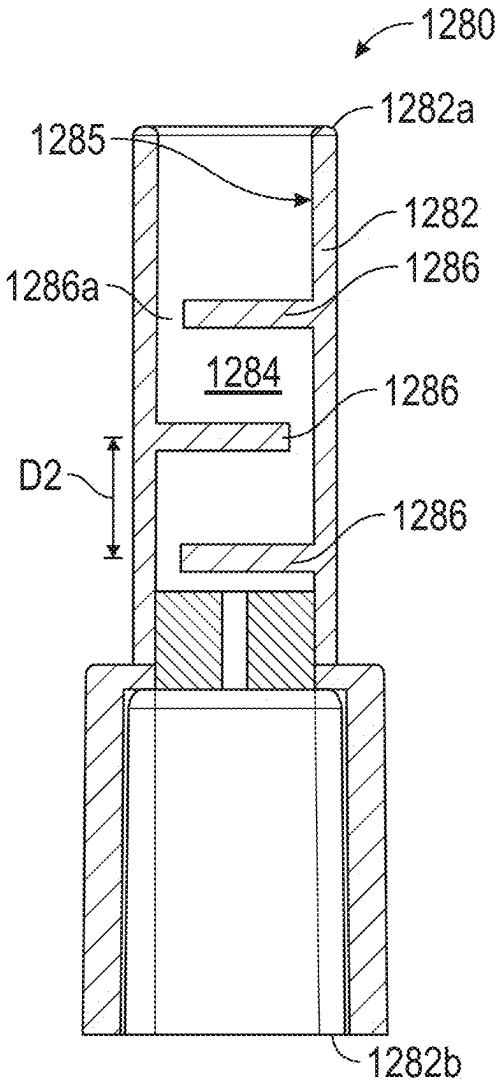
1286
1286
1282b
1287

FIG. 7E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1282b

FIG. 7F

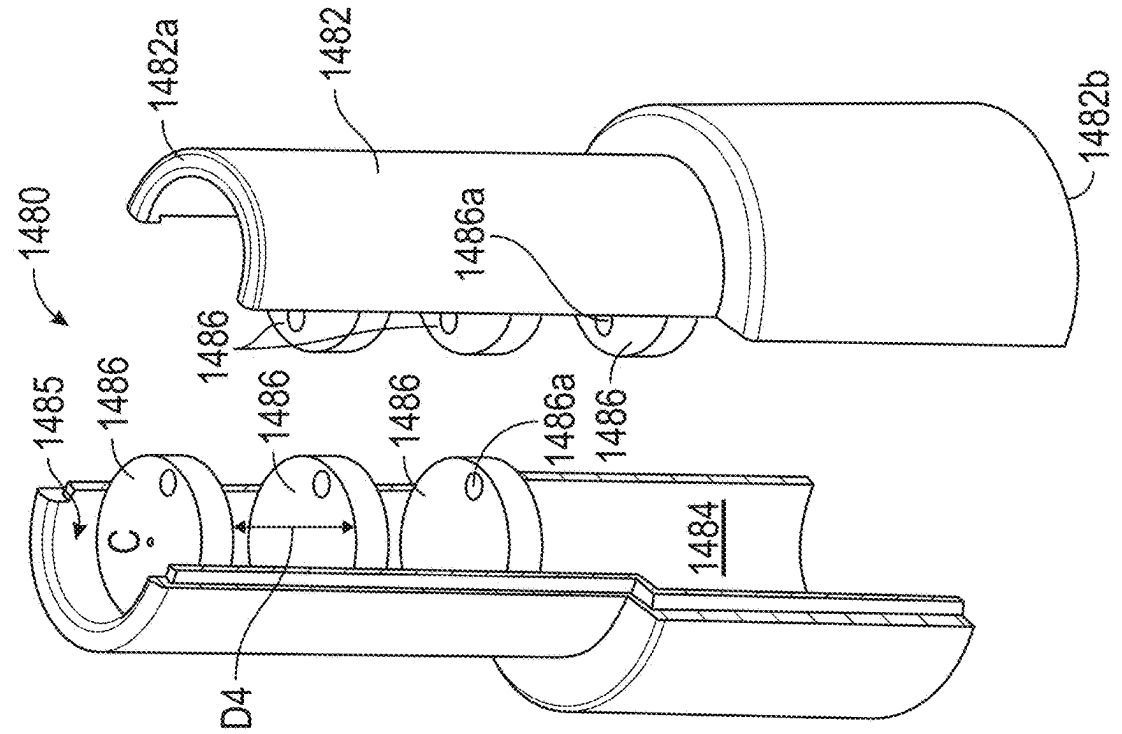
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FIG. 7H

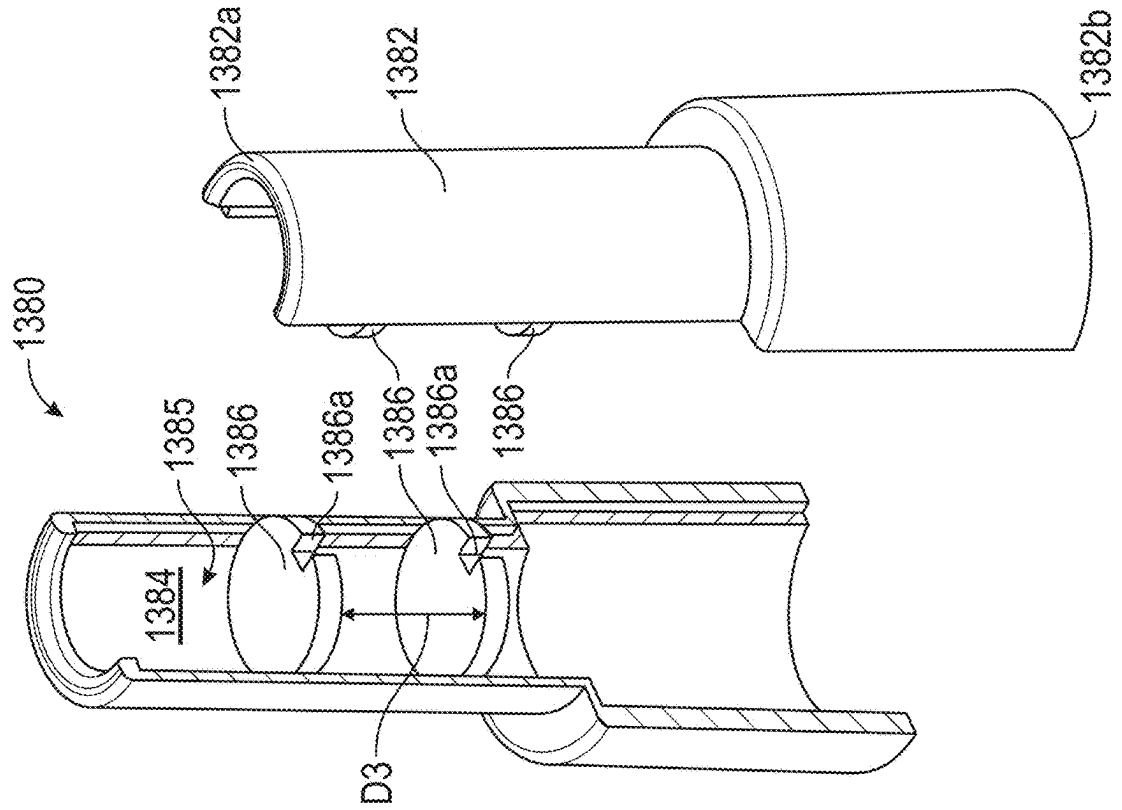
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FIG. 7G

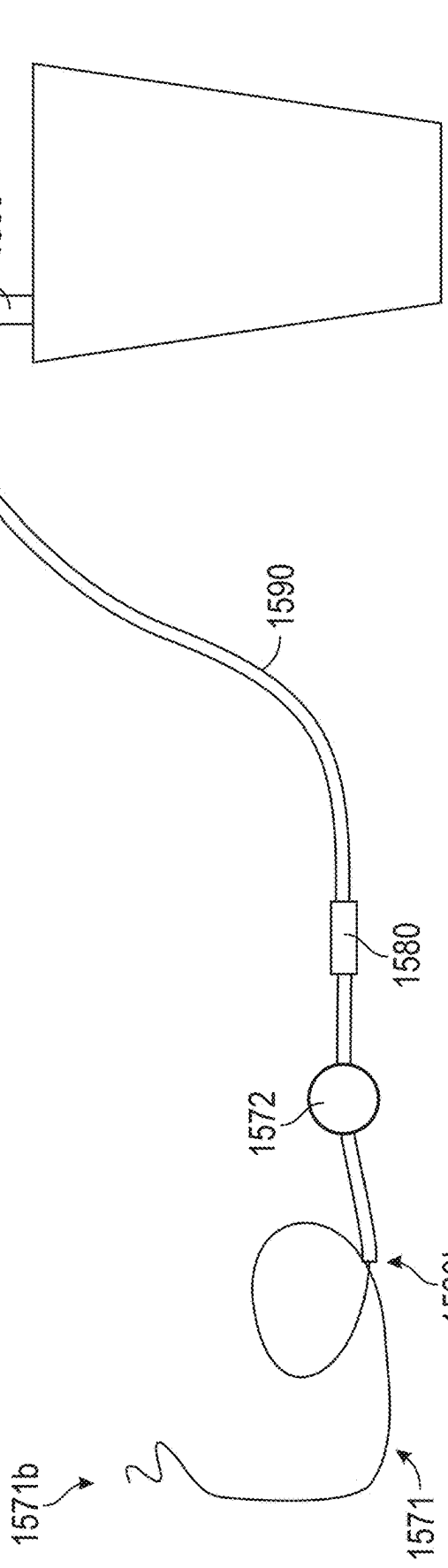

FIG. 7I

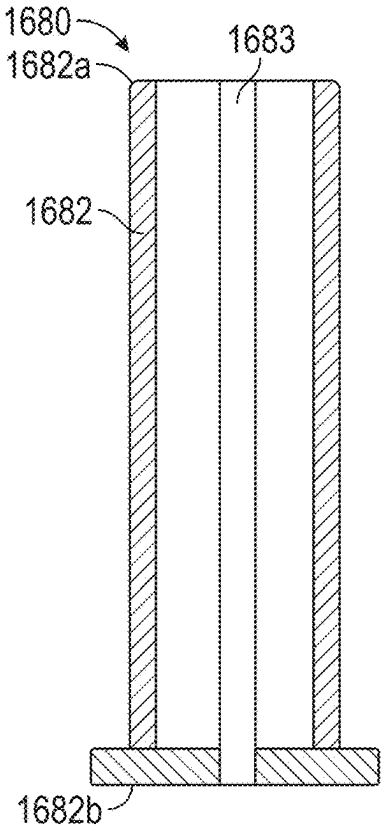

FIG. 8A

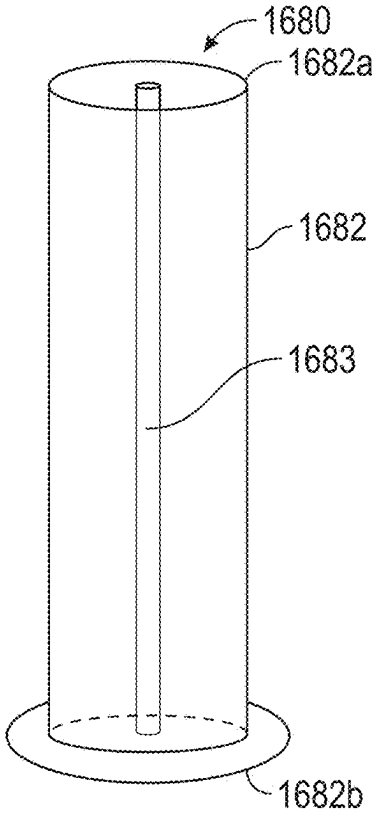

FIG. 8B

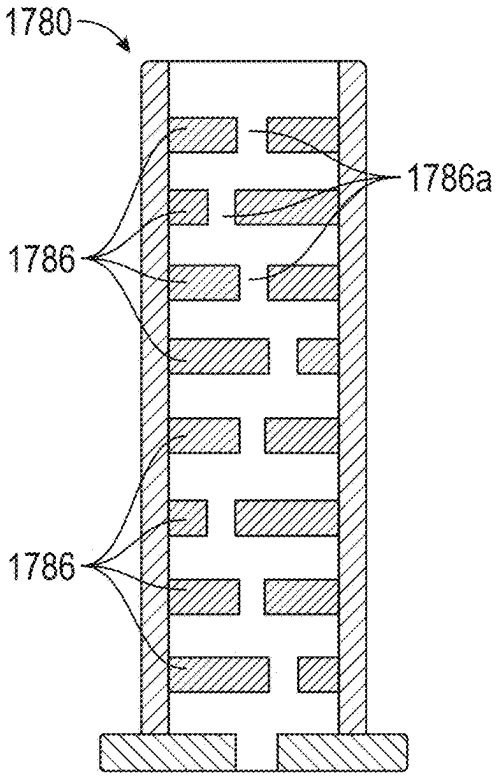

FIG. 8C

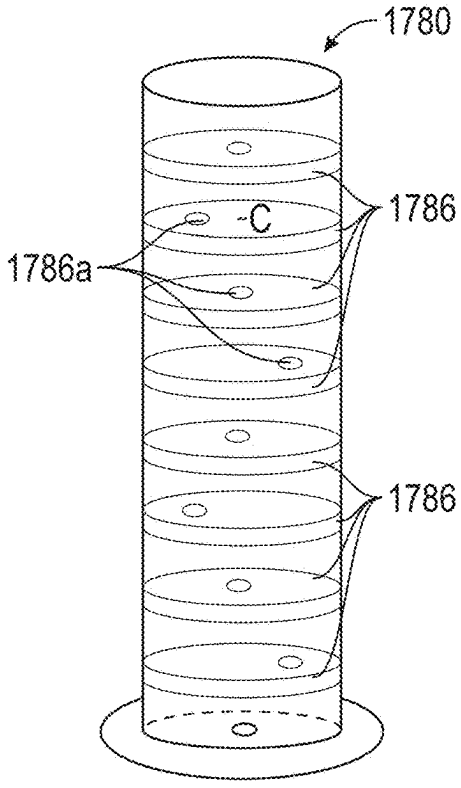

FIG. 8D

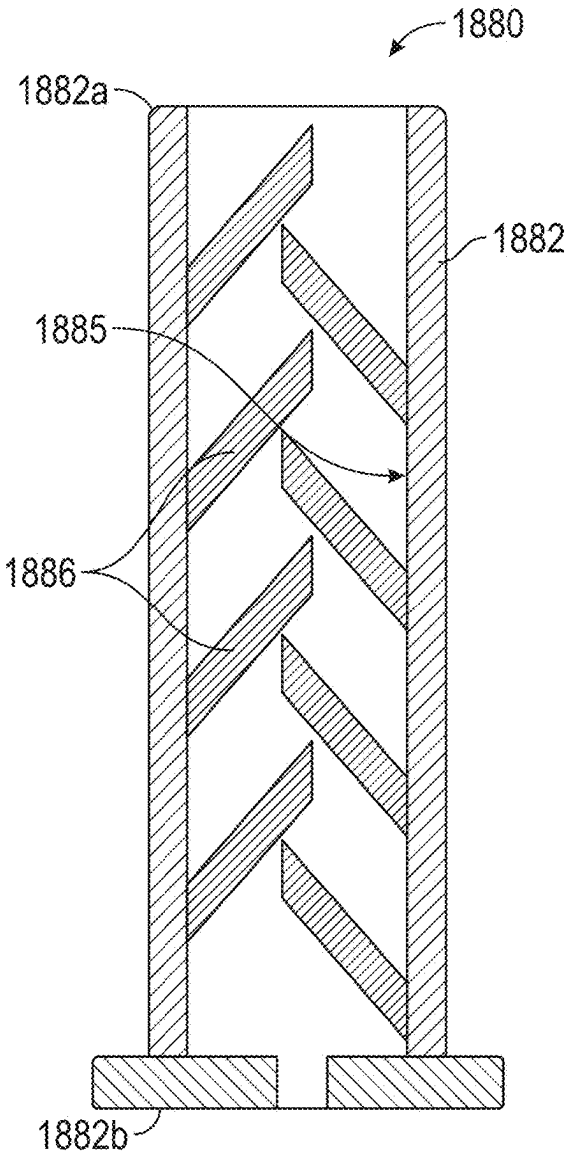
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FIG. 8E

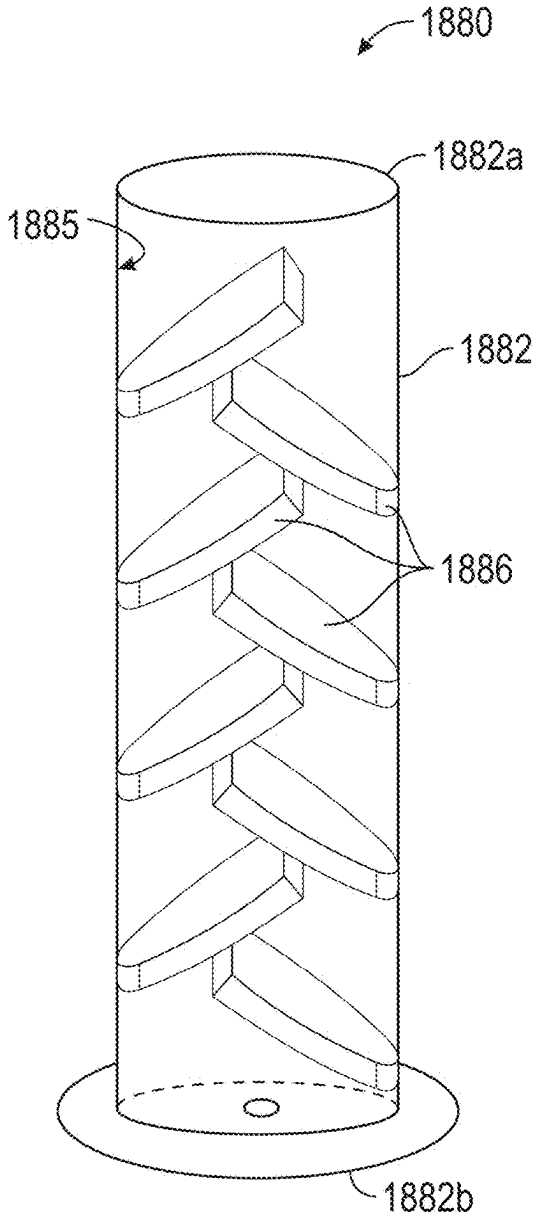
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FIG. 8F

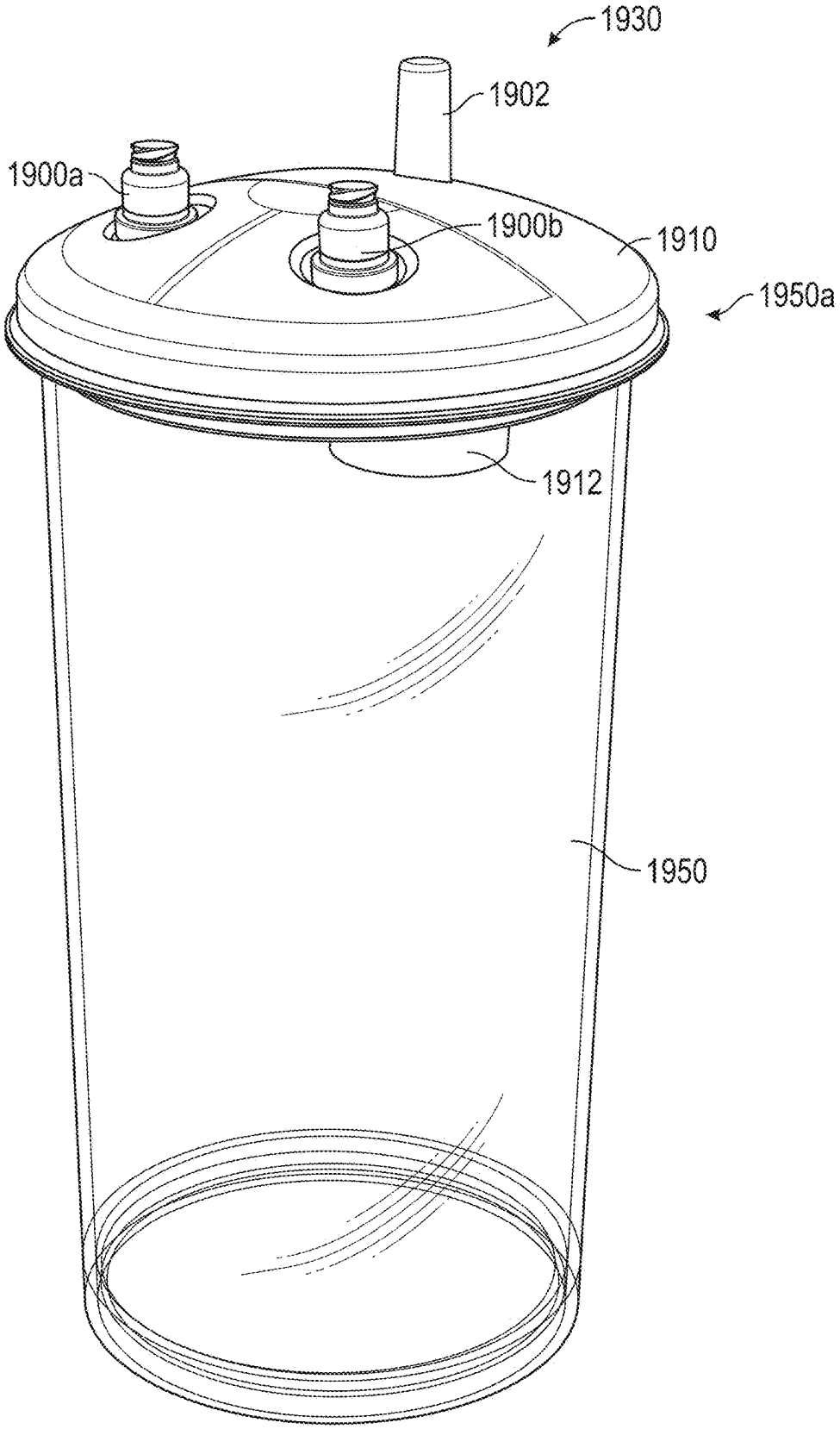

FIG. 9A

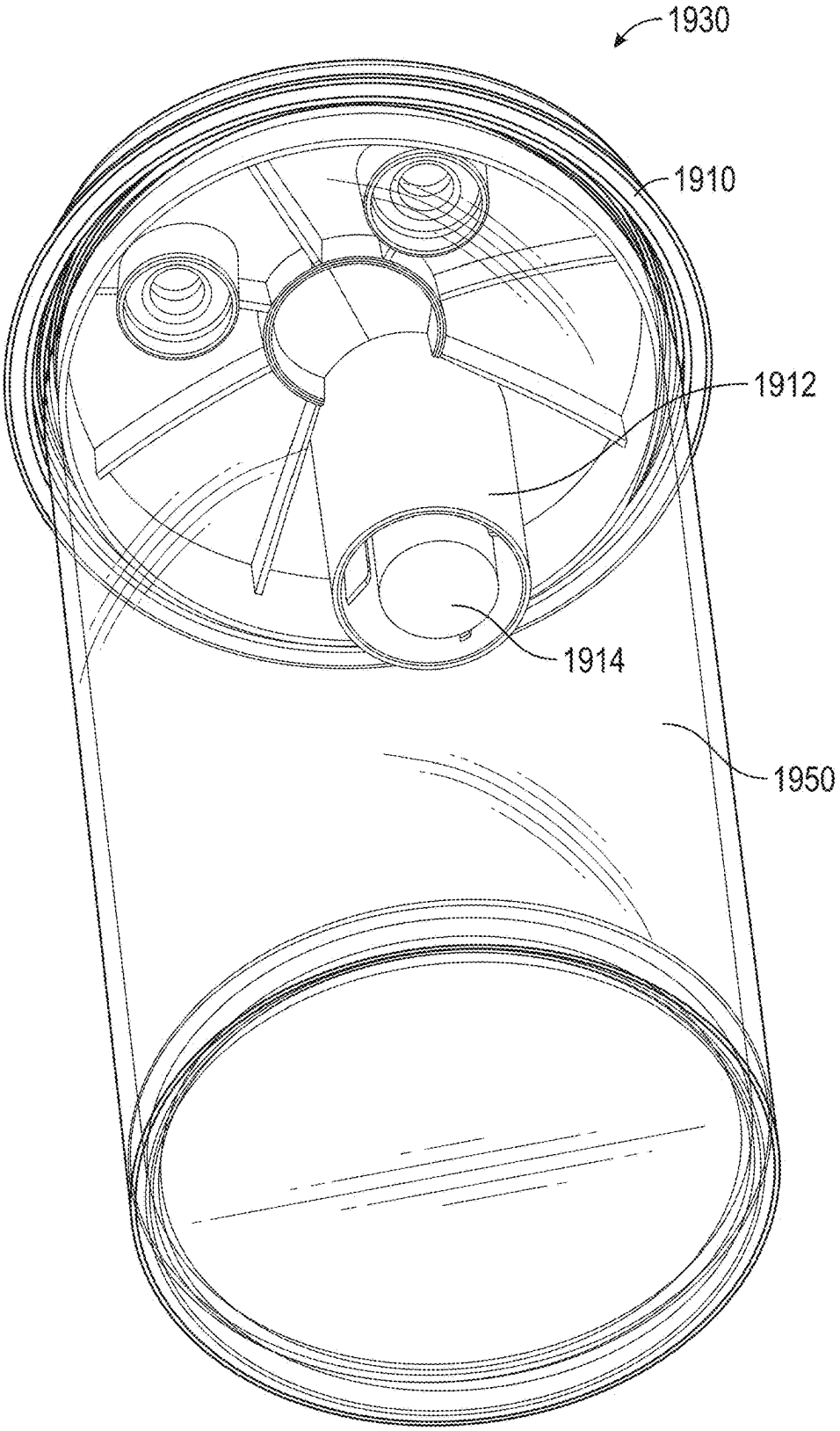

FIG. 9B

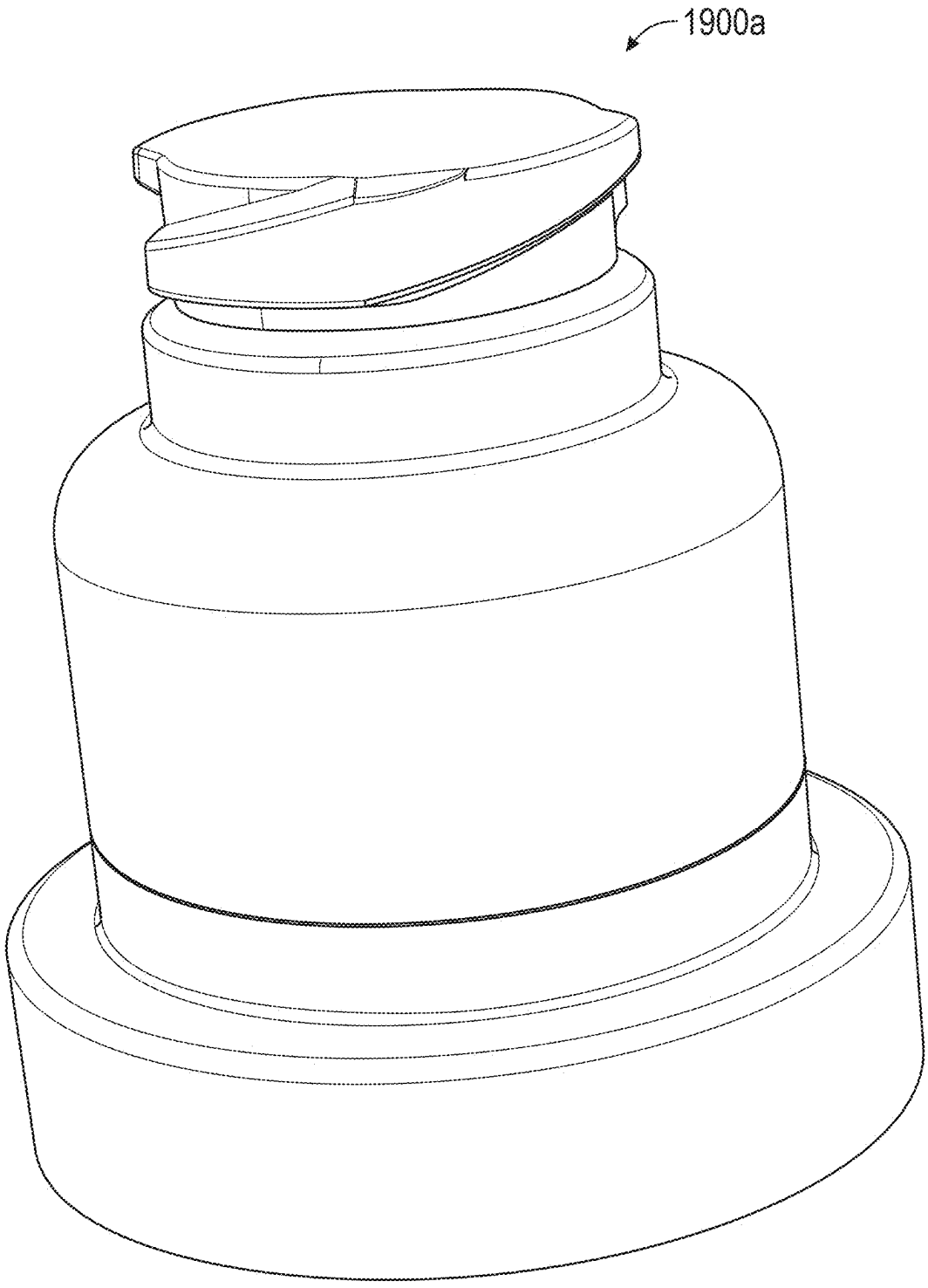

FIG. 9C

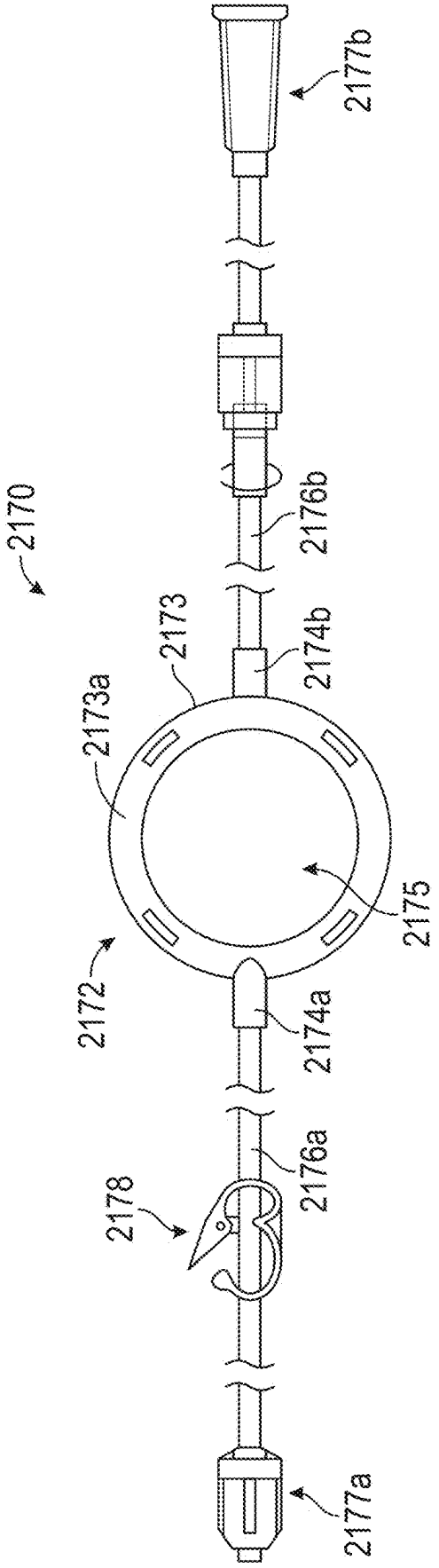

FIG. 10A

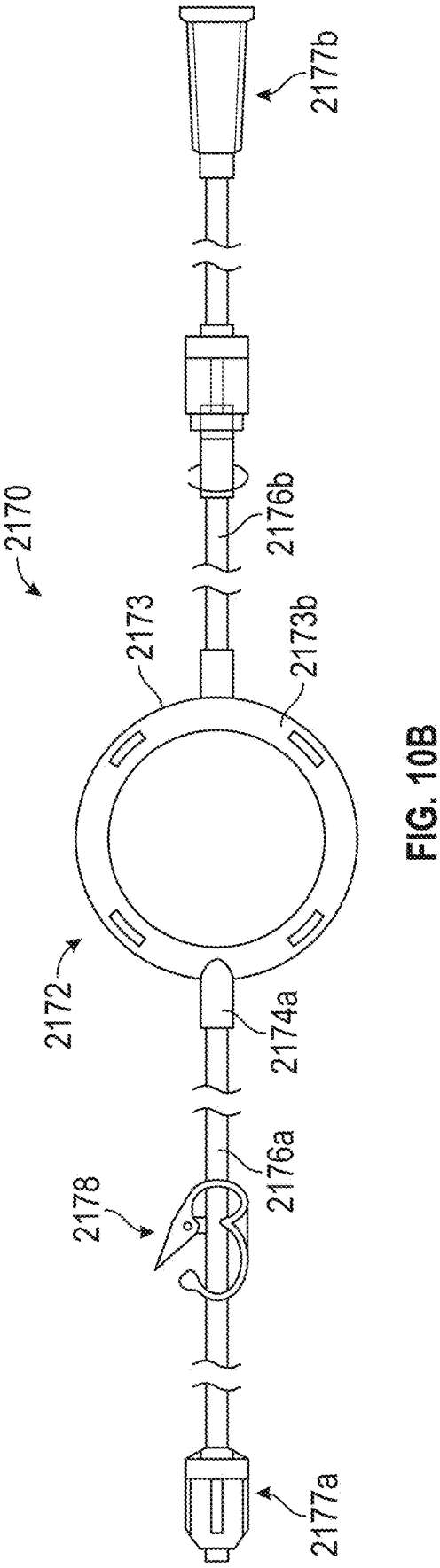

FIG. 10B

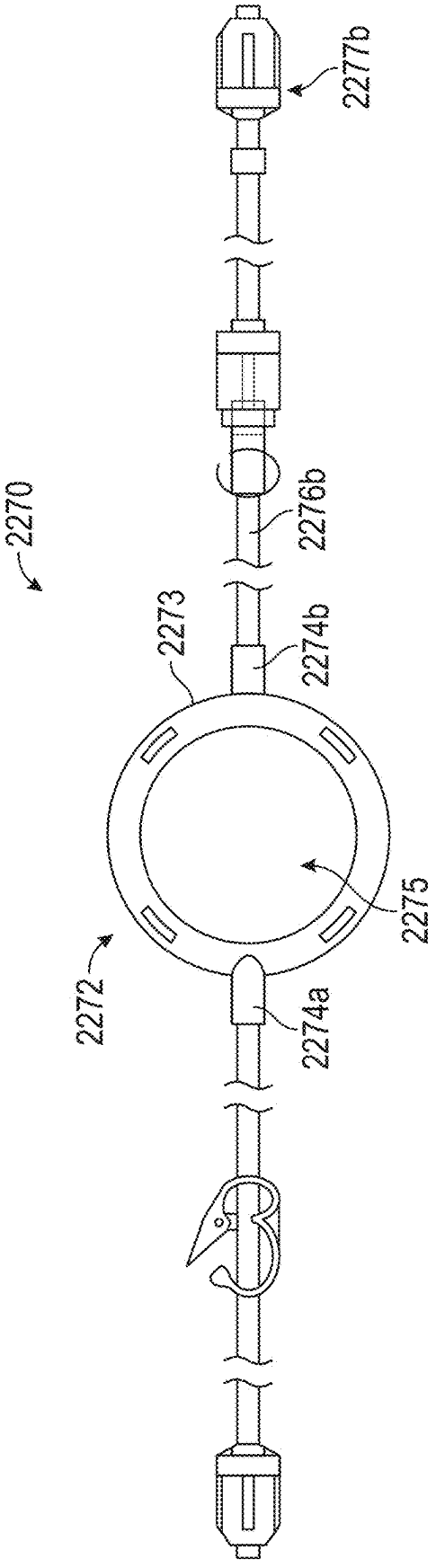

FIG. 11A

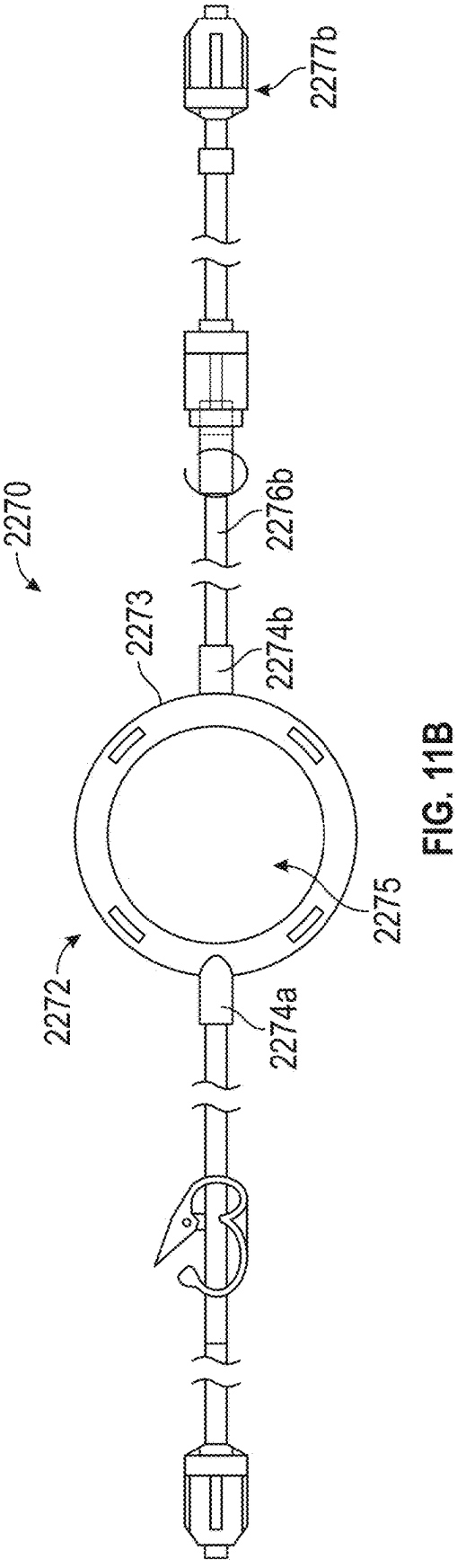

FIG. 11B

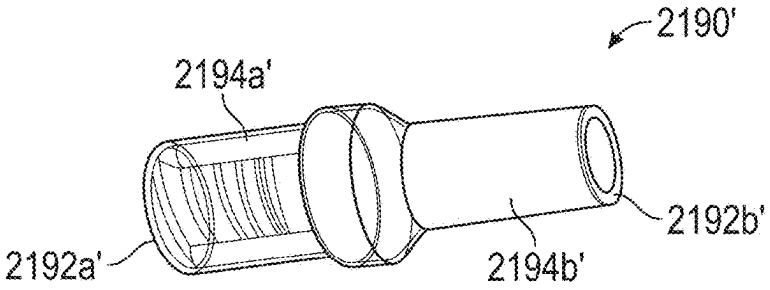

FIG. 11C

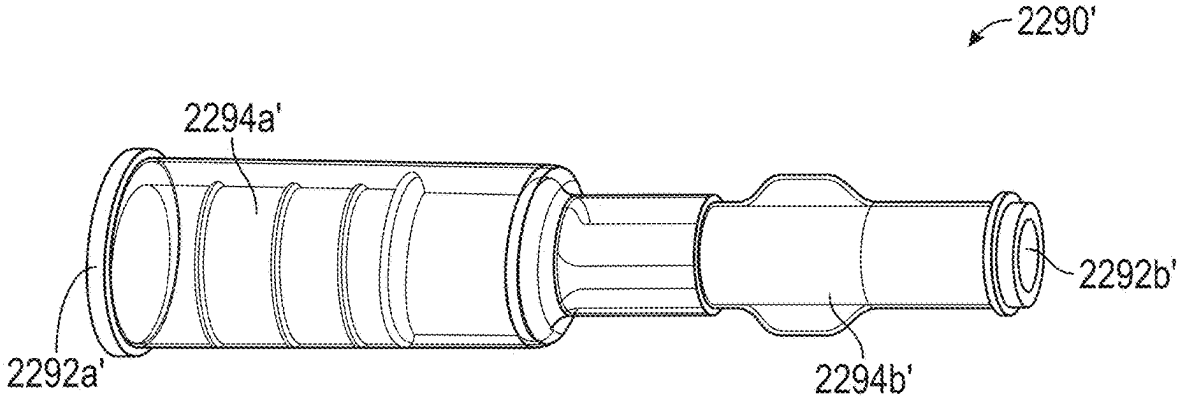

FIG. 11D

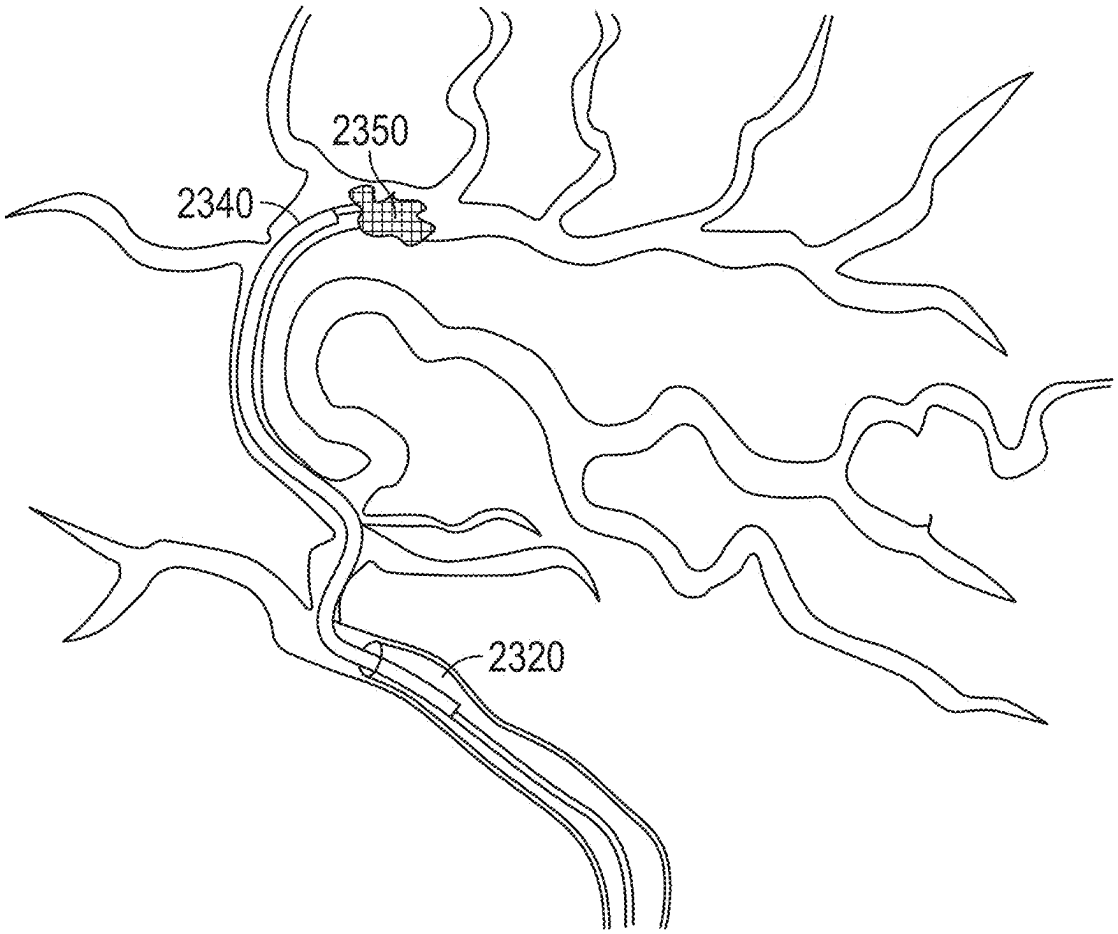

FIG. 12

DEVICES AND METHODS FOR ENHANCED ASPIRATION-INDUCED THROMBECTOMY

INCORPORATION BY REFERENCE

[0001] This application is a continuation application of International Patent Application No. PCT/US2023/070626 filed Jul. 20, 2023, which claims the priority benefit of U.S. Provisional Patent Application No. 63/391,472, filed Jul. 22, 2022, the entirety of each of which is hereby incorporated by reference herein. All publications and patent applications mentioned in this specification are herein incorporated by reference in their entirety, as if each individual publication or patent application was specifically and individually indicated to be incorporated by reference in its entirety.

FIELD

[0002] This disclosure relates generally to the field of thrombectomy, and more specifically to the field of aspiration based thrombectomy. Described herein are hemostasis valves for maintaining vacuum during guide catheter removal.

BACKGROUND

[0003] Thrombotic restrictions and occlusions within a patient's blood vessels are a significant medical problem and often require intervention to remove these restrictions and blockages to restore health to patients. While applicable to a wide range of vascular applications in both the arterial and venous systems, including a variety of small vessels such as arterial blockages in the neuro vasculature (ischemic stroke), the following background illuminates the problems primarily through the example of patients suffering with Pulmonary Embolisms.

[0004] Venous thromboembolic disease (VTE) is a worldwide crisis. There are over 10 million cases of deep vein thrombosis (DVT) and pulmonary embolism (PE) diagnosed globally per year, with 1 million cases occurring in the United States and over 700,000 in France, Italy, Germany, Spain, Sweden, and the United Kingdom combined each year. There are approximately 60,000 to 100,000 deaths from PE in the United States each year. DVT and PE are part of the same continuum of disease, with over 95% of emboli originating in the lower extremities. When PE occurs, the severity depends on the embolic burden and its effect on the right ventricle as well as underlying cardiopulmonary comorbidities. Death can result from the acute increase in pulmonary artery (PA) pressure with increased right ventricular (RV) afterload and dysfunction.

[0005] Patients with high-risk pulmonary embolism (PE) and other ischemic conditions were treated primarily with thrombolytic therapy delivered systemically or more locally through Catheter Directed Thrombolytics. These approaches result in multiple catheterization lab visits, lengthy hospital stays and often lead to bleeding complications. Newer approaches to both PE and ischemic stroke include single session thrombectomy (aspiration of the clot) without the use of thrombolytics. These thrombectomy treatments include positioning the distal end of an aspiration catheter adjacent the clot and applying suction in an effort to aspirate the clot through the catheter and into a cannister outside of the sterile field.

[0006] Conventional thrombectomy procedures use a vacuum pressure syringe (i.e., lock the plunger for a negative pressure vacuum) on the guide catheter during an aspiration procedure. However, if the clot shears at the guide catheter during retraction, the vacuum inside of the rotating hemostasis valve (RHV) needs to be maintained to not lose the clot while the guide catheter is removed to clear the clot from tip. If the RHV is opened, blood flow will push the clot off the tip of the guide catheter creating a new stroke in the patient. Splitting the aspiration so it connects with the pump improves clot retention on the guide but does not solve the problem entirely.

[0007] Accordingly, a new way is needed to maintain vacuum on the guide catheter while removing the aspiration catheter.

SUMMARY

[0008] One aspect of the present disclosure is directed to an aspiration system for a thrombectomy procedure. The aspiration system can include a source of vacuum; an aspiration canister including a first port, a second port, and a third port. The third port can be in fluid communication with the source of vacuum, The aspiration system can include a first aspiration line including a proximal end removably connected to the first port, wherein the first aspiration line is configured to be in fluid communication with a first catheter to provide a first fluid flow path between a distal end of the first catheter and the aspiration canister. The aspiration system can include a second aspiration line including a proximal end removably connected to the second port, wherein the second aspiration line is configured to be in fluid communication with a second catheter to provide a second fluid flow path between a distal end of the second catheter and the aspiration canister, the second catheter having an inner diameter smaller than the first catheter. The aspiration system can include a flow reducer positioned along the first fluid flow path and configured to reduce a fluid flow rate along the first fluid flow path proximal to the flow reducer when vacuum is applied to the first aspiration line. The aspiration system can provide uninterrupted vacuum to the first and second aspiration lines when the first and second aspiration lines are connected to the first and second ports. The aspiration system can provide vacuum to the first aspiration line at or above a minimum vacuum pressure threshold for maintaining a clot engaged to a distal tip of the first catheter.

[0009] In any of the embodiments described herein, the first port can include a first self-sealing port configured to seal the aspiration canister when the first aspiration line is not connected to the first self-sealing port, and the second port can include a second self-sealing port configured to seal the second self-sealing port when the second aspiration line is not connected to the second self-sealing port.

[0010] In any of the embodiments described herein, the flow reducer can be positioned at a distal region of the first aspiration line.

[0011] In any of the embodiments described herein, the flow reducer can be connected to the first port.

[0012] In any of the embodiments described herein, the minimum vacuum pressure threshold can be −14 inHg.

[0013] In any of the embodiments described herein, the flow reducer can include a main body including a first end, a second end, and a cavity; a fluid flow path segment extending from the first end to the second end; a restrictor including a hole; and one or more baffles extending from an

inner surface of the main body. The one or more baffles each can include one or more slots.

[0014] In any of the embodiments described herein, the one or more slots can be offset relative to one another to increase a length of the fluid flow path segment.

[0015] In any of the embodiments described herein, the one or more slots can be spaced by about 1 mm from each other.

[0016] In any of the embodiments described herein, the one or more baffles can form an angle of about 90° with respect to the inner surface of the main body.

[0017] In any of the embodiments described herein, the first aspiration line can include a clot retrieval device.

[0018] In any of the embodiments described herein, the clot retrieval device can include a distal port and a proximal port, the distal port having a diameter larger than a diameter of the proximal port.

[0019] In any of the embodiments described herein, the first aspiration line can include a first tubing section distal to the clot retrieval device and a second tubing section proximal to the clot retrieval device, the second tubing section can have an inner diameter smaller than an inner diameter of the first tubing section to reduce the fluid flow rate through the second tubing section.

[0020] In any of the embodiments described herein, the flow reducer can be positioned proximal to the clot retrieval device.

[0021] In any of the embodiments described herein, the flow reducer can be connected to a proximal port of the clot retrieval device.

[0022] In any of the embodiments described herein, the flow reducer can be configured to reduce the fluid flow rate by at least about 27%.

[0023] In any of the embodiments described herein, the flow reducer can be configured to reduce the fluid flow rate by at least about 31%.

[0024] In any of the embodiments described herein, the flow reducer can be configured to reduce the fluid flow rate by at least about 35%.

[0025] In any of the embodiments described herein, the flow reducer can be configured to reduce the fluid flow rate by at least about 46%.

[0026] In any of the embodiments described herein, the flow reducer can be configured to reduce the fluid flow rate by between 25% and 50%.

[0027] In any of the embodiments described herein, the flow reducer can be configured to maintain the fluid flow rate below a maximum threshold value, wherein the maximum threshold value is between 140 ml/min and 200 mL/min.

[0028] In any of the embodiments described herein, the aspiration system can include the first catheter, wherein the first catheter can be coupled to a hemostasis valve. The aspiration system can be configured to provide vacuum to the first aspiration line at or above the minimum vacuum pressure threshold for maintaining the clot engaged to the distal tip of the first catheter while the hemostasis valve is open.

[0029] Another aspect of the present disclosure is related to a method of performing a thrombectomy procedure. The method can include connecting a distal end of a first aspiration line to a first catheter to establish a first fluid flow path between the first catheter and an aspiration canister. A proximal end of the first aspiration line can be coupled to a first port of the aspiration canister. A flow reducer can be positioned along the first fluid flow path. The method can include connecting a distal end of a second aspiration line to a second catheter to establish a second fluid flow path between the second catheter and the aspiration canister. A proximal end of the second aspiration line can be coupled to a second port of the aspiration canister. The method can include advancing the first catheter and the second catheter though a vasculature of a patient to a target vascular site having a clot while the second catheter is positioned within a lumen of the first catheter; applying vacuum to the aspiration canister to apply vacuum to the first catheter and the second catheter along the first fluid flow path and the second fluid flow path; and retracting the second catheter out of a hemostasis valve of the first catheter while maintaining a vacuum pressure in the first catheter at or greater than a minimum vacuum pressure threshold for maintaining the clot engaged to a distal tip of the first catheter. The flow reducer can reduce a fluid flow rate along the first fluid flow path proximal to the flow reducer.

[0030] In any of the embodiments described herein, the minimum vacuum pressure threshold can be about −14 inHg.

[0031] In any of the embodiments described herein, maintaining the vacuum pressure in the first catheter at or greater than the minimum vacuum pressure threshold can include maintaining the vacuum pressure between −14 inHg and −28 inHg.

[0032] In any of the embodiments described herein, the method can include closing the hemostasis valve after retracting the second catheter out of the hemostasis valve and closing the second aspiration line. The flow reducer can be configured to retain the fluid flow rate along the first fluid flow path proximal to the flow reducer at or below a maximum threshold value when the hemostasis valve and second aspiration line are closed.

[0033] In any of the embodiments described herein, the maximum threshold value of the fluid flow rate can be between 140 ml/min and 200 mL/min.

[0034] In any of the embodiments described herein, the first aspiration line can include a clot retrieval device.

[0035] In any of the embodiments described herein, the clot retrieval device can include a distal port and a proximal port, the distal port having a larger diameter larger than a diameter of the proximal port.

[0036] In any of the embodiments described herein, the first aspiration line includes a first tubing section distal to the clot retrieval device and a second tubing section proximal to the clot retrieval device, wherein the second tubing section has an inner diameter smaller than an inner diameter of the first tubing section to reduce the fluid flow rate through the second tubing section.

[0037] In any of the embodiments described herein, the flow reducer can be positioned proximal to the clot retrieval device.

[0038] In any of the embodiments described herein, the flow reducer can be connected to a proximal port of the clot retrieval device.

[0039] In any of the embodiments described herein, the flow reducer can be positioned along a distal section of the first aspiration line.

[0040] In any of the embodiments described herein, the flow reducer can be connected to the first port.

[0041] In any of the embodiments described herein, the flow reducer can include a plurality of baffles, each baffle including a slot to facilitate fluid flow therethrough.

[0042] In any of the embodiments described herein, the slots of adjacent baffles are offset relative to one another to increase a length of the fluid flow path within the flow reducer.

[0043] In any of the embodiments described herein, the flow reducer can reduce the fluid flow rate by at least about 27%.

[0044] In any of the embodiments described herein, the flow reducer can reduce the fluid flow rate by at least about 31%.

[0045] In any of the embodiments described herein, the flow reducer can reduce the fluid flow rate by at least about 35%.

[0046] In any of the embodiments described herein, the flow reducer can reduce the fluid flow rate by at least about 46%.

[0047] In any of the embodiments described herein, the flow reducer can reduce the fluid flow rate by between 25% and 50%.

[0048] In any of the embodiments described herein, each of the first port and the second port can include a self-sealing port.

[0049] In any of the embodiments described herein, the aspiration canister can include a third port coupled to a vacuum source, wherein the third port has a different structure than the first port and the second port.

[0050] One aspect of the present disclosure is directed to a valve system comprising one or more of the following: a first port configured to be fluidly connected to a proximal end of a first catheter; a second port configured to be fluidly connected to a source of vacuum; a third port configured to receive a second catheter therethrough, such that the second catheter is configured to be coaxially disposed in a lumen of the first catheter; and a compressible region between the first port and the third port and distal to the second port.

[0051] In any of the embodiments described herein, application of compression to the compressible region reduces vacuum at the third port and substantially maintains or increases vacuum at the first port.

[0052] In any of the embodiments described herein, the valve further comprises a first vacuum line fluidly connected to the second port and a second vacuum line connected to the third port.

[0053] In any of the embodiments described herein, the first vacuum line and the second vacuum line are fluidly connected to a common vacuum line, wherein the common vacuum line is configured to fluidly connect the second port and the third port to the source of vacuum.

[0054] In any of the embodiments described herein, the valve further comprises a split connector that is configured to connect the first and second vacuum lines to the common vacuum line.

[0055] In any of the embodiments described herein, the compressible region comprises an elastic material comprising an embedded fiber braid.

[0056] In any of the embodiments described herein, the compressible region comprises silicone, polyurethane, or a combination thereof.

[0057] Another aspect of the present disclosure is directed to a method of adjusting vacuum at a valve system. The method comprises one or more of the following steps: connecting a proximal end of a first catheter to a first port of the valve system; connecting a second port of the valve system to a source of vacuum; disposing a second catheter through a third port of the valve system, such that the second catheter is configured to be coaxially disposed in a lumen of the first catheter; and applying compression to a compressible region of the valve system.

[0058] In any of the embodiments described herein, the compressible region is between the first port and the third port and distal to the second port.

[0059] In any of the embodiments described herein, application of compression to the compressible region reduces vacuum at the third port and substantially maintains or increases vacuum at the first port.

[0060] In any of the embodiments described herein, the method further includes connecting a first vacuum line to the second port and a second vacuum line to the third port.

[0061] In any of the embodiments described herein, the method further includes connecting the first vacuum line and the second vacuum line to a common vacuum line; and connecting the common vacuum to the source of vacuum.

[0062] In any of the embodiments described herein, the method further includes connecting a split connector between the first and second vacuum lines and the common vacuum line.

[0063] In any of the embodiments described herein, the compressible region comprises an elastic material comprising an embedded fiber braid.

[0064] In any of the embodiments described herein, the compressible region comprises silicone, polyurethane, or a combination thereof.

[0065] Another aspect of the present disclosure is directed to an aspiration canister comprising: a reservoir; a lid configured to be coupled to the reservoir; and a valve disposed in the lid.

[0066] In any of the embodiments described herein, the valve is configured such that one or more vacuum lines are configured to be added or removed during a procedure. In any of the preceding embodiments, the valve is a needless valve.

[0067] Another aspect of the present disclosure is directed to a method of switching between aspiration lines during a thrombectomy procedure. The method comprises: coupling a first vacuum line to a first port disposed in a lid of an aspiration canister; coupling a second vacuum line to a second port disposed in the lid of the aspiration canister; and disconnecting the first vacuum line from the first port while not substantially losing vacuum at the second vacuum line.

[0068] In any of the embodiments described herein, one or both of the first port and the second port comprise a needless valve.

[0069] In any of the embodiments described herein, any of the steps are configured to be performed during active thrombectomy.

[0070] In any of the embodiments described herein, any of the steps are configured to be performed before active thrombectomy.

BRIEF DESCRIPTION OF THE DRAWINGS

[0071] The foregoing is a summary, and thus, necessarily limited in detail. The above-mentioned aspects, as well as other aspects, features, and advantages of the present tech-

nology are described below in connection with various embodiments, with reference made to the accompanying drawings.

[0072] FIG. **1** illustrates an embodiment of a valve system.

[0073] FIG. **2** illustrates an embodiment of a split vacuum line.

[0074] FIG. **3** illustrates an embodiment of an aspiration system.

[0075] FIG. **4** illustrates an embodiment of a canister of an aspiration system.

[0076] FIGS. **5**A-**5**C illustrate an embodiment of a canister of an aspiration system.

[0077] FIG. **6**A illustrates an embodiment of a canister of an aspiration system with a cap secured to a port.

[0078] FIG. **6**B illustrates the cap shown in FIG. **6**A.

[0079] FIG. **7**A illustrates an embodiment of a canister of an aspiration system with a flow reducer secured to a valve.

[0080] FIG. **7**B illustrates an embodiment of a flow reducer.

[0081] FIG. **7**C illustrates an exploded view of embodiment of a flow reducer with four baffles.

[0082] FIG. **7**D illustrates a cross-section view of the flow reducer shown in FIG. **7**C.

[0083] FIG. **7**E illustrates an exploded view of an embodiment of a flow reducer with three baffles.

[0084] FIG. **7**F illustrates a cross-section view of the flow reducer shown in FIG. **7**E.

[0085] FIG. **7**G illustrates an exploded view of an embodiment of a flow reducer with four baffles.

[0086] FIG. **7**H illustrates an exploded view of an embodiment of a flow reducer with four baffles.

[0087] FIG. **7**I illustrates an embodiment of a canister of an aspiration system with a flow reducer secured to a distal end of an aspiration line.

[0088] FIG. **8**A illustrates a cross section view of an embodiment of a flow reducer.

[0089] FIG. **8**B illustrates a partially transparent view of the flow reducer shown in FIG. **8**A.

[0090] FIG. **8**C illustrates a cross section view of an embodiment of a flow reducer with eight baffles.

[0091] FIG. **8**D illustrates a partially transparent view of the flow reducer shown in FIG. **8**C.

[0092] FIG. **8**E illustrates a cross section view of another embodiment of a flow reducer with eight baffles.

[0093] FIG. **8**F illustrates a partially transparent view of the flow reducer shown in FIG. **8**E.

[0094] FIGS. **9**A-**9**B illustrate an embodiment of a canister of an aspiration system with self-sealing valves.

[0095] FIG. **9**C illustrates an embodiment of the sealing valve shown in FIGS. **9**A-**9**B.

[0096] FIGS. **10**A-**10**B illustrate an embodiment of an aspiration line with a clot retrieval device.

[0097] FIGS. **11**A-**11**B illustrate an embodiment of an aspiration line with a clot retrieval device and connectors for a self-sealing port.

[0098] FIGS. **11**C-**11**D illustrate embodiments of adapters for use with the aspiration lines shown in FIGS. **10**A-**11**B.

[0099] FIG. **12** illustrates a first catheter and a second catheters inside the vasculature of a patient.

[0100] The illustrated embodiments are merely examples and are not intended to limit the disclosure. The schematics are drawn to illustrate features and concepts and are not necessarily drawn to scale.

DETAILED DESCRIPTION

[0101] The foregoing is a summary, and thus, necessarily limited in detail. The above-mentioned aspects, as well as other aspects, features, and advantages of the present technology will now be described in connection with various embodiments. The inclusion of the following embodiments is not intended to limit the disclosure to these embodiments, but rather to enable any person skilled in the art to make and use the contemplated invention(s). Other embodiments may be utilized, and modifications may be made without departing from the spirit or scope of the subject matter presented herein. Aspects of the disclosure, as described and illustrated herein, can be arranged, combined, modified, and designed in a variety of different formulations, all of which are explicitly contemplated and form part of this disclosure.

[0102] Any of the devices, structures, features, system, or methods described herein may be utilized in connection with any suitable aspiration system. For example, any embodiment described herein may be utilized in connection with any of the aspiration systems as described in U.S. Pat. Nos. 10,835,272; 11,065,018; 11,25,9821 or in U.S. patents application Ser. No. 17/036,258 or U.S. Ser. No. 17/857,598, each of which is hereby incorporated by reference herein.

Modified Valve System

[0103] FIG. **1** shows a valve system **100**. The valve system **100** may incorporate any suitable type of valve (e.g., a hemostasis valve or a rotating hemostasis valve) that may be utilized to allow passage of one or more catheter systems through the valve system **100** and/or to allow application of aspiration and/or vacuum pressure through the valve system **100** and/or any catheter systems passed therethrough. For example, the catheter systems may comprise one or more catheters (e.g., a guide catheter, aspirate catheter, guidewire, etc.) as described in any of the U.S. patents or patent applications discussed and incorporated by reference herein. A distal entry port **120** of the valve system **100** may be connected directly or indirectly to one or more catheter systems to be inserted into a patient.

[0104] In some instances, a guide catheter (or any other suitable catheter) may be connected directly or indirectly to distal entry port **120** while a secondary device (e.g., an aspiration catheter or any other suitable insertion device) may pass through a proximal entry port **125** and be inserted into the guide catheter through the distal entry port **120**. An aspiration source may be coupled to the side port **130** to apply aspiration and/or vacuum pressure at least through the valve system **100** (e.g., the distal entry port **120**) and to any fluidly connected catheter systems.

[0105] During retraction of the secondary device, concern must be taken to ensure that a loss of vacuum pressure does not occur at the distal entry port **120** or along any connected catheter systems. In some instances, any loss of vacuum pressure may result in dislodgement of a clot, thrombus, or other vascular occlusion that has been captured by a connected catheter system during an aspiration procedure. For example, if fluid communication between the aspiration source through the side port **130** and the distal entry port **120**, then a clot held at the end of a catheter system connected to the distal entry port **120** may no longer remain engaged to the catheter system and may become pass back into a patient's vasculature. This would result in harm to the patient by creating an additional occlusion risk to the patient.

[0106] With reference to FIG. **1**, the valve system **100** may include a modified region **110** configured to allow a healthcare practitioner to, manually or automatically, temporarily inhibit fluid communication between the proximal entry port **125** and the distal entry port **120**. Temporarily isolating the proximal entry port **125** from fluid communication with the remainder of the valve system **100** may advantageously facilitate removal of a secondary device, as described herein, while minimizing any risk of loss of vacuum pressure through the distal entry port **120** and any related connected catheter systems.

[0107] In some instances, the modified region **110** may be compressible by a healthcare practitioner to manually shut off the distal entry port **120** of the valve system **100** when external compression is applied to the compressible region **110**. Applying compression to the compressible region **110** of the valve system **100** may advantageously inhibit substantial loss of vacuum through side port **130** by isolating the valve system **100** into two regions: a proximal region **150** and a distal region **140**. When the compressible region **110** is engaged, the distal region **140** of the valve system **100** may be configured to substantially maintain any present vacuum pressure even if the proximal region **150** of the valve system **100** experiences a substantial reduction in vacuum pressure (e.g., due to opening of the proximal entry port **125** to permit withdrawal of a secondary device). As shown in FIG. **1**, compressible region **110** may comprise a resilient tube fluidly connecting the distal region **140** with the distal entry port **120** and the proximal region **150** with the distal entry port **125**. The resilient tube may be compressible, while also having sufficient resilience and/or hoop strength to inhibit collapse of the tube during application of standard aspiration pressures used during an aspiration procedure. In some instances, the compressible region **110** may have sufficient burst strength to inhibit expansion during a high-pressured contrast injection procedure. For example, the compressible region **110** may comprise silicone, polyurethane, elastic materials comprising an embedded fiber braid, and/or any other material with sufficient properties.

[0108] Alternatively, or additionally, the valve system **100** shown in FIG. **1** may be used in conjunction with a split vacuum line **200**, as illustrated in FIG. **2**, or alone to maintain vacuum on the guide catheter (or any other suitable catheter) while removing the guide catheter (or any other suitable catheter) with the clot still engaged at the tip. In some embodiments, the valve system **100** can be used with an aspiration system (e.g., the aspiration systems described with respect to FIGS. **3-12**) to maintain vacuum on a catheter while removing the catheter with the clot still engaged at the tip.

[0109] As shown in FIGS. **2-3**, a split aspiration or vacuum line **200** comprises a common vacuum line **240** split at connector **210** (e.g., Wye connector) into a first vacuum line **220** and a second vacuum line **230**. Port **250** of common vacuum line **240** fluidly connects to the canister **270** of the aspiration pump **260**, first vacuum line **220** fluidly connects to a valve system (e.g., a rotating hemostasis valve) on a proximal end of a first catheter (e.g., guide catheter), and second vacuum line **240** fluidly connects to a valve system (e.g., a rotating hemostasis valve) on a proximal end of a second catheter (e.g., procedure catheter, aspiration catheter, etc.) configured to be disposed in the first catheter. The split vacuum line **200** increases the potential vacuum source from a fixed volume RHV to a continuous pump system. The first vacuum line **220** can include a clot retrieving device **300** positioned between a distal end and a proximal end of the first vacuum line **220**. The second vacuum line **230** can include a clot retrieving device **310** positioned between a distal end and a proximal end of the first vacuum line **230**. The clot retrieving devices **300**, **310** can each retain clots aspirated via the first and second catheters connected to the first and second vacuum lines **220**, **230**.

[0110] In some embodiments, as shown in FIG. **4**, an aspiration canister **730** may comprise one or more closeable valves or ports **700** installed on the lid **710** coupled to a reservoir **750**. The closeable port **700** enables a vacuum line **740** to be added and removed as needed. Each of the ports **700** is self-shutting or self-sealing, such that when the port **700** is not connected to a line **740**, the port **700** is closed and vacuum pressure is substantially maintained or vacuum pressure is not substantially lost within the canister **730**. In some instances, the canister **730** allows a physician to add additional vacuum lines or aspiration lines at any stage during a procedure. Any additional aspiration lines (e.g., a secondary line) may be fluidly connected to one of the closeable ports **700** at any stage prior to or during an aspiration procedure. In some instances, multiple aspiration lines may be added and/or removed during an aspiration procedure. For example, during an aspiration procedure, a healthcare practitioner may desire to include an additional aspiration line to provide additional aspiration through a secondary device as described herein (e.g., a secondary catheter or a guide catheter) by connecting a new aspiration line between one of the closeable ports **700** and the secondary device during the procedure. Aspiration through the secondary device may occur as an alternative or in addition to aspiration through a primary device (e.g., a first catheter). In contrast, ports that are not self-sealing may result in an unacceptable loss of pressure when a line is not connected to the port, preventing replacement or addition of an aspiration line during an aspiration procedure. The closeable port **700** may comprise any suitable closeable needless valve connector.

[0111] FIGS. **5A-5C** show an embodiment of an aspiration canister including two valves or ports. The aspiration canister **830** can include a first valve or port **800***a*, a second valve or port **800***b*, and an aspiration port **802**. The first port **800***a*, second port **800***b*, and aspiration port **802** can be positioned on a lid **810** which can removably secured to a reservoir **850** of the aspiration canister **830**, as shown in FIG. **5C**. The aspiration port **802** can be coupled (e.g., by a tube) to a source of vacuum, such as an aspiration pump, to provide vacuum to the aspiration canister **830** and connectors in fluid communication therewith. A vacuum line (not shown), which can include any of the same or similar features and functions as the vacuum line **740**, can be secured to each of the first and second ports **800***a*, **800***b*. In some embodiments, a single vacuum line can be connected to the first port **800***a* or the second port **800***b*. In some embodiments, however, each of the first and second ports **800***a*, **800***b* can receive and secure a distinct vacuum line. This can beneficially allow physicians to add and/or remove vacuum lines based on a desired aspiration procedure. For example, while a first vacuum line is secured to the first port **800***a*, a second vacuum line can be secured to the second port **800***b* to allow aspiration through both the first and

second vacuum lines. As described in further detail herein, each of the first and second vacuum lines can be coupled to a unique catheter.

[0112] As shown in FIG. **5**B, the lid **810** can include a filter housing **812**. The filter housing can be disposed inside the reservoir **850** when the lid **810** is secured to the reservoir **850**. When secured to the reservoir **850**, the filter housing **812** can be positioned on a top portion **850***a* of the reservoir **850**. The filter housing **812** can receive a filter (not shown). The filter can be removably secured to the filter housing **812**. The filter can prevent blood overflow and thus prevent the blood flowing out of the reservoir **850**. For example, the filter can absorb blood as the blood collects inside the reservoir **850** and reaches the top portion **850***a* of the reservoir **850**. The filter can also provide a visual indication to clinicians about the amount of blood inside the reservoir **850**. For instance, the filter may turn red as the filter absorbs blood, which may provide an indication that blood has reached the top portion **850***a* of the reservoir **850**.

[0113] As shown in FIGS. **5**A-**5**C, the ports **800***a*, **800***b*, and **802** can have the same structure as one another, for example, to allow coupling to standardized tubing connections.

[0114] In certain embodiments, one of the ports **800***a* and **800***b* may be closed or sealed before or during an aspiration procedure. For example, in procedures, aspiration may be provided to only a single catheter during an aspiration procedure. In other procedures, aspiration may be performed through two catheters, each coupled to one of the ports **800***a* and **800***b*, and one of catheters may be removed during the procedure. In such procedures, the port **800***a* or **800***b* in communication with the removed catheter may be closed or sealed to prevent a loss of vacuum pressure in the canister.

[0115] In some embodiments, as shown in FIG. **6**A, a cap **920** can be secured to the first port **800***a* and/or the second port **800***b* to seal the first and/or second ports **800***a*, **800***b*. When only one vacuum line is secured to one of the first and/or second ports **800***a*, **800***b* and the other is not use, the cap **920** can be secured to the port not in use. When secured to a port, the cap **920** can beneficially seal the port thus preventing aspiration through that port. This can beneficially increase or maintain the vacuum pressure at the port that is in use by preventing aspiration at the port not in use.

[0116] Also shown in FIG. **6**A is an embodiment of an aspiration tube **970** and connection **972**. The aspiration tube **970** can be connected to the aspiration port **802**. The connection **972** can facilitate connection of the aspiration tube **970** to an aspiration pump, such as aspiration pump **260**. The aspiration pump can be in fluid communication with the aspiration canister **830** and provide aspiration to the first and second ports **800***a*, **800***b* via the aspiration tube **970**. In some embodiments, the connection **972** can include an addition filter, which may provide redundancy, to prevent the flow of undesirable material into the aspiration pump.

[0117] As shown in FIG. **6**B, the cap **920** can include a tab **922**, a stopper **924**, a ring portion **926**, and a connecting member **928**. The ring portion **926** can include an opening **926***a* which can receive a port, such as ports **800***a*, **800***b*. The cap **920** can be secured to the to the first and/or second ports **800***a*, **800***b* by inserting the first and/or second ports **800***a*, **800***b* through the opening **926***a* of the ring portion **926**. The stopper **924** can be inserted into an opening of the first and/or second ports **800***a*, **800***b*. Contact between the stopper **924** and an inner surface of the first and/or second ports **800***a*, **800***b* can beneficially create a seal. This can beneficially stop aspiration at the first and/or second ports **800***a*, **800***b*. The cap **920** can include a flexible and/or stretchable material. The stopper **924** can be removed from the first and/or second ports **800***a*, **800***b* by pulling the tab **922**. This can beneficially allow clinicians to easily seal and/or open the ports **800***a*, **800***b* and/or connect additional vacuum lines to the ports **800***a*, **800***b* as needed.

[0118] FIG. **7**A shows an embodiment of an aspiration canister with a single port for coupling the canister with a catheter, an aspiration port for coupling the catheter with a vacuum source, and a flow reducer secured to the port. The aspiration canister **1030** can include a port **1000** for coupling the canister with a catheter and an aspiration port **1002** for coupling the canister with a vacuum source. Although the aspiration canister **1030** shown in FIG. **7**A includes a single port **1000**, the aspiration canister can include more than one port **1000** (e.g., two, three, etc.) in some embodiments. A flow reducer **1080** can be secured to the port **1000**. As will be further described, the flow reducer **1080** can be configured to reduce the flow rate through the flow reducer **1080** and into the canister **1030**. This can beneficially reduce blood loss during a procedure (e.g., a thrombectomy procedure). In certain embodiments, the flow reducer **1080** can be configured to reduce the flow rate while maintaining sufficient vacuum to aspirate a clot or prevent dislodgement of a clot engaged with or corked on a distal end of a catheter.

[0119] FIG. **7**B shows a cross section of an embodiment of a flow reducer **1080**. The flow reducer **1080** can include a main body **1082** having a first end **1082***a* and a second end **1082***b*. The first end **1082***a* can include a first opening **1083***a* and the second end **1082***b* can include a second opening **1083***b*. A fluid flow path **1084** can extend between the first opening **1083***a* and the second opening **1083***b*. The flow reducer **1080** can be secured to a port **1000** by positioning the flow reducer **1080** over the port **1000** so that the second opening **1083***b* receives the port **1000**. In some embodiments, a lower portion **1082***c* of the main body **1082** can include a cavity **1082***d*. A shape of the cavity **1082***d* can correspond to a shape of the port **1000**. This can beneficially allow the cavity **1082***d* to receive and secure the port **1000**. A friction fit between the cavity **1082***d* and the flow reducer **1080** can prevent the flow reducer **1080** from accidentally being dislodged from the port **1000**.

[0120] In some embodiments, one or more baffles can be positioned along the fluid flow path **1084**. For example, and as shown in FIG. **7**B, the main body **1082** of the flow reducer **1080** can include a baffle **1086** extending from an inner surface **1085** of the main body **1082**. To allow aspiration and/or flow of blood through the fluid flow path **1084**, the baffle **1086** can include one or more slots **1086***a*. In some embodiments, the one or more slots **1086***a* can be positioned along an edge of the baffle **1086** so that the one or more slots **1086***a* are adjacent the inner surface **1085** of the main body **1082**, as shown in FIG. **7**B. The one or more slots **1086***a* can be positioned closer to a center point C of the baffle so that the one or more slots **1086***a* are not adjacent the inner surface **1085** of the main body **1082**. The flow reducer **1080** can include a restrictor **1087**. The restrictor **1087** can include a hole **1087***a* which can extend across the entire restrictor **1087**. In some embodiments, the hole **1087***a* has a diameter of about 1 mm, 2 mm, 3 mm, 4 mm, 5 mm, or any other suitable diameter. As will be further described, when aspiration is applied to the canister **1030** via the aspiration tube

1070, the restrictor **1087** and baffle **1086** can reduce fluid flow rate along the fluid flow path **1084**. Although reference is made to the flow reducer **1080** including one baffle **1086**, the flow reducer can include more than one baffle **1086** (e.g., two, three, four, five, six, etc.) Additional baffles may further reduce the fluid flow rate along the flow path **1084**. For example, the main body **1082** can include a second baffle (not shown) extending from the inner surface **1085** of the main body **1082**.

[0121] FIGS. **7**C-**7**D show an embodiment of a flow reducer **1180** including four baffles **1186**. The flow reducer **1180** can include any of the same or similar features and functions as the flow reducer **1080**, which is described in relation to FIGS. **7**A-**7**B. Each of the baffles **1186** can include a slot **1186***a*. Each slot **1186***a* can be positioned along an edge of each baffle **1186** so that each slot **1186***a* is adjacent an inner surface **1185** of the main body **1182**. In some embodiments, the slots **1186***a* from directly adjacent baffles **1186** can be positioned on opposite regions along the perimeter of their respective baffles **1186** so as to increase or maximize the distance between the slots **1186***a*. This can beneficially increase a length of the fluid flow path **1184**, and consequently decrease the flow rate along the fluid flow path **1184** extending between the first end **1182***a* and the second end **1182***b* of the main body **1182**. In some embodiments, the baffles **1186** can be vertically spaced from each other by a distance D**1**. In some embodiments, the distance D**1** can be about 1 mm. In some embodiments, the distance D**1** can be about 0.5 mm, about 1.5 mm, or any other suitable distance. In some embodiments, the flow reducer **1180** with four baffles **1186** and a restrictor **1187** may reduce flow from an aspiration catheter connected to an aspiration cannister, such as aspiration cannister **1030**, by about 35%, at least about 35%, or up to about 35%. In some embodiments, the flow reducer **1180** may reduce flow by between 25% and 45% or any other suitable amount.

[0122] FIG. **7**E-**7**F show an embodiment of a flow reducer **1280** including three baffles **1286**. The flow reducer **1280** can include any of the same or similar features and functions as the flow reducers **1080**, **1180**, which are described in relation to FIGS. **7**A-**7**D. Each of the baffles **1286** can include a slot **1286***a*. Each slot **1286***a* can be positioned along an edge of each baffle **1286** so that each slot **1286***a* is adjacent an inner surface **1285** of the main body **1282**. In some embodiments, the slots **1286***a* from directly adjacent baffles **1286** can be positioned on opposite regions along the perimeter of their respective baffles **1186** so as to increase or maximize the distance between the slots **1286***a*. This can beneficially increase a length of the fluid flow path **1284**, and consequently decrease the flow rate along the fluid flow path **1284** extending between the first end **1282***a* and the second end **1282***b* of the main body **1282**. In some embodiments, the baffles **1286** can be vertically spaced from each other by a distance D**2**. In some embodiments, the distance D**2** can be about 1 mm. In some embodiments, the distance D**2** can be about 0.5 mm, about 1.5 mm, or any other suitable distance. In some embodiments, the flow reducer **1280** with three baffles **1286** and a restrictor **1287** may reduce flow from an aspiration catheter connected to an aspiration cannister, such as aspiration cannister **1030**, by about 27%, at least about 27%, or up to about 27%. In some embodiments, the flow reducer **1280** may reduce flow by between 17% and 35% or any other suitable amount. In certain embodiments, a flow reducer **1280** may reduce flow by an amount less than a flow reducer **1180** under the same conditions (e.g., to due the great number of baffles and/or longer flow path of the flow reducer **1180**).

[0123] FIG. **7**G shows an embodiment of a flow reducer **1380** including four baffles **1386**. Each baffle **1386** may have a thickness of about 1 mm. In some embodiments, the thickness can be about 0.5 mm, about 1.5 mm, or any other suitable thickness. The flow reducer **1380** can include any of the same or similar features and functions as the flow reducers **1080**, **1180**, **1280** which are described in relation to FIGS. **7**A-**7**F. Each of the baffles **1386** can include a slot **1386***a*. Each slot **1386***a* can be positioned along an edge of each baffle **1386** so that each slot **1386***a* is adjacent an inner surface **1385** of the main body **1382**. Each slot **1386***a* can be a substantially square shape. For instance, the slots **1386***a* can measure about 1 mm by 1 mm.

[0124] In some embodiments, the slots **1386***a* from directly adjacent baffles **1386** can be positioned on opposite regions along the perimeter of their respective baffles **1386** so as to increase or maximize the distance between the slots **1386***a*. This can beneficially increase a length of the fluid flow path **1384**, and consequently decrease the flow rate along the fluid flow path **1384** extending between the first end **1382***a* and the second end **1382***b* of the main body **1382**. In some embodiments, the baffles **1386** can be vertically spaced from each other by a distance D**3**. In some embodiments, the distance D**3** can be about 1 mm. In some embodiments, the distance D**3** can be about 0.5 mm, about 1.5 mm, or any other suitable distance. In some embodiments, the flow reducer **1380** with four baffles **1386** and a restrictor (not shown) may reduce flow from an aspiration catheter connected to an aspiration cannister, such as aspiration cannister **1030**, by about 31%, at least about 31%, or up to about 31%. In some embodiments, the flow reducer **1380** may reduce flow by between 21% and 41% or any other suitable amount. In certain embodiments, a flow reducer **1280** may reduce flow by an amount less than a flow reducer **1180** under the same conditions (e.g., to due the great number of baffles and/or longer flow path of the flow reducer **1180**).

[0125] FIG. **7**H shows an embodiment of a flow reducer **1480** including six baffles **1486**. Each baffle **1486** may have a thickness of about 1.5 mm. The flow reducer **1480** can include any of the same or similar features and functions as the flow reducers **1080**, **1180**, **1280**, **1380** which are described in relation to FIGS. **7**A-**7**G. Each of the baffles **1486** can include a slot **1486***a*. Each slot **1486***a* can be positioned between an edge of the baffles **1486** and a center point C of the baffle **1486** so that the slots **1486***a* are not directly adjacent to the inner surface **1485** of the main body **1482**. Each slot **1486***a* can include a substantially circular shape.

[0126] In some embodiments, the slots **1486***a* from directly adjacent baffles **1486** can be positioned on opposite regions around the center point C of their respective baffles **1486** so as to increase or maximize the distance between the slots **1486***a*. This can beneficially increase a length of the fluid flow path **1484**, and consequently decrease the flow rate along the fluid flow path **1484** extending between the first end **1482***a* and the second end **1482***b* of the main body **1482**. In some embodiments, the baffles **1486** can be vertically spaced from each other by a distance D**4**. In some embodiments, the distance D**4** can be about 1 mm. In some embodiments, the flow reducer **1480** with six baffles **1486**

and a restrictor (not shown) may reduce flow from an aspiration catheter connected to an aspiration cannister, such as aspiration cannister **1030**, by about 46%, at least about 46%, or up to about 46%. In some embodiments, the flow reducer **1480** may reduce flow by between 36% and 56% or any other suitable amount.

[0127] While shown and described with respect to the aspiration canister **1030** and port **1000**, one of skill in the art would understand that the flow reducer **1080** and other flow reducers described herein can be used with or modified to be used with any of the canisters described herein to reduce the flow rate of fluid into the aspiration canister. As described in further detail herein, in certain embodiments, a flow reducer may be used in combination with an aspiration canister having two ports for coupling to two catheters. For example, the flow reducer can be placed on one of the ports to reduce the flow rate from one of the catheters. Alternatively, a flow reducer may be placed on each of the ports to reduce the flow rate from each catheter.

[0128] Although the flow reducers described herein are described and shown as being secured to a port of the aspiration canister, the flow reducer can be positioned distal to the port(s) of the aspiration canister in some embodiments. For example, a flow reducer **1580** can be positioned at or near a distal end **1590***b* of a vacuum or aspiration line **1590**, as shown in FIG. **7**I. The aspiration line **1590** can be connected to a port **1500** by securing a proximal end **1590***a* of the aspiration line **1590** to a port **1500** of a canister **1530**. The distal end **1590***b* of the aspiration line **1590** can be coupled to an aspiration catheter **1571**, This can beneficially place the aspiration line **1590** in fluid communication with the aspiration canister **1530** and thus provide aspiration to the aspiration line **1590** and the catheter **1571**.

[0129] The flow reducer **1580** can reduce the flow rate of fluid through the flow reducer **1580** and proximal of the flow reducer **1580**. Flow rate distal of the flow reducer **1580** may be greater than the flow rate proximal of the reducer **1580**. Accordingly, the flow reducer **1580** may desirably be positioned distally along the aspiration line **1590** to provide a greater length of aspiration line **1590** or flow path having a reduced flow rate and a shorter length of the aspiration line or flow path without a reduced flow rate. This may beneficially reduce a total amount of blood aspirated into the aspiration canister **1530** over a particular period of time in comparison to a flow reducer positioned more proximally along the aspiration line **1590** and/or directly connected to a port of the aspiration canister **1530**.

[0130] The aspiration canister **1530** can have any of the same or similar features and functions as any of the other aspiration canisters described herein.

[0131] As shown in FIG. **7**I, the aspiration line **1590** can include a clot pod or clot retrieval device **1572** for retaining an aspirated clot therein. The aspiration catheter **1571** can be advanced though the vasculature of a patient so that aspiration at a distal end **1571***b* of the aspiration catheter **1571** causes the aspiration catheter **1571** to aspirate clots from the vasculature of a patient into the clot retrieval device **1572**. The clot retrieval device **1572** can beneficially allow for visualization of the clot once the clot is removed from the vasculature of the patient. Various examples of clot retrieval devices are shown and described in International Patent Application No. PCT/US2022/078113, filed Oct. 14, 2022, the contents of which are herein incorporated by reference in their entirety.

[0132] As shown in FIG. **7**I, the flow reducer **1580** may be positioned along the aspiration line **1590** proximal to the clot retrieval device **1572** to prevent or restrict a clot from entering the flow reducer **1580**. In some embodiments, the flow reducer **1580** may be directly connected to a proximal end of the clot retrieval device **1572** to increase the length of the flow path having a reduced flow rate.

[0133] Although reference is made to the aspiration canister **1530** including a single port **1500**, the aspiration canister **1530** can include more than one port with an aspiration line, a flow reducer, and/or a catheter in fluid communication with the aspiration canister **1530**. Additionally, the aspiration line **1590** may be used with any of the aspiration canisters described herein.

[0134] FIGS. **8**A-**8**F show additional embodiments of flow reducers for use with an aspiration canister. As shown in FIGS. **8**A-**8**B, a flow reducer **1680** can include a single opening **1683** extending from a first end **1682***a* to a second end **1682***b* of a main body **1682** of the flow reducer **1680**. A flow reducer **1780**, as shown in FIGS. **8**C-**8**D, can include eight baffles **1786**. Each baffle **1786** can include a slot **1786***a*. The baffles **1786** may include one baffle **1786** with a slot **1786***a* positioned substantially along a center point of the baffle **1786**. Two baffles **1786** separated by a baffle **1786** having a slot **1786***a* positioned substantially along a center point of the baffle **1786**, can include slots **1786***a* positioned on opposite regions around the center point C of their respective baffles **1786**. The slots **1786***a* can include a substantially circular shape. In some embodiments, the flow reducer can include baffles extending from an inner surface of the flow reducer at an angle other than 90°. For example, as shown in FIGS. **8**E-**8**F, a flow reducer **1880** can include eight baffles **1886**. Directly adjacent baffles **1886** can extend from opposite sides of an inner surface **1885** of the main body **1882**. A gap G between each pair of baffles **1886** allows fluid flow between a first end **1882***a* and a second end **1882***b* of the main body **1882** while reducing flow rate.

[0135] FIGS. **9**A-**9**B show an embodiment of an aspiration canister with self-shutting or self-sealing ports. The aspiration canister **1930** can include any of the same or similar features and functions as the other aspiration canisters described herein. The aspiration canister **1930** can include a first self-sealing port **1900***a*, a second self-sealing port **1900***b*, and an aspiration port **1902**. A vacuum line (not shown), which can include any of the same or similar features and functions as the vacuum line **740** or vacuum line **1590**, can be secured to each of the first and second self-sealing ports **1900***a*, **1900***b*.

[0136] As shown in FIGS. **9**A-**9**B, the ports **1900***a* and **1900***b* may have a different structure than the aspiration port **1902** that couples the canister **1930** to the aspiration pump. This may prevent accidental coupling of one of the vacuum lines connected to a catheter directly to the aspiration pump.

[0137] As shown in FIG. **9**B, a lid **1910** of the aspiration canister **1930** can include a filter housing **1912**. The filter housing can be disposed inside the reservoir **1950** when the lid **1910** is secured to the reservoir **1950**. When secured to the reservoir **1950**, the filter housing **1912** can be positioned on a top portion **1950***a* of the reservoir **1950**. The filter housing **1912** can receive a filter **1914**. The filter **1914** can be removably secured to the filter housing **1912**. The filter **1914** can prevent blood overflow and thus prevent the blood flowing out of the reservoir **1950**. For example, the filter **1914** can absorb blood as the blood collects inside the

reservoir **1950** and reaches the top portion **1950***a* of the reservoir **1950**. As discussed in relation to FIGS. **5**A-**5**C, the filter **1914** can also provide a visual indication about the amount of blood inside the reservoir **1950**. For instance, the filter **1914** may turn red as the filter **1914** absorbs blood which may provide an indication that blood has reached the top portion **1950***a* of the reservoir **1950**.

[0138] FIG. **9**C shows an embodiment of a perspective view of a self-sealing port **1900***a*. While a port **1900***a* is shown, one of skill in the art would understand that the port **1900***b* can include any of the same or similar features and functions. The self-sealing port **1900***a* enables a vacuum line to be added and removed as needed. The self-sealing port **1900***a* can be self-shutting or self-sealing, such that when the port is not connected to a vacuum line, the self-sealing port **1900***a* is closed and vacuum pressure is substantially maintained, or vacuum pressure is not substantially lost within the aspiration canister. The self-sealing port **1900***a* can beneficially allow the connection of a second aspiration line to an aspiration canister without significant vacuum pressure loss and/or allow immediate vacuum pressure at the second aspiration line. This can prevent vacuum pressure loss along a first catheter connected to a first aspiration line when a second catheter is disconnected from the aspiration canister.

[0139] In some instances, the self-sealing ports **1900***a* and **1900***b* allow a physician to add additional aspiration lines at any stage during a procedure. Any additional aspiration lines (e.g., a secondary line) may be fluidly connected to one of the ports **1900***a* and **1900***b* at any stage prior to or during an aspiration procedure. In some instances, multiple aspiration lines may be added and/or removed during an aspiration procedure. For example, during an aspiration procedure, a healthcare practitioner may desire to include an additional aspiration line to provide additional aspiration through a secondary device as described herein (e.g., a secondary catheter or a guide catheter) by connecting a new aspiration line between one of the self-sealing ports and the secondary device during the procedure. Aspiration through the secondary device may occur as an alternative or in addition to aspiration through a primary device (e.g., a first catheter). In contrast, ports that are not self-sealing may result in an unacceptable loss of pressure when a line is not connected to the port, preventing replacement or addition of an aspiration line during an aspiration procedure. The ports **1900***a* and **1900***b* may comprise any suitable closeable needless valve connector.

[0140] FIGS. **10**A-**10**B illustrate an embodiment of an aspiration line **2170** including a clot retrieval device **2172**. The aspiration line **2170** can include any of the same or similar features and functions as the aspiration line **1590**, which is described in relation to FIG. **7**I. The clot retrieval device **2172** can include a body **2173** enclosing a chamber which communicates with a first port **2174***a* and a second port **2174***b*. In some embodiments, the body **2173** can include a flush port (not illustrated) that is configured to allow the injection of saline or other fluid into the chamber to improve clot visualization once it is trapped in a filter **2175**.

[0141] In some embodiments, the body **2173** includes a housing having a top portion **2173***a* and a bottom portion **2173***b*. In some examples, the body **2173** includes a filter **2175** positioned in the chamber between the top portion **2173***a* and the bottom portion **2173***b*. In some examples, the first port **2174***a* is configured to connect to a first end of a tubing section **2176***a* that is fluidly connected to a proximal end of an aspiration catheter, such as aspiration catheter **1571** (e.g., to a valve, such as an RHV, of the catheter). In some embodiments, the first tubing section **2176***a* includes a connector **2177***a* positioned at a second end of the first tubing section **2176***a* that is configured to engage or mate with a corresponding connector of the aspiration catheter (e.g., of a valve, such as an RHV, of the catheter).

[0142] In some embodiments the second port **2174***b* is configured to connect to a first end of a second tubing section **2176***b* that is fluidly connected to an aspiration canister, such as aspiration canister **1530**, in communication with an aspiration source (e.g., a pump). In some embodiments, the second tubing section **2176***b* includes a connector **2177***b* positioned at a second end of the second tubing section **2176***b* that is configured to engage or mate with a corresponding connector of the aspiration canister, and/or flow reducer coupled to the port of the canister. For example, the connector **2177***b* can be connected to a port, which can include any of the same or similar features and functions as ports **800***a*, **800***b*, and/or a flow reducer, which can include any of the same or similar features and functions as the flow reducer **1080** or any other flow reducers described herein. In some embodiments, the aspiration line **2170** can include a clamp **2178**. The clamp **2178** can be positioned over the first tubing section **2176***a* to allow the user to engage the clamp **2178** and control fluid flow along the aspiration line **2170**. For example, the clamp **2178** can be closed to restrict and/or reduce flow along the aspiration line **2170** proximal to the clamp **2178** and opened to allow and/or increase the fluid flow along the aspiration line **2170** proximal to the clamp **2178**. In some embodiments, at least a portion of the body **2173** of the clot retrieval device **2172** can be optically transparent to improve clot visualization once the clot is trapped in the clot retrieval device **2172**.

[0143] In some embodiments, the filter **2175** can be circular in shape. In some embodiments, the filter **2175** can be secured between the top portion **2173***a* and the bottom portion **2173***b* of the body **2173**. In some examples, the filter **2175** of the clot retrieval device **2172** may be provided with different pore sizes based on the needs of the physician or the patient. For example, in some embodiments, the filter **2175** can include 1 mm holes that catches solid clot debris as blood is driven through the aspiration line **2170**. In some embodiments, the pore sizes may be at most 1 mm, at most 2 mm, at most 3 mm, at most 4 mm, at most 5 mm, etc.

[0144] In some embodiments, the aspiration line **2170** aspirates blood which can flow through the first tubing section **2176***a* and enter the clot retrieval device **2172** of the aspiration line **2170**. The aspirated blood can then be filtered by the filter **2175**. Material that is greater in size than the openings on the filter **2175** is prevented from leaving the clot retrieval device **2172**, while material that is smaller in size than the openings on the filter **2175** flows out of the clot retrieval device **2172** via the second tubing section **2176***b*. In some embodiments, the user can slow down fluid flow along the aspiration line **2170** by engaging the clamp **2178**. In some embodiments, the user can inspect the clot or other larger aspirated material caught by the clot retrieval device **2172**. In some embodiments, the material trapped in the clot retrieval device **2172** can be removed from the clot retrieval device **2172** and tested by the user.

[0145] The first port **2174***a* may be larger, smaller, or the same size as the second port **2174***b* and/or may be configured to fluidly connect tubing sections that are larger, smaller, or the same size as the second port **2174***b*. In some instances, the first port **2174***a* may be larger than the second port **2174***b* such that the first port **2174***a* is configured to fluidly connect to a first tube or tubing section (e.g., first tubing section **2176***a*) being larger than a second tube or tubing section (e.g., second tubing section **2176***b*) that may be fluidly connected to the second port **2174***b*. The first port **2174***a*, in some embodiments, may be configured to fluidly connect to a standard tube (e.g., a tube having an inner diameter of about 0.1 inches). The second port **2174***b* may be smaller than the first port **2174***a* such that second tubing section **2176***b* is smaller than first tubing section **2176***a*. In some instances, the smaller size of the second tubing section **2176***b* may advantageously facilitate in decreasing a priming time of the system such that the aspiration source is configured to "prime" (e.g., apply negative pressure at least throughout the length of the second tubing section **2176***b* and the clot retrieval device **2172**). The smaller tube size may facilitate priming by decreasing the overall internal tube volume between the aspiration source and the clot retrieval device **2172** that requires priming. In some instances, the smaller tube size may advantageously decrease a blood fluid flow rate through the second tubing section **2176***b* so as to reduce a potential amount of blood loss during an aspiration procedure.

[0146] FIGS. **11**A-**11**B illustrate an embodiment of an aspiration line **2270** including a clot retrieval device **2272**. The aspiration line **2270** can include any of the same or similar features and functions as the aspiration line **2170**, which is described in relation to FIGS. **10**A-**10**B. The clot retrieval device **2272** can include a body **2273** enclosing a chamber which communicates with a first port **2274***a* and a second port **2274***b*. In some embodiments, the body **2273** can include a flush port (not illustrated) that is configured to allow the injection of saline or other fluid into the chamber to improve clot visualization once it is trapped in a filter **2275**.

[0147] In some embodiments, a second port **2274***b* is configured to connect to a first end of a second tubing section **2276***b* that is fluidly connected to an aspiration source (e.g., a pump), such as aspiration canister **1930**. In some embodiments, the second tubing section **2276***b* includes a connector **2277***b* positioned at a second end of the second tubing section **2276***b* that is configured to engage or mate with a corresponding connector, port, and/or flow reducer coupled to an aspiration container. For example, the connector **2277***b* can be connected to a port, which can include any of the same or similar features and functions as a self-sealing port, such as self-sealing ports **1900***a*, **1900***b*, which are described in relation to FIG. **9**A.

[0148] FIGS. **11**C-**11**D illustrate embodiments of adapters which can be used with the aspiration lines **2170**, **2270**. As shown in FIG. **11**C, an adapter **2190'** can include a first end **2192***a'*, a second end **2192***b'*, a self-sealing port **2194***a'* and a coupling member **2194***b'*. In some embodiments, the adapter **2190'** can be connected to a connector, such as connector **2177***b*. The adapter **2190***b'* can be connected to the connector **2177***b* by inserting the coupling member **2194***b'* into the connector **2177***b*. A friction fit between the connector **2177***b* and the coupling member **2194***b'* can prevent the coupling member **2194***b'* from accidentally being dislodged from the connector **2177***b*. The self-sealing port **2194***a'* can be connected to a self-sealing port, such as self-sealing ports **1900***a*, **1900***b* of the aspiration canister **1930**. The adapter **2190'** can allow the aspiration line **2170** to be connected to an aspiration canister having self-sealing ports. This can beneficially allow users to connect the aspiration line **2170** to aspiration canisters with self-sealing ports, such as aspiration canister **1930**, and aspiration canisters with non-self-sealing ports, such as aspiration canister **830**.

[0149] As shown in FIG. **11**D, an adapter **2290'** can include a first end **2292***a'*, a second end **2292***b'*, an attachment member **2294***a'* and a coupling member **2294***b'*. In some embodiments, the adapter **2290'** can be connected to a connector, such as connector **2277***b*. The adapter **2290***b'* can be connected to the connector **2277***b* by inserting the coupling member **2294***b'* into the connector **2277***b*. A friction fit between the connector **2277***b* and the coupling member **2294***b'* can prevent the coupling member **2294***b'* from accidentally being dislodged from the connector **2277***b*. The attachment member **2294***a'* can be connected to a port, such as ports **800***a*, **800***b*. The adapter **2290'** can allow the aspiration line **2270** to be connected to an aspiration canister having non-self-sealing ports. This can beneficially allow users to connect the aspiration line **2270** to aspiration canisters with non-self-sealing ports, such as aspiration canister **830**, and aspiration canisters with self-sealing ports, such as aspiration canister **1930**. DUAL PORT ASPIRATION CANISTER OPERATION

[0150] Any of the dual port aspiration canisters described herein can be used to connect one or more catheters. For example, a first catheter can be in fluid communication with an aspiration line connected to a first port (e.g., port **800***a* of aspiration canister **830**; port **1900***a* of the aspiration canister **1930**, etc.), and a second catheter can be connected to a second aspiration line connected to the second port (e.g., port **800***b* of aspiration canister **830**; port **1900***b* of the aspiration canister **1930**, etc.). When connected to the aspiration canister through the first and second aspiration lines, aspiration at distal ends of the first and/or second catheters can be used to remove (e.g., aspirate) clots from a vasculature of a patient.

[0151] In some embodiments, the first and second catheters can each have a lumen extending a length of the first and second catheters, respectively. One of the first and second catheters can be coaxially disposed in the lumen of the other of the first and second catheters. For example, the second catheter can include an outer diameter smaller than an inner diameter of the first catheter to allow the second catheter to extend through the lumen of the first catheter. In some embodiments, the first catheter can include an inner diameter of about .088" and an outer diameter of about .110". The inner and outer diameters of the first catheter can be smaller or greater that .088" (e.g., .086" 0.087", .089", .090", etc.) and .110" (e.g., .108", .109", .111", .112", etc.) respectively. In some embodiments, the second catheter can include an inner diameter of about .071" and an outer diameter of about .085". The inner and outer diameters of the second catheter can be smaller or greater than .071" (e.g., .069" 0.070", .072", .073", etc.) and .085" (e.g., .083" 0.084", .086", .087", etc.) respectively. In some cases the outer diameter of the second catheter can be between about .053" to about .085", and the inner diameter can between about .035" to about .071".

[0152] The difference in inner/outer diameter between the first and second catheter may allow one of the first and/or second catheters to have a higher flow rate than the other catheter when aspiration is applied (e.g., in the absence of any obstructions, such as the present of the second catheter within the first catheter). For example, the first catheter may include a lumen having an inner diameter larger than that of the second catheter which may result in the first catheter having a fluid flow rate (in the absence of the second catheter within the first catheter) greater than a fluid flow rate within the first catheter (e.g., with vacuum applied from the same dual port canister). To reduce the fluid flow rate from the first catheter into the canister, a flow reducer, such as flow reducers **1080**, **1180**, **1280**, **1380**, **1480**, **1580**, **1680**, **1780**, **1880** can be secured along the fluid path from the first catheter to the aspiration canister (e.g., secured to the first port (e.g., port **800***a*, **1900***a*, etc.) of the canister or along the aspiration line between the first catheter and the aspiration canister). The flow reducer can beneficially reduce the fluid flow rate proximal to the flow reducer (e.g., where the canister is positioned proximal to the flow reducer and the catheter is positioned distal to the flow reducer). In some embodiments, the flow reducer can cause the fluid flow rate proximal to the flow reducer to approximate the fluid flow rate along the second catheter. As will be further described below, this can beneficially reduce blood loss during a thrombectomy procedure. In certain embodiments, each catheter can include a flow reducer. For example, a flow reducer may be positioned along the flow path from the second catheter to the aspiration canister to reduce the fluid flow rate proximal of the flow reducer.

[0153] In a thrombectomy procedure, a first catheter (e.g., a guide catheter) and a second catheter (e.g., an aspiration catheter) may be inserted into the vasculature of a patient to retrieve a clot. The first catheter can be advanced through the vasculature of a patient so that the distal tip of the first catheter is positioned adjacent the clot. The second catheter can be advanced through the first catheter, for example, through a valve such as an RHV at a proximal end of the first catheter, to the location of the clot. A distal end of the second catheter can extend beyond the distal end of the first catheter. Aspiration at the distal end of the first can allow the first catheter to aspirate the clot. In some embodiments (e.g., if a catheter is too large for aspiration by the second catheter, the clot may become engaged with or corked on the distal end of the second catheter. In other embodiments, if the clot is too large for aspiration by the second catheter and/or too large to engage with the distal end of the second catheter, the clot may be aspirated by the first catheter. In other embodiments, if the clot is too large for aspiration by the first catheter, the clot may become engaged with or corked on the distal end of the first catheter.

[0154] In some embodiments, (e.g., while a clot is lodged at the distal of the second catheter or after aspiration of at least a portion of the clot by the second catheter), the second catheter can be retracted (e.g., to remove an engaged clot from the vasculature of the patient). The RHV at the proximal end of the first catheter may be opened for removal of the second catheter from the proximal end of the first catheter. When the RHV is open and the second catheter is removed from the RHV, the open state of the RHV results in a lower flow rate and a lower pressure through the aspiration line of the first catheter in comparison to when the RHV is in a closed state. When the second catheter has been removed from the body and aspiration is occurring through the aspiration line coupled to the second catheter, the open state of the aspiration line of the second catheter causes a lower pressure and lower flow rate through the aspiration line of the first catheter.

[0155] It is desirable that a substantial loss of vacuum pressure does not occur at the distal end of the first catheter. In some instances, a loss of vacuum pressure to a vacuum pressure below a threshold value may result in dislodgement of a clot, thrombus, or other vascular occlusion that has been captured by the first catheter during an aspiration procedure. In some embodiments, a vacuum pressure of at least −14 inHg may prevent the clot, thrombus, or other vascular occlusion that has been captured by the first catheter during an aspiration procedure from dislodging. In some embodiments, a vacuum pressure of at least −380 mmHg may prevent the clot, thrombus, or other vascular occlusion that has been captured by the first catheter during an aspiration procedure from dislodging. As used herein, when the vacuum pressure is described as a negative value, such as −14 inHg, vacuum pressures below a threshold value refer to vacuum pressures having an absolute value below the absolute value of the threshold value, vacuum pressures above or greater than a threshold value are vacuum pressures having an absolute value greater than the absolute value of the threshold value.

[0156] Aspiration through both the first and second catheters can beneficially reduce the risk of the clot being dislodged from the first catheter as the second catheter is retracted from the first catheter.

[0157] To maintain or increase the vacuum pressure at the distal end of the first catheter when the second catheter is retracted from the first catheter, aspiration through the aspiration line connected to the second catheter can be prevented (e.g., using a clamp, such as clamp **2178**). This can cause the vacuum pressure at the first catheter to increase, thereby reducing the risk of a clot being dislodged from the distal end of the first catheter. Closing of the aspiration line connected to the second catheter may also cause an increase in flow rate through the first aspiration line.

[0158] Additionally, to maintain or increase the vacuum pressure at the distal end of the first catheter when the second catheter is retracted from the first catheter, the RHV of the first catheter can be closed. This can cause the vacuum pressure at the second catheter to increase, thereby reducing the risk of a clot being dislodged from the distal end of the second catheter. Closing of the RHV of the first catheter may also cause an increase in flow rate through the first aspiration line.

[0159] The second aspiration catheter and/or RHV may be at least temporarily left open during a procedure by a physician. Accordingly, it is desirable that vacuum pressure through the first catheter is sufficient to retain a clot, thrombus or other vascular occlusion while both the second aspiration catheter and/or RHV are open.

[0160] As described herein, when the aspiration line of the second catheter is closed and the RHV is closed, the flow rate within the first catheter may increase. As described herein, a flow restrictor may reduce the flow rate to reduce blood loss. However, reduction in flow rate by a flow restrictor may reduce the vacuum pressure within the first catheter. The flow restrictors described herein may be configured to reduce the flow rate below a desired maximum

threshold value for blood loss in situations where both the RHV and the aspiration line of the second catheter are closed, while allowing sufficient vacuum pressure in the first catheter to prevent dislodgement of a clot, thrombus, or other vascular occlusion at the distal end of the first catheter. For example, the flow restrictor may reduce the flow rate proximal to the aspiration line connected to the first catheter from about 245 ml/min, when a flow restrictor is not used, to at least about 190 ml/min, at least about 180 ml/min, at least about 170 ml/min, at least about 160 ml/min, at least about 150 ml/min, or any other suitable flow rate. In situations where the aspiration catheter and/or RHV are at least temporarily left open during a procedure by a physician, vacuum pressure through the first catheter can be maintained from about −530 mmHg to about −635 mmHg, which can beneficially reduce the risk of the clot dislodging from the first catheter. In some embodiments, vacuum pressure through the first catheter can be at least about −500 mmHg, −520 mmHg, −550 mmHg, −580 mmHg, −600 mmHg, −620 mmHg, and/or −650 mmHg, even when the aspiration catheter and/or RHV are at least temporarily left open.

[0161] FIG. **12** shows an example of first and second catheters deployed inside the vasculature of a patient. Each of the first aspiration catheter **2320** and the second aspiration catheter **2340** can be in fluid communication with a distinct aspiration line (e.g., aspiration line **1590**), a port (e.g., port **1500**), and an aspiration canister (e.g., canister **1530**). The first catheter **2320** can include a lumen having a diameter larger than an exterior diameter of the second catheter **2340** so as to allow the first catheter **2320** to receive the second catheter **2340** and allow the second catheter **2340** to extend and advance though the lumen of the first catheter **2320**.

[0162] In some embodiments, a flow reducer (e.g., **1080**, **1180**, **1280**, **1380**, **1480**, **1580**, **1680**, **1780**, **1880**, etc.) can be positioned along the fluid flow path between the catheter **2320** and the canister. In some embodiments, a flow reducer (e.g., **1080**, **1180**, **1280**, **1380**, **1480**, **1580**, **1680**, **1780**, **1880**, etc.) can be positioned along the flow path between the catheter **2340** and the canister.

[0163] Fluid connection of the first and second aspiration catheters **2320**, **2340** to the aspiration canister can beneficially allow the first and second aspiration catheters **2320**, **2340** to apply aspiration when the aspiration catheters **2320**, **2340** are connected to the aspiration canister. In some embodiments, the catheter **2320** can be coupled to a valve (e.g., a hemostasis valve or a rotating hemostasis valve), which can be opened to allow for advancement/retraction of the catheter **2340** through the catheter **2320**. In some embodiments, the catheter **2340** may also be coupled to a valve (e.g., a hemostasis valve or a rotating hemostasis valve) to allow for advancement of another device (e.g., another catheter) through the catheter **2320**

[0164] During a thrombectomy procedure, the first catheter **2320** can be advanced through the vasculature of a patient towards the location of a clot **2350**. In some embodiments, it may be desirable to advance the second catheter **2340** through the first catheter **2320** to reach the clot **2350**. In some embodiments, the clot **2350** may become engaged with or corded at a distal end of the second catheter. In such cases, it may be necessary to remove the second catheter **2340** from the vasculature of the patient to remove the clot **2350**. As the second catheter **2340** is retracted from the first catheter **2320**, debris from the stuck clot **2350** can dislodge. In such embodiments, application of vacuum at both the first and second catheters **2320**, **2340** can beneficially prevent the debris from flowing distally into the vasculature of the patient by aspirating the debris and thus reducing the risk of embolization.

[0165] In some embodiments, the clot **2350** may become engaged with or corked at the distal end of the catheter **2320**. Vacuum through the first catheter **2320** may prevent dislodgement of the clot **2350** from the catheter **2320**. In some instances, it may not be readily apparent if portions of a clot are engaged with the catheter **2320** or the catheter **2340**. In such instances, vacuum through both the catheters **2320** and **2340** may prevent debris from flowing distally into the vasculature of the patient by aspirating the debris and thus reducing the risk of embolization.

[0166] In some steps of a thrombectomy procedure, fluid flow rate along the first catheter **2320** and the aspiration line connected to the first catheter **2320** may be greater than a fluid flow rate along the second catheter **2340** and the aspiration line connected to the second catheter **2340** or may increase to a greater flow rate than in previous steps of the procedure. To reduce the fluid flow rate along the first catheter **2320** and the aspiration line connected to the first catheter **2320**, a flow reducer (e.g., **1080**, **1180**, **1280**, **1380**, **1480**, **1580**, **1680**, **1780**, **1880**, etc.) can be positioned along the flow path between the first catheter **2320** and the aspiration canister. The flow reducer can beneficially reduce the flow rate proximal to the flow reducer and thus reduce blood loss. The flow reducer can also maintain the fluid flow rate or reduce an amount of increase of the fluid flow rate proximal to the flow reducer when the second catheter **2340** is outside of the first catheter **2320**, and the RHV of the first catheter is closed and/or the second aspiration line is closed in comparison to the increase in fluid flow rate that would occur in the absence of the flow reducer.

[0167] The flow reducer may also be configured to allow sufficient vacuum pressure to prevent dislodgement of the clot **2350** from the catheter **2320** in instances where the clot is engaged thereto, for example, when the second catheter **2340** is outside of the first catheter **2320** and the RHV is open and/or the second aspiration line is open.

[0168] Any of the embodiments described herein may be used with a clot filtering device, such as the embodiments shown and described in International Patent Application No. PCT/US2022/078113, filed Oct. 14, 2022, the contents of which are herein incorporated by reference in their entirety.

[0169] As used in the description and claims, the singular form "a", "an" and "the" include both singular and plural references unless the context clearly dictates otherwise. For example, the term "vacuum line" may include, and is contemplated to include, a plurality of vacuum lines. At times, the claims and disclosure may include terms such as "a plurality," "one or more," or "at least one;" however, the absence of such terms is not intended to mean, and should not be interpreted to mean, that a plurality is not conceived.

[0170] In some embodiments, any of the RHVs, aspiration line configurations, and/or clot filtering devices may be used in manual thrombectomy procedures, in roboticized thrombectomy procedures, or in hybrid manual-automatic thrombectomy procedures. Various examples of automatic thrombectomy systems are shown and described in U.S. patent application Ser. No. 17/527,393 filed Nov. 16, 2021, the contents of which are herein incorporated by reference in their entirety.

[0171] The term "about" or "approximately," when used before a numerical designation or range (e.g., to define a length or pressure), indicates approximations which may vary by (+) or (−) 5%, 1% or 0.1%. All numerical ranges provided herein are inclusive of the stated start and end numbers. The term "substantially" indicates mostly (i.e., greater than 50%) or essentially all of a device, substance, or composition.

[0172] As used herein, the term "comprising" or "comprises" is intended to mean that the devices, systems, and methods include the recited elements, and may additionally include any other elements. "Consisting essentially of" shall mean that the devices, systems, and methods include the recited elements and exclude other elements of essential significance to the combination for the stated purpose. Thus, a system or method consisting essentially of the elements as defined herein would not exclude other materials, features, or steps that do not materially affect the basic and novel characteristic(s) of the claimed disclosure. "Consisting of" shall mean that the devices, systems, and methods include the recited elements and exclude anything more than a trivial or inconsequential element or step. Embodiments defined by each of these transitional terms are within the scope of this disclosure.

[0173] The examples and illustrations included herein show, by way of illustration and not of limitation, specific embodiments in which the subject matter may be practiced. Other embodiments may be utilized and derived therefrom, such that structural and logical substitutions and changes may be made without departing from the scope of this disclosure. Such embodiments of the inventive subject matter may be referred to herein individually or collectively by the term "invention" merely for convenience and without intending to voluntarily limit the scope of this application to any single invention or inventive concept, if more than one is in fact disclosed. Thus, although specific embodiments have been illustrated and described herein, any arrangement calculated to achieve the same purpose may be substituted for the specific embodiments shown. This disclosure is intended to cover any and all adaptations or variations of various embodiments. Combinations of the above embodiments, and other embodiments not specifically described herein, will be apparent to those of skill in the art upon reviewing the above description.

1-60. (canceled)

61. A method of performing a thrombectomy procedure, the method comprising:

connecting a distal end of a first aspiration line to a first catheter to establish a first fluid flow path between the first catheter and an aspiration canister, wherein a proximal end of the first aspiration line is coupled to a first port of the aspiration canister;

connecting a distal end of a second aspiration line to a second catheter to establish a second fluid flow path between the second catheter and the aspiration canister, wherein a proximal end of the second aspiration line is coupled to a second port of the aspiration canister;

advancing the first catheter and the second catheter though a vasculature of a patient to a target vascular site having a clot while the second catheter is positioned within a lumen of the first catheter;

applying uninterrupted vacuum to the aspiration canister to apply uninterrupted vacuum to the first catheter and the second catheter along the first fluid flow path and the second fluid flow path; and

retracting the second catheter out of a hemostasis valve of the first catheter while maintaining a vacuum pressure in the first catheter at or greater than a minimum vacuum pressure threshold for preventing debris from the clot from flowing distally into the vasculature of the patient.

62. The method of claim **61**, wherein the minimum vacuum pressure threshold is −14 inHg.

63. The method of claim **62**, wherein maintaining the vacuum pressure in the first catheter at or greater than the minimum vacuum pressure threshold comprises maintaining the vacuum pressure between −14 inHg and −28 inHg.

64. The method of claim **61**, further comprising closing the hemostasis valve after retracting the second catheter out of the hemostasis valve and closing the second aspiration line.

65. The method of claim **64**, further comprising maintaining a fluid flow rate along at least a portion of the first fluid flow path at or below a maximum threshold value when the hemostasis valve and the second aspiration line are closed, wherein the maximum threshold value of the fluid flow rate is between 140 ml/min and 200 mL/min.

66. The method of claim **64**, wherein the vacuum pressure in the first catheter is maintained after retracting the second catheter out of the hemostasis valve and closing the second aspiration line.

67. The method of claim **64**, wherein the vacuum pressure in the first catheter increases after retracting the second catheter out of the hemostasis valve and closing the second aspiration line.

68. The method of claim **61**, wherein the first aspiration line comprises a clot retrieval device.

69. The method of claim **68**, wherein the clot retrieval device comprises a distal port and a proximal port, the distal port having a diameter larger than a diameter of the proximal port.

70. The method of claim **68**, wherein the first aspiration line comprises a first tubing section distal to the clot retrieval device and a second tubing section proximal to the clot retrieval device, wherein the second tubing section has an inner diameter smaller than an inner diameter of the first tubing section to reduce a fluid flow rate through the second tubing section.

71. The method of claim **68**, wherein at least a portion of the clot retrieval device is transparent to allow clot visualization.

72. The method of claim **61**, wherein each of the first port and the second port comprises a self-sealing port.

73. The method of claim **72**, wherein the aspiration canister comprises a third port coupled to a vacuum source, wherein the third port has a different structure than the first port and the second port.

74. The method of claim **61**, further comprising restricting the application of vacuum to the first catheter by closing a clamp positioned along the first aspiration line.

75. The method of claim **61**, further comprising restricting the application of vacuum to the second catheter by closing a clamp positioned along the second aspiration line.

76. The method of claim **61**, wherein retracting the second catheter out of the hemostasis valve of the first catheter further comprises maintaining a vacuum pressure in the

second catheter at or greater than a minimum vacuum pressure threshold of the second catheter.

77. The method of claim **76**, wherein the minimum vacuum pressure threshold of the second catheter is a minimum vacuum pressure threshold for preventing debris from the clot from flowing distally from the second catheter into the vasculature of the patient.

78. The method of claim **76**, wherein the minimum vacuum pressure threshold of the second catheter is a minimum vacuum pressure threshold for maintaining the clot engaged to a distal tip of the second catheter.

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