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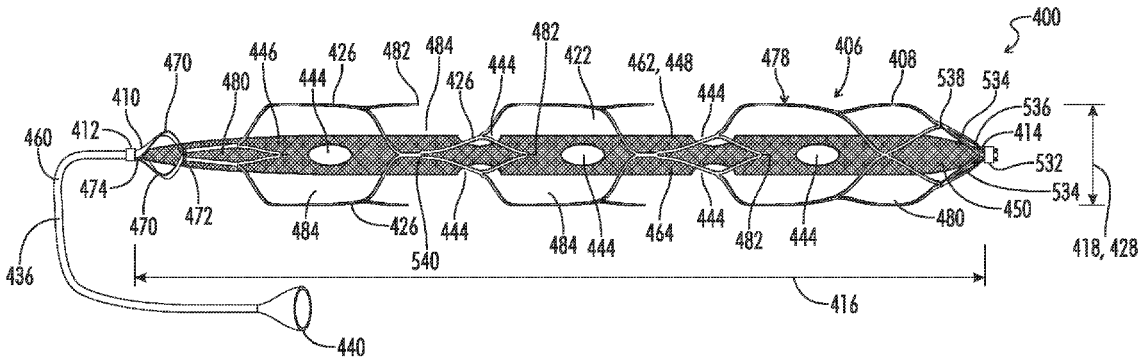

FIG. 38

(57) **Abstract:** A platform of devices for removing obstructions and other objects within a blood vessel or other interior lumen of an animal is provided. The system may be deployed in the lumen from a catheter(s) and the system may include a cage comprising a suction catheter comprising one or more suction openings in order to draw the clot or other object into the cage interior.

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INTERNATIONAL PATENT APPLICATION

CLOT RETRIEVAL SYSTEM

BACKGROUND

TECHNICAL FIELD

[0001] The present invention relates to a deployable system for removing a blood clot or other object from a lumen of an animal.

BACKGROUND OF THE INVENTION

[0002] Acute ischemic strokes develop when a blood clot (thrombus) blocks an artery supplying blood to the brain. Needless to say, when a blood clot creates such a blockage, time in removing the clot is critical.

[0003] The removal of intracranial obstructions is limited by several factors, such as the distance of the intracranial obstruction from the femoral access site, the tortuosity (twists and turns in the artery as it enters the base of the skull) of the cervical and proximal intracranial vasculature, the small size of the vessels and the extremely thin walls of intracranial vessels, which lack a significant muscular layer. These limitations require a device to be small and flexible enough to navigate through tortuous vessels within a guide catheter and microcatheter, expand after delivery at the site of occlusion and be retrievable into the microcatheter and yet be strong enough to dislodge strongly adherent thrombus from the vessel wall. In addition, the device should distally entrap or encase the thrombus to prevent embolization to other vessels and to completely remove the occlusion. The device should be retrievable without the need for proximal occlusion of the vessel, which carries risk of further ischemia and risk of vessel injury. The device should be simple to use and be capable of multi-use within the same patient treatment. The device should not be abrasive and should not have sharp corners exposed to the endothelial layer of the vessel wall.

[0004] Currently available intravascular thrombus and foreign body removal devices lack several of these features. Currently available devices include the MERCI™ RETRIEVER clot retriever device marketed by Concentric Medical, Inc. (Mountainview, CA), the PENUMBRA™ system marketed by Penumbra Inc. (Alameda, CA) to retrieve clots, and the newer stent retrieval devices TREVO™ (Stryker, Kalamazoo, MI) and SOLITAIRE™ (eV3 Endovascular Inc.,

Plymouth, MA, which is a subsidiary of Covidien). All the devices are ineffectual at removing organized hard thrombus that embolize to the brain from the heart and from atherosclerotic proximal vessels. These "hard" thrombi constitute the majority of strokes which are refractory to medical treatment and are therefore referred for removal by mechanical means through an endovascular approach. The MERCI retrieval system is comprised of coiled spring-like metal and associated suture material. The method of use is deployment distal to the thrombus and by withdrawing the device through the thrombus, the thrombus becomes entangled in the coil and mesh and then is retrieved. The MERCI system requires occlusion of the proximal vessel with a balloon catheter and simultaneous aspiration of blood while the thrombus is being removed. Most of the time, the device fails to dislodge the thrombus from the wall of the vessel and often, even when successfully dislodging the thrombus, the thrombus embolizes into another or the same vessel due to the open ended nature of the device.

[0005] The next attempt at a thrombus removal system was the PENUMBRA. The PENUMBRA is a suction catheter with a separator that macerates the thrombus which is then removed by suction. The device is ineffective at removing hard, organized thrombus which has embolized from the heart, cholesterol plaque from proximal feeding arteries and other foreign bodies.

[0006] The SOLITAIRE and TREVO systems are self-expanding non-detachable stents. The devices are delivered across the thrombus which is then supposed to become entwined in the mesh of the stent and which is then removed in a manner similar to the MERCI system. Again, these devices are ineffectual at treating hard thrombus. In fact, the thrombus is often compressed against the vessel wall by the stent which temporarily opens the vessel by outwardly pressing the clot against the vessel wall. Upon retrieval of the devices, the clot remains or is broken up into several pieces which embolize to vessels further along the vessel.

[0007] Thus, there is a need for new, easy-to-use, easy-to-manufacture, safe surgical devices for removing obstructions, such as blood clots, from internal lumens of humans and other animals in a timely manner.

BRIEF SUMMARY

[0008] The present disclosure provides several systems for removing obstructions and other objects within a blood vessel or other lumen of an animal. The system may be deployed in the lumen from a distal end of a catheter and, in some embodiments, includes a pull wire having a proximal end and a distal end; a distal body attached to the pull wire, the distal body comprising an interior, an exterior, a proximal end, a distal end, a plurality of proximal memory metal strips located at the proximal end, a proximal hub/junction located in the distal body interior, and a

distal hub/junction located distal relative to the proximal hub/junction. The distal body has a relaxed state wherein the distal body has a first height and width and a collapsed state wherein the distal body has a second height and width, the second height less than said first height, the second width less than the first width. The system further includes a catheter having an interior, a proximal end leading to the interior and a distal end leading to the interior, the catheter comprised of a biocompatible material and configured to envelope the distal body when the distal body is in the collapsed state. Each of the proximal memory metal strips has a proximal end and a distal end and preferably, in the relaxed state, each of the proximal ends of the proximal memory metal strips is located proximal relative to the proximal hub/junction. Preferably, in the relaxed state, the proximal ends of the proximal memory metal strips are configured to move towards each other and towards the pull wire when an operator moves the proximal hub/junction distally and closer to the stationary distal hub/junction (i.e., when the operator decreases the distance between the hubs/junctions). Preferably, in the relaxed state, the proximal ends of the proximal memory metal strips are configured to move away from each other and away from the pull wire by moving the proximal hub/junction proximally away from the stationary distal hub/junction (i.e., when the operator increases the distance between the hubs/junctions).

[0009] Optionally, the system further includes a plurality of memory metal connector strips, the plurality of memory metal connector strips each having a proximal end attached to a proximal memory metal strip and a distal end attached to the proximal hub/junction. Optionally, the connector strips are integral with the proximal hub/junction (i.e., optionally, the connector strips and the proximal hub/junction are formed from the same piece of memory metal). Optionally, the proximal hub/junction is a tube having an aperture and the pull wire passes through the aperture. Optionally, in the relaxed state, the proximal hub/junction is slideable along the pull wire (i.e., at least a segment of the pull wire). Optionally, in the relaxed state, the proximal memory metal strips are distributed substantially evenly about a perimeter of the distal body. Optionally, the distal hub/junction is a tube having an aperture. Optionally, the distal hub/junction is attached to the pull wire such that the distal hub/junction is not slideable along the pull wire. Optionally, the distal body further comprises a lead wire extending distally from the distal hub/junction. Optionally, the distal body comprises a basket comprised of a plurality of memory metal strips distal relative to the proximal memory metal strips. Optionally, the distal hub/junction, the proximal hub/junction, and the distal basket are comprised of a nitinol having the same material composition. Optionally, the distal body further comprises an x-ray marker.

Optionally, the proximal memory metal strips form a claw, the claw having a closeable proximal end formed by the proximal ends of the proximal memory metal strips. Optionally, between 2 and 4 proximal memory metal strips form the claw. Optionally, the distal body, in the relaxed state, has a tapered shape in which the distal body height and width decrease from the proximal end to the distal end. Optionally, the distal body, in the relaxed state, has a bullet shape. Optionally, the proximal hub/junction and the distal hub/junction are generally cylindrical in shape and each has an outer diameter and an inner diameter that forms the apertures of the proximal and distal hub/junctions, the outer diameters of the proximal and distal hub/junctions are substantially the same size, and the inner diameters of the proximal and distal hubs/junctions are substantially the same size. Optionally, the outer diameters of the proximal and distal hubs/junctions are from about 0.011 inches to about 0.054 inches, and the inner diameters of the proximal and distal hubs/junctions are from about 0.008 inches to about 0.051 inches. Optionally, the pull wire is generally cylindrical and the diameter of the pull wire is between about 0.008 inches and about 0.051 inches. Optionally, the proximal memory metal strips have a length of between about 10 and about 60 millimeters. Optionally, the first height and first width of the distal body are between about 2 millimeters (mm) and about 6 millimeters. Optionally, the proximal memory metal strips are configured to a separate a clot from a blood vessel wall.

[0010] The present invention also provides a method of removing an object from an interior lumen of an animal, the lumen having an interior wall forming the lumen. In some embodiments, the method includes:

a) providing a system comprising: i) a pull wire having a proximal end and a distal end; ii) a distal body attached to the pull wire, the distal body comprising a proximal end, a distal end, and a claw, the claw comprised of a plurality of memory metal strips, the distal body having a relaxed state wherein the distal body has a first height and width and a collapsed state wherein the distal body has a second height and width, the second height less than said first height, the second width less than said first width; and iii) a catheter having an interior, a proximal end leading to the interior and a distal end leading to the interior, the catheter comprised of a biocompatible material and configured to envelope the distal body when said distal body is in said collapsed state;

b) positioning the system in the lumen;

c) deploying the distal body from the distal end of the catheter;

d) allowing the height and width of said distal body to increase; and

e) moving the memory metal strips towards each other and the pull wire so as to capture the obstruction. Optionally, the claw and the memory metal strips are located at the proximal end of said distal body and the distal body is deployed distal to said object. Optionally, the proximal memory metal strips have a proximal end forming the proximal end of the claw and a distal end, and the method includes moving the proximal ends of the memory metal strips towards each other and the pull wire so as to capture the obstruction. Optionally, the distal body further comprises a proximal hub/junction located in the distal body interior, and a distal hub/junction located distal relative to the proximal hub/junction, each of the memory metal strips has a proximal end and a distal end, each of the proximal ends of the memory metal strips is located proximal relative to the proximal hub/junction, and the proximal ends of the memory metal strips are configured to move towards each other and towards the pull wire by moving the proximal hub/junction distally and closer to the distal hub/junction, and the proximal ends of the memory metal strips are configured to move away from each other and away from the pull wire by moving the proximal hub/junction proximally and away from the distal hub/junction, and the method further comprises moving the proximal hub/junction distally and closer to the distal hub/junction so as to capture the obstruction in the claw. Optionally, the interior lumen is an intracranial artery and the obstruction is a blood clot. Optionally, the method further comprises using the clot to move the proximal hub/junction toward the distal hub/junction and exert tension on the proximal memory metal strips. Optionally, the method further comprises using a tube to move the proximal hub/junction toward the distal hub/junction and exert tension on the proximal memory metal strips.

[0011] The present invention also provides a method of manufacturing a system for removing objects within an interior lumen of an animal. In some embodiments, the method includes:

a) providing a single tube comprised of a memory metal, the single tube having an exterior, a hollow interior, a wall separating the exterior from the hollow interior, a proximal portion comprising an aperture leading to the hollow interior, a distal portion comprising an aperture leading to the hollow interior, and a middle portion between the proximal portion and the distal portion;

b) cutting the wall of the middle portion with a laser;

c) removing the pieces of the middle portion cut by the laser to form a proximal tube, a middle portion comprising a plurality of memory metal strips attached to the proximal tube and a distal tube;

d) altering the shape of the middle portion;

e) allowing the middle portion to expand relative to the distal tube and the proximal tube;

f) cutting the memory metal strips to form a first segment comprising the proximal tube and a proximal segment of the memory metal strips, and a second segment comprising the distal tube and a distal segment of the memory metal strips; and

g) joining the proximal segments to the distal segments such that the distal segments form the proximal end of a distal body, such that the proximal tube is located inside an interior of said distal body, and such that the proximal tube is located distal relative to the proximal end.

[0012] Optionally, the method further includes placing a pull wire through the proximal tube such that the proximal tube is slideable along at least a segment of the pull wire. Optionally, the method further includes attaching the pull wire to the distal tube. Optionally, the step of joining the proximal segments to the distal segments comprises welding or soldering the proximal segments to the distal segments. Optionally, after the step of joining the proximal segments to the distal segments, the proximal end forms a claw comprised of between 2 and 4 memory metal strips, the claw memory metal strips configured to move towards each by moving said proximal tube distally and closer to the distal tube, and the claw memory metal strips configured to move away from each other by moving the proximal tube proximally and away from said distal tube. Optionally, the method further includes not altering the shape of the proximal and distal portions while altering the shape of the middle portion. Optionally, the method further includes cooling the proximal portion, the middle portion, and the distal portion after step D) and, after cooling, the proximal and distal portions have substantially the same size as the proximal and distal portions had prior to step A). Optionally, the method of allowing said middle portion to expand comprises heating the middle portion. Optionally, the method of altering the shape of the middle portion comprises using a mandrel. Optionally, the mandrel is tapered. Optionally, the proximal portion and the distal portion are not cut by the laser. Optionally, prior to cutting the memory metal tube, the memory metal tube has an outer diameter that is from about 0.011 inches to about 0.054 inches and an inner diameter that is from about 0.008 inches to about 0.051 inches.

[0013] In an alternate embodiment, the present disclosure provides a system for removing objects from an interior lumen of an animal that includes:

a pull wire having a proximal end and a distal end;

a distal body attached to the pull wire, the distal body comprising an interior, a proximal end, a distal end, a distal body length extending from the proximal end to the distal end, a proximal

hub/junction (preferably in the form of a tube) forming the proximal end of the distal body, a basket comprised of a plurality of cells formed by a plurality of basket strips, a plurality of proximal strips, and, optionally a distal hub/junction (preferably in the form of a tube) forming a distal end of the basket, the basket comprising a basket interior, each proximal strip having a proximal end attached to the proximal hub/junction, and a distal end attached to a cell, the distal body having a relaxed state wherein the distal body has a first height and a first width, and a collapsed state wherein the distal body has a second height and a second width, the second height less than the first height, the second width less than the first width; and

a catheter having an interior, a proximal end leading to the interior and a distal end leading to the interior, the catheter comprised of a biocompatible material and configured to envelope the distal body when the distal body is in the collapsed state,

wherein, in the relaxed state, the basket comprises a first pair of distal crowns not attached to another cell of the basket and pointing generally in the distal direction, the first pair of distal crowns located approximately the same distance from the proximal hub/junction and approximately 180 degrees relative to each other (e.g., between about 150 degrees and about 180 degrees relative to each other), and further wherein the basket further comprises a second pair of distal crowns not attached to another cell of the basket and pointing generally in the distal direction, the second pair of distal crowns located distally relative to, and approximately 90 degrees relative to, the first pair of distal crowns (e.g., each distal crown of the second pair of distal crowns is located approximately 60 degrees to 90 degrees relative to a distal crown of the first pair of distal crowns), the distal crowns in the second pair of distal crowns located approximately the same distance from the proximal hub/junction and further wherein each of the distal crowns in the first and second pair of distal crowns comprises an x-ray marker, the x-ray maker more visible under x-ray as compared to the basket strips when the distal body is located in a cranial blood vessel inside the body of a human and the x-ray is taken from outside the human's body. Optionally, instead of a distal hub/junction, the basket includes an open distal end.

[0014] Optionally, the x-ray markers are comprised of a material different than the material forming the basket strips. Optionally, in the relaxed state, the basket interior is substantially hollow. Optionally, in the relaxed state, the distal body does not have another x-ray marker that is located approximately the same distance from the proximal hub/junction as the first pair of x-ray markers and the distal body does not have another x-ray marker that is located approximately the same distance from the proximal hub/junction as the second pair of x-ray markers. In other

words, the first and second pair of x-ray markers are the only markers their respective distances from the proximal hub/junction. Optionally, each distal crown in the first and second pair of distal crowns forms part of an enlarged cell and further wherein the surface area of each enlarged cell in the relaxed state is greater than the surface area of each of the other individual cells of the basket and further wherein the enlarged cells are configured to allow a thrombus to pass therethrough and into the basket interior. Optionally, in the relaxed state, the distal body does not have another free distal-pointing crown that is located approximately the same distance from the proximal hub/junction as the first pair of distal crowns and the distal body does not have another free distal-pointing crown that is located approximately the same distance from the proximal hub/junction as the second pair of distal crowns. Optionally, the basket strips are comprised of a memory metal. Optionally, each of the distal crowns in the first pair and second pair of distal crowns curve radially inward toward the basket interior in the relaxed state, wherein the distal crowns of the first pair of distal crowns are configured to contact each other when an exterior, external compressive force (such as a thrombus) is exerted on a distal crown of the first pair of distal crowns when the distal body is in the relaxed state, and further wherein the distal crowns of the second pair of distal crowns are configured to contact each other when an exterior, external compressive force (such as a thrombus) is exerted on a distal crown of the second pair of distal crowns when the distal body is in the relaxed state. Optionally, the proximal hub/junction is located approximately in the center of the first height and first width in the relaxed state. For example, preferably the proximal hub/junction is located within 0.5 mm of the center of first width and the first height. Optionally, the catheter is comprised of a polymeric material (i.e., one or more polymeric materials such as silicone, PVC, latex rubber or braided nylon). Optionally, the pull wire is comprised of a biocompatible metallic material (e.g., a biocompatible metal or a biocompatible metal alloy). Optionally, the proximal end of a first proximal strip is located at least about 65 degrees (e.g., between about 65 and about 180 degrees) relative to the distal end of the first proximal strip, wherein the proximal end of a second proximal strip is located at least about 65 degrees (e.g., between about 65 and about 180 degrees) relative to the distal end of the second proximal strip, and further wherein the first and second proximal strips intersect adjacent and distal to the proximal hub/junction (e.g., within about 0 and about 4 mm of the proximal hub/junction). Optionally, each distal crown forms part of a cell that further comprises a proximal crown pointing generally in the proximal direction and connected to a memory metal strip (e.g., a proximal strip comprised of a memory metal or a basket strip comprised of a memory metal). In other words, the proximal crowns are not free.

Optionally, the basket, the proximal hub/junction and the proximal strips are comprised of a memory metal, wherein the proximal hub/junction comprises a proximal end and a distal end, and further wherein the proximal strips are integral with the distal end of the proximal hub/junction. Optionally, the length of the distal body from the proximal hub/junction to the distal hub/junction (not including any lead wire) is from about 20 mm to about 65 mm. Optionally, the system is used in a method of removing a blood clot from a blood vessel of an animal the method comprising the steps of:

a) providing the system;

b) positioning the system in the lumen;

c) deploying the distal body from the distal end of the catheter;

d) allowing the height and width of the distal body to increase;

e) irradiating the distal body with x-rays;

f) moving the clot into the distal basket interior; and

g) moving the distal body proximally out of the blood vessel.

[0015] Optionally, the method further comprises irradiating the distal body with x-rays at at least two different angles. Optionally, at least one x-ray marker attached to the distal crowns is distal to the clot when the distal body is deployed from the distal end of the catheter. Optionally, the method further comprises applying contrast dye proximally and distally to the clot. Optionally, the method further comprises providing a suction catheter having a proximal end and a distal end, and attaching the distal end of the suction catheter to the clot by applying suction to the suction catheter. Optionally, the method further comprises aspirating by hand a pre-determined volume of fluid from the suction catheter using a syringe and then locking the syringe at the pre-determined volume. Optionally, the method further comprises delivering the suction catheter adjacent to the clot by advancing the catheter over the pull wire.

[0016] In yet another embodiment, the system includes:

a pull wire having a proximal end and a distal end;

a distal body attached to the pull wire, the distal body comprising an interior, a proximal end, a distal end, a distal body length extending from the proximal end to the distal end, a proximal hub/junction (preferably in the form of a tube) forming the proximal end of the distal body, a basket comprised of a plurality of cells formed by a plurality of basket strips, a plurality of proximal strips, and optionally a distal hub/junction (preferably in the form of a tube) forming a distal end of the basket, the basket comprising a basket interior, each proximal strip having a proximal end attached to the proximal hub/junction, and a distal end attached to a cell, the distal

body having a relaxed state wherein the distal body has a first height and a first width, and a collapsed state wherein the distal body has a second height and a second width, the second height less than the first height, the second width less than the first width; and

a catheter having an interior, a proximal end leading to the interior and a distal end leading to the interior, the catheter comprised of a biocompatible material and configured to envelope the distal body when the distal body is in the collapsed state,

wherein, in the relaxed state, the basket comprises a first pair of distal crowns not attached to another cell of the basket and pointing generally in the distal direction, the first pair of distal crowns located approximately the same distance from the proximal hub/junction and approximately 180 degrees relative to each other (e.g., between about 150 degrees and about 180 degrees relative to each other), and further wherein the basket further comprises a second pair of distal crowns not attached to another cell of the basket and pointing generally in the distal direction, the second pair of distal crowns located distally relative to, and approximately 90 degrees relative to, the first pair of distal crowns (e.g., each distal crown of the second pair of distal crowns is located approximately 60 degrees to 90 degrees relative to a distal crown of the first pair of distal crowns), the distal crowns in the second pair of distal crowns located approximately the same distance from the proximal hub/junction, wherein each distal crown of the first and second pair of distal crowns form a cell, each cell further comprising a proximal crown pointing generally in the proximal direction and connected to a memory metal strip, wherein each of the distal crowns in the first pair and second pair of distal crowns curve radially inward toward the basket interior in the relaxed state, wherein the distal crowns of the first pair of distal crowns are configured to contact each other when an exterior, external compressive force (e.g., a thrombus) is exerted on a distal crown of the first pair of distal crowns when the distal body is in the relaxed state, and further wherein the distal crowns of the second pair of distal crowns are configured to contact each other when an exterior, external compressive force (e.g., a thrombus) is exerted on a distal crown of the second pair of distal crowns when the distal body is in the relaxed state. When it is said that a proximal crown pointing generally in the proximal direction and is connected to a memory metal strip, it is meant that the proximal crown is either connected to a basket strip or a proximal strip comprised of a memory metal (e.g., nitinol). Optionally, instead of a distal hub/junction, the basket includes an open distal end.

[0017] Optionally, the proximal hub/junction is located approximately in the center of the first height and first width in the relaxed state. For example, preferably the proximal hub/junction is located within 0.5 mm of the center of first width and the first height. Optionally, the catheter is

comprised of a polymeric material (i.e., one or more polymeric materials such as silicone, PVC, latex rubber or braided nylon). Optionally, the pull wire is comprised of a biocompatible metallic material (e.g., a biocompatible metal or a biocompatible metal alloy). Optionally, in the relaxed state, the basket interior is substantially hollow. Optionally, the proximal end of a first proximal strip is located at least about 65 degrees (e.g., between about 65 and about 180 degrees) relative to the distal end of the first proximal strip, wherein the proximal end of a second proximal strip is located at least about 65 degrees (e.g., between about 65 and about 180 degrees) relative to the distal end of the second proximal strip, and further wherein the first and second proximal strips intersect adjacent and distal to the proximal hub/junction (e.g., within about 0 mm and about 4 mm of the proximal hub/junction). Optionally, each distal crown in the first and second pair of distal crowns forms part of an enlarged cell and further wherein the surface area of each enlarged cell in the relaxed state is at least twice as large as the surface area of each other individual cell of the basket and further wherein the enlarged cells are configured to allow a thrombus to pass therethrough and into the basket interior. Optionally, the pull wire is attached to the proximal hub/junction. Optionally, the basket, the proximal hub/junction and the proximal strips are comprised of a memory metal, wherein the proximal hub/junction comprises a proximal end and a distal end, and further wherein the proximal strips are integral with the distal end of the proximal hub/junction. Optionally, the distal body further comprises a lead wire extending distally from the distal hub/junction, the lead wire having a length of from about 3 mm to about 10 mm. Optionally, the distal hub/junction, the proximal hub/junction, and the basket are comprised of a nitinol having the same material composition and further wherein the proximal and the distal hubs/junctions are tubular and generally cylindrical in shape and each has an outer diameter and an inner diameter, the inner diameter forming apertures of the proximal and distal hubs/junctions and further wherein the outer diameters of the proximal and distal hubs/junctions are substantially the same size and further wherein the inner diameters of the proximal and distal hubs/junctions are substantially the same size. Optionally, the length of the distal body from the proximal hub/junction to the distal hub/junction (not including any lead wire) is from about 20 mm to about 65 mm.

[0018] Optionally, the system is used in a method of removing a blood clot from a blood vessel of an animal the method comprising the steps of:

a) providing the system;

b) positioning the system in the lumen;

c) deploying the distal body from the distal end of the catheter;

d) allowing the height and width of the distal body to increase;

e) irradiating the distal body with x-rays;

f) moving the clot into the distal basket interior; and

g) moving the distal body proximally out of the blood vessel.

[0019] Optionally, the method further comprises irradiating the distal body with x-rays at at least two different angles.

[0020] In still further embodiments, the present disclosure provides yet another embodiment of a system for removing objects from an interior lumen of an animal. The system may include a pull wire having a proximal end and a distal end. The system may also include a distal body attached to the pull wire (e.g., the distal end of the pull wire). The distal body may include an interior, a perimeter, a proximal end, a distal end, a distal body length extending from the proximal end to the distal end, a proximal junction forming the proximal end of the distal body, a plurality of proximal strips, a basket comprised of a plurality of cells formed by a plurality of basket strips, and a distal junction forming a distal end of the basket. The basket may include a basket interior. Each proximal strip may have a distal end attached to a cell and a proximal end, and the proximal ends of the proximal strips may converge at the proximal junction. The distal body may have a relaxed state wherein the distal body has a first height and a first width, and a collapsed state wherein the distal body has a second height and a second width, the second height less than the first height, the second width less than the first width. Optionally, in the relaxed state, the basket comprises a series of at least three pair of cells located on the distal body perimeter having a proximal crown pointing generally in the proximal direction and attached to a memory metal strip and a free distal crown pointing generally in the distal direction. Optionally, in the series, the proximal-most free distal crowns are located at the 12 and 6 o'clock positions and located about the same distance (i.e., the same distance +/- 5 millimeters (mm)) from the proximal junction, the next proximal-most free distal crowns are located at the 3 and 9 o'clock positions and located about the same distance (i.e., the same distance +/- 5 mm) from the proximal junction, and the succeeding proximal-most free distal crowns are located at the 12 and 6 o'clock positions and located about the same distance (i.e., the same distance +/- 5 mm) from the proximal junction. Each free distal crown may form part of a different enlarged cell that is configured to allow a thrombus to enter the basket interior. Optionally, in the relaxed state, the basket comprises a plurality of distal cells distal to the distal-most free distal crowns of the series. The plurality of distal cells may have a proximal crown attached to another cell of the basket and pointing generally in the proximal direction and a distal crown pointing generally in

the distal direction and attached to the distal junction. Optionally, each enlarged cell has a proximal end, a distal end comprising a distal crown pointing generally in the distal direction, and a length extending from the proximal end to the distal end of the respective enlarged cell. Optionally, in the relaxed state, each distal cell has a length extending from the proximal crown to the distal crown of the respective distal cell. Optionally, in the relaxed state, each of the enlarged cells is longer than each of the distal cells. Optionally, for some, most or each of the enlarged cells, the distance from the proximal end of the enlarged cell to the free distal crown of the enlarged cell is less than the distance from the free distal crown of the enlarged cell to the distal end of the enlarged cell. Optionally, in the relaxed state, the basket does not have any free crowns that point generally in the proximal direction. Optionally, the distal body, in the relaxed state, comprises a distal tapered region in which the distal body height and width decrease as the basket approaches the distal junction. Optionally, each of the enlarged cells is longer than each of the pair of cells in the series. Optionally, in the relaxed state, each of the enlarged cells extends from the 6 o'clock position to the 12 o'clock position or the 3 o'clock position to the 9 o'clock position. Optionally, in the relaxed state, the basket further comprises a plurality of proximal cells proximal to the proximal-most free distal crowns of the series. Optionally, the plurality of proximal cells have a proximal crown attached to the proximal junction and pointing generally in the proximal direction and a distal crown pointing generally in the distal direction and attached to another cell of the basket. Optionally, the proximal crowns of the cells comprising the proximal-most free distal crowns are attached to the distal ends of the proximal strips. Optionally, in the relaxed state, for each of the enlarged cells, two basket strips meet to form the distal crown located at the distal end of the enlarged cell. Optionally, each basket strip has a basket strip proximal end, a basket strip distal end, and a basket strip length extending from the proximal end to the distal end. Optionally, for at least some, most, or each of the enlarged cells, the maximum angle between the two basket strips at the same location along the distal body length is at least 90 degrees. Optionally, in the relaxed state, for said at least some, most or each of the enlarged cells, two basket strips meet to form the free distal crowns of the enlarged cell, wherein each basket strip has a basket strip proximal end, a basket strip distal end, and a basket strip length extending from the proximal end to the distal end, and further wherein the maximum angle between the two basket strips at the same location along the distal body length is no more than 40 degrees. Optionally, for at least some, most or each of the enlarged cells, the average angle between the two basket strips is at least 90 degrees. Optionally, for at least some, most or each of the enlarged cells, each of the basket strip lengths are approximately equal to ½

of the distal body height and width. Optionally, from at least the proximal crowns of the cells comprising the next proximal-most free distal crowns to the proximal ends of the enlarged cells formed by the succeeding free distal crowns, the basket has no cells other than the enlarged cells and the cells comprising the free distal crowns. Optionally, from at least the proximal-most free distal crowns to the proximal ends of the enlarged cells formed by the succeeding free distal crowns, the basket has no cells other than the enlarged cells and the cells comprising the free distal crowns. Optionally, the distal crowns of the enlarged cells are attached to another cell of the basket. Optionally, in the relaxed state, the basket further comprises an additional pair of cells located about the same distance (i.e., the same distance +/- 5 mm) from the proximal junction as the cells comprising the proximal-most pair of free distal crowns and located at the 9 and 3 o'clock positions. Optionally, each cell of the additional pair of cells having a proximal crown attached to a memory metal strip and a distal crown attached to another cell of the basket. Optionally, the additional pair of cells adjoin the enlarged cells formed by the proximal-most free distal crowns. Optionally, from at least the distal crowns of the additional pair of cells to the proximal ends of the enlarged cells formed by the succeeding free distal crowns, the basket has no cells other than the enlarged cells, the cells comprising the free distal crowns and the additional pair of cells. Optionally, in the relaxed state, the basket comprises a series of bridge memory metal strips having a proximal end attached to a distal crown of a cell and a distal end attached to a proximal crown of a distally-located cell. Optionally, a proximal pair of bridge memory metal strips are located at the 3 and 9 o'clock positions. Optionally, a more distally-located pair of bridge memory metal strips are located at the 12 and 6 o'clock positions. Optionally, each of the pair of bridge memory metal strips forms part of at least one enlarged cell. Optionally, the bridge memory metal strips are the sole distally-extending basket strips attached to the respective proximal crowns and the sole proximally-extending basket strips attached to the respective distal crowns. Optionally, in the relaxed state, each of the pair of bridge memory metal strips forms part of two enlarged cells. Optionally, the bridge memory metal strips are substantially parallel to the distal body length. Optionally, the plurality of distal cells is comprised of four cells located about the same distance (i.e., the same distance +/- 5 mm) from the proximal junction. Optionally, each cell has a center, and the centers of the cells are spaced at approximately 90 degree intervals about the distal body perimeter. Optionally, each of said four cells adjoins two of the other of said four cells. Optionally, each of said four cells comprises two lateral crowns pointing generally in a direction perpendicular to the distal body length and further wherein each lateral crown of one of said four cells adjoins a lateral crown of

an adjacent one of said four cells. Optionally, the distal body has no more than four cells at any location along the distal body length. Optionally, each of the enlarged cells are approximately the same size. Optionally, in the relaxed state, the basket interior is substantially hollow. Optionally, the basket comprises a series of at least five pairs of cells located on the distal body perimeter having a proximal crown pointing generally in the proximal direction and attached to a memory metal strip and a free distal crown pointing generally in the distal direction, wherein in the series, the next proximal-most free distal crowns after the succeeding free distal crowns are located at the 3 and 9 o'clock positions and located about the same distance (the same distance +/- 5 mm) from the proximal junction, and the distal-most free distal crowns are located at the 12 and 6 o'clock positions and located about the same distance (the same distance +/- 5 mm) from the proximal junction. Optionally, the enlarged cells formed by the proximal-most free distal crowns are adjoining, the enlarged cells formed by the next proximal-most free distal crowns are adjoining and the enlarged cells formed by the succeeding free distal crowns are adjoining. Optionally, each of the enlarged cells formed by the next proximal-most free distal crowns adjoins an enlarged cell formed by a proximal-most free distal crown and an enlarged cell formed by a succeeding free distal crown. Optionally, the distal body further comprises a lead wire extending distally from the distal junction. Optionally, the system further comprises a catheter having an interior, a proximal end leading to the interior and a distal end leading to the interior, the catheter comprised of a biocompatible material and configured to envelop the distal body when the distal body is in the collapsed state. Optionally, for each enlarged cell, the free distal crown is aligned with the distal crown located at the distal end of the enlarged cell. Optionally, the distal body, in the relaxed state comprises a proximal tapered region in which the distal body height and width decrease as the proximal strips approach the proximal junction. Optionally, the system is used in a method of removing a blood clot from a blood vessel of an animal that includes: a) providing the system; b) positioning the system in the blood vessel; c) allowing the height and width of the distal body to increase; d) moving the blood clot into the basket interior; and e) moving the distal body proximally out of the blood vessel.

[0021] Optionally, instead of three pair of cells in the series, the series may include only two pair of cells located on the distal body perimeter having a proximal crown pointing generally in the proximal direction and attached to a memory metal strip and a free distal crown pointing generally in the distal direction, and, in the series, the proximal-most free distal crowns may be located at the 12 and 6 o'clock positions and located about the same distance (the same distance +/- 5 mm) from the proximal junction, and the next proximal-most free distal crowns may be

located at the 3 and 9 o'clock positions and located about the same distance (the same distance +/- 5 mm) from the proximal junction. In such embodiment, the distal body and system may have any feature mentioned above in connection with the distal body having at least three pairs of cells with free distal crowns.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] FIG. 1A illustrates a side, elevation view of a memory metal tube prior to being cut by a laser.

[0023] FIG. 1B illustrates a side, elevation view of the memory metal tube of FIG. 1A being cut by a laser.

[0024] FIG. 2A illustrates a side, elevation view of the memory metal tube of FIG. 1B after being cut by a laser; in FIG. 2A, the tube is shown as though it were flat for purposes of illustrating the cut pattern only.

[0025] FIG. 2B illustrates a side, perspective view of the memory metal tube of FIG. 1B after being cut by a laser.

[0026] FIG. 2C illustrates another side, perspective view of the memory metal tube of FIG. 1B after being cut by a laser; in FIG. 2C, the tube is rotated as compared to FIG. 2B.

[0027] FIGs. 3A-3H illustrate a method of manufacturing a distal body of one embodiment of the present invention using the laser cut memory metal tube of FIGs. 1 and 2; in FIGs. 3A-3H, the basket portion of the distal body is not shown for simplicity of illustration.

[0028] FIGs. 4A-4D illustrate the welding steps of the method of manufacturing shown in FIG. 3; in FIGs. 4A-4D, the basket portion of the distal body is not shown for simplicity of illustration.

[0029] FIGs. 5 and 6 illustrate different locations that connector strips may be welded to the proximal memory metal strips.

[0030] FIG. 7 illustrates a side, elevation view of a catheter and the distal body of FIG. 6.

[0031] FIG. 8 illustrates a side, elevation view of a deployable system of one embodiment of the present invention being used to capture a blood clot; in FIG. 8, the basket portion of the distal body is not shown for simplicity of illustration.

[0032] FIG. 9 illustrates a side, elevation view of a claw of one embodiment of the present invention being closed by a claw actuator tube; in FIG. 9, the basket portion of the distal body is not shown for simplicity of illustration.

[0033] FIG. 10 illustrates a side, elevation view of a deployable system of one embodiment of the present invention being used to capture a blood clot; in FIG. 10, the basket portion of the distal body is not shown for simplicity of illustration.

[0034] FIG. 11 illustrates a first, perspective view of a distal body of an alternate embodiment of the present invention; the distal body is in what is referred to herein as "Orientation 1".

[0035] FIG. 12A illustrates a second, perspective view of the distal body of FIG. 11; the distal body is in what is referred to herein as "Orientation 2".

[0036] FIG. 12B illustrates a proximal, elevation view of the proximal strips of the distal body of FIG. 11.

[0037] FIG. 13 illustrates a close-up, perspective view of two unattached distal-pointing crowns of the distal body of FIG. 11.

[0038] FIG. 14A illustrates a native memory metal tube used to manufacture the distal body of FIG. 11; the native tube has been rolled out flat and the lines in the tube indicate where the tube has been cut by a laser.

[0039] FIG. 14B illustrates a first, perspective view of the distal body manufactured from the native tube of FIG. 14A; the distal body is in Orientation 1.

[0040] FIG. 14C illustrates a second, perspective view of the distal body manufactured from the native tube of FIG. 14A; the distal body is in Orientation 2.

[0041] FIGs. 15A-G illustrate stepwise use of the distal body of FIG. 11 in retrieving a soft clot; the distal body is in Orientation 1.

[0042] FIGs. 16A-H illustrate stepwise use of the distal body of FIG. 11 in retrieving a hard clot; the distal body is in Orientation 1.

[0043] FIGs. 17A-G illustrate stepwise use of the distal body of FIG. 11 in retrieving a soft clot; the distal body is in Orientation 2.

[0044] FIGs. 18A-G illustrate stepwise use of the distal body of FIG. 11 in retrieving a hard clot; the distal body is in Orientation 2.

[0045] FIGs. 19A-N illustrate stepwise use of the distal body of FIG. 11 in retrieving a deformable, cohesive adherent clot; the distal body is in Orientation 2.

[0046] FIG. 20A illustrates a view of a native memory metal tube used to manufacture a distal body of yet another embodiment of the present invention; the native tube has been rolled out flat, the lines in the tube indicate where the tube has been cut by a laser, and the distal body of FIGs. 20A-20C is slightly shorter than the distal body of FIGs. 11-19 and is meant for use in tortuous blood vessels.

[0047] FIG. 20B illustrates a first, perspective view of the distal body manufactured from the native tube of FIG. 20A; the distal body is in Orientation 1.

[0048] FIG. 20C illustrates a second, perspective view of the distal body manufactured from the native tube of FIG. 20A; the distal body is in Orientation 2.

[0049] FIG. 21 shows a perspective view of a clot retrieval system that includes the distal body of FIGs. 20B-C being delivered in a blood vessel using a delivery catheter.

[0050] FIG. 22 shows a perspective view of the distal body of FIG. 21, after deployment of the distal body and retraction of the delivery catheter, in a blood vessel.

[0051] FIG. 23 shows a perspective view of the distal body of FIG. 21; as compared to FIG. 22, the distal body has been moved proximally and tension has been exerted on the pull wire.

[0052] FIG. 24 shows a perspective view of a suction catheter that is being delivered over the pull wire of the system of FIG. 21.

[0053] FIG. 25 shows a perspective view of the distal end of the suction catheter of FIG. 24 being pushed into a clot; a syringe is sucking the clot to the suction catheter because the user has pulled back on the lever of the syringe.

[0054] FIG. 26 shows a perspective view of the distal end of the suction catheter of FIG. 24 being pushed into a clot; in FIG. 26, the user has locked the syringe lever at the desired volume.

[0055] FIG. 27 shows a perspective view of the system of FIG. 24; in FIG. 27, the suction catheter has partially sucked the distal body and clot into the suction catheter.

[0056] FIG. 28 shows a perspective view of the system of FIG. 24; in FIG. 28, the suction catheter has completely sucked the distal body and clot into the suction catheter.

[0057] FIG. 29 shows a perspective view of the system of FIG. 24; the system, and captured clot, is being removed proximally from the vessel.

[0058] FIG. 30 illustrates a right side perspective view of a mandrel used to prepare unattached distal-pointing crowns that curve radially toward the basket interior.

[0059] FIG. 31 illustrates a right side elevation view of the mandrel of FIG. 30.

[0060] FIG. 32 illustrates an alternate embodiment of a distal body; in the distal body of FIG. 32, the proximal strips converge and are soldered or welded at the proximal hub/junction and the basket strips located at the distal end of the basket converge and are soldered or welded at the distal hub/junction.

[0061] FIG. 33A illustrates a native memory metal tube used to manufacture a distal body of another embodiment of the present invention; the native tube has been rolled out flat and the lines in the tube indicate where the tube has been cut by a laser.

[0062] FIG. 33B illustrates a first, perspective view of the distal body manufactured from the native tube of FIG. 33A; in FIG. 33B, the distal body is in Orientation 1.

[0063] FIG. 33C illustrates a second, perspective view of the distal body manufactured from the native tube of FIG. 33A; in FIG. 33C, the distal body is in Orientation 2.

[0064] FIG. 34A illustrates a first, perspective view of a distal body of another embodiment of the present invention; in FIG. 34A, the distal body is in Orientation 1.

[0065] FIG. 34B illustrates a second, perspective view of the distal body of FIG. 34A; in FIG. 34B, the distal body is in Orientation 2.

[0066] FIG. 35A illustrates a first, perspective view of a proximal portion of a distal body of another embodiment of the present invention; in FIG. 35A, the distal body is in Orientation 1.

[0067] FIG. 35B illustrates a second, perspective view of the proximal portion of the distal body of FIG. 35A; in FIG. 35B, the distal body is in Orientation 2.

[0068] FIG. 36A illustrates a front perspective view of a distal body of another embodiment of the present invention; in FIG. 36A, the distal body is in the relaxed state.

[0069] FIG. 36B illustrates another front perspective view of the distal body of FIG. 36A without the proximal and distal hubs/junctions and pull wire.

[0070] FIG. 36C illustrates an enlarged front perspective view of the distal body of FIG. 36A.

[0071] FIG. 36D illustrates an enlarged front perspective view of the area labelled 36D in FIG. 36C.

[0072] FIG. 36E illustrates an enlarged front perspective view of the area labelled 36E in FIG. 36C.

[0073] FIG. 36F illustrates an enlarged front perspective view of the area labelled 36F in FIG. 36C.

[0074] FIG. 36G illustrates an enlarged front perspective view of the area labelled 36G in FIG. 36E.

[0075] FIG. 36H illustrates an enlarged front perspective view of the area labelled 36H in FIG. 36F.

[0076] FIG. 36I illustrates a top plan view of the distal body of FIG. 36A.

[0077] FIG. 36J illustrates a front elevation view of the distal body of FIG. 36A.

[0078] FIG. 36K illustrates a bottom plan view of the distal body of FIG. 36A.

[0079] FIG. 36L illustrates a rear elevation view of the distal body of FIG. 36A.

[0080] FIG. 36M illustrates a proximal elevation view of the distal body of FIG. 36A; in FIG. 36M, the miniature clock faces illustrate the 12, 3, 6 and 9 o'clock positions.

[0081] FIG. 36N illustrates a distal elevation view of the distal body of FIG. 36A; in FIG. 36N, the miniature clock faces illustrate the 12, 3, 6 and 9 o'clock positions.

[0082] FIG. 37A illustrates a front perspective view of a distal body of another embodiment of the present invention; in FIG. 37A, the distal body is in the relaxed state.

[0083] FIG. 37B illustrates another front perspective view of the distal body of FIG. 37A without the proximal and distal hubs/junctions and pull wire.

[0084] FIG. 37C illustrates a top plan view of the distal body of FIG. 37A.

[0085] FIG. 37D illustrates a front elevation view of the distal body of FIG. 37A.

[0086] FIG. 37E illustrates a bottom plan view of the distal body of FIG. 37A.

[0087] FIG. 37F illustrates a rear elevation view of the distal body of FIG. 37A.

[0088] FIG. 37G illustrates an enlarged front elevation view of the area labelled 37G in FIG. 37A.

[0089] FIG. 37H illustrates a proximal elevation view of the distal body of FIG. 37A; in FIG. 37H, the miniature clock faces illustrate the 12, 3, 6 and 9 o'clock positions.

[0090] FIG. 37I illustrates a distal elevation view of the distal body of FIG. 37A; in FIG. 37I, the miniature clock faces illustrate the 12, 3, 6 and 9 o'clock positions.

[0091] FIG. 37J illustrates an enlarged front perspective view of the area labelled 37J in FIG. 37A.

[0092] FIG. 37K illustrates an enlarged rear elevation view of the area labelled 37K in FIG. 37F.

[0093] FIG. 38 illustrates a side elevation view of a distal body and an expandable suction catheter of another embodiment of the present invention.

[0094] FIG. 39 illustrates a side elevation view of a non-expandable suction catheter of another embodiment of the present invention with the suction catheter made transparent to show the inner blocking catheter.

[0095] FIG. 39A illustrates a side elevation of a distal end of a suction catheter of another embodiment of the present invention.

[0096] FIG. 39B illustrates a side elevation of a distal end of a suction catheter of another embodiment of the present invention.

[0097] FIG. 40 illustrates a side perspective view of a distal body and an expandable suction catheter of another embodiment of the present invention.

[0098] FIG. 41 illustrates a side perspective view of a distal body and an expandable suction catheter of another embodiment of the present invention.

[0099] FIG. 42 illustrates a side perspective view of a distal body, a portion of an expandable suction catheter and a guide catheter of another embodiment of the present invention.

[00100] FIG. 43 illustrates a side perspective view of the distal body and suction catheter of FIG. 42.

[00101] FIG 44A illustrates a side perspective view of the distal body and suction catheter of FIG. 42 being used to capture a clot in a pulmonary blood vessel; as shown by the arrows pointing upward, the distal body is expanding into the clot; as shown by the arrows pointing toward the suction catheter, a suction force is drawing the clot towards the suction catheter.

[00102] FIG 44B illustrates a side perspective view of the distal body and suction catheter of FIG. 44A being used to capture the clot; as compared to FIG. 44A, in FIG. 44B, the distal body is fully expanded (i.e., fully in its relaxed state).

[00103] FIGs. 45A-45G illustrate side perspective views of the stepwise sequence of the distal body and suction catheter of FIG. 42 being used to capture a clot in a pulmonary blood vessel, with the guide catheter also shown in FIGs. 45B-45G, and with FIG. 45G showing how the clot is being moved proximally out of the blood vessel.

[00104] FIG. 46A illustrates a side perspective view of a distal body and an expandable suction catheter of another embodiment of the present invention.

[00105] FIG. 46B illustrates a side perspective closeup view of the distal body and expandable suction catheter of FIG. 46A.

DETAILED DESCRIPTION

[00106] With reference to FIGs. 1-10, the present disclosure provides a deployable system, generally designated by the numeral **10**, for removing an obstruction such as a blood clot **12** or other object from a blood vessel **14** or other interior lumen of an animal. In addition to a blood clot **12**, the obstruction may be, for example, extruded coils during aneurysm treatment, intravascular embolic material such as onyx or other obstructions requiring mechanical intravascular removal from small distal vessels. In the drawings, not all reference numbers are included in each drawing for the sake of clarity.

[00107] Referring further to FIGs. 1-10, the deployable system **10** includes a pull wire **16** that has a proximal end (not shown) and a distal end **20**. Optionally, the diameter of the pull wire is between about 0.008 inches and about 0.051 inches. Preferably, the pull wire **16** is comprised of a biocompatible metallic material.

[00108] The system **10** further includes a distal body **22**, which is attached to the pull wire **16**. The distal body **22** has a proximal end **24**, a distal end **26**, an interior **28**, and an exterior **30**.

The distal body **22** has a collapsed state, wherein the distal body **22** has a first height and width and is configured to fit into a catheter **50** (see FIG. 10A), and a relaxed state wherein the distal body **22** has a different height **32** and width and is configured to expand to about the height and width of a human blood vessel **14** when the distal body **22** is deployed from the catheter **50** (see FIGS. 10B-G). The distal body **22** further includes a proximal hub/junction **74** and a distal hub/junction **76** that is located distal relative to the proximal hub/junction **74**. In some embodiments, the distal body **22** includes a plurality of strips **40** comprised of a memory metal (e.g., a memory metal alloy such as nitinol) that form the proximal end **24** of the distal body **22**. Optionally, the proximal memory metal strips **40** each have a distal end **44** and a proximal end **42** that forms an openable and closeable claw **46**. Optionally, the proximal memory metal strips **40** are attached to the proximal hub/junction **74** through connector memory metal strips **48**. In such embodiments, the proximal hub/junction **74** may be slideable along at least a segment of the pull wire **16**, in contrast to the distal hub/junction **76**, which is optionally fixed to the pull wire **16** and not slideable along the pull wire **16**. Moving the proximal hub/junction **74** distally and closer to the distal hub/junction **76** (i.e., shortening the distance **88** between the proximal hub/junction **74** and distal hub/junction **76** by moving the proximal hub/junction **74** distally while keeping the distal hub/junction **76** stationary) exerts tension on the connector memory metal strips **48** and, in turn, the proximal memory metal strips **40**. This tension, in turn, causes the proximal ends **42** of the proximal memory metal strips **40** to move radially toward each other and the pull wire **16**. As the proximal ends **42** of the proximal memory metal strips **40** move radially toward each other and the pull wire **16**, the claw **46** (formed by the proximal memory metal strips **40**) is brought from the open position to at least a partially closed position, which in turn, separates the obstruction **12** from the wall of the human lumen **14** and captures the obstruction **12**. See FIG. 3H, FIG. 8, FIG. 9F, and FIG. 10F and 10G. Conversely, preferably, movement of the proximal hub/junction **74** proximally and away from the distal hub/junction **76** (i.e., increasing the distance **88** between the hubs/junctions **74** and **76**) releases the tension in the proximal memory metal strips **40**, which in turn, causes the proximal ends **42** of the proximal memory metal strips **40** to move away from each other and the pull wire **16**, opening the claw **46**. The claw **46** and proximal hub/junction **74** form several functions. First, as described, closing of the claw **46** captures the obstruction **12**. Second, closing the claw **46** retracts the claw **46** from the wall of the lumen **14** so that the claw **46** does not scrape against (and damage) the lumen wall while capturing the obstruction **12**. Third, closing the claw **46** reduces the height and width of the distal body **22**, which allows the distal body **22** to be re-sheathed in the catheter **50**, which

may be desired, for example, if the operator seeks to re-deploy the distal body **22** in another location in the body (which may be the case if the operator originally deploys the distal body **22** in the wrong location in the lumen **14**). For purposes of the present invention, "closing the claw" embraces both partially closing the claw **46** (where the proximal ends **42** of the proximal memory metal strips **40** do not contact the pull wire **16**) and fully closing the claw **46** (where the proximal ends **42** contact the pull wire **16**).

[00109] The claw **46** may be comprised of any number of proximal memory metal strips **40**. Preferably, however, between 2 and 4 proximal memory metal strips **40** comprise the claw **46** (it being understood that the connector strips **48**, if present, merely serve to tether the claw **46** to the proximal hub/junction **74**). Preferably, the proximal memory metal strips **40** have a length of between about 10 and about 60 millimeters. The proximal memory metal strips **40** can be thought of as arms of the claw **46**.

[00110] In some embodiments, the connector strips **48** are integral with the proximal hub/junction **74** (i.e., formed from the same piece of memory metal). In other embodiments, the proximal hub/junction **74** may be welded or soldered to the connector strips **48**. Optionally, in the relaxed state, the proximal memory metal strips **42** are distributed substantially evenly about a perimeter of the distal body **22**.

[00111] Optionally, the distal body **22** includes a lead wire **52** extending distally from the distal body **22**. Optionally, the lead wire **52** extends distally from the distal hub/junction **76**. If present, the lead wire **52** may be used to facilitate movement of the system **10** in the lumen **14**.

[00112] Optionally, the distal body **22** includes a basket **54** distal to the proximal memory metal strips **40**, the basket **54** comprised of a plurality of memory metal strips **56** distal relative to the proximal memory metal strips **40**. The distal memory metal strips **56** may, for example, form a basket **54** with a plurality of mesh openings **58**. Optionally, the size of the mesh openings **58** in the basket **54** when the distal body **22** is in its relaxed state is less (preferably significantly less) than the diameter of an average-sized ischemic blood clot **12** so that the blood clot **12** does not escape from the distal basket **54** after being captured by the distal body **22**. Optionally, the basket **54** has an open proximal end **60** and a substantially closed distal end **62**, which is formed by distal tube **76**. Optionally, the distal and proximal hubs/junctions **74** and **76** and the distal basket **54** are comprised of a nitinol having the same material composition. Optionally, the size of the mesh openings **58** decreases from the proximal end **60** of the basket **54** to the distal end **62**. The distal basket **54** is best seen in FIG. 2 and can be comprised of a different number of cell

patterns. The distal basket **54** is not shown in FIGs. 3-10 for ease of illustrating the other components in the system **10**.

[00113] Optionally, the proximal hub/junction **74** and the distal hub/junction **76** are cylindrical tubes comprising substantially circular apertures that span the length of the hubs/junctions **74** and **76** and the hubs/junctions **74** and **76** have approximately the same inner diameter **72** and the same outer diameter **70**. Preferably, the inner diameter **72** is at least slightly larger than the diameter of the pull wire **16** so that the pull wire **16** can slide through the proximal hub/junction **74**. In some embodiments, the outer diameters **70** of the proximal and distal hubs/junctions **74** and **76** may be from about 0.011 inches to about 0.054 inches and the inner diameters **72** of the proximal and distal hubs/junctions **74** and **76** may be from about 0.008 inches to about 0.051 inches.

[00114] Optionally, the distal body **22** further comprises an x-ray marker **64** that is more visible under x-ray as compared to the proximal memory metal strips **40** when the distal body **22** is located in a cranial blood vessel inside the body of a human and the x-ray is taken from outside the human's body. If the connector strips **48** are welded or soldered to the proximal memory metal strips **40**, the x-ray markers **64** may be, for example, located at the welding or soldering site. In some cases, the increased thickness at the welding or soldering site may in of itself comprise the x-ray marker **64**. Preferably, the x-ray marker **64** is comprised of a radiopaque material. Some examples of radiopaque materials can include, but are not limited to, gold, platinum, palladium, tantalum, tungsten alloy, polymer material loaded with radiopaque filler, and the like. Preferably, the proximal memory metal strips **40** are comprised of nitinol and the x-ray marker **64** is comprised of a material having a density greater than the nitinol.

[00115] A catheter **50** with an open proximal end (not shown) and an open distal end **66** initially envelopes the system **10**. As used herein, the term "catheter" generally refers to any suitable tube through which the system **10** can be deployed. Preferably, the catheter **50** is sterile and comprised of a biocompatible material (i.e., a material that does not irritate the human body during the course of a 45 minute operation that involves using the system **10** to remove a clot **12** from an intracranial blood vessel **14**). The catheter **50** can be any suitable shape, including but not limited to generally cylindrical. Preferably, the catheter **50** is a microcatheter. For purposes of the present invention, when it is said that the catheter **50** envelopes the system **10**, it will be understood that the catheter **50** envelopes at least one component of the system **10** (preferably, the distal body **22**, the lead wire **52**, and the pull wire **16**). In some embodiments, the catheter **50** is about 2.5 French in diameter. Optionally, the catheter **50** is delivered to the region of the

lumen **14** that has the obstruction **12** as follows: a guide wire is delivered to the obstruction region past the obstruction **12**; the catheter **50** is delivered over the guide wire; the guide wire is removed; and the system **10** is delivered with its pull wire **16** and lead wire **52** through the catheter **50**. Optionally, the pull wire **16** is used to push the system **10** through the catheter **50** as well as to retrieve the distal body **22** after capturing the obstruction **14** as described below. The system **10** may utilize a plurality of catheters **50**, such as, for example, a wider catheter that travels to the brain and a very flexible, smaller diameter microcatheter that is delivered from the first catheter and travels through the small arteries of the brain. Preferably, the catheter **50** is comprised of a biocompatible, polymeric material (i.e., one or more polymeric materials such as silicone, PVC, latex rubber or braided nylon).

[00116] Optionally, in the relaxed, opened-claw state, the distal body **22** or optionally just the distal basket **54** has a tapered shape (e.g., substantially conical or bullet in shape) so that the distal body **22** or just the distal basket **54** tapers from the distal body **22** or the distal basket's **54** proximal end to the distal end.

[00117] The proximal end of the system **10** is shown at the left end of FIGs. 1 and 3-10 and the distal end of the system **10** is shown at the right end of FIGs. 1 and 3-10 because a principal use of the system **10** is to remove a blood clot **12** from a human intracranial artery **14**, in which case the system **10** generally will enter the artery **14** at its proximal end by the surgeon entering the patient's body near the groin and pushing the catheter **50** towards the brain. The diameter of human arteries **14** generally decrease from their proximal end to their distal end. However, when used in other types of lumens, the distal body **22** may be located proximally relative to the catheter **50** as the term proximally and distally are used in that lumen.

[00118] The surgeon may deploy the distal body **22** by, for example, moving the catheter **50** proximally so as to unsheathe the distal body **22** or by pushing the distal body **22** out of the catheter **50.**

[00119] Use of the system **10** will now be described to remove a blood clot **12 from** an intracranial artery **14** of a human ischemic stroke patient, however, it will be appreciated that the system **10** may be used to remove other objects from other interior lumens.

[00120] A catheter **50**, which contains the collapsed distal body **22** is positioned in the lumen **14** distal to the clot **12**. See FIG. 10A.

[00121] The distal body **22** is deployed from the catheter **50** and the height and width of the distal body **22** expand to about the height and width of the blood vessel **14**. See FIG. 10B.

[00122] The catheter **50** is pulled proximally and a claw-actuator tube **90** is deployed into the blood vessel **14**. See FIG. 10C.

[00123] The distal body **22** is moved proximally so that the clot **12** is located in the interior **28** of the distal body **22**. See FIGs. 10D and 10E.

[00124] The claw-actuator tube **90** is moved distally, which pushes the proximal hub/junction **74** distally so that the distance **88** between the proximal hub/junction **74** and the distal hub/junction **76** (which is fixed to the pull wire **16** and kept stationary) decreases. Distal movement of the proximal hub/junction **74** exerts tension on the connector and proximal memory metal strips **40** and **48**, which in turn, closes the claw **46.** See FIG. 10F. (The claw actuator tube **90** should float on the pull wire **16** – i.e., have an aperture extending the tube's length that has a diameter larger than the diameter of the pull wire **16** – and the aperture of the claw actuator tube **90** should be smaller than the diameter of the proximal hub/junction **74** so that the claw actuator tube **90** pushes the proximal hub/junction **74**).

[00125] The system **10** is withdrawn proximally and removed from the body. See FIG. 10G.

[00126] To test the efficacy of the system **10**, a distal body **22** with a distal basket **54**, proximal and distal hubs/junctions **74** and **76**, and a claw **46** comprised of three proximal memory metal strips **42** was tested in a flow model that included a tube and a moist cotton ball located in the tube. The cotton ball was used to simulate a blood clot. The system **10** was deployed distal to the cotton ball. The claw **46** was closed by moving the proximal hub/junction **74** distally to capture the cotton ball. The system **10** and cotton ball were withdrawn proximally in the tube.

[00127] In some embodiments, the distal body **22** is prepared by a process that includes one or more of the following steps, as illustrated in FIGs. 1-4

a) providing a single tube **68** comprised of a memory metal such as nitinol, the single tube **68** having an exterior, a substantially hollow interior, a wall separating the exterior from the substantially hollow interior, an open proximal end **74**, an open distal end **76,** a middle portion **78** between the open proximal end **74** and the open distal end **76** (see FIG. 1A);

b) cutting the wall of the middle portion **78** with a laser **80** (see FIG. 1B)**;**

c) removing the pieces of the middle portion **78** cut by the laser **80** to form a proximal tube **74**, a distal tube **76** and a middle portion **78** comprising a plurality of memory metal strips **82** attached to the proximal tube **74**;

d) altering the shape of the middle portion **78** using a mandrel and allowing the middle portion **78** to expand relative to the distal tube **76** and proximal tube **74** to form the distal basket **54**;

e) quenching the middle portion **78** at room temperature;

f) removing the mandrel from the middle portion **78** (see FIGs. 2 and 3A);

g) mechanically or chemically electropolishing the middle portion **78** to remove oxides;

h) cutting the memory metal strips **82** to form a first segment **84** comprising the proximal tube **74** and a proximal segment of the memory metal strips **82** and a second segment **86** comprising the distal tube **76** and a distal segment of the memory metal strips **82** (see FIG. 3B); and

i) joining the proximal segments to the distal segments such that the distal segments form the proximal end **24** of the distal body **22**, such that the proximal tube **74** is located inside the interior **28** of the distal body **22**, and such the proximal tube **74** is located distal relative to the distal body proximal end **24** (see FIGs. 3C-3E).

[00128] In some embodiments, the method further includes placing the pull wire **16** through the proximal tube **74** so that the proximal tube **74** is slideable along at least a segment of the pull wire **16**.

[00129] In some embodiments, the method further includes attaching the pull wire **16** to the distal tube **76** so that the distal tube **76** is not slideable along the pull wire **16** but instead the distal tube **76** moves with the pull wire **16**.

[00130] In some embodiments, after step i, the proximal end **24** of the distal body **22** forms a claw **46** comprised of between 2 to 4 proximal memory metal strips **40**, the claw proximal memory metal strips **40** configured to move towards each other and the pull wire **16** by moving the proximal tube **74** distally and toward the distal tube **76** (i.e., decreasing the distance **88** between the tubes **74** and **76**) and the claw memory metal strips **40** configured to move away from each other and away from the pull wire (i.e., increasing the distance **88** between the tubes **74** and **76**) by moving the proximal tube **76** proximally and away from the distal tube **76** (as described previously).

[00131] In some embodiments, the middle portion **78** is expanded by heating the mandrel and the middle portion **78** by, for example, placing the mandrel and the middle portion **78** in a fluidized sand bath at about 500°C for about 3 to about 7 minutes. As the middle portion **78** is heated, the heating causes the crystalline structure of the memory metal tube **68** to realign. Preferably, the mandrel is tapered (e.g., substantially conical or bullet in shape) so that the distal

basket **54** formed from the middle portion **78** tapers from the proximal end **60** to the distal end **62**. Preferably, the proximal and distal ends of the tube **74** and **76** are not shape set by the mandrel and are not cut by the laser **80** so that the proximal and distal ends **74** and **76** do not change in shape and only slightly expand in size under heating and return to the size of the native tube **68** after the heat is removed. Preferably, the laser cuts are programmed via a computer. To ensure that the laser cuts only one surface of the tube wall at the time (and not the surface directly opposite the desired cutting surface), the laser **80** is preferably focused between the inner and outer diameter of the desired cutting surface and a coolant is passed through the memory metal tube **68** so that the laser **80** cools before reaching the surface directly opposite the desired cutting surface.

[00132] The portions of the wall not cut by the laser **80** create the distal basket **53**, proximal and distal tubes **74** and **76**, and memory metal strips **40**, **48** and **56**, as described.

[00133] Preferably, the memory metal selected for the native tube **68** has a heat of transformation below average human body temperature (37°C) so that the distal body **22** has sufficient spring and flexibility after deployment from the catheter **50** in the human blood vessel **14**.

[00134] In some embodiments, the native tube **68** (and hence the distal and proximal tubes **74** and **76**) have an outer diameter of less than about 4 French, e.g., a diameter of about 1 to about 4 French. In some embodiments, the diameter of the pull wire **16** is between about 0.008 inches and about 0.051, as noted above, and in such embodiments, the diameter of the pull wire **16** may be approximately equal to the inner diameter **72** of the native nitinol tube **68.**

[00135] Without being bound by any particular theory, it is believed that manufacturing the distal body **22** from a single memory metal tube **68** provides ease of manufacturing and safety from mechanical failure and provides tensile strength necessary for the system **10** to remove hard thrombus **12** and other obstructions.

[00136] **<u>The embodiments of Figures 11-29</u>**

[00137] Figures 11-29 illustrate an alternate embodiment **200** that includes one or more of the following additional features, as described below: twisting proximal strips/tethers **252**, unattached/free distal-pointing crowns **258** that optionally curve inward and have x-ray markers **244**, and enlarged openings/drop zones **262** in the basket **246** immediately distal to the unattached, distal-pointing crowns **258** that allow the obstruction or other object **270** to enter the distal basket interior **222**.

[00138] More specifically, as shown in FIGs. 11-29, the system **200** may include a pull wire **202** having a proximal end **204** and a distal end **206**, as described above, a distal body **216** attached to the pull wire **202**, the distal body **216** comprising an interior **222**, a proximal end **218**, a distal end **220**, a distal body length **226** extending from the proximal end **218** to the distal end **220**, a distal body height **224,** a proximal hub/junction **228** (preferably in the form of a tube and which has a proximal end **230** and a distal end **232**) forming the proximal end **218** of the distal body **216**, a basket **246** comprised of a plurality of cells/openings **248** formed by a plurality of basket strips **291** that preferably are comprised of a memory metal, optionally a distal hub/junction **236** that forms the distal end of the basket **246** (preferably in the form of a tube that has a proximal end **238** and a distal end **240**), and a plurality of proximal strips **252** (preferably the proximal strips **252** are comprised of a memory metal), each proximal strip **252** having a proximal end **254** attached to the proximal hub/junction/tube **228**, and a distal end **256** attached to a cell **248** (more specifically a proximal-pointing crown of a cell **248** located at the proximal end of the basket **246**), the basket comprising a basket interior **292**, the distal body **216** having a relaxed state wherein the distal body **216** has a first height and width, a collapsed state wherein the distal body **216** has a second height and width, the second height less than the first height, the second width less than the first width; and a delivery catheter **208** for delivering the distal body **216**, as described above, having an interior **210**, a proximal end **212** leading to the interior **210** and a distal end **214** leading to the interior **210**, the delivery catheter **208** comprised of a biocompatible (preferably polymeric) material and configured to envelope the distal body **216** when the distal body **216** is in the collapsed state. Optionally, the basket interior **292** is substantially hollow – i.e., unlike U.S. Patent Publication No. 2013/0345739, the basket interior **292** does not contain an inner elongate body. Optionally, instead of a distal hub/junction **236**, the basket **246** includes an open distal end. Optionally, at least two cells **250** of the basket **246** comprise a proximal crown **260** pointing generally in the proximal direction and a distal crown **258** pointing generally in the distal direction, and the distal crowns **258** of the at least two cells **250** are not attached to another cell **248** of the basket **246**. In other words, the distal crowns **258** of at least two cells **250** are free floating and are not attached to any strip except for the strips forming part of the at least two cells **250**; such distal crowns **258** are referred to below as unattached, distal-pointing crowns **258**. Preferably, the distal tips of the unattached, distal-pointing crowns **258** terminate at an x-ray marker **244.** (Cells labeled with the numerals **250**, **250A, 250B, 250C,** and **250D** refer to the at least two cells that include a proximal crown **260** pointing generally in the proximal direction and an unattached, distal-pointing crown **258**, cells

labeled with the numerals **262**, **262A, 262B, 262C,** and **262D** refer to the enlarged cells/drop zones adjacent to (preferably immediately distal to) an unattached, distal-pointing crown **258,** and cells designated with numeral **248** refer to generally the cells of the basket **246**). (When it is said that the enlarged cells/drop zones **262** are preferably immediately distal to an unattached, distal-pointing crown **258**, it will be understood that at least a portion of an enlarged cell/drop zone **262** is immediately distal to an unattached, distal-pointing crown **258**, and that a portion of the enlarged cell/drop zone **262** may be proximal to an unattached, distal-pointing crown **258**, as shown in FIGs. 11-12 due to the shape of the enlarged cells/drop zones **262**). It will be understood that part number **250** refers generally to one or more of the at least two cells, whereas part numbers **250A, 250B, 250C,** and **250D** refer to a specific one of the at least two cells. Similarly, it will be understood that part number **262** refers generally to one or more of the enlarged cells/drop zones, whereas part numbers **262A, 262B, 262C,** and **262D** refer to a specific one of the enlarged cells/drop zones. Similarly, it will be understood that part number **258** refers generally to one or more of the unattached, distal-pointing crowns, whereas part numbers **258A, 258B, 258C,** and **258D** refer to a specific one of the unattached, distal-pointing crowns.

[00139] Optionally, at least two of the unattached, distal-pointing crowns **258** are located approximately 180 degrees (e.g., about 150 to about 180 degrees) relative to each other and approximately the same distance from the proximal hub/junction/tube **228**, as best seen in FIG. 12A. Optionally, the basket **246** comprises a first pair of unattached, distal-pointing crowns **258A** and **258B**, each of the first pair of unattached, distal-pointing crowns **258A** and **258B** is located approximately the same distance from the proximal hub/junction/tube **228** and approximately 180 degrees relative to each other, and the basket **246** further comprises a second pair of unattached, distal-pointing crowns **258C** and **258D** located distally relative to, and approximately 90 degrees (e.g., between about 60 and about 90 degrees) relative to, the first pair of unattached, distal-pointing crowns **258A** and **258B**. Optionally, the second pair of unattached, distal-pointing crowns **258C** and **258D** form cells **250C** and **250D** that are adjacent to, but offset from, the cells **250A** and **250B** formed by the first pair of unattached, distal-pointing crowns **258A** and **258B**. (In other words, optionally, the center of cell **250A** is about 90 degrees relative to the centers of cells **250C** and **250D** and optionally the center of cell **250B** is also about 90 degrees relative to the centers of cells **250C** and **250D**). Optionally, at least one of (and preferably all) the unattached, distal-pointing crowns **258A, 258B, 258C or 258D** comprise an x-ray marker **244** that is more visible under x-ray as compared to the basket strips **291** when the distal body **216** is located in a cranial blood vessel **266** inside the body of a human and the x-ray

is taken from outside the human's body. Preferably, the x-ray marker **244** is a radiopaque material. Some examples of radiopaque materials can include, but are not limited to, gold, platinum, palladium, tantalum, tungsten alloy, polymer material loaded with radiopaque filler, and the like. Preferably, the basket strips **291** are comprised of nitinol and the x-ray marker **244** is comprised of a material having a density greater than the nitinol. In some embodiments, the x-ray markers **244** comprise a heavy metal welded or soldered to the unattached, distal-pointing crowns **258**. Optionally, the unattached, distal-pointing crowns **258** curve subtly towards the interior **222** of the distal basket **246**, which decreases the likelihood that the unattached, distal-pointing crowns **258** will rub against and damage the vessel wall **268**. Optionally, the basket **246** comprises at least two cells proximal to the at least two cells **250** that include the unattached, distal-pointing crowns **258**. Optionally, the unattached, distal-pointing distal crowns **258** are located about at least 5 mm (e.g., about 5 to about 30 mm) from the proximal hub/junction/tube **228**. Optionally, the unattached, distal-pointing crowns **258** are located at least about 5 mm from the distal hub/junction/tube **236**. Optionally, the unattached, distal-pointing crowns **258** of the at least two cells **250** also each form part (namely a portion of the proximal boundary) of an enlarged cell **262** (which is the entry point of hard thrombus **270B** into the basket interior **222**) and further wherein the surface area of the enlarged cells **262** in the relaxed state is greater than the surface area of the other cells of the basket **246** in the relaxed state. Optionally, the unattached, distal-pointing crowns **258** serve several functions: 1) they form flex points of the basket **246**, which makes it easier for the system **200** to navigate the curves of the blood vessels **266** of the brains; 2) through the use of x-ray markers **244** on the unattached, distal-pointing crowns **258**, they allow the operator to locate the enlarged cells **262** of the basket **246** that form the point at which hard thrombuses **270B** enter the basket **246**; and 3) they allow the operator to ratchet or force the object **270** into the basket **246** by moving the unattached, distal-pointing crowns **258** proximally and distally relative to the object **270**. (As explained below, the numeral **270** refers to clots/thrombuses and other objects generally, and **270A** refers to a soft clot, **270B** refers to a hard clot and **270C** refers to a deformable, cohesive, adherent clot). Optionally, the proximal end **254** of a proximal strip **252** is located about 65-180 degrees (preferably approximately 180 degrees) relative to the distal end **256** of the same proximal strip **252**, as best seen in FIG. 12B. In other words, preferably the proximal end **254** of a first proximal strip **252** is attached to the 12 o'clock position on the proximal tube **228** and the distal end **256** of the first proximal strip **252** (which terminates at a proximal cell **248** of the basket **246**) is located at the 6 o'clock position (i.e., 180 degrees from the start position), and the proximal end **254** of a second

proximal strip **252** is attached to the 6 o'clock position on the proximal tube **228** and the distal end **254** (which terminates at a cell **248** of the basket **246)** of the second proximal strip **252** is located at the 12 o'clock position (i.e., 180 degrees from the start position). This twisting feature serves two functions: 1) it allows the proximal strips **252** to surround the object **270**; and 2) it allows the manufacturer to insert a mandrel into the basket **246** during the shape-setting procedure. Optionally, the pull wire **202** is attached to the proximal tube **228** (e.g., by gluing, welding, soldering or the like). Preferably, the pull wire **202** does not extend through the distal basket interior **222**. Optionally, the proximal strips **252** are integral with the distal end **232** of the proximal tube **228** and the entire distal body **216** is created from a single tube **264** of a memory metal. Optionally, the proximal crowns **260** of the at least two cells **250** that include the unattached, distal pointing-crowns **258** are each attached to another cell **248** of the basket **246**. In other words, preferably the basket **246** does not have any free-floating proximal-pointing crowns, as free-floating proximal-pointing crowns could damage the vessel **266** when the distal body **216** is pulled proximally. Optionally, the system **200** further comprises a lead wire **286** extending distally from the distal tube **236**, the lead wire **286** having a length of from about 3 mm to about 10 mm. Optionally, the distal hub/junction/tube **236**, the proximal hub/junction/tube **228**, and the basket **246** are comprised of a nitinol having the same material composition. In other words, as with the prior embodiment of FIGs. 1-10, optionally the entire distal body **216** is manufactured from a single tube of nitinol **264**. Optionally, the proximal and distal hubs/junctions/tubes **228** and **236** comprise an x-ray marker **244** that is more visible under x-ray as compared to the basket strips **291** when the distal body **216** is located in a cranial blood vessel **266** inside the body of a human and the x-ray is taken from outside the human's body. Preferably, the x-ray marker **244** is a radiopaque material. Some examples of radiopaque materials can include, but are not limited to, gold, platinum, palladium, tantalum, tungsten alloy, polymer material loaded with radiopaque filler, and the like. Preferably, the basket strips **291** are comprised of nitinol and the x-ray marker **244** is comprised of a material having a density greater than the nitinol. In some embodiments, the proximal and distal hubs/junctions/tube interiors **234** and **242** may comprise tantalum welded or otherwise attached to the interior **234** and **242** of the proximal and distal hubs/junctions/tubes **228** and **236**. Optionally, the proximal and the distal tubes **228** and **236** are generally cylindrical in shape and each has an outer diameter and an inner diameter, the inner diameter forming apertures of the proximal and distal tubes **228** and **236** and further wherein the outer diameters of the proximal and distal tubes **228** and **236** are substantially the same size and further wherein the inner diameters of the proximal and distal

tubes **228** and **236** are substantially the same size. Optionally, the outer diameters of the proximal and distal tubes **228** and **236** are from about 0.011 inches to about 0.054 inches, and further wherein the inner diameters of the proximal and distal tubes **228** and **236** are from about 0.008 inches to about 0.051 inches. Optionally, the pull wire **202** is generally cylindrical and further wherein the diameter of the pull wire **202** is between about 0.008 inches and about 0.051 inches. Optionally, the distal body **216** has a length of between about 10 and about 60 millimeters. Optionally, the first height **224** and first width **226** of the distal body **216** are between about 2 millimeters and about 6 millimeters.

[00140] The present disclosure also provides a method of removing a clot **or** other object **270** from an interior lumen **266** of an animal, the method comprising the steps of:

a) providing the system **200** of Figures 11-29, wherein at least two cells **250** of the basket **246** comprise a proximal crown **260** pointing generally in the proximal direction and a distal crown **258** pointing generally in the distal direction, and the distal crowns **258** of the at least two cells **250** are not attached to another cell **248** of the basket **246** (i.e., free-floating), and further wherein at least one of the unattached, distal-pointing crowns **258** comprises an x-ray marker **244**;

b) positioning the system **200** in the lumen **266**;

c) deploying the distal body **216** from the distal end **214** of the delivery catheter **208**;

d) allowing the height and width **224** and **226** of the distal body **216** to increase;

e) irradiating the x-ray marker **244** with x-ray radiation and

f) moving the object **270** into the distal basket interior **222**.

[00141] Optionally, the object **270** enters the distal basket interior **222** adjacent to (preferably adjacent and immediately distal to) at least one of the unattached, distal-pointing crowns **258** – i.e., in the enlarged cells/drop zones **262**. In some embodiments, the distal body **216** is deployed so that at least one (e.g., preferably the two proximal **258A** and **258B**) of the unattached, distal-pointing crowns **258** is distal to the object **270**. As explained below, the x-ray markers **244** of the unattached, distal-pointing crowns **258** are used to locate the distal body **216** relative to the clot or other object **270**. It will be appreciated that clots **270** can generally be located in blood vessels **266** by injecting a contrast dye, for example, into the blood vessel **266** proximal and distal to the believed area of obstruction and viewing on an x-ray where the fluid stops moving in the blood vessel **266**. It will also be appreciated that if the object **270** is not a blood clot but is a radio-opaque object, the object **270** may be viewed on an x-ray.

[00142] FIGs. 11 and 14B illustrate a first, perspective view of one embodiment of a distal body **216** with twisting proximal strips **252**, unattached distal-pointing crowns **258** that subtly curve inward and have x-ray markers **244**, and enlarged openings/drop zones **262** in the basket **246** that allow the obstruction or other object **270** to enter. In FIGs. 11 and 14B, the distal body **216** is in Orientation 1. (To prepare a basket **246** with unattached distal-pointing crowns **258** that curve inward toward the basket interior **292,** a mandrel **900** such as that illustrated in FIGs. 63 and 64 may be used. The mandrel **900** includes a generally cylindrical body **901** with tapered proximal and distal ends **902** and **903** that slope like the ends of a pencil. The cylindrical body **901** includes two grooves **904** that extend around the circumference of the cylindrical body **901**. The grooves **904** include tapered portions **905** that slope towards the distal end **903**, which are designed to shape the unattached distal-pointing crowns **258**. The grooves **904** are generally in the shape of a truncated cone, as shown in FIGs. 30-31). The two proximal, unattached distal-pointing crowns **258A** and **258B** are located approximately the same distance from the proximal hub/junction/tube **228** and are oriented approximately 180 degrees relative to each other. The two distal, unattached distal-pointing crowns **258C** and **258D** are located approximately the same distance from the proximal hub/junction/tube **228** as each other (and distal to the two proximal, unattached distal-pointing crowns **258A** and **258B)** and are oriented approximately 180 degrees relative to each other and approximately 90 degrees to the proximal, unattached distal-pointing crowns **258A** and **258B**. For example, for purposes of FIGs. 11-29, "approximately the same distance from the proximal hub/junction/tube **228**" means that if one free distal crown **258A** of the first pair of distal crowns **258A/258B** is located X distance from the proximal hub/junction/tube **228**, the other distal crown **258B** of the first pair of distal crowns **258A/258B** is located X distance plus or minus (+/-) 3 millimeters (mm) from the proximal hub/junction/tube **228**. Similarly, if one free distal crown **258C** of the second pair of distal crowns **258C/258D** is located Y distance from the proximal hub/junction/tube **228**, the other distal crown **258D** of the second pair of distal crowns **258C/258D** is located Y distance plus or minus (+/-) 3 mm from the proximal hub/junction/tube **228**. In a preferred embodiment, the first free distal crowns **258A** and **258B** are located the same distance +/- 0.5 mm from the proximal hub/junction/tube **228**. Similarly, in a preferred embodiment, the second free distal crowns **258C** and **258D** are located the same distance +/- 0.5 mm from the proximal hub/junction/tube **228**.

[00143] The two proximal enlarged openings/drop zones **262A** and **262B** distal to the proximal, unattached distal pointing crowns **258A** and **258B** are located approximately the same

distance from the proximal hub/junction/tube **228** and the centers of the two proximal enlarged openings/drop zones **262A** and **262B** are oriented approximately 180 degrees relative to each other. (As noted above, preferably, the proximal, unattached distal-pointing crowns **258A** and **258B** form part of the proximal boundary of the proximal, enlarged cells/drop zones **262A** and **262B,** and the distal, unattached distal-pointing crowns **258C** and **258C** form part of the proximal boundary of the distal, enlarged cells/drop zones **262C** and **262D**). The two distal, enlarged openings/drop zones **262C** and **262D** distal to the distal, unattached distal pointing crowns **258C** and **258D** are located approximately the same distance from the proximal hub/junction/tube **228** and the centers of the distal, enlarged openings/drop zones **262C** and **262D** are oriented approximately 180 degrees relative to each other and approximately 90 degrees relative to the proximal enlarged openings/drop zones **262A** and **262B**. FIGs. 12A and 14C illustrate a second view of the distal body **216** of FIG. 11 (Orientation 2). FIG. 13 is a close-up view of two unattached, distal-pointing crowns **262**. The lines in FIG. 14 show how a nitinol tube **264** is cut with a laser to create the distal body **216** shown in FIG. 14B and FIG. 14C. It will be appreciated that FIG. 14B is a simplified view of the distal body **216** and orientation shown in FIG. 11 and FIG. 14C is a simplified view of the distal body **216** and orientation shown in FIG. 12A.

[00144] As described below, FIGs. 15-19 describe how the distal body **216** is used to retrieve, soft clots **270A**, hard clots **270B**, and deformable, cohesive adhesive clots **270C** in a human intracranial artery **266**. (In FIGs. 15-19, the center of the artery **266** is denominated by the dashed line). As explained below, the distal body **216** has four rows of x-ray markers namely, 1) a first row of one x-ray marker, which is located inside the proximal tube denominated by the numeral **228, 244**; 2) a second row of two x-ray markers, which are located at the two proximal, unattached distal-pointing crowns (the two markers are oriented 180 degrees relative to each other) denominated by the numerals **258A, 244** and **258B, 244**; 3) a third row of two x-ray markers, which are located at the two distal, unattached distal-pointing crowns (these two markers are oriented 180 degrees relative to each other and 90 degrees relative to the two proximal, unattached distal-pointing crowns) denominated by the numerals **258C, 244** and **258D, 244**; and 4) a fourth row of one x-ray marker, which is located inside the distal tube denominated by the numeral **236, 244**. (It will be appreciated that the first number in the sequence describes the position of the x-ray marker and the second number, **244**, represents the fact that the item is an x-ray marker). As explained below, upon deploying the distal body **216** so that the two proximal, unattached distal-pointing crowns **258A, 244** and **258B, 244** are immediately distal to

the clot **270**, the surgeon interventionalist (i.e., operator of the distal body **216**) detects the four rows of x-ray markers using x-ray radiation from a first vantage point and from a second vantage point that is offset from the first vantage point (e.g. 90 degrees). Next, the surgeon moves the distal body **216** proximally relative to the clot **270** and takes additional x-rays from the first and second vantage points. As explained in greater detail below, the surgeon uses the x-ray markers of the proximal and distal, unattached distal-pointing crowns, namely **258A, 244; 258B, 244; 258C, 244;** and **258D, 244** (more specifically, the convergence or lack thereof of the proximal and distal, unattached distal-pointing crowns **258A, 244; 258B, 244; 258C, 244;** and **258D, 244** as shown on the x-ray) to determine whether the clot **270** is located inside the distal body interior **222** or whether the clot **270** is collapsing the distal body **216**.

[00145] More specifically, FIGs. 15A-G illustrate stepwise use of the distal body **216** in retrieving a soft clot **270A** in a human intracranial artery **266**. (The distal body **216** in FIGS. 15A-15G is in Orientation 1). First, as always, the surgeon determines the location of the clot **270A** in the vessel **266** using, for example, a contrast dye injected proximal and distal to the clot **270A**. Next, the delivery catheter **208**, which is enveloping the distal body **216**, is positioned in the blood vessel **266** so that the two proximal, unattached distal-pointing crowns **258A** and **258B** are immediately distal to the clot **270A**. See FIG. 15B. The distal body **216** is then deployed from the delivery catheter **208** by moving the catheter **208** proximally. The soft clot **270A**, which is unable to collapse the distal body **216**, then enters the distal body interior **222**. See FIG. 15C. However, at this time, the surgeon is unaware that the clot **270A** has entered into the distal body interior **222**. Thus, without moving the distal body **216**, the surgeon irradiates the four rows of x-ray markers at a first vantage point (i.e., from the front of the distal body **216** in the orientation shown in FIGs. 15A-G; i.e., into the page). As shown in FIG. 15D, the first vantage point shows four rows of x-ray markers. The first row is a single point, which represents the x-ray marker located in the proximal tube **228, 244**; the proximal tube x-ray marker **228, 244** always appears as a single point. The second row is a single point, which represents the x-ray marker located at the front, proximal, unattached distal-pointing crown **258B, 244**; the reason that this second row of markers is a single point is that the rear x-ray marker of the second row **258A, 244** is hidden from view because it is directly behind the front x-ray marker of the second row **258B, 244**. The third row has two points, which represents the two x-ray markers located at the distal, unattached distal-pointing crowns **258C, 244** and **258D, 244**; the reason that this third row of markers has two points is that neither marker in the third row **258C, 244** and **258D, 244** is hidden from view on the x-ray at this angle – rather, one marker **258C, 244** is located above the

other marker **258D, 244** – and as shown in FIG. 15C, the distal body **216** is not collapsed at the distal, unattached distal-pointing crowns **258C, 244** and **258D, 244**. The fourth row is a single point, which represents the x-ray marker located in the distal tube **236, 244**; the distal tube x-ray marker **236, 244** always appears as a single point. Without moving the distal body **216**, the surgeon then irradiates the four rows of x-ray markers from a second vantage point 90 degrees offset from the first vantage point (i.e., from the bottom of the distal body **216** in the orientation shown in FIG. 15A). As shown, the first row is, as always, a single point, which represents the x-ray marker located in the proximal tube **228, 244**. The second row has two points, which represents the two x-ray markers located at the proximal, unattached distal-pointing crown **258A, 244** and **258B, 244**; the reason that this second row of markers shows up as two points is that neither marker **258A, 244** and **258B, 244** in the second row is hidden from view on the x-ray at this offset angle – rather, one marker **258B, 244** is located above the other marker **258A, 244** – and the distal body **216** is not collapsed at the proximal, unattached distal-pointing crowns **258A, 244** and **258B, 244**. The third row is a single point, which represents the x-ray marker located at the bottom, distal, unattached distal-pointing crown **258D, 244**; the reason that this third row of markers is a single point is that the top x-ray marker of the third row **258C, 244** is directly behind the bottom x-ray marker of the third row **258D, 244**, and thus, hidden from view. The fourth row is, as always, a single point, which represents the x-ray marker located in the distal tube **236, 244**. The surgeon, thus, concludes that neither the x-ray markers at the second row **258A, 244** and **258B, 244** nor the x-ray markers at the third row **258C, 244** and **258D, 244** (i.e., the x-ray markers at both the proximal and distal unattached distal pointing-crowns) have converged. As shown in FIG. 15E, the surgeon then moves the distal body **216** proximally relative to the soft clot **270A** so that the distal, unattached distal-pointing crowns **258C, 244** and **258D, 244** are immediately distal to the clot **270A** and then the surgeon irradiates the four rows of x-ray markers again from the first vantage point and the second vantage point. As shown in FIG. 15F, the results are the same as FIG. 15D. With the results from FIGs. 15D and 15F, the surgeon concludes that neither x-ray markers at the second row **258A, 244** and **258B, 244** nor the x-ray markers at the third row **258C, 244** and **258D, 244** (i.e., the x-ray markers at both the proximal and distal unattached distal pointing-crowns) converged at either the original position of the distal body **216** (FIGs. 15C and 15D) or the position after moving the distal body **216** proximally (FIGs. 15E and 15F), and, thus, the distal body **216** was expanded in the vessel **266** in both positions. Thus, the surgeon concludes that the clot is a soft clot **270A** that has entered into the distal body interior **222** and the surgeon removes the distal body **216** and the soft clot

270A, captured by the distal body **216**, by moving the distal body **216** proximally out of the vessel **266**, as shown in FIG. 15G.

[00146] FIGs. 16A-H illustrate stepwise use of the distal body **216** in retrieving a hard clot **270B** in a human intracranial artery **266**. (In FIGs. 16A-H, the distal body **216** is in Orientation 1). First, as always, the surgeon determines the location of the clot **270B** in the vessel **266** using, for example, a contrast dye injected proximal and distal to the clot **270B**. Next, the delivery catheter **208**, which is enveloping the distal body **216**, is positioned in the blood vessel **266** so that the two proximal, unattached distal-pointing crowns **258A** and **258B** are immediately distal to the clot **270B**. See FIG. 16B. The distal body **216** is then deployed from the delivery catheter **208** by moving the catheter **208** proximally. The hard clot **270B**, which is located above the distal body **216**, collapses the distal body **216**, as shown in FIG. 16C. However, at this time, the surgeon is unaware that the clot **270B** has collapsed the distal body **216**. Thus, without moving the distal body **216**, the surgeon irradiates the x-ray markers at a first vantage point (i.e., from the front of the distal body **216**; i.e., into the page). As shown in FIG. 16D, the first vantage point shows four rows of x-ray markers. The first row is, as always, a single point, representing the x-ray marker located in the proximal tube – i.e., **228, 244**. The second row is a single point, which represents the x-ray marker located at the front, proximal, unattached distal-pointing crown **258B, 244**; the reason that this second row of markers is a single point is that the rear x-ray marker of the second row **258A, 244** is hidden from view because it is directly behind the front x-ray marker of the second row **258B, 244**. The third row has two points, which represents the two x-ray markers located at the distal, unattached distal-pointing crowns **258C, 244** and **258D, 244**; the reason that this third row of markers has two points is that neither marker in the third row is hidden from view on the x-ray at this angle – rather, one marker **258C, 244** is located above the other marker **258D, 244** – and as shown in FIG. 16C, the distal body **216** is not collapsed at the distal, unattached distal-pointing crowns **258C, 244** and **258D, 244**. The fourth row is, as always, a single point, representing the x-ray marker located in the distal tube **236, 244**. Without moving the distal body **216**, the surgeon then irradiates the markers from a second vantage point 90 degrees offset from the first vantage point (i.e., from the bottom of the distal body **216**). As shown, the first row is, as always, a single point, which represents the x-ray marker located in the proximal tube **228, 244**. The second row has two points, which represents the two x-ray markers located at the proximal, unattached distal-pointing crowns **258A, 244** and **258B, 244**; the reason that this second row of markers shows up as two points is that neither marker in the second row is hidden from view on the x-ray at this offset angle – rather, one

marker **258B, 244** is located above the other marker **258A, 244** – and although the distal body **216** is collapsed at the proximal, unattached distal-pointing crowns as shown in FIG. 16C, the second row of x-ray markers have not converged because the clot **270B** is on top of the second row of x-ray markers. The third row is a single point, which represents the x-ray marker located at the bottom, distal, unattached distal-pointing crown **258D, 244**; the reason that this third row of markers is a single point is that the top x-ray marker of the third row **258C, 244** is directly behind the bottom x-ray marker of the third row **258D, 244**, and thus, hidden from view. The fourth row is, as always, a single point, which represents the x-ray marker located in the distal tube **236, 244**. The surgeon, thus, concludes that neither the second row **258A, 244** and **258B, 244** nor the third row **258C, 244** and **258D, 244** of x-ray markers (i.e., the x-ray markers at both the proximal and distal unattached distal pointing-crowns) has converged. As shown in FIG. 16E, the surgeon then moves the distal body **216** proximally so that the distal, unattached distal-pointing crowns **258C, 244** and **258D, 244** are immediately distal to the clot **270B** and the surgeon then irradiates the x-markers again from the first vantage point. As shown in FIG. 16F, the first row is, as always, a single point, representing the x-ray marker located in the proximal tube **228, 244**. The second row is a single point, which represents the x-ray marker located at the front, proximal, unattached distal-pointing crown **258B, 244**; the reason that this second row of markers is a single point is that the rear x-ray marker of the second row **258A, 244** is hidden from view because it is directly behind the front x-ray marker of the second row **258B, 244**. The third row has only one point because the clot **270B**, which is on top of the third row of x-ray markers **258C, 244** and **258D, 244** (i.e., the markers at the distal, unattached distal-pointing crowns), has pushed the third row of x-ray markers **258C, 244** and **258D, 244** together. The fourth row is, as always, a single point, representing the x-ray marker located in the distal tube **236, 244**. Without moving the distal body **216**, the surgeon then irradiates the markers from a second vantage point 90 degrees offset from the first vantage point (i.e., from the bottom of the distal body). As shown, the first row is, as always, a single point, which represents the x-ray marker located in the proximal tube **228, 244**. The second row has two points, which represents the two x-ray markers located at the proximal, unattached distal-pointing crown **258A, 244** and **258B, 244**; the reason that this second row of markers shows up as two points is that neither marker in the second row is hidden from view on the x-ray at this offset angle and the distal body **216** is not collapsed at the proximal, unattached distal-pointing crowns **258A, 244** and **258B, 244**. The third row is a single point, which represents the x-ray marker located at the bottom, distal, unattached distal-pointing crown **258D, 244**; the reason that this third row of markers is a

single point is that the bottom x-ray marker of the third row **258D, 244** is directly in front of the top x-ray marker of the third row **258C, 244**, and thus, the top x-ray marker of the third row **258C, 244** is hidden from view. The fourth row is, as always, a single point, which represents the x-ray marker located in the distal tube **236, 244**. Knowing that the distal, unattached distal-pointing crowns **258C, 244** and **258D, 244** have converged as shown in FIG. 16F, the surgeon moves the distal body **216** proximally and the hard clot **270B** falls into the distal body interior **222** in the enlarged cell/drop zone **262C** immediately distal to the top, distal, unattached distal-pointing crown **258C**. See FIG. 16G. To confirm that the hard clot **270B** has entered the distal body interior **222**, the surgeon takes x-rays from the first and second vantage points. The results are shown in FIG. 16H. As compared to 16F, the front x-ray view of FIG. 16H shows that the distal, unattached distal-pointing crowns **258C, 244** and **258D, 244** are not converged, and, thus, the surgeon concludes that the hard clot **270B** has entered the distal body interior **222**. The surgeon then removes the distal body **216** and the hard clot **270B**, captured by the distal body **216**, by moving the distal body **216** proximally out of the vessel **266**.

[00147] FIGs. 17A-G illustrate stepwise use of the distal body **216** in retrieving a soft clot **270A** in a human intracranial artery **266**. (In FIGs. 17A-G, the distal body **216** is in Orientation 2). First, as always, the surgeon determines the location of the clot **270A** in the vessel **266** using, for example, a contrast dye injected proximal and distal to the clot **270A**. Next, the delivery catheter **208**, which is enveloping the distal body **216**, is positioned in the blood vessel **266** so that the two proximal, unattached distal-pointing crowns **258A** and **258B** are immediately distal to the clot **270A**. See FIG. 17B. The distal body **216** is then deployed from the catheter **208** by moving the catheter **208** proximally. The soft clot **270A**, which is unable to collapse the distal body **216**, then enters the distal body interior **222**. See FIG. 17C. However, at this time, the surgeon is unaware that the clot **270A** has entered into the distal body interior **222**. Thus, without moving the distal body **216**, the surgeon irradiates the x-ray markers at a first vantage point (i.e., from the front of the distal body; into the page). As shown in FIG. 17D, the first vantage point shows four rows of x-ray markers. The first row is, as always, a single point, representing the x-ray marker located in the proximal tube **228, 244**. The second row has two points, which represents the two x-ray markers located at the proximal, unattached distal-pointing crowns **258A, 244** and **258B, 244**; the reason that this second row of markers has two points is that neither marker in the second row is hidden from view on the x-ray at this angle – rather, one marker **258A, 244** is located above the other marker **258B, 244** – and as shown in FIG. 17C, the distal body **216** is not collapsed at the proximal, unattached distal-pointing crowns

258A, 244 and **258B, 244**. The third row has a single point, which represents the x-ray marker located at the front (in Orientation 2), distal, unattached distal-pointing crown **258C, 244**; the reason that this third row of markers is a single point is that the rear (in Orientation 2) x-ray marker **258D, 244** of the third row is hidden from view because it is directly behind the front x-ray marker **258C, 244** of the third row. The fourth row is, as always, a single point, representing the x-ray marker located in the distal tube **236, 244**. Without moving the distal body, the surgeon then irradiates the markers from a second vantage point 90 degrees offset from the first vantage point (i.e., from the bottom of the distal body, as shown in this view). As shown, the first row is, as always, a single point, which represents the x-ray marker located in the proximal tube **228, 244**. The second row is a single point, which represents the x-ray marker located at the bottom (in Orientation 2), proximal, unattached distal-pointing crown **258B, 244**; the reason that this second row of markers is a single point is that the top (in Orientation 2) x-ray marker of the second row **258A, 244** is directly behind the bottom x-ray marker of the second row **258B, 244**, and thus, hidden from view. The third row has two points, which represents the two x-ray markers located at the distal, unattached distal-pointing crowns **258C, 244** and **258D, 244**; the reason that this third row of markers shows up as two points is that neither marker in the third row is hidden from view on the x-ray at this offset angle and the distal body **216** is not collapsed at the distal, unattached distal-pointing crowns **258C, 244** and **258D, 244**. The fourth row is, as always, a single point, which represents the x-ray marker located in the distal tube **236, 244**. The surgeon, thus, concludes that neither the second row **258A, 244** and **258B, 244** nor the third row of x-ray markers **258C, 244** and **258D, 244** (i.e., the x-ray markers at both the proximal and distal unattached distal pointing-crowns) has converged. As shown in FIG. 17E, the surgeon then moves the distal body **216** proximally relative to the clot **270A** so that the distal, unattached distal-pointing crowns **258C, 244** and **258D, 244** are immediately distal to the clot **270A** and then the surgeon irradiates the x-markers again from the first vantage point and the second vantage point. As shown in FIG. 17F, the results are the same as FIG. 17D. With the results from FIGs. 17D and 17F, the surgeon concludes that neither the second row **258A, 244** and **258B, 244** nor the third row of x-ray markers **258C, 244** and **258D, 244** (i.e., the x-ray markers at both the proximal and distal unattached distal pointing-crowns) were converged at either the original position of the distal body **216** (FIG. 17C and 17D) or the position after moving the distal body **216** proximally (FIG. 17E and 17F), and, thus, the distal body **216** was expanded in the vessel **266** in both positions. Thus, the surgeon concludes that the clot **270A** is a soft clot **270A** that has entered into the distal body interior **222** and the surgeon removes the distal body

216 and the soft clot **270A**, captured by the distal body **216**, by moving the distal body **216** proximally out of the vessel **266**, as shown in FIG. 17G.

[00148] FIGs. 18A-G illustrate stepwise use of the distal body **216** in retrieving a hard clot **270B** in a human intracranial artery **266**. (In FIGS. 18A-G, the distal body **216** is in Orientation 2). (As described below, the primary differences between FIGs 18A-G and FIGs. 16A-G is that the clot **270B** enters the distal body interior **222** in an enlarged cell/drop zone **262A** immediately distal to one of the proximal, unattached distal-pointing crowns **258A** in FIGs. 18A-G, as compared to FIGs. 16A-G where the clot **270B** enters the distal body interior **222** in an enlarged cell/drop zone **262C** immediately distal to one of the distal, unattached distal-pointing crowns **258C**). First, as always, the surgeon determines the location of the clot **270B** in the vessel **266** using, for example, a contrast dye injected proximal and distal to the clot **270B**. Next, the delivery catheter **208**, which is enveloping the distal body **216**, is positioned in the blood vessel **266** so that the two proximal, unattached distal-pointing crowns **258A** and **258B** are immediately distal to the clot **270B**. See FIG. 18B. The distal body **216** is then deployed from the catheter **208** by moving the catheter **208** proximally. The hard clot **270B**, which is located above the distal body **216**, collapses the distal body **216**, as shown in FIG. 18C. However, at this time, the surgeon is unaware that the clot **270B** has collapsed the distal body **216**. Thus, without moving the distal body **216**, the surgeon irradiates the x-ray markers at a first vantage point (i.e., from the front of the distal body in Orientation 2; into the page). As shown in FIG. 18D, the first vantage point shows four rows of x-ray markers. The first row is, as always, a single point, representing the x-ray marker located in the proximal tube **228, 244**. The second row has only one point because the clot **270B**, which is on top of the second row of x-ray markers **258A, 244** and **258B, 244** (i.e., the markers at the proximal, unattached distal-pointing crowns), has pushed them together. The third row has only one point, which represents the x-ray marker located at the front (in Orientation 2), proximal, unattached distal-pointing crown **258C, 244**; the reason that this third row of markers is a single point is that the rear (in this view) x-ray marker of the third row **258D, 244** is hidden from view because it is directly behind the front x-ray marker of the third row **258C, 244**. The fourth row is, as always, a single point, representing the x-ray marker located in the distal tube **236, 244**. Without moving the distal body, the surgeon then irradiates the markers from a second vantage point 90 degrees offset from the first vantage point (i.e., from the bottom of the distal body **216**). As shown, the first row is, as always, a single point, which represents the x-ray marker located in the proximal tube **228, 244**. The second row has a single point because the top (in Orientation 2) x-ray marker of the second row **258A, 244** is located

behind the bottom (in Orientation 2) x-ray marker **258B, 244** and thus, the top x-ray marker of the second row **258A, 244** is hidden from view. The third row has two points, which represents the x-ray markers located at the distal, unattached distal-pointing crowns **258C, 244** and **258D, 244**; in this x-ray view neither of the x-ray markers of the third row is hidden from view. The fourth row is, as always, a single point, which represents the x-ray marker located in the distal tube **236, 244**. The surgeon, thus, concludes that the second row of x-ray markers **258A, 244** and **258B, 244** (i.e., the x-ray markers at the proximal, unattached distal pointing-crowns) has converged. As shown in FIG. 18E, the surgeon then moves the distal body **216** proximally so that the distal, unattached distal-pointing crowns **258C, 244** and **258D, 244** are immediately distal to the clot **270B**. Unbeknownst to the surgeon, the clot **270B** enters the distal body interior **222** immediately distal to the top (in Orientation 2), proximal unattached distal-pointing crown **258A** and the distal body **216** is no longer collapsed. The surgeon then irradiates the x-markers again from the first vantage point. As shown in FIG. 18F, the first row is, as always, a single point, representing the x-ray marker located in the proximal tube **228, 244**. The second row has two x-ray markers because the distal body **216** is not collapsed and neither the top (in Orientation 2) **258A, 244** nor the bottom **258B, 244** (in Orientation 2) x-ray marker of the second row (i.e., the marker at the proximal, unattached distal-pointing crowns) is hidden from view. The third row has only one point because the rear (in Orientation 2), distal unattached distal-pointing crown **258D, 244** is hidden behind the front (in Orientation 2), distal, unattached distal pointing-crown **258C, 244**. The fourth row is, as always, a single point, representing the x-ray marker located in the distal tube **236, 244**. Without moving the distal body **216**, the surgeon then irradiates the markers from a second vantage point 90 degrees offset from the first vantage point (i.e., from the bottom of the distal body **216**). As shown, the first row is, as always, a single point, which represents the x-ray marker located in the proximal tube **228, 244**. The second row has a single point because the x-ray marker at the top (in Orientation 2), proximal, unattached distal-pointing crown **258A, 244** is hidden behind the bottom (in Orientation 2), proximal, unattached-distal pointing crown **258B, 244**. The third row has two points because neither the front nor the rear x-ray markers at the distal, unattached, distal-pointing crowns **258C, 244** and **258D, 244** is hidden from view. The fourth row is, as always, a single point, which represents the x-ray marker located in the distal tube **236, 244**. Based on the information from FIGs. 18D and 18F, the surgeon concludes that the clot **270B** has entered into the distal body interior **222**. The surgeon then removes the distal body **216** and the hard clot **270B**, captured by the distal body **216**, by moving the distal body **216** proximally out of the vessel **266**, as shown in FIG.

18G. Upon comparing FIGs. 16A-G and FIGs. 18A-G it will be appreciated that the orientation of the enlarged cells/drop zone **262A-D** relative to the orientation of a hard clot **270B** determine which enlarged cell/drop zone **262A, 262B, 262C,** or **262D**, the hard clot **270** enters the distal body interior **222** through. For example, in FIG. 16C, the hard clot **270B** is located above the distal body **216**, and thus, the hard clot **270B** must enter through the enlarged cell/drop zone located at the top of the distal body, which in the orientation of the distal body shown in FIGs. 16A-G, is the enlarged cell/drop zone **262C** immediately distal to the top, distal, unattached, distal-pointing crown **258C**. In FIG. 18C, the hard clot **270B** is again located above the distal body and, thus, the hard clot **270B** must enter through the enlarged cell/drop zone located at the top of the distal body. However, in FIG. 18C, the enlarged cell/drop zone located at the top of the distal body **216**, in the orientation of the distal body **216** shown in FIGs. 18A-G, is the enlarged cell/drop zone **262A** immediately distal to the top, proximal, unattached, distal-pointing crown **258A**.

[00149] FIGs. 19A-N illustrate stepwise use of the distal body **216** in retrieving a deformable cohesive, adherent clot **270C**– i.e., a clot that is difficult to break up and is tightly adhered to the vessel wall **268** - in a human intracranial artery **266**. (In FIGS. 19A-N, the distal body **216** is in Orientation 2). First, as always, the surgeon determines the location of the clot **270C** in the vessel **266** using, for example, a contrast dye injected proximal and distal to the clot **270C**. Next, the delivery catheter **208**, which is enveloping the distal body **216**, is positioned in the blood vessel **266** so that the two proximal, unattached distal-pointing crowns **258A** and **258B** are immediately distal to the clot **270C**. See FIG. 19B. The distal body **216** is then deployed from the catheter **208** by moving the catheter **208** proximally. The deformable, cohesive adherent clot **270C**, which is located above the distal body **216**, collapses the distal body **216**, as shown in FIG. 19C. However, at this time, the surgeon is unaware that the clot **270C** has collapsed the distal body **216**. Thus, without moving the distal body **216**, the surgeon irradiates the x-ray markers at a first vantage point (i.e., from the front of the distal body; i.e., into the page). As shown in FIG. 19D, the first vantage point shows four rows of x-ray markers. The first row is, as always, a single point, representing the x-ray marker located in the proximal tube **228, 244**. The second row has a single point, corresponding to the top (in Orientation 2) and bottom (in Orientation 2), proximal, unattached distal-pointing crowns **258A, 244** and **258B, 244**, which have converged because the clot **270C** is collapsing the distal body **216**. The third row has a single point, which represents the x-ray marker located at the front (in Orientation 2), distal, unattached distal-pointing crown **258C, 244**; the x-ray marker located at the rear, distal,

unattached distal-pointing crown **258D, 244** is hidden from view. The fourth row is, as always, a single point, representing the x-ray marker located in the distal tube **236, 244**. Without moving the distal body **216**, the surgeon then irradiates the markers from a second vantage point 90 degrees offset from the first vantage point (i.e., from the bottom of the distal body). As shown, the first row is, as always, a single point, which represents the x-ray marker located in the proximal tube **228, 244**. The second row has a single point, which corresponds to the bottom (in Orientation 2), proximal, unattached distal-pointing crown **258B, 244**; the top (in Orientation 2), proximal, unattached distal-pointing crown **258A, 244** is located behind the bottom, proximal, unattached distal-pointing crown **258B, 244** and hidden from view. The third row has two points, which correspond to the front (in Orientation 2) **258C, 244** and rear **258D, 244** (in Orientation 2), distal, unattached distal-pointing crowns, neither of which is blocked in this view. The fourth row is, as always, a single point, which represents the x-ray marker located in the distal tube **236, 244**. As shown in FIG. 19E, the surgeon then moves the distal body **216** proximally (i.e., slightly withdraws the distal body **216**). The surgeon then irradiates the x-markers again from the first and second vantage points. As shown in FIG. 19F, the results are exactly the same as in FIG. 19D. Based on the observation that the proximal, unattached distal-pointing crowns **258A, 244** and **258B, 244** have converged at both the original position (FIGs. 19C and 19D in which the proximal, unattached distal-pointing crowns **258A, 244** and **258B, 244** are immediately distal to the clot **270C**) and the second position (FIGs. 19E and 19F), the surgeon concludes that the clot **270C** is a deformable cohesive, adherent clot **270C**. The surgeon then oscillates the distal body **216** proximally and distally a small distance (e.g., about 1mm to about 2 mm) in the vessel **266**, and the clot **270C** begins to enter the distal body **216**, as shown in FIG. 19G. The surgeon then irradiates the x-markers again from the first and second vantage points. As shown in FIG. 19H, the results are exactly the same as in FIG. 19D and FIG. 19F except that the second row of markers **258A, 244** and **258B, 244** (at the proximal, unattached distal-pointing crowns) are beginning to move apart. The surgeon then moves the distal body **216** proximally again, as shown in FIG. 19I. The surgeon then irradiates the x-markers again from the first and second vantage points. As shown in FIG. 19J, the results are exactly the same as in FIGs. 19D and 19F, as the clot **270C** has caused the second row of markers **258A, 244** and **258B, 244** to re-converge. The surgeon then oscillates the distal body **216** proximally and distally a small distance (e.g., about 1mm to about 2 mm) in the vessel **266**, and the clot **270C** begins to further enter the distal body interior **222**, as shown in FIG. 19K. The surgeon then irradiates the x-markers again from the first and second vantage points. As shown in FIG. 19L,

the results are the same as in FIG. 19H. The surgeon then moves the distal body **216** again proximally, and, instead of collapsing the second row of markers **258A, 244** and **258B, 244**, the clot **270C** fully enters the distal body interior **222**, as shown in FIG. 19M. The surgeon then irradiates the x-markers again from the first and second vantage points. As shown in FIG. 19N, the results show that the second row of markers **258A, 244** and **258B, 244** (at the proximal, unattached distal-pointing crowns) have moved apart. Satisfied that the x-ray markers in the second row **258A, 244** and **258B, 244** (at the proximal, unattached distal-pointing crowns) are sufficiently far apart and that the x-ray markers in the third row (at the distal, unattached distal-pointing crowns) **258C, 244** and **258D, 244** have stayed far apart, the surgeon concludes that the deformable cohesive, adherent clot **270C** has been sufficiently captured by the distal body **216** and the surgeon then removes the distal body **216** and the clot **270C**, captured by the distal body **216**, by moving the distal body **216** proximally out of the vessel **266**.

[00150] Several observations can be made from FIGs. 15-19, as indicated above. For example, the x-ray markers at the proximal and distal, unattached distal-pointing crowns **258A-D, 244** provide the surgeon feedback concerning the interaction between the distal body **216** and the clot **270** in the blood vessel **266**. In addition, the guiding principle of a soft clot **270A** is that the soft clot **270A** does not collapse the distal body **216**, and thus, x-ray markers at the proximal and distal, unattached distal-pointing crowns **258A-D, 244** always appear as two points except when a marker is hidden behind another marker (due to the view). When it comes to a hard clot **270B**, the hard clot **270B** is generally able to enter the distal body interior **222** without needing to oscillate the distal body **216** proximally and distally (unlike a deformable cohesive, adherent clot **270C**). However, to capture the hard clot **270B**, the hard clot **270B** must be oriented properly relative to the enlarged cell/drop zones **262A, 262B, 262C,** or **262D**. (This is the reason that the distal body **216** has four enlarged cells/drop zones: one enlarged cells/drop zone at 0 degrees **262B**, one enlarged cells/drop zone at 90 degrees **262C**, one enlarged cells/drop zone at 180 degrees **262A** and one enlarged cells/drop zone at 270 degrees **262D**). As a guiding principle, an enlarged cell/drop zone **262A, 262B, 262C,** or **262D** is properly oriented to the clot **270B** when the x-ray markers at the proximal, unattached distal-pointing crowns **258A, 244** and **258B, 244** or the distal, unattached distal pointing crowns **258C, 244** and **258D, 244** are together at both a first x-ray view and a second x-ray view 90 degrees relative to the first x-ray view, and the hard clot **270B** can enter the enlarged cell/drop zone **262A, 262B, 262C,** or **262D** by moving the distal body **216** proximally. See FIG. 16F and 18D. Finally, the guiding principal of retrieval of deformable cohesive, adherent clots **270C** is that oscillation of the distal

body **216** causes the deformable cohesive, adherent clots **270C** to gradually enter the distal basket interior **222** over time.

[00151] FIGs. 20A, 20B and 20C show a distal body **216** that is similar to the distal body **216** of FIGs. 14A, 14B and 14C except that the distal body **216** of FIGs. 20A, 20B and 20C is slightly shorter and its unattached, distal-pointing crowns **258A, 258B, 258C,** and **258D** are closer to the proximal tube **228**. The shortened distal body **216** of FIGs. 20A, 20B and 20C is particularly adapted for tortuous blood vessels **266**. FIG. 21-29 show stepwise deployment of the distal body **216** of FIGs. 20A, 20B and 20C in use with a manual (i.e., hand-operated), volume-dependent (i.e. volume locked) suction catheter **272** that is locked at between about 10 to about 60 cubic centimeters (cc). Optionally, the suction catheter **272** has an outer diameter of between about 0.05 inches and about 0.09 inches and its outer diameter is substantially larger than the outer diameter of the delivery catheter **208**. The clot **270** is located in the vessel **266** through the use of, for example, contrast dye injected proximal and distal to the clot **270**. As shown in FIG. 21, a delivery catheter **208** containing the distal body **216** of FIGs. 20A, 20B and 20C is positioned in the tortuous vessel **266** distal to the clot **270**. The delivery catheter **208** is withdrawn, deploying the distal body **216**. See FIG. 22. The distal body **216** is moved proximally relative to the clot **270** and tension is exerted on pull wire **202**. See FIG. 23. While maintaining tension on the pull wire **202,** a suction catheter **272** having a proximal end **274** and a distal end **276** is delivered over the pull wire **202** that is attached to the distal body **216**. See FIG. 24. (The reason for exerting tension on the pull wire **202** is that the pull wire **202** serves as the guide/track for the movement of the suction catheter **272** and without tension, the suction catheter **272** and pull wire **202** could end up in the ophthalmic artery **288**). The distal end **276** of the suction catheter **272** is positioned against the clot **270**. A syringe **278** is attached to the suction catheter **272** using a rotating hemostatic valve **290**, which allows the surgeon to aspirate while a pull wire **202** is in the system. The surgeon aspirates the syringe **278** by pulling back on the lever **280** to a mark on the base **282** corresponding to between about 10 and about 60 cubic centimeters of fluid. The surgeon then locks the lever **280** (and attached plunger) into place, leaving the suction catheter **272** under suction. The surgeon captures the clot **270** in the distal body **216** using the techniques described in FIGs. 15-19. The distal body **216** and clot **270** become captured by the suction catheter **272**. See FIGs. 27 and 28. The surgeon then removes the suction catheter **272** and the distal body **216** and the clot **270**, captured by the suction catheter **272**, by moving the suction catheter **272** proximally out of the vessel **266**. See FIG. 29.

It is believed that the suction catheter **272** would be helpful in the event that a small portion of the clot **270** breaks off when retrieving the clot **270** using the distal body **216.**

[00152] To examine effectiveness of the systems **200**, the systems **200** of FIGs. 11-20, without the use of a suction catheter **272**, were used to retrieve soft and hard clots **270A** and **270B** induced in a pig weighing between 30 to 50 kg. The weight of the pig was chosen so that the size of its vessels **266** would be approximate to the size of a human vessel. The pig was anesthetized. Several hard clots **270B** were prepared by mixing pig blood and barium and incubating the mixture for 2 hours. Several soft clots **270A** were prepared by mixing pig blood, thrombin and barium and incubating the mixture for 1 hour. The clots **270A** and **270B**, each of which had a width of 4 to 6 mm and a length of 10 to 40 mm, were then inserted into a vessel **266** having a diameter of 2 to 4 mm. (Only one clot **270A** and **270B** was located in the vessel **266** at a time). Angiograms were then performed to confirm occlusion. After waiting ten minutes after confirming occlusion, the distal bodies **216** of FIGs. 11-20 were then delivered distal to the clots **270A** and **270B** as described above and were used to retrieve the clots **270A** and **270B** as described in FIGs. 11-19. In each case, the distal bodies **216** were successful in retrieving the clots **270A** and **270B.** As shown, the distal body height in the relaxed state tapers/decreases as the proximal strips **252** approach the proximal hub/junction/tube **228** and also tapers/decreases as the basket strips **291** located at the distal end **220** of the basket **246** converge at the distal hub/junction/tube **236**.

[00153] **The alternate embodiment of FIG. 32**

[00154] FIG. 32 shows a distal body **216** in which the proximal strips proximal ends **254** converge and are soldered or welded at the proximal hub/junction **228** and the basket strips **291** located at the distal end **220** of the basket **246** converge and are soldered or welded at the distal hub/junction **236**. To create such an embodiment, the distal body **216** may be prepared from a single tube, as described above, and the proximal and distal tubes may be clipped and the proximal ends **254** of the proximal strips **252** soldered or welded together (and optionally to the pull wire **202**) and the basket strips **291** located at the distal end **220** of the basket **246** may also be welded or soldered or welded together. Optionally, the proximal and distal hubs/junctions **228** and **236** may include x-ray markers **244** as described above.

[00155] **The alternate embodiments of FIGs. 33-35**

[00156] FIGs. 33A-33C and FIGs. 34A-34B (and the close-up views shown in FIGs. 35A and 35B) show an alternate embodiment in which no cells are proximal to the proximal-most cells **250A** and **250B** that have a free distal crown **258A** and **258B.** (FIGs. 33A-35B do not

show the pull wire or catheter, both of which are preferably used with the distal body **216** and shown elsewhere, e.g., in FIGs. 11-20, and FIGs. 33B-33C and FIG. 35A-35B do not show the proximal hub **228**). FIGs. 33A-33C has four pair of cells (only a few such cells are labelled with **250** or **250B** and visible) with free distal-pointing crowns **258A-258H**, which create four pairs of enlarged openings **262A-262H**. FIGs. 34A-34B has five pair of cells (again not all labelled) with free distal-pointing crowns **258A-258J**, which create five pairs of enlarged openings **262A-262J**. More particularly, like FIGs. 11-20, in FIGs. 33A-33C and FIGs. 34A-34B, the distal body **216** has a proximal pair of free distal crowns **258A** and **258B** that have x-ray markers **244** and are located approximately the same distance from the proximal junction **228** and between 150 degrees and 180 degrees apart and then a second pair of free distal crowns **258C** and **258D** that have x-ray markers **244,** and are located distal to the proximal pair of free distal crowns **258A** and **258B.** Like FIGs. 11-20, in FIGs. 33A-33C and FIGs. 34A-34B, the second pair of distal crowns **258C** and **258D** are located approximately the same distance from the proximal junction **228,** are located between 150 degrees and 180 degrees apart and are located between about 60 degrees and about 90 degrees relative to the proximal pair of free distal crowns **258A** and **258B**.

[00157] The embodiments of FIGs. 33A-33C, FIGs. 34A-34B and FIGs. 35A-35B have several additional features. For example, in FIGs. 33A-33C, FIGs. 34A-34B, and FIGs. 35A-35B, the proximal pair of cells **250A** and **250B** having free distal crowns **258A** and **258B** each have a proximal crown **297A** and **297B** attached to a proximal strip **252**. In FIGs. 33A-33C and FIGs. 34A-34B, distal to the second pair of free distal crowns **258C** and **258D,** the distal body **216** has a third pair of free distal crowns **258E** and **258F** that have x-ray markers **244,** are located approximately the same distance from the proximal junction **228** and are located between 150 degrees and 180 degrees apart and are located between about 60 degrees and about 90 degrees relative to the second pair of free distal crowns **258C** and **258D**. In FIGs. 33A-33C and FIGs. 34A-34B, distal to the third pair of free distal crowns **258E** and **258F,** the distal body **216** also has a fourth pair of free distal crowns **258G** and **258H** that have x-ray markers **244,** are located approximately the same distance from the proximal junction **228** and are located between 150 degrees and 180 degrees apart and are located between about 60 degrees and about 90 degrees relative to the third pair of free distal crowns **258E** and **258F**. In FIGs. 34A-34B, distal to the fourth pair of free distal crowns **258G** and **258H,** the distal body **216** also has a fifth pair of free distal crowns **258I** and **258J** that have x-ray markers **244,** are located approximately the same distance from the proximal junction **228** and are located between 150 degrees and 180 degrees

apart and are located between about 60 degrees and about 90 degrees relative to the fourth pair of free distal crowns **258G** and **258H**. An advantage having eight unattached distal-pointing crowns **258A-258H** that are sequentially offset (as in FIGs. 33A-33C) and ten unattached distal-pointing crowns **258A-258J** that are sequentially offset (as in FIGs. 34A-34B) is that each free distal crown **258A-258J** creates an enlarged cell **262A-262J.** Thus, in FIGs. 33A-33C and FIGs. 34A-34B, eight and ten, respectively, sequentially offset enlarged cells **262A-262H** are formed, creating multiple clot entry points. In FIG. 34A-34B, with the exception of the enlarged cells **262A-262H**, all of the cells located between the cells **250A** and **250B** (**250A** is hidden in FIGs. 34A-34B but shown in FIGs. 35A-35B) having the proximal pair of free distal crowns **258A** and **258B** and the cells having the distal-most pair of free distal crowns **258I** and **258J** have free distal crowns. Indeed, with the exception of the enlarged cells **262A-262H**, all of the cells located between proximal-most free-distal crowns **258A** and **258B** and distal-most free crowns **258I** and **258J** have free distal crowns **258C-258H**. By contrast, the distal body **216** of FIGs. 33A-33C has an intermediate group of cells **248** (i.e., a stent-like structure) with non-free distal crowns (distal crowns that are attached to a basket strip **291**) between the second pair of enlarged openings **262C** and **262D** and the third pair of enlarged openings **262E** and **262F**. In FIG. 34A-34B, all of the cells **248** having distal crowns that are attached to a basket strip **291** are located at the distal end of the distal body **216** (i.e., distal to the distal-most enlarged openings **262G** and **262H**) to create a substantially closed distal end of the basket **246** to capture the clot.

[00158] In addition, in FIGs. 33A-33C, 34A-34B, FIGs. 35A-35B, the distal body **216** has two proximal three-dimensional openings **293** that are located 180 degrees apart, as best seen in FIG. 33C and FIG. 34A and the close-up views of FIGs. 35A and 35B. (The proximal three-dimensional openings **293** are aligned and create a continuous void). One such three-dimensional opening **293** has a proximal end at the intersection point **294** of the proximal strips **252** and a distal end at a distal crown **299** attached to a first strut **295** located (lengthwise) approximately the same distance from the proximal hub/junction **228** as the free distal crowns **258A** and **258B** of the first pair of free distal crowns. The other such three-dimensional opening **293** is on the other side of the distal body **216** and has a proximal end at the intersection point **294** of the proximal strips **252** and a distal end at another distal crown **298** attached to a second strut **296** that is also located (lengthwise) approximately the same distance from the proximal hub/junction **228** as the free distal crowns **258A** and **258B** of the first pair of free distal crowns. The second strut **296** is located 180 degrees from the first strut **295**. As shown in FIG. 35A, the intersection point **294** of the proximal strips **252** may be located approximately in the widthwise

and heightwise center of the distal body **216** and the proximal crowns **297A** and **297B** of the proximal-most cells **250A** and **250B** having the free distal crowns **258A** and **258B** may be located approximately 150 degrees to 180 degrees apart (e.g., at the 12 o'clock and 6 o'clock positions as shown in FIG. 35A and the 3 o'clock and 9 o'clock positions in FIG. 35B) and at the maximum height/width of the distal body **216**. The proximal crowns **297A** and **297B** of the proximal-most cells **250A** and **250B** having the free distal crowns **258A** and **258B** also are attached to the proximal strips **252** as shown in FIGs. 35A and 35B. Similarly, the bridge memory metal strips (distal struts) **295** and **296** may be located approximately 150 degrees to 180 degrees apart (e.g., at the 3 o'clock and 9 o'clock positions as shown in FIG. 35A and the 12 o'clock and 6 o'clock positions in FIG. 35B), at the maximum height/width of the distal body **216**, and approximately 60 degrees to 90 degrees relative to the free distal crowns **258A** and **258B**.

[00159] **The Embodiments of FIGs. 36-37**

[00160] FIGs. 36A-36N and 37A-37K (also referred to herein as FIGs. 36-37 for brevity) show alternate embodiments of distal bodies **216** that are similar to the embodiments of FIGs. 11-35. The distal bodies **216** may be made by any method known in the art including but not limited to those described in U.S. Patent No. 9,566,412, the entire contents of which are incorporated herein by reference.

[00161] FIGs. 36-37 are CAD drawings drawn to scale. However, it will be appreciated that other dimensions are possible.

[00162] More particularly, FIGs. 36-37 provide a system for removing objects from an interior lumen of an animal. The system may include, as previously described, a pull wire **202** having a proximal end (not shown in FIGs. 36-37) and a distal end **206**. The system of FIGs. 36-37 also includes a distal body **216** that may be attached to the pull wire **202**, preferably the pull wire distal end **206**. As with the prior embodiments of FIGs. 11-35, the distal body **216** may include an interior **222**, a perimeter **300**, a proximal end **218**, a distal end **220**, a distal body length **226** extending from the proximal end **218** to the distal end **220**, a proximal junction/hub/tube **228** that may be attached to the pull wire **202** and may form the proximal end **218** of the distal body **216**, a plurality of proximal strips **252**, a basket **246** comprised of a plurality of cells formed by a plurality of basket strips **291**, and a distal junction/hub/tube **236** forming a distal end **302** of the basket **246**. As with the prior embodiments of FIGs. 11-35, the basket **246** may include a basket interior **346**, each proximal strip **252** may have a distal end **256** attached to a cell and a proximal end **254**, the proximal ends **254** of the proximal strips **252** may

converge at the proximal junction **228**. As with the prior embodiments of FIGs. 11-35, the distal body **216** may have a relaxed state wherein the distal body **216** has a first height **224** and a first width **225**, and a collapsed state (not shown in FIGs. 36-37) wherein the distal body **216** has a second height and a second width, the second height less than the first height **224**, the second width less than the first width **225**. As with prior embodiments, in the embodiments of FIGs. 36-37, the proximal strips **252** and the basket strips **291** are preferably comprised of a memory metal.

[00163] Like the embodiments of FIGs. 33-35, in the embodiments of FIGs. 36-37, in the relaxed state, the basket **246** may include a series of at least three pair of cells **250A-250F** located on the distal body perimeter **300** having a proximal crown **260** pointing generally in the proximal direction and attached to a memory metal strip (either a proximal strip **252** or basket strip **291**) and a free distal crown **258A-258F** pointing generally in the distal direction. Optionally, as shown in FIGs. 36-37, in the series, the proximal-most free distal crowns **258A, 258B** are located at the 12 and 6 o'clock positions and located about the same distance from the proximal junction **228**, the next proximal-most free distal crowns **258C, 258D** are located at the 3 and 9 o'clock positions and located about the same distance from the proximal junction **228**, and the succeeding proximal-most free distal crowns **258E, 258F** are located at the 12 and 6 o'clock positions (i.e., substantially aligned with proximal-most free distal crowns **258A, 258B**) and located about the same distance from the proximal junction **228**. Optionally, each free distal crown **250A-250F** forms part of a different enlarged cell **262A-262F** that is configured to allow a thrombus to enter the basket interior **346**. In other words, like the prior embodiments, the enlarged cells **262A-262F** are designed to capture a clot/thrombus. In the proximal and distal end views of FIGs. 36M, 36N, 37H, and 37I, miniature clocks with clock hands are used to illustrate the 12, 3, 6 and 9 o'clock positions.

[00164] For purposes of FIGs. 36-37, when it is said that a component, such as a free distal crown **258A-258J**, is located "about the same distance from the proximal junction" **228**, if one component (e.g., one free distal crown **258A** of the pair of proximal-most free distal crowns **258A/258B**) is located X distance from the proximal junction **228**, the other component (e.g., the other free distal crown **258B** of the pair of proximal-most free distal crowns **258A/258B**) is located X distance plus or minus (+/-) 5 millimeters (mm) from the proximal junction **228**. In a preferred embodiment, the other component is located X distance plus or minus (+/-) 3 mm from the proximal junction **228**, more preferably X distance plus or minus (+/-) 0.5 mm from the proximal junction **228**. (The same relationship will hold true for the other pairs of free distal

crowns **258C-258F** in the series – e.g., if one free distal crown **258C** of the next proximal-most pair of free distal crowns **258C/258D** is located Y distance from the proximal junction **228**, the other free distal crown **258D** of the next proximal-most pair of free distal crowns **258C/258D** is located Y distance plus or minus (+/-) 5 mm from the proximal junction **228**. Again, more preferably the other component is located Y distance plus or minus (+/-) 3 mm from the proximal junction **228**, more preferably Y distance plus or minus (+/-) 0.5 mm from the proximal junction **228**. The same relationship holds true from **258E** and **258F**.

[00165] In FIG. 37, like the embodiment of FIG. 34, the series includes at least five pair of cells **250A-250J** located on the distal body perimeter **300** having a proximal crown **260** pointing generally in the proximal direction and attached to a memory metal strip (either a proximal strip **252** or basket strip **291**) and a free distal crown **258A-258J** pointing generally in the distal direction, and in the series, after the succeeding free distal crowns **258E, 258F**, the next proximal-most free distal crowns **258G, 258H** are located at the 3 and 9 o'clock positions and located about the same distance from the proximal junction **228** and form enlarged cells **262G, 262H**, and the distal-most free distal crowns **258I, 258J** are located at the 12 and 6 o'clock positions and located about the same distance from the proximal junction **228** and form the most distally-located enlarged cells **262I, 262J**. Again, about the same distance from the proximal hub **228**, means the same distance +/- 5 mm from the proximal junction **228**. In a preferred embodiment, **258G/258H** are located the same distance +/- 3 mm from the proximal junction **228**, more preferably the same distance +/- 0.5 mm from the proximal junction. The same relationship holds true from **258I** and **258J**.

[00166] As with prior embodiments, FIGs. 36-37 illustrate that in the relaxed state, the basket **246** may comprise a plurality of distal cells **248D** distal to the distal-most free distal crown (i.e. **258E, 258F** in FIG. 36 and **258I, 258J** in FIG. 37) that have a proximal crown attached to another cell of the basket **246** and pointing generally in the proximal direction and a distal crown pointing generally in the distal direction and attached to the distal junction **236**. In other words, the distal cells **248D** are designed to retain a clot/thrombus in the basket interior **346**.

[00167] As with prior embodiments, FIGs. 36-37 illustrate that, in the relaxed state, each enlarged cell **262A-262J** may have a proximal end **308** that may be comprised of two proximal crowns pointing generally in the proximal direction, a distal end **310** that may comprise a distal crown pointing generally in the distal direction, and a length **312** extending from the proximal end **308** to the distal end **310** of the respective enlarged cell **262A-262J**.

[00168] As with prior embodiments, FIGs. 36-37 illustrate that in the relaxed state, each distal cell **248D** may have a length **314** extending from the proximal crown to the distal crown **307** of the respective distal cell **248D**.

[00169] As with prior embodiments, FIGs. 36-37, and particularly FIG. 36J, illustrate that in the relaxed state, each of the enlarged cells **262A-262J** may be longer than each of the distal cells **248D**.

[00170] As with prior embodiments, FIGs. 36-37, and particularly FIG. 36J, illustrate that in the relaxed state, for each of the enlarged cells **262A-262J**, the distance **316** from the proximal end **308** of the enlarged cell **262A-262J** to the free distal crown **258A-258J** of the enlarged cell **262A-262J** may be less than the distance **318** from the free distal crown **258A-258J** of the enlarged cell **262A-262J** to the distal end **310** of the enlarged cell **262A-262J**. In other words, the free distal crowns **258A-258J** do not protrude far enough into the enlarged cells **262A-262J** to prevent a clot from entering the basket interior **346** through the enlarged cells **262A-262J**.

[00171] As with prior embodiments, FIGs. 36-37 illustrate that the distal body **216** may further comprise a lead wire **286** extending distally from the distal junction **236**. As with prior embodiments but not shown in FIGs. 36-37, the system may further comprise a catheter having an interior, a proximal end leading to the interior and a distal end leading to the interior, the catheter comprised of a biocompatible material and configured to envelop the distal body **216** when the distal body **216** is in the collapsed state. Deployment and use of the system may be as shown in FIGs. 15-29.

[00172] As with prior embodiments, FIGs. 36-37 illustrate that in the relaxed state, the basket **246** preferably does not have any free crowns that point generally in the proximal direction, as free proximal crowns could damage the vessel as mentioned previously.

[00173] As with prior embodiments, FIGs. 36-37 illustrate that the distal body **216**, in the relaxed state, may comprise a distal tapered region **322** in which the distal body height **224** and width **225** decrease as the basket **246** approaches the distal junction **236**.

[00174] As with prior embodiments, FIGs. 36-37 illustrate that the distal body **216**, in the relaxed state may comprise a proximal tapered region **320** in which the distal body height **224** and width **225** decrease as the proximal strips **252** approach the proximal junction **228**. It will be appreciated that the tapering of the proximal region **320** may take on a variety of shapes as shown in FIGs. 36 and 37.

[00175] As with prior embodiments, FIGs. 36-37 illustrate that in the relaxed state, each of the enlarged cells **262A-262J** may be longer than each of the pair of cells **250A-250J**.

[00176] As with prior embodiments, FIGs. 36-37 illustrate that in the relaxed state, each of the enlarged cells **262A-262J** may extend from the 6 o'clock position to the 12 o'clock position or the 3 o'clock position to the 9 o'clock position, as best seen in the close-up views of FIGs. 36C, 36E and 36F and 37G but also shown in FIGs. 36A-36B, 36I-36L, 37A-37F.

[00177] As with the prior embodiments of FIGs. 11-19 and 21-32, FIG. 36 illustrates that in the relaxed state the basket **246** may further comprise a plurality of proximal cells **342** proximal to the proximal-most free distal crowns **258A, 258B**, the plurality of proximal cells **342** having a proximal crown attached to the proximal junction **228** and pointing generally in the proximal direction and a distal crown pointing generally in the distal direction and attached to another cell of the basket **246**. However, such proximal cells **342** are optional and not shown in FIG. 37, due to the length of the basket **246** which includes ten enlarged cells **262A-262J**. If the proximal cells **342** are not included, optionally, as with the prior embodiments of FIGs. 20 and 33-35, FIG. 37 illustrates that in the relaxed state the proximal crowns of the cells **250A, 250B** comprising the proximal-most free distal crowns **258A, 258B** may be attached to the distal ends **256** of the proximal strips **252**. Without being bound by any particular theory, a purpose of the proximal cells **342** may be to allow the clot to rest on the proximal cells **342** prior to entering through the enlarged cells **262A-262J**.

[00178] In preliminary clot capture animal studies using a swine thrombectomy model, it has been observed the distal body **216** of FIG. 37 is particularly adept at capturing a clot. (Preliminary clot capture animal studies were performed using conditions similar to that described in Ulm et al., Preclinical Evaluation of the NeVaTM Stent Retriever: Safety and Efficacy in the Swine Thrombectomy Model, Interv Neurol. 2018 Apr;7(5):205-217). Without being bound by any particular theory, it is believed that the clot capture ability of the distal body **216** of FIG. 37 is due to the minimal interference at the enlarged cells **262A-262J** (i.e., that the basket strips **291** are flared apart at the distal crowns located at the distal ends **310** of the enlarged cells **262A-262J**).

[00179] Thus, as shown in FIG. 37, in the relaxed state, for at least some enlarged cells **262A-262J** (preferably for most, more preferably for each enlarged cell **262A-262J**), two basket strips **291** meet to form the distal crown located at the distal end **310** of the enlarged cell **262A-262J**, and the two basket strips **291** form an angle **328** greater than 65 degrees, more preferably greater than 70 degrees, more preferably greater than 75 degrees, more preferably greater than 80 degrees, more preferably greater than 85 degrees, more preferably greater than 90 degrees, more preferably greater than 95 degrees, more preferably greater than 100 degrees at the respective

distal crown located at the distal end **310** of the enlarged cell **262A-262J**. Preferably, the angle **328** is less than 150 degrees. It is believed that the flared nature of the basket strips **291** meeting at the distal crown at the distal end **310** of the enlarged cells **250A-250J** assists in allowing the clot to enter the basket interior **346**. By comparison, the basket strips **291** meeting to form the free distal crowns **258A-258J** may have a much smaller angle **326** at the respective free distal crown **258A-258J**, given that cells **250A-250J** are not intended to be clot capture cells. For example, the angle **326** at the respective free distal crown **258A-258J** may be less than 50 degrees, more preferably less than 45 degrees, more preferably less than 40 degrees. In other words, for some, most or all enlarged cells **262A-262J**, the angle **328** at the distal crown at the distal end **310** may be at least 2 times (more preferably at least 2.5 times, more preferably at least 3 times) as large as the angle **326** at the free distal crown **258A-258J**. Preferably, angle **328** is no more than 5 times as large as angle **326**. Due to the symmetry of the distal body **216**, the angle **326** at free distal crown **258A** may be substantially the same as the angle **326** at free distal crown **258B**, the angle **326** at free distal crown **258C** may be substantially the same as the angle **326** at free distal crown **258D**, the angle **326** at free distal crown **258E** may be substantially the same as the angle **326** at free distal crown **258F**, the angle **326** at free distal crown **258G** may be substantially the same as the angle **326** at free distal crown **258H**, the angle **326** at free distal crown **258I** may be substantially the same as the angle **326** at free distal crown **258J**. Similarly, the angle **328** at the distal crown at the distal end **310** of enlarged cell **262A** may be substantially the same as the angle **328** at the distal crown of enlarged cell **262B**, the angle **328** at the distal crown at the distal end **310** of enlarged cell **262C** may be substantially the same as the angle **328** at the distal crown of enlarged cell **262D**, the angle **328** at the distal crown at the distal end **310** of enlarged cell **262E** may be substantially the same as the angle **328** at the distal crown of enlarged cell **262F**, the angle **328** at the distal crown at the distal end **310** of enlarged cell **262G** may be substantially the same as the angle **328** at the distal crown of enlarged cell **262H**, and the angle **328** at the distal crown at the distal end **310** of enlarged cell **262I** may be substantially the same as the angle **328** at the distal crown of enlarged cell **262J.**

[00180] Because the basket strips **291** may be non-linear, the angles **326** and **328** may be determined as if the basket strips **291** were straight from their proximal ends **330** to their distal ends **332**. (*See* dashed lines **350** and **355** in FIG. 37K). In other words, the angles **326** and **328** may be the average (mean) angle between the basket strips **291** along the basket strip lengths. In such measurements, the angles **326** and **328** are measured by drawing an arc between a point on each basket strip **291** at the same position along the distal body length **226**. Alternatively, the

angles **326** and **328** may be the maximum angle between the basket strips **291** along the basket strip lengths, drawing an arc between a point on each of the two basket strips **291** at the same position along the distal body length **226**. *See* FIG. 37A, 37E, 37F, 37G for showing how arcs are drawn and maximum angles **326** and **328** are measured.

[00181] As an example, the maximum angles **328** between the basket strips **291** forming the distal crowns at the distal ends **310** of the enlarged cells **262C, 262F,** and **262G**, as illustrated in FIGs. 37E-37G, are approximately 100 degrees, whereas the maximum angles **326** between the basket strips **291** forming free distal crowns **258C, 258F,** and **258G**, as illustrated in FIGs. 37E-37G, by comparison are about 40 degrees. (It should be noted that the maximum angle **328** between the basket strips **291** forming the distal crown at the distal end **310** of distal-most enlarged cell **262J**, as illustrated in FIG. 37E, is approximately 80 degrees, showing that there may be variability in the angles **326, 328**).

[00182] Relatedly, optionally, in the relaxed state, each of the basket strips **291** meeting at the distal crown at the distal end **310** of some or all of the enlarged cells **250A-250J** extends proximally from the respective distal crown at the distal end **310** at an angle **348** of at least 32.5 degrees, more preferably at least 35 degrees, more preferably at least 37.5 degrees, more preferably at least 40 degrees, more preferably at least 42.5 degrees, more preferably at least 45 degrees, more preferably at least 47.5 degrees, more preferably at least 50 degrees relative to a line bisecting the respective distal crown that is parallel to the distal body length **226** as best seen in FIG 37K. The angle **348** may be determined by measuring the basket strip **291** as if it were straight from the proximal end **330** to the distal end **332**. Thus, for example, each basket strip length, as measured from drawing a straight line from the proximal end **330** to the distal end **332** of the basket strip **291** may be at least 32.5 degrees, more preferably at least 35 degrees, more preferably at least 37.5 degrees, more preferably at least 40 degrees, more preferably at least 42.5 degrees, more preferably at least 45 degrees, more preferably at least 47.5 degrees, more preferably at least 50 degrees relative to a line bisecting the respective distal crown that is parallel to the distal body length **226** (as well as an adjacent bridge memory metal strip **336**, which as explained herein may be substantially parallel to the distal body length **226**). *See* FIG. 36K (dotted line **350** representing basket strip length, dotted line **226** drawn through the respective distal crown that is parallel to the distal body length **226,** and angle **348** between the lines **350** and **226** measuring 45 degrees). Relatedly, for some, most or all the free distal crowns **258A-258J**, the basket strip lengths, as measured from drawing a straight line from the proximal end **330** to the distal end **332** of the basket strip **291** may be less than 25 degrees, more

preferably less than 22.5 degrees, more preferably less than 20 degrees relative to a line that bisects the free distal crowns **258A-258J** and is parallel to the distal body length **226**. *See* FIG. 36K (dotted line **355** representing basket strip length, dotted line **226** drawn through distal crown **258H** that is parallel to the distal body length **226,** and angle **354** between the lines **355** and **226** measuring 18 degrees at free distal crown **258H**). Thus, for some, most or each enlarged cell **262A-262J**, angle **348** at free distal crowns **258A-258J** may be twice, more preferably 2.5 times, more preferably 3 times the size of angle **354**.

[00183] Relatedly, in FIG. 37E, which shows a top plan view, the distal ends **332** of the basket strips **291** forming the distal crown of enlarged cell **262J** are located approximately in the center of the distal body width **225** and the proximal ends **330** of the basket strips **291** are located approximately at the front and rear of the distal body **216.** The proximal end **330** and distal ends **332** of the basket strips **291** meeting to form the distal crown located at the distal end **310** of enlarged cell **262H** are also shown in the perspective view of FIG. 37G. Optionally, the lengths of each basket strip **291** meeting at the distal crown at the distal end **310** of some or all of the enlarged cells **250A-250J**, as measured from their proximal ends **330** to their distal ends **332**, may be approximately equal to ½ of the distal body width **225** and height **224**.

[00184] Relatedly, optionally, as shown in the embodiment of FIG. 37 and best seen in FIG. 37G and 37K, in the relaxed state, for at least some enlarged cells **262A-262J** (preferably for each enlarged cell **262A-262J**), in the relaxed state, the two basket strips **291** meeting to form the distal crown located at the distal end **310** of the enlarged cell **262A-262J** may have distal ends **332** meeting at the respective distal crown and located approximately in the center of the distal body height **224** or width **225** and a proximal end **330** attached to another cell of the basket **246** and located approximately at the top, bottom or front side, or rear side of the distal body **216**. In other words, in FIGs. 37F and 37K, which show front and rear elevation views, the distal ends **332** of the basket strips **291** forming the distal crown of enlarged cells **262G** and **262H** are located approximately in the center of the distal body height **224** and the proximal ends **330** of the basket strips **291** are located approximately at the top and bottom of the distal body **216.**

[00185] As with the prior embodiments of FIGs. 34A-34B, in the distal body **216** of FIG. 37, as seen in FIGs. 37E-37F for example, in the relaxed state, due to the space occupied by the ten enlarged cells **250A-250J,** from at least the proximal crowns **260** of the cells **250C, 250D** comprising the next proximal-most free distal crowns **258C, 258D** to the proximal ends **308** of the enlarged cells **262I, 262J** formed by the distal-most pair of free distal crowns **258I, 258J**, the

basket **246** has no cells other than the enlarged cells **262A-262J** and the cells **250C-250J** comprising the free distal crowns **258C-258J**.

[00186] In the distal body **216** of FIG. 36, in the relaxed state, due to the space occupied by the six enlarged cells **250A-250F,** as seen in FIGs. 37E-37F for example, from at least the proximal crowns **260** of the cells **250C, 250D** comprising the next proximal-most free distal crowns **258B, 258C** to the proximal ends **308** of the enlarged cells **262E, 262F** formed by the succeeding pair of free distal crowns **258E, 258F** the basket **246** has no cells other than the enlarged cells **250A-250F** and the cells **262C-262F** comprising the free distal crowns **258C-258F**.

[00187] The distal bodies **216** may be substantially symmetrical from front to rear and bottom to top, as shown in FIGS. 36I-36L and 37C-37F for example.

[00188] As with prior embodiments, FIGs. 36-37 illustrate that in the relaxed state, the distal crowns located at the distal end **310** of the enlarged cells **250A-250J** may be attached to another cell of basket **246** (i.e., are not free floating).

[00189] Optionally, as with prior embodiments, in the embodiment of FIG. 36, as best seen in FIGs. 36J and 36L, in the relaxed state, the basket **246** further comprises an additional pair of cells **344** located about the same distance from the proximal junction **228** as the cells **250A, 250B** comprising the proximal-most pair of free distal crowns **258A, 258B** and located at the 9 and 3 o'clock positions, each cell of the additional pair of cells **344** having a proximal crown attached to a memory metal strip (either a basket strip **291** or a proximal strip **252**) and a distal crown attached to another cell of the basket **246** (i.e., a non-free floating distal crown). Again, about the same distance means the same distance from the proximal hub **228** +/- 5 mm. (In preferred embodiments, the additional pair of cells **344** are located the same distance +/- 3 mm, more preferably the same distance +/- 0.5 mm, from the proximal hub **228**). As best seen in FIGs. 36J and 36L, the additional pair of cells **344** may adjoin the enlarged cells **262A, 262B** formed by the proximal-most free distal crowns **258A, 258B**. Optionally, from at least the distal crowns of the additional pair of cells **344** to the proximal ends of the enlarged cells **262E, 262F** formed by the succeeding free distal crowns **258E, 258F**, the basket **246** has no cells other than the enlarged cells **262A-262F**, the cells **250A-250F** comprising the free distal crowns **258A-258F** and the additional pair of cells **344**.

[00190] As with prior embodiments, FIGs. 36-37 illustrate that in the relaxed state, the basket **246** may comprise a series of struts/bridge memory metal strips **295** having a proximal end **334** attached to a distal crown of a cell and a distal end **336** attached to a proximal crown of

a distally-located cell. The proximal-most pair of bridge memory metal strips **295** may be located at the 3 and 9 o'clock positions, the next proximal-most pair of bridge memory metal strips **295** may be located at the 12 and 6 o'clock positions, the succeeding proximal-most pair of bridge memory metal strips may be located at the 3 and 9 o'clock positions, so that the bridge memory strips **295,** like the free distal crowns **258A-258J**, alternate along the distal body length **226**. Each of the pair of bridge memory metal strips **295** may form part of at least one enlarged cell **262A-262J**. Optionally, the bridge memory metal strips **295** are the sole distally-extending basket strips **291** attached to the respective proximal crowns and the sole proximally-extending basket strips **291** attached to the respective distal crowns.

[00191] As with prior embodiments, FIGs. 36-37 illustrate that in the relaxed state, each of the pair of bridge memory metal strips **295** may form part of two enlarged cells **262A-262J**. As with prior embodiments, FIGs. 36 and 37 illustrate that in the relaxed state the bridge memory metal strips **295** may be substantially parallel to the distal body length **226**.

[00192] As with prior embodiments, FIGs. 36-37 illustrate that in the relaxed state, the plurality of distal cells **248D** may be comprised of four distal cells **248D** located about the same distance from the proximal junction **228**, each cell having a center **340**, and the centers **340** of the cells **248D** may be spaced at approximately 90 degree intervals about the distal body perimeter **300**, and each of said four distal cells **248D** may adjoin two of the other of said distal four cells **248D**, as best seen in FIGs. 36C and 36D. Again, about the same distance means the same distance from the proximal hub **228** +/- 5 mm. (In preferred embodiments, the four distal cells **248D** are located the same distance +/- 3 mm, more preferably the same distance +/- 0.5 mm, from the proximal hub **228**). Optionally, in the relaxed state, as best seen in FIGs. 36C and 36D, each of the four distal cells **248D** comprises two lateral crowns **338** pointing generally in a direction perpendicular to the distal body length **226** and each lateral crown **338** of one of said four cells **248D** adjoins a lateral crown **338** of an adjacent of said four cells **248D**.

[00193] As with prior embodiments, FIGs. 36-37 illustrate that the distal body **216** preferably has no more than four cells at any location along the distal body length **226**.

[00194] As with prior embodiments, FIGs. 36-37 illustrate that each of the enlarged cells **260A-260J** may be approximately the same size.

[00195] As with prior embodiments, FIGs. 36-37 illustrate that in the relaxed state, the basket interior **346** may be substantially hollow.

[00196] As with prior embodiments, FIGs. 36-37 illustrate that in the relaxed state, the enlarged cells **262A, 262B** formed by the proximal-most free distal crowns **258A, 258B** may be

adjoining, the enlarged cells **262C, 262D** formed by the next proximal-most free distal crowns **258C, 258D** may be adjoining and the enlarged cells **262E, 262F** formed by the succeeding free distal crowns **258E, 258F** may be adjoining. Optionally, as shown in the illustrations of FIGs. 36-37, in the relaxed state each of the enlarged cells **262C, 262D** formed by the next proximal-most free distal crowns **258C, 258D** adjoins an enlarged cell **262A, 262B** formed by a proximal-most free distal crown **258A, 258B** and an enlarged cell **262E, 262F** formed by a succeeding free distal crown **258E, 258F**.

[00197] As with prior embodiments, FIGs. 36-37 illustrate that in the relaxed state, for at least some enlarged cells **262A-262J** (preferably for each enlarged cell, as shown in the illustrations), the free distal crown **258A-258J** may be aligned with the distal crown **307** located at the distal end **310** of the enlarged cell **262A-262J**.

[00198] As with prior embodiments, FIGs. 36-37 illustrate that in the relaxed state, the distal cells **248D** may be substantially the same size and attached to the distal junction **236** by a basket strip **291** having a proximal end attached to a distal crown of a distal cell **248D** and a distal end attached to the distal junction **236**.

[00199] As with prior embodiments, FIGs. 36-37 illustrate that in the relaxed state, the cells **250A-250J** comprising the free distal crowns **258A-258J** may be substantially the same size.

[00200] As with prior embodiments, the system of FIGs. 36-37 may be used in a method of removing a blood clot from a blood vessel of an animal the method comprising the steps of: a) providing the system; b) positioning the system in the blood vessel; c) allowing the height **224** and width **225** of the distal body **216** to increase; d) moving the blood clot into the basket interior **346**; and e) moving the distal body **216** proximally out of the blood vessel.

[00201] As with prior embodiments, in FIGs. 36-37, not all parts are labelled in every drawing for clarity.

[00202] The embodiments of FIGs. 36-37 may include any feature described or shown with the prior embodiments. For example, as illustrated in FIGs. 36-37, the proximal junction **228** and distal junction **236** may be located approximately in the center of the distal body width **225** and distal body height **224** in the relaxed state. Additionally, as illustrated in FIGs. 36-37, each pair of enlarged cells **262A/262B; 262C/262D; 262E/262F; 262G/262H; 262I/262J** may be substantially aligned such that each pair of enlarged cells **262A/262B; 262C/262D; 262E/262F; 262G/262H; 262I/262J** and the substantially hollow interior **346** create a void extending from one side of the basket **246** through the substantially hollow interior **346** to the

opposite side of the basket **246**. In addition, FIGs. 36-37 illustrate the previously mentioned and shown twisting proximal strips **252**. For example, the proximal end **254** of a first proximal strip **252** may be located at least about 65 degrees relative to the distal end **256** of the first proximal strip **252**, the proximal end **254** of a second proximal strip **252** may be located least about 65 degrees relative to the distal end **256** of the second proximal strip **252**, and the first and second proximal strips **252** may intersect adjacent and distal to the proximal junction **228** and the intersection may be located approximately in the center of the first height **224** and first width **225** in the relaxed state. In addition, FIG. 37 illustrate that the distal body **216** may have a void located between the proximal junction **228** and the cells **250A, 250B** comprising the proximal-most free distal crowns **258A, 258B**. In addition, FIGs. 36-37 illustrate that the basket **246** has a non-uniform outward radial force from the proximal strips **252** to the basket distal end **302**. As with prior embodiments, in the embodiments of FIGs. 36-37, the free distal crowns of each pair of free distal crowns **258A/258B; 258C/258D; 258E/258F; 258G/258H; 258I/258J** may be configured to contact each other when an exterior, external compressive force is exerted on the free distal crowns **258A-258J** when the distal body **216** is in the relaxed state. As with prior embodiments, in the embodiments of FIGs. 36-37, the proximal junction **228** and distal junction **236** may be in the form of tubes. In addition, the distal body **216** may include the three-dimensional openings **293** mentioned previously. As with the prior embodiments, in the embodiments of FIGs. 36 and 37, some or all of the free distal crowns **258A-258J**, as well as proximal and distal junctions **228** and **236**, may include x-ray markers, as previously described.

[00203] The Embodiments of FIGs. 38-46

[00204] FIGs. 38-46 illustrate yet another clot retrieval system **400** in accordance with the present invention. The system **400** of FIGs. 38-46 is particularly adapted to capture a clot **402** (e.g., a pulmomary embolism) in a pulmonary blood vessel **404**, which taper in diameter less gradually than cranial vessels. The system **400** includes a suction catheter (also known as an aspiration catheter) **436** that optionally passes into the interior **422** of a cage **408** and includes one or more suction openings **444** so that when the suction catheter **436** is connected to a suction source (such as a syringe or pump that is proximal to the suction opening **444** and located adjacent to the suction catheter proximal end **440**) that applies a proximal suction force (i.e., a suctional force in the proximal direction such as shown in FIGs. 44A and 44B where the arrows generally point in the proximal direction), the surgeon is able to use the suction opening **444** to draw a clot **402** into the interior **422** of the cage **408**. Nonetheless, the system of FIGs. 38-46 may be used to retrieve other objects in other lumens of the body.

[00205] In the embodiment of FIGs. 38-46, the system **400** may include a distal body, which may be in the form of a cage **408** comprising a cage proximal end **410** that may comprise a proximal junction **412**, a cage distal end **414**, a cage length **416** extending from the cage proximal end **410** to the cage distal end **414**, a cage height **418** perpendicular to the cage length **416**, a cage width perpendicular to the cage length **416** and cage height **418**, a cage interior **422** and a cage perimeter (not specifically labelled but denoted in other embodiments with numeral **300**) comprised of a plurality of memory metal strips **426**. Optionally, the cage **408** has a relaxed state wherein the cage has a first height **428** and a first width, and a collapsed state wherein the cage has a second height **432** and a second width, the second height **432** of the cage **408** less than the first height **428** of the cage **408**, the second width of the cage **408** less than the first width of the cage **408**. In some embodiments, as shown in FIGs. 38 and 40-41 and 46, the cage **408** is in the form of a stent retriever with a plurality of cells **480** and is similar in design to the distal bodies of the previous embodiments. In other embodiments, as shown in FIGs. 42-45 the cage **408** may take a slightly different design.

[00206] The system **400** may also include a suction catheter **436** comprising a generally hollow interior **438**, a proximal end **440** located proximal to the cage proximal end **410**, and a distal end **442**. The suction catheter **436** may be attached to the cage proximal end **410** and may pass into the cage interior **422**. In some embodiments, the suction catheter **436** may be attached to the cage distal end **414**, as shown in FIG. 38. In other embodiments, the suction catheter distal end **442** may be proximal to the cage distal end **414**, as shown in FIGs. 40-46. Within the cage interior **422**, the suction catheter **436** may comprise at least one suction opening **444**, which preferably is located between the cage proximal end **410** and the cage distal end **414**, and leads to the suction catheter generally hollow interior **438**. The at least one suction opening **444** allows the suction catheter **436** to apply suction force to draw the clot **402** from outside the cage interior **422** into the cage interior **422**, as shown in FIGs. 44A-44B, for example.

[00207] In some embodiments, the suction catheter **436** is not expandable, as shown in FIG. 39. In other embodiments, the suction catheter **436** may comprise an expandable distal tip **446**, which may be comprised of a memory metal. In such embodiments, the suction catheter **436** may comprise an expandable distal tip **446** that is located adjacent to the suction catheter distal end **442** and is comprised of a memory metal framework **448** and, optionally, a film/coating **450** attached to the memory metal framework **448**. Optionally, the expandable distal tip **446** has a relaxed state wherein the expandable distal tip **446** has a first height **452** and a first width, and a collapsed state wherein the expandable distal tip **446** has a second height **456** and a second

width, the second height **456** of the expandable distal tip **446** is less than the first height **452** of the expandable distal tip **446**, as best seen comparing FIG. 45E with FIG. 45D. Optionally, the first height **452** of the expandable distal tip **446** is less than the first height **428** of the cage **408** and the first width of the expandable distal tip **446** is less than the first width of the cage **408**, as shown in FIG. 38, and FIGs. 40-45.

[00208] Optionally, in the relaxed state, the expandable distal tip **446** of the suction catheter **436** is tapered in shape (e.g., in the shape of a funnel) in the relaxed state, as shown in FIGs. 40-45. Optionally, the distal end **442** of the suction catheter **436** forms the maximum height and width of the expandable distal tip **446** in the relaxed state, as shown in FIGs. 40-45. Optionally, the distal end **442** of the suction catheter **436** is flared inward, as shown in FIGs. 39A and 39B.

[00209] Optionally, the cage **408** comprises a width and a height **418** of between about 15 and about 35 millimeters in the relaxed state. Optionally, the suction catheter **436** comprises a non-expandable proximal segment **460**, which is comprised of a different material than the expandable distal tip **446**, is located immediately proximal to the expandable distal tip **446**, and the non-expandable proximal segment **460** is configured to maintain substantially the same height and same width when the expandable distal tip **446** moves between the collapsed state and the relaxed state. Optionally, the expandable distal tip **446** comprises a maximum width in the relaxed state that is between about 2 and about 6 times greater than the width of the proximal segment. Optionally, the expandable distal tip **446** comprises a maximum height in the relaxed state that is between about 2 and about 6 times greater than the height of the proximal segment.

[00210] FIGs. 46A and 46B show drawings (drawn to scale) of a prototype of a particular embodiment of an expandable distal tip **446** that was made. In FIGs. 46A and 46B, the proximal ends **474** of the proximal memory metal strips **470** are attached to the outer wall/outer circumference of the non-expandable proximal segment **460.** In addition, the expandable distal tip **446** is comprised of a film **450** chemically bonded to the proximal memory metal strips **470** at least partially along the length of the proximal memory metal strips **470** (e.g., a distance of at least 2 millimeters). The device of FIGs. 46A and 46B was made by dipping the proximal memory metal strips **470** (made of nitinol) and the film **450** in the same polymer and then brushing a solvent on the proximal memory metal strips **470** and film **450** to attach/chemically bond the proximal memory metal strips **470** and the film **450**. This process created several advantages including having a covered area in the expandable distal tip portion **474** that is able to expand and collapse in its height **452** and width **456** with the cage **408** – i.e., as the cage

expands and collapses in height. In other words, as depicted in FIGs. 46A and 46B, the expanded distal tip **446** may be co-extensive with a proximal portion of the cage **408**, with the film **450** present for a portion (e.g., between about 5% and about 50%, more preferably between about 5% and about 33%, more preferably between about 5% and about 25%, more preferably between about 15% and about 25%) of the cage length **416**. For example the film **450** may have a length **451** (parallel to the cage length **416)** of from about 2 millimeters to about 30 millimeters, more preferably from about 5 to about 25 millimeters, more preferably from about 5 millimeters to about 20 millimeters, more preferably from about 10 millimeters to about 15 millimeters. In addition, the cage **408** was designed to have larger cells **480A** distal to the expandable distal tip **446** (to allow for clot to enter the cage interior **422)** and smaller cells **480B** at the distal portion of the cage **408** to prevent captured clot from escaping out of the cage distal end **414**. In exemplary embodiments, the larger cells **480A** have a surface area that is between about 150% and about 500% of the surface area of the smaller cells **480B** in the relaxed state. However, other dimensions are possible. In effect, the suction opening **444** is located at the distal end of the expandable distal tip **446** (and proximal to the large cells **480A** as well as distal to the cage proximal end **410)** and allows the suction force from the syringe or other suction source to be applied to draw the clot through the large cells **480A.** In addition, as visible from viewing FIGs. 46A and 46B, which is depicted in the relaxed state, the first height **452** of the expandable distal tip **446** is equal to the first height **428** of the cage **408** and the first width of the expandable distal tip **446** is equal to the first width of the cage **408**.

[00211] Optionally, the memory metal framework **448** is comprised of woven/braided linear memory metal strands **462**, as shown in FIGs. 38 and 40-46. Examples of woven/braided linear memory metal strands with films/coatings are known in the art. For example, the Anaconda suction catheters with such frameworks and films/coatings are sold by Anaconda Biomed SL (Barcelona, Spain) and described in European Patent Application EP3634768, where it is described that the woven/braided linear strands may be dipped into a polymeric coating or sprayed onto the strands and that the film/coating may create a watertight compartment. Woven/braided linear strands also are described in Applicant's own U.S. Patent Nos. 10,321,925 and 10,226,268, for example. The contents of the aforementioned European Patent Application and U.S. Patents are incorporated herein by reference. Optionally, each woven linear strand may rotate about the distal portion perimeter relative to the cage length/longitudinal axis a plurality of times in a helical fashion. Optionally, the suction catheter expandable distal tip **446** may be flexible and invertible, as with the Anaconda suction catheter.

[00212] Optionally, the at least one suction opening **444** is located at the distal end **442** of the suction catheter **436**, as shown in FIGs. 39B, and 40-46. Alternatively, the distal end **442** of the suction catheter **436** may be closed, as shown in FIGs. 38-39 and 39A.

[00213] Optionally, as shown in FIGs. 38-40, the at least one suction opening **444** is located in the film **450** proximal to the suction catheter distal end **442**. It will be understood that the term "at least one suction opening" allows for the suction catheter **436** to have multiple suction openings **444** within the cage interior **422**, as shown in FIG. 38, 39B and 40 for example. Optionally, if one side of the suction catheter **436** (e.g., the top) includes a suction opening **444**, preferably the opposite side (e.g., the bottom) also includes an aligned suction opening **444**, as best seen in FIG. 38 and 39B. This can also be inferred in FIG. 40, for example, because there is no film **450** on the side opposite of the suction opening **444** visible. In other words, optionally, the centers of the suction openings **444** are aligned longitudinally and located between 150 and 180 degrees apart.

[00214] Optionally, the cages **408** comprise a plurality of x-ray markers **524** located between the suction catheter distal end **442** and the cage distal end **414**, as best seen in FIGs. 42-44. Optionally, as best seen in FIGs. 42-44, the x-ray markers **524** are aligned longitudinally (i.e., each of the x-ray markers **524** is located approximately the same distance from the cage proximal end **410**). Without being bound by any particular theory, the plurality of x-ray markers **524** may inform the operator/surgeon the location of the cage **408** relative to the clot **402** so that the operator deploys the cage **408** in the correct location in the vessel **404**.

[00215] Optionally the proximal end **440** of the suction catheter **436** is connected to a syringe or a pump, not shown but well-known in the art.

[00216] Optionally, the cage **408** is not free floating on the suction catheter **436** but instead the attachment of the suction catheter **436** to the cage **408** is configured to allow an operator to pull the cage **408** proximally by pulling the suction catheter **436** proximally and to push the cage **408** distally by pushing the suction catheter **436** distally. In other words, the surgeon may be able to move the cage **408** proximally and distally by moving the suction catheter **436** proximally and distally.

[00217] Optionally, the proximal **440** end of the suction catheter **436** comprises a tapered (e.g., funnel shaped) hub/coupler **468** configured to connect the proximal end **440** to a suction source, as shown in FIG. 38, 40, 41 and 43 and 46 for example.

[00218] Optionally, in the relaxed state, the cage **408** comprises a tapered proximal region **528** in which the cage height **418** and the cage width decrease as the memory metal strips **426**

located at the proximal end of the cage **408** approach the cage proximal end **410**, as shown in FIGs. 38, and 40-46.

[00219] Optionally, in the relaxed state, the cage **408** comprises a tapered distal region **530** in which the cage height **418** and the cage width decrease as the memory metal strips **426** located at the distal end of the cage **408** approach the cage distal end **414**, as shown in FIGs. 38, and 40-46.

[00220] Optionally, the cage **408** further comprises a cage proximal junction **412** located at the cage proximal end **410** and a plurality of proximal strips **470**, each proximal strip **470** having a distal end **472** and a proximal end **474**, the proximal ends of the proximal strips **470** converging at the cage proximal junction **412**, and further wherein the suction catheter **436** passes through the cage proximal junction **412**, as shown in FIG. 38.

[00221] Optionally, as shown in FIGs. 38 and 40-45, the cage **408** further comprises a cage distal junction **532** located at the cage distal end **414** and a plurality of distal strips **534**, each distal strip **534** having a distal end **536** and a proximal end **538**, the distal ends **536** of the distal strips **534** converging at the cage distal junction **532**.

[00222] Optionally, the suction catheter **436** is attached to the cage distal junction **532**, as shown in FIG. 38. Optionally, the suction catheter distal end **442** may extend distally beyond the cage distal end **414**. Optionally, the suction catheter **436** is not attached to the cage distal end **414**.

[00223] Optionally, the suction catheter **436** has a length of from about 60 centimeters to about 150 centimeters.

[00224] Optionally, the suction catheter **436** comprises a plurality of suction openings **444** and at least some of the plurality suction openings **444** are located proximal to the suction catheter distal end **442**, as shown in FIGs. 38-40.

[00225] Optionally, as shown in FIGs. 38 and 40-41 the cage **408** is comprised of a framework **478** comprising a plurality of cells **480** formed by the plurality of memory metal strips **426**. Optionally, in the relaxed state, at least one of the suction openings **444** located proximal to the suction catheter distal end **442** is aligned with a cell **480** to allow the operator to use the suction opening **444** to move the clot through the cell **480** and into the cage interior **422**. For example, as shown in FIGs. 38 and 40-41, the heightwise center of the suction opening **422** may be aligned with the heightwise center of the cell **480** so that the suction force is centered in the cell **480**. Optionally, in the relaxed state, as shown in FIGs. 38 and 40-41, the framework **478** comprises at least one pair of distal crowns **482** not attached to another cell **480** and pointing

generally in the distal direction, the distal crowns **482** in the at least one pair of distal crowns **482** located approximately the same distance from the cage proximal end **410** and located between 150 degrees and 180 degrees relative to each other. Optionally, each distal crown in the at least one pair of distal crowns **482** forms part of a different enlarged cell **484**, each enlarged cell **484** having a center. Optionally, the centers of the enlarged cells **484** of the at least one pair of distal crowns **482** are between 150 degrees and 180 degrees relative to each other. Optionally, the enlarged cells **484** are configured to allow a clot **402** to pass therethrough and into the cage interior **422**. Optionally, one or more of the suction openings **444** located proximal to the suction catheter distal end **442** is aligned with an enlarged cell **484**. Optionally, as shown in FIG. 38, as with prior embodiments, the enlarged cells **484** are sequentially offset (e.g., the proximal-most pair of enlarged cells **484** are offset 60-90 degrees from the next proximal most pair of enlarged cells **484**, which are offset 60-90 degrees from the succeeding proximal-most pair of enlarged cells and so forth) and the suction openings **444** are likewise sequentially offset.

[00226] Optionally, as shown in FIG. 38, the cage **408** further comprises a cage proximal junction **412** located at the cage proximal end **410** and a plurality of proximal strips **470**, each proximal strip **470** having a distal end **472** attached to a proximal crown **540** of a cell of the cage **408** and a proximal end **474**, the proximal ends of the proximal strips **470** converging at the cage proximal junction **412**.

[00227] Optionally, as shown in FIG. 45E, the system **400** further comprises a delivery catheter **488** having an interior, a proximal end (not shown) leading to the interior and a distal end **494** leading to the interior, the delivery catheter **488** comprised of a biocompatible material and configured to envelop the cage **408** and the suction catheter **436** prior to deployment from the delivery catheter **488**. The system **400** may also include a guide catheter **542** as shown in FIGs. 42 and 45E and 45F.

[00228] Optionally, as shown in FIG. 39, the system **400** may include an inner blocking catheter **498** located in the suction catheter generally hollow interior **438** and moveable proximally and distally in the suction catheter generally hollow interior **438**, the inner blocking catheter **498** comprising an open proximal end **500**, an open distal end **502** and a generally hollow interior. Without being bound by any particular theory, the inner blocking catheter **498** may be used to block a suction hole(s) **444** in the suction catheter **436**, as shown in FIG. 39 where the proximal suction holes **444** are blocked. Optionally, the inner blocking catheter **498** and the suction catheter **436** each comprise an outer diameter and an inner diameter and further

wherein the outer diameter of the inner blocking catheter **498** is between about 85% to about 99.9% of the size of the inner diameter of the suction catheter **436**.

[00229] Optionally, the heightwise/widthwise center of the suction catheter **436** is located approximately in the heightwise/widthwise center of the cage **408** in the relaxed state, as shown in FIGs. 38 and 40-45.

[00230] Optionally, though not shown, the cage **408** may further include scaffolding memory metal strips **426** extending from the cage perimeter inwardly to the suction catheter **436** to help maintain the suction catheter **436** in the center of the cage **408**.

[00231] Optionally, in the relaxed state, the cage **408** has a minimum height **418** and width at the cage proximal end **410**, as shown in FIGs 40-46.

[00232] Optionally, except for the suction catheter **436**, the cage interior **422** is hollow.

[00233] Optionally, as shown in FIG. 38, the cage proximal end **410** is in the form of a tube.

[00234] Optionally, as shown in FIGs. 38-46, the suction catheter **436** is fixedly attached to at least some of the cage memory metal strips **426**.

[00235] Optionally, as shown in FIG. 38 and FIGs. 40-41 and 46, in the relaxed state, the cage **408** is comprised of a plurality of cells **480** but does not have any free proximal crowns **540** pointing generally in the proximal direction but does have free distal crowns **482** pointing generally in the distal direction.

[00236] Optionally, the system further includes a lead wire **512** extending distally from the cage distal end **414**.

[00237] Generally, as exemplified in FIGs. 44A and 44B, and 45A-45G, the system **400** may be used in a method of removing a blood clot **402** from an animal the method comprising the steps of:

[00238] a) providing a delivery catheter **488** having an interior, a proximal end and a distal end **494**, the delivery catheter **488** enveloping the cage **408** (see FIG. 45C);

[00239] b) deploying the cage **408** from the delivery catheter distal end **494** so the cage **408** moves from the collapsed state to the relaxed state (see FIGs. 45D and 45E);

[00240] c) applying suction to the suction catheter **436** to move the blood clot **402** into the cage interior **422** (see FIG. 45F as well as FIGs. 44A and 44B); and

[00241] d) moving the cage **408** and blood clot **402** proximally out of the animal (see FIG. 45G) e.g., by pulling proximally on the suction catheter **436**.

[00242] Optionally, the method further comprises connecting a syringe or a pump (not shown but known in the art) to the suction catheter proximal end **440** and using the syringe or the pump to apply suction to the suction catheter **436**.

[00243] Optionally, as shown in FIG. 39, the method further comprises, before step c), providing an inner blocking catheter **498** located in the suction catheter generally hollow interior **438** and moving the inner blocking catheter **498** proximally or distally in the suction catheter generally hollow interior **438** to cover a suction opening **444** in the suction catheter **436**.

[00244] Optionally, steps b) and c) occur in a lung of the animal.

[00245] Without being bound by any particular theory, FIGs. 44A and 44B and 45D and 45E show how the cage **408** may gradually move from the collapsed state to the relaxed state. Unlike the prior embodiment as best seen in FIG. 22, where the distal body is deployed distally to the clot **402**, in the embodiment of FIGs. 38-45, the cage **408** may be deployed at the site of the clot **402**, as best seen in FIGs. 44A-44B and 45D and 45E where the cage proximal end **410** is distal to the clot's **402** proximal end and the cage distal end **414** is proximal to the clot's **402** distal end. In addition to a delivery catheter **488**, a guide catheter **542** having a larger diameter than the delivery catheter **488** may also be used, as shown in FIGs. 45C-45G. After clot **402** capture, the suction catheter **436**, the cage **408** and the clot **402** may be moved (fully or partially) into the guide catheter **542**, as shown in FIG. 45G.

[00246] **PARTS LIST**

Clot retrieval system	400
Clot	402
Pulmonary blood vessel	404
Distal body	406
Cage	408
Cage proximal end	410
Cage proximal junction	412
Cage distal end	414
Cage length	416
Cage height	418
Cage width	Not shown
Cage interior	422
Plurality of memory metal strips	426
Cage first height	428
Cage first width	Not shown

Cage second height	432
Cage second width	Not shown
Suction catheter	436
Suction catheter hollow interior	438
Suction catheter proximal end	440
Suction catheter distal end	442
Suction opening	444
Suction catheter expandable distal tip	446
Memory metal framework	448
Film	450
Film length	451
Expandable distal tip first height	452
Expandable distal tip second height	456
Suction catheter non-expandable proximal segment	460
Woven linear memory metal strands	462
Plurality of braided mesh openings	464
Tapered hub	468
Plurality of proximal strips	470
Proximal strip distal end	472
Proximal strip proximal end	474
Cell	480
Free distal crowns	482
Enlarged cell	484
Delivery catheter	488
Delivery catheter distal end	494
Inner blocking catheter	498
Inner blocking catheter open proximal end	500
Inner blocking catheter open distal end	502
Lead wire	512
Plurality of x-ray markers	524
Tapered proximal region	528
Tapered distal region	530
Cage distal junction	532
Cage distal strips	534
Cage distal strips distal ends	536
Cage distal strips proximal ends	538

Proximal crown	540
Guide catheter	542

[00247] Having now described the invention in accordance with the requirements of the patent statutes, those skilled in the art will understand how to make changes and modifications to the disclosed embodiments to meet their specific requirements or conditions. Changes and modifications may be made without departing from the scope and spirit of the invention, as defined and limited solely by the following claims. In particular, although the system has been exemplified for use in retrieving blood clots, the system may be used to retrieve other objects from animal lumens. In addition, the steps of any method described herein may be performed in any suitable order and steps may be performed simultaneously if needed.

[00248] Terms of degree such as "substantially", "about" and "approximately" as used herein mean a reasonable amount of deviation of the modified term such that the end result is not significantly changed. For example, these terms can be construed as including a deviation of at least ± 5% of the modified term if this deviation would not negate the meaning of the word it modifies.

CLAIMS

What is claimed is:

1. A system for removing a blood clot from a human blood vessel, the system comprising:

a distal body comprising a cage comprising a cage proximal end, a cage distal end, a cage length extending from the cage proximal end to the cage distal end, a cage height perpendicular to the cage length, a cage width perpendicular to the cage length and cage height, a cage interior and a cage perimeter comprised of a plurality of memory metal strips, wherein the cage has a relaxed state wherein the cage has a first height and a first width, and a collapsed state wherein the cage has a second height and a second width, the second height of the cage less than the first height of the cage, the second width of the cage less than the first width of the cage; and

a suction catheter comprising a generally hollow interior, a proximal end located proximal to the cage proximal end, and a distal end, the suction catheter attached to the cage and passing into the cage interior, the suction catheter, within the cage interior, comprising at least one suction opening located between the cage proximal end and the cage distal end, the at least one suction opening leading to the generally hollow interior.

2. The system of claim 1 wherein the suction opening is configured to allow an operator to draw a clot from outside the cage interior into the cage interior when a proximal suction force is applied to the suction catheter.

3. The system of claim 2 wherein the suction catheter is connected to a syringe or a pump and the syringe or pump is configured to apply a proximal suction force to the suction opening to draw a clot into the cage interior.

4. The system of claim 1 wherein the proximal end of the suction catheter comprises a tapered hub configured to connect the proximal end of the suction catheter to a suction source.

5. The system of claim 1 wherein the cage is comprised of a framework comprising a plurality of cells formed by the plurality of memory metal strips.

6. The system of claim 5, wherein, in the relaxed state, a suction opening is aligned with a cell.

7. The system of claim 6 wherein, in the relaxed state, a suction opening is aligned with a lengthwise center of a cell.

8. The system of claim 5 wherein, in the relaxed state, the framework comprises at least one pair of distal crowns not attached to another cell and pointing generally in the distal direction, the distal crowns in the at least one pair of distal crowns located approximately the same distance from the cage proximal end and located between 150 degrees and 180 degrees relative to each

other, wherein each distal crown in the at least one pair of distal crowns forms part of a different enlarged cell, each enlarged cell having a center,

wherein the centers of the enlarged cells of the at least one pair of distal crowns are between 150 degrees and 180 degrees relative to each other, and further wherein the enlarged cells are configured to allow a clot to pass therethrough and into the cage interior, and further wherein a suction opening is aligned with an enlarged cell.

9. The system of claim 8 wherein a heightwise center of a suction opening is aligned with a heightwise center of an enlarged cell.

10. The system of claim 1 wherein, within the cage interior, the suction catheter comprises at least one pair of suction openings proximal to the suction catheter distal end, each of the at least one pair of suction openings having a center, the centers of the at least one pair of suction openings located between 150 degrees and 180 degrees relative to each other.

11. The system of claim 10 wherein the suction catheter distal end is open.

12. The system of claim 1 wherein the suction catheter comprises an expandable distal tip located adjacent to the suction catheter distal end and comprised of a memory metal framework and a film attached to the memory metal framework, wherein the expandable distal tip has a relaxed state wherein the expandable distal tip has a first height and a first width, and a collapsed state wherein the expandable distal tip has a second height and a second width, the second height of the expandable distal tip less than the first height of the expandable distal tip and the second width of the expandable distal tip less than the first width of the expandable distal tip, and further wherein the first height of the expandable distal tip is less than the first height of the cage and the first width of the expandable distal tip is less than the first width of the cage.

13. The system of claim 12 wherein, in the relaxed state, the expandable distal tip of the suction catheter is tapered in shape, and further wherein the distal end of the suction catheter forms the maximum height and width of the expandable distal tip in the relaxed state.

14. The system of claim 12 wherein the cage comprises a maximum width and a maximum height of between about 15 millimeters and about 35 millimeters in the relaxed state, wherein the suction catheter comprises a non-expandable proximal segment immediately proximal to the expandable distal tip, the non-expandable proximal segment configured to maintain substantially the same height and same width when the expandable distal tip moves between the collapsed state and the relaxed state, and further wherein the expandable distal tip comprises a maximum width in the relaxed state that is between about 2 and about 6 times greater than the width of the proximal segment and further wherein the expandable tip comprises a maximum height in the

relaxed state that is between about 2 and about 6 times greater than the height of the proximal segment.

15. The system of claim 12 wherein the memory metal framework is comprised of woven linear memory metal strands forming a plurality of braided mesh openings and further wherein the film covers the mesh openings.

16. The system of claim 12 wherein the suction catheter comprises at least one pair of suction openings located in the film proximal to the suction catheter distal end, each of the at least one pair of suction openings having a center, the centers of the at least one pair of suction openings located between 150 degrees and 180 degrees relative to each other.

17. The system of claim 1 wherein the suction catheter is attached to the cage proximal end.

18. The system of claim 1 wherein the attachment of the suction catheter to the cage is configured to allow an operator to pull the cage proximally by pulling the suction catheter proximally and to push the cage distally by pushing the suction catheter distally.

19. The system of claim 1 wherein, within the cage interior, the suction catheter comprises a plurality of suction openings leading to the generally hollow interior and at least some of the plurality of suction openings are located proximal to the suction catheter distal end.

20. The system of claim 1 wherein the system further comprises a delivery catheter having an interior, a proximal end leading to the interior and a distal end leading to the interior, the delivery catheter comprised of a biocompatible material and enveloping the cage and the suction catheter.

21. The system of claim 1 wherein the distal end of the suction catheter extends distally beyond, and is not attached to, the cage distal end.

22. The system of claim 1 further comprising an inner blocking catheter located in the suction catheter generally hollow interior and moveable proximally and distally in the suction catheter generally hollow interior, the inner blocking catheter comprising an open proximal end, an open distal end and a generally hollow interior.

23. The system of claim 22 wherein the inner blocking catheter and the suction catheter each comprise an outer diameter and an inner diameter and further wherein the outer diameter of the inner blocking catheter is between about 85% to about 99.9% of the size of the inner diameter of the suction catheter.

24. The system of claim 1 wherein the heightwise and widthwise center of the suction catheter is located approximately in the heightwise and widthwise center of the cage in the relaxed state.

25. The system of claim 1 wherein, except for the suction catheter, the cage interior is hollow, and further wherein the system comprises a lead wire extending distally from the cage distal end.

26. A system for removing a blood clot from a human blood vessel, the system comprising:

a distal body comprising a cage comprising a cage proximal end, a cage distal end, a cage length extending from the cage proximal end to the cage distal end, a cage height perpendicular to the cage length, a cage width perpendicular to the cage length and cage height, a cage interior and a cage perimeter comprised of a plurality of memory metal strips, wherein the cage has a relaxed state wherein the cage has a first height and a first width, and a collapsed state wherein the cage has a second height and a second width, the second height of the cage less than the first height of the cage, the second width of the cage less than the first width of the cage; and

a suction catheter comprising a generally hollow interior, a proximal end located proximal to the cage proximal end, and a distal end, the suction catheter attached to at least some of the cage memory metal strips, the suction catheter comprising at least one suction opening, the at least one suction opening leading to the generally hollow interior.

27. The system of claim 26 wherein the suction catheter is fixedly attached to at least some of the plurality of memory metal strips.

28. The system of any one of claims 26-27 wherein the suction catheter comprises an expandable distal tip located adjacent to the suction catheter distal end, wherein the expandable distal tip has a relaxed state wherein the expandable distal tip has a first height and a first width, and a collapsed state wherein the expandable distal tip has a second height and a second width, the second height of the expandable distal tip less than the first height of the expandable distal tip and the second width of the expandable distal tip less than the first width of the expandable distal tip.

29. The system of claim 28 wherein the expandable distal tip is comprised of a film, the film is chemically bonded to at least some of the memory metal strips.

30. The system of any one of claims 28- 29 wherein the first height of the expandable distal tip is equal to the first height of the cage and the first width of the expandable distal tip equal to the first width of the cage.

31. The system of any one of claims 28-30, wherein the expandable distal tip is comprised of a film, wherein the suction catheter comprises a non-expandable proximal segment immediately proximal to the expandable distal tip, the non-expandable proximal segment configured to

maintain substantially the same height and same width when the expandable distal tip moves between the collapsed state and the relaxed state, and comprising an outer wall, wherein at least some of the memory metal strips are proximal memory metal strips comprising a proximal end attached to the outer wall of the non-expandable proximal segment, a distal end, and further wherein the film is attached to the proximal memory metal strips.

32. The system of claim 31 wherein the film has a film length parallel to the cage length and the film length is from about 5 millimeters to about 25 millimeters.

33. The system of any one of claims 28-32, wherein, in the relaxed state, the expandable distal tip of the suction catheter is tapered in shape, and further wherein the distal end of the suction catheter forms the maximum height and width of the expandable distal tip in the relaxed state.

34. The system of any one of claims 28-33 wherein the cage comprises a plurality of cells adjacent to the cage distal end.

35. The system of system of any one of claims 28-33 wherein the cage comprises a plurality of small cells adjacent to the cage distal end and a plurality of large cells located between the plurality of small cells and the suction catheter distal end, the large cells having a larger surface area than the small cells in the relaxed state.

36. The system of claim 35 wherein the large cells have a surface area that is between 150% and 500% of the surface area of the small cells in the relaxed state.

37. The system of any one of claims

37. The system of any one of claims 28-36 wherein the suction opening is configured to allow an operator to draw a clot from outside the cage interior into the cage interior when a proximal suction force is applied to the suction catheter.

38. The system of any one of claims 28-37 wherein the suction catheter is connected to a syringe or a pump and the syringe or pump is configured to apply a proximal suction force to the suction opening to draw a clot into the cage interior.

39. The system of any one of claims 26-38 wherein the at least one suction opening is located between the cage proximal end and the cage distal end.

40. The system of any one of claims 26-39 wherein the at least one suction opening is located at the suction catheter distal end.

41. The system of any one of claims 26-40 wherein the cage memory metal strips located at the cage distal end converge at a cage distal junction.

42. The system of claim 41 wherein the cage memory metal strips located at the cage distal end are soldered or welded to the cage distal junction.

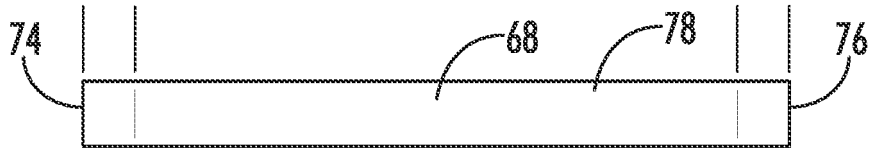


FIG. 1A

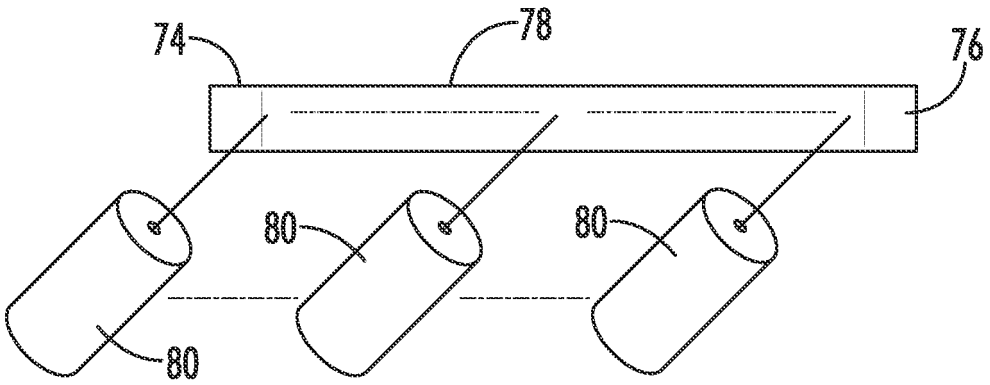


FIG. 1B

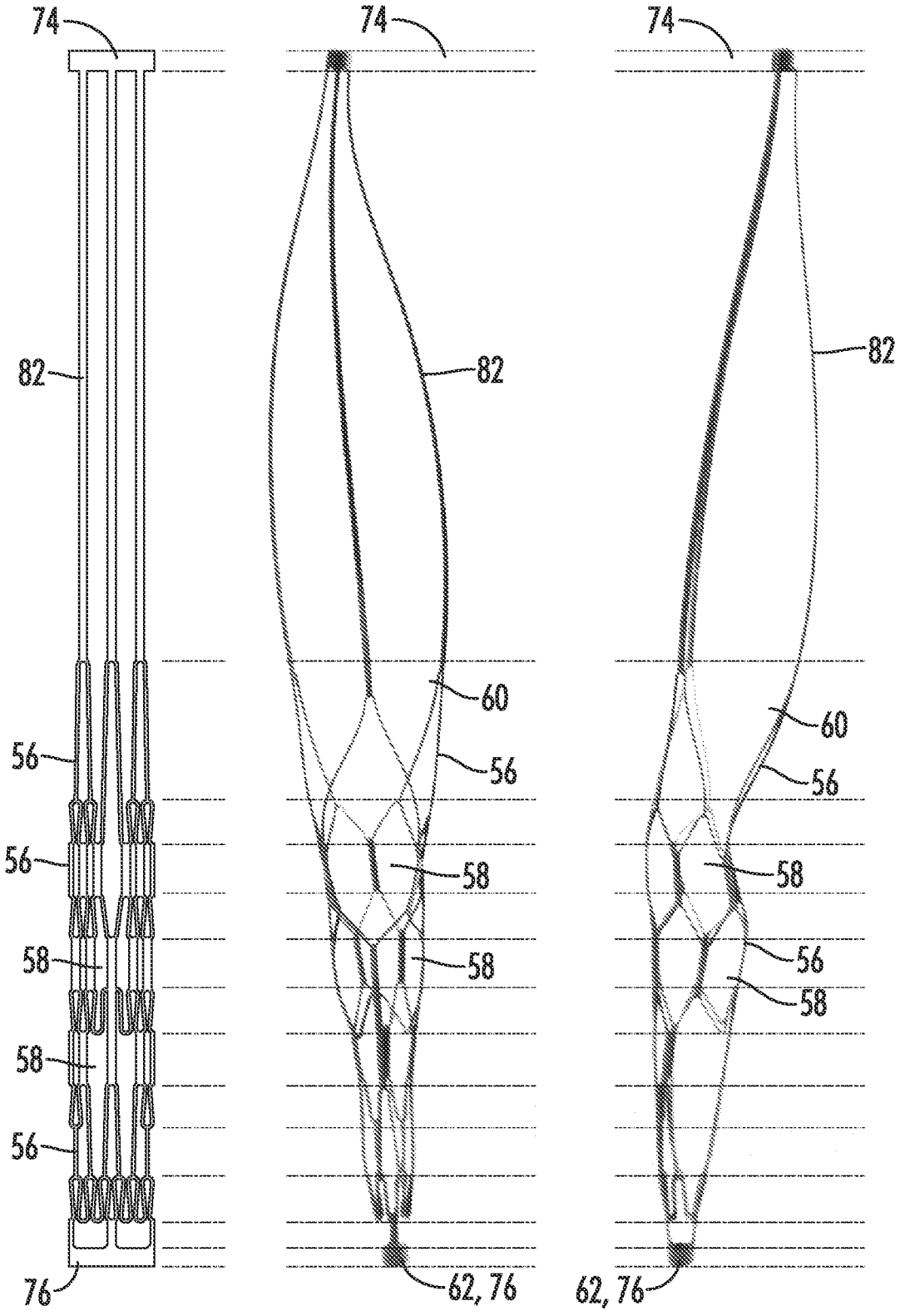


FIG. 2A FIG. 2B FIG. 2C

FIG. 3A

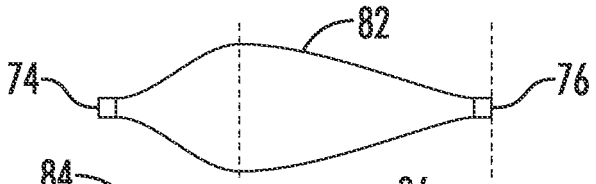


FIG. 3B

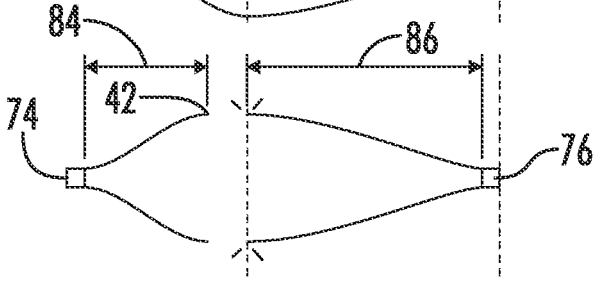


FIG. 3C

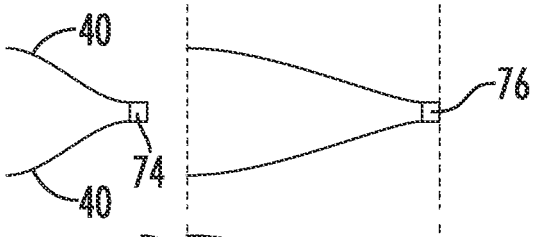


FIG. 3D

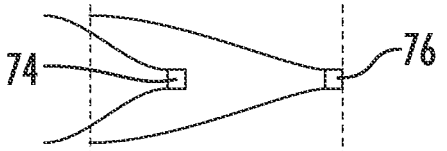


FIG. 3E

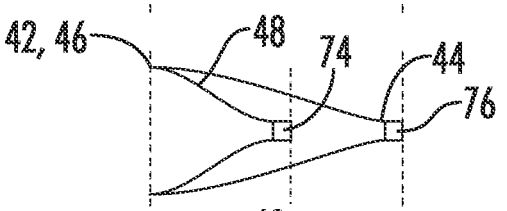


FIG. 3F

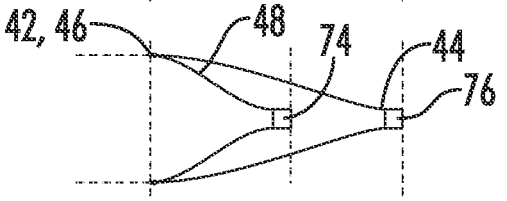


FIG. 3G

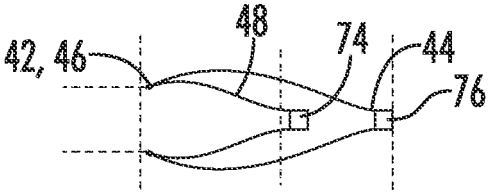
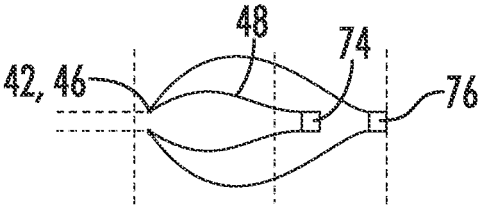


FIG. 3H



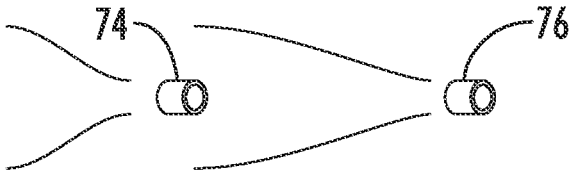


FIG. 4A

FIG. 4B

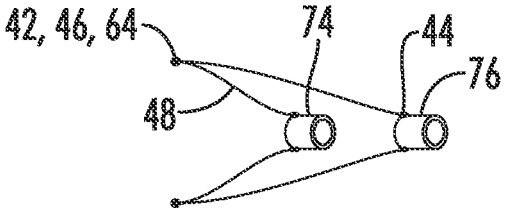


FIG. 4C

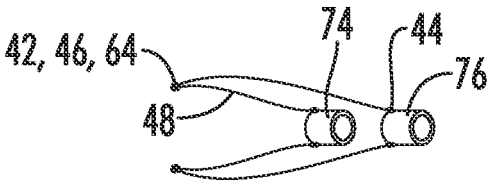


FIG. 4D

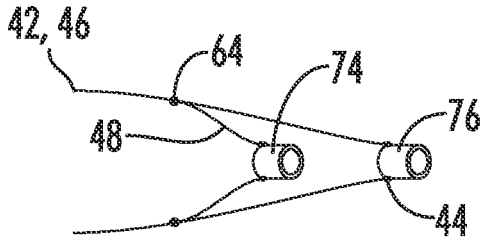


FIG. 5

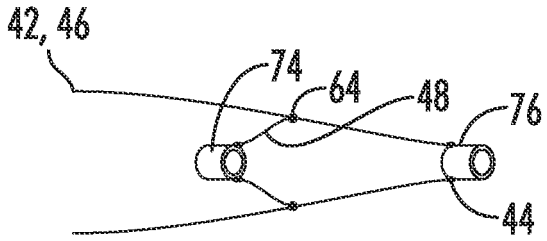


FIG. 6

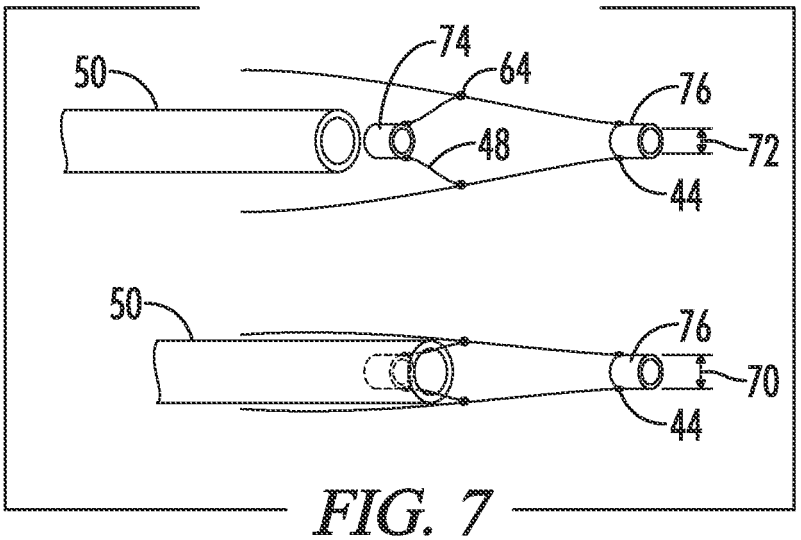


FIG. 7

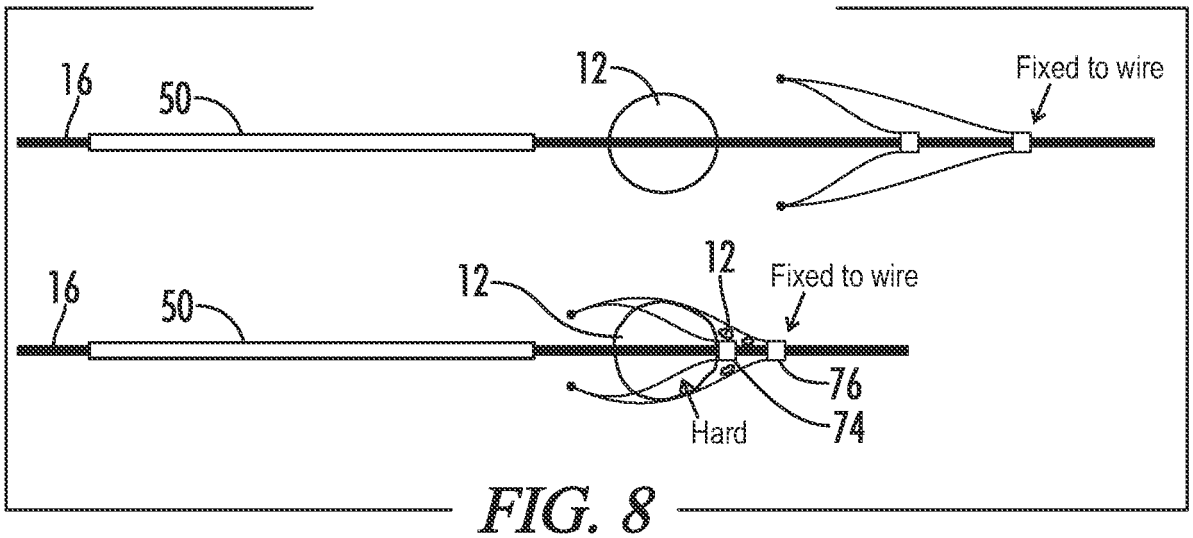
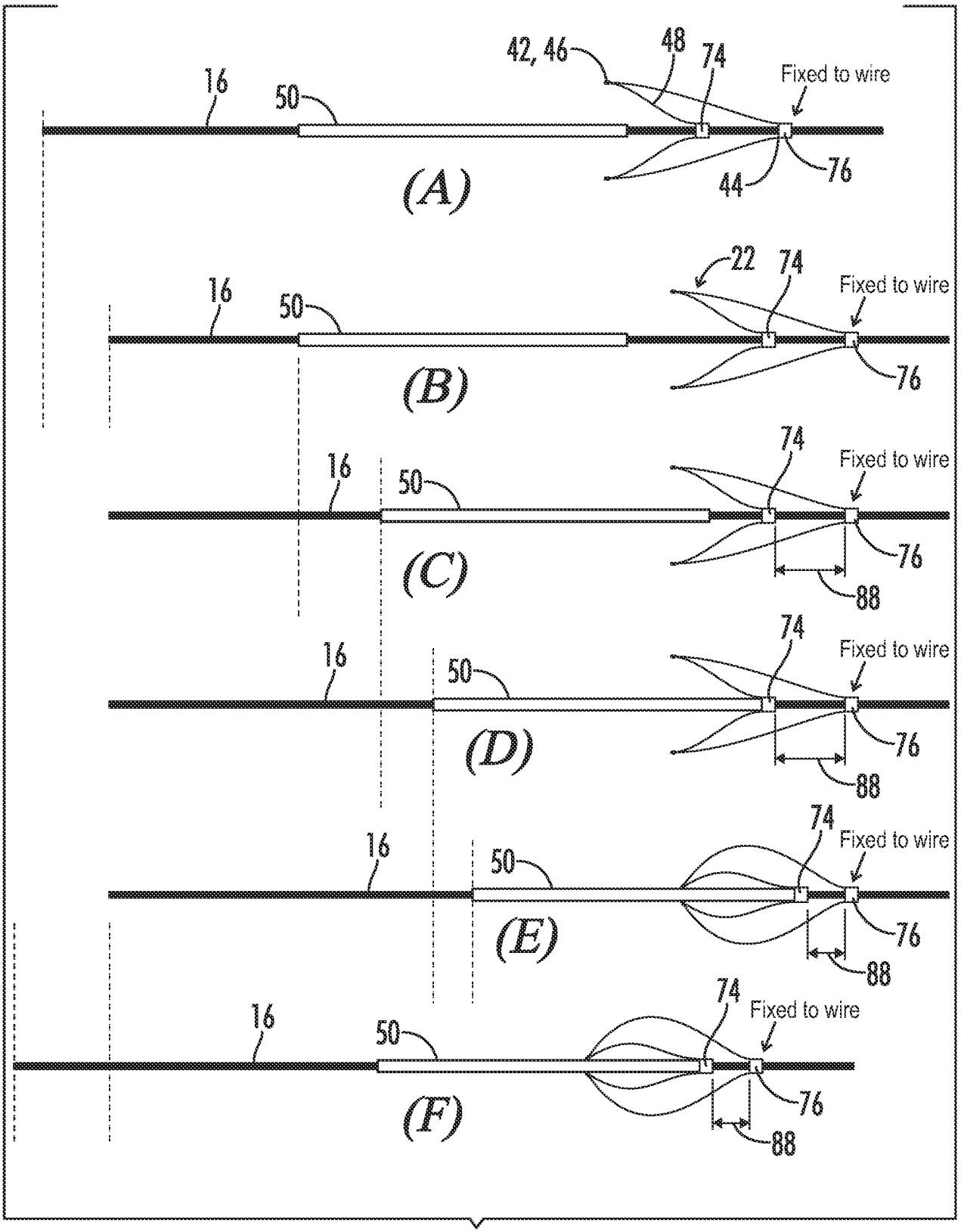


FIG. 8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16
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(B)
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(C)
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88
74
Fixed to wire
16
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(D)
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Fixed to wire
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(E)
76
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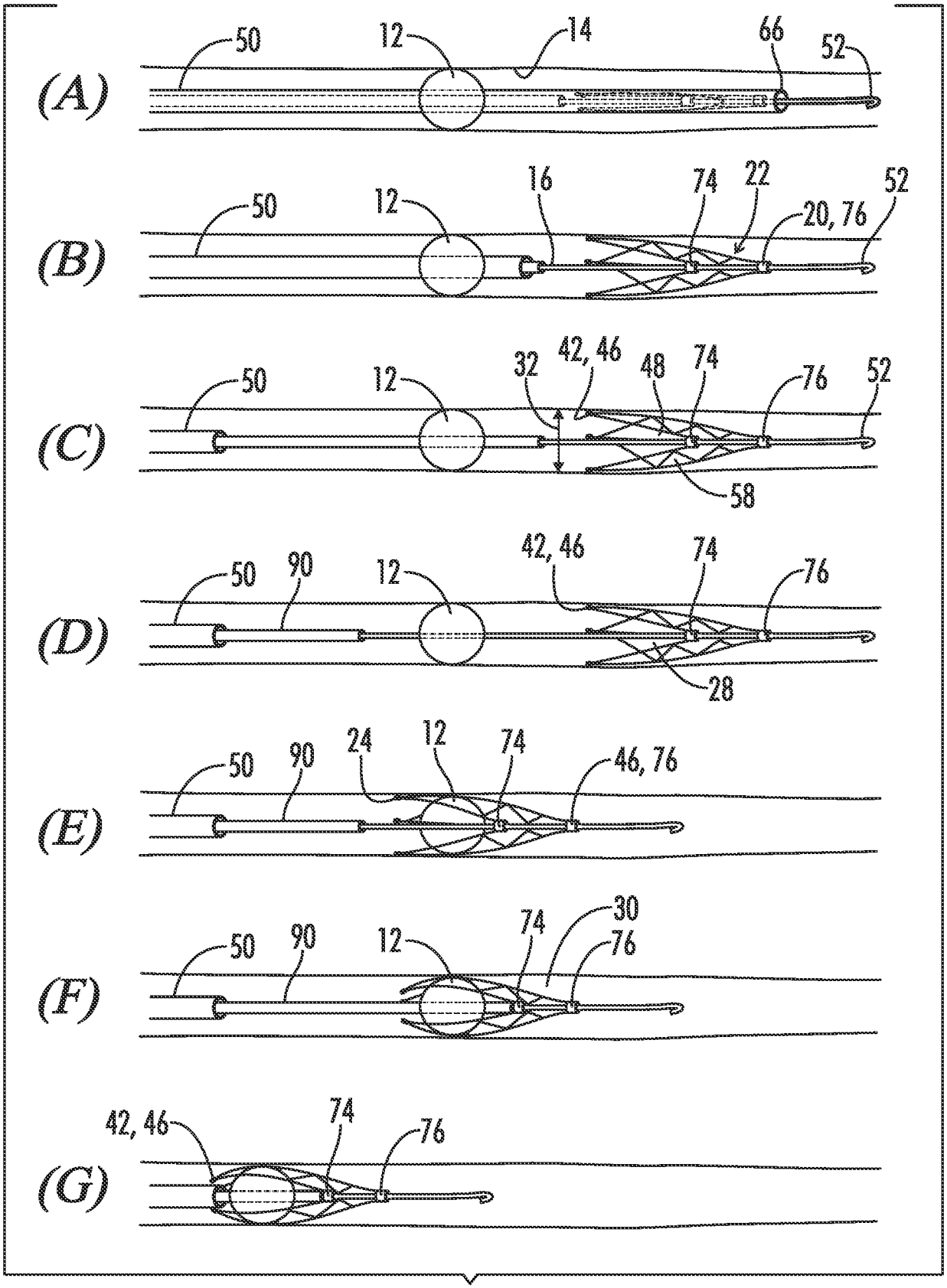
74
Fixed to wire
16
50
(F)
76
88

FIG. 9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(D)
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(E)
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(F)
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(G)
42, 46
74
76

FIG. 10

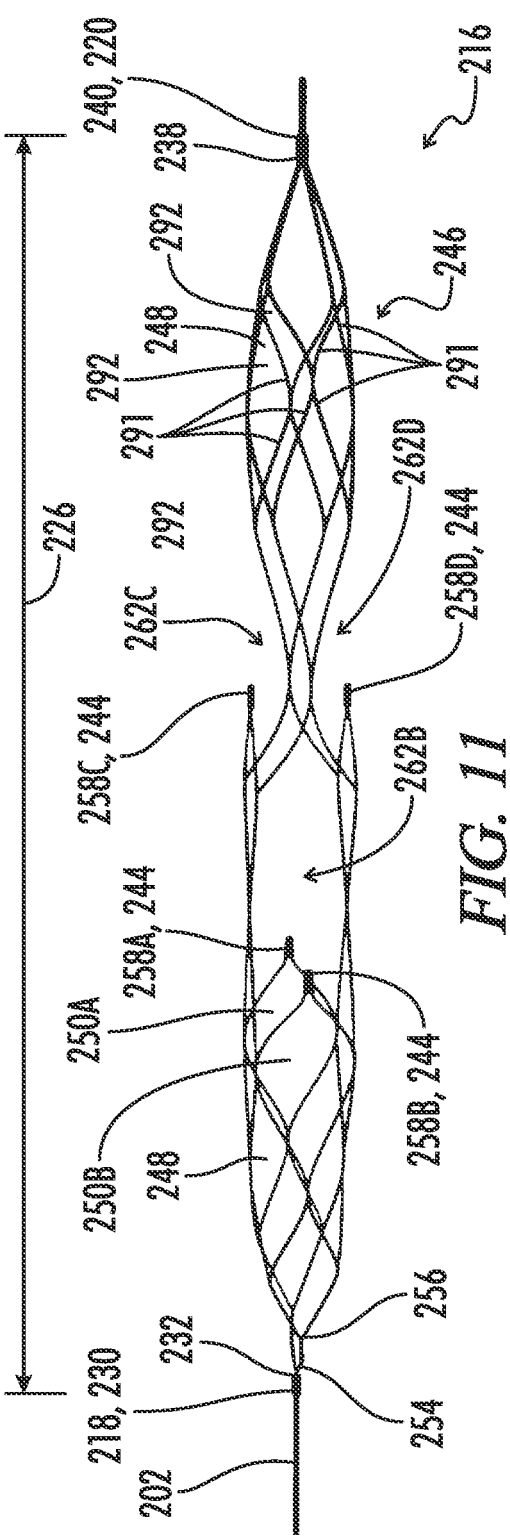


FIG. 11

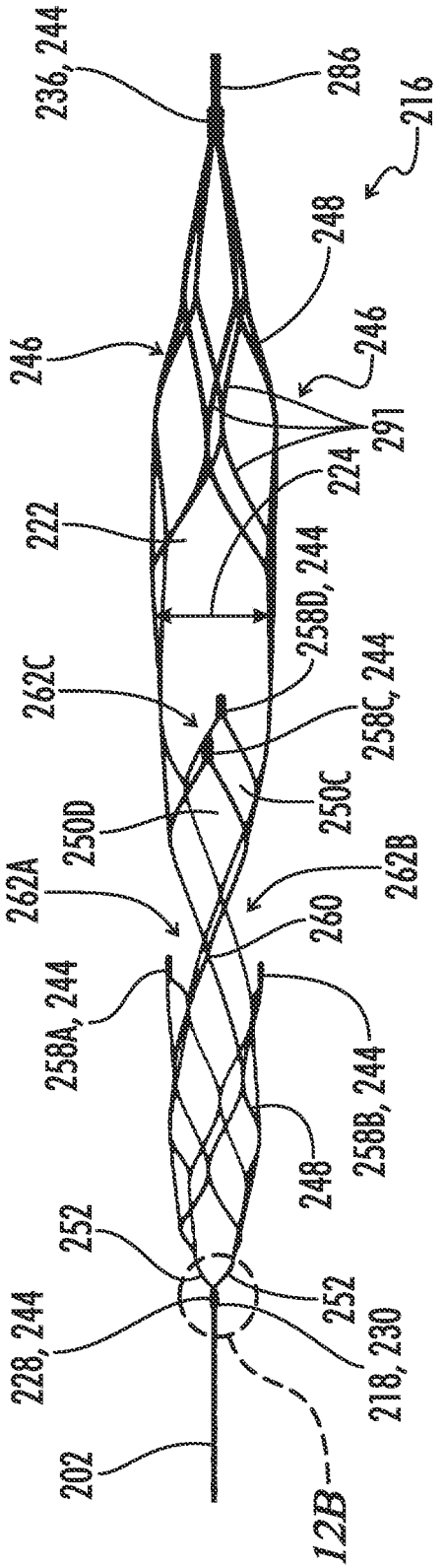


FIG. 12A

FIG. 12B

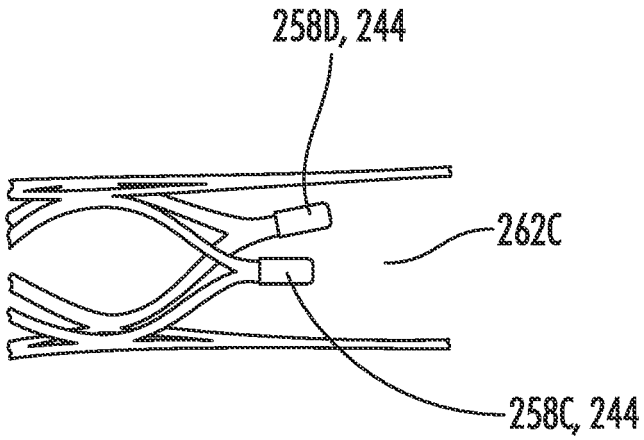


FIG. 13

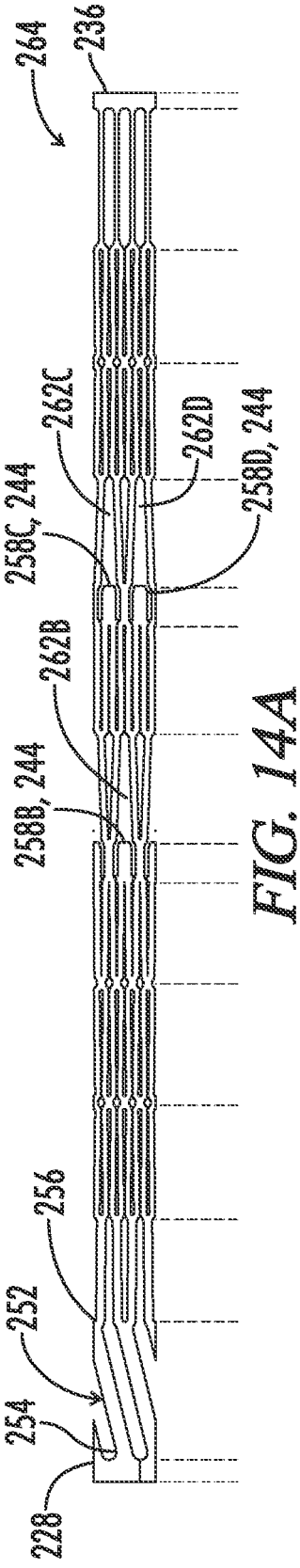


FIG. 14A

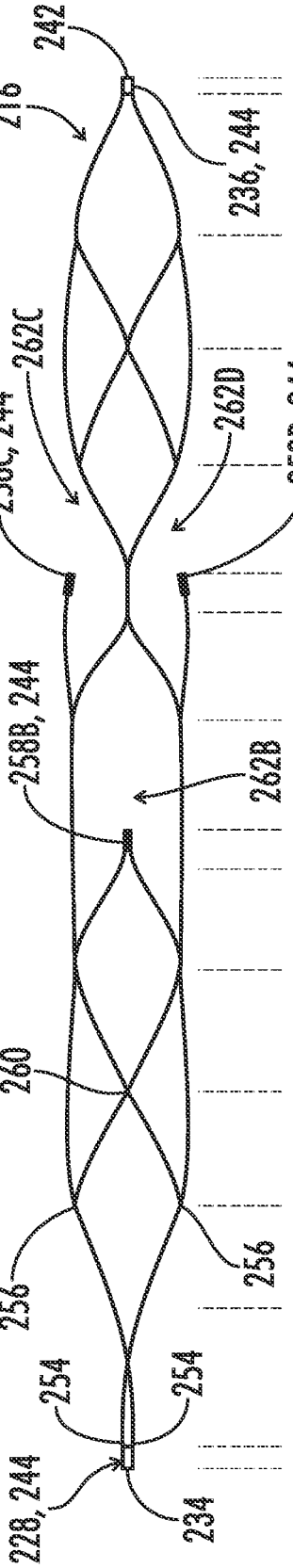


FIG. 14B

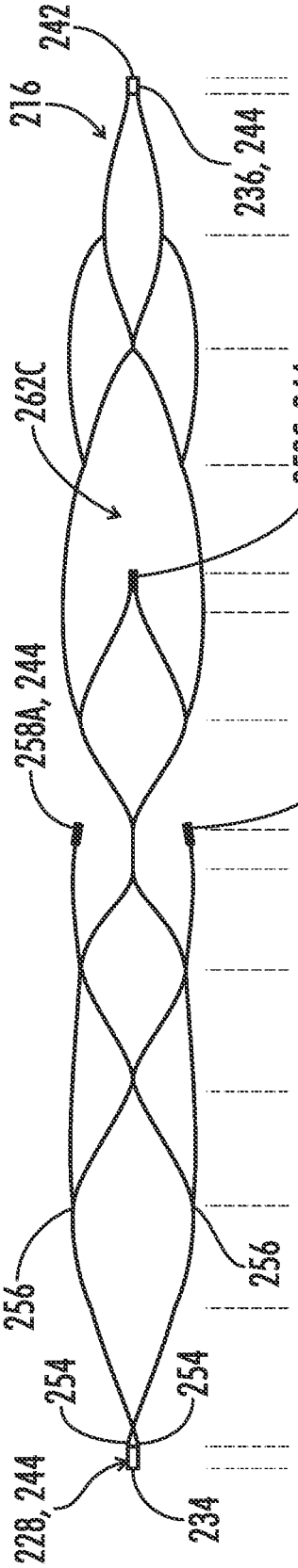


FIG. 14C

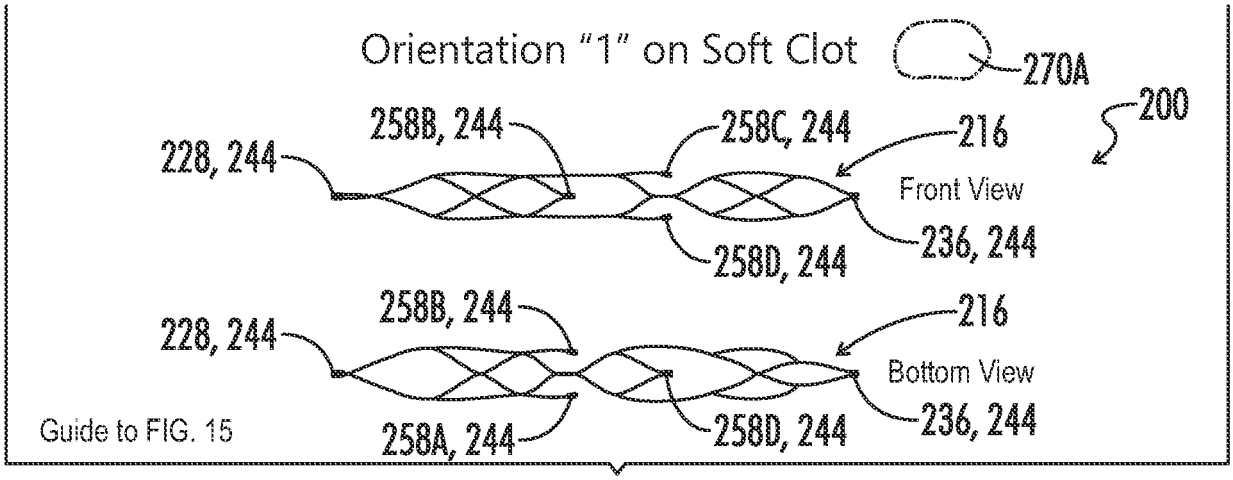


FIG. 15A

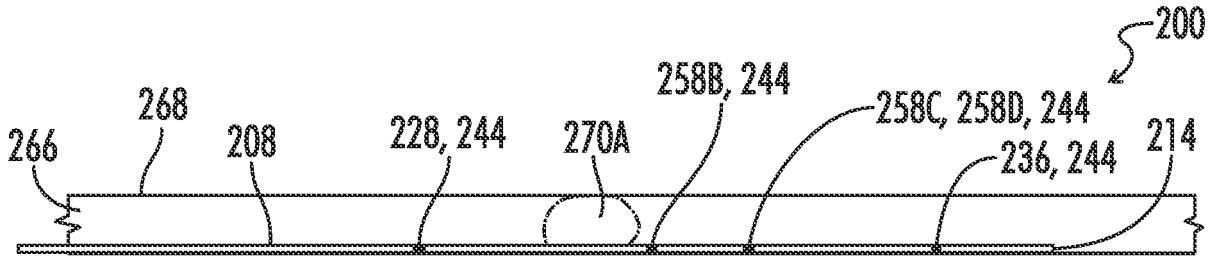


FIG. 15B

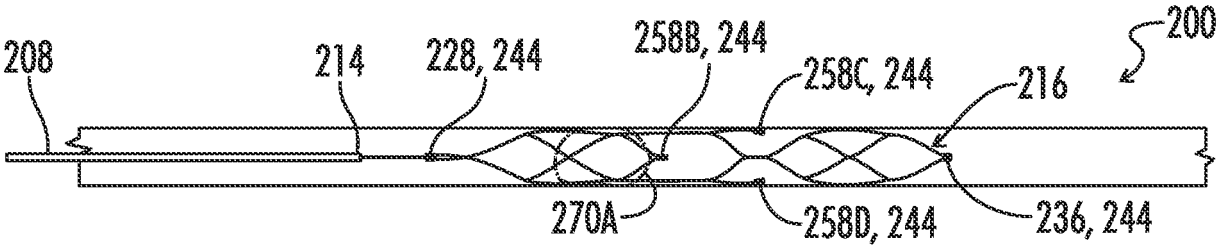


FIG. 15C

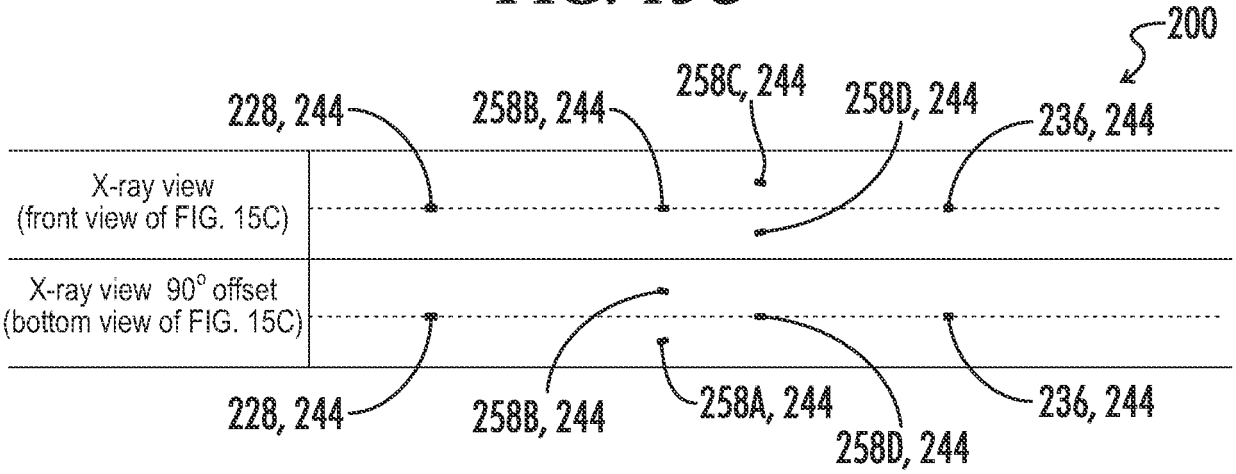


FIG. 15D

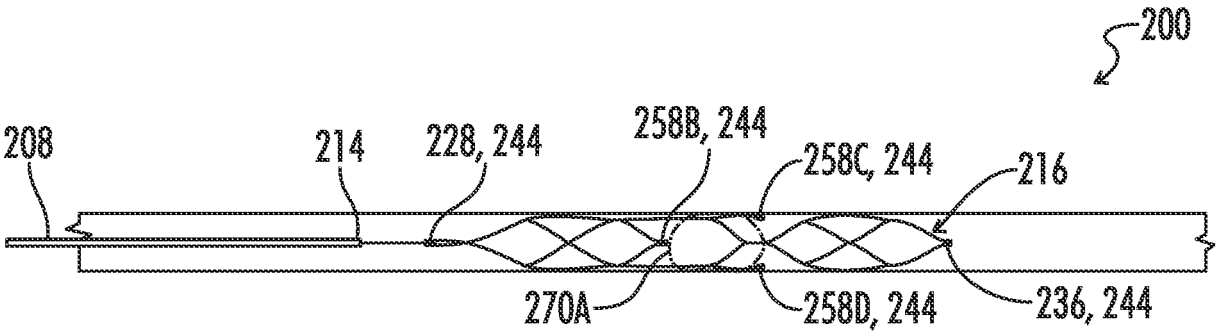


FIG. 15E

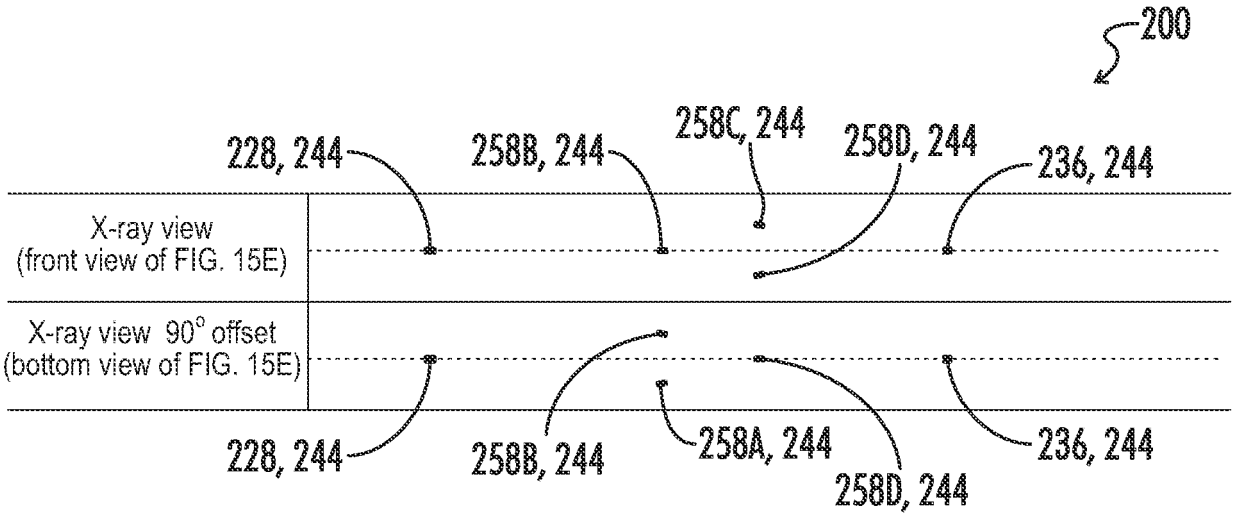


FIG. 15F

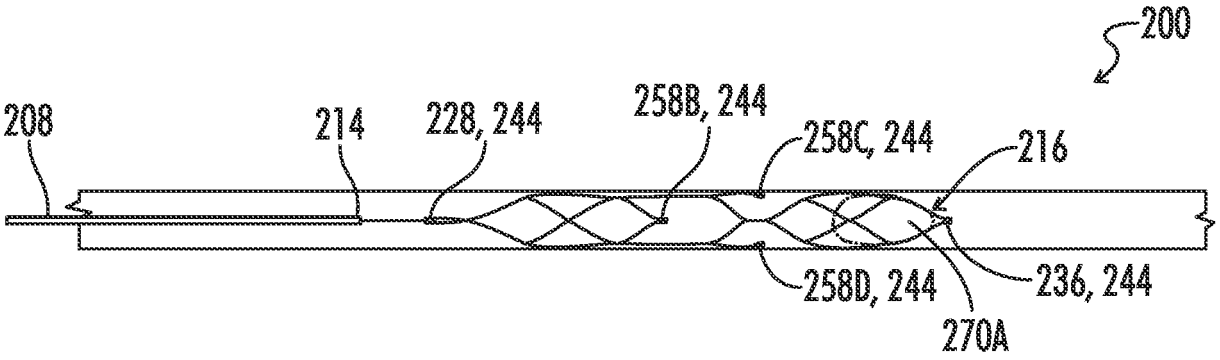


FIG. 15G

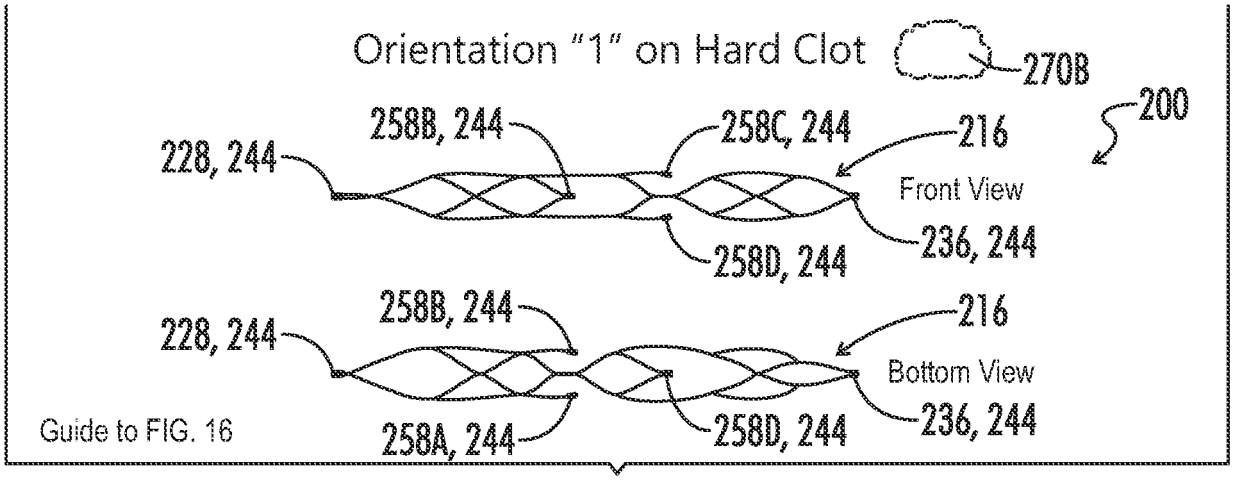


FIG. 16A

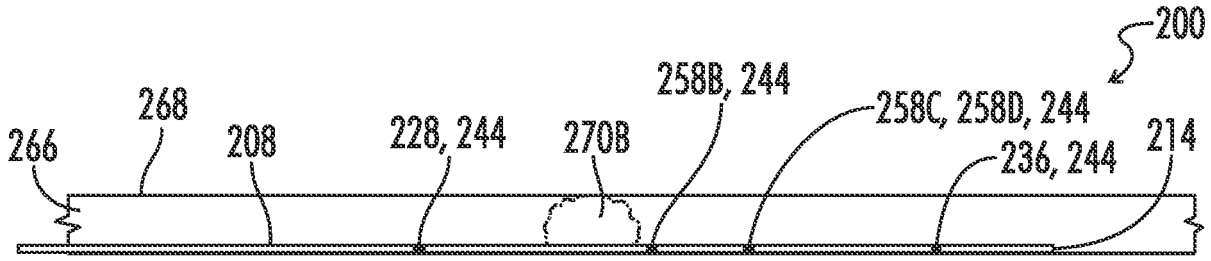


FIG. 16B

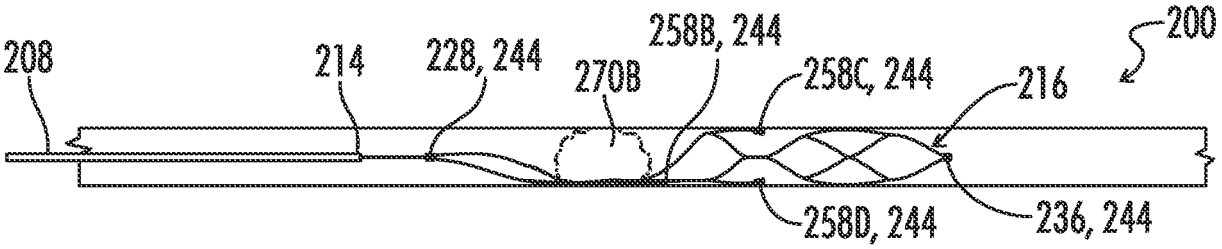


FIG. 16C

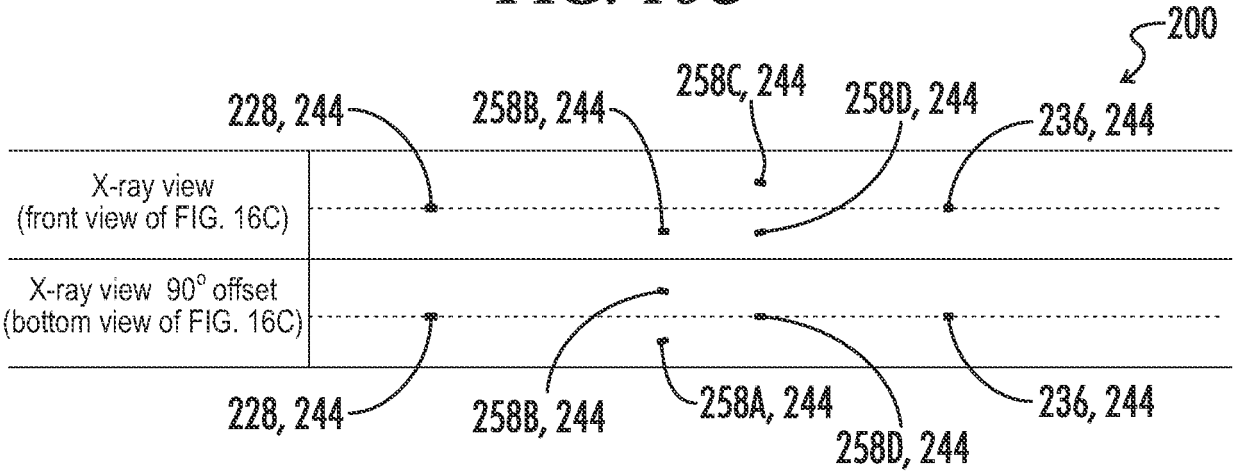


FIG. 16D

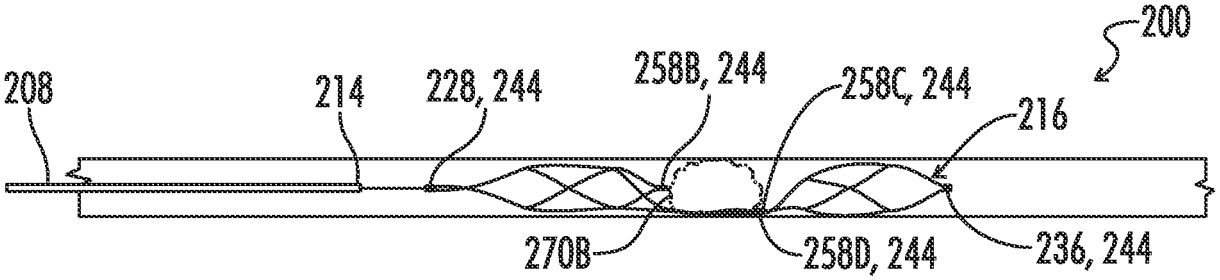


FIG. 16E

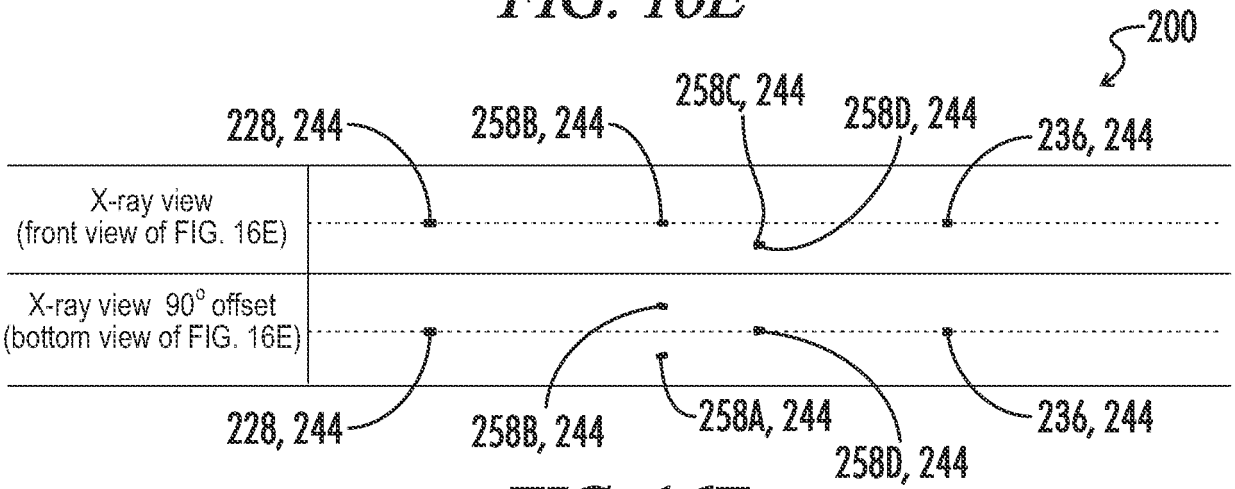


FIG. 16F

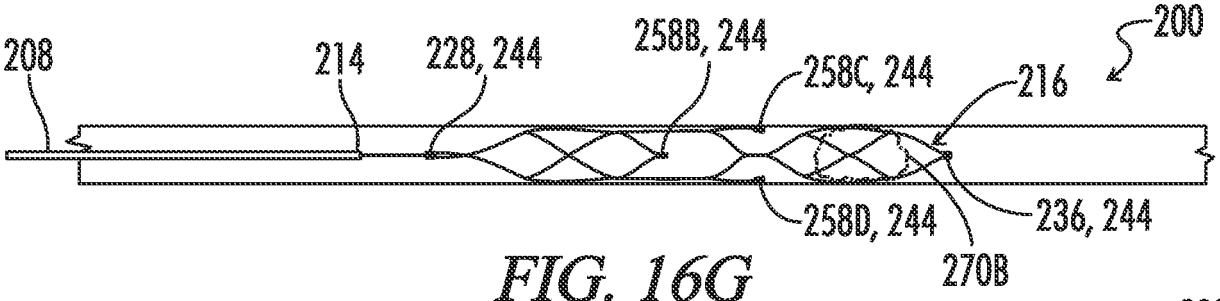


FIG. 16G

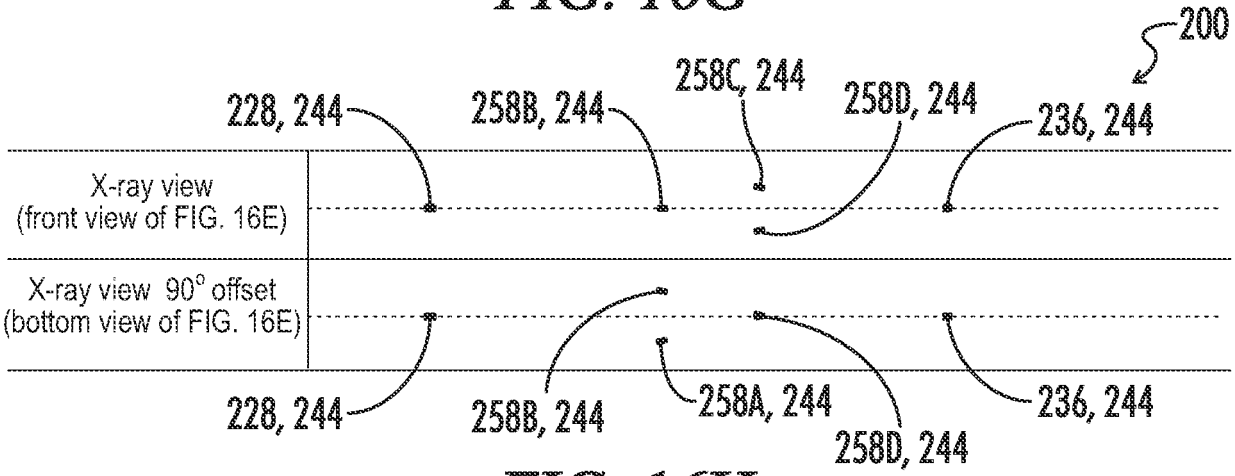


FIG. 16H

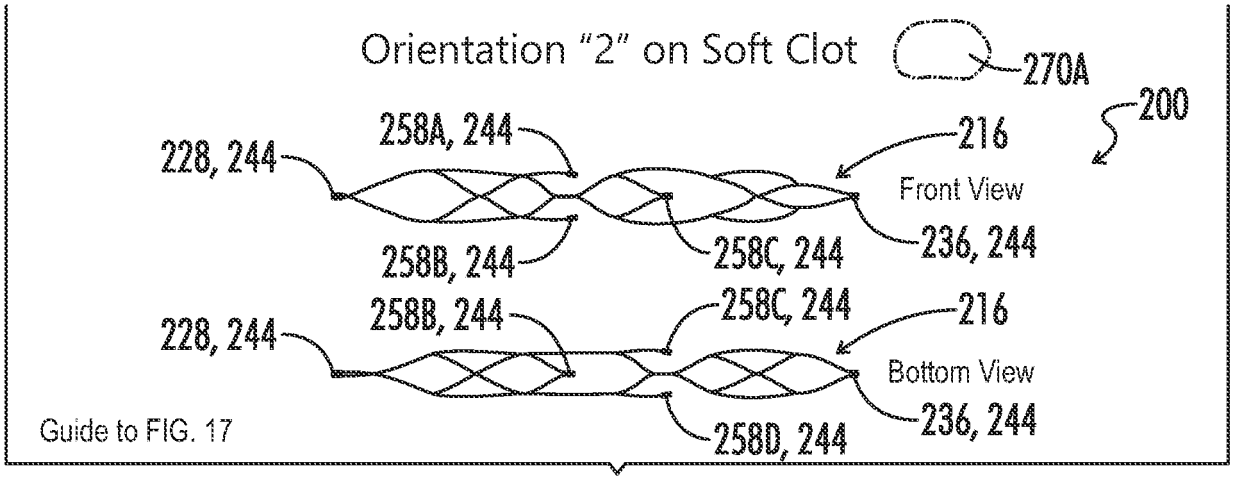


FIG. 17A

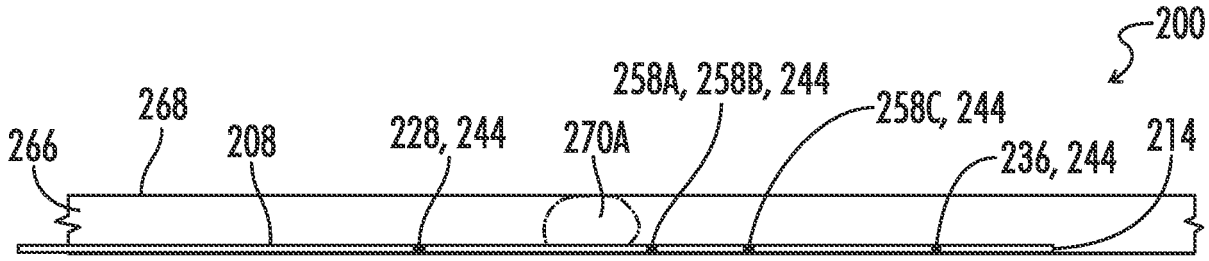


FIG. 17B

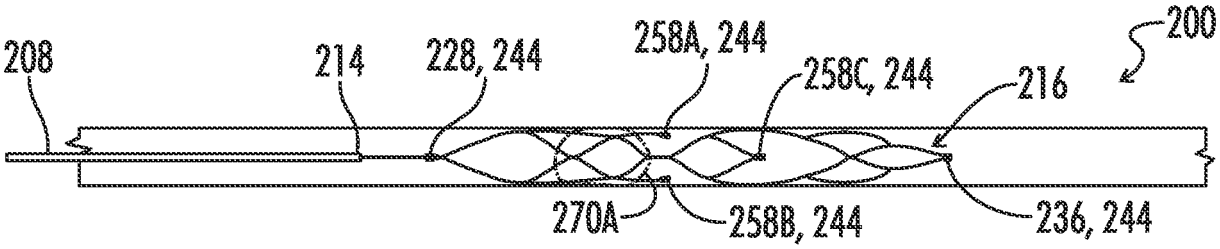


FIG. 17C

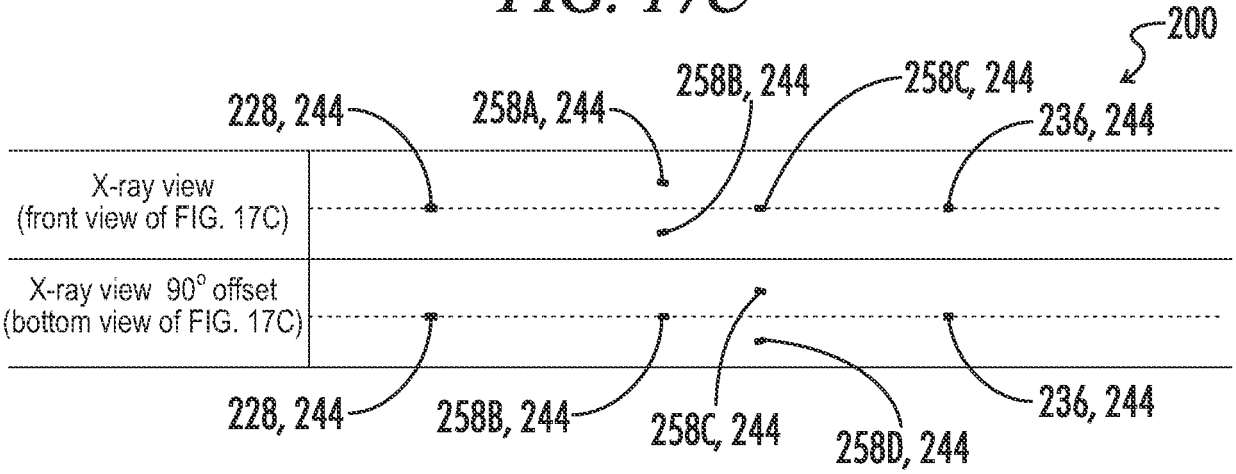


FIG. 17D

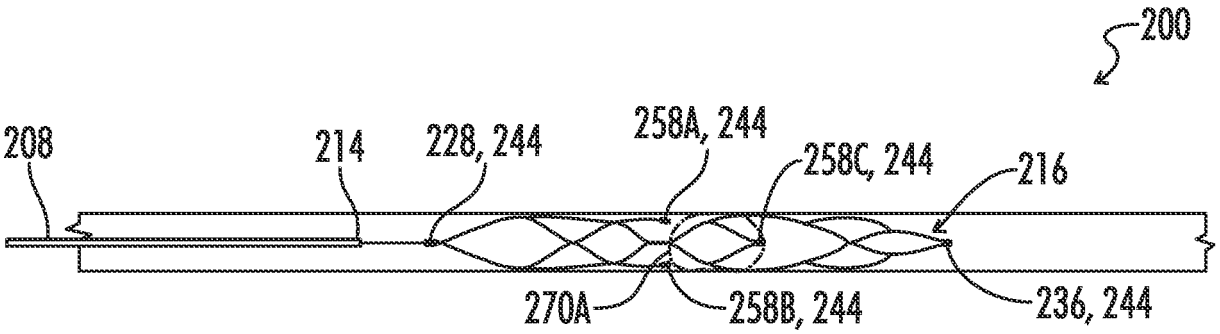


FIG. 17E

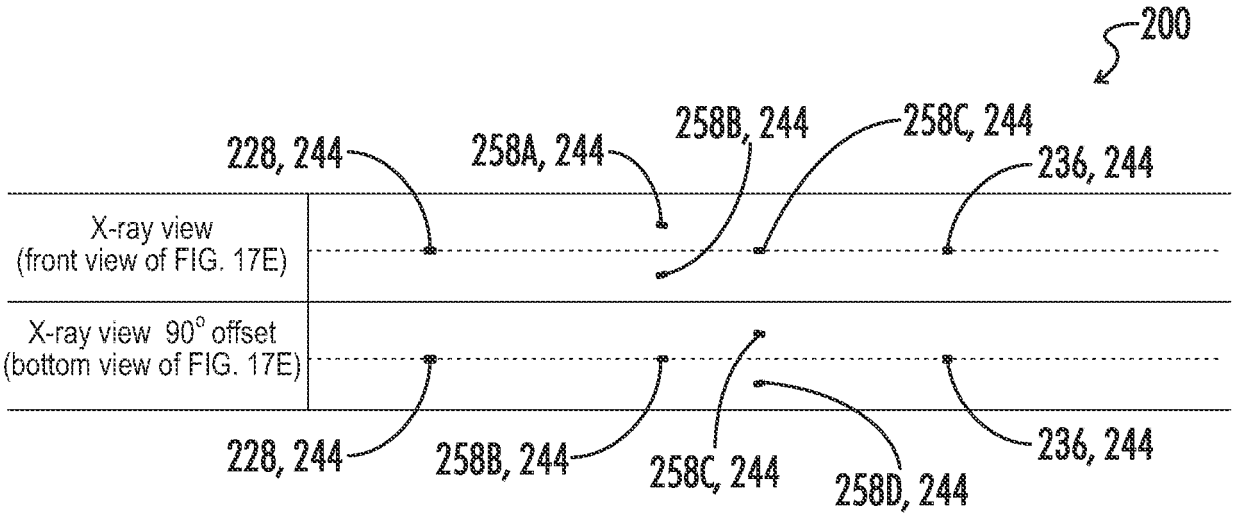


FIG. 17F

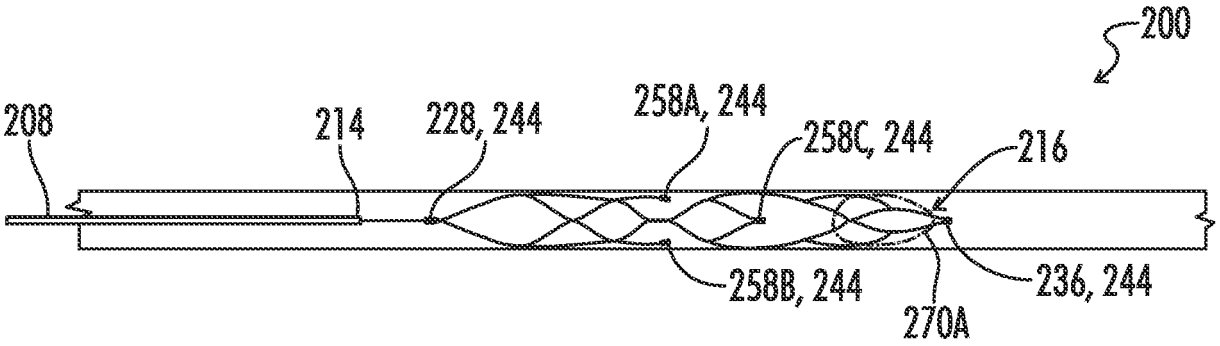


FIG. 17G

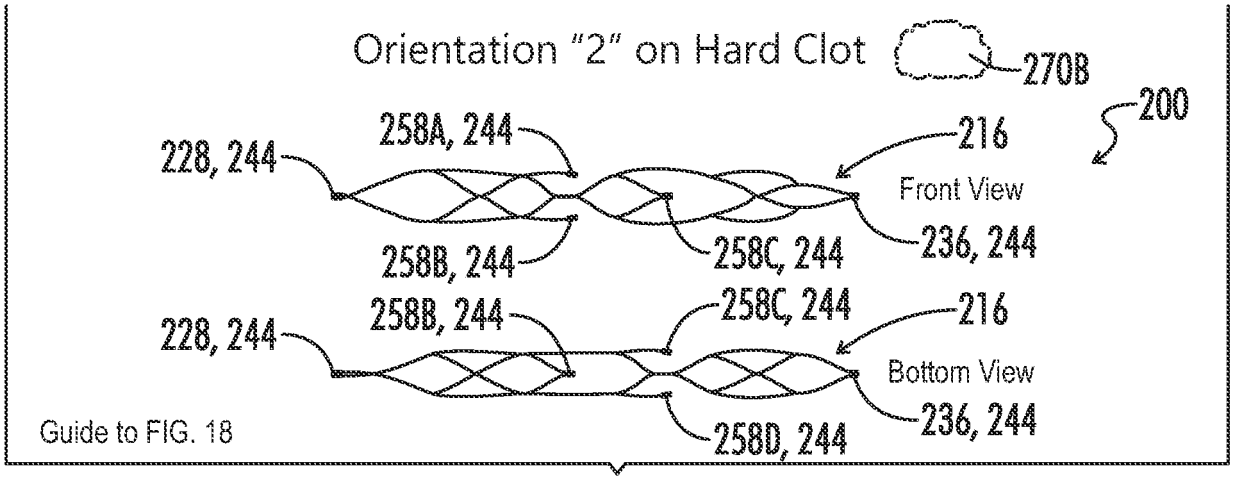


FIG. 18A

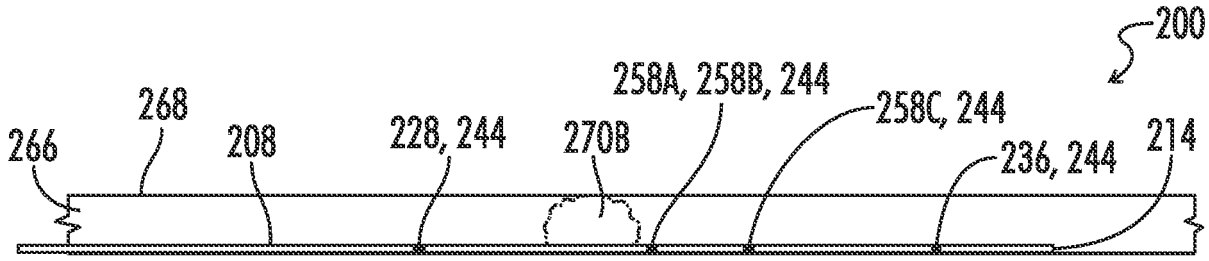


FIG. 18B

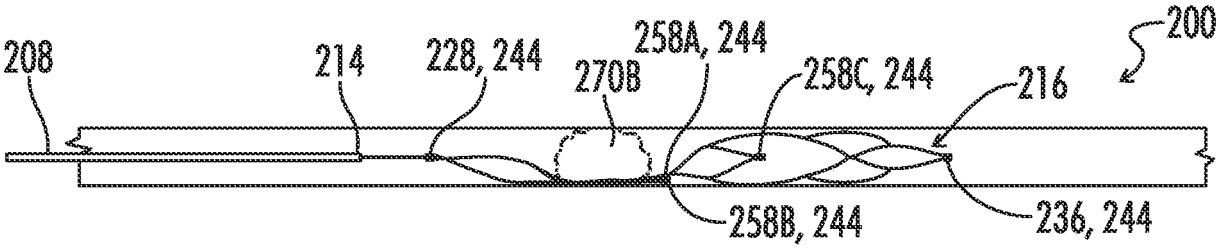


FIG. 18C

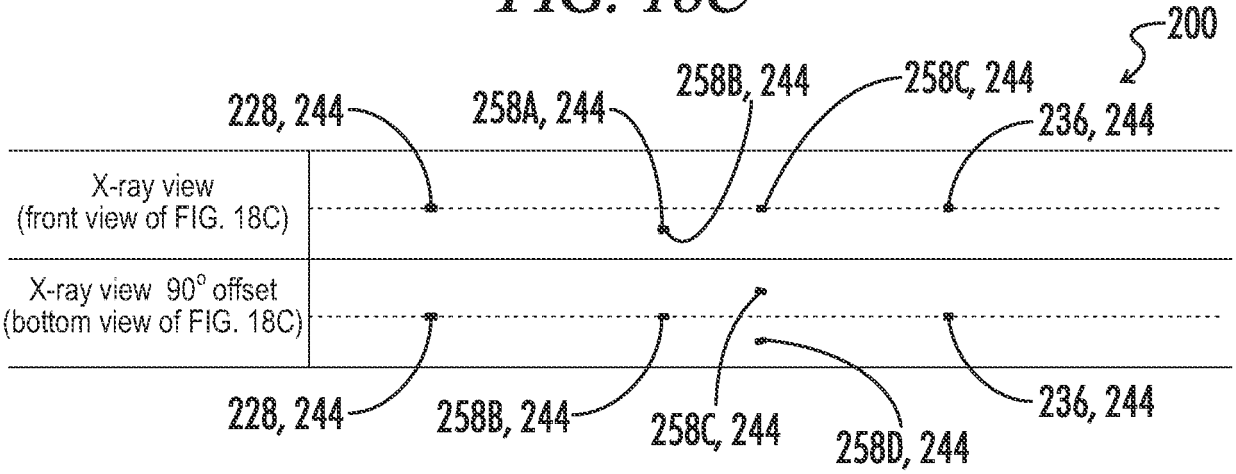


FIG. 18D

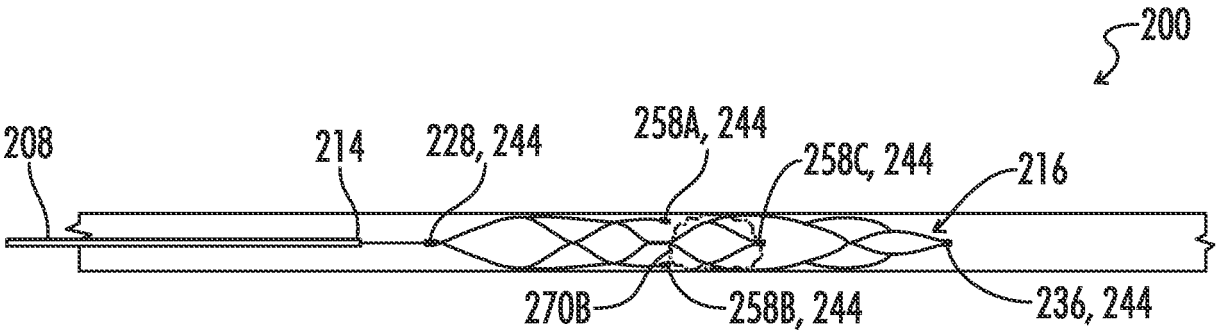


FIG. 18E

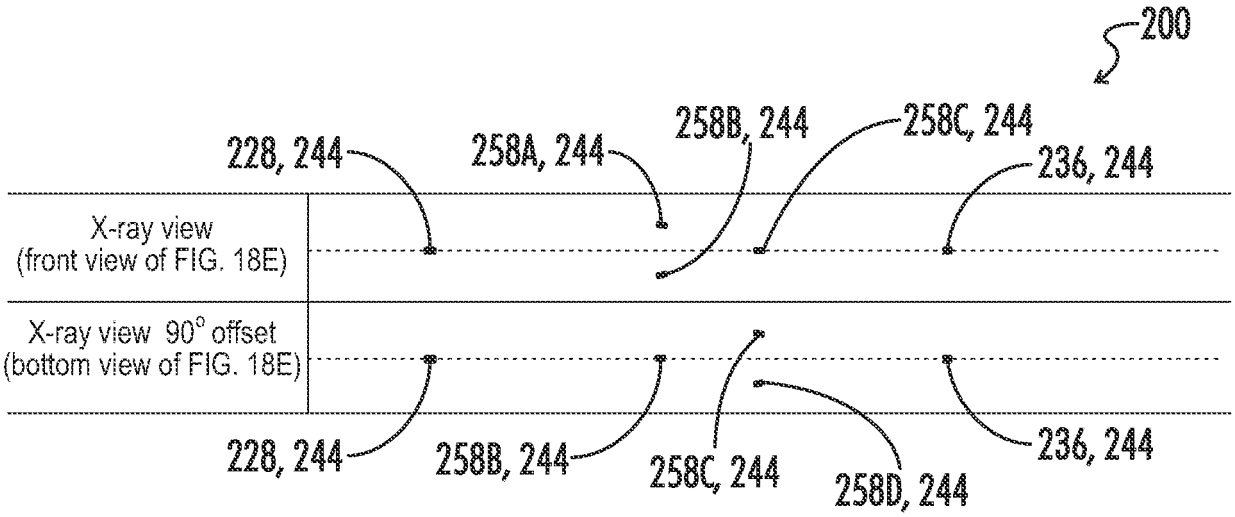


FIG. 18F

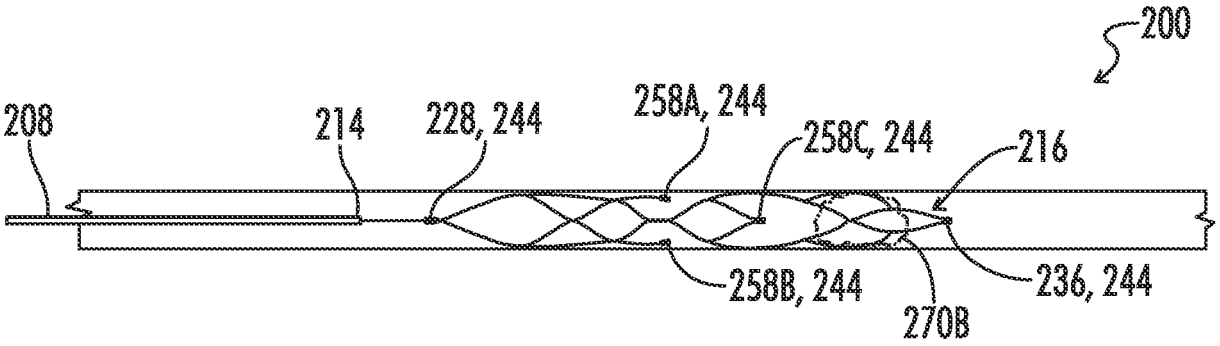


FIG. 18G

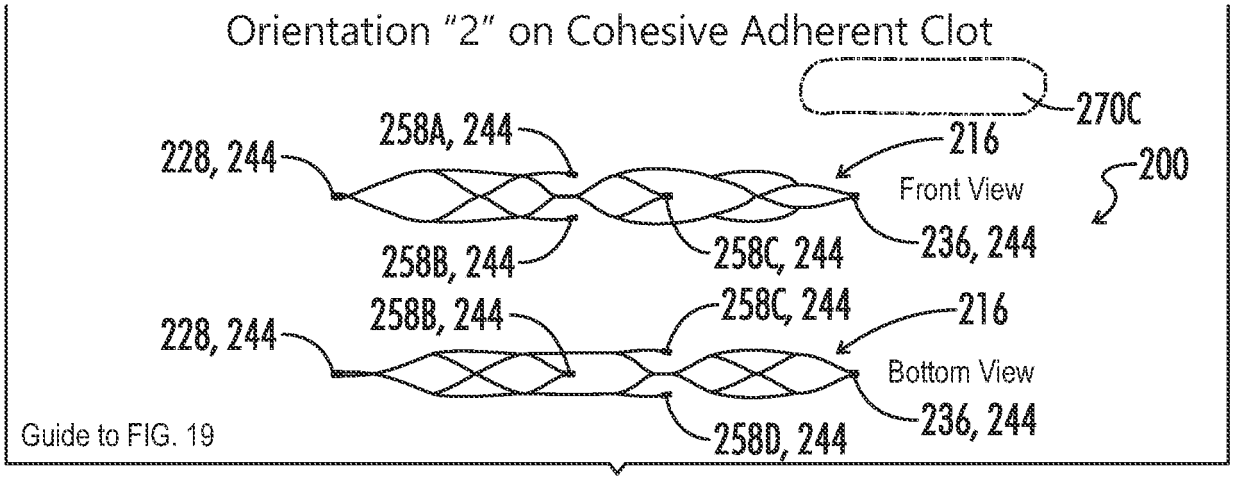


FIG. 19A

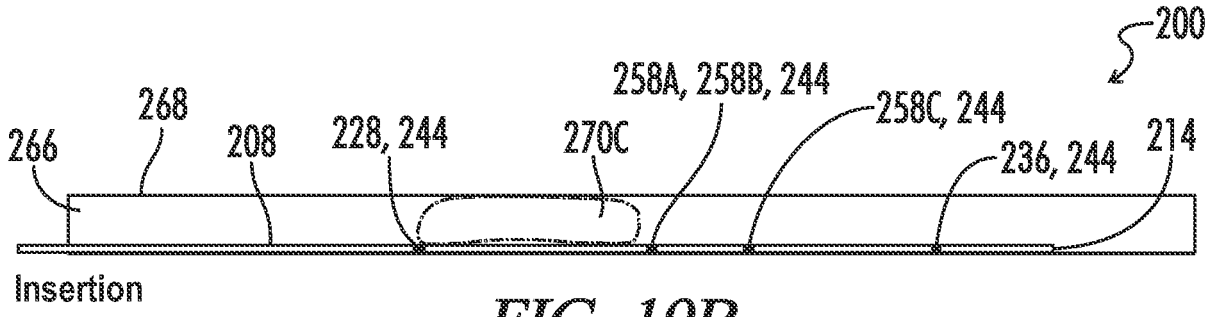


FIG. 19B

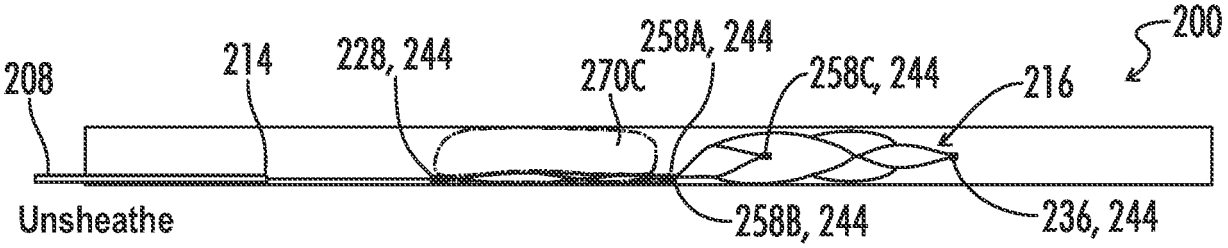


FIG. 19C

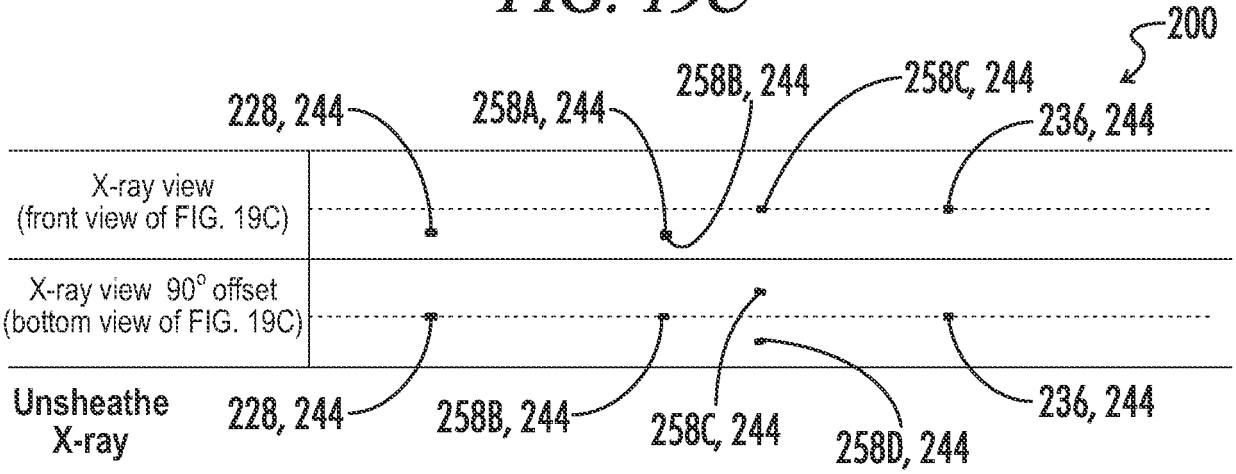


FIG. 19D

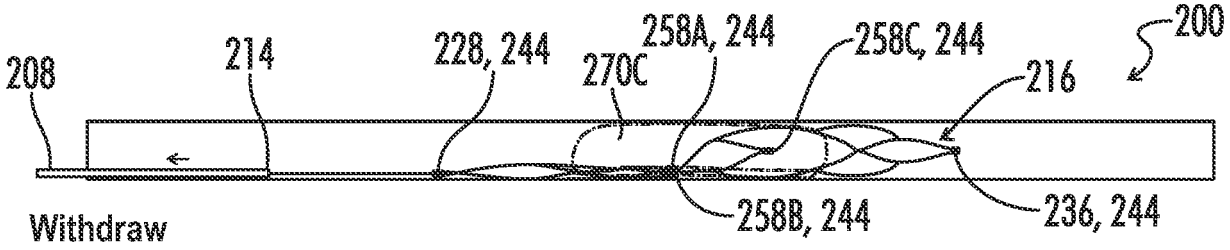


FIG. 19E

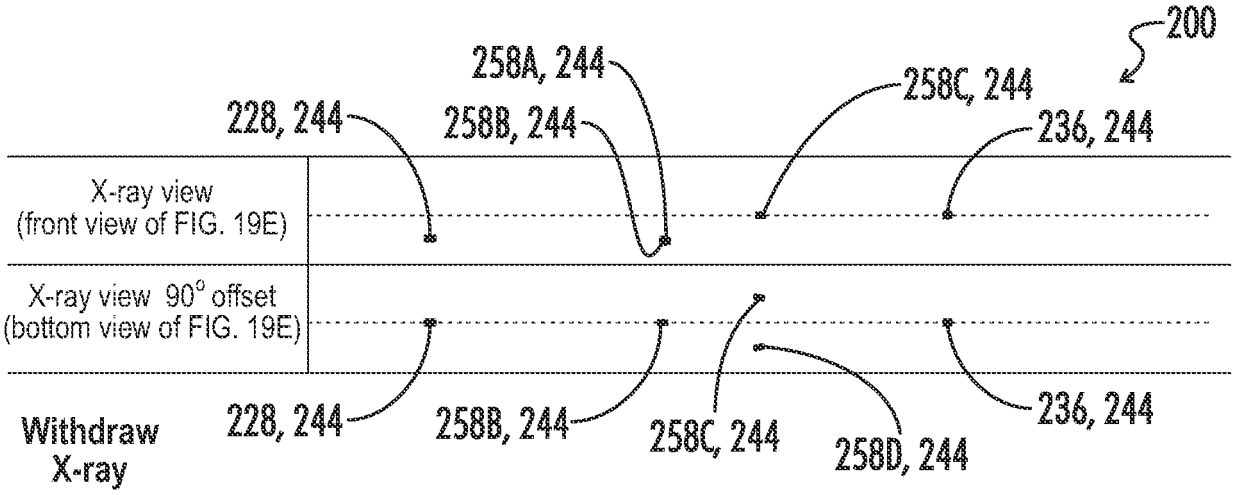


FIG. 19F

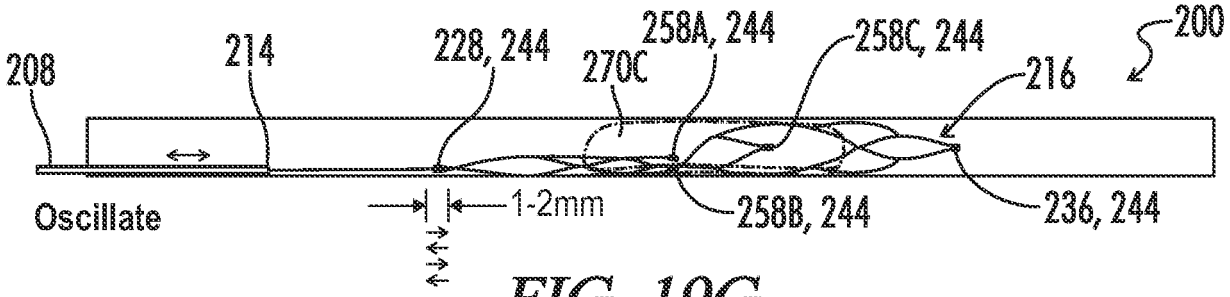


FIG. 19G

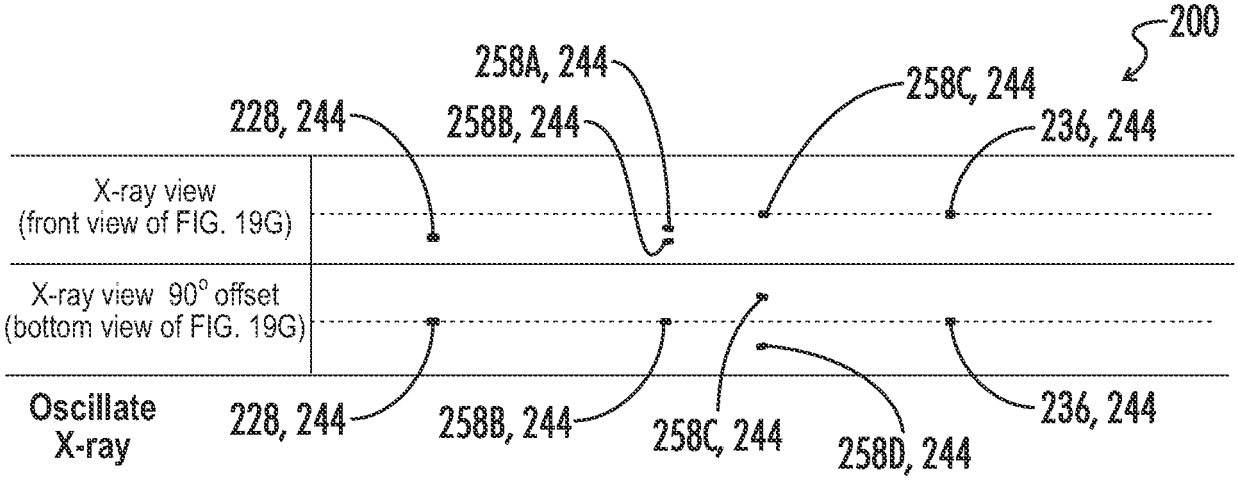


FIG. 19H

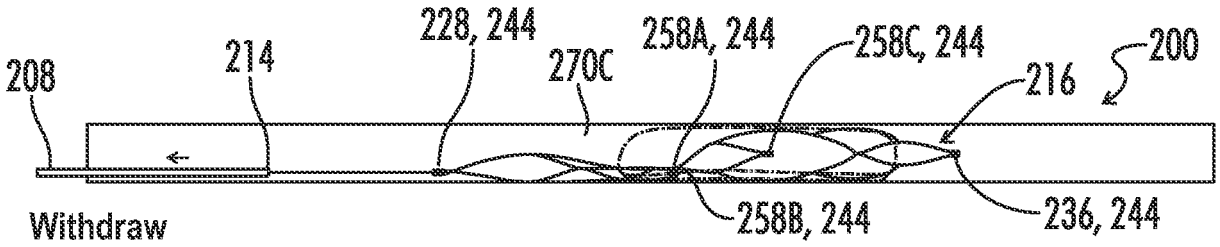


FIG. 19I

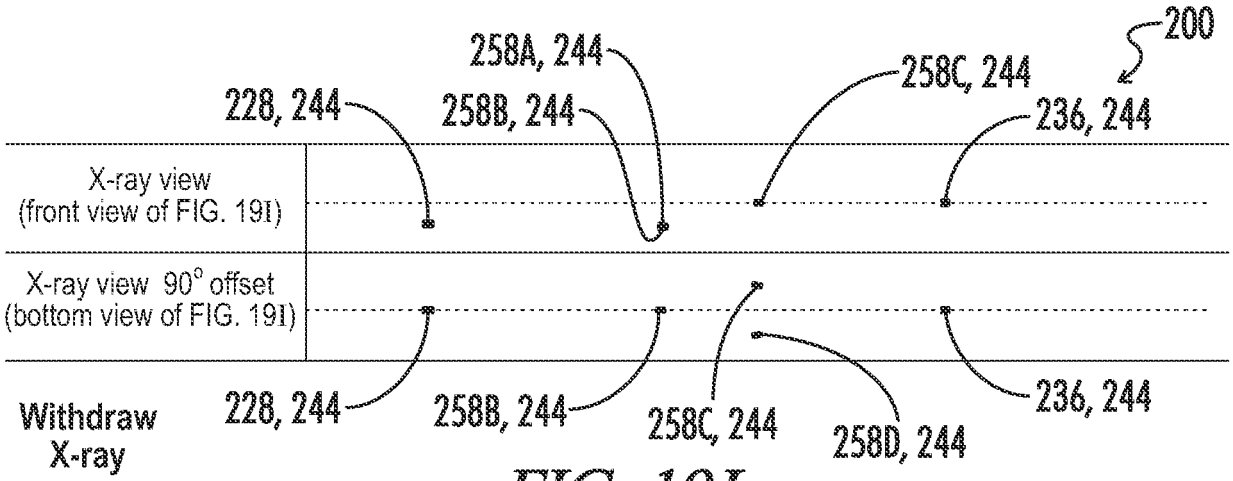


FIG. 19J

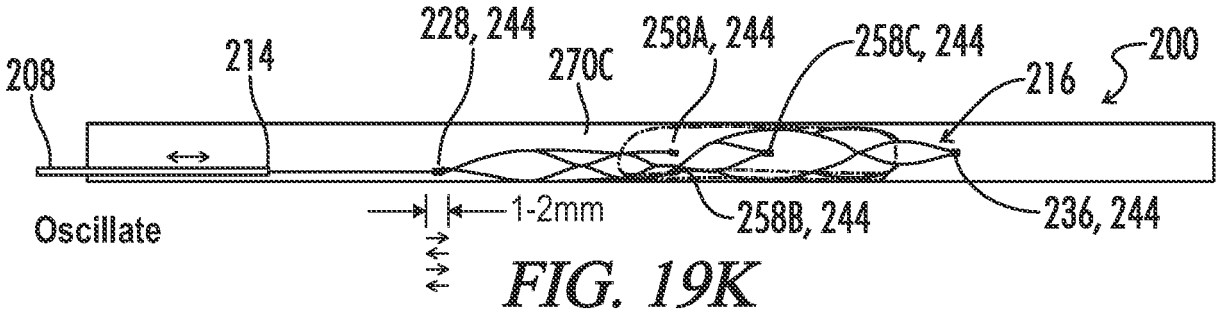


FIG. 19K

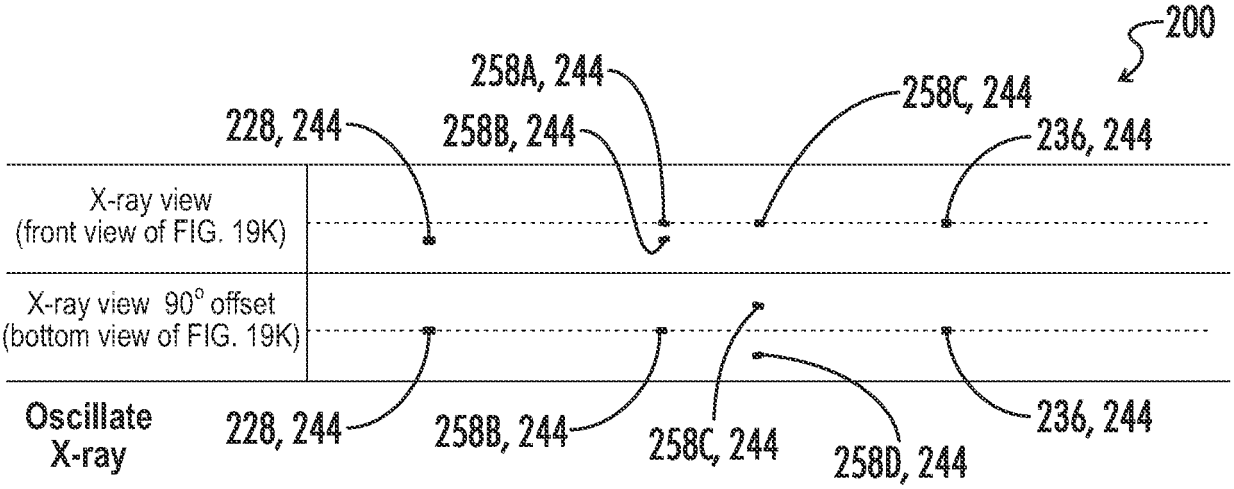


FIG. 19L

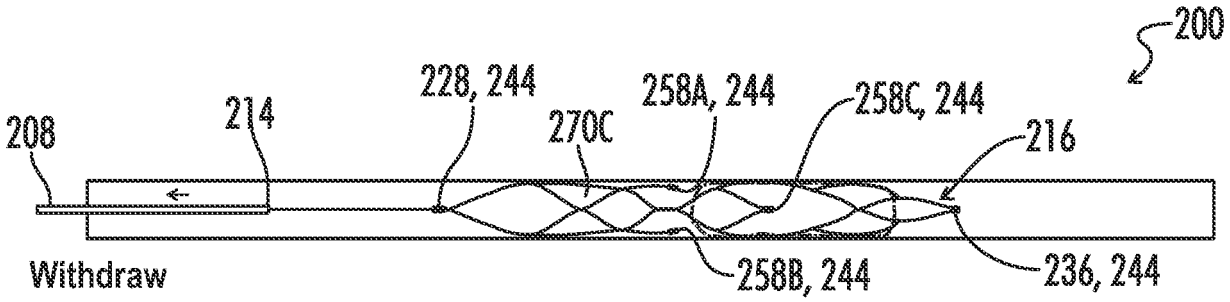


FIG. 19M

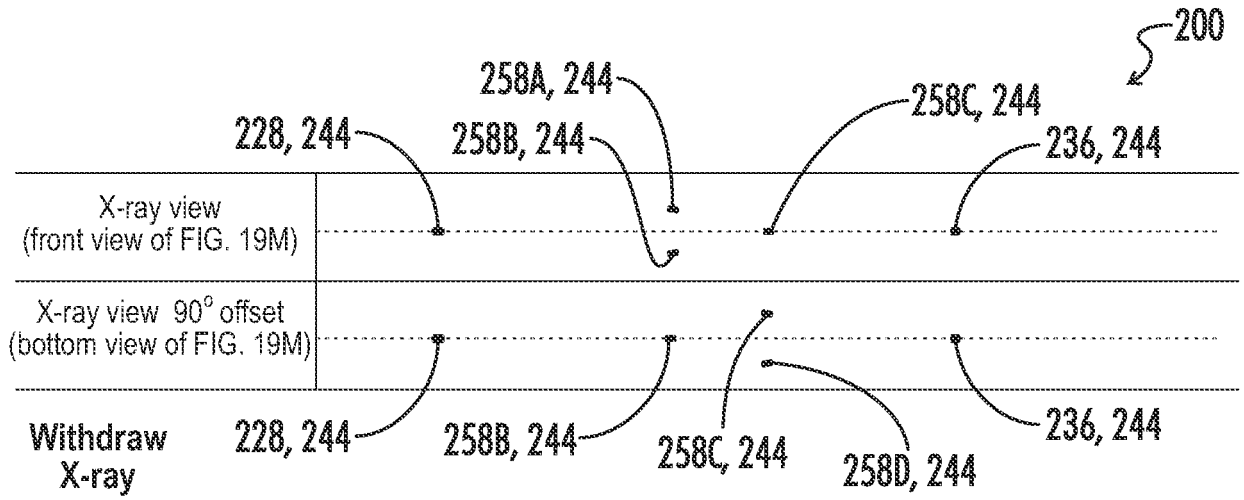


FIG. 19N

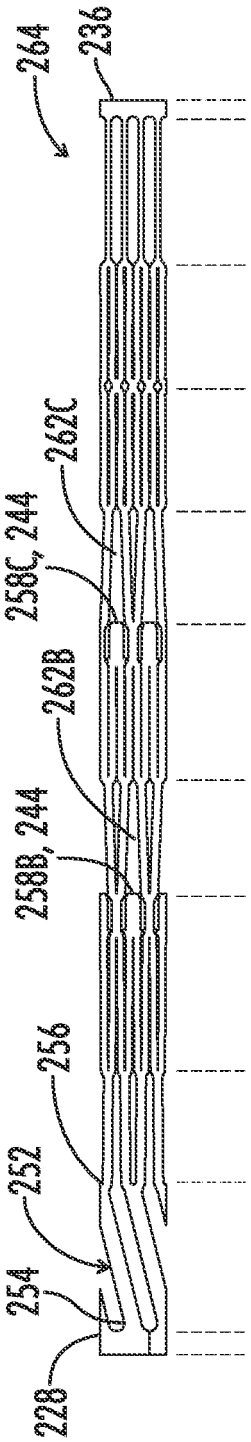


FIG. 20A

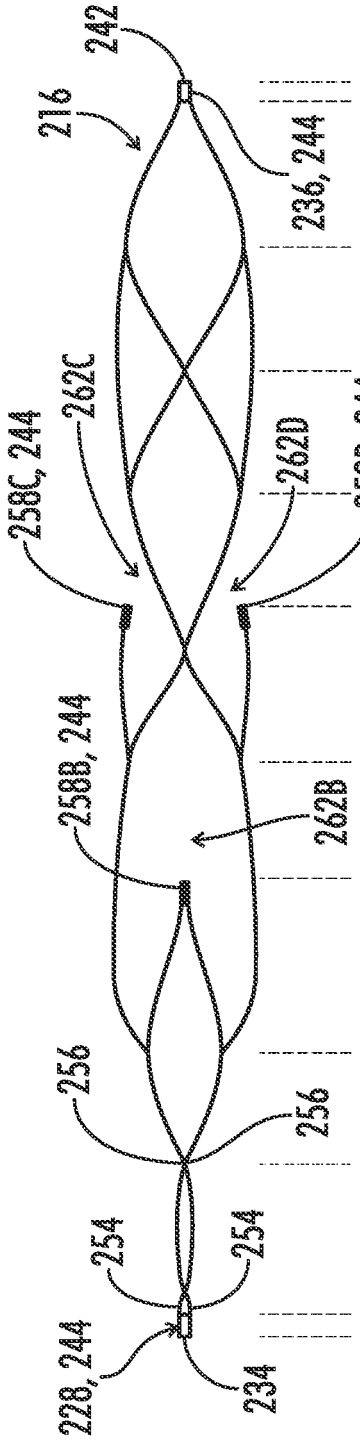


FIG. 20B

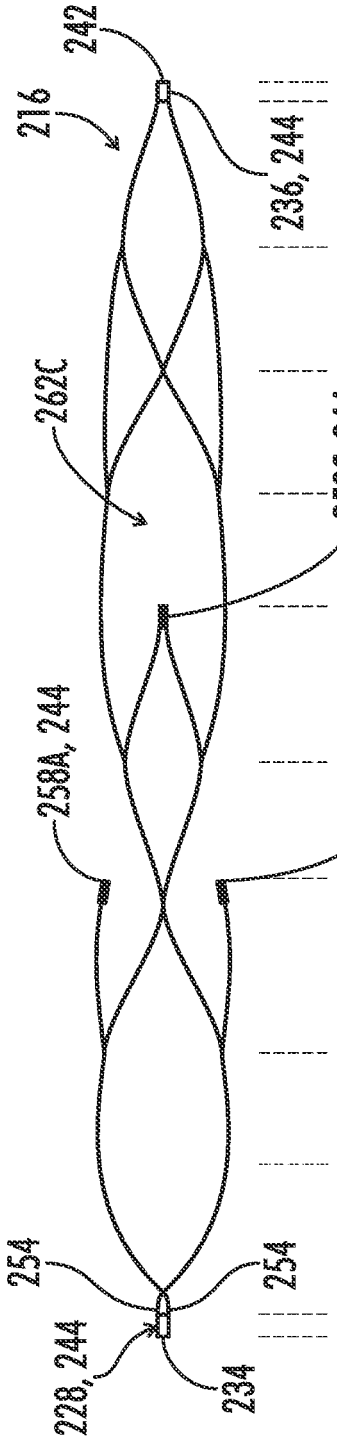


FIG. 20C

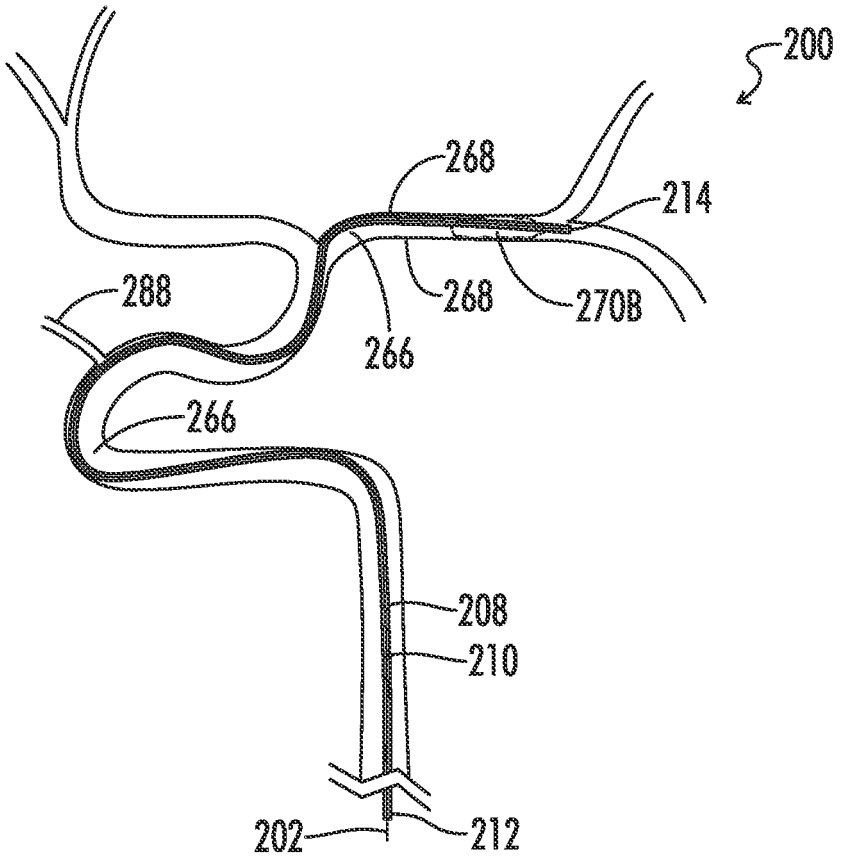

200
268
214
288
268
270B
266
266
208
210
202
212

FIG. 21

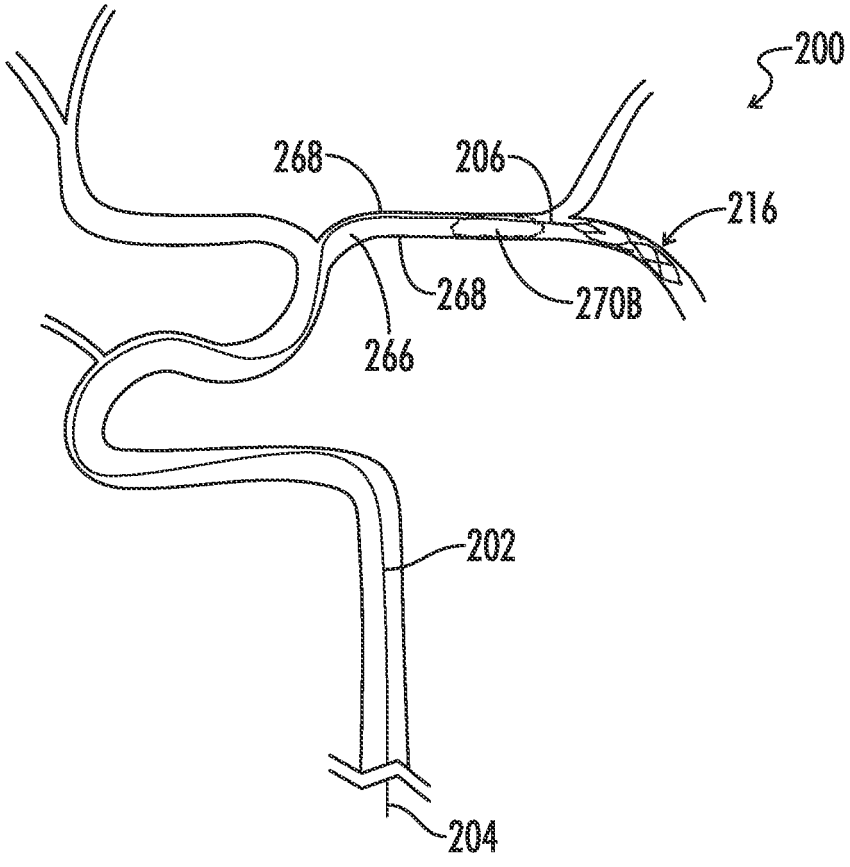

200
268
206
216
268
270B
266
202
204

FIG. 22

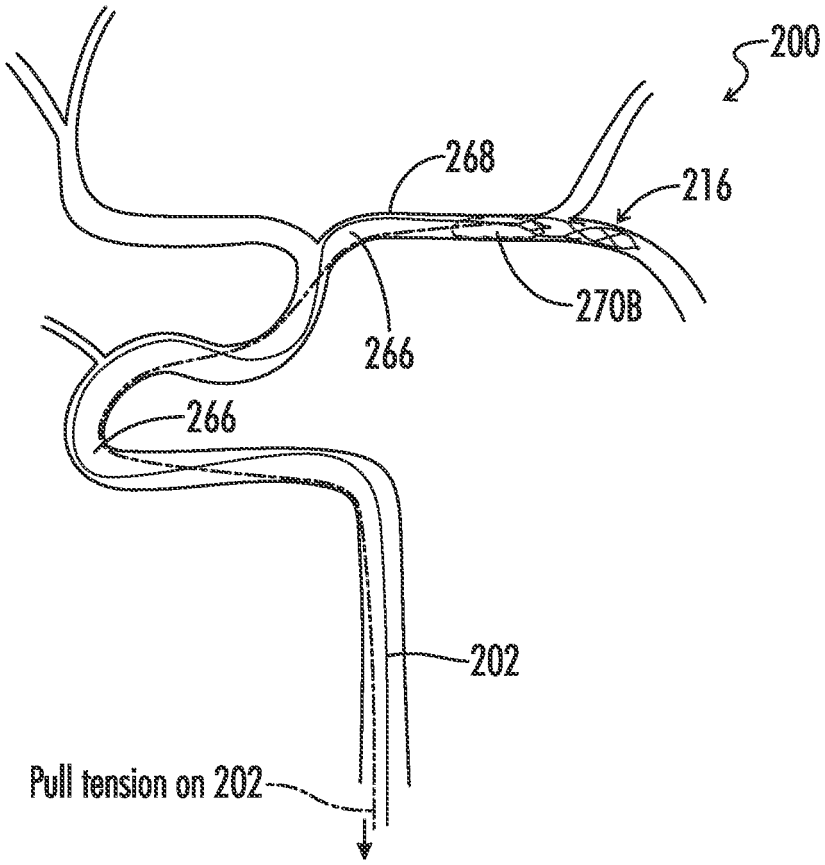

200
268
216
270B
266
266
202
Pull tension on 202

FIG. 23

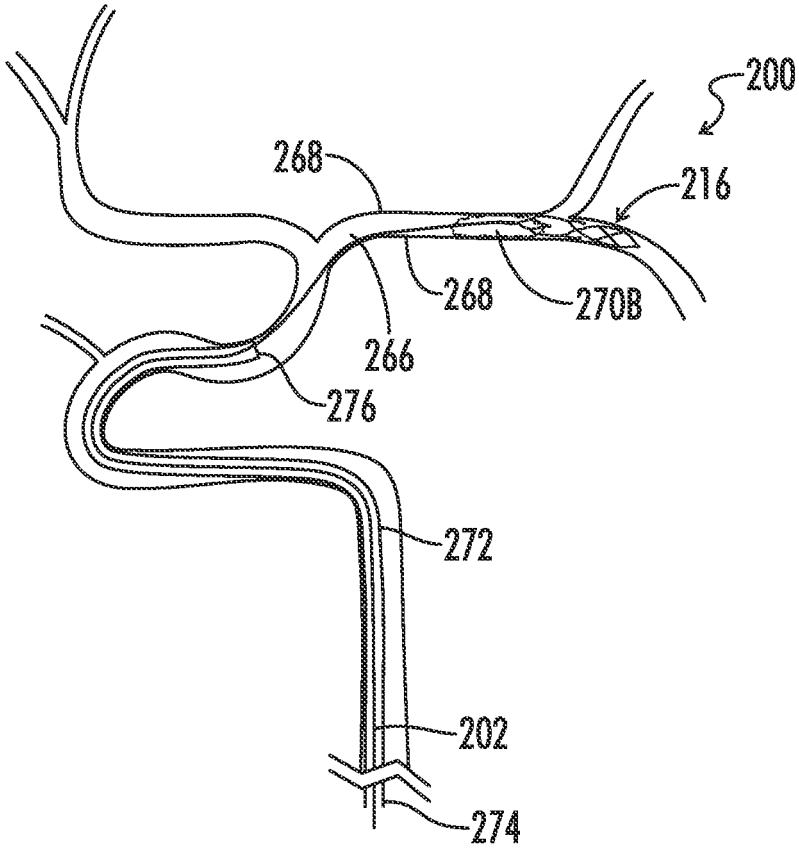

200
268
216
268
270B
266
276
272
202
274

FIG. 24

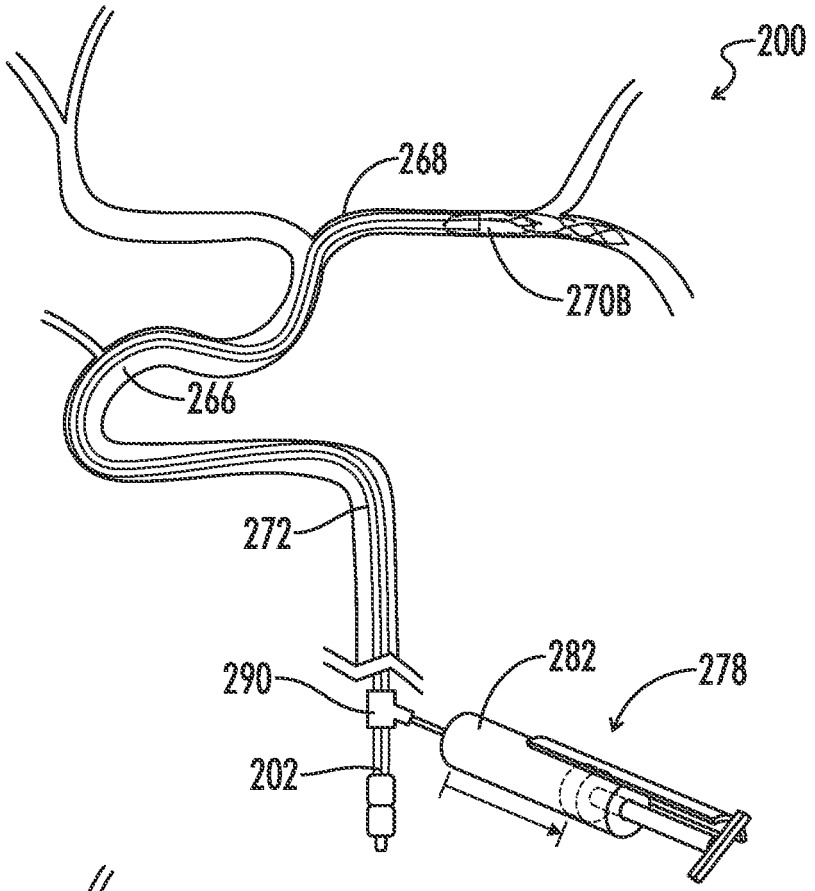

200
268
270B
266
272
290
282
278
202

FIG. 25

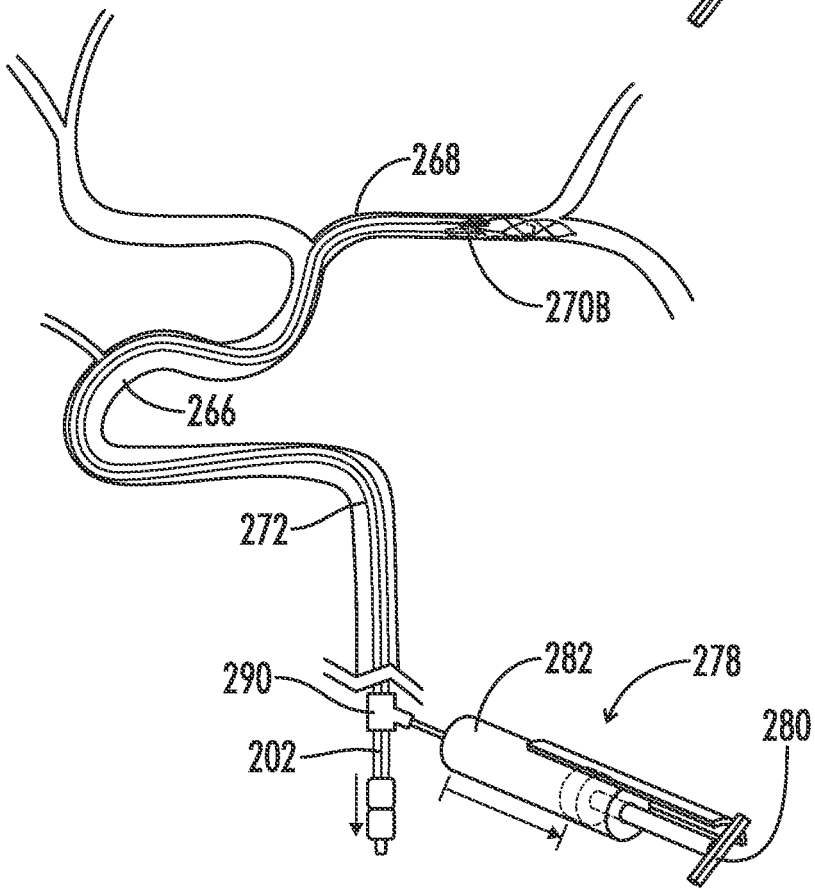

268
270B
266
272
290
282
278
280
202

FIG. 26

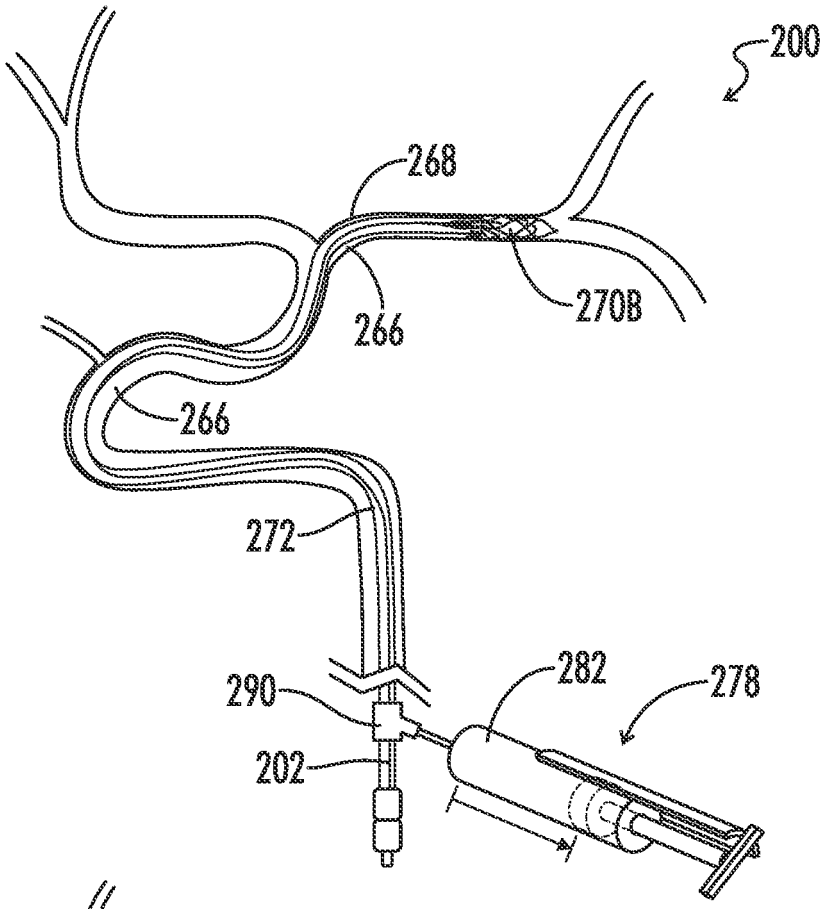

200
268
266
270B
266
272
290
282
278
202

FIG. 27

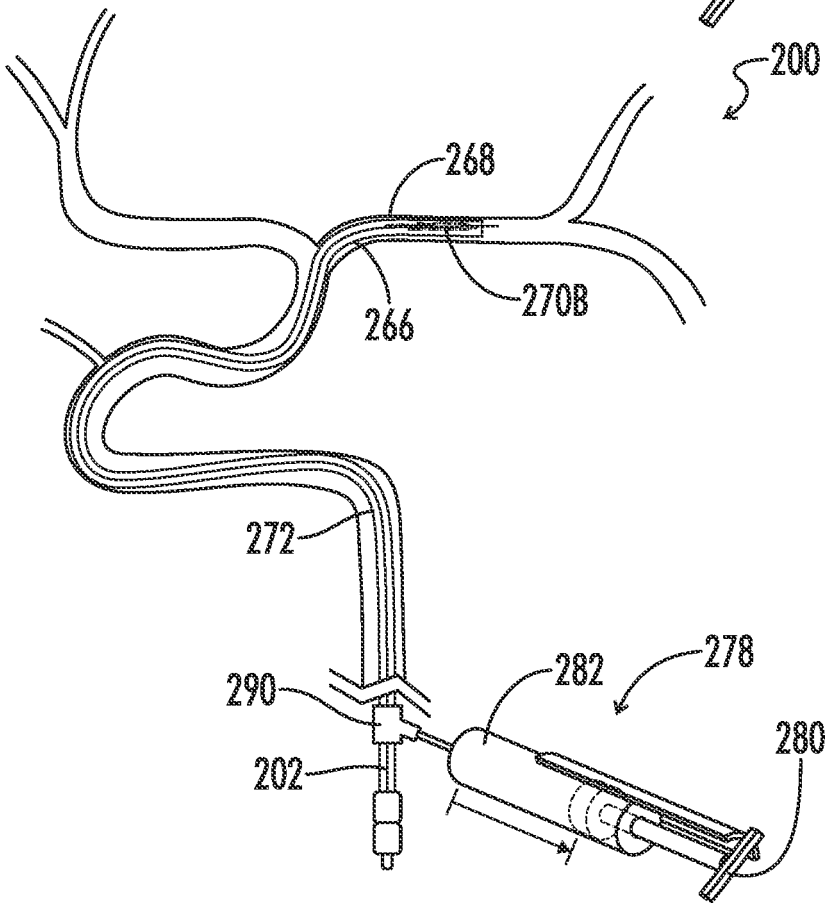
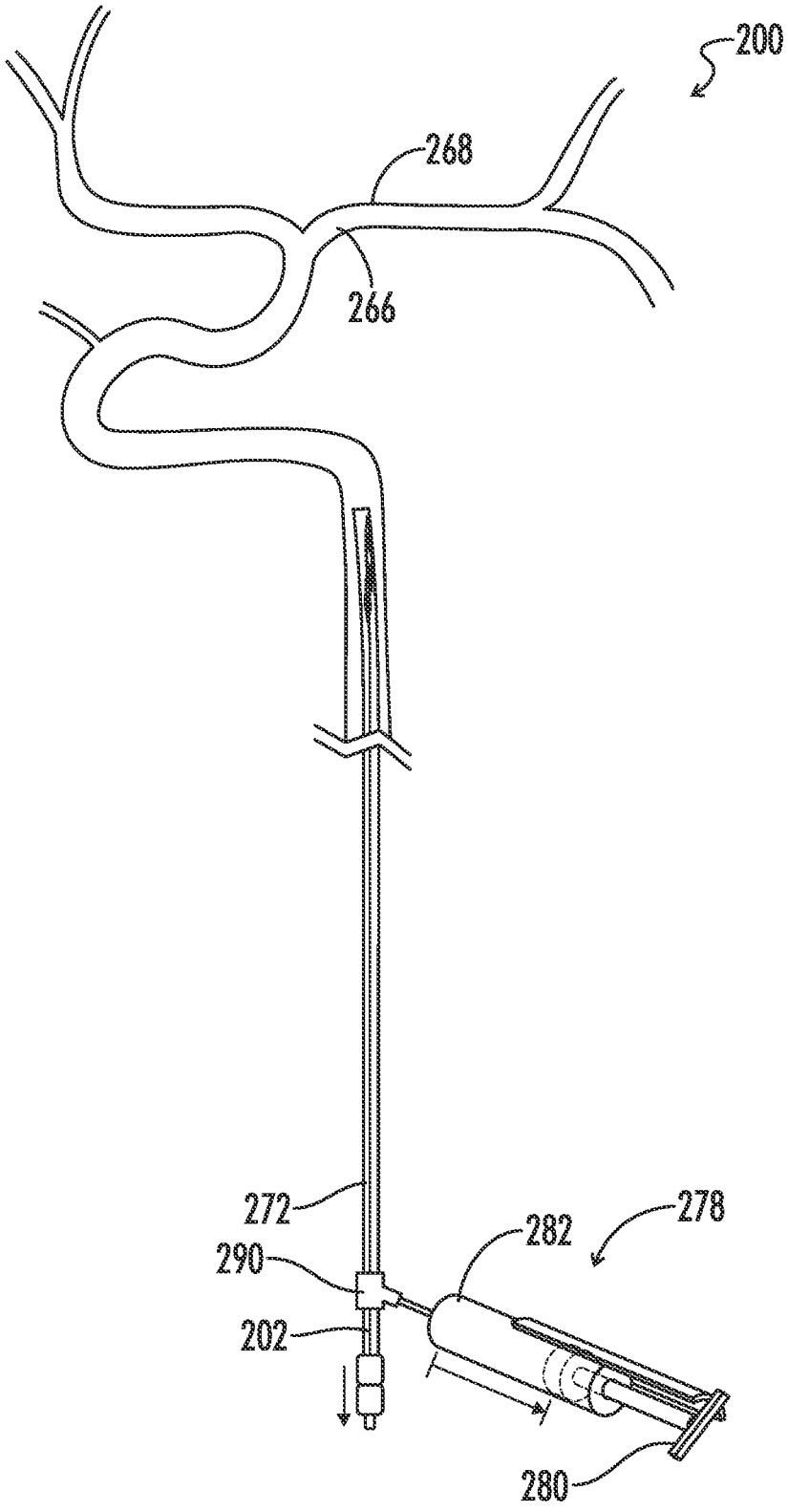

200
268
266
270B
272
290
282
278
280
202

FIG. 28

FIG. 29



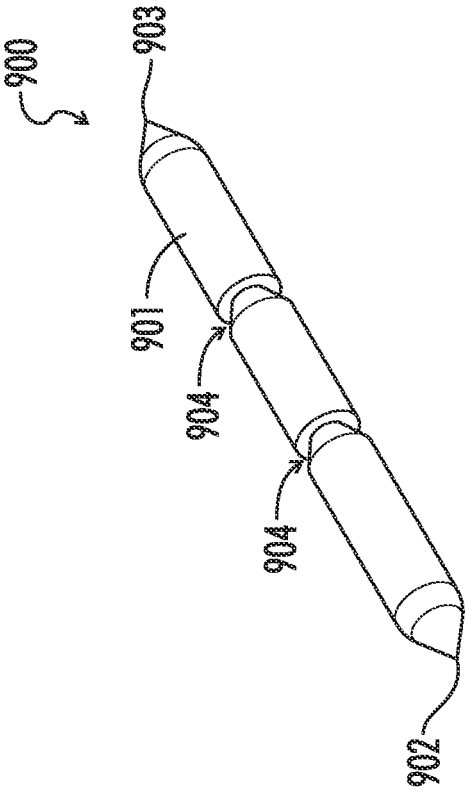


FIG. 30

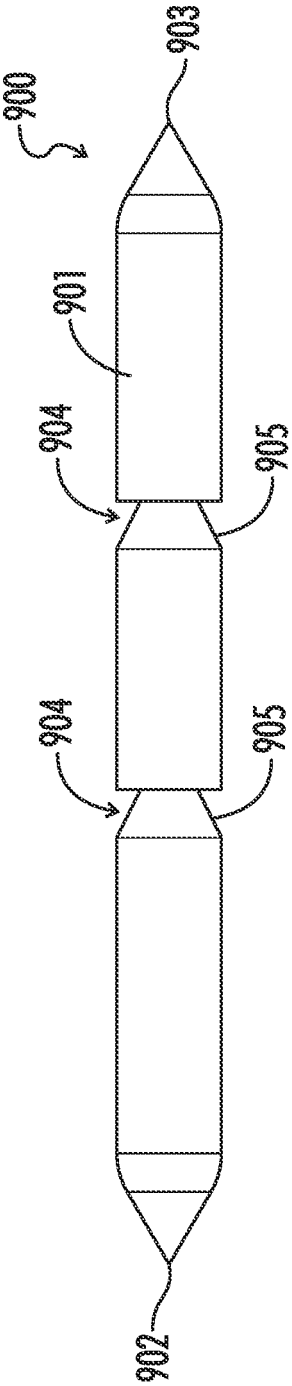


FIG. 31

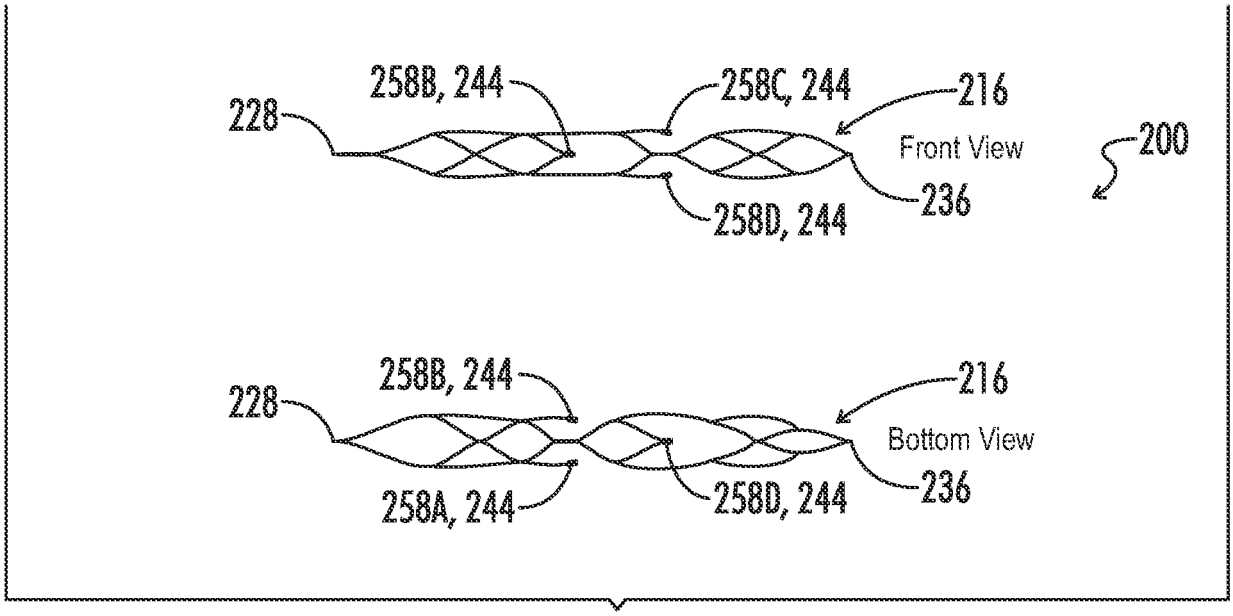

228
258B, 244
258C, 244
216
Front View
200
236
258D, 244
228
258B, 244
216
Bottom View
236
258A, 244
258D, 244

FIG. 32

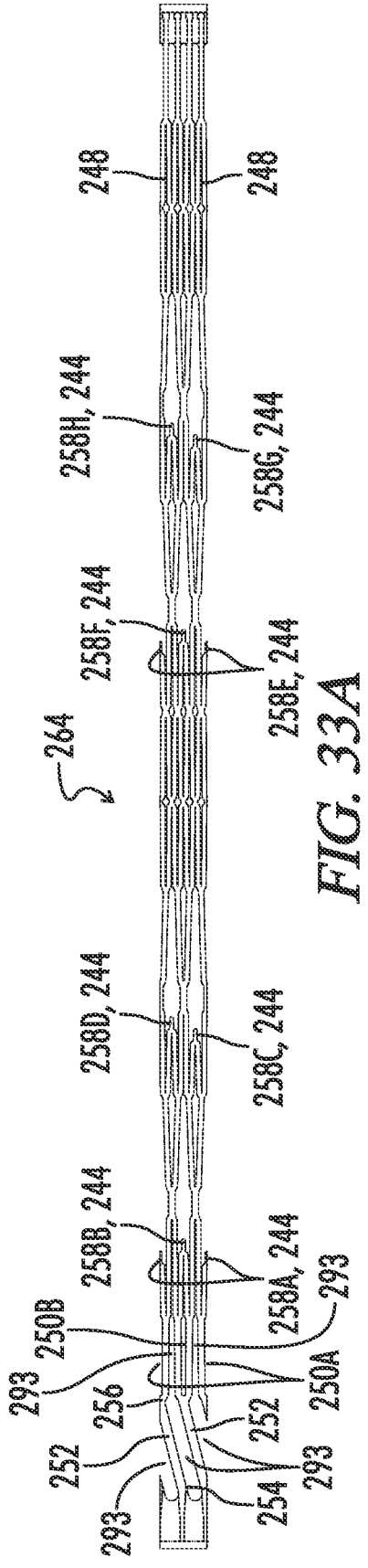


FIG. 33A

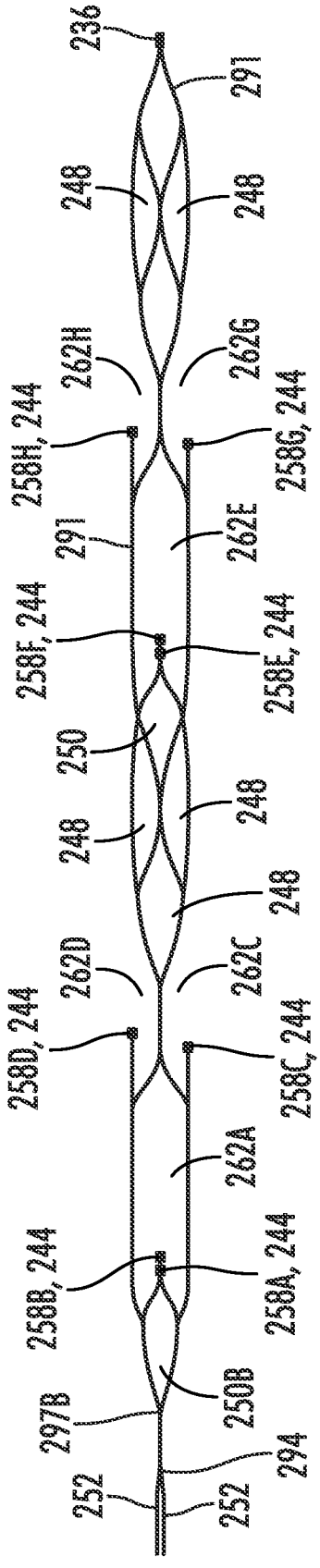


FIG. 33B

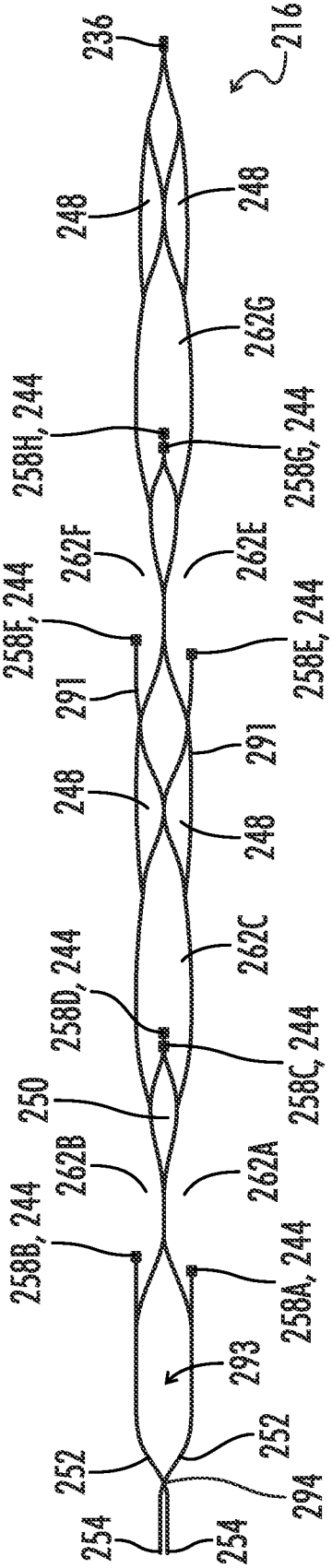


FIG. 33C

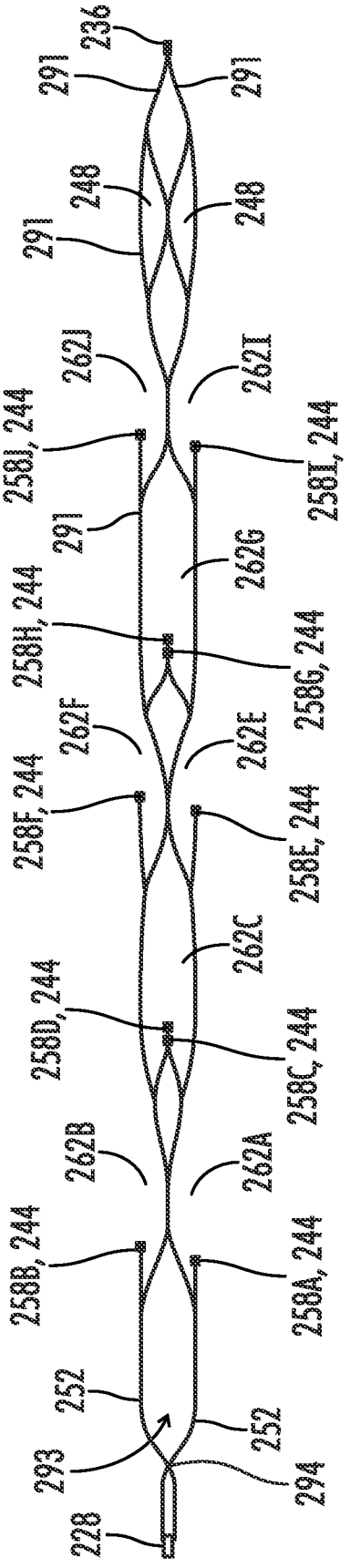


FIG. 34A

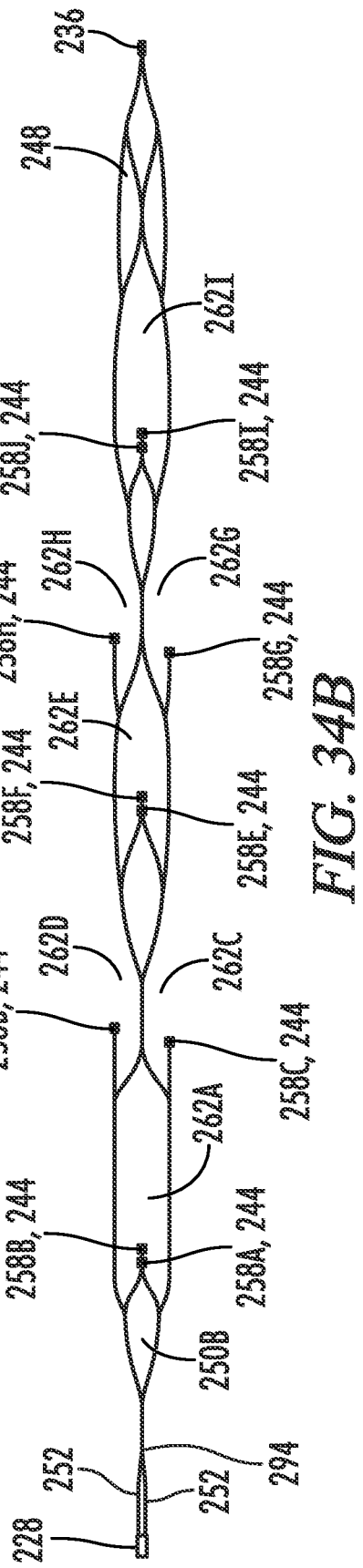


FIG. 34B

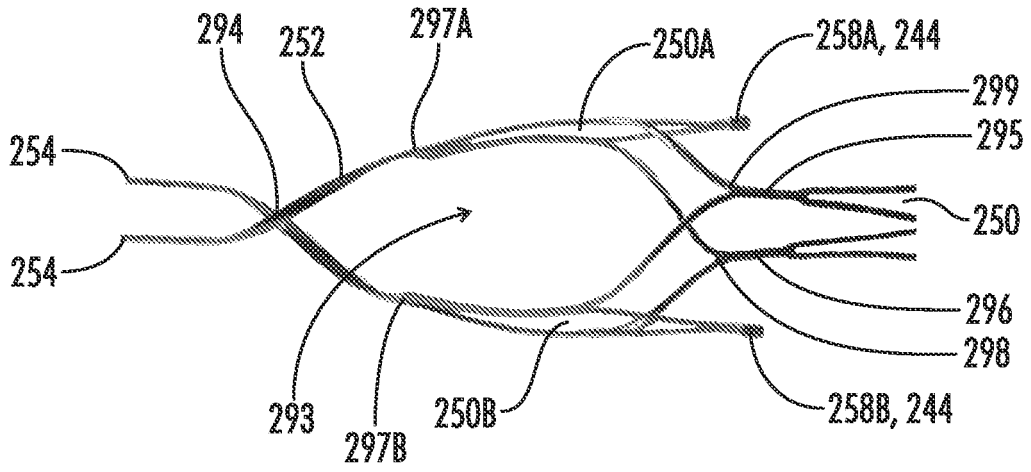


FIG. 35A

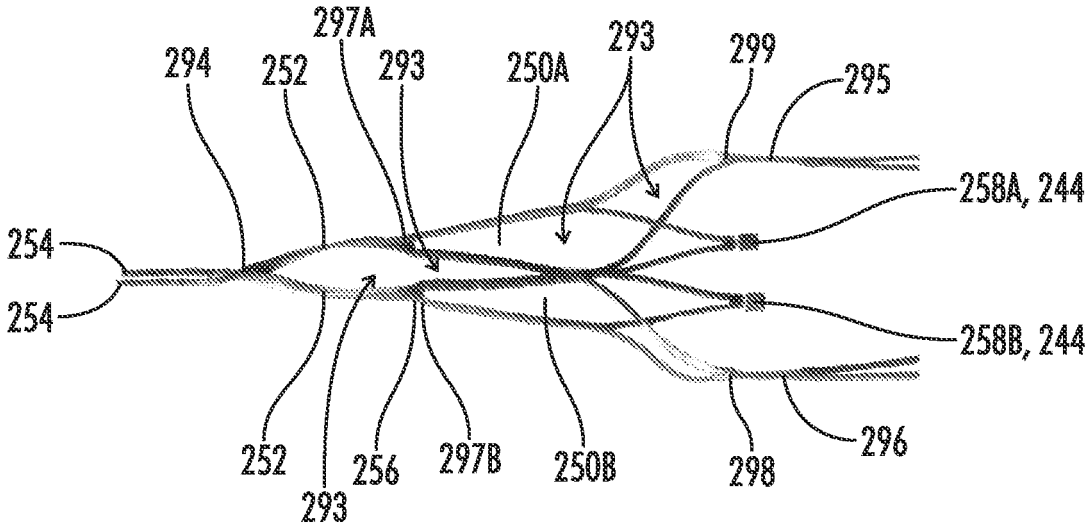


FIG. 35B

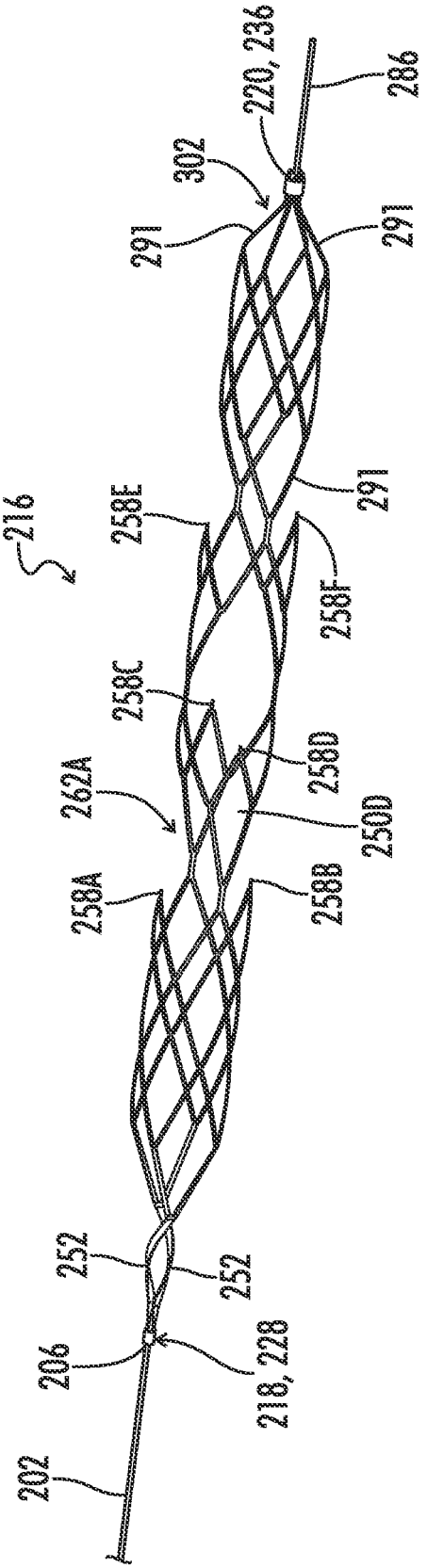


FIG. 36A

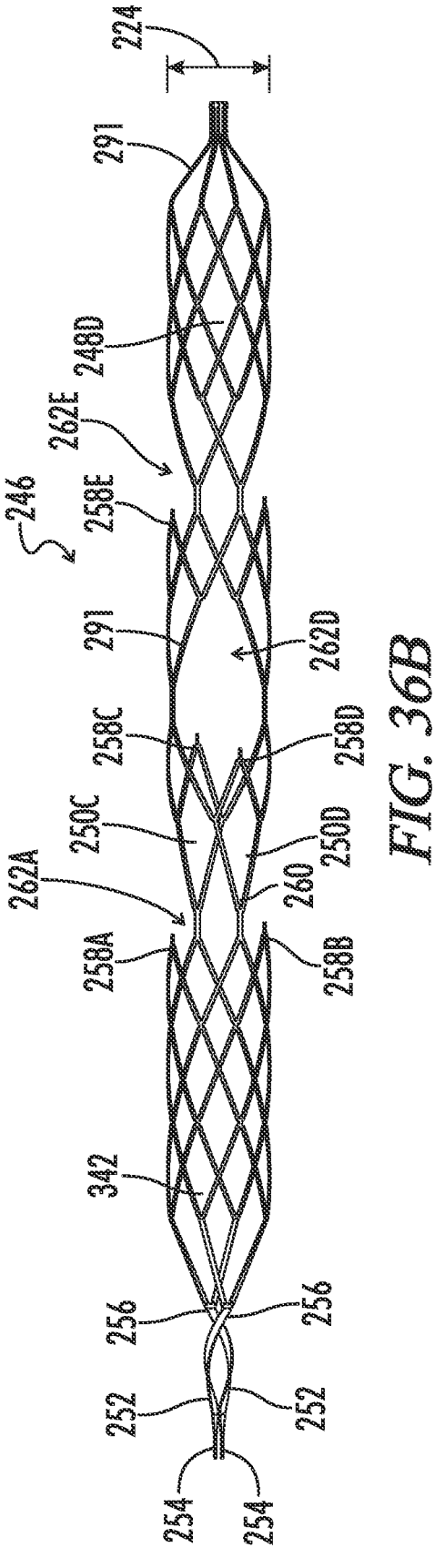


FIG. 36B

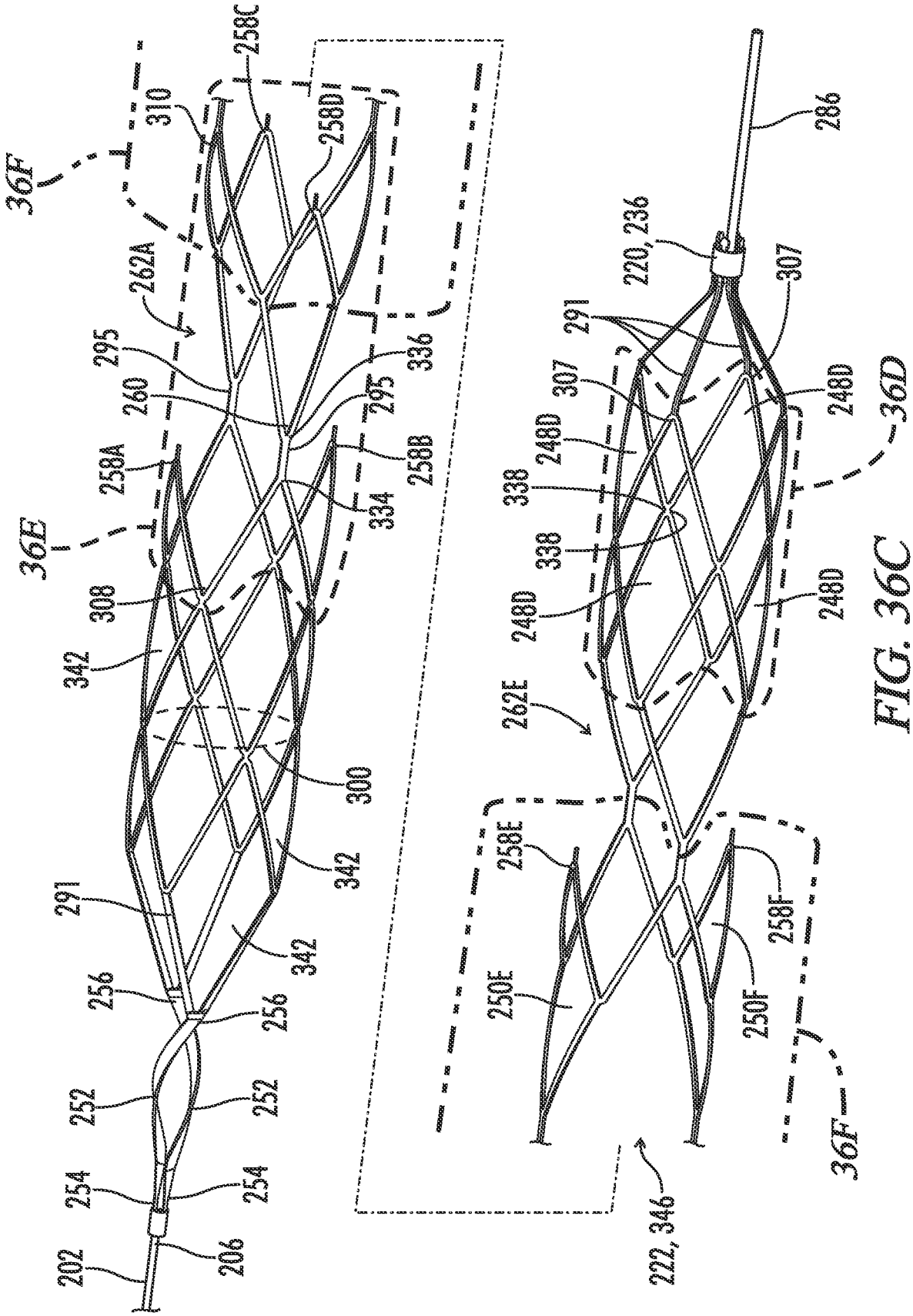

36F
310
258C
258D
262A
295
260
258A
36E
308
342
334
258B
336
295
300
342
342
291
256
256
252
252
254
254
202
206
222, 346
36F
250E
258E
262E
248D
338
248D
338
248D
307
291
220, 236
307
286
248D
36D
250F
258F

FIG. 36C

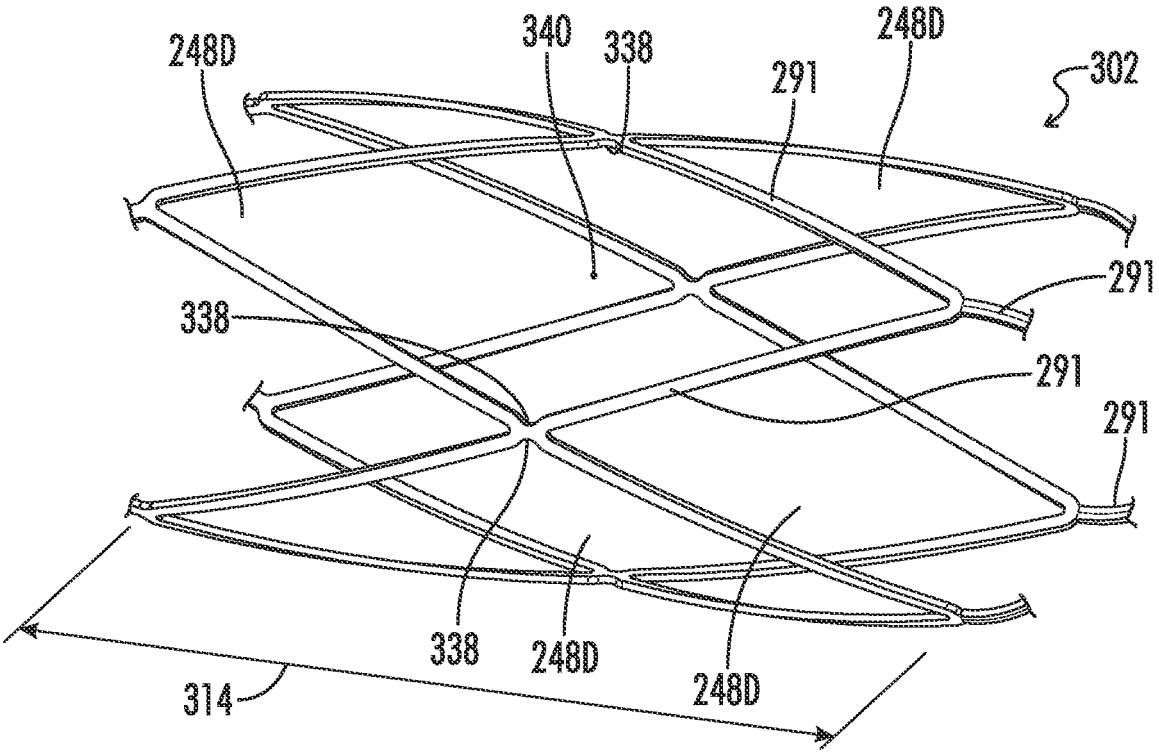


FIG. 36D

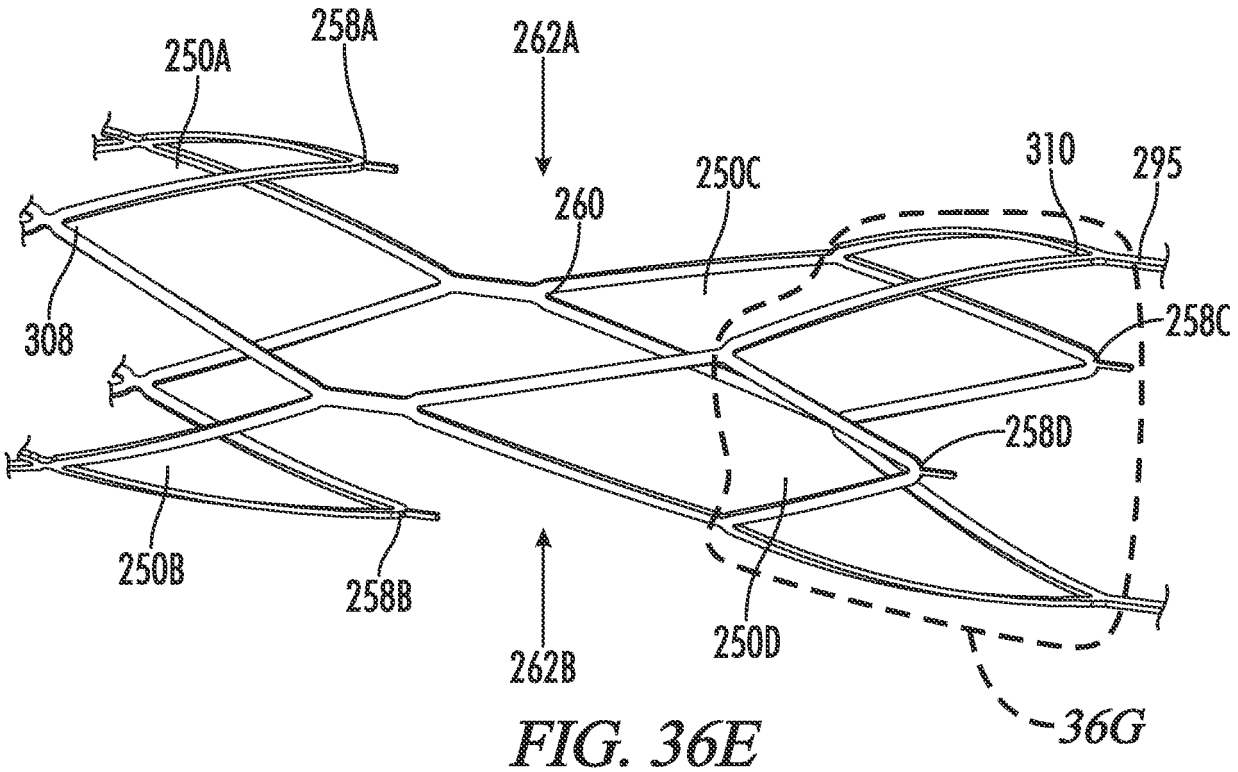


FIG. 36E

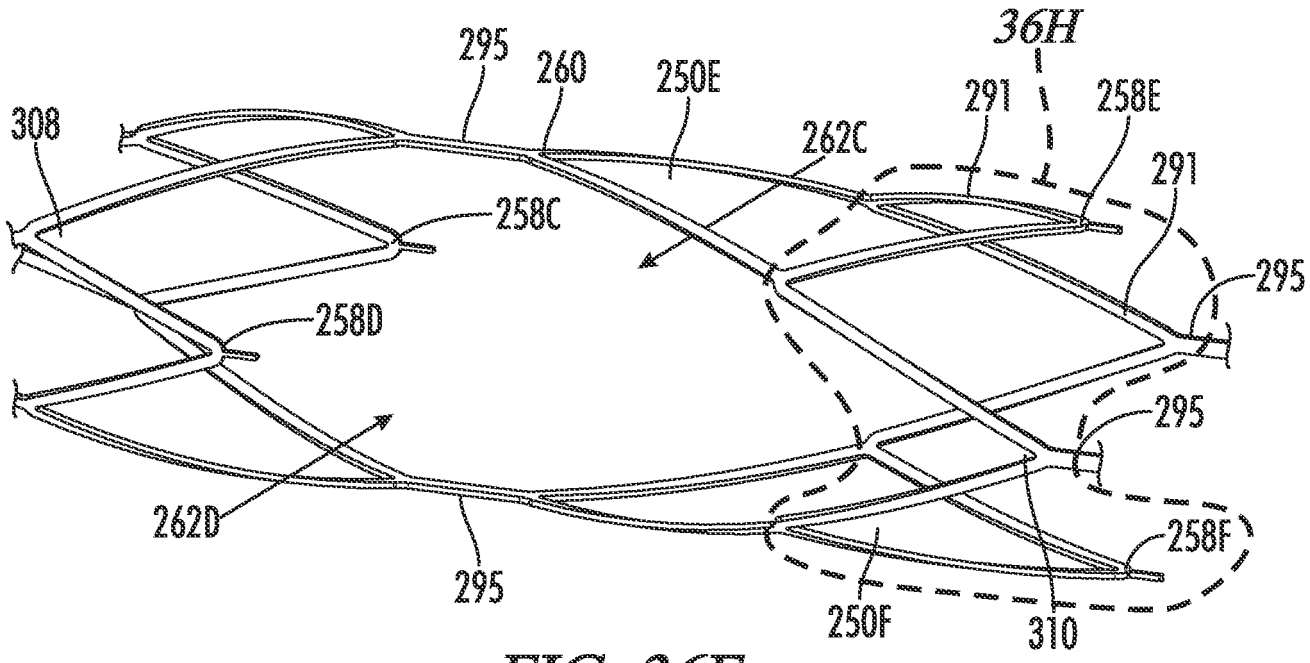


FIG. 36F

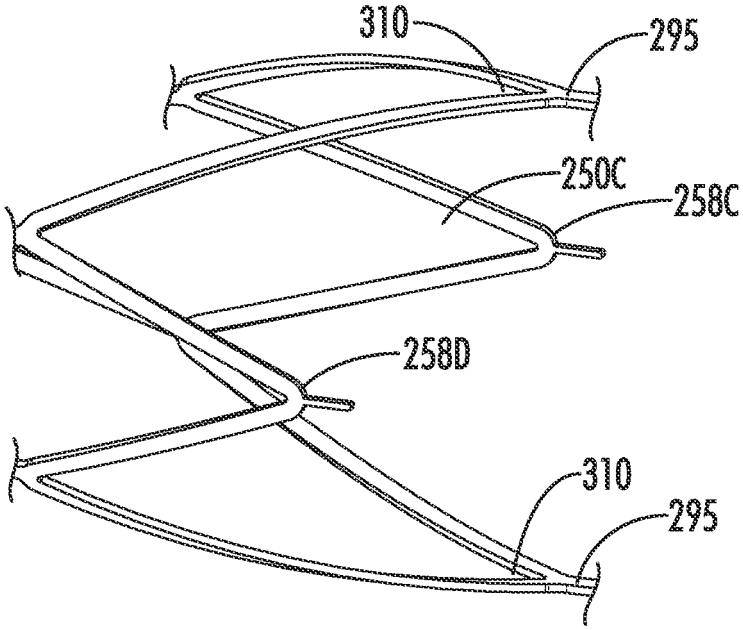


FIG. 36G

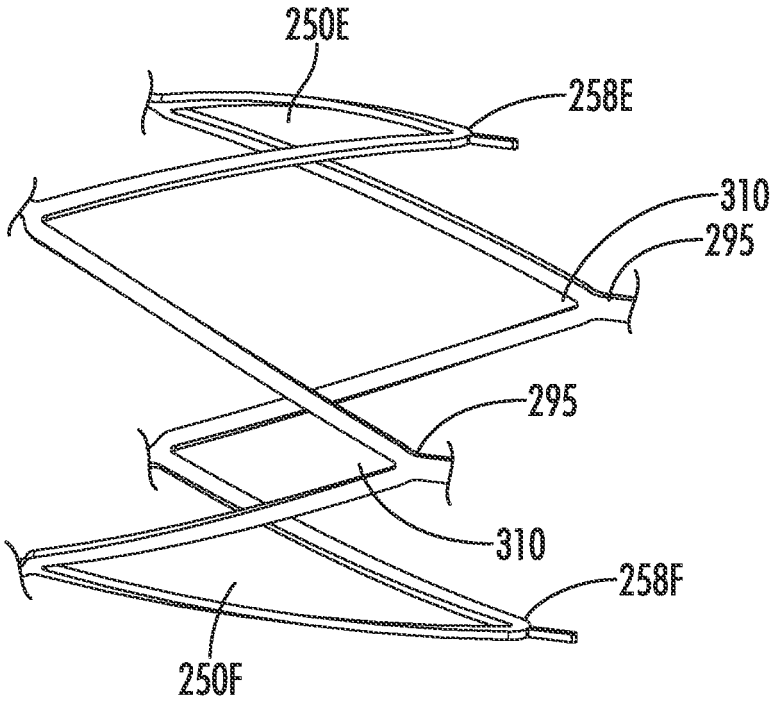


FIG. 36H

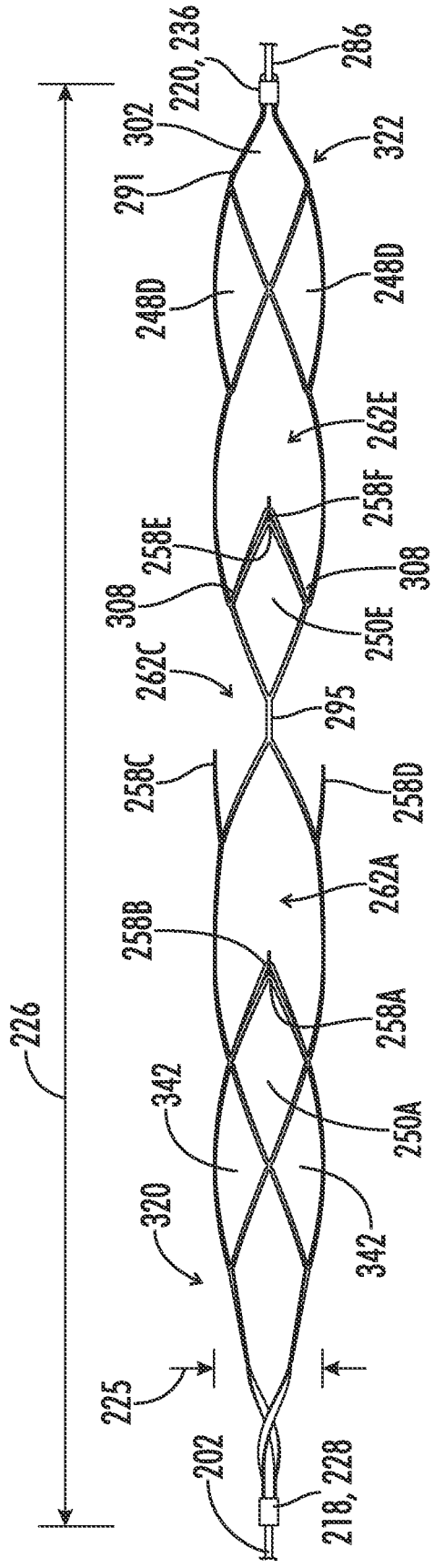


FIG. 36I

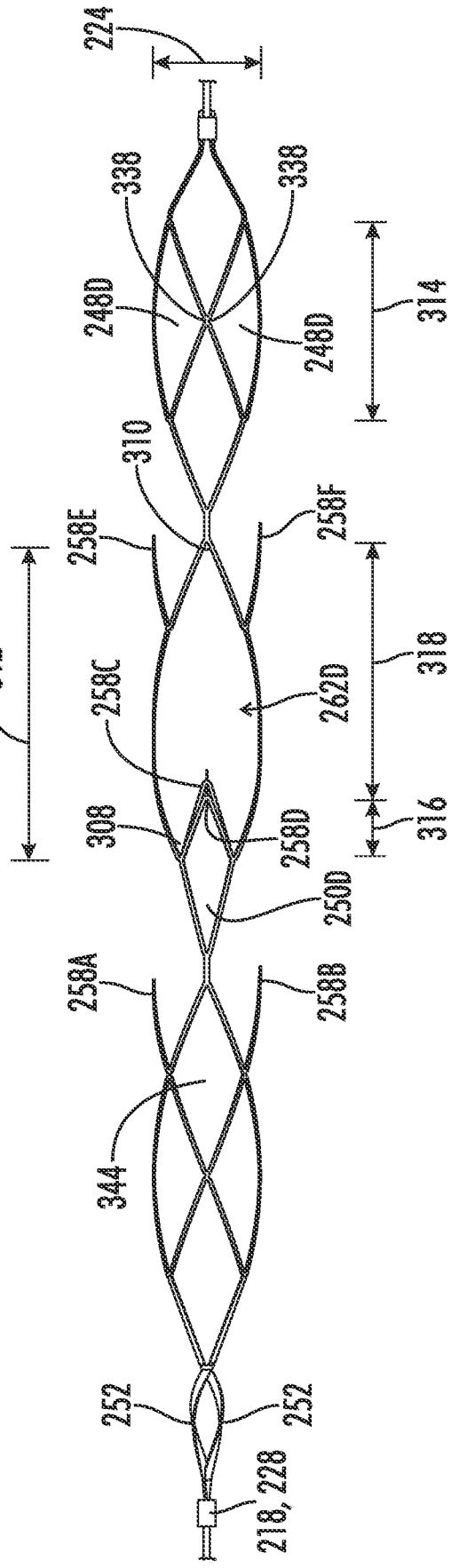


FIG. 36J

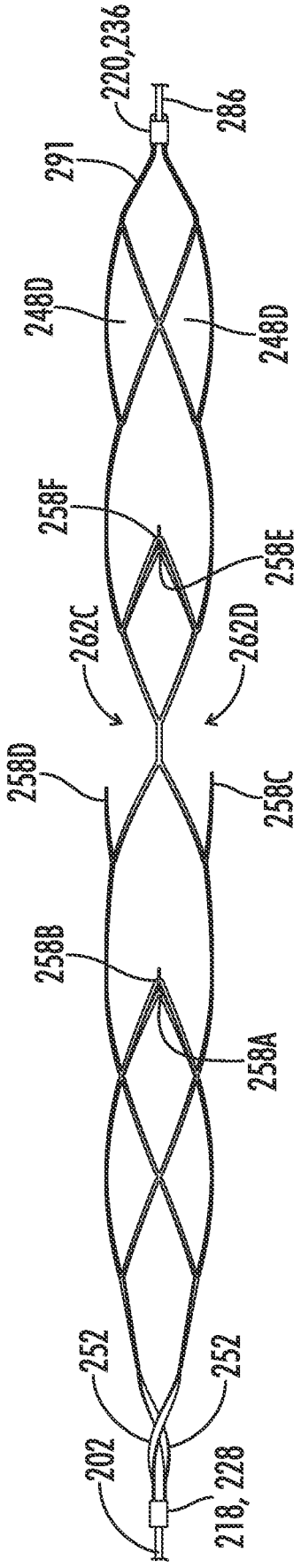


FIG. 36K

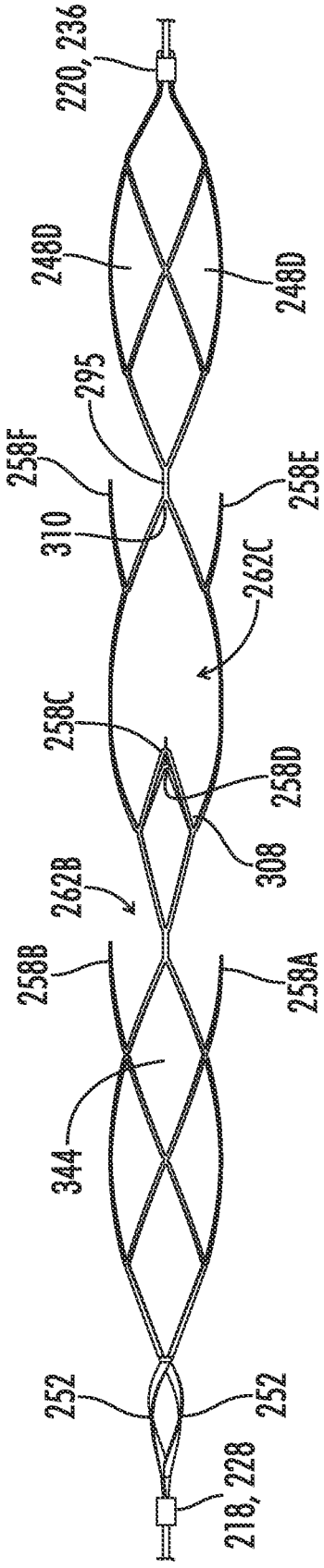


FIG. 36L

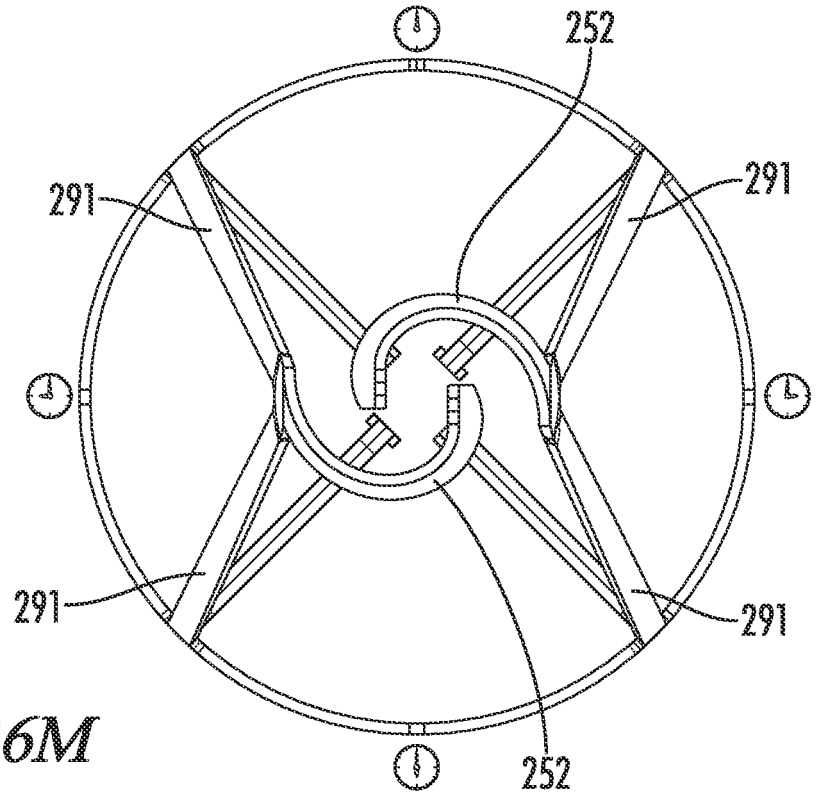


FIG. 36M

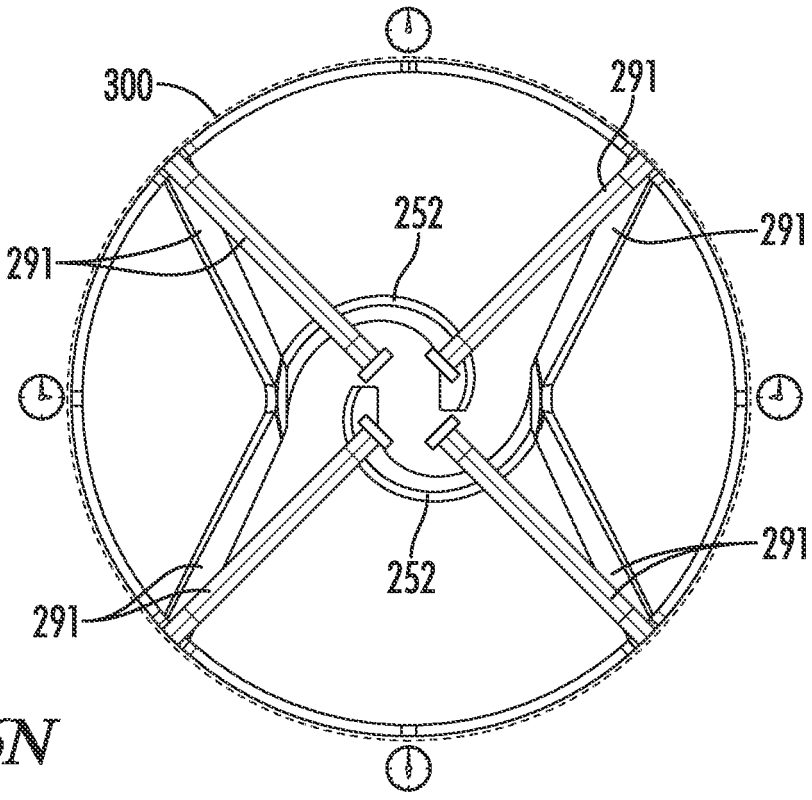


FIG. 36N

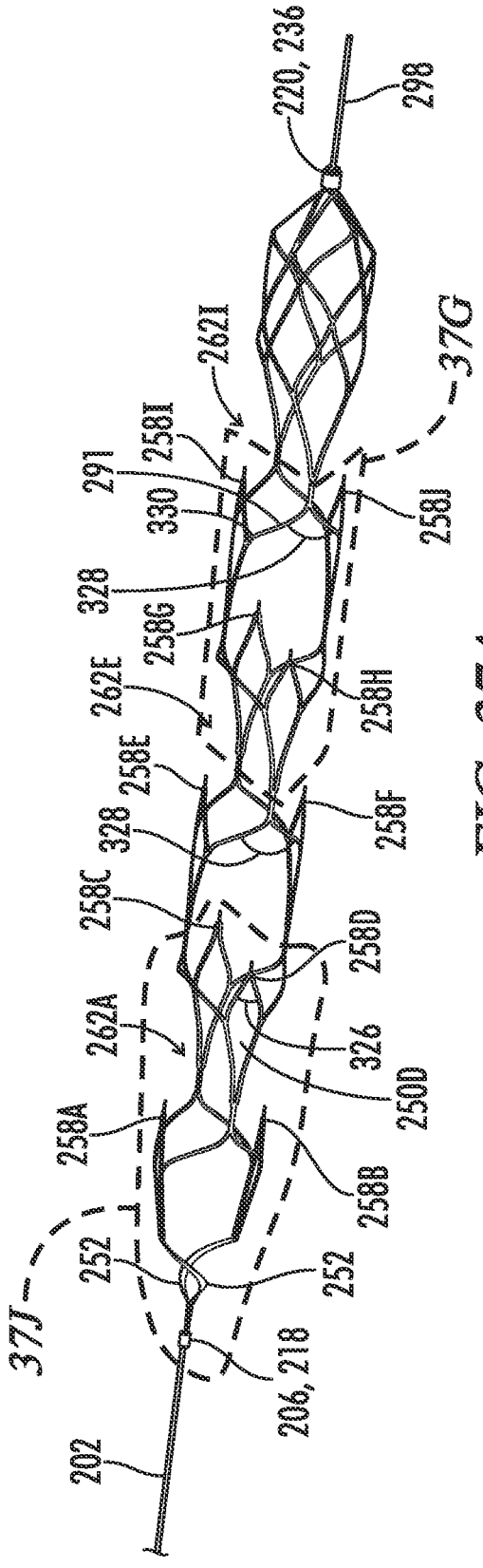


FIG. 37A

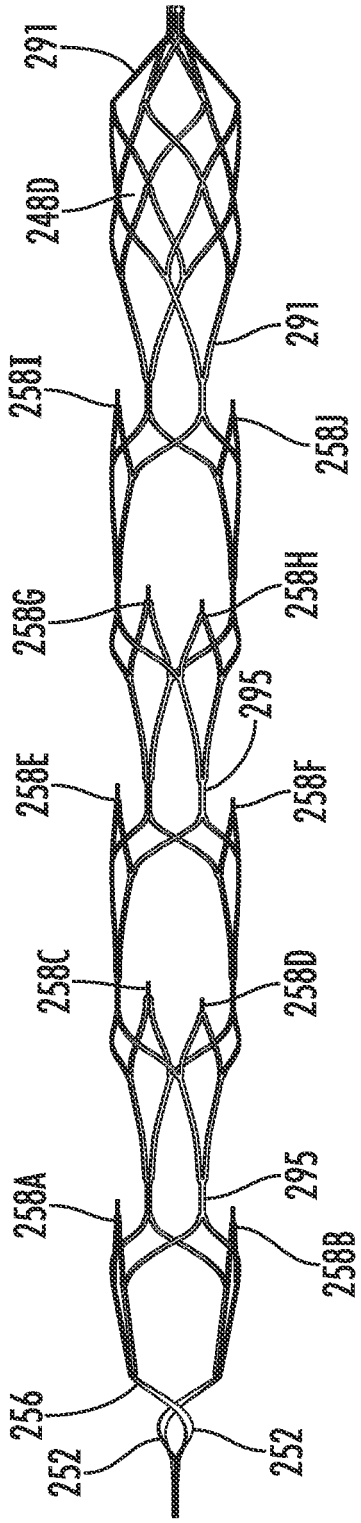


FIG. 37B

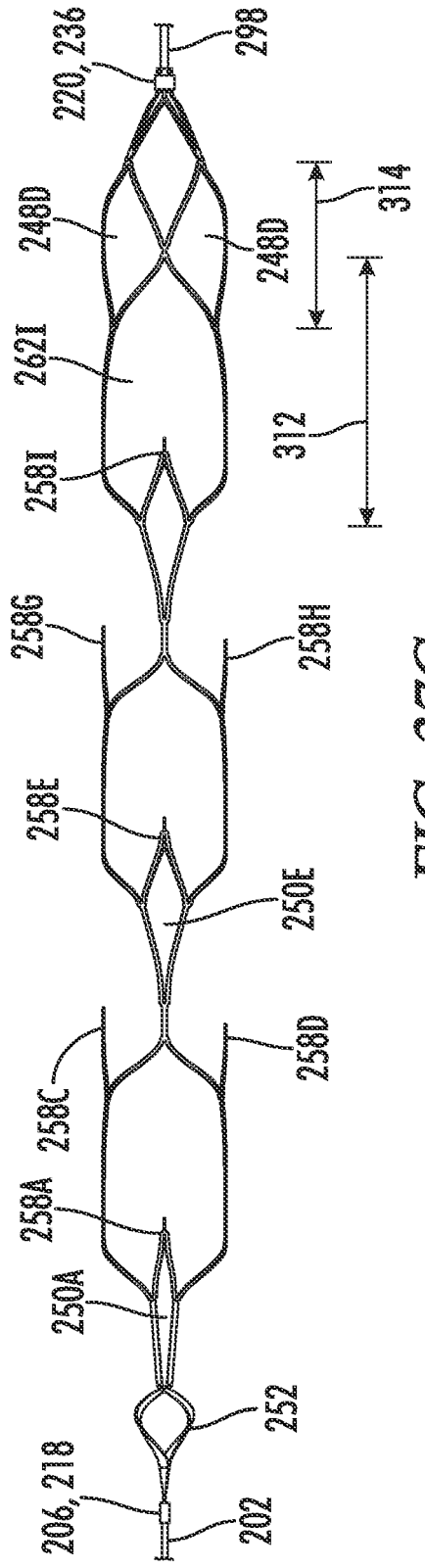


FIG. 37C

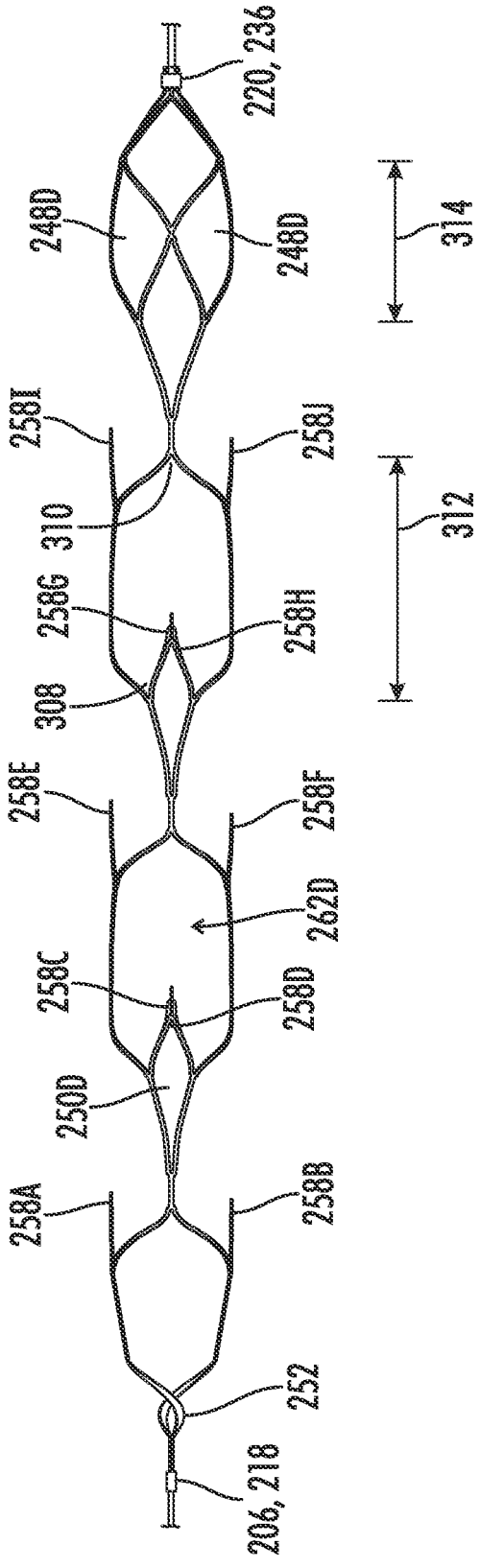


FIG. 37D

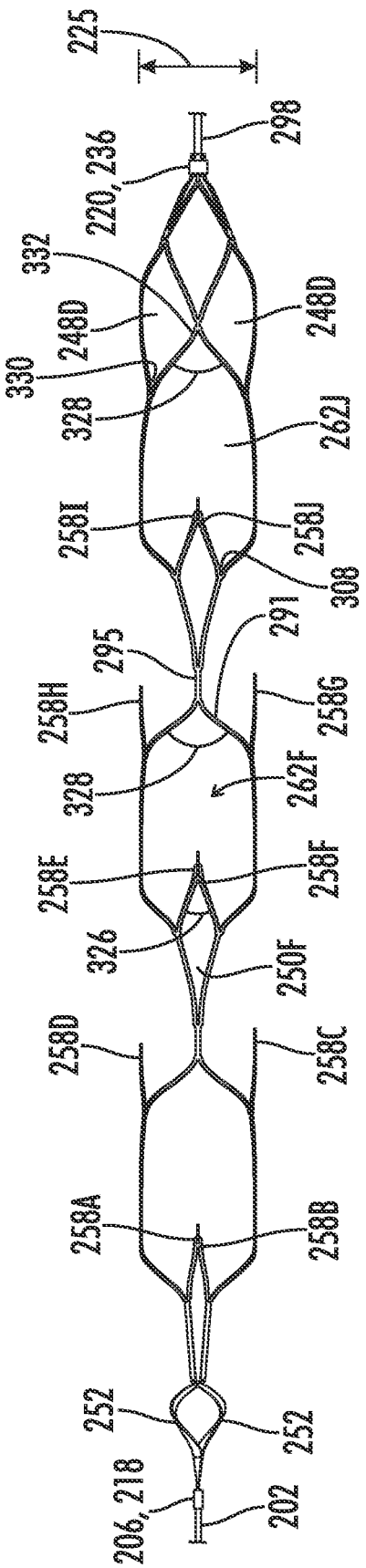


FIG. 37E

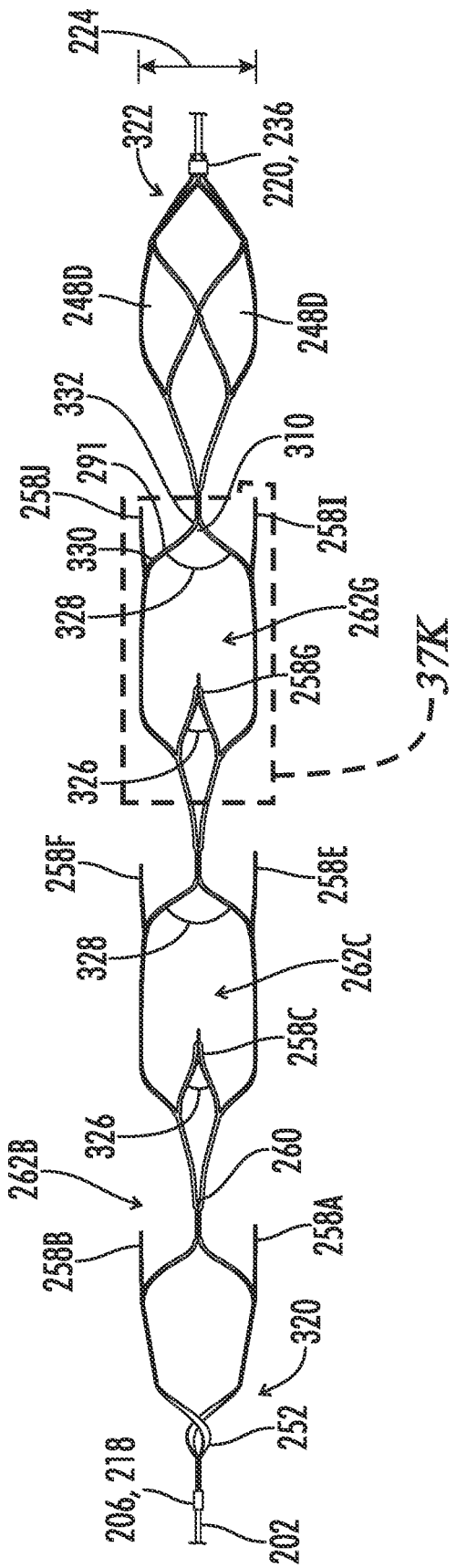
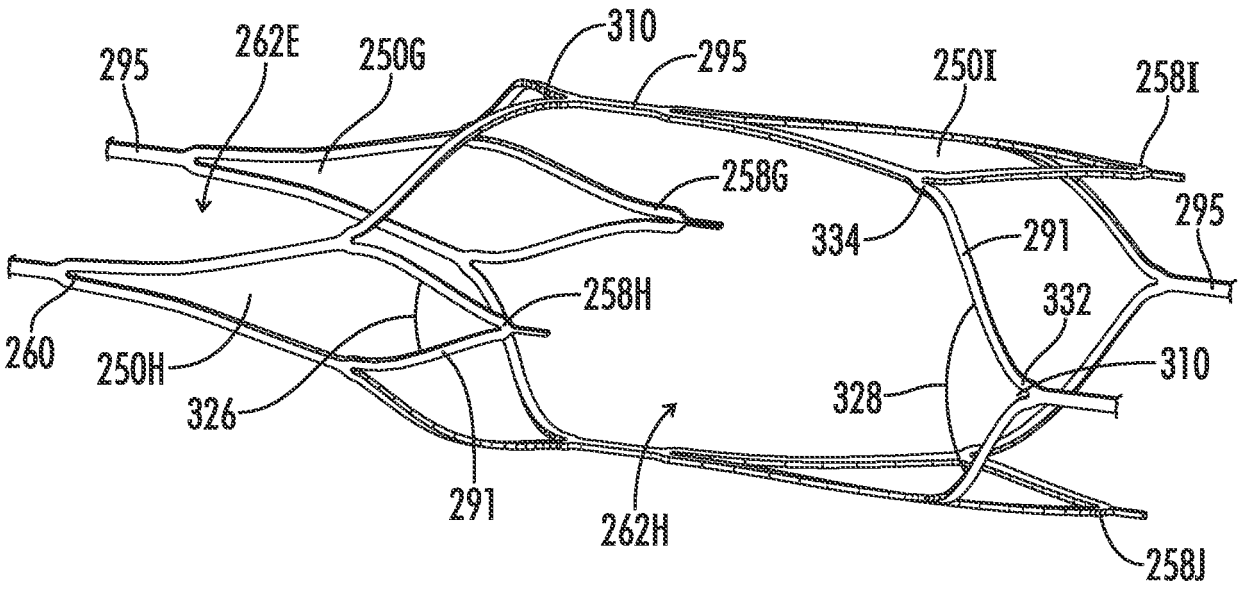


FIG. 37F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250G
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250I
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258G
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258H
332
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250H
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310
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291
262H
258J

FIG. 37G

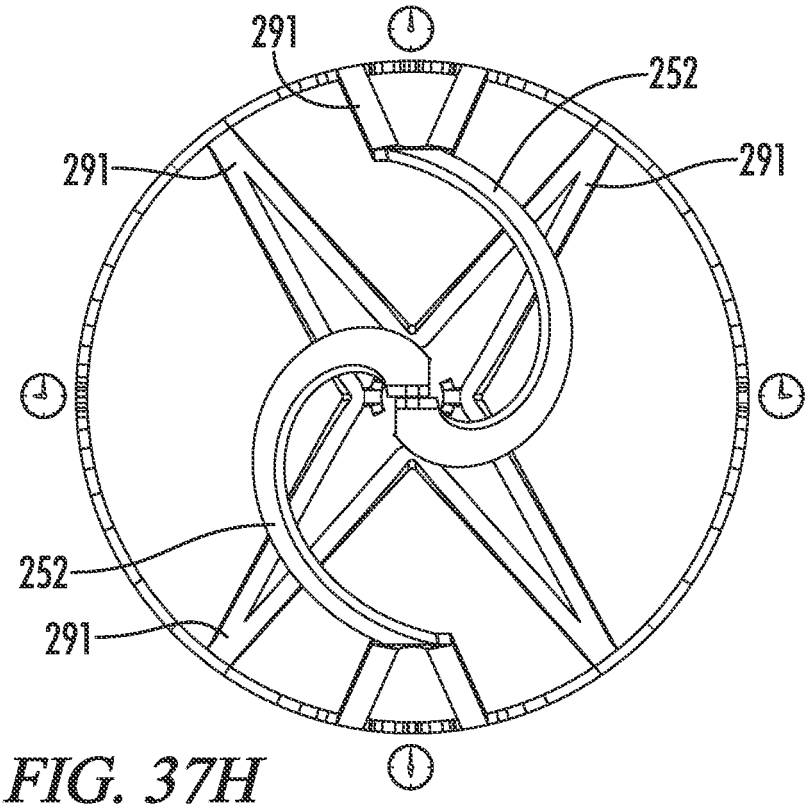

FIG. 37H

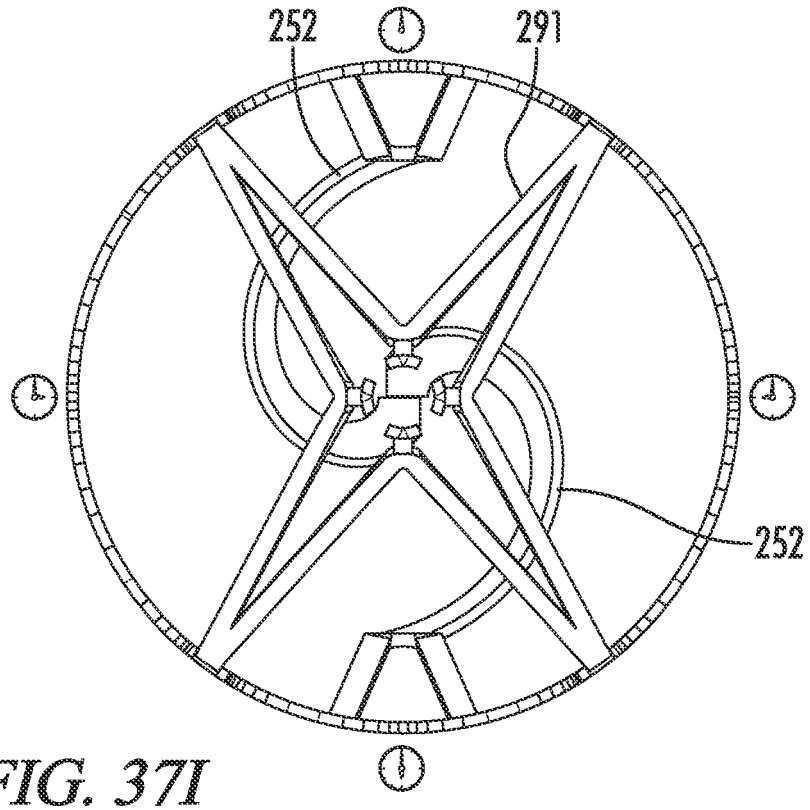

FIG. 37I

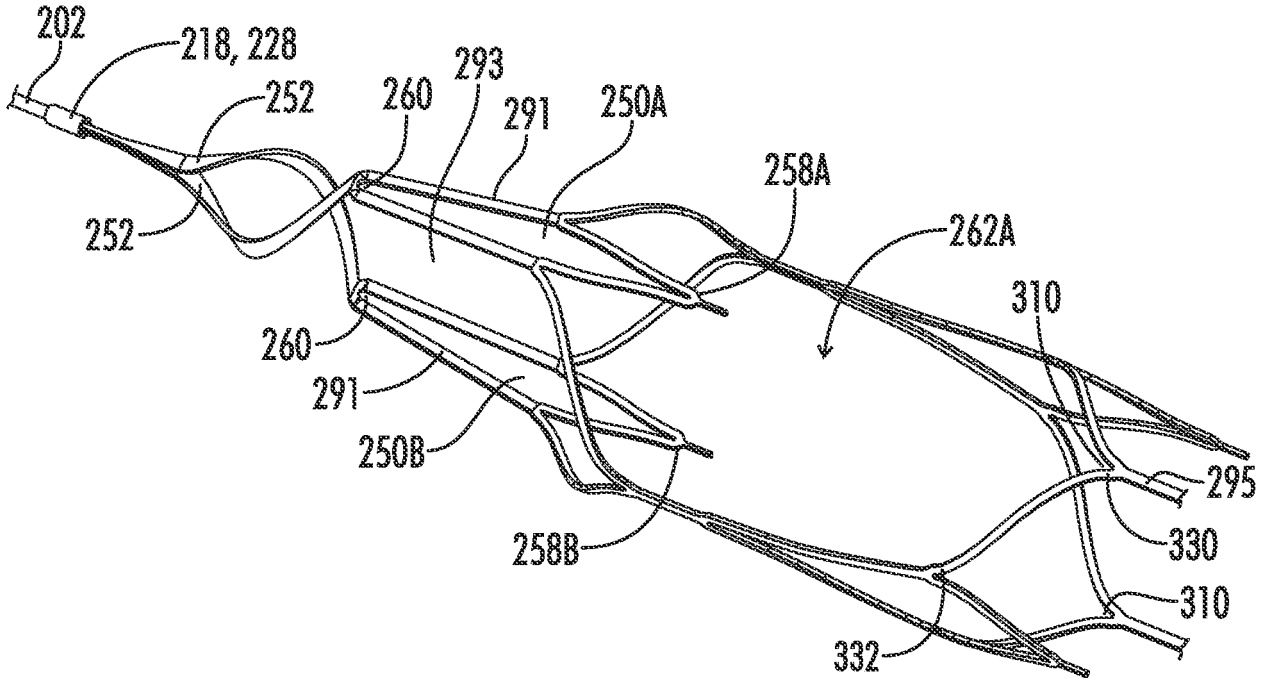

FIG. 37J

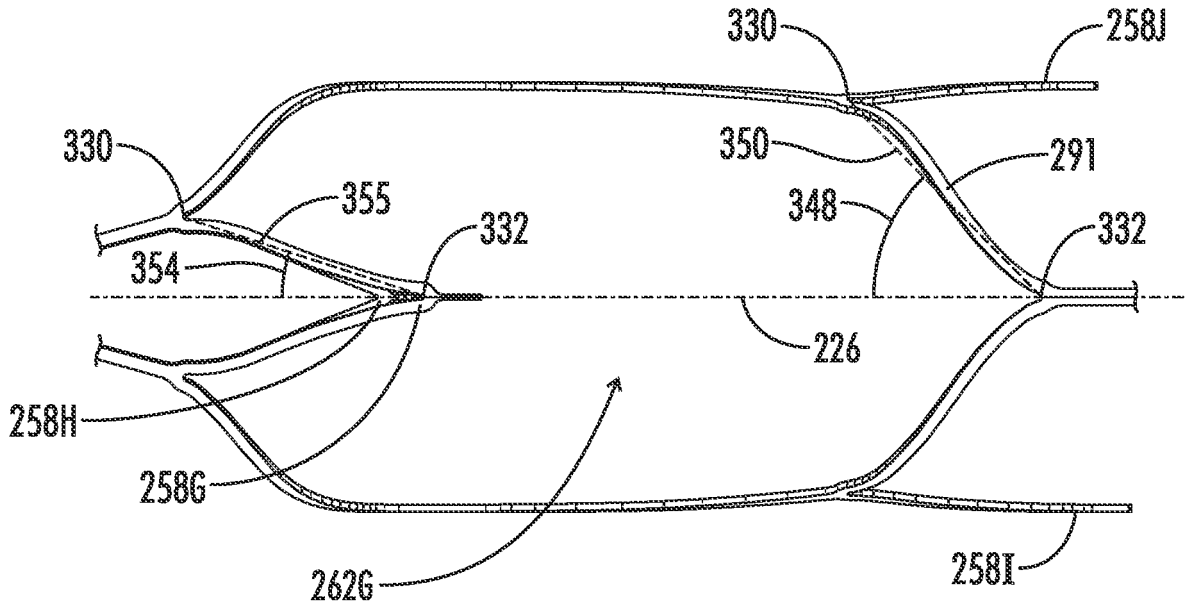

FIG. 37K

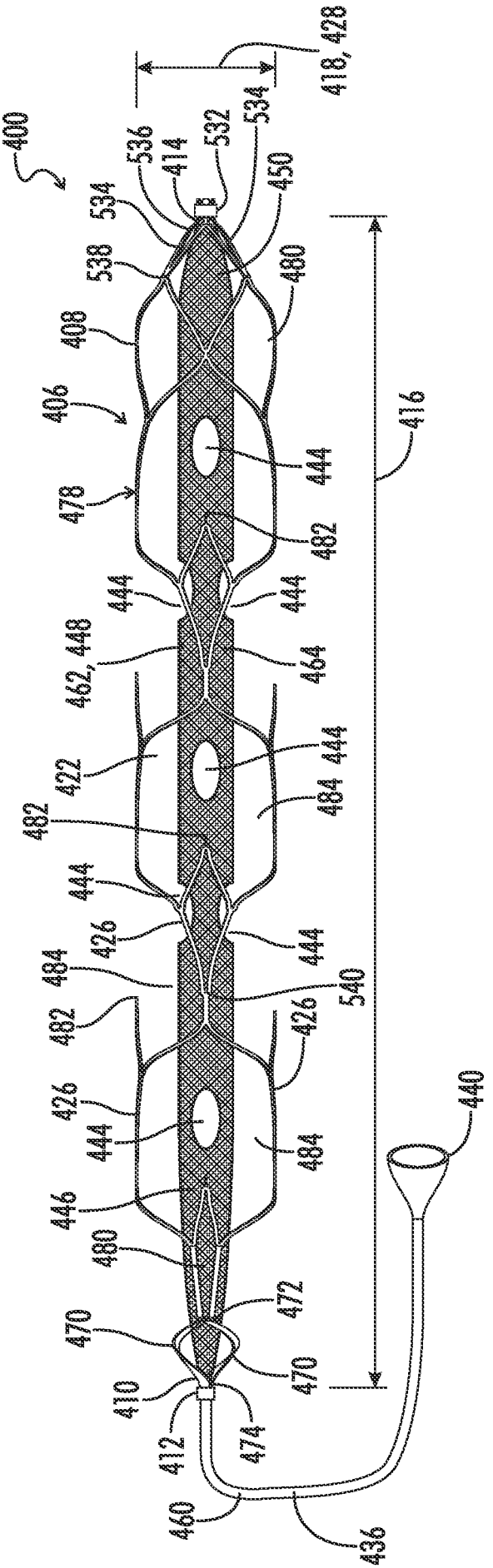
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FIG. 38

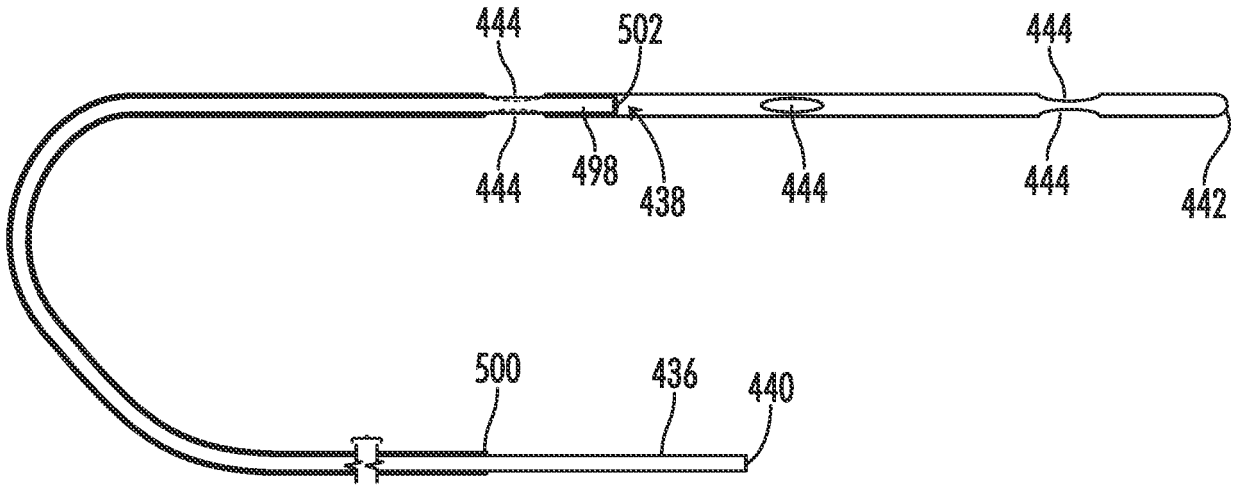

FIG. 39

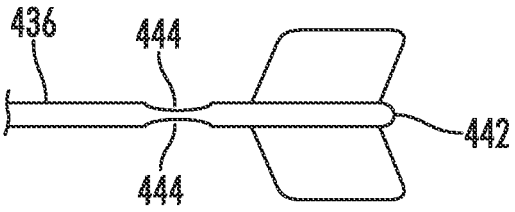

FIG. 39A

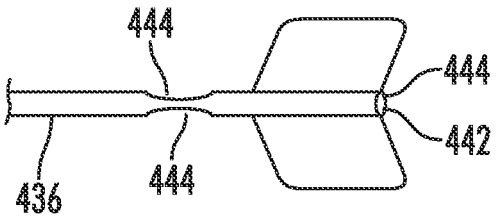

FIG. 39B

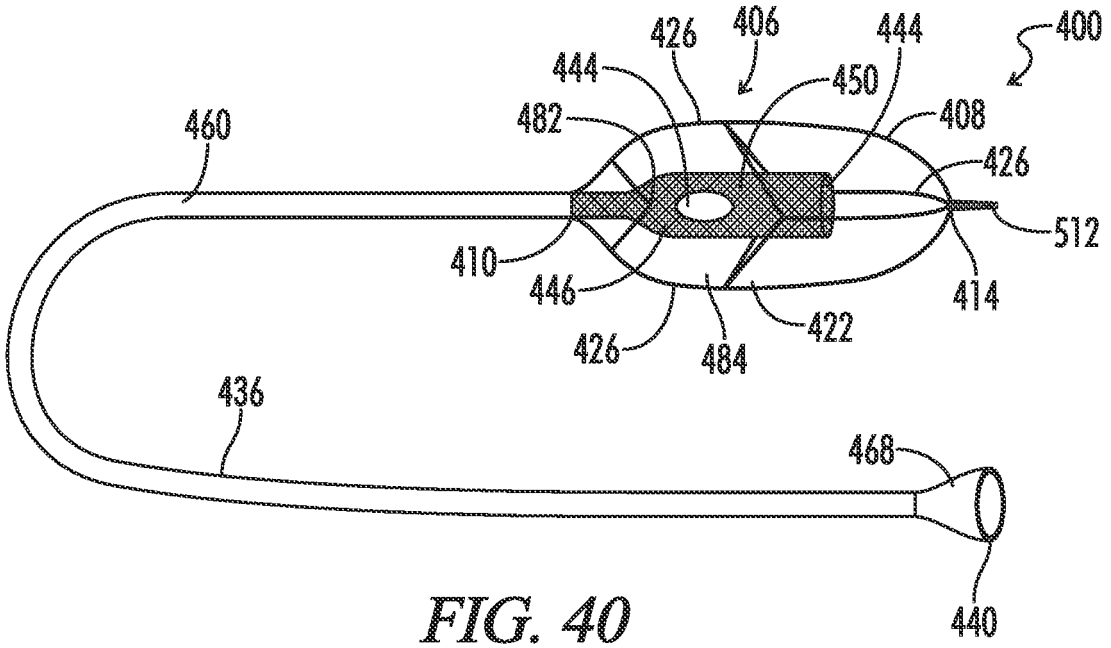
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FIG. 40

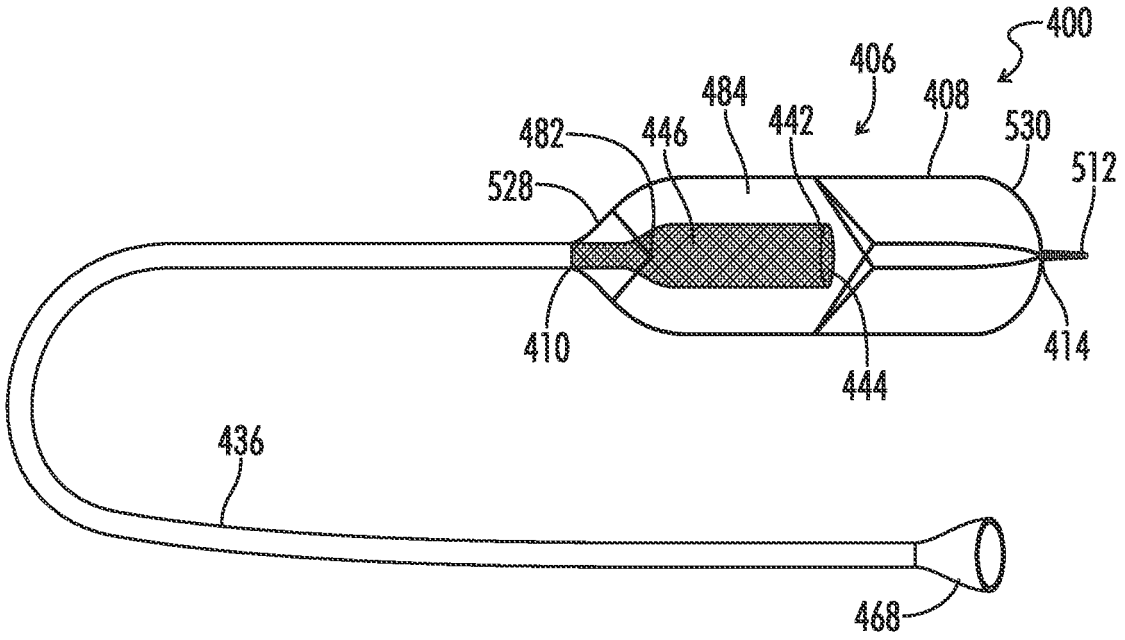
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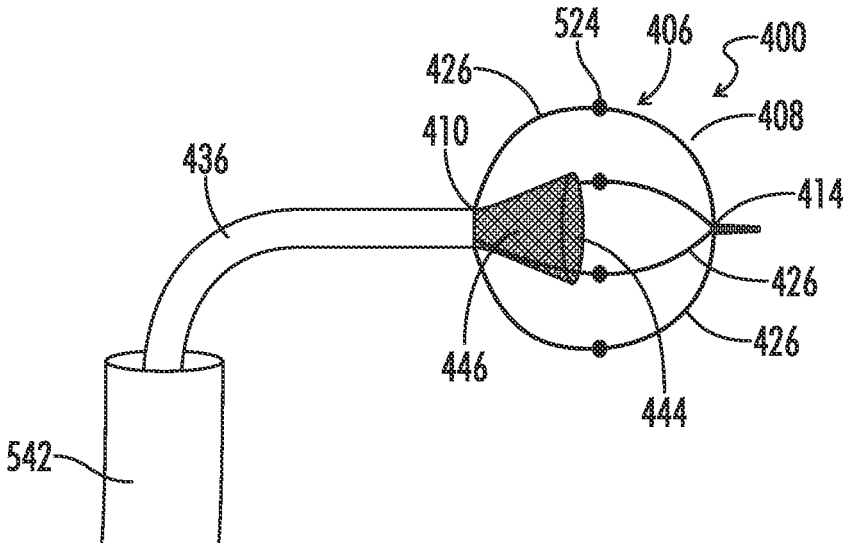
FIG. 41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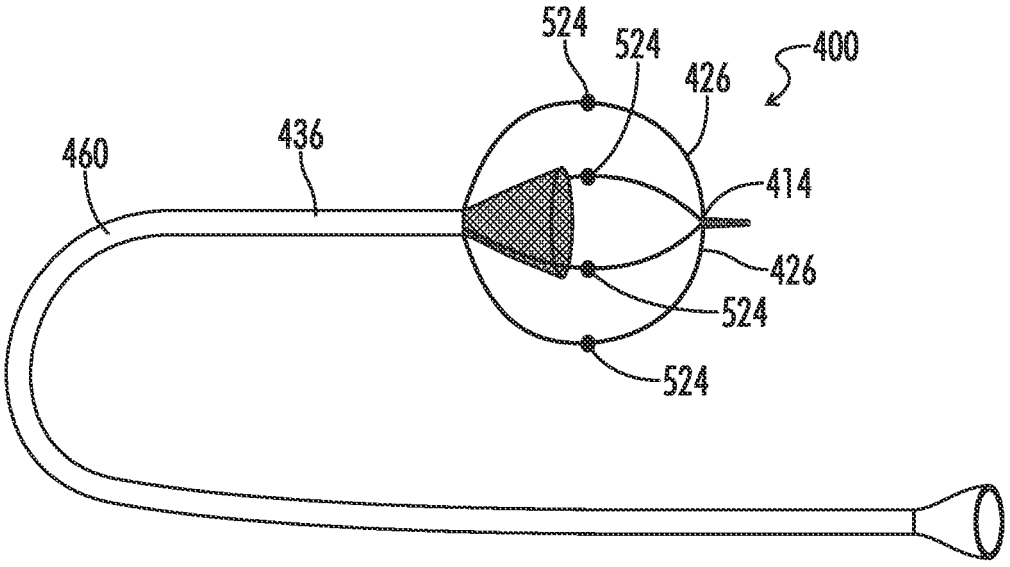
542

FIG. 42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426
400
460
436
414
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FIG. 43

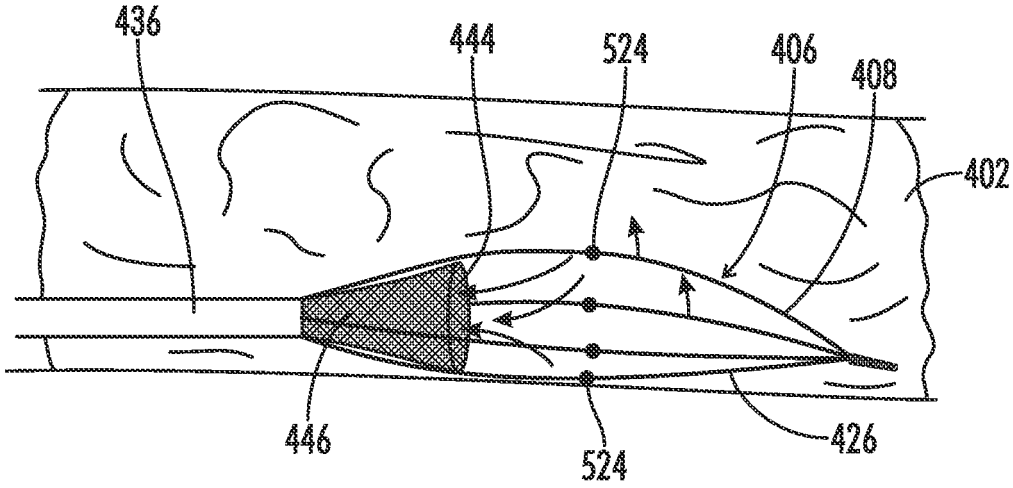

FIG. 44A

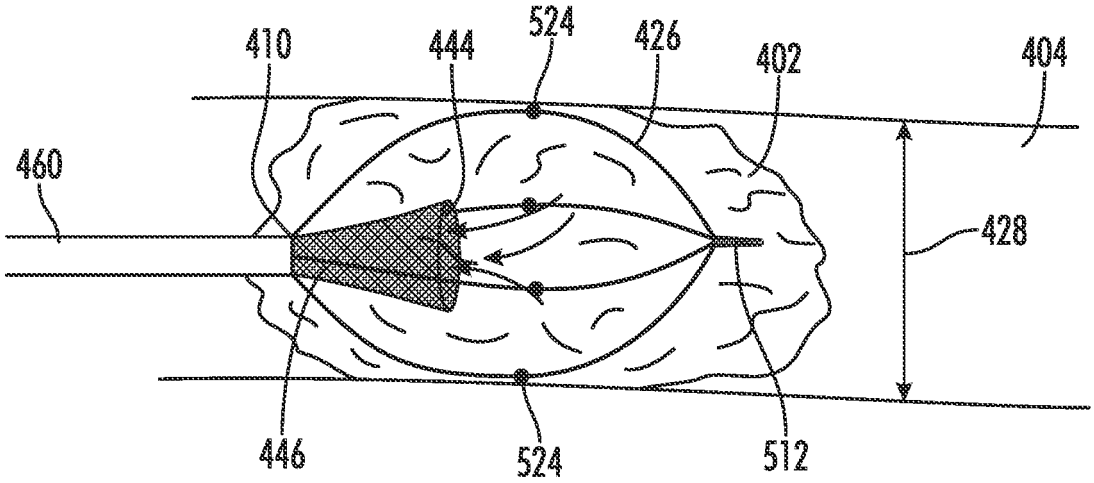

FIG. 44B

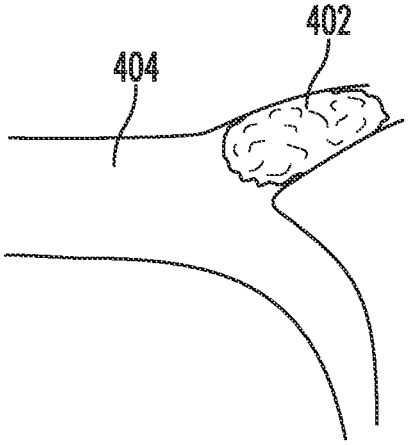

FIG. 45A

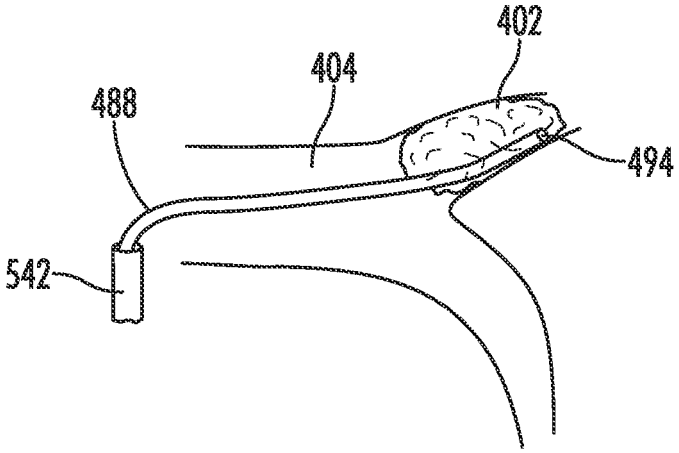

FIG. 45B

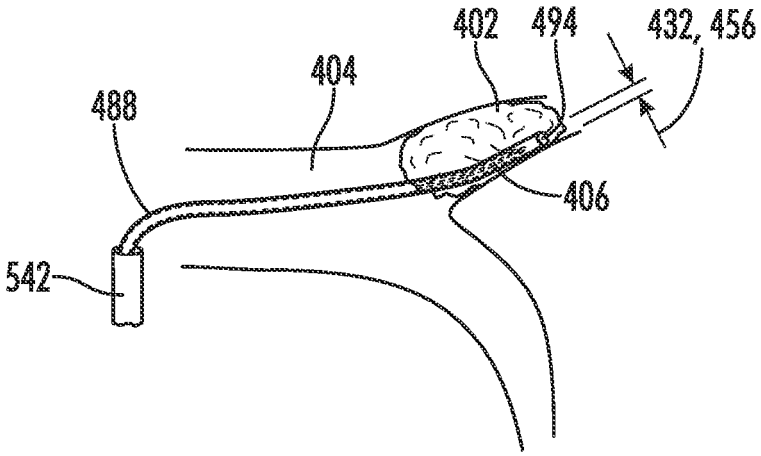

FIG. 45C

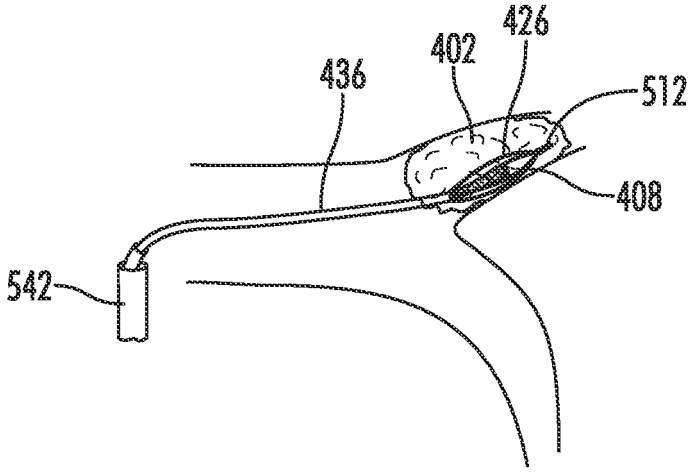

FIG. 45D

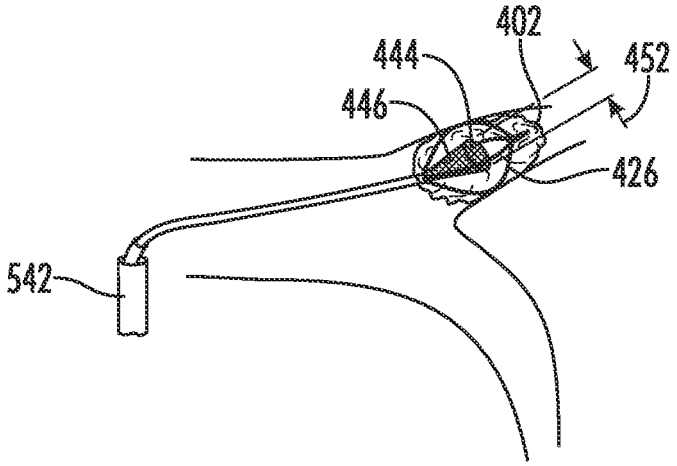

FIG. 45E

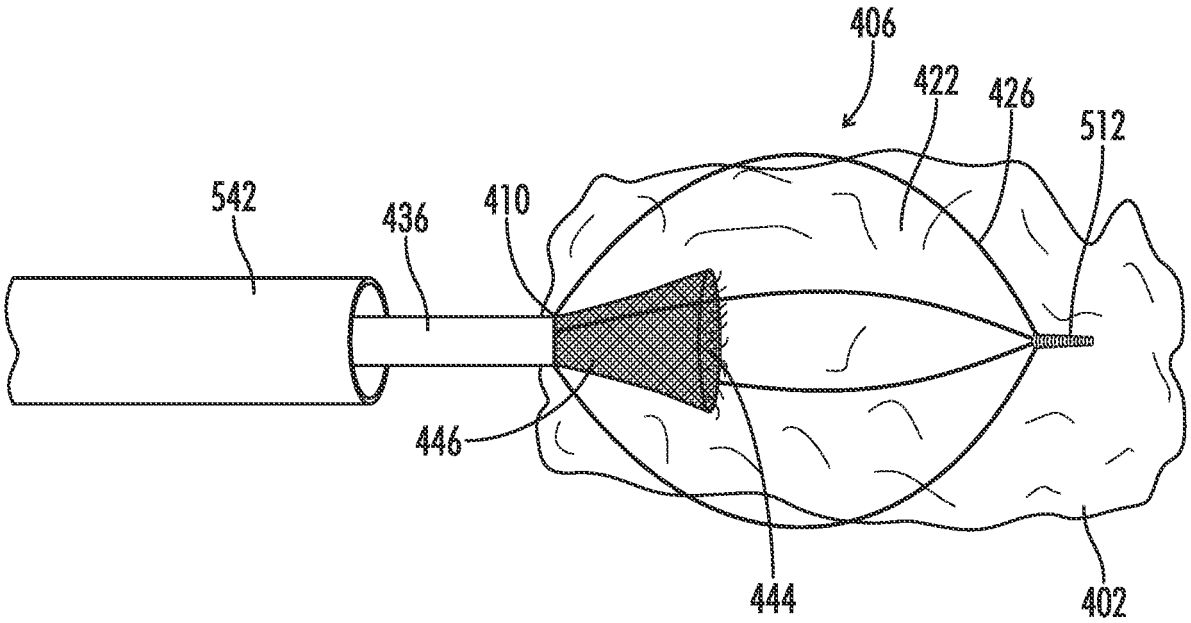

FIG. 45F

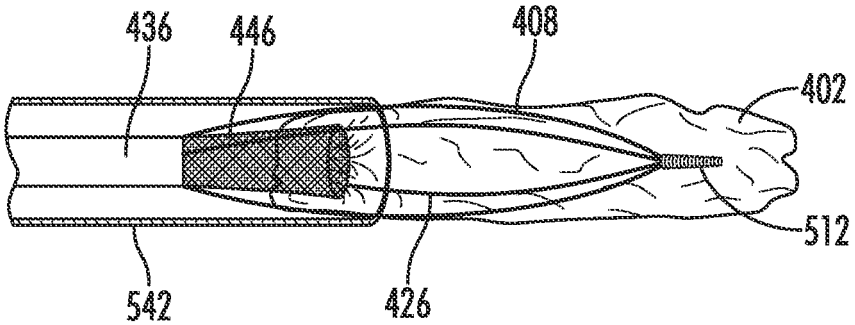

FIG. 45G

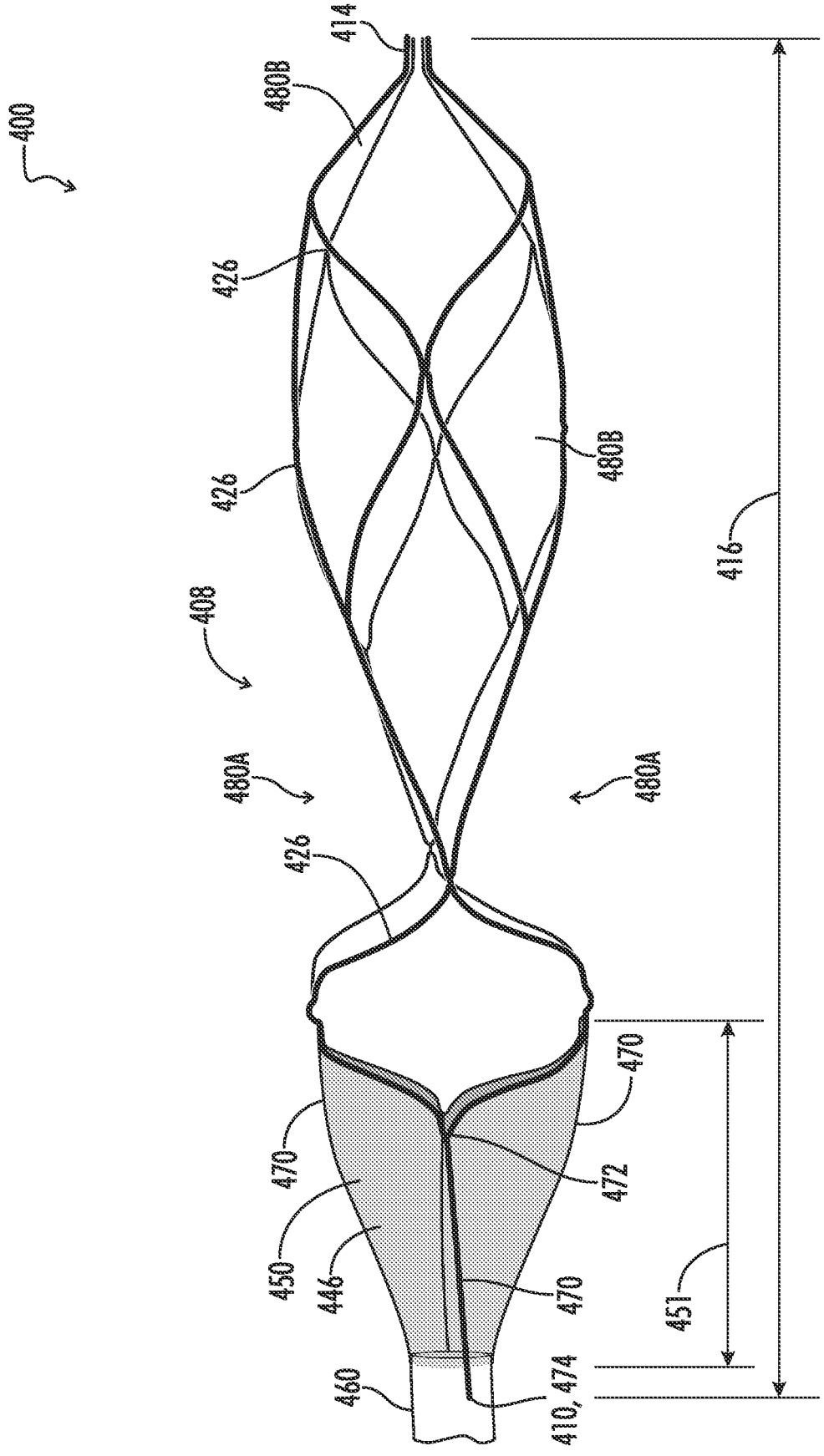
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FIG. 46A

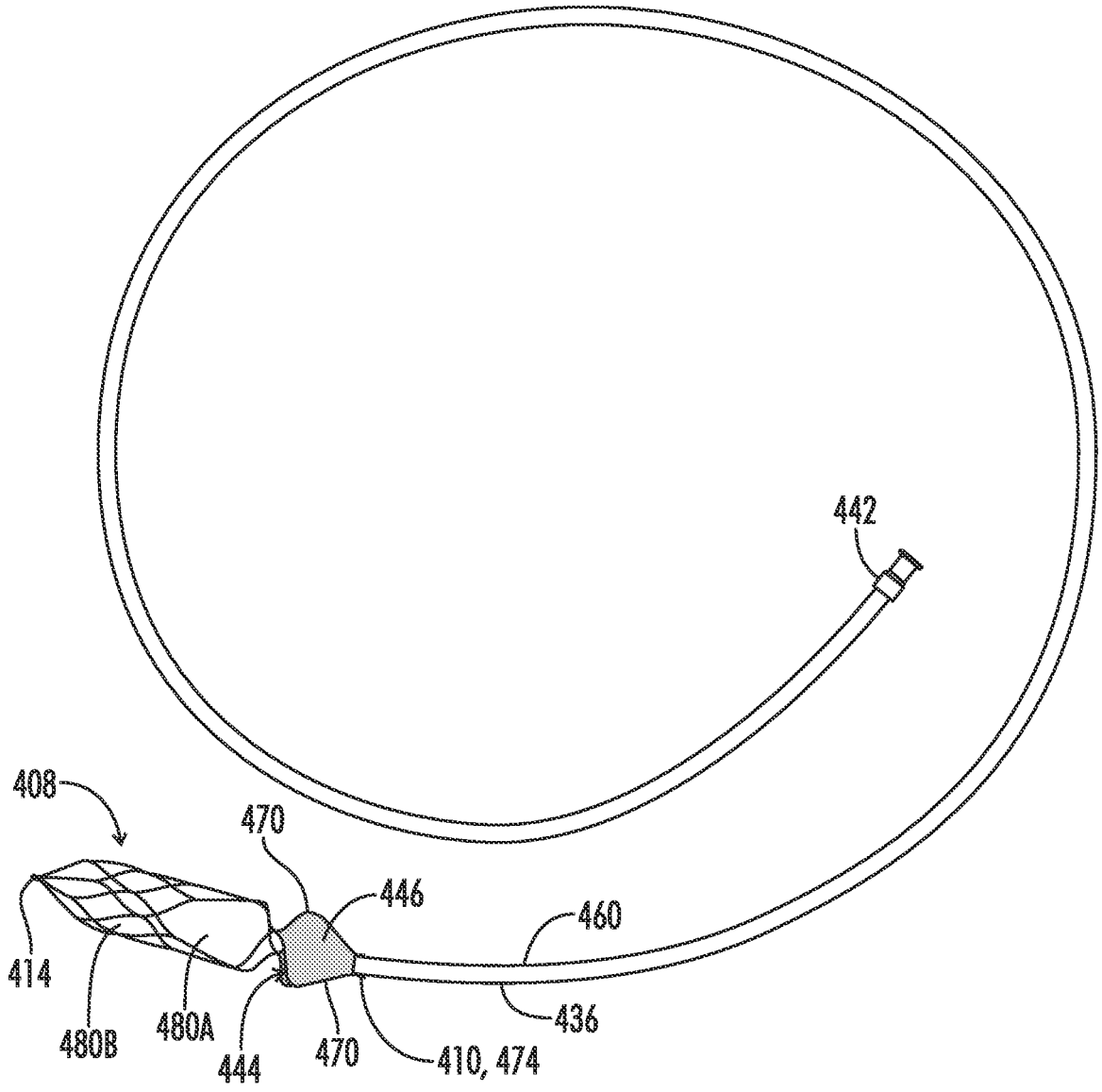

FIG. 46B