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(54) **ENHANCED MEDICAL DEVICE FOR USE IN BODILY CAVITIES, FOR EXAMPLE AN ATRIUM**

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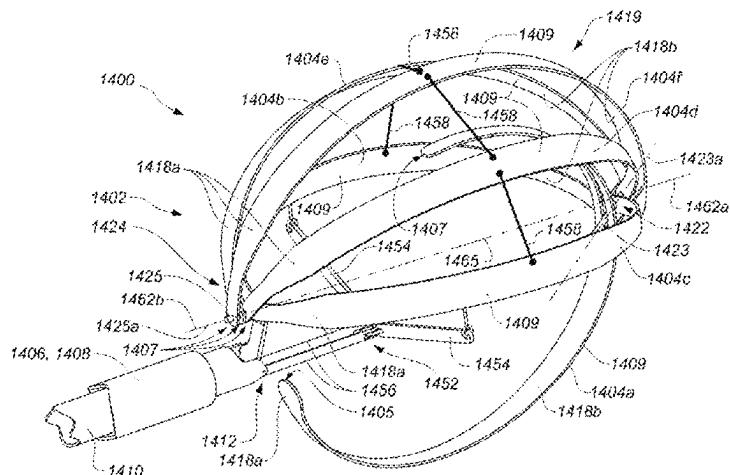
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(57) **ABSTRACT**

Systems, methods, and devices allow intravascular or percutaneous mapping, orientation and/or ablation, in bodily cavities or lumens. A device includes elongate members, moveable between an unexpanded configuration and an expanded or fanned configuration. The elongate members form a stack in the unexpanded configuration to fit through a catheter sheath. The elongate members follow respective arcuate or curvilinear paths as advanced from the sheath into the bent or coiled stack configuration, adopting volute, scroll or rho shapes, and may be nested. The elongated members are fanned or radially spaced circumferentially with respect to one another into the expanded or fanned configuration. Transducer elements carried by elongate members sense various physiological characteristics of or proximate tissue,

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and/or may apply energy to or proximate tissue. The elongate members are rotatable in groups or as a group in the expanded configuration. The device is retractable.

## 21 Claims, 60 Drawing Sheets

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- Office Action issued in U.S. Appl. No. 15/784,722 mailed Mar. 23, 2020.
- Office Action issued in U.S. Appl. No. 15/784,775 mailed Mar. 23, 2020.
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- Amendment filed in U.S. Appl. No. 15/697,744 on May 27, 2020.
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- Amendment and Statement on the Substance of the Interview filed in U.S. Appl. No. 15/784,775 on Jul. 9, 2020.
- Notice of Allowance issued in U.S. Appl. No. 15/784,647 mailed on Jul. 23, 2020.
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- Notice of Allowance issued in U.S. Appl. No. 15/784,555 mailed on Aug. 11, 2020.
- Amendment and Statement on the Substance of the Interview filed in copending U.S. Appl. No. 15/725,662 on Aug. 13, 2020.
- Amendment and Statement on the Substance of the Interview filed in U.S. Appl. No. 15/725,731 on Aug. 13, 2020.
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- Office Action issued in Chinese Appln. No. 201810941271.5 mailed Nov. 3, 2020. English translation provided.

\* cited by examiner

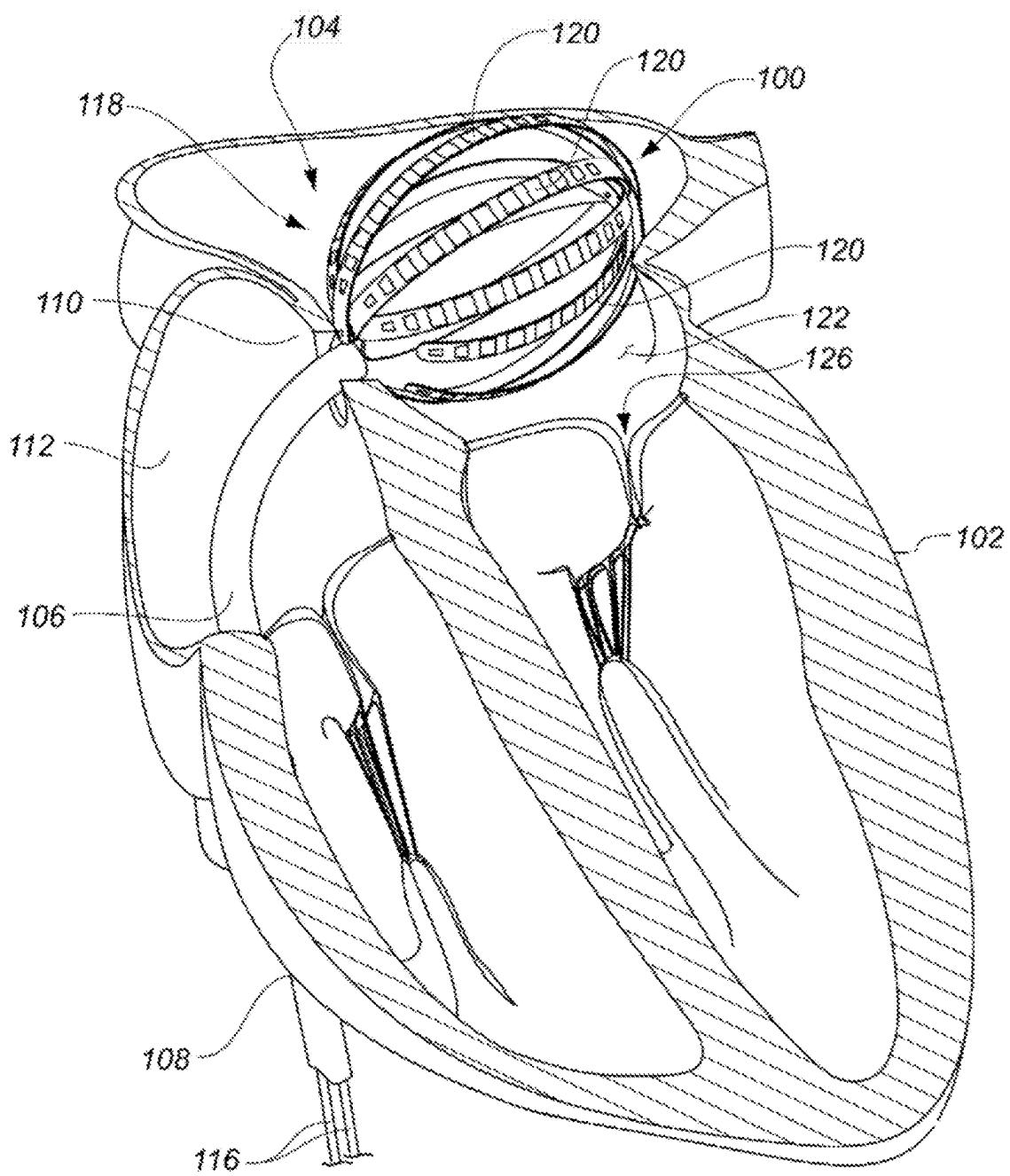


FIG. 1

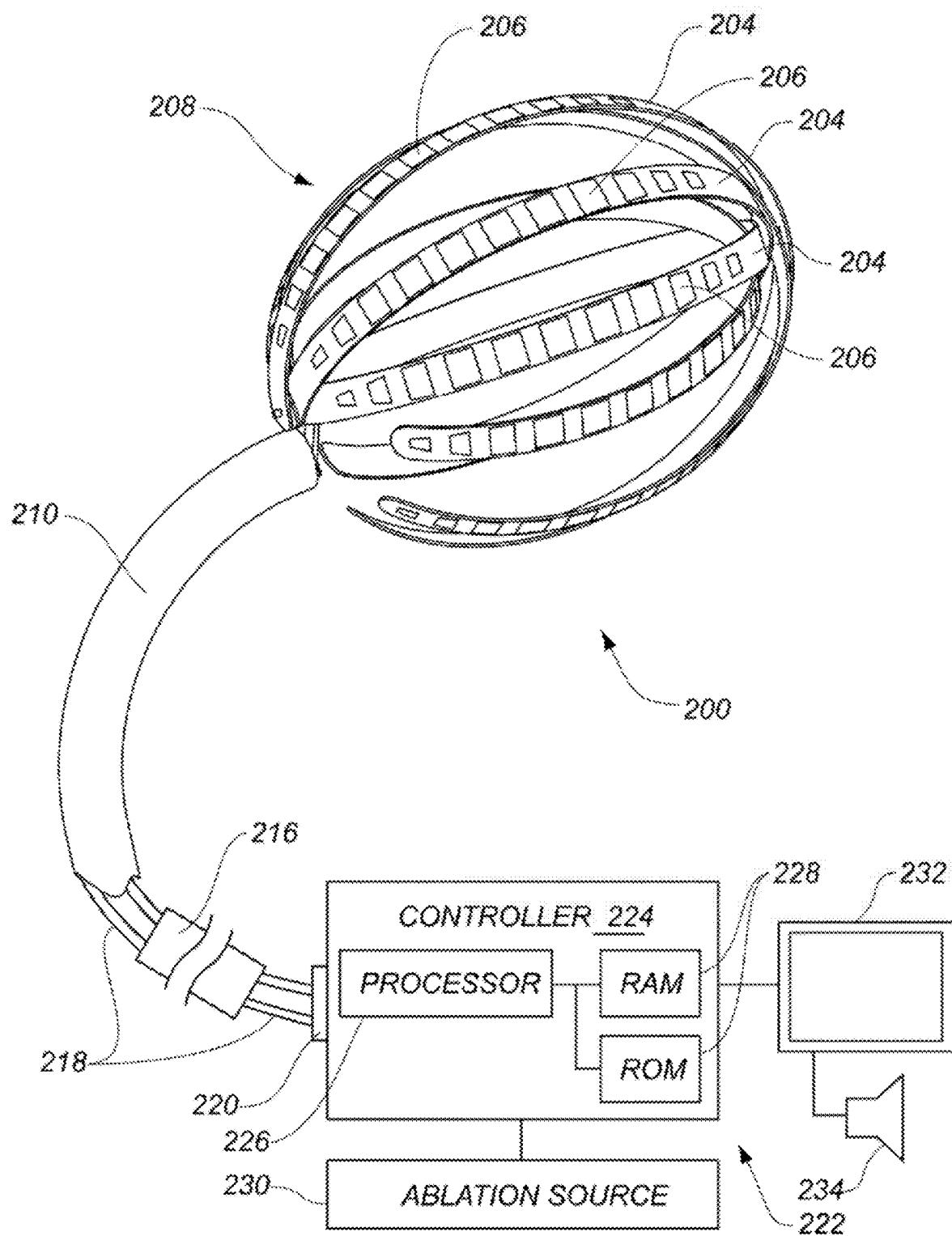


FIG. 2

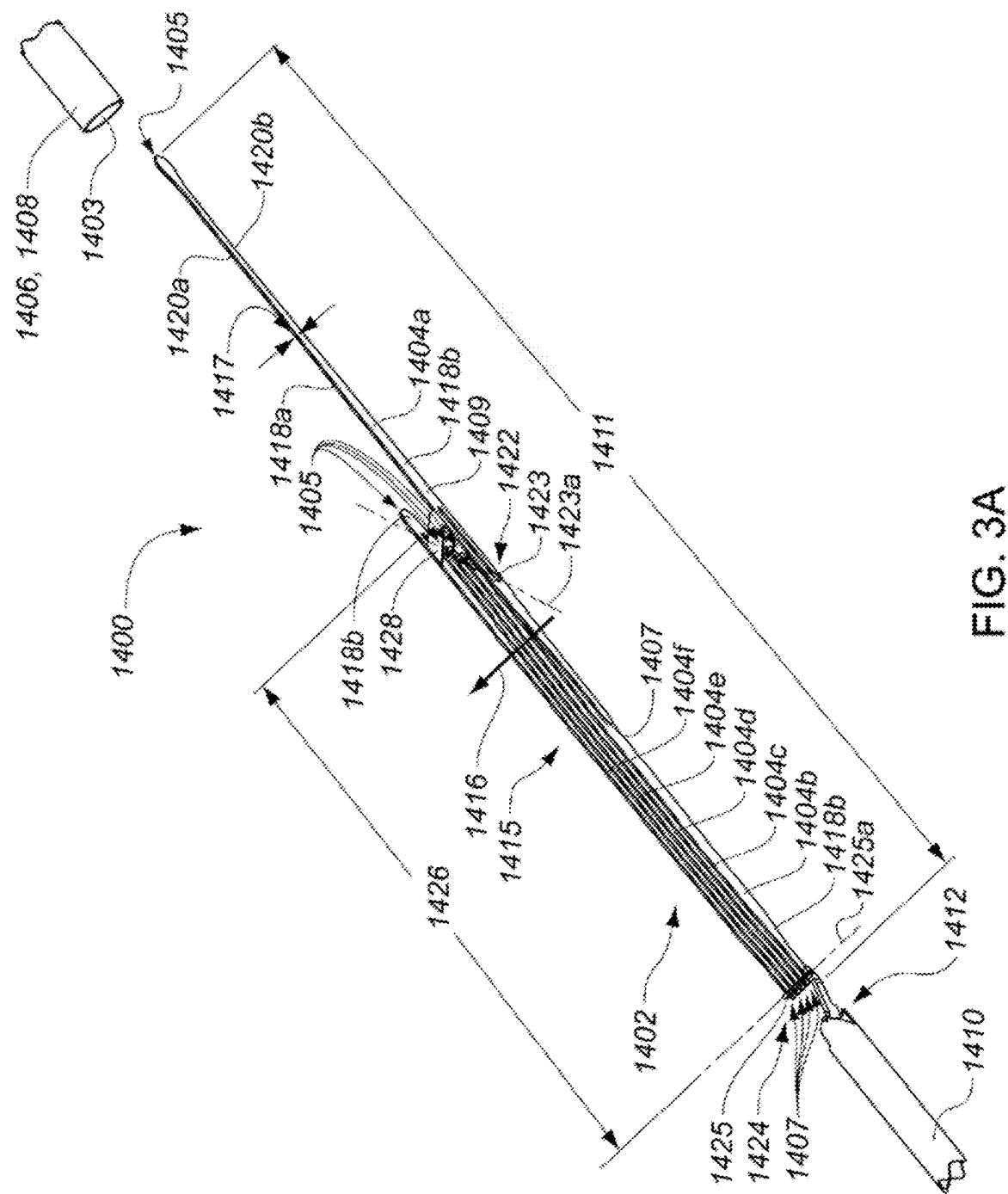
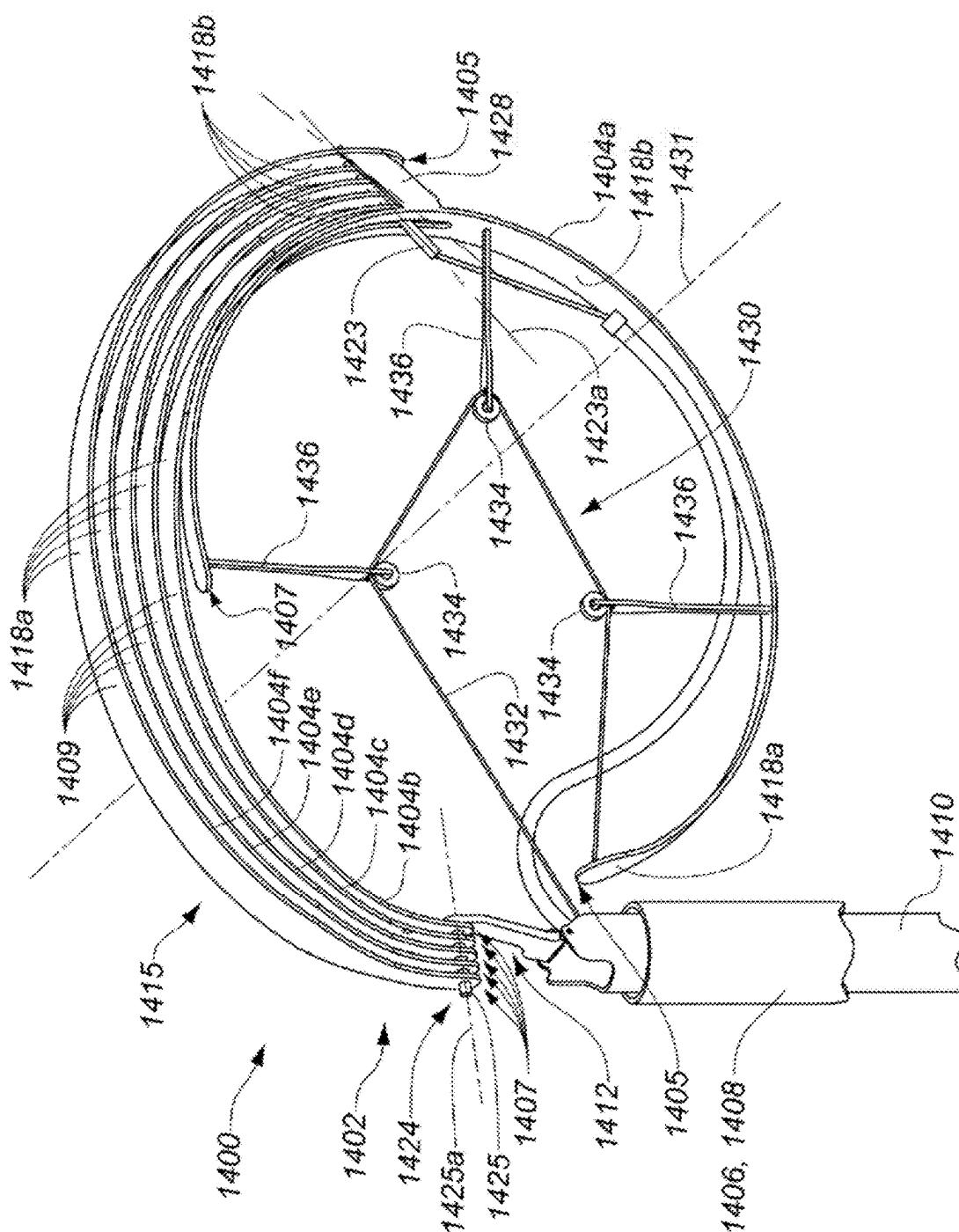


FIG. 3A



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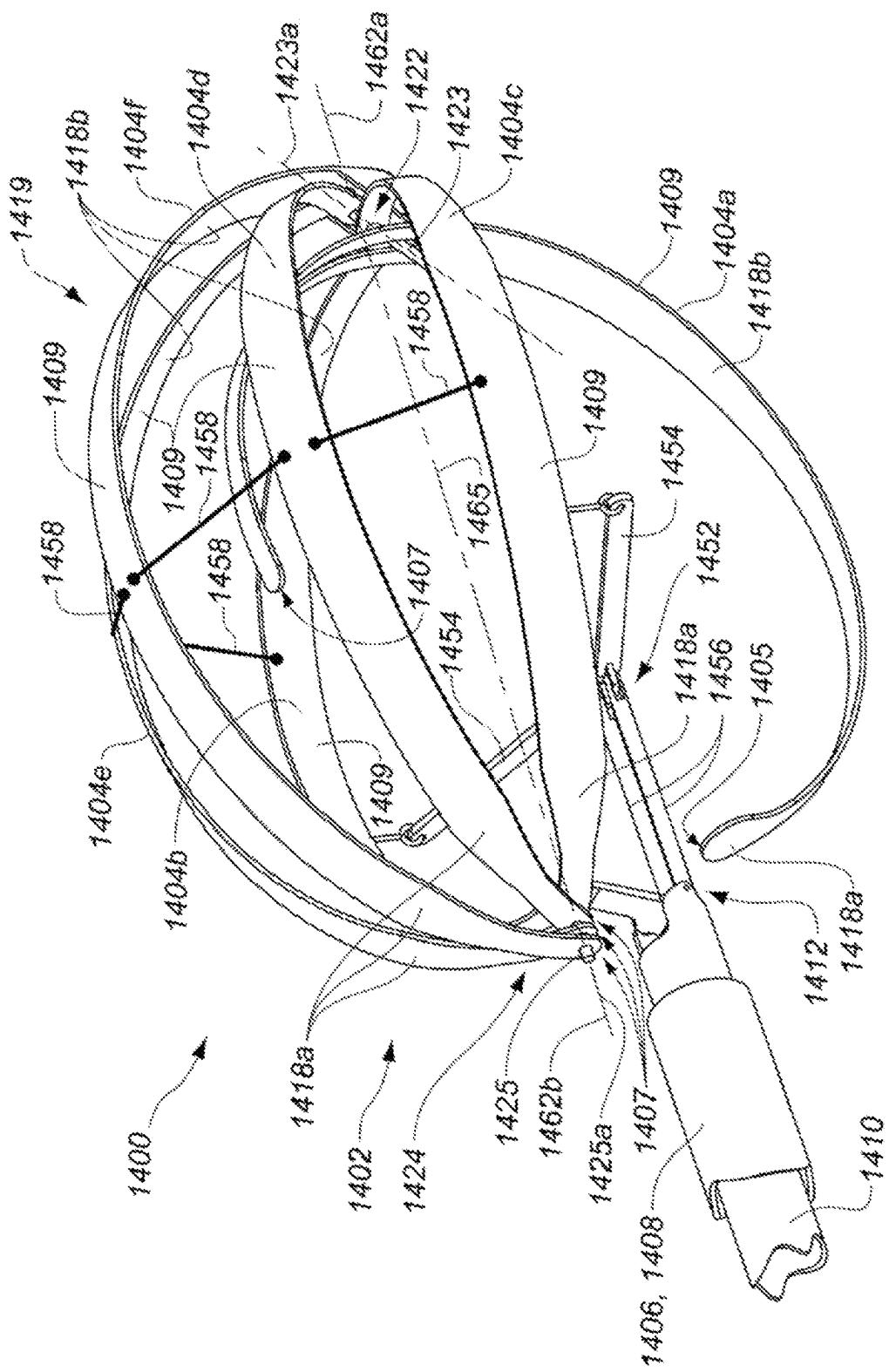


FIG. 3C

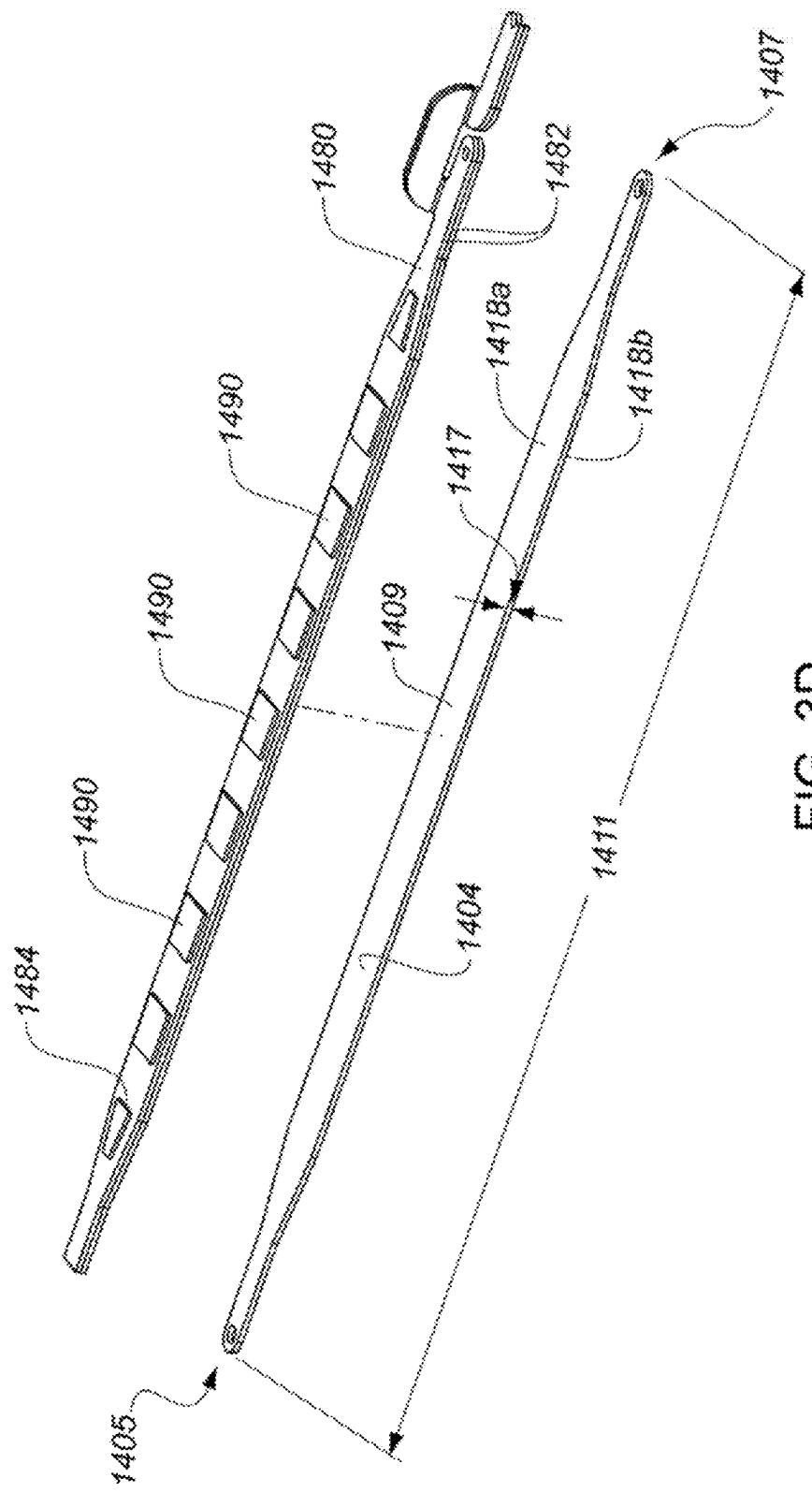


FIG. 3D

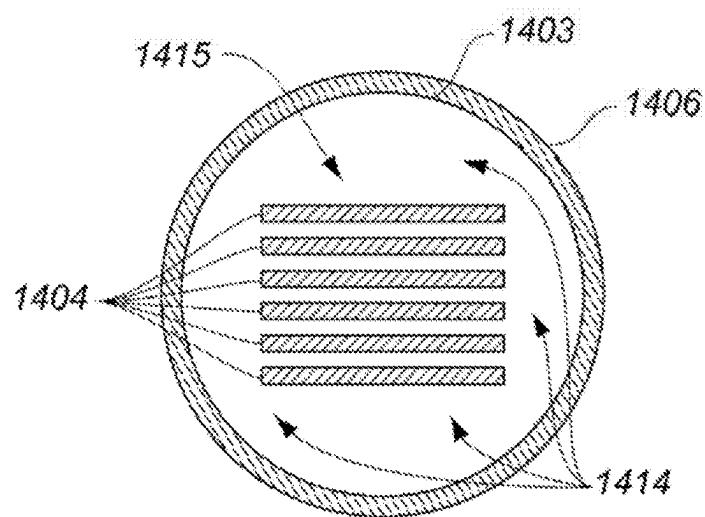


FIG. 3E

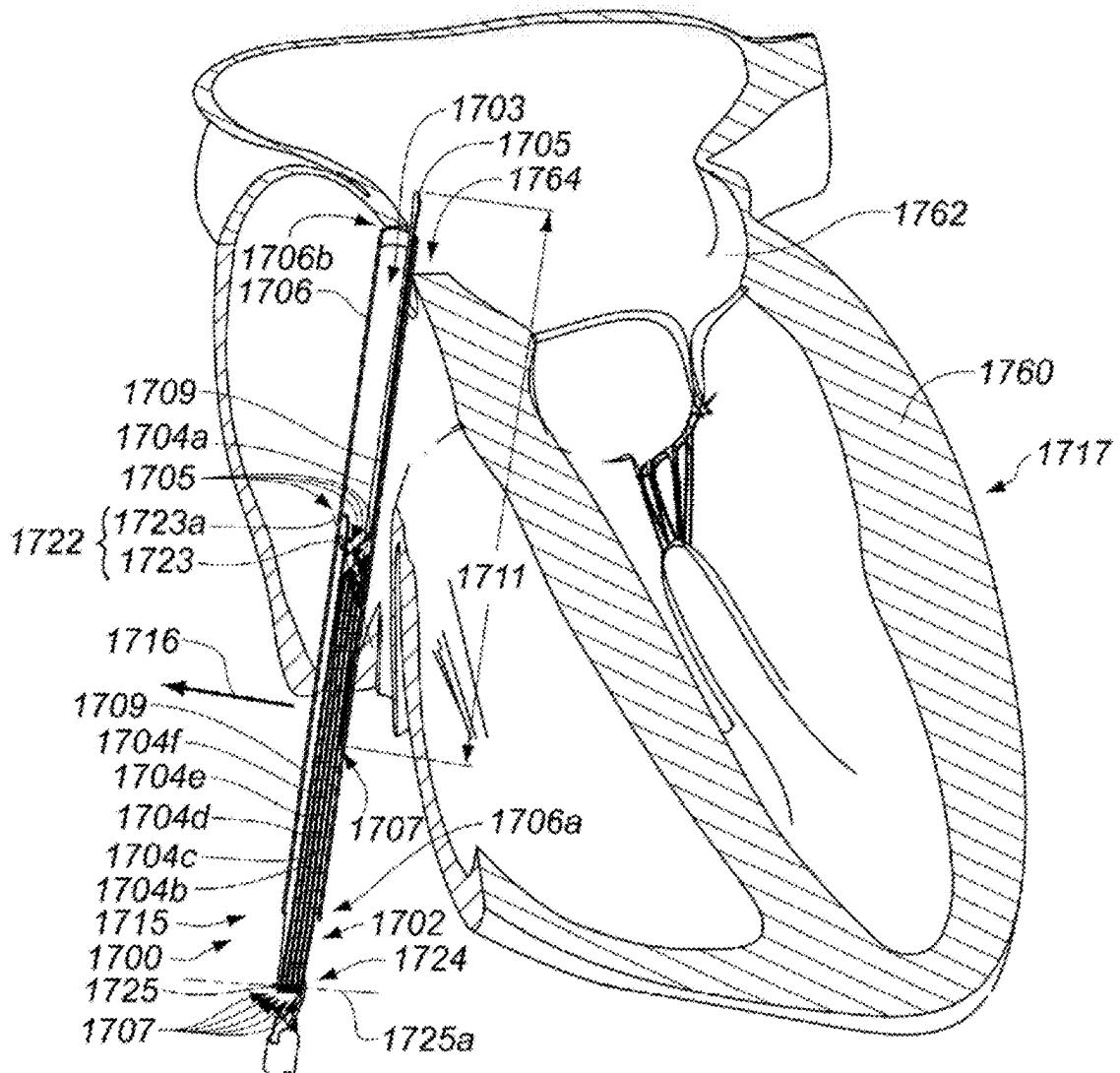


FIG. 4A

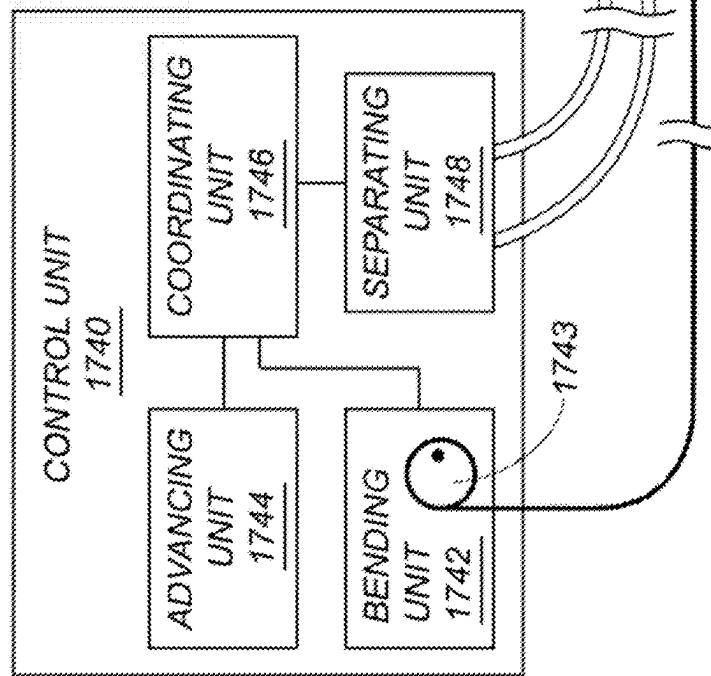
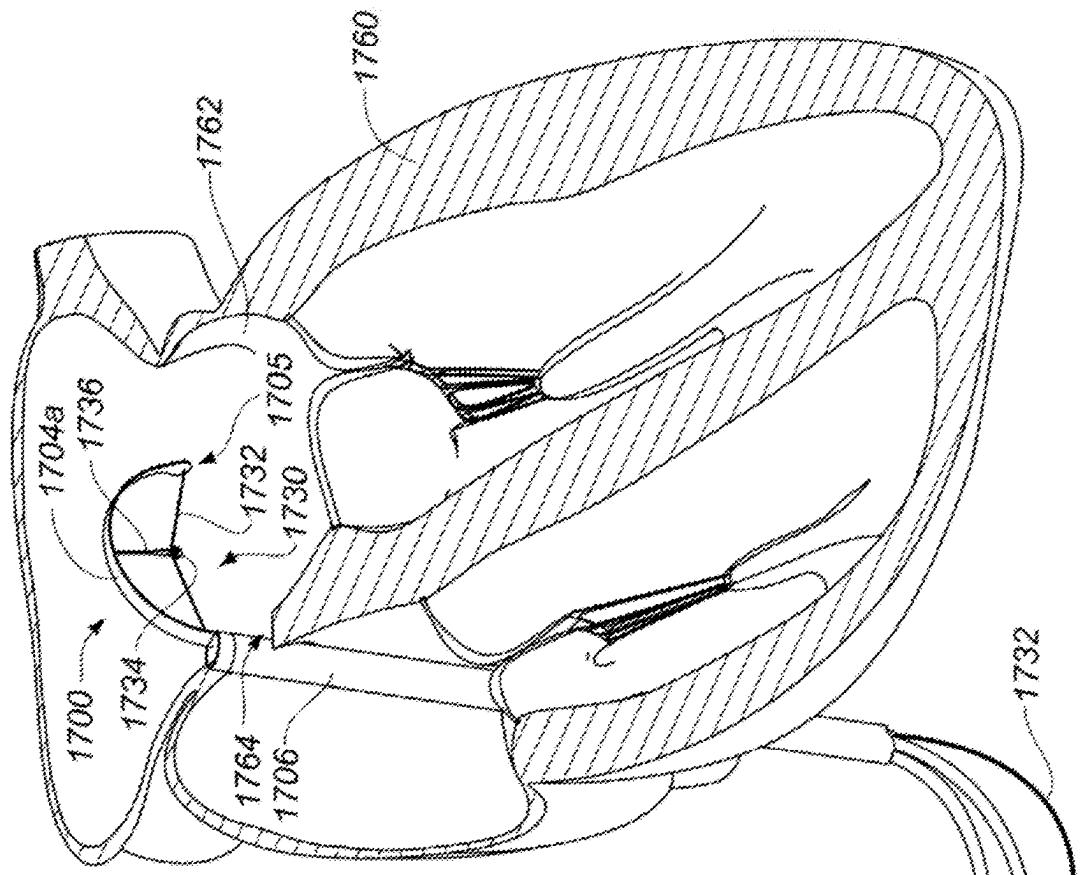


FIG. 4B

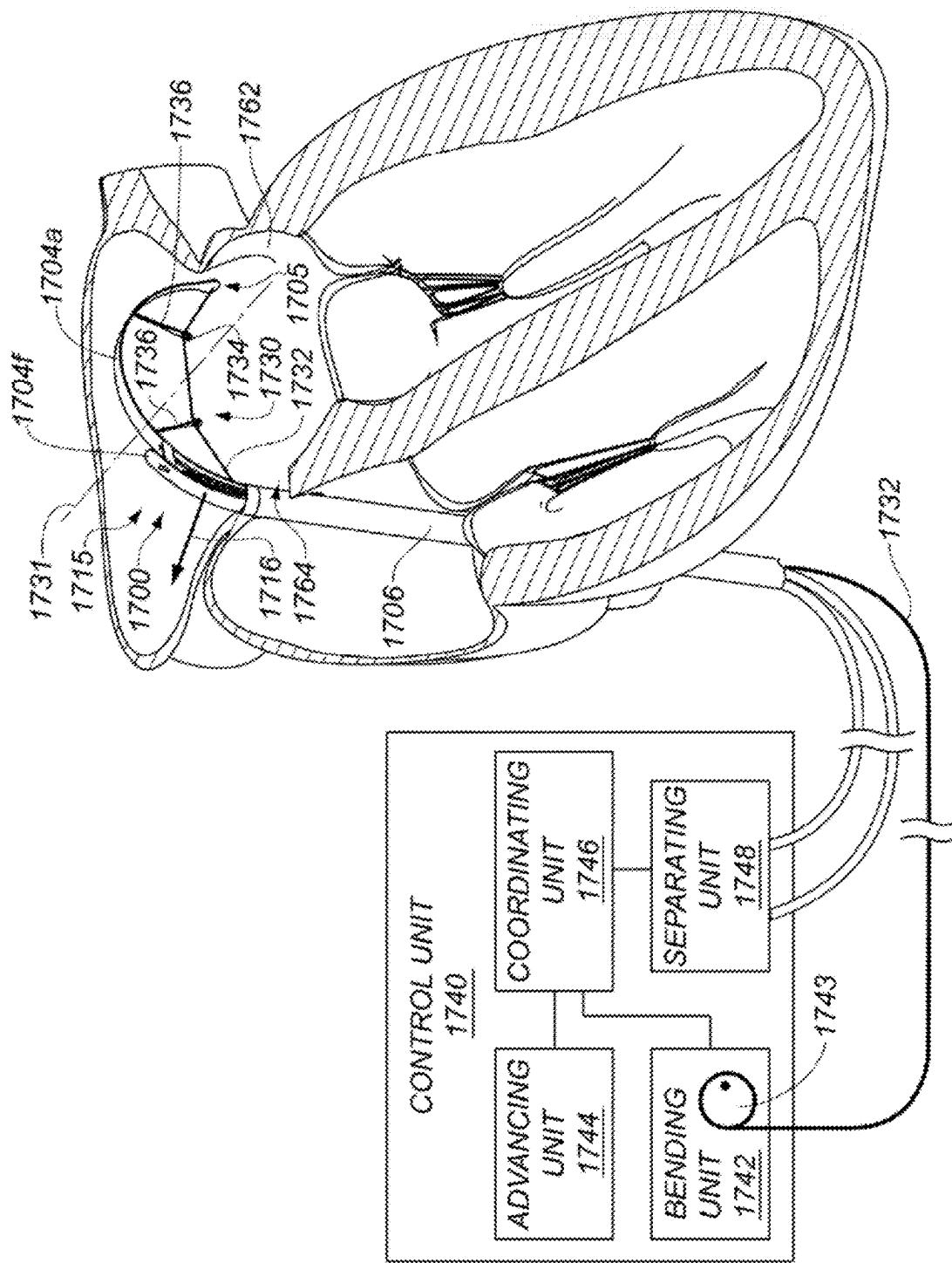
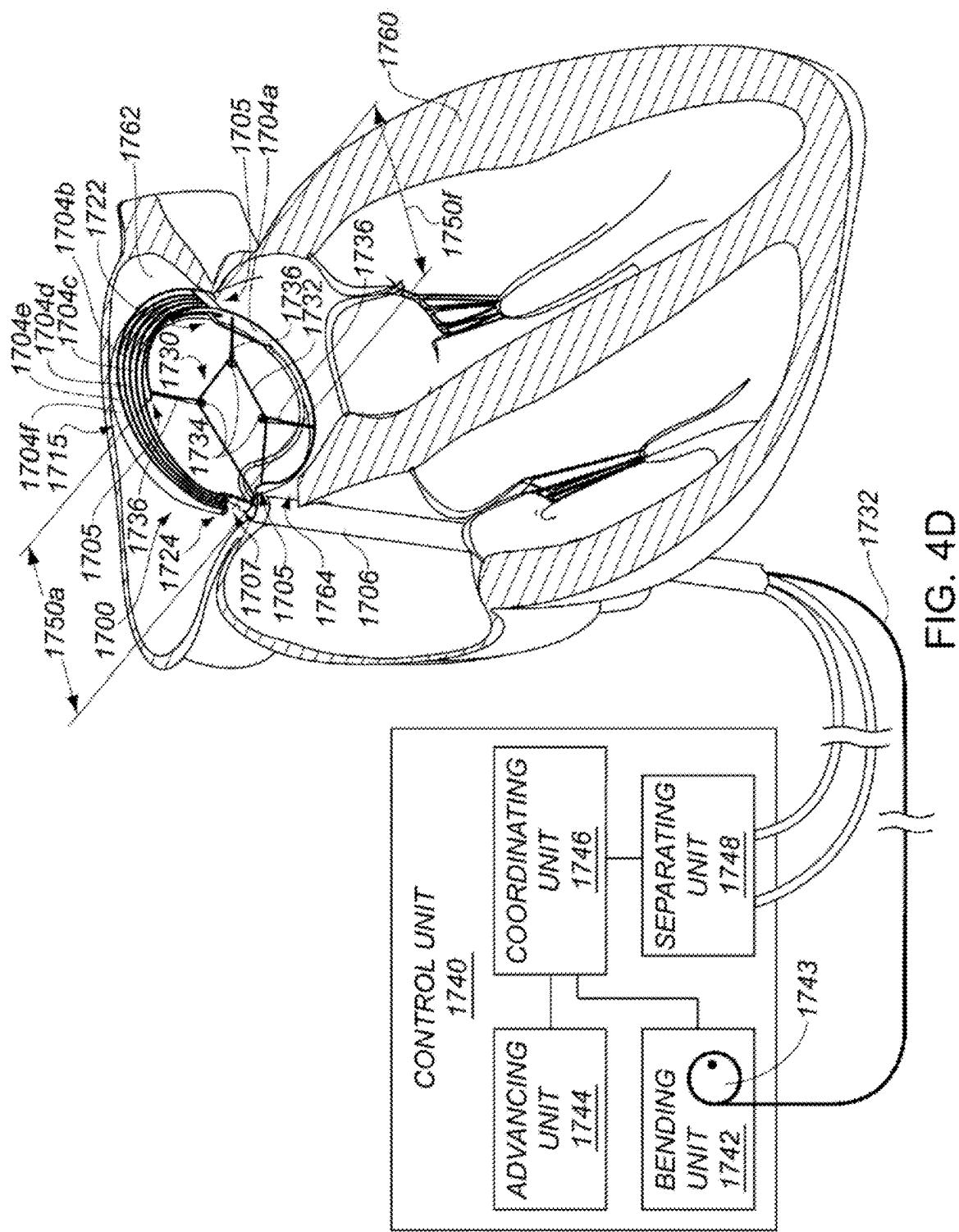


FIG. 4C



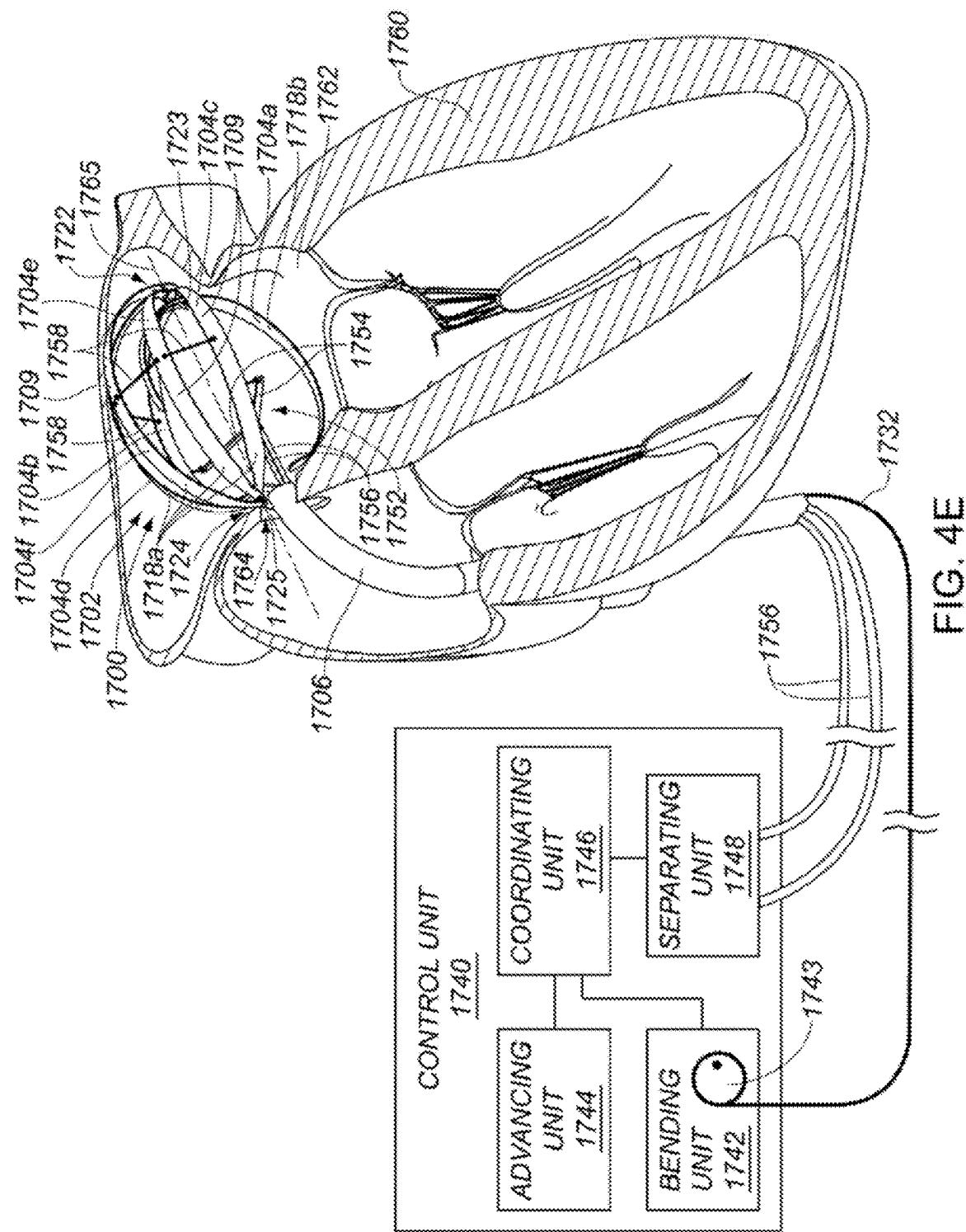


FIG. 4E

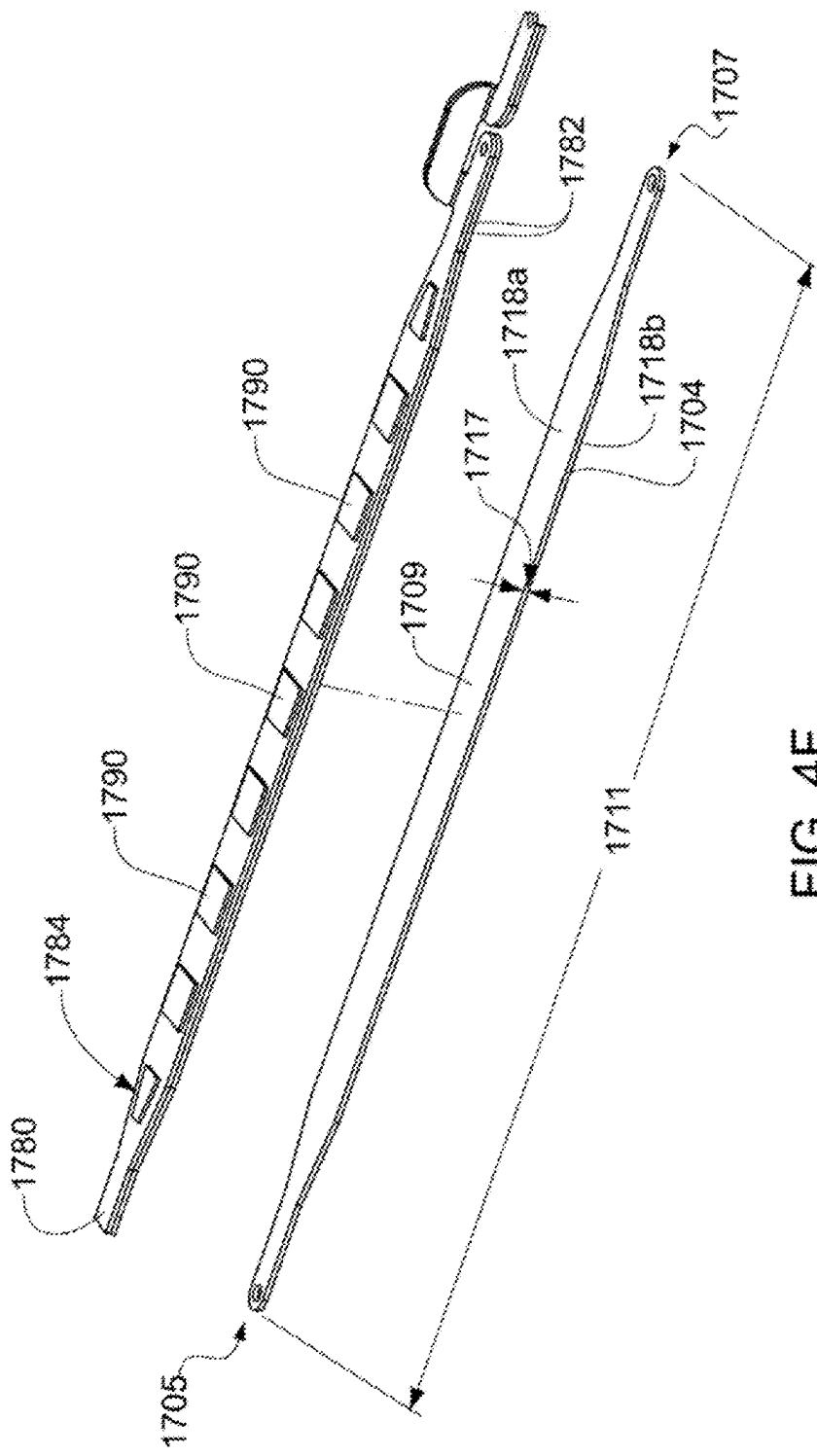


FIG. 4F

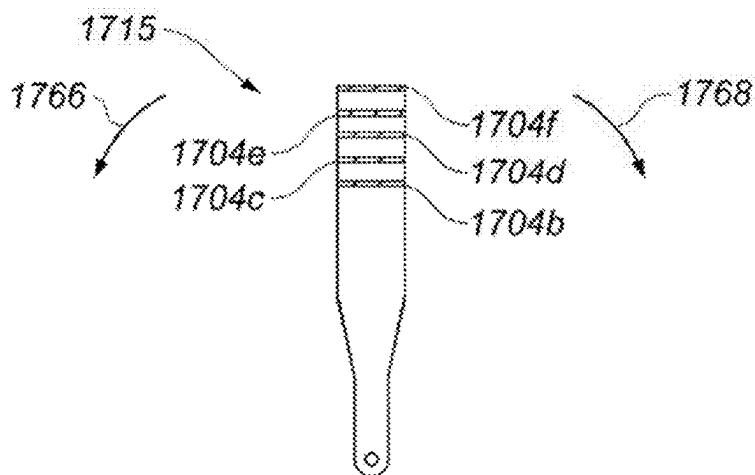


FIG. 4G

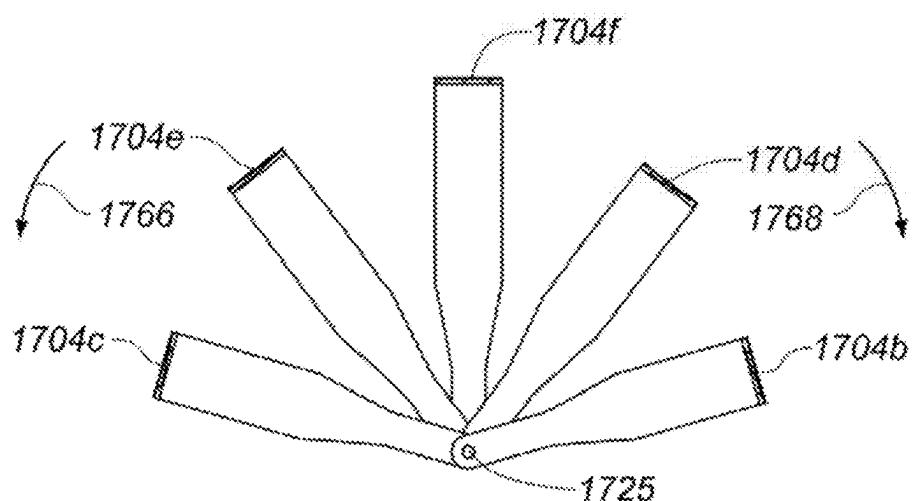


FIG. 4H

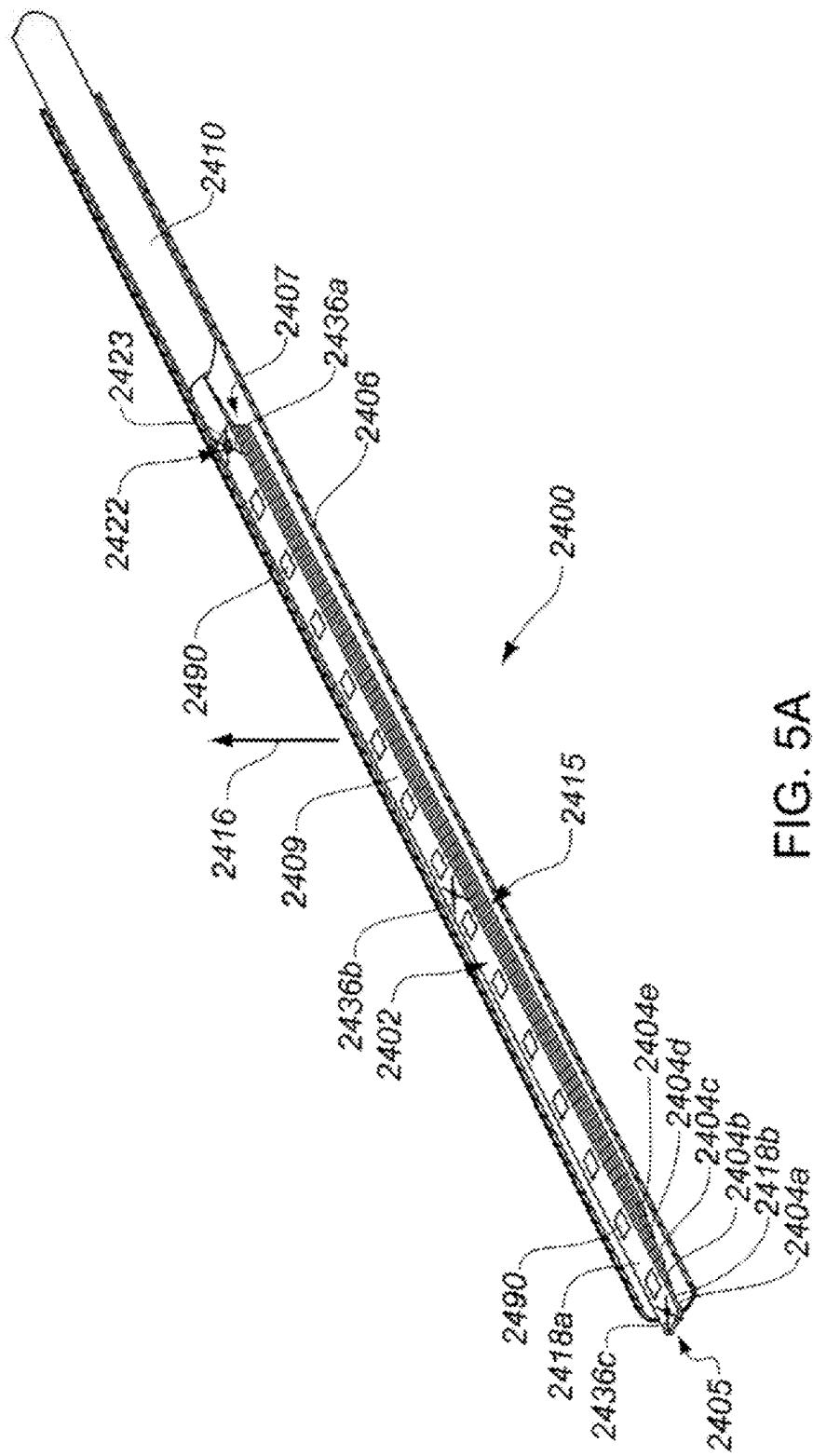


FIG. 5A

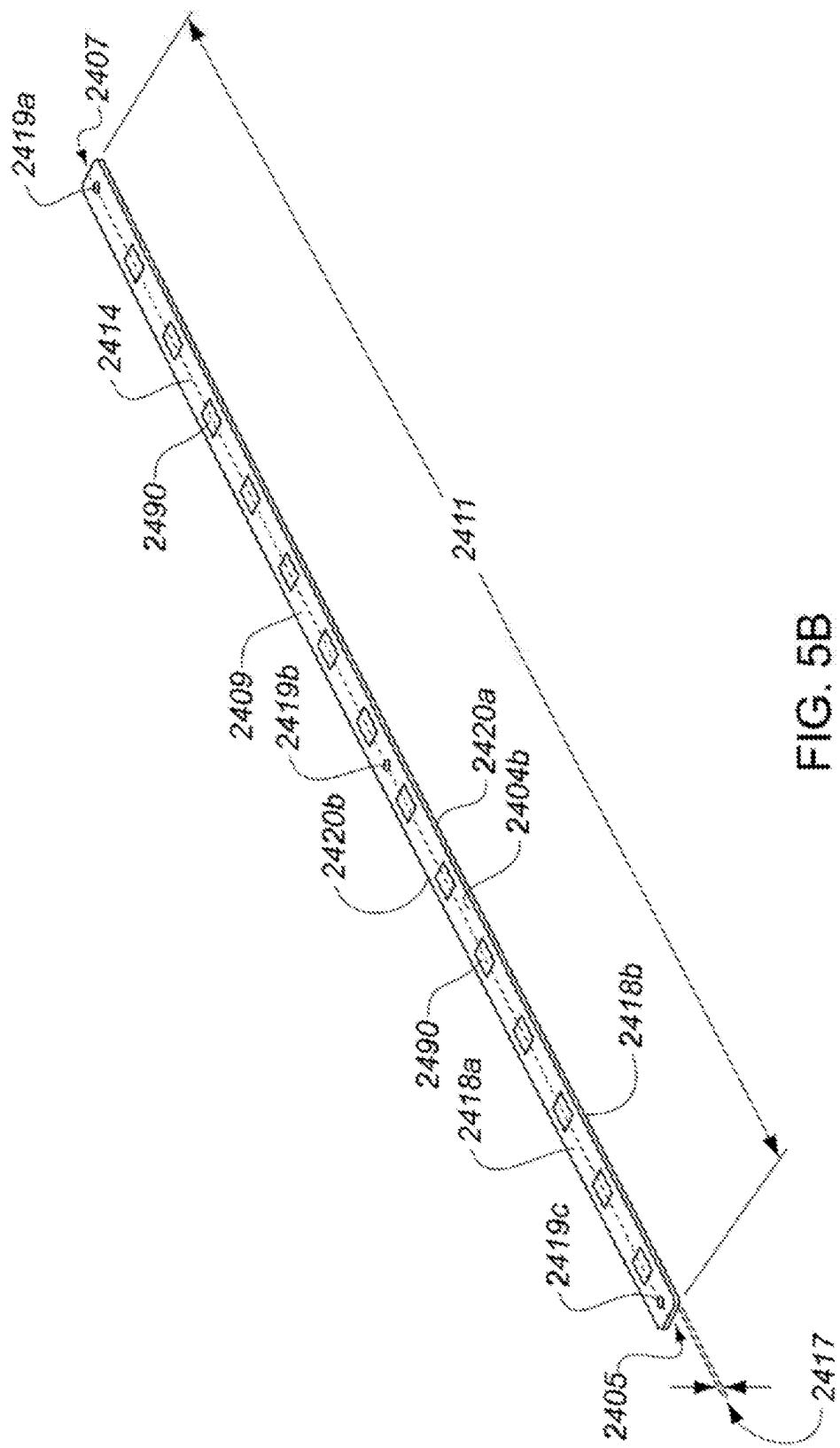


FIG. 5B

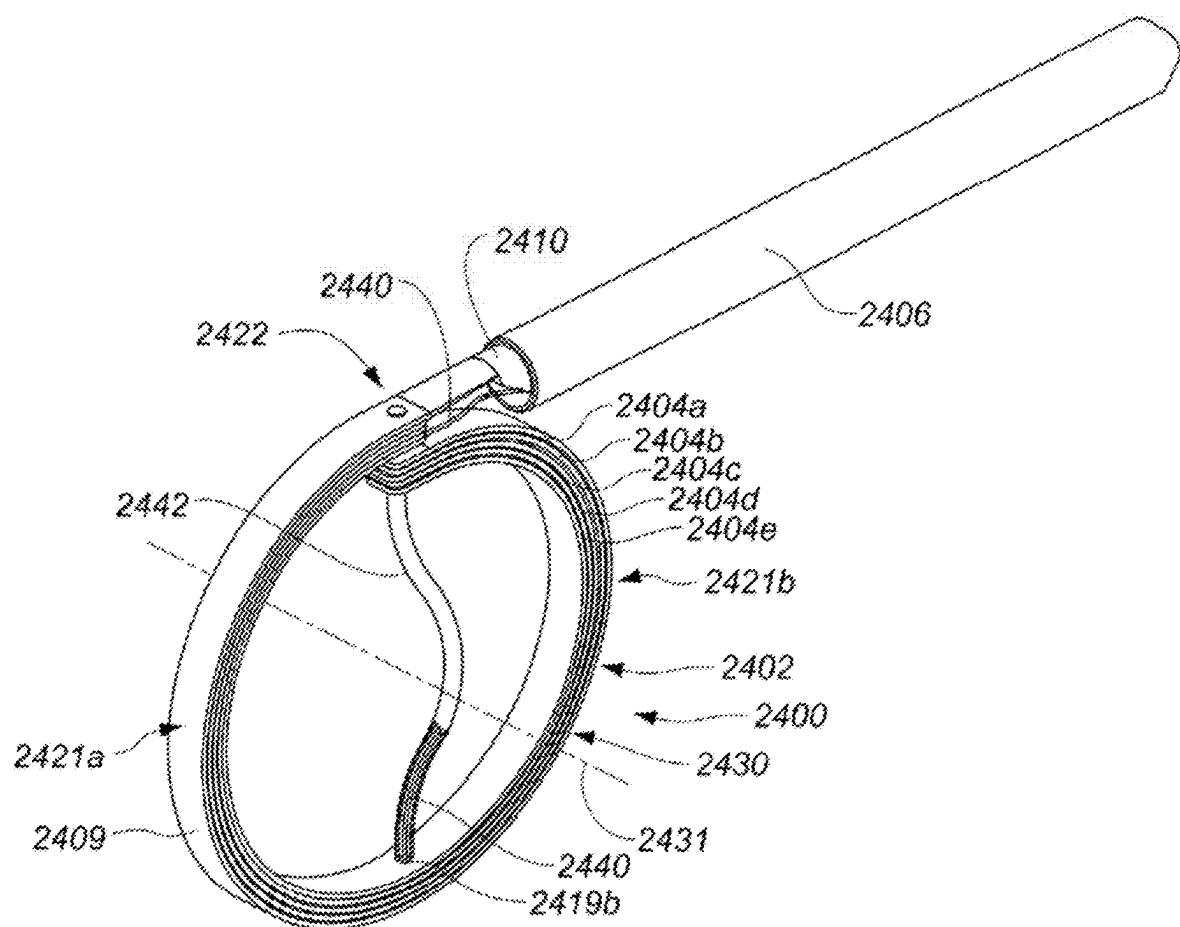


FIG. 5C

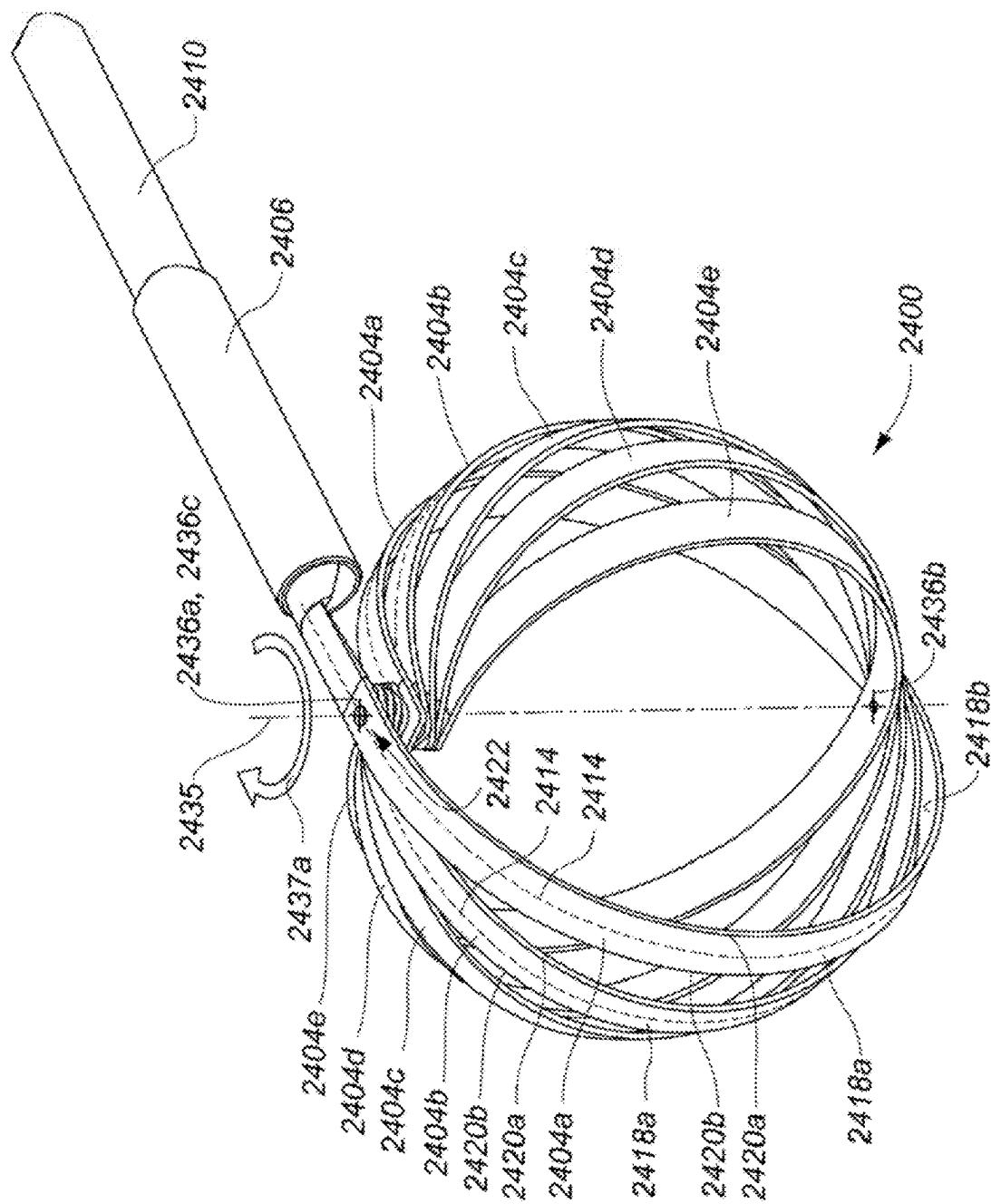


FIG. 5D

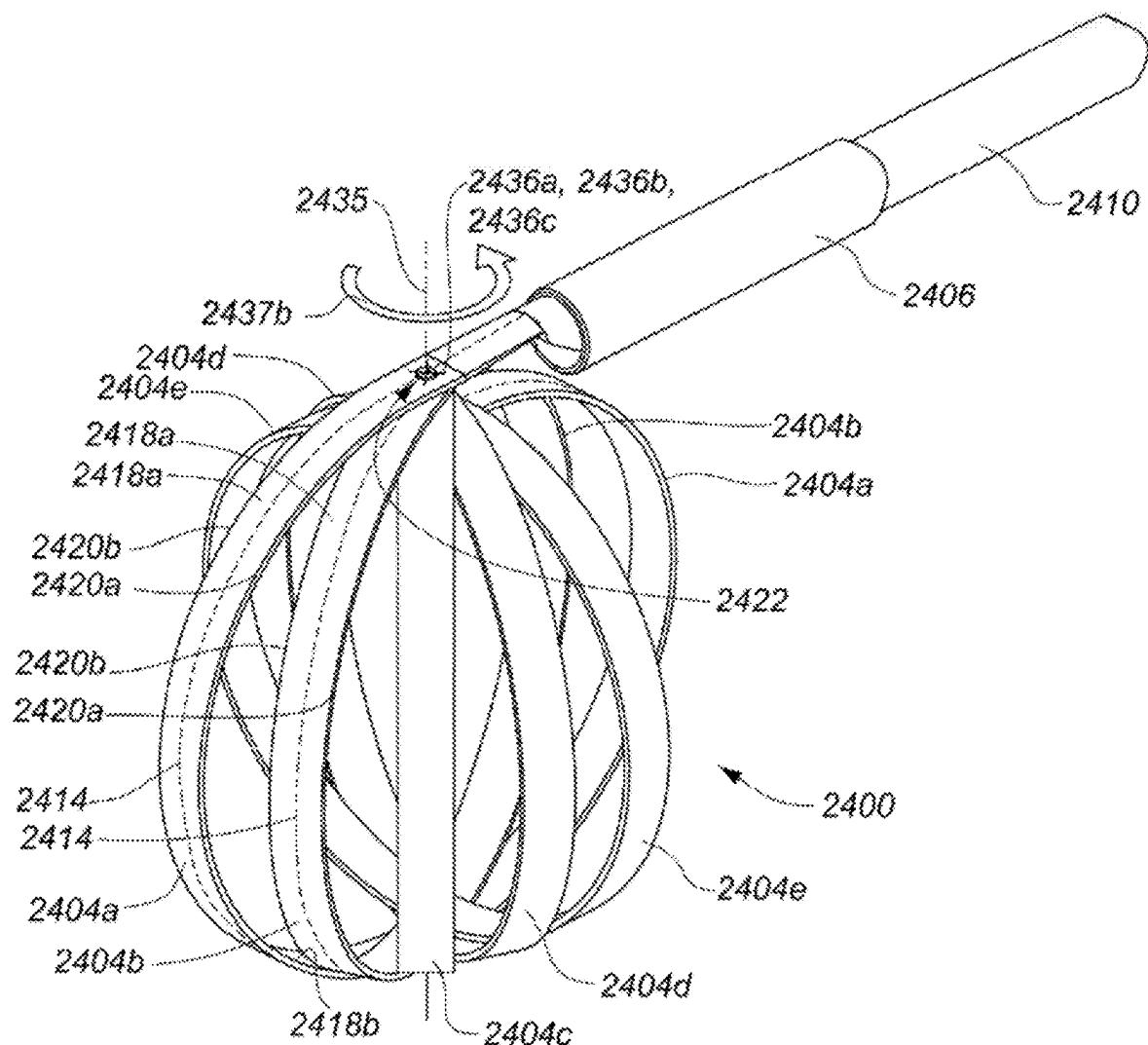


FIG. 5E

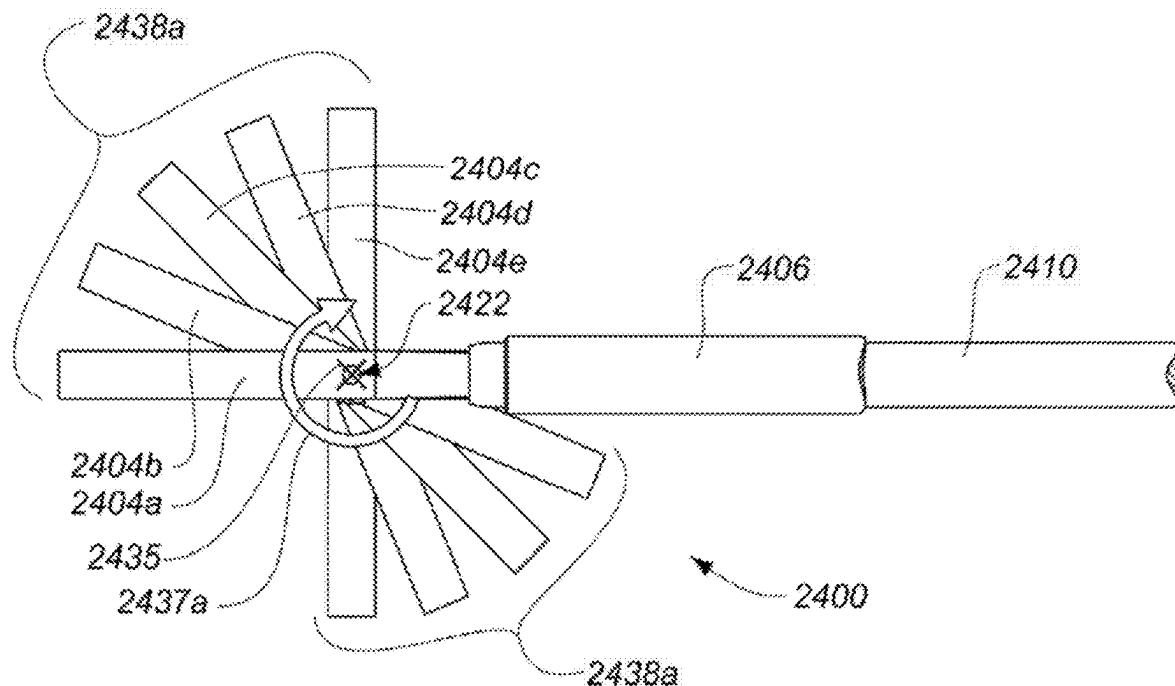


FIG. 5F

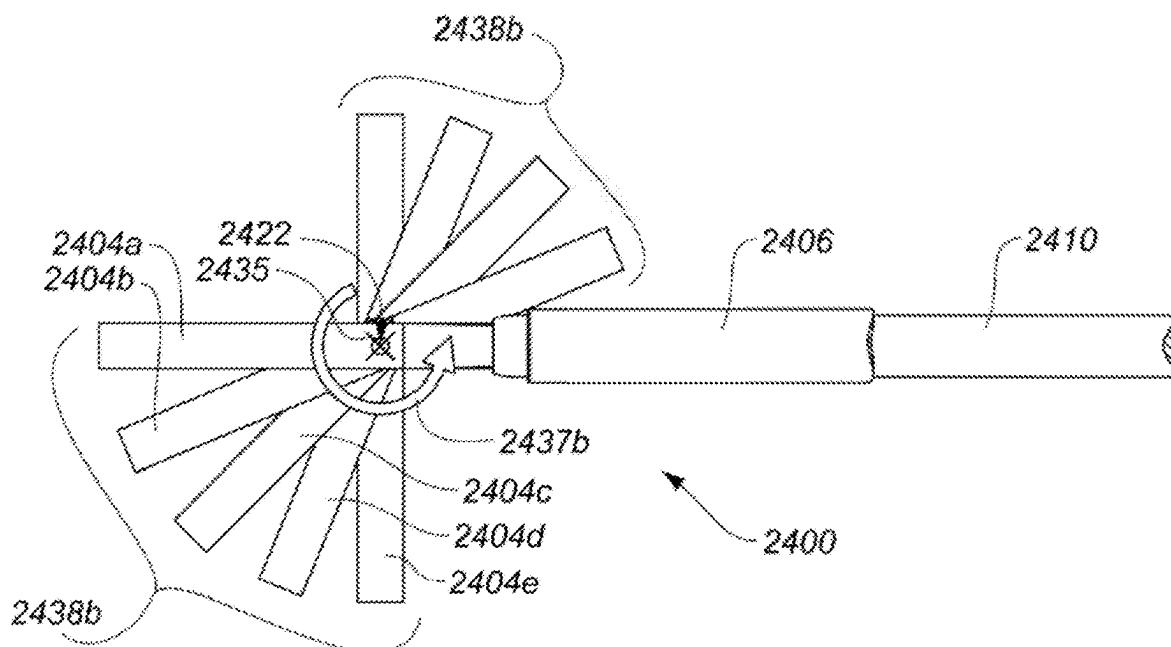


FIG. 5G

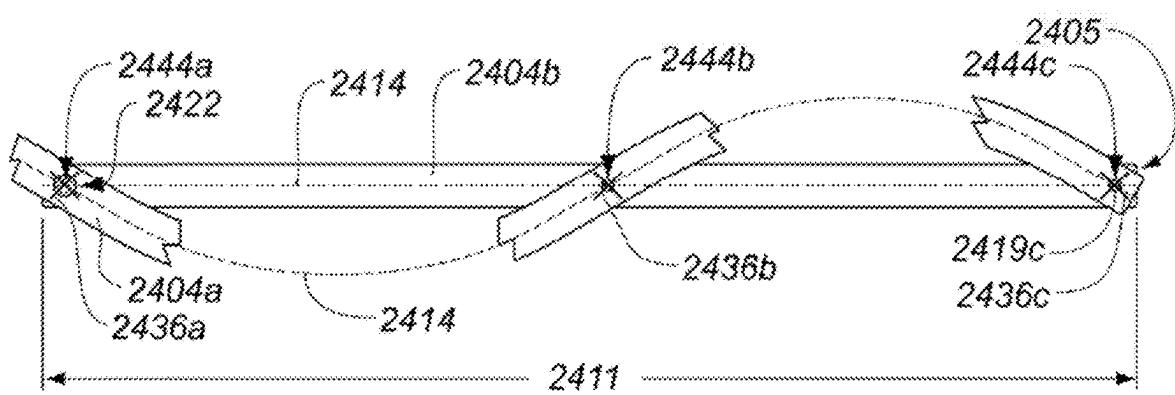
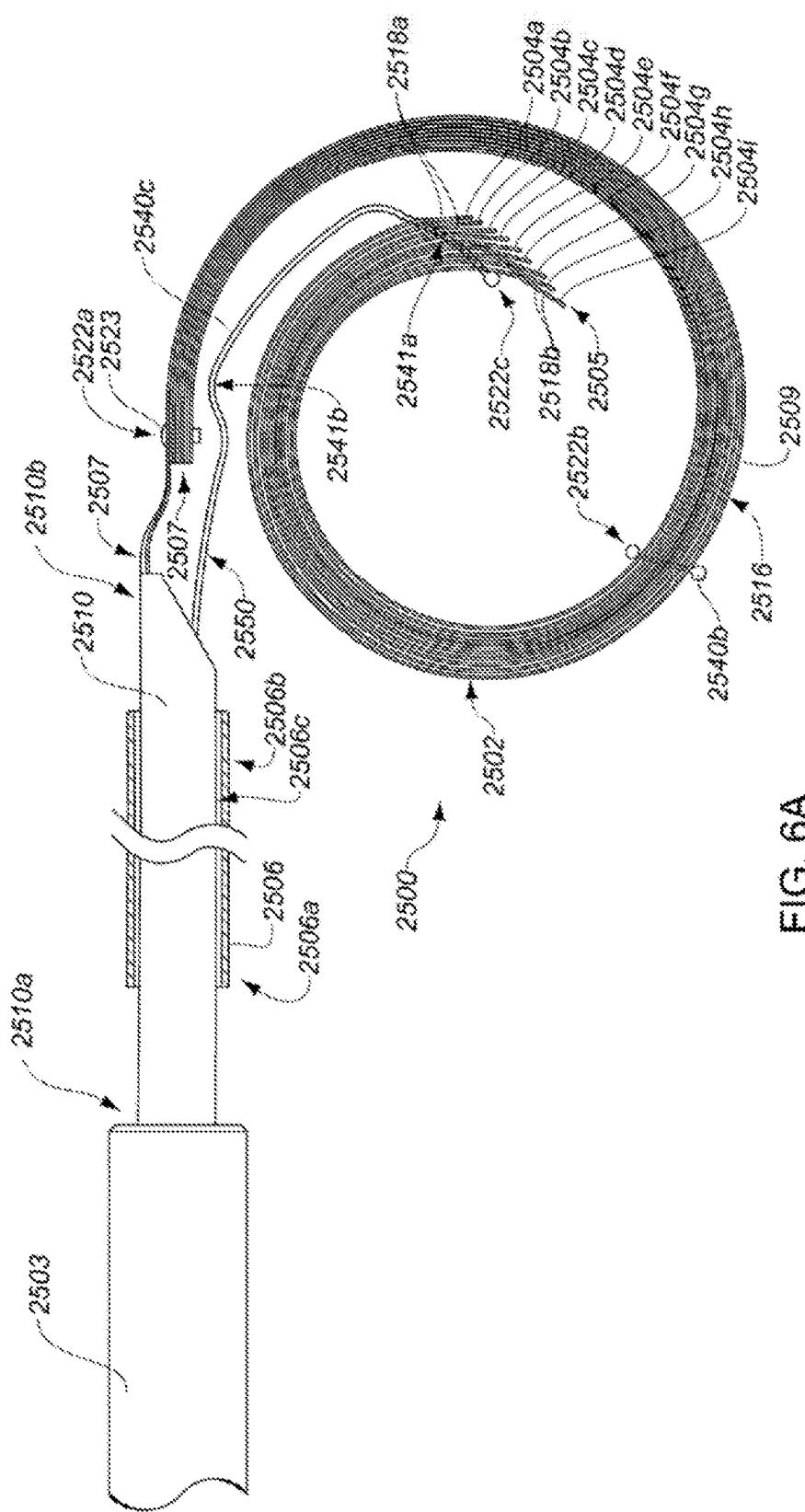


FIG. 5H



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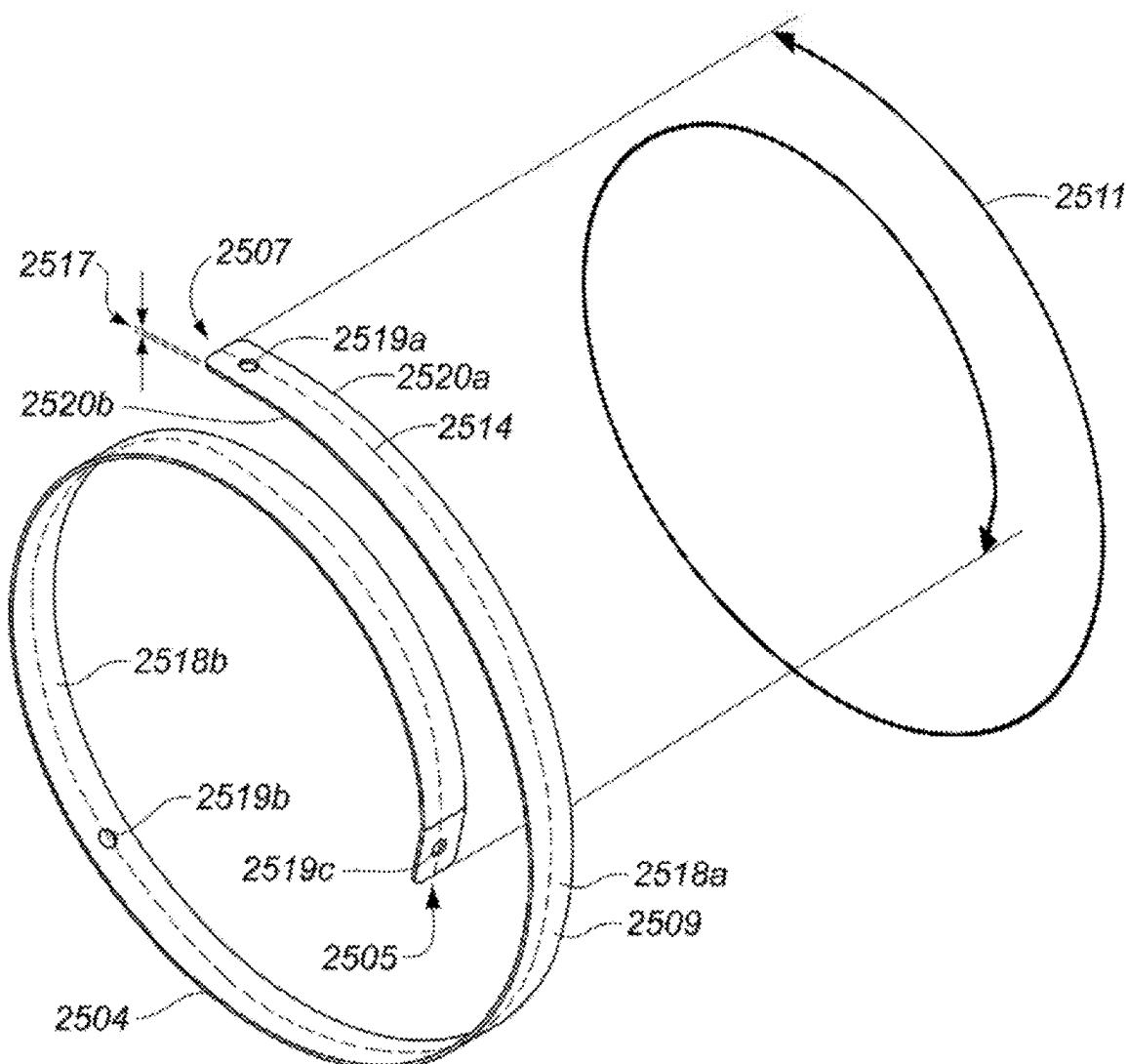


FIG. 6B

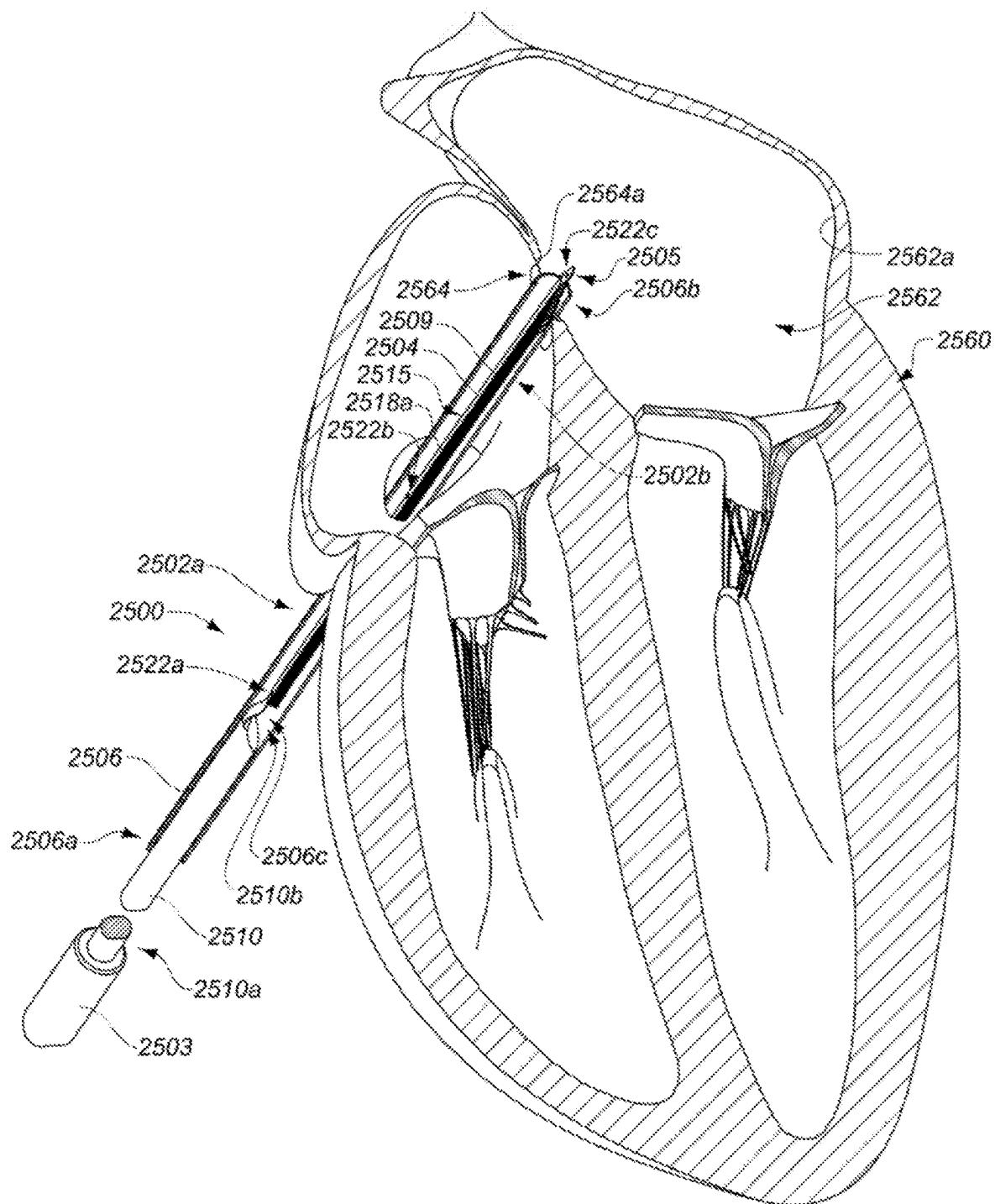


FIG. 6C

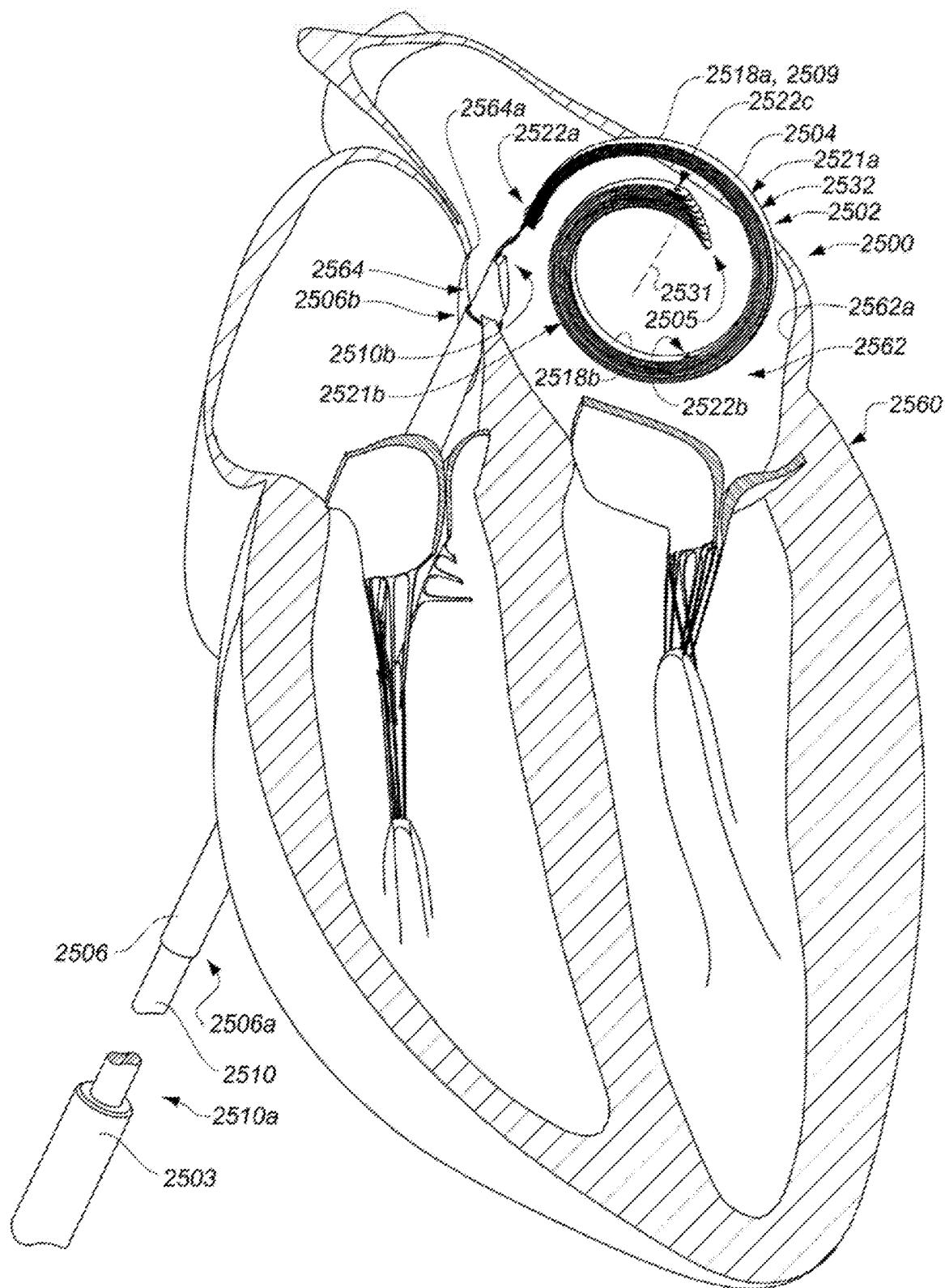


FIG. 6D

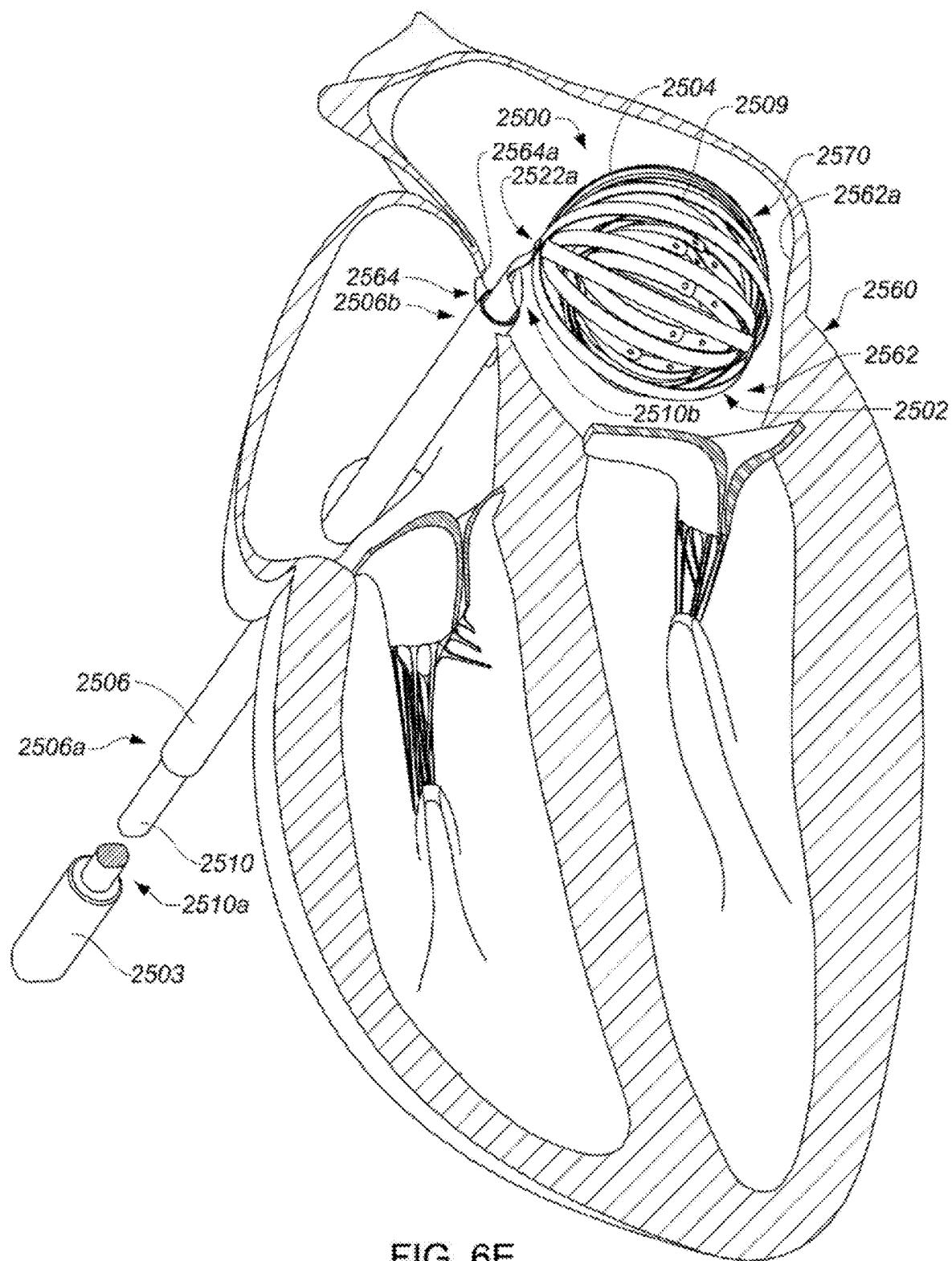


FIG. 6E

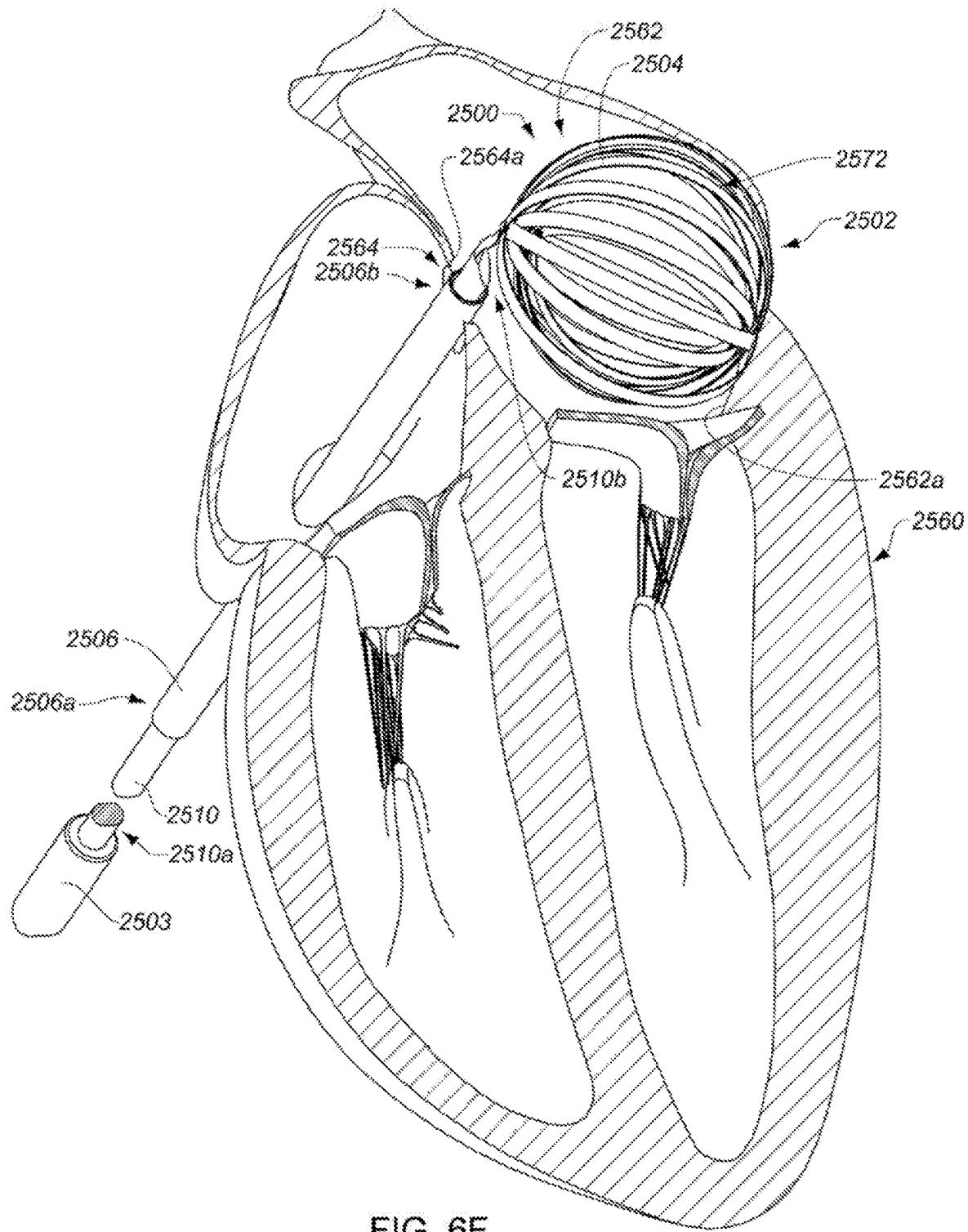


FIG. 6F

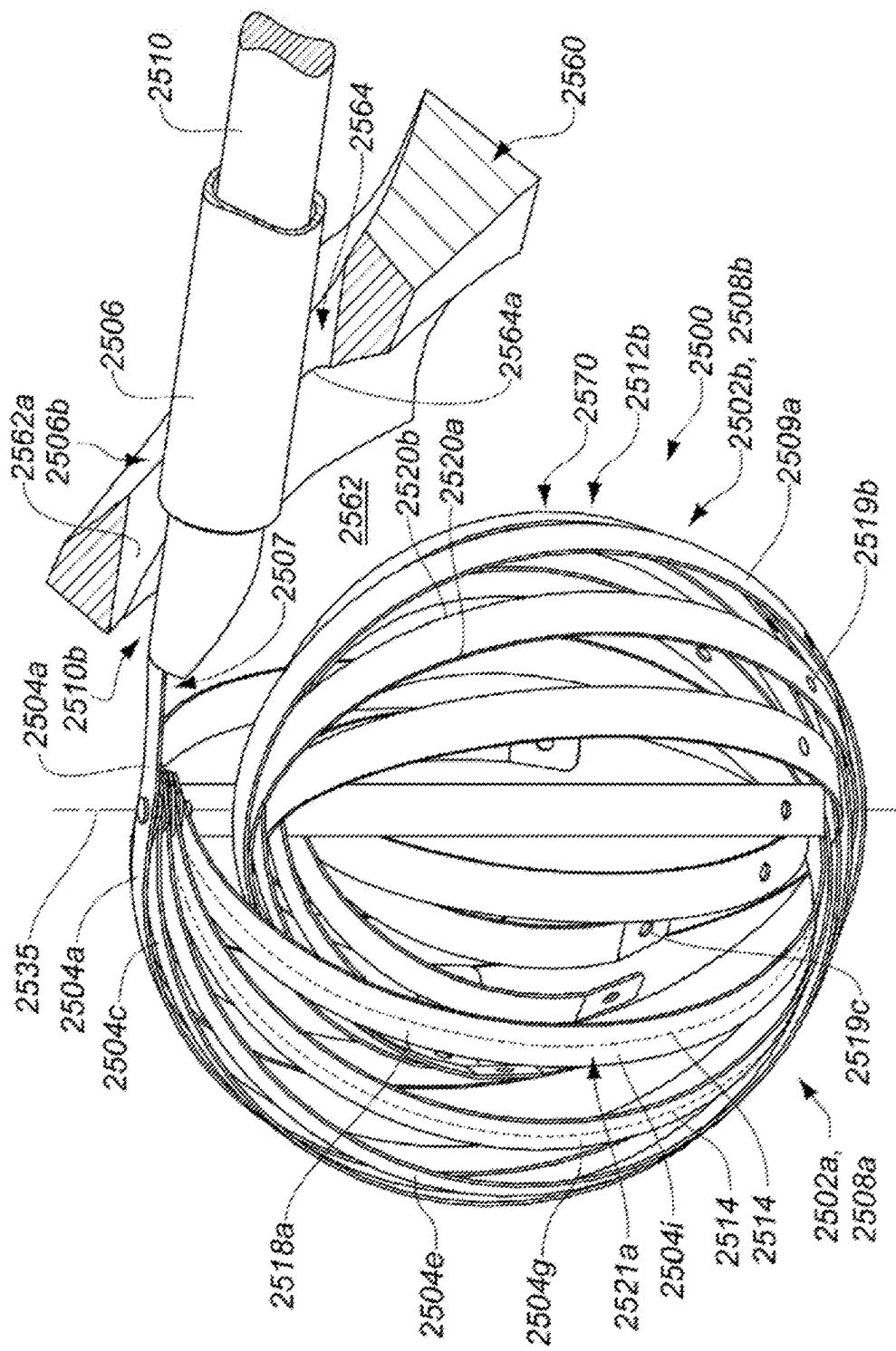


FIG. 6G

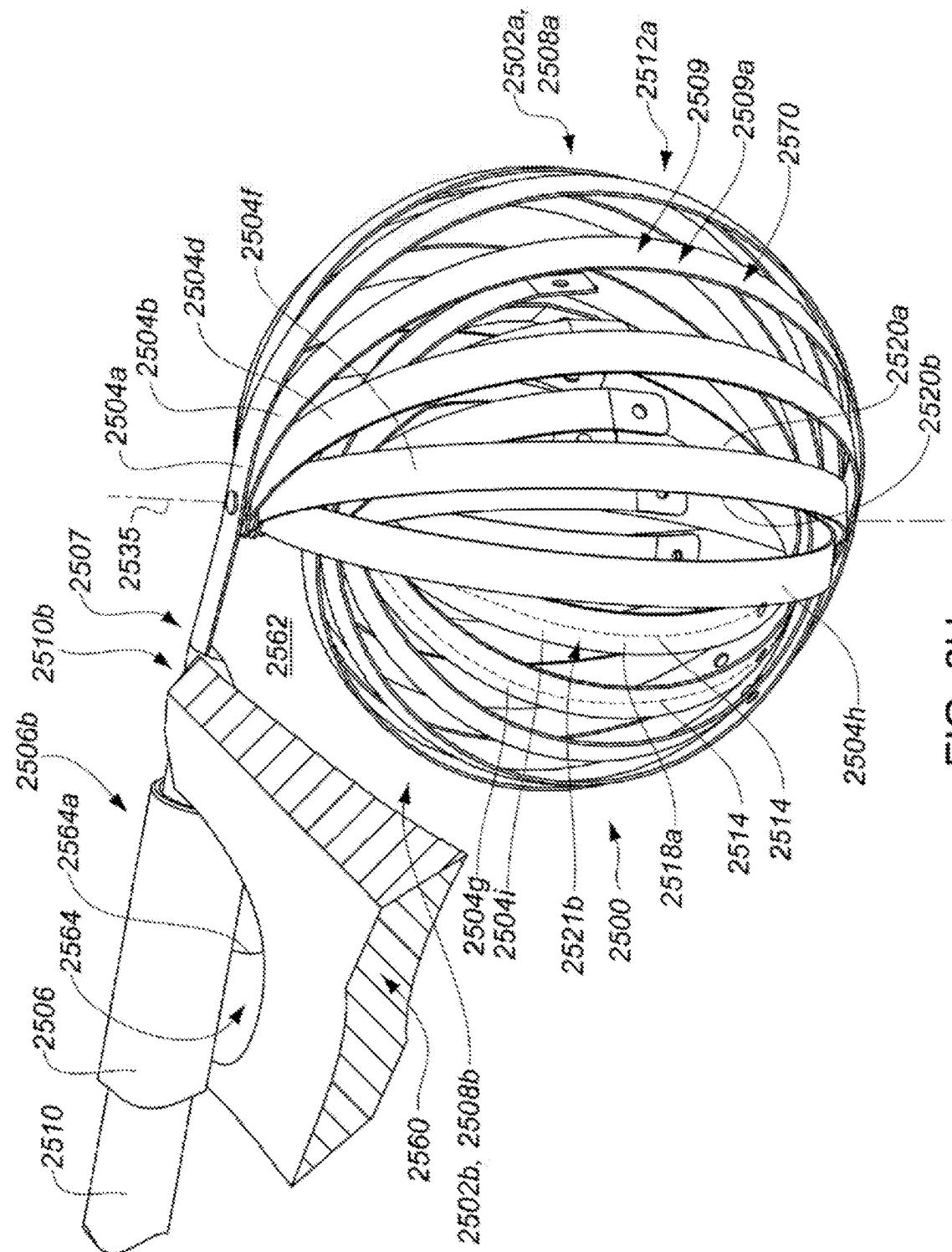


FIG. 6H

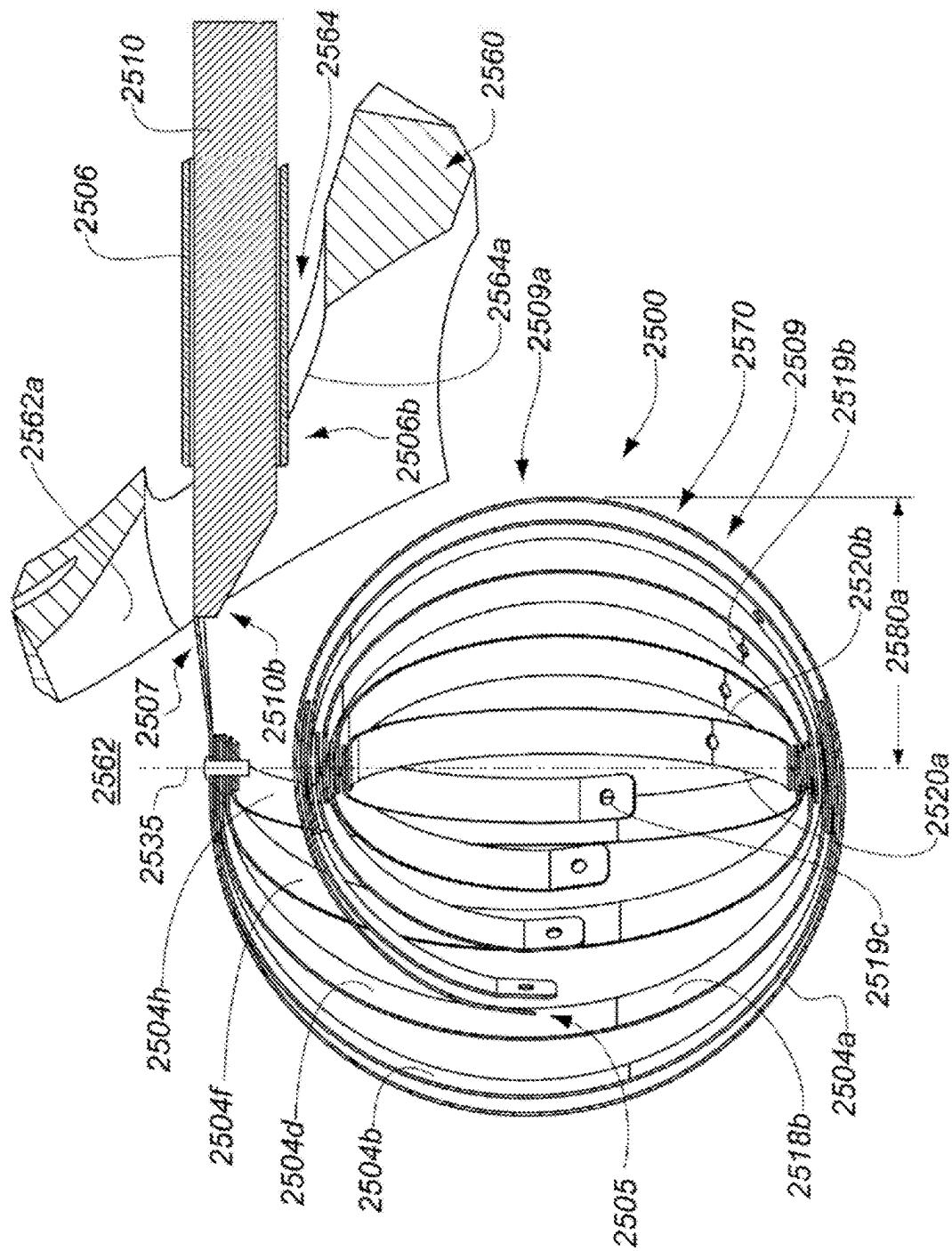


FIG. 6I

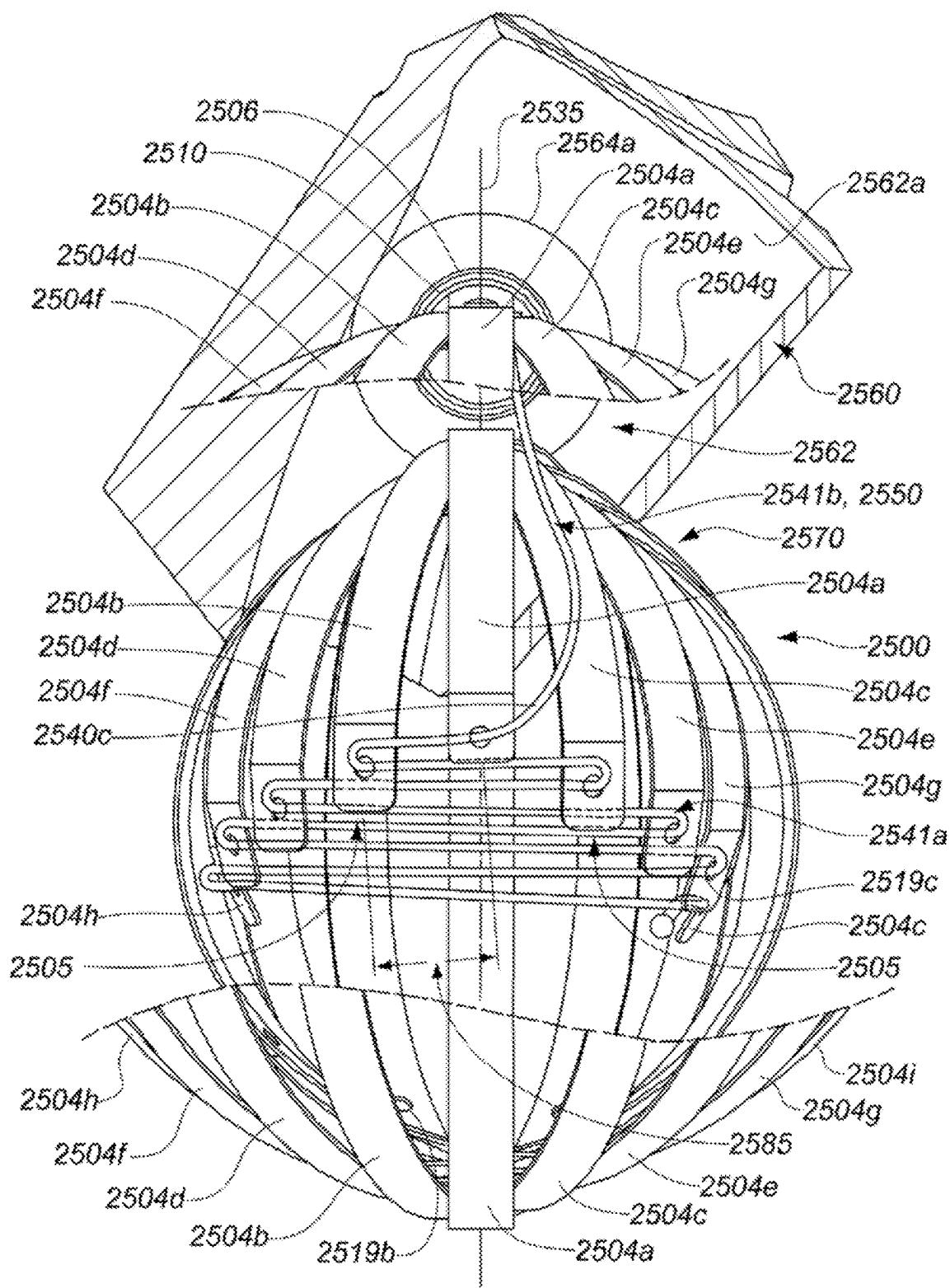
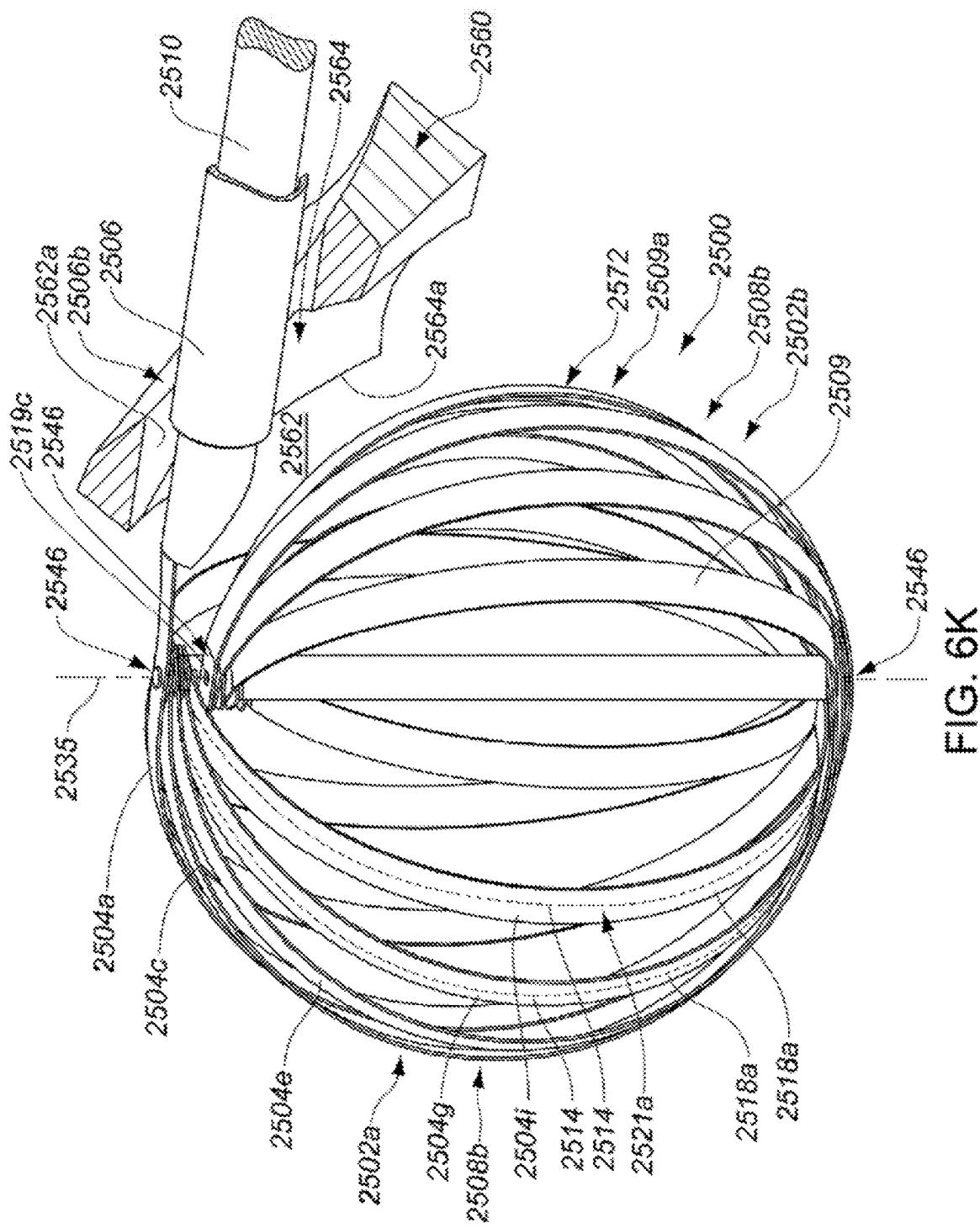


FIG. 6J



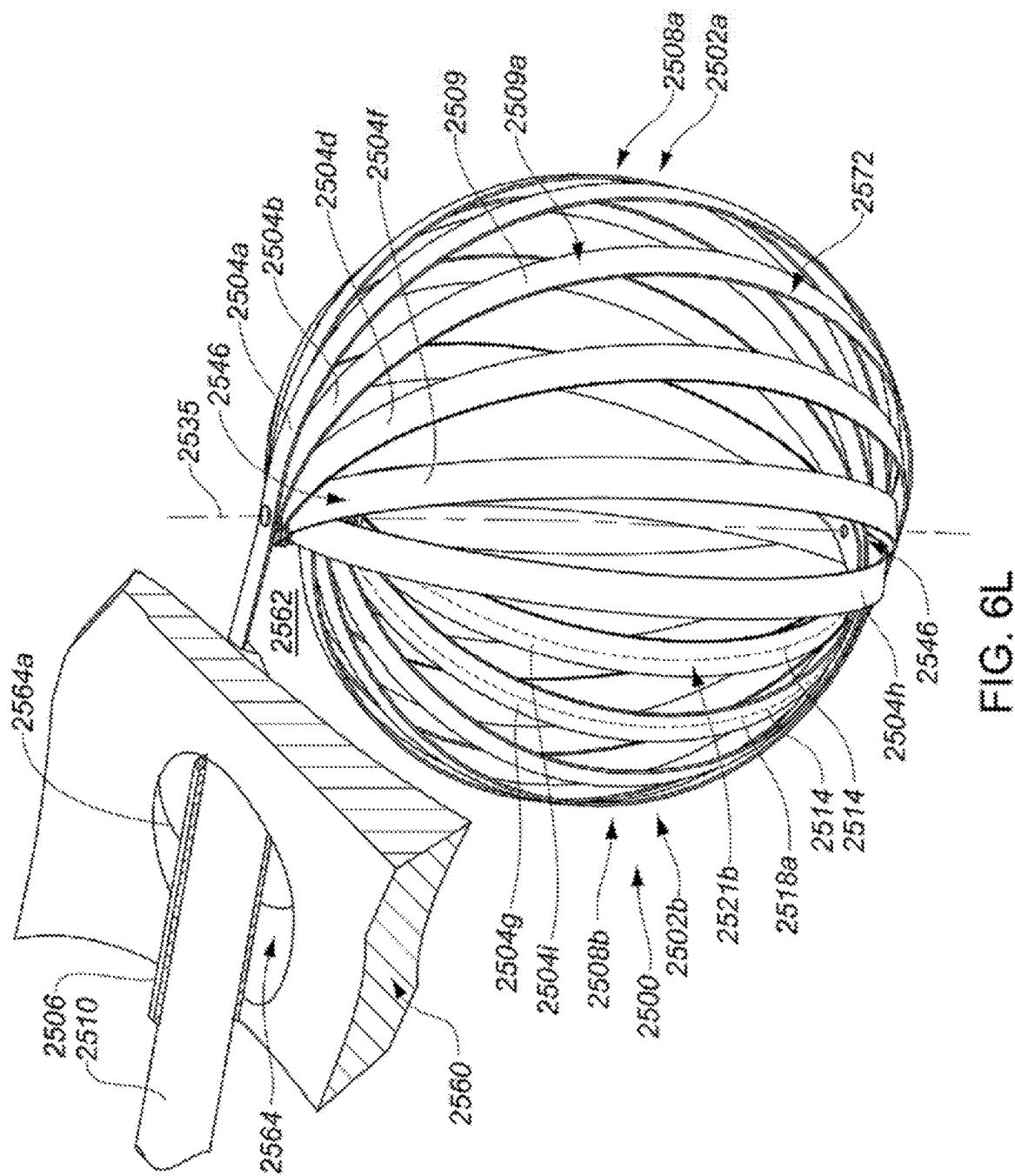


FIG. 6L

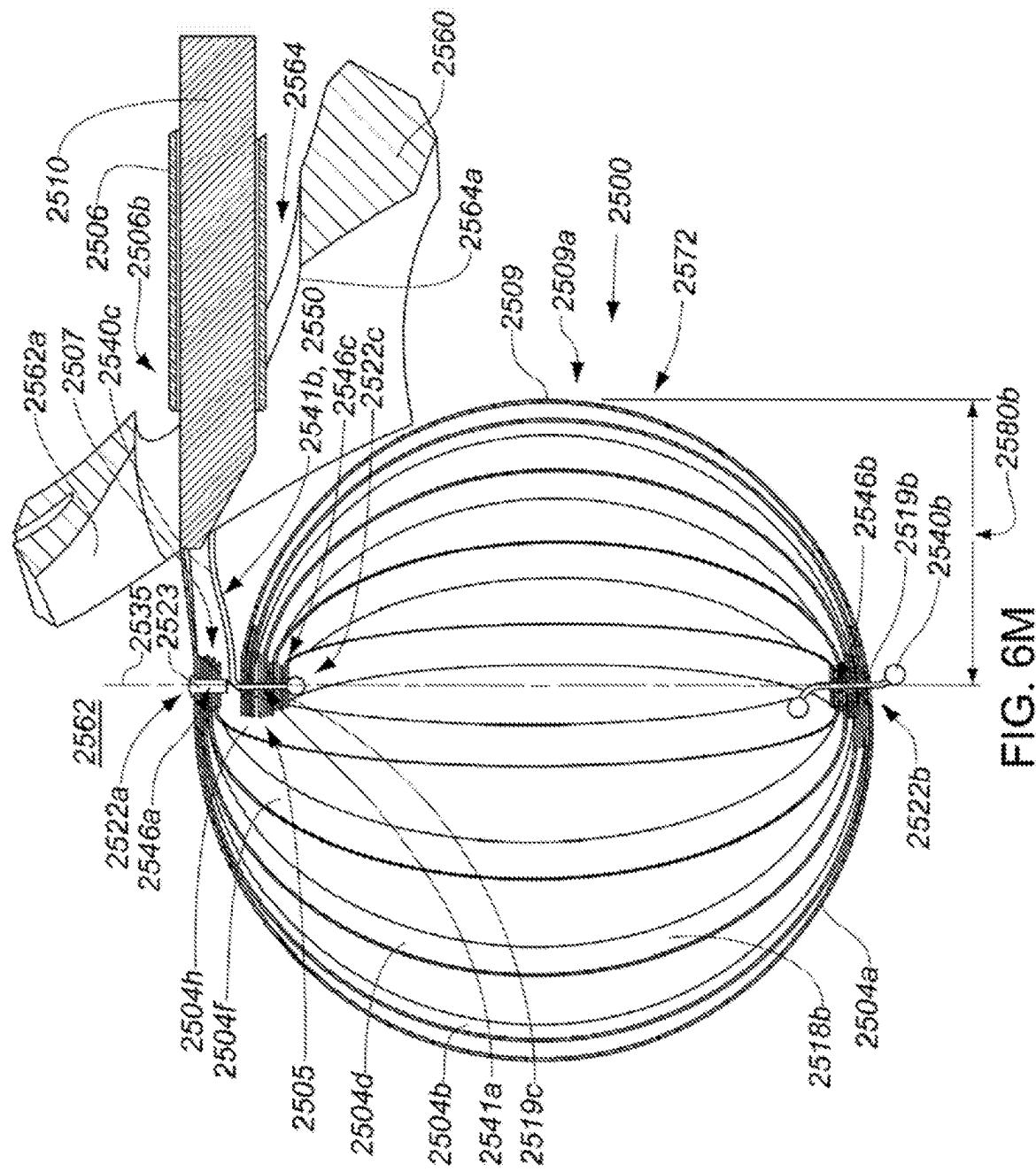


FIG. 6M

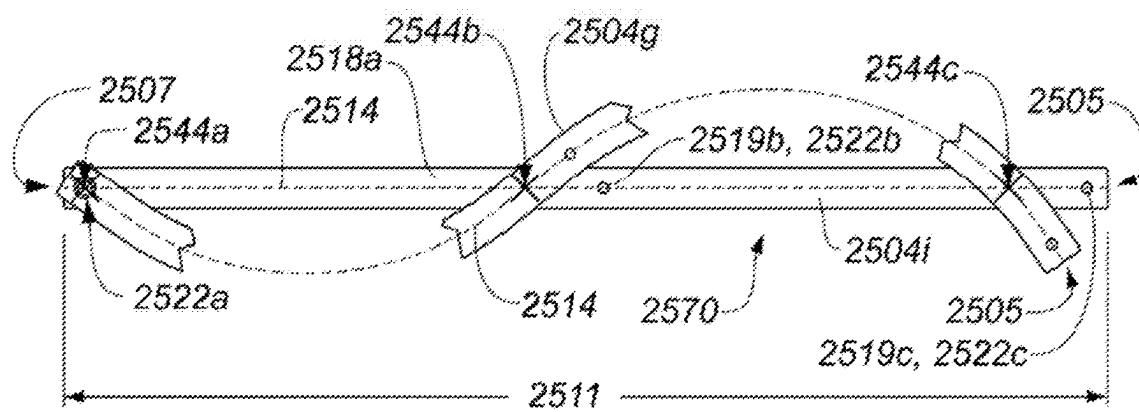


FIG. 6N

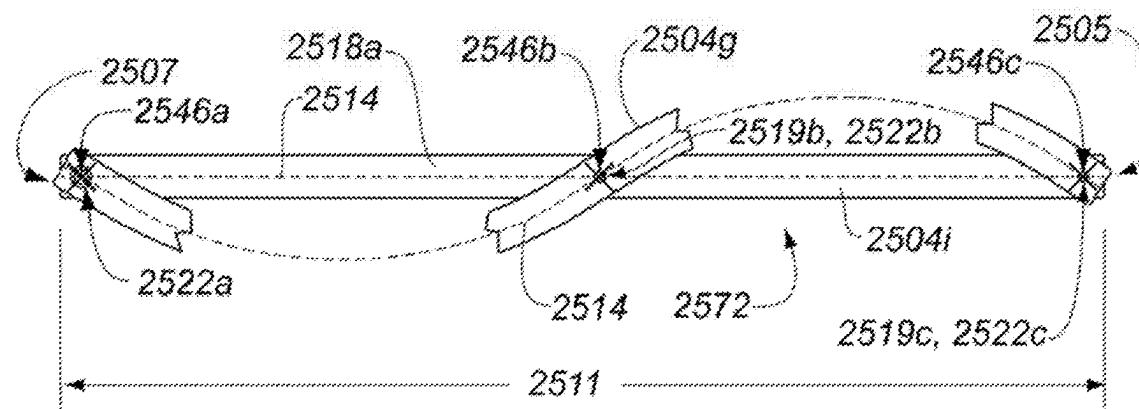


FIG. 6O

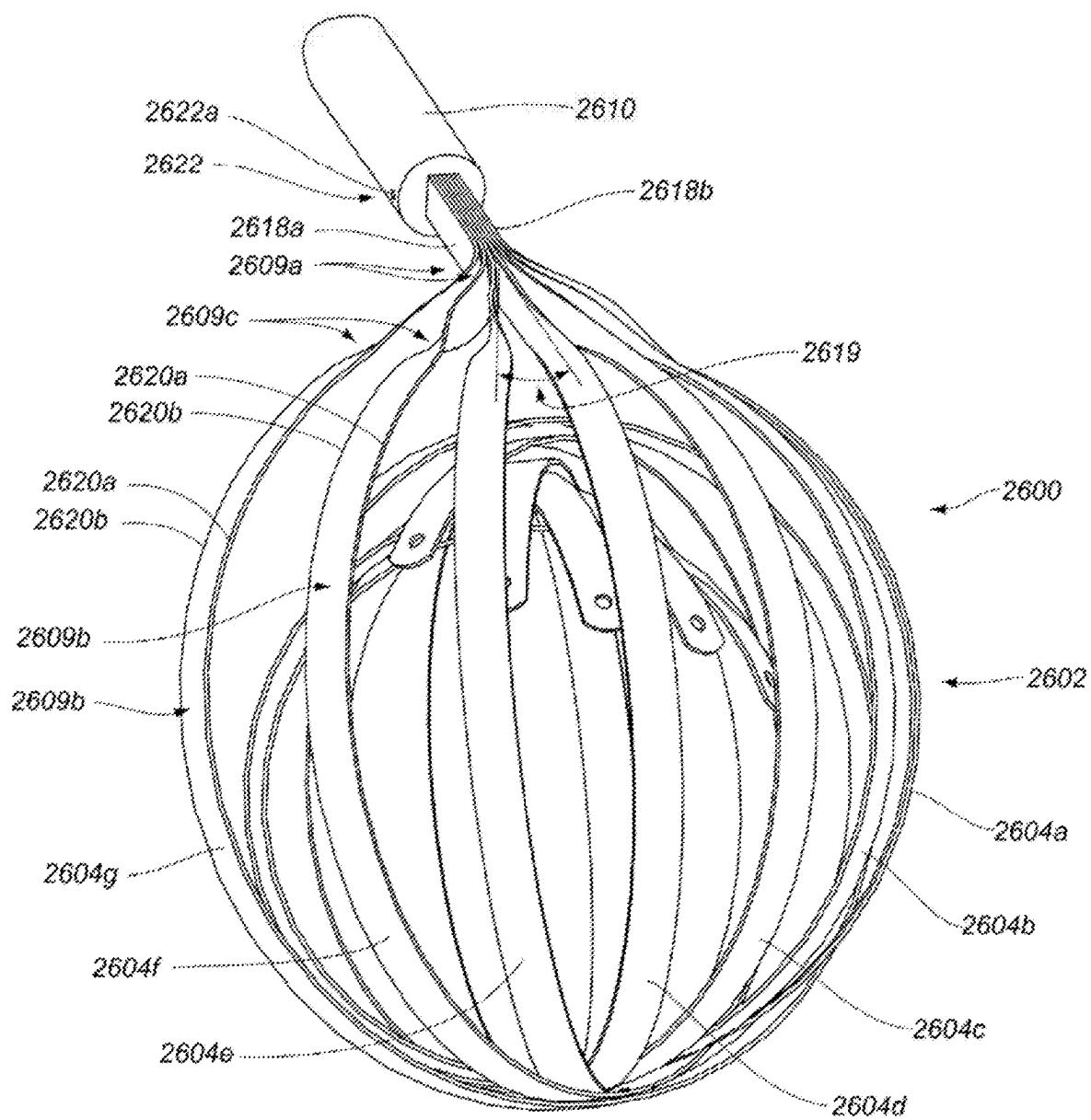
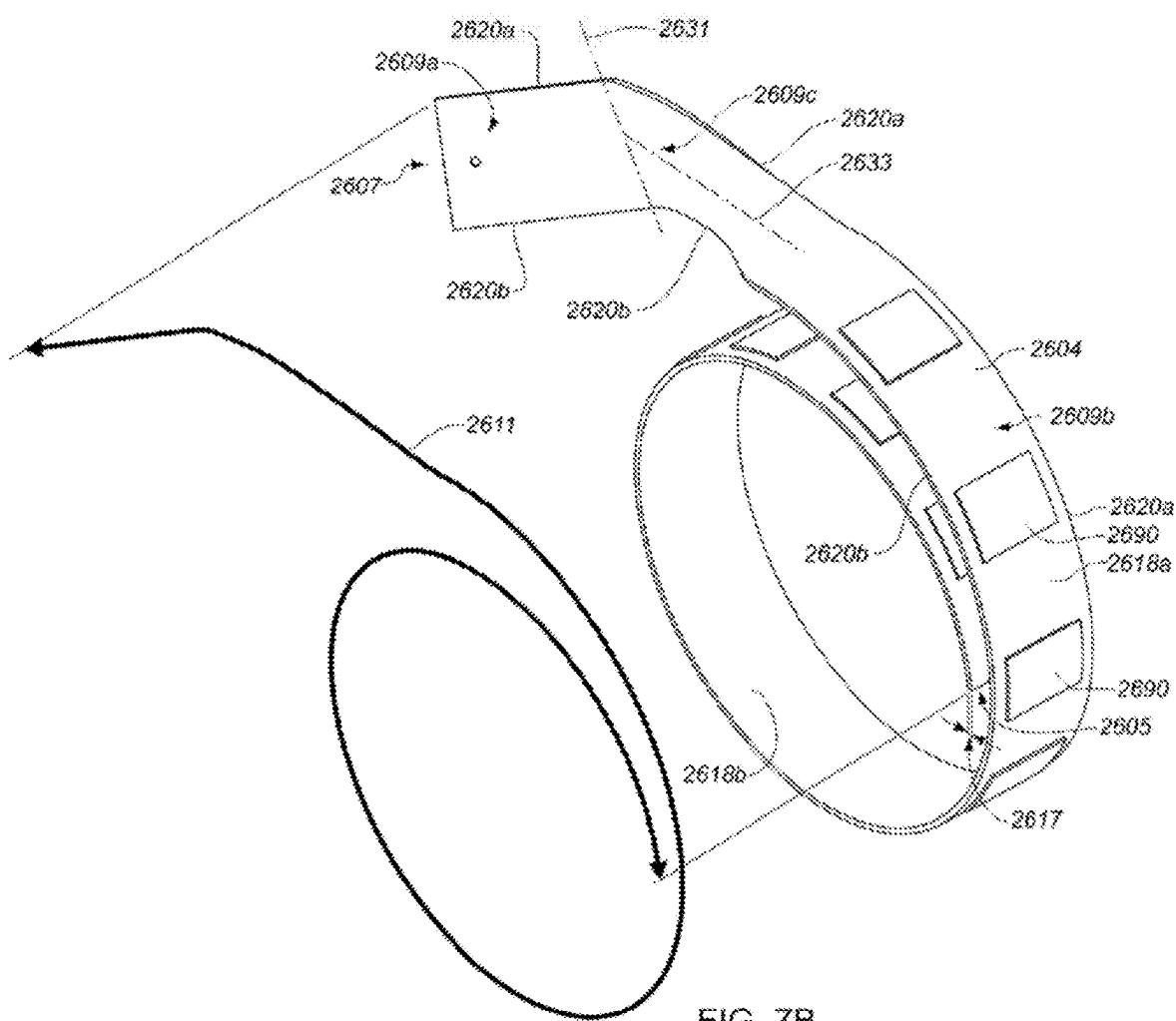


FIG. 7A



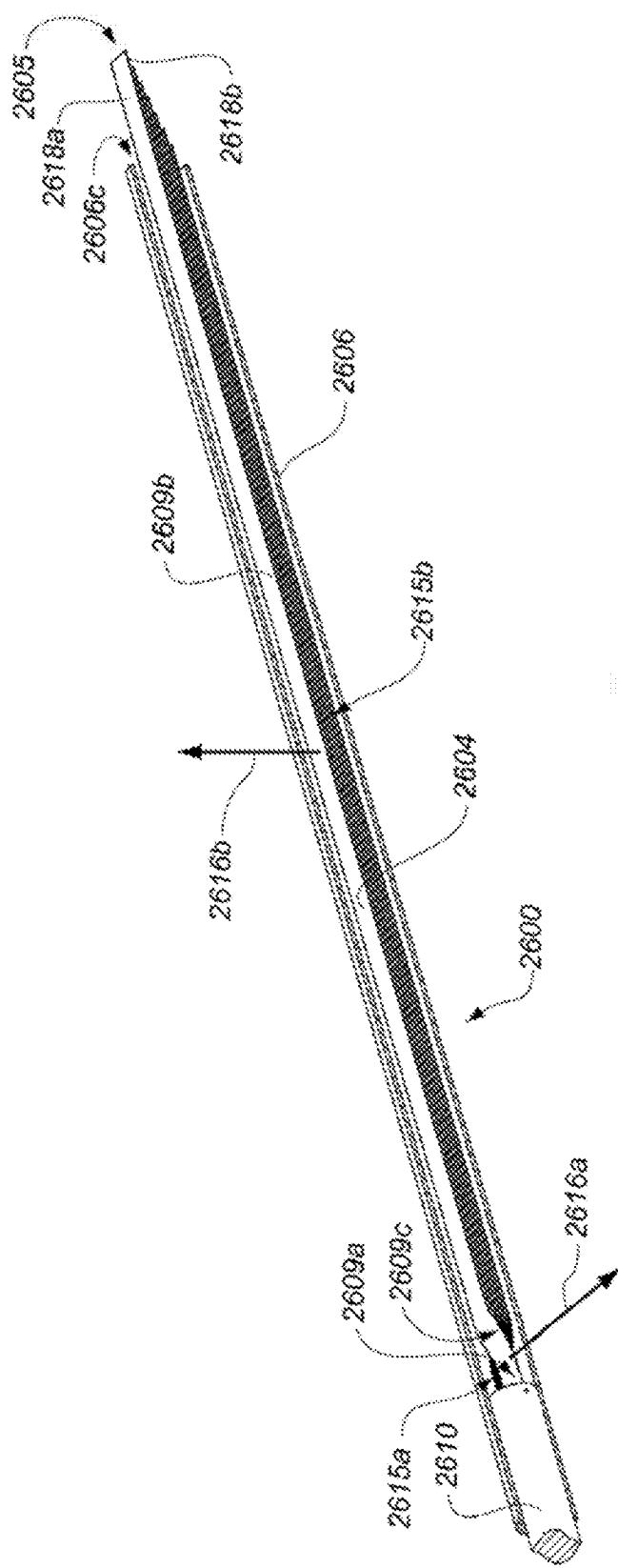


FIG. 7C

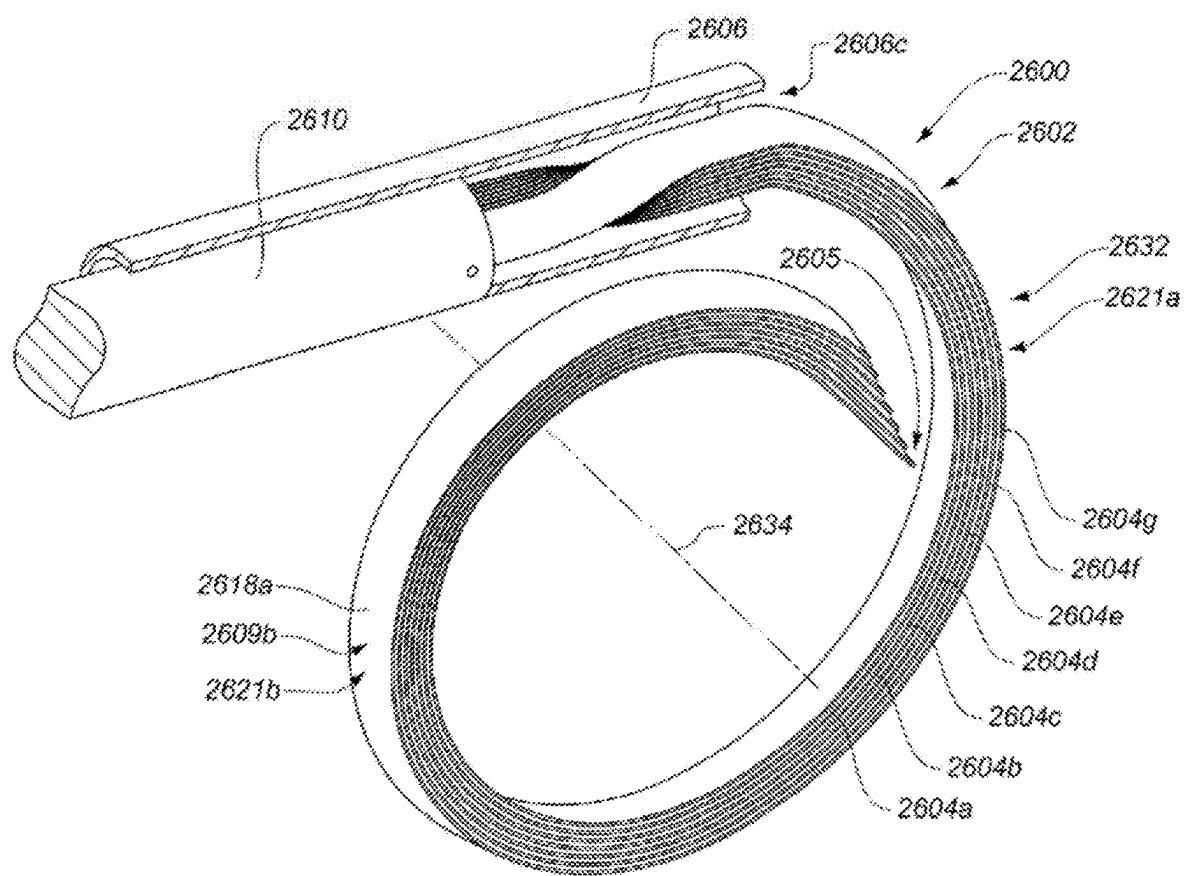
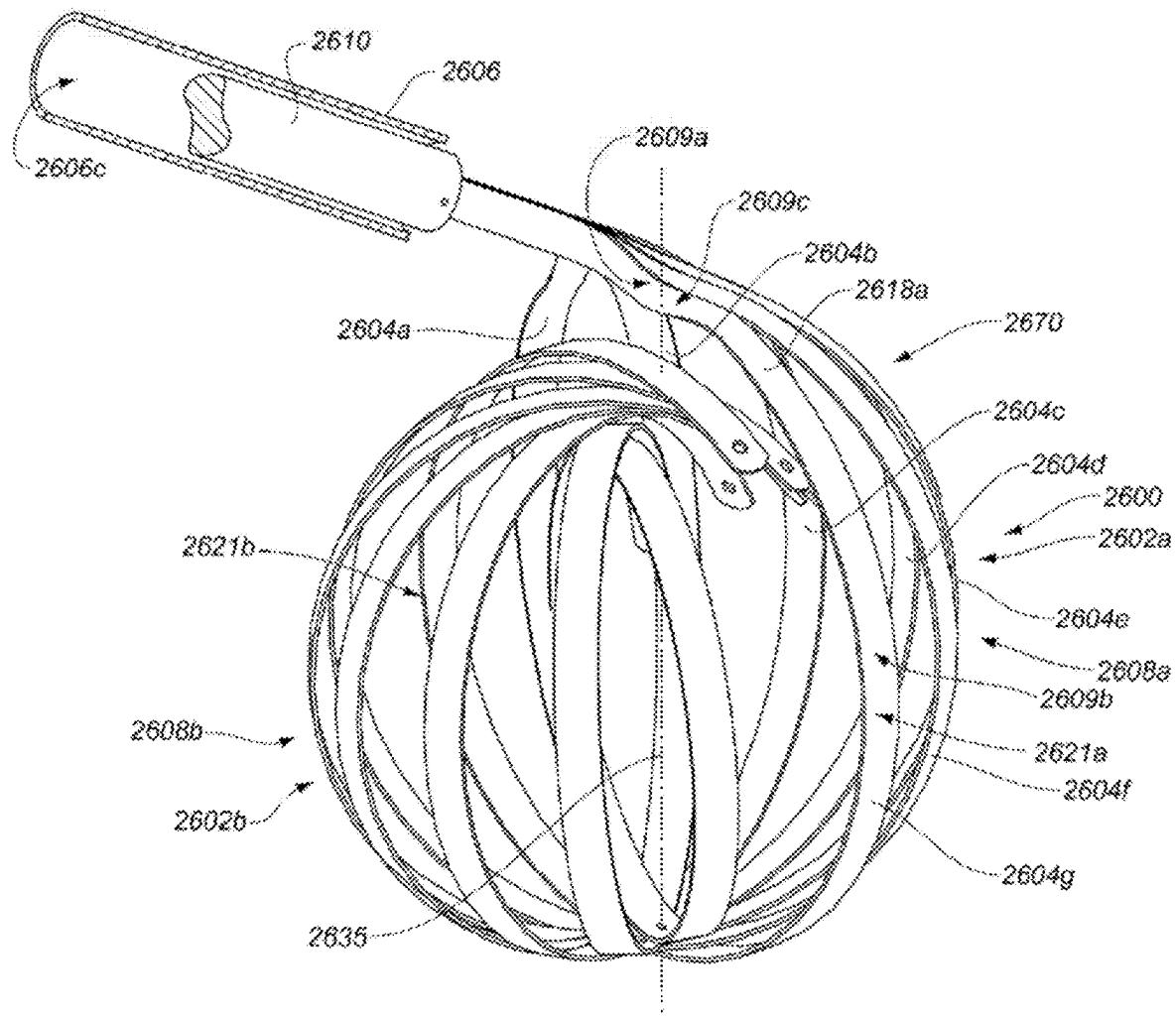


FIG. 7D



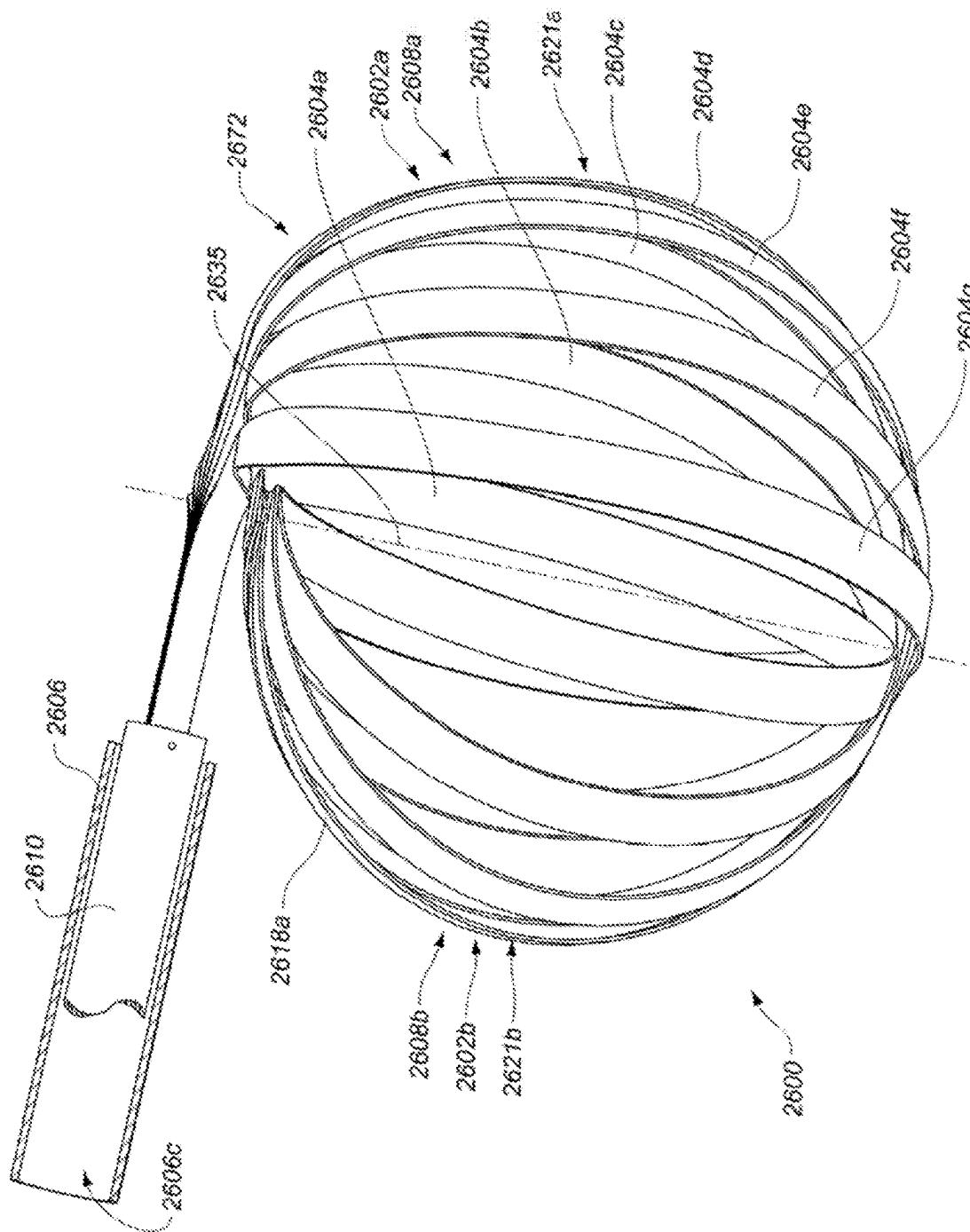


FIG. 7F

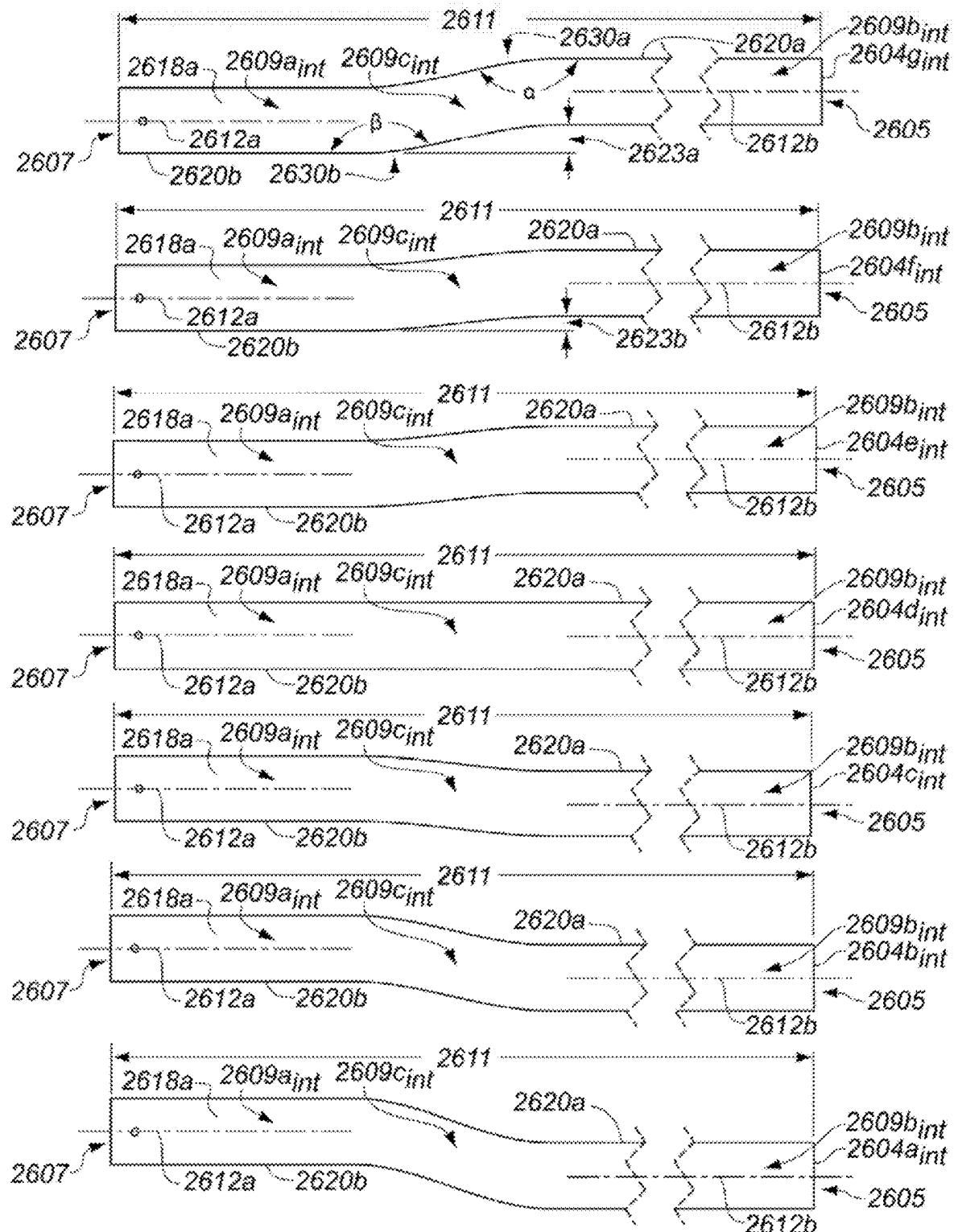


FIG. 7G

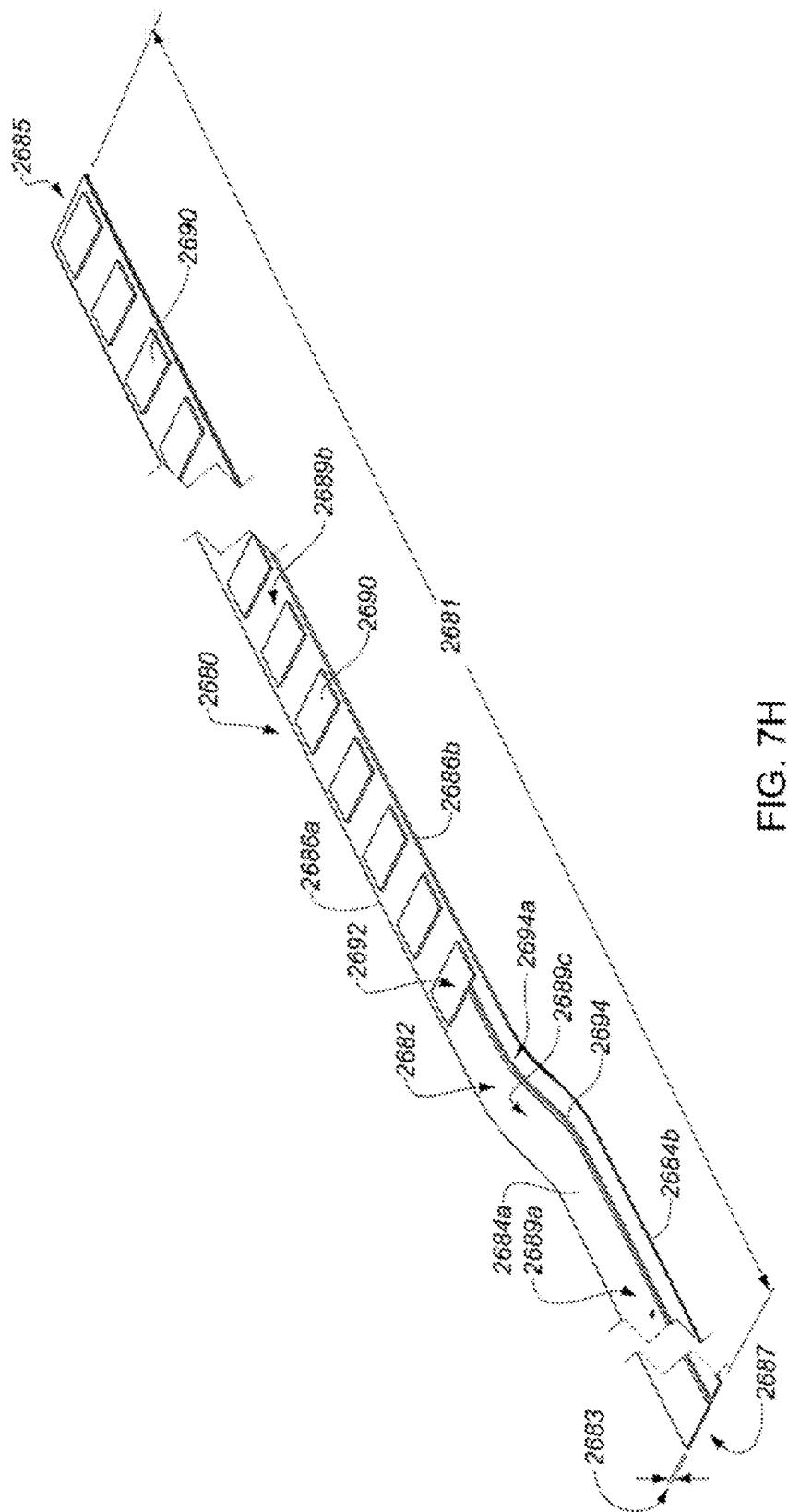


FIG. 7H

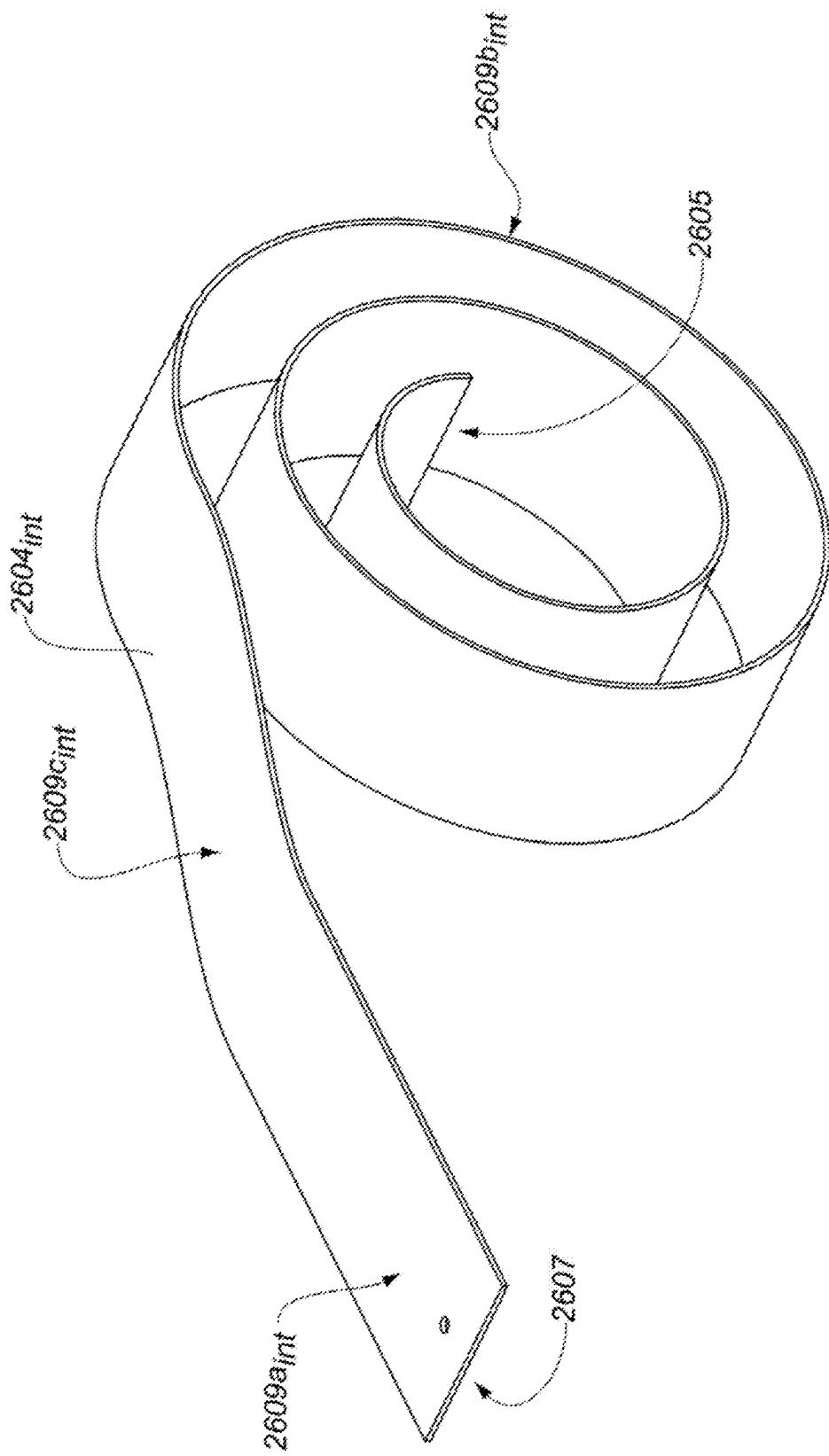


FIG. 7I

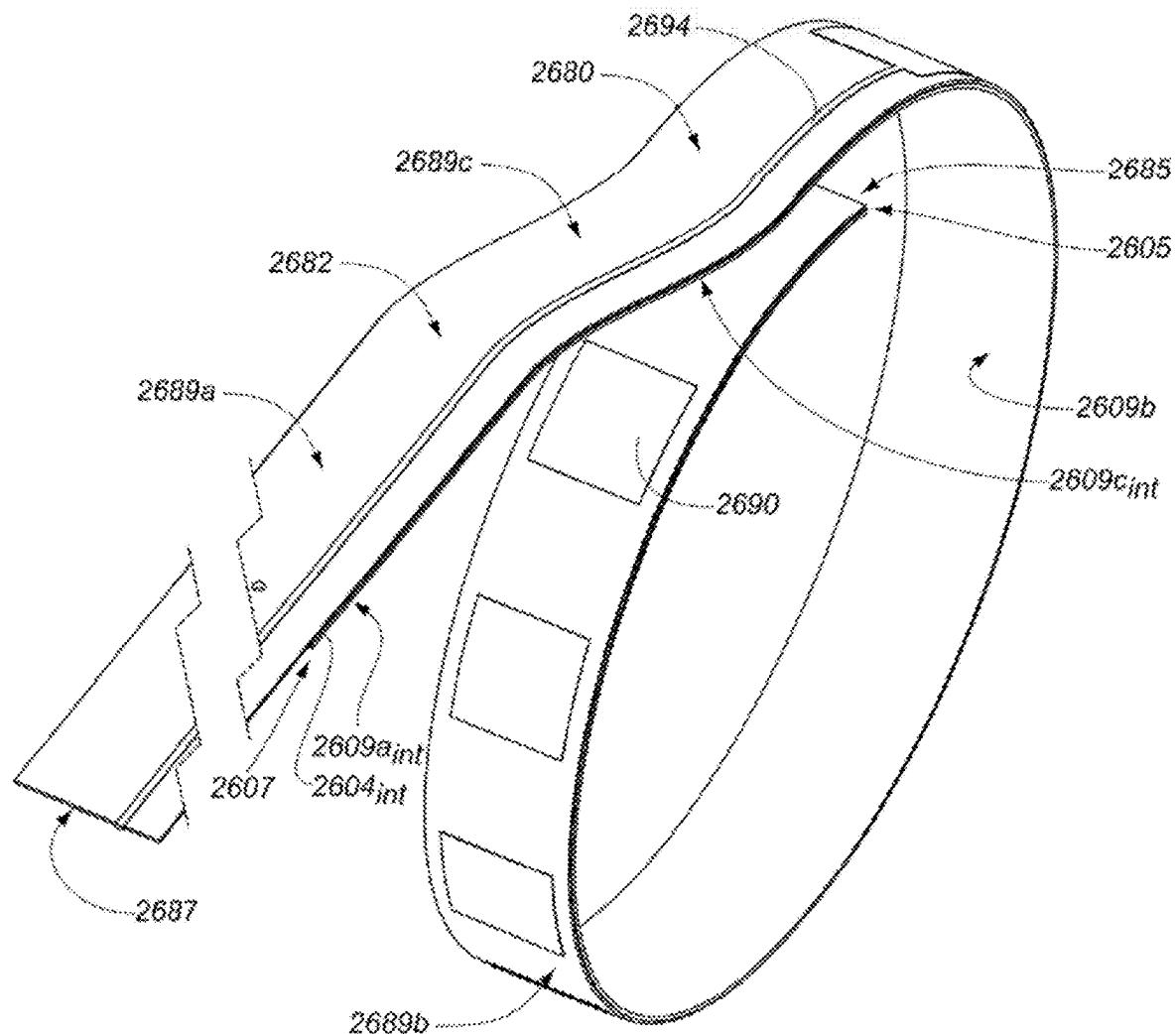


FIG. 7J

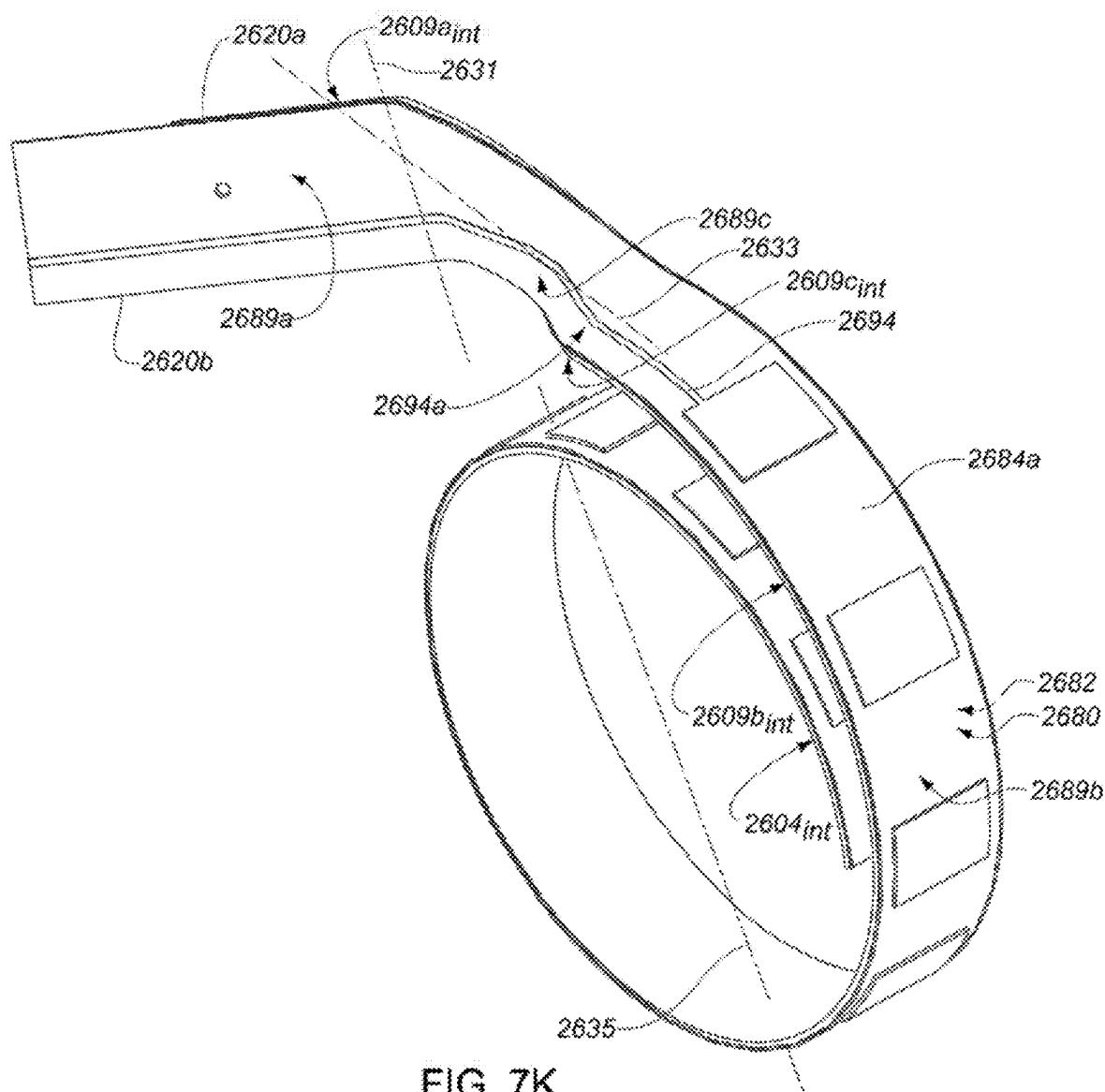


FIG. 7K

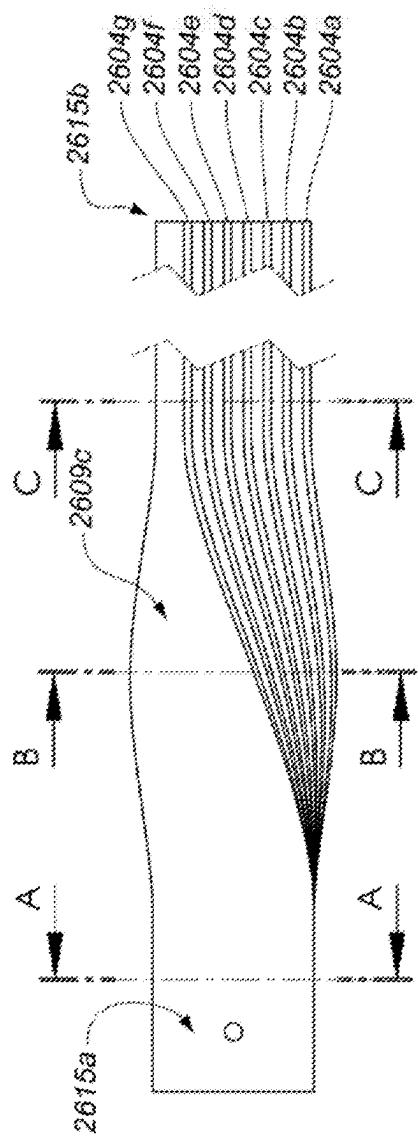


FIG. 7L

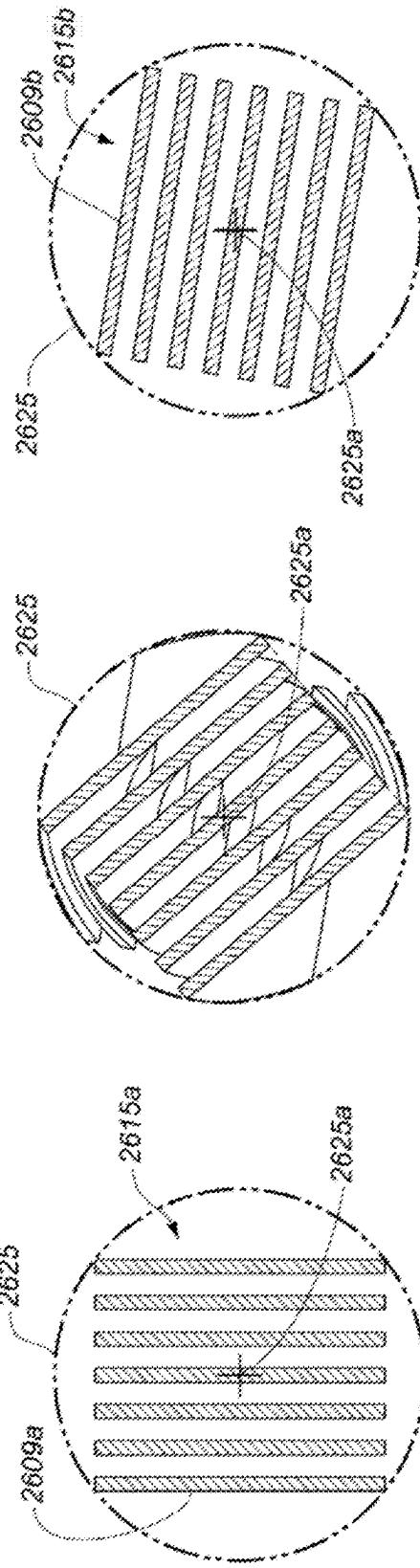


FIG. 7L (C-C)

FIG. 7L (B-B)

FIG. 7L (A-A)

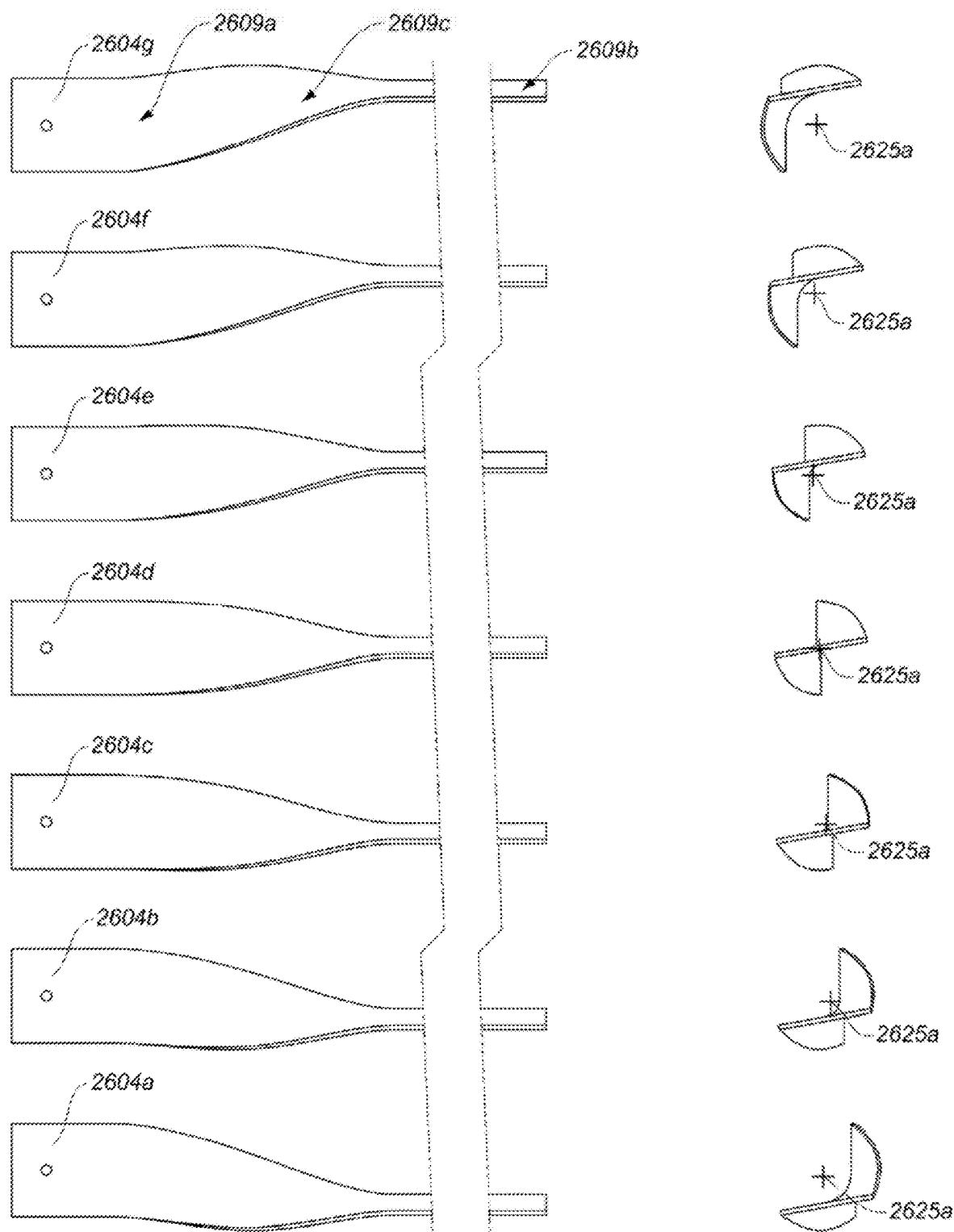


FIG. 7M

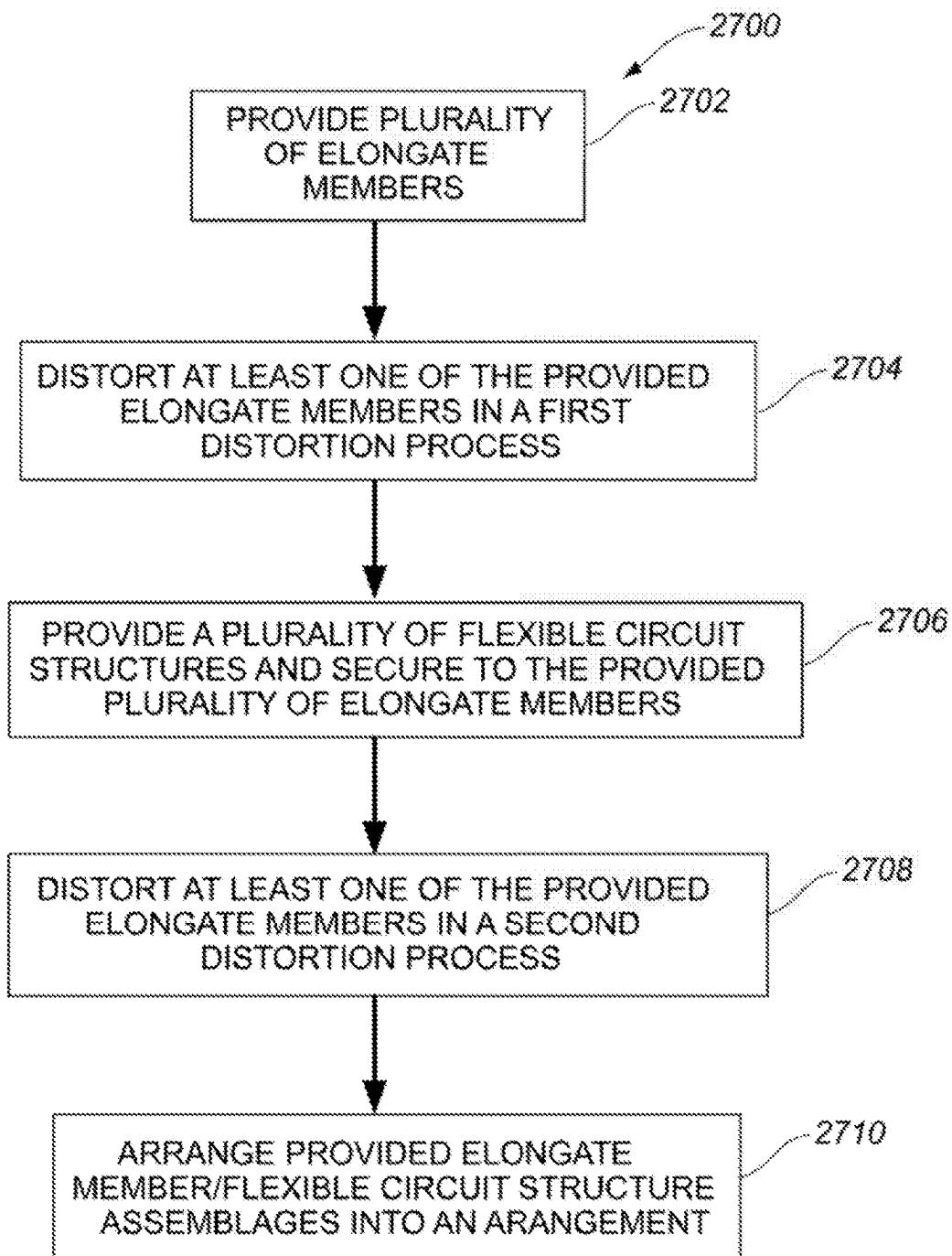


FIG. 8

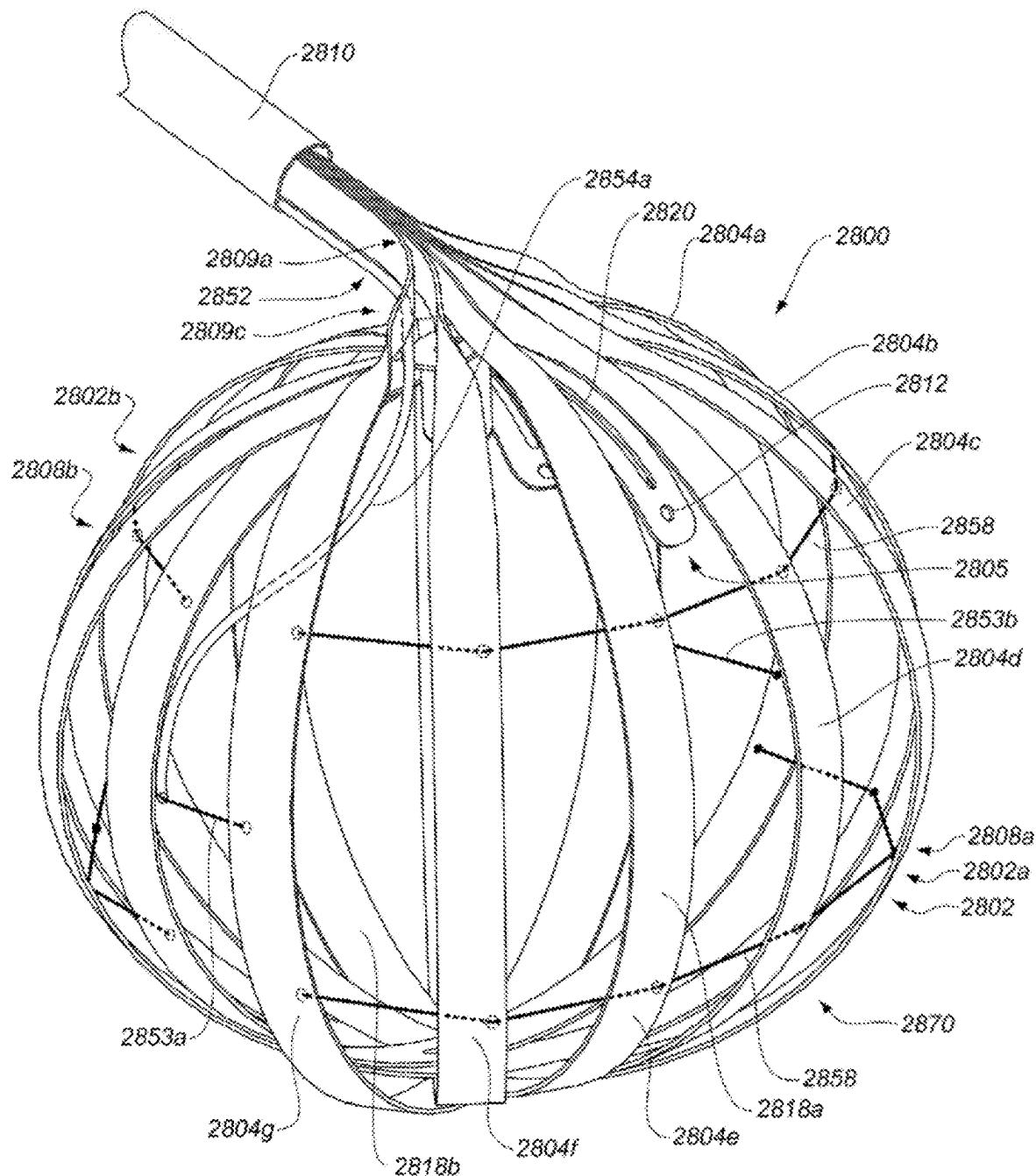


FIG. 9A

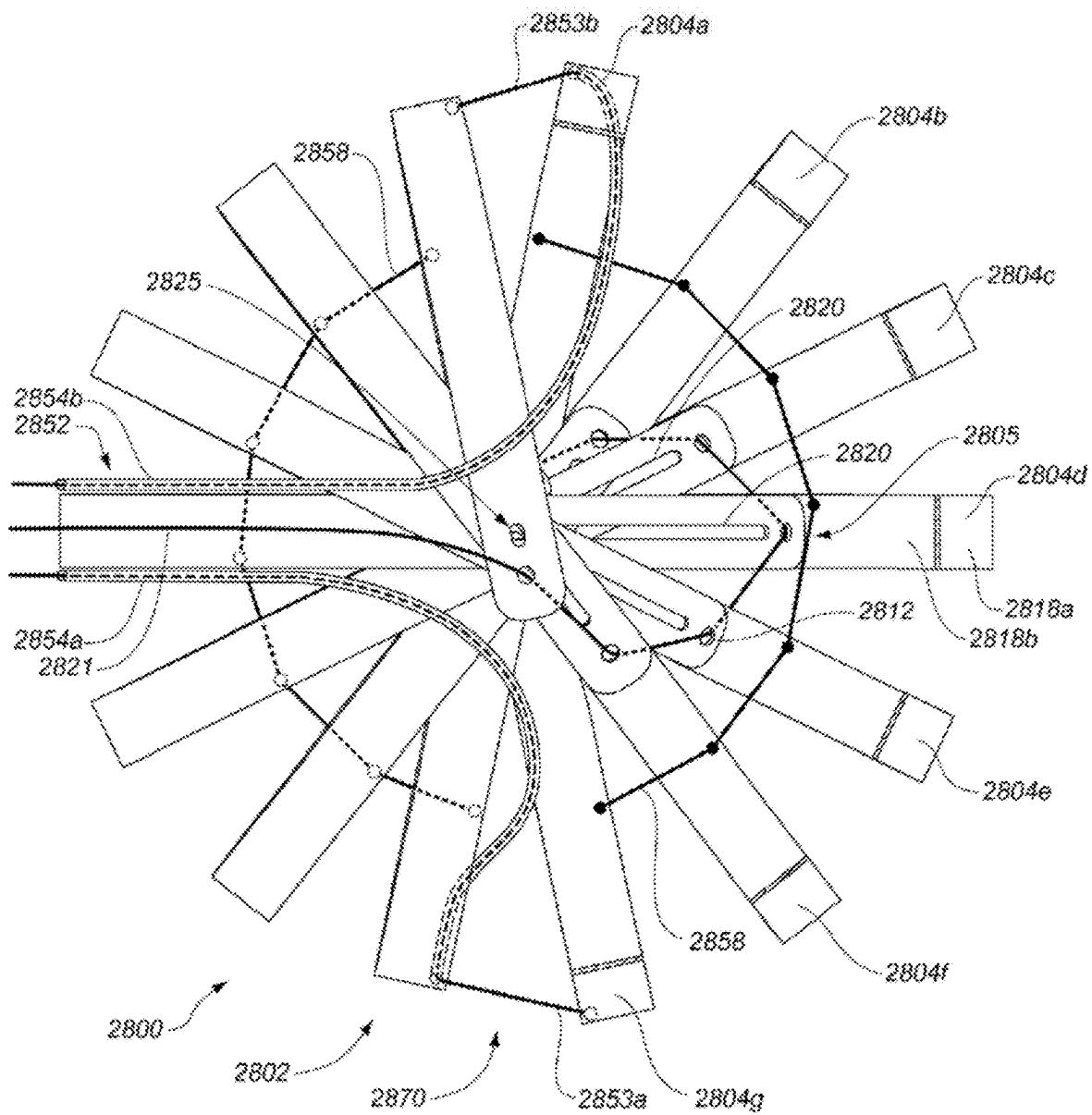


FIG. 9B

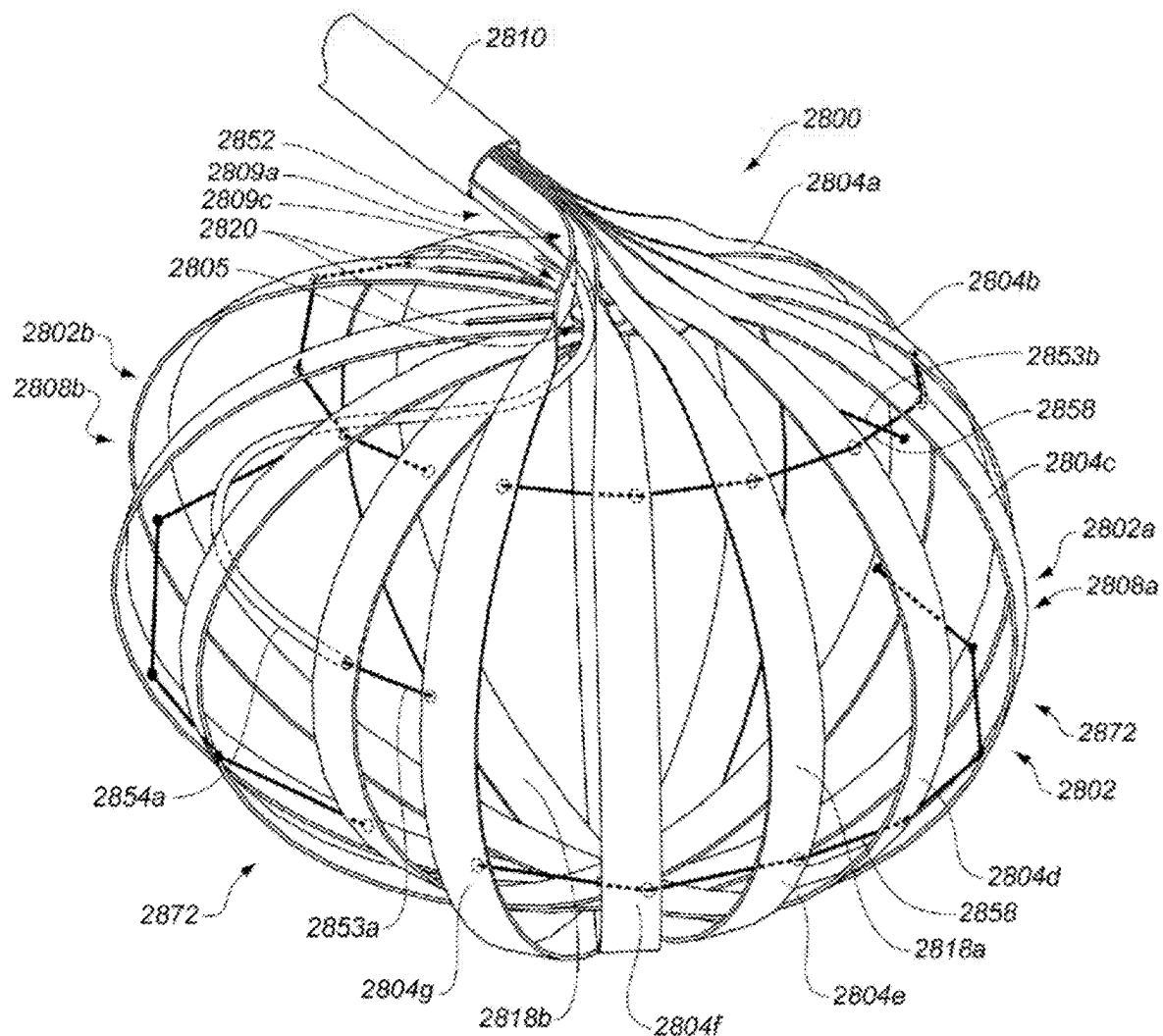


FIG. 9C

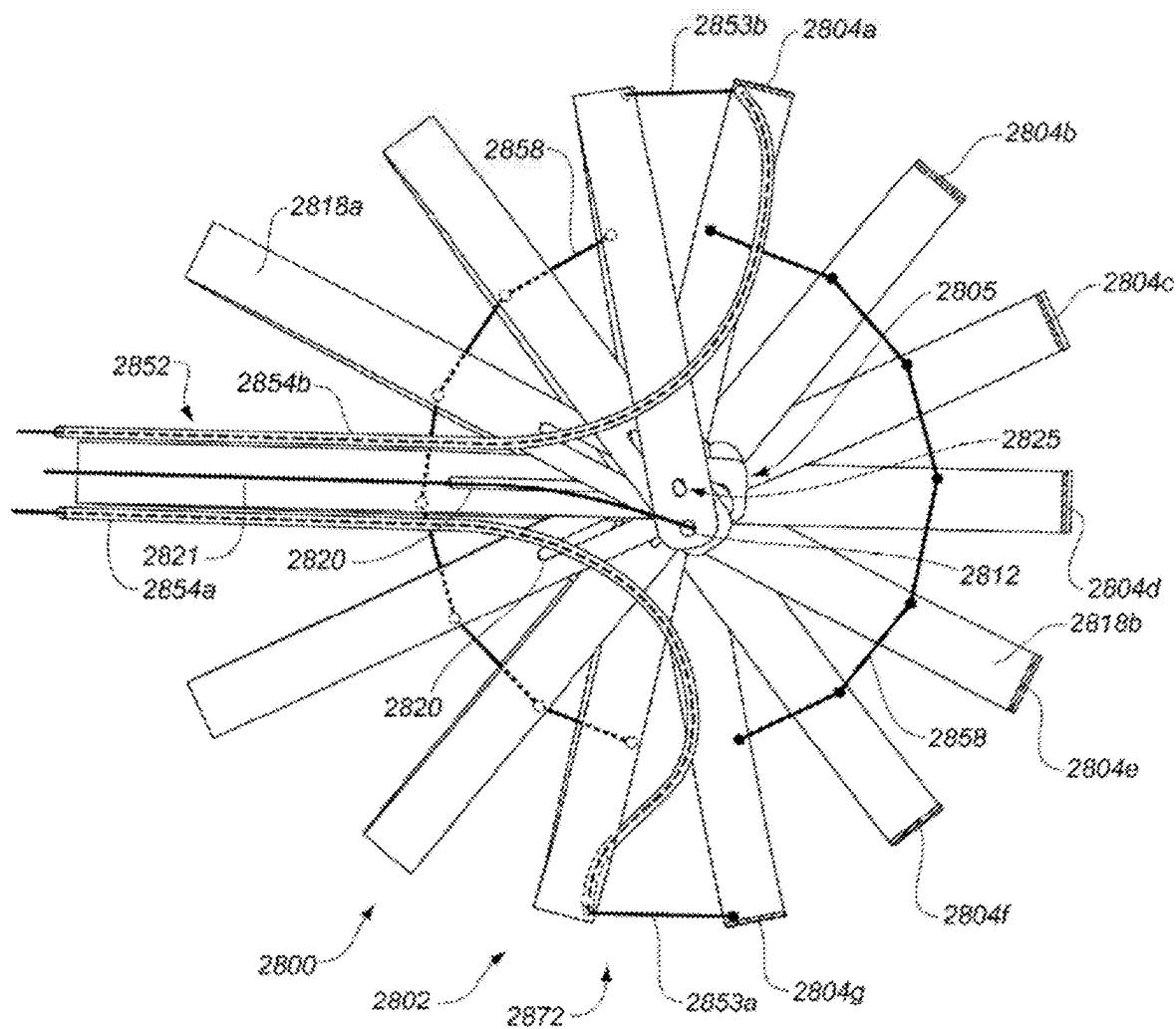


FIG. 9D

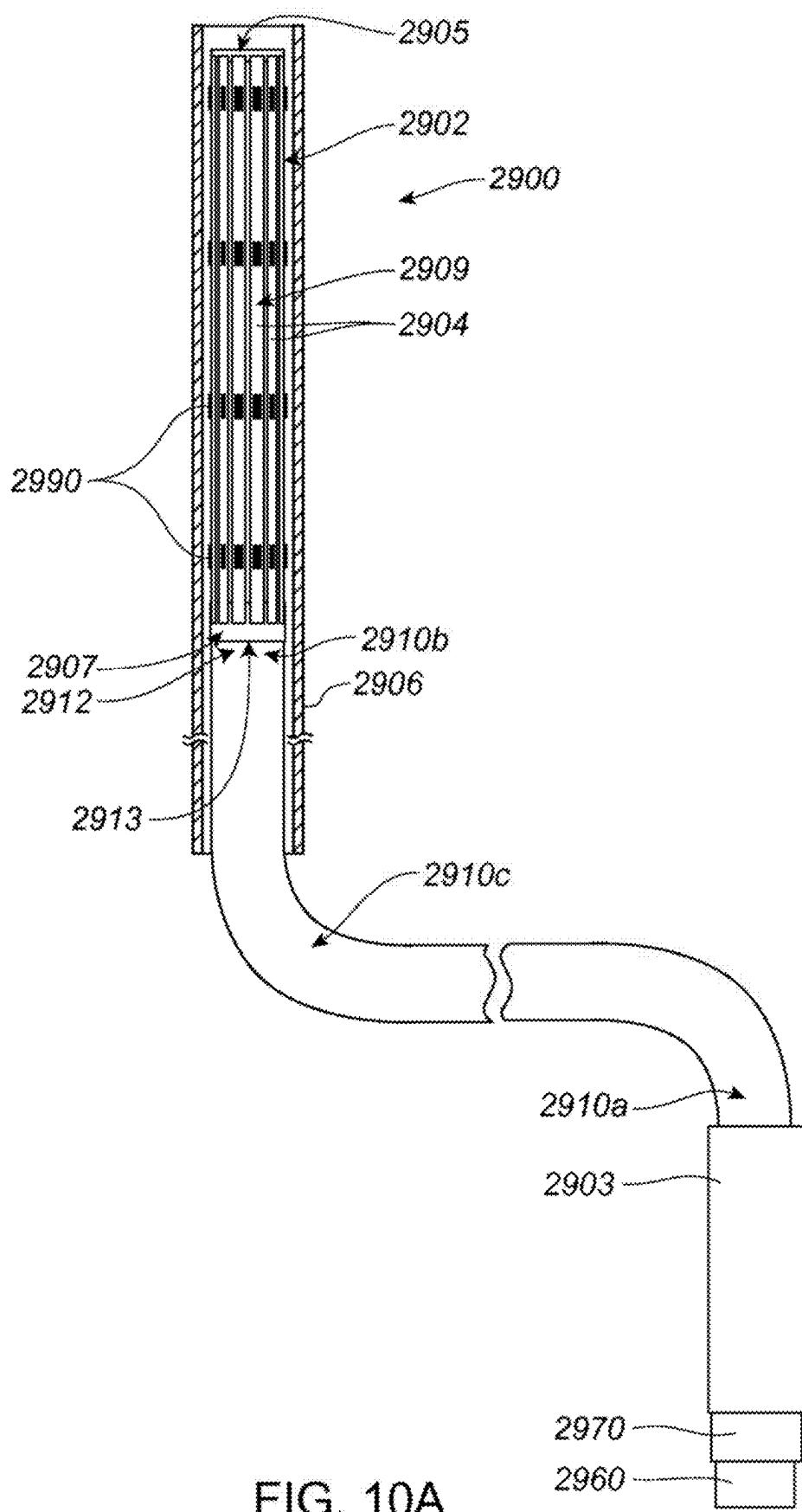


FIG. 10A

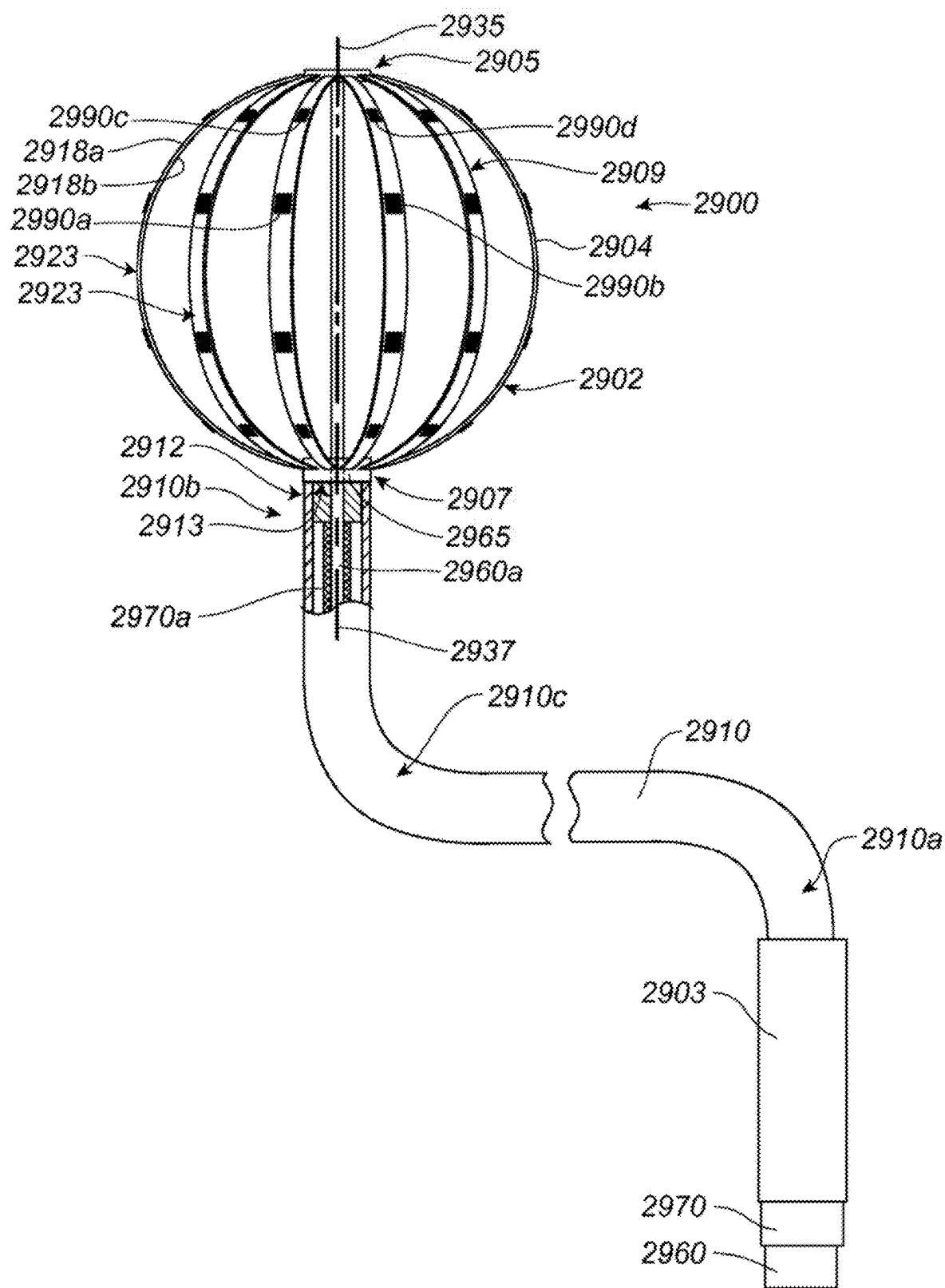


FIG. 10B

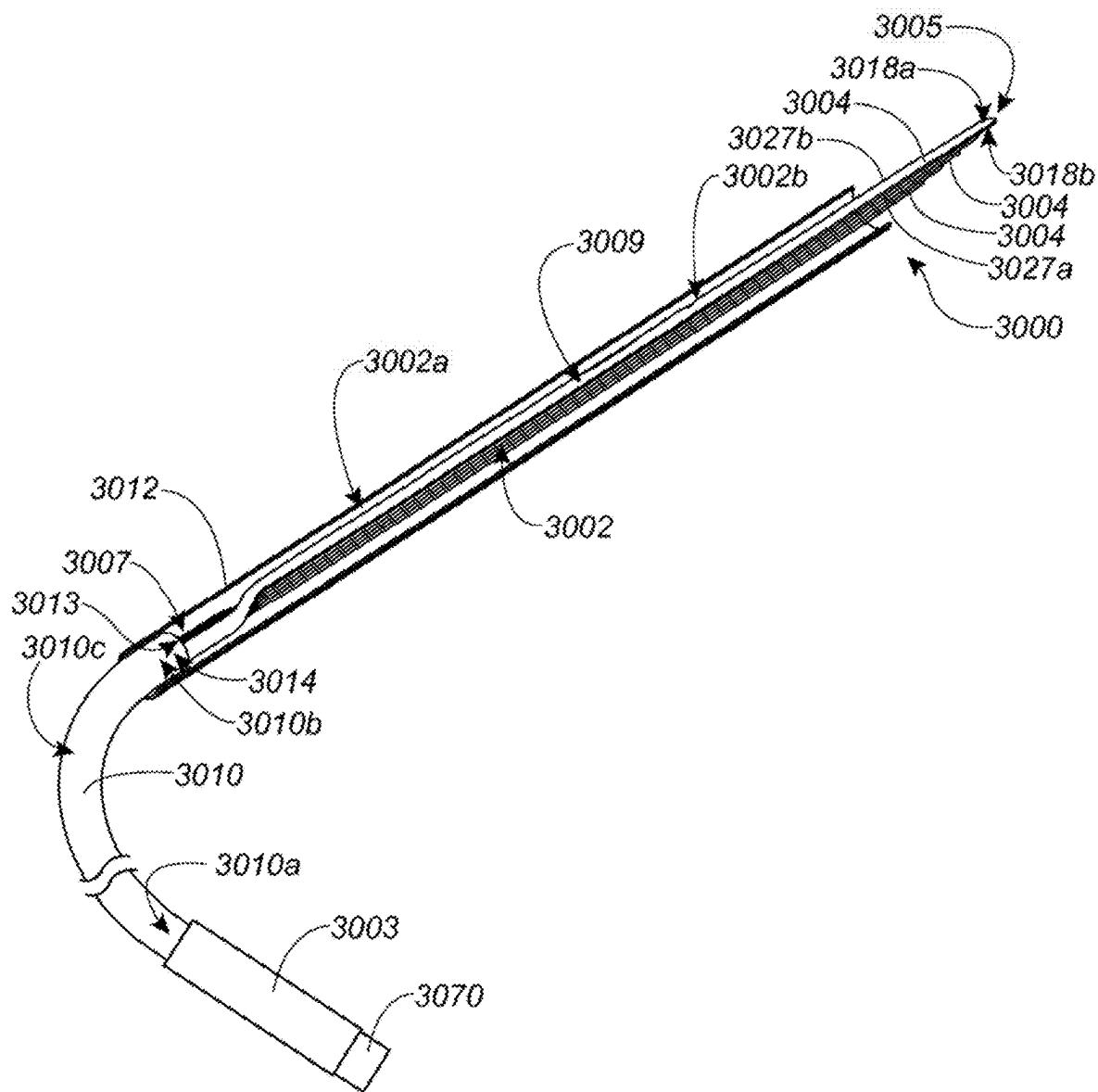


FIG. 11A

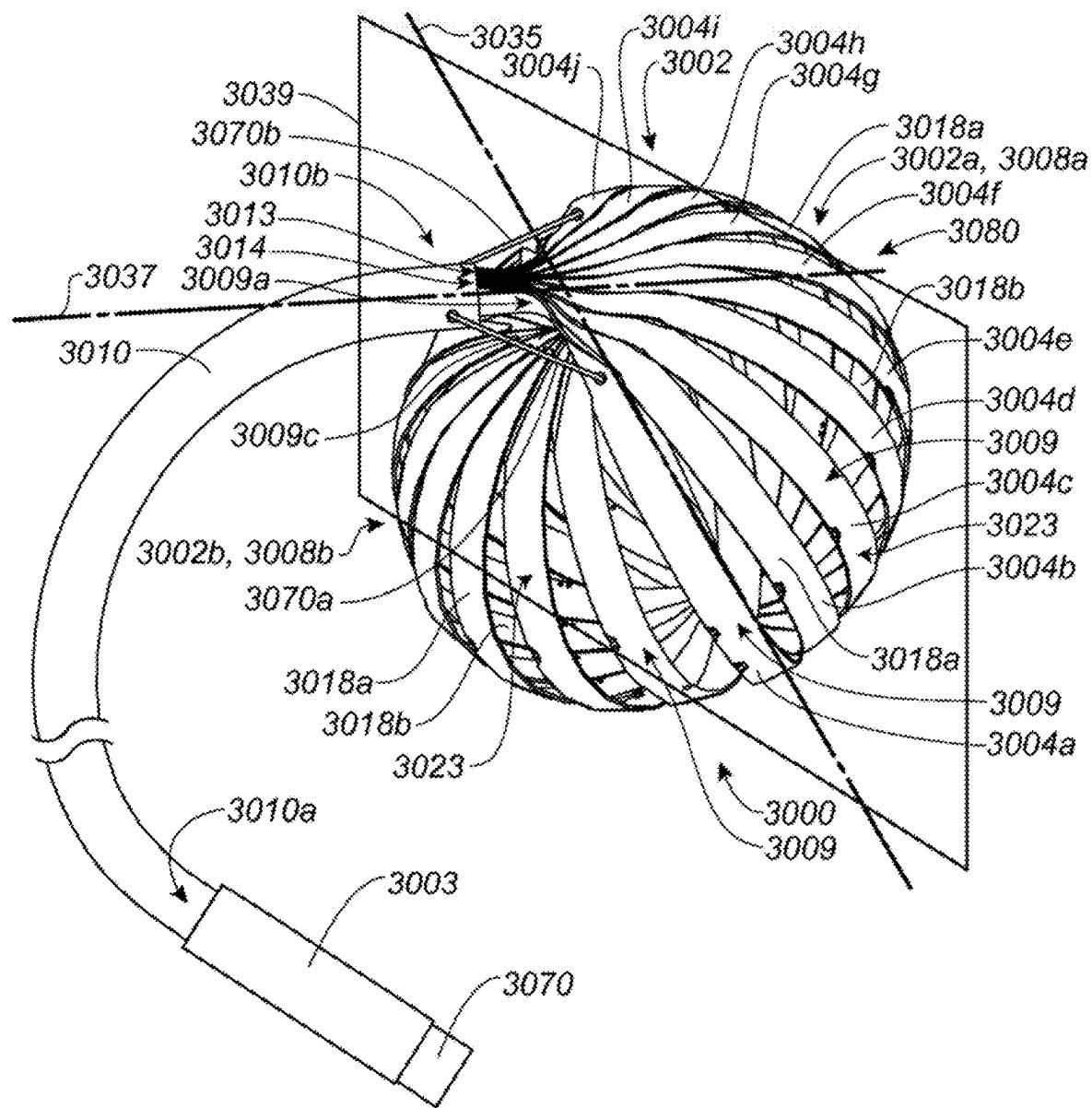


FIG. 11B

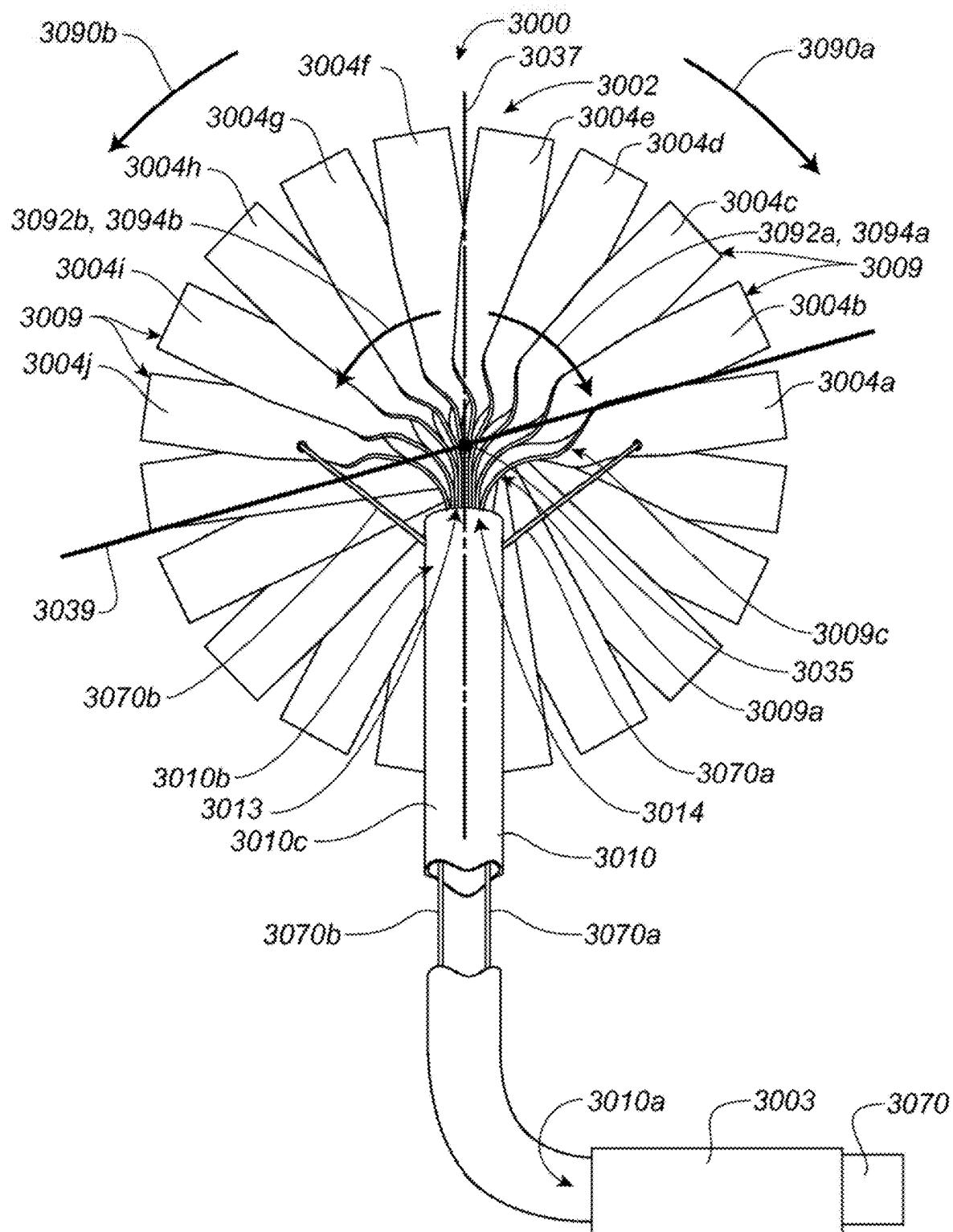


FIG. 11C

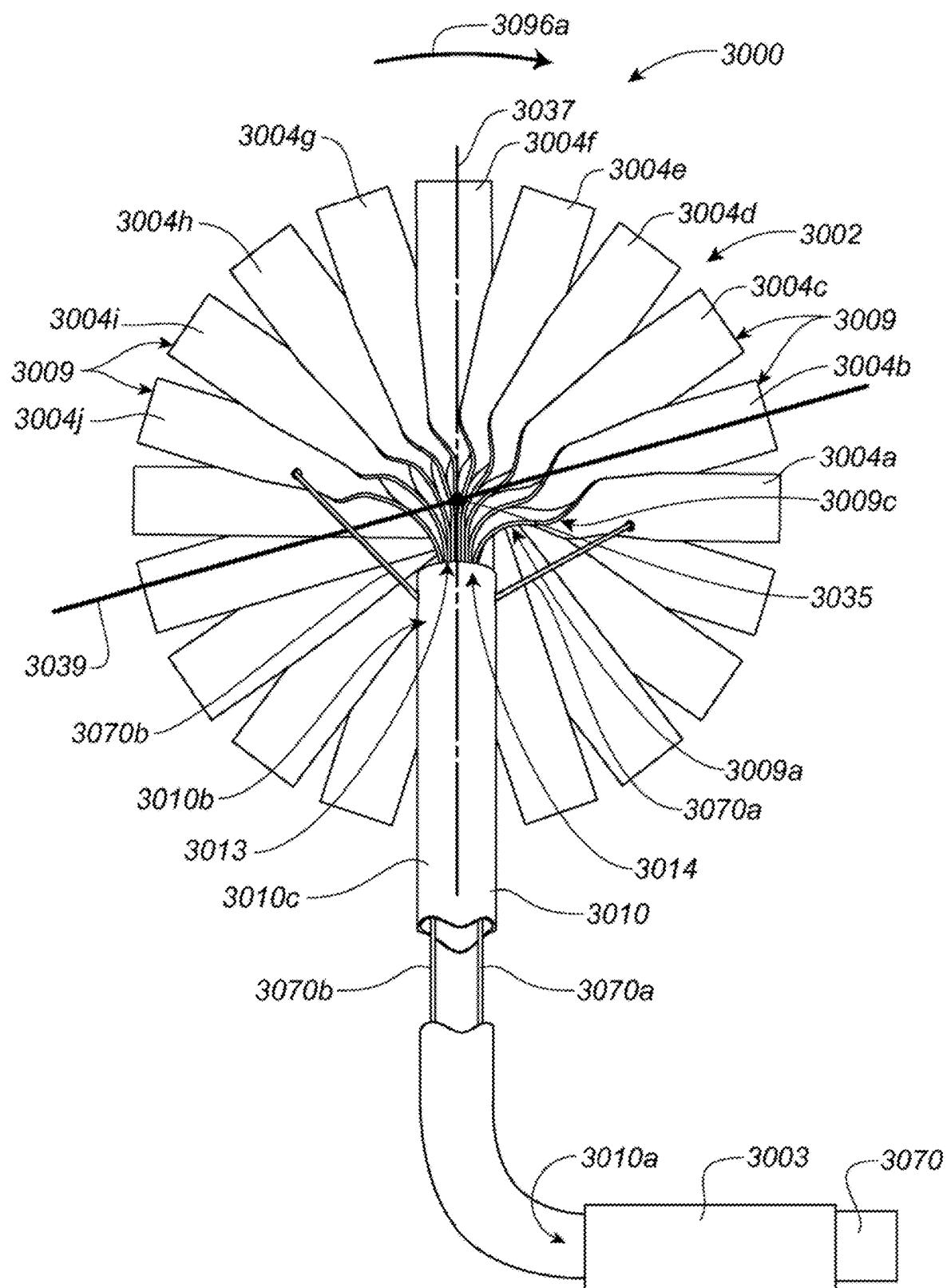


FIG. 11D

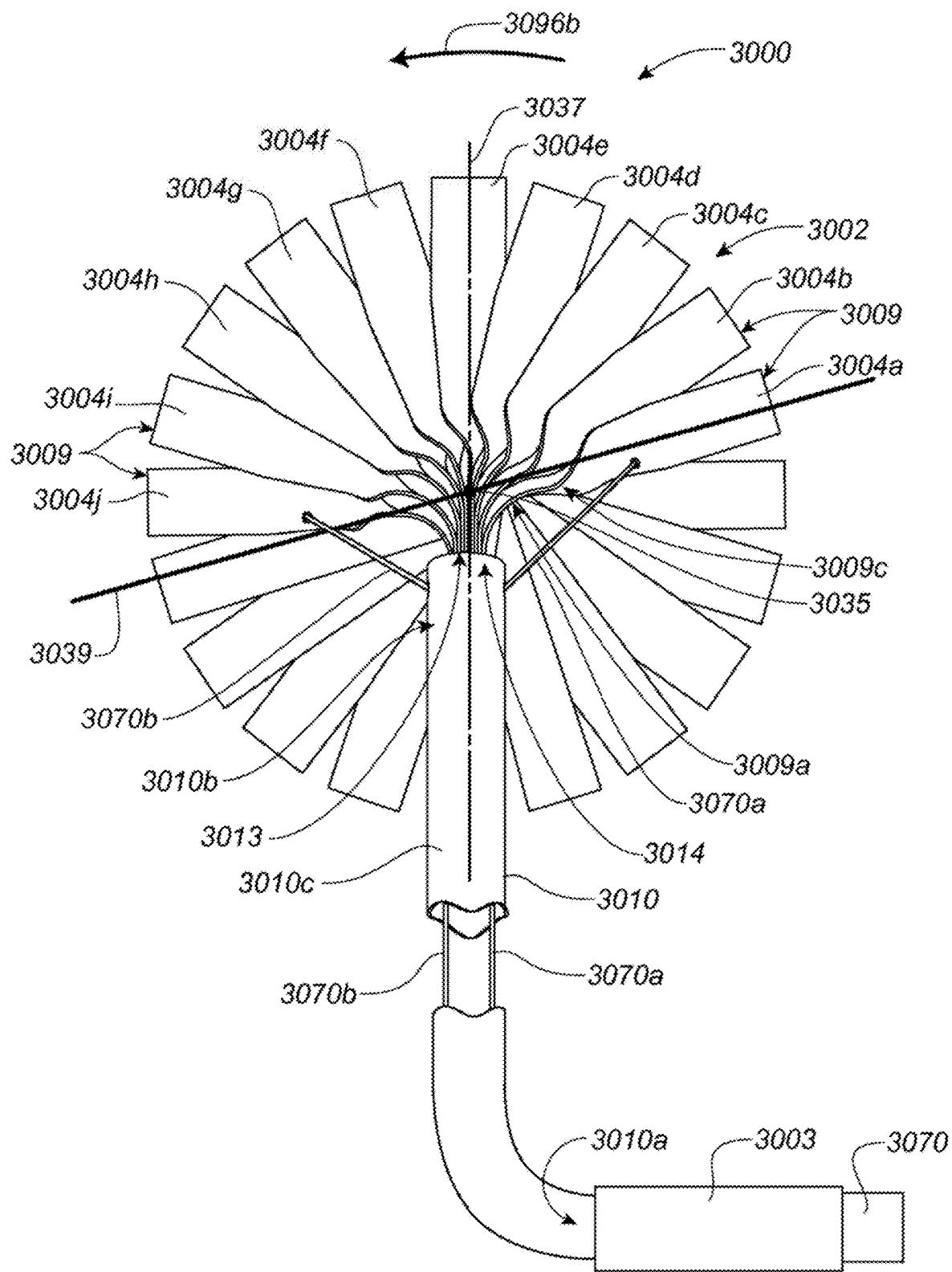


FIG. 11E

**ENHANCED MEDICAL DEVICE FOR USE IN  
BODILY CAVITIES, FOR EXAMPLE AN  
atrium**

**CROSS-REFERENCE TO RELATED  
APPLICATIONS**

This application is a continuation of U.S. patent application Ser. No. 18/951,919, filed Nov. 19, 2024, which is a continuation of U.S. patent application Ser. No. 17/182,732, filed Feb. 23, 2021, now U.S. Pat. No. 12,178,490, issued Dec. 31, 2024, which is a continuation of U.S. patent application Ser. No. 15/299,640, filed Oct. 21, 2016, now U.S. Pat. No. 11,399,881, issued Aug. 2, 2022, which is a continuation of U.S. patent application Ser. No. 13/782,903, filed Mar. 1, 2013, now U.S. Pat. No. 9,492,228, issued Nov. 15, 2016, which is a continuation-in-part of International Application PCT/US2012/022061, filed Jan. 20, 2012, which claims the benefit of each of: (1) U.S. Provisional Application No. 61/515,141, filed Aug. 4, 2011, (2) U.S. Provisional Application No. 61/488,639, filed May 20, 2011, (3) U.S. Provisional Application No. 61/485,987, filed May 13, 2011, and (4) U.S. Provisional Application No. 61/435,213, filed Jan. 21, 2011, the entire disclosures of each of the applications identified in this cross-reference to related applications section are hereby incorporated herein by reference.

**BACKGROUND**

**Technical Field**

This disclosure is generally related to surgery, and more particularly to intravascularly or percutaneously deployed medical devices suitable for determining locations of cardiac features or ablating regions of cardiac tissue, or both.

**Description of the Related Art**

Cardiac surgery was initially undertaken using highly invasive open procedures. A sternotomy, which is a type of incision in the center of the chest that separates the sternum (chest bone) was typically employed to allow access to the heart. In the past several decades, more and more cardiac operations are performed using intravascular or percutaneous techniques, where access to inner organs or other tissue is gained via a catheter.

Intravascular or percutaneous surgeries benefit patients by reducing surgery risk, complications and recovery time. However, the use of intravascular or percutaneous technologies also raises some particular challenges. Medical devices used in intravascular or percutaneous surgery need to be deployed via catheter systems which significantly increase the complexity of the device structure. As well, doctors do not have direct visual contact with the medical devices once the devices are positioned within the body. Positioning these devices correctly and operating the devices successfully can often be very challenging.

One example of where percutaneous medical techniques have been employed is in the treatment of a heart disorder called atrial fibrillation. Atrial fibrillation is a disorder in which spurious electrical signals cause an irregular heartbeat. Atrial fibrillation has been treated with open heart methods using a technique known as the "Cox-Maze procedure." During this procedure, physicians create lesions in a specific pattern in the left and right atria which block various paths taken by the spurious electrical signals. Such

lesions were originally created using incisions, but are now typically created by ablating the tissue with various techniques including radio frequency (RF) energy, microwave energy, laser energy and cryogenic techniques. The procedure is performed with a high success rate under the direct vision that is provided in open procedures, but is relatively complex to perform intravascularly or percutaneously because of the difficulty in creating the lesions in the correct locations. Various problems, potentially leading to severe adverse results, may occur if the lesions are placed incorrectly.

Key factors which are needed to dramatically improve the intravascular or percutaneous treatment of atrial fibrillation are enhanced methods for deployment, positioning and operation of the treatment device. It is particularly important to know the position of the elements which will be creating the lesions relative to cardiac features such as the pulmonary veins and mitral valve. The continuity and transmurality characteristics of the lesion patterns that are formed can impact the ability to block paths taken within the heart by spurious electrical signals.

Several methods have been previously developed for positioning intravascularly or percutaneously deployed medical devices within the heart. For example, commonly assigned U.S. Patent Application Publication 2009/0131930 A1, which is herein incorporated by reference in its entirety, describes a device that is percutaneously guided to a cavity of bodily organ (e.g., a heart). The device can discriminate between fluid within the cavity (e.g., blood) and tissue that forms an inner or interior surface of the cavity (i.e., surface tissue) to provide information or mapping indicative of a position or orientation, or both of the device in the cavity. Discrimination may be based on flow or some other characteristic, for example electrical permittivity or force. The device can selectively ablate portions of the surface tissue based on the information or the mapping. In some cases, the device may detect characteristics (e.g., electrical potentials) indicative of whether ablation was successful. The device includes a plurality of transducer elements that are percutaneously guided in an unexpanded configuration and positioned at least proximate the surface tissue in an expanded configuration. Various expansion mechanisms that include a helical member or an inflatable member are described.

The desire to employ intravascular or percutaneous techniques that employ devices that can fit through catheter sheaths of ever smaller sizes (e.g., on the order of approximately 20-24 French in some cases, 18-20 French in other cases and 16-18 French or less in yet other cases) has increased. In some instances, devices deliverable via larger or smaller sized catheter sheets may be employed. Additional challenges therefore exist in creating a device that can assume an unexpanded configuration for passage through these smaller sheaths and yet, can also assume an expanded configuration suitable for positioning a portion of the device proximate to a tissue surface within the cavity.

The treatment of atrial fibrillation is but one example of a cardiac surgery that requires improved configurable devices. There are many others that require similar improved devices, such as mitral valve repair.

There is a need for enhanced methods and apparatus that allow a portion of a configurable device to assume a delivery or unexpanded configuration suitable for passage though a small bodily opening leading to a bodily cavity, and a deployed or expanded configuration suitable for positioning the portion of the device at least proximate to a tissue that forms an interior surface of the cavity.

There is a need for enhanced methods and apparatus that allow a portion of a configurable device to assume a delivery or unexpanded configuration suitable for passage through a small bodily opening leading to a bodily cavity, and a deployed or expanded configuration suitable for positioning the portion of the device at least proximate to a tissue that forms an interior surface of the cavity, the enhanced methods and apparatus being further suitable for the determination of the relative position of anatomical features within the cavity such as pulmonary veins and a mitral valve with respect to the configurable medical device.

There is a further need for enhanced methods and apparatus that allow a portion of a configurable device to assume a delivery or unexpanded configuration suitable for passage through a small bodily opening leading to a bodily cavity, and a deployed or expanded configuration suitable for positioning the portion of the device at least proximate to a tissue that forms an interior tissue surface of the cavity, the enhanced methods and apparatus being further suitable for treatment of the interior tissue surface. Treatment may include the formation of lesions in a specified position relative to anatomical features within the cavity such as pulmonary veins and a mitral valve.

There is a further need for enhanced methods and apparatus that allow a portion of a configurable device to assume a delivery or unexpanded configuration suitable for passage through a small bodily opening leading to a bodily cavity, and a deployed or expanded configuration suitable for positioning a plurality of transducer elements over a region extending across a majority of an interior tissue surface of the cavity. In particular, there is a need for enhanced methods and apparatus to arrange a plurality of transducer elements in a two- or three-dimensional grid or array capable of mapping, ablating, and/or stimulating an inside surface of a bodily cavity or lumen without requiring mechanical scanning.

#### BRIEF SUMMARY

The present design of a medical device with enhanced capabilities for deployment, positioning and ablating within a bodily cavity such as an intra-cardiac cavity is disclosed. In particular, the device is configurable from a first or unexpanded configuration in which a portion of the device is sized for delivery to a bodily cavity via a catheter sheath to a second or expanded configuration in which the portion of the device is expanded to position various transducer elements at least proximate a tissue surface within the bodily cavity. The device may employ a method for distinguishing tissue from blood and may be used to deliver positional information of the device relative to ports in the atrium, such as the pulmonary veins and mitral valve. The device may employ characteristics such as blood flow detection, impedance change detection or deflection force detection to discriminate between blood and tissue. The device may also improve ablation positioning and performance by ablating using the same elements used for discriminating between blood and tissue. Other advantages will become apparent from the teaching herein to those of skill in the art.

A medical system may be summarized as including a device that includes a plurality of elongate members, each elongate member in the plurality of elongate members including a first end and a second end, an intermediate portion positioned between the first end and the second end, and a respective length between the first end and the second end. A portion of the device is selectively moveable between an unexpanded configuration in which at least the respective

intermediate portions of the elongate members of the plurality of elongate members are arranged successively with respect to one another along a first direction in a stacked arrangement, the stacked arrangement sized to be delivered through a bodily opening leading to a bodily cavity, and an expanded configuration in which each of at least some of the plurality of elongate members are fanned about each of one or more axes. When the portion of the device is in the expanded configuration, at least one elongate member of the plurality of elongate members is arranged such that the one or more axes pass through the at least one elongate member of the plurality of elongate members at two or more locations, each location of the two or more locations spaced from another location of the two or more locations along the respective length of the at least one elongate member of the plurality of elongate members.

The one or more axes may include two or more axes, and the at least one elongate member of the plurality of elongate members may be arranged such that each axis of the two or more axes passes through a respective one of the two or more locations when the portion of the device is in the expanded configuration. At least a first axis of the two or more axes may be collinear with a second axis of the two or more axes when the portion of the device is in the expanded configuration. Each elongate member of the at least some of the plurality of elongate members may cross the at least one elongate member of the plurality of elongate members in an X configuration about at least one axis of the one or more axes when the portion of the device is in the expanded configuration.

The device may include at least one coupler arranged to physically couple each elongate member of the at least some of the plurality of elongate members together with the at least one elongate member of the plurality of elongate members. The at least one coupler may include a plurality of the couplers, each coupler of the plurality of the couplers spaced from at least one other one of the plurality of the couplers along the respective length of the at least one elongate member of the plurality of elongate members. The at least one coupler may include a flexible line arranged to be received in at least one opening provided in the at least one elongate member of the plurality of elongate members.

The at least one elongate member of the plurality of elongate members may be twisted about a twist axis extending along a portion of the respective length of the at least one elongate member of the plurality of elongate members. The two or more locations may include at least three locations.

Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including a structure that includes a plurality of elongate members. Each elongate member of the plurality of elongate members includes a proximal end, a distal end, an intermediate portion positioned between the proximal end and the distal end, and a thickness. Each intermediate portion includes a front surface and a back surface opposite across the thickness of the elongate member from the front surface. The structure is selectively moveable between an unexpanded configuration in which at least the respective intermediate portions of the elongate members of the plurality of elongate members are arranged with respect to one another front surface-toward-back surface in a stacked array sized for delivery through a bodily opening leading to a bodily cavity, and an expanded configuration in which the respective intermediate portions of at least some of the plurality of elongate members are angularly spaced with respect to one another about a first axis. Each of the at least some of the

plurality of elongate members further includes a curved portion arranged to extend along at least a portion of a respective curved path that intersects the first axis at each of a respective at least two spaced apart locations along the first axis when the structure is in the expanded configuration.

In some embodiments each elongate member of the plurality of elongate members includes a respective length between the proximal end and the distal end, and at least a first elongate member of the at least some of the plurality of elongate members crosses a second elongate member of the at least some of the plurality of elongate members at a location along the respective length of the second elongate member of the at least some of the plurality of elongate members when the structure is in the expanded configuration. At least a first elongate member of the at least some of the plurality of elongate members may cross a second elongate member of the at least some of the plurality of elongate members in an X configuration at each of at least one of the respective at least two spaced apart locations along the first axis intersected by the at least a portion of the respective curved path extended along by the curved portion of the second elongate member of the at least some of the plurality of elongate members when the structure is in the expanded configuration.

The device may include at least one coupler arranged to physically couple each elongate member of the at least some of the plurality of elongate members together with at least one other elongate member of the plurality of elongate members. In some embodiments each elongate member of the plurality of elongate members includes a respective length between the proximal end and the distal end, and the at least one coupler includes a plurality of couplers, each coupler of the plurality of couplers spaced from another coupler of the plurality of couplers along the respective length of the at least one other elongate member of the plurality of elongate members. At least one of the respective at least two spaced apart locations along the first axis intersected by at least the portion of the respective curved path extended along by the curved portion of at least a first elongate member of the at least some of the plurality of elongate members may be positioned between a first coupler of the plurality of couplers and at least a second coupler of the plurality of couplers when the structure is in the expanded configuration.

In some embodiments each elongate member of the plurality of elongate members includes a respective length between the proximal end and the distal end, and at least one elongate member of the plurality of elongate members is twisted about a twist axis extending along a portion of the respective length of the at least one elongate member of the plurality of elongate members. The respective at least two spaced apart locations along the first axis intersected by at least the portion of the respective curved path extended along by the curved portion of at least a first one of the at least some of the plurality of elongate members when the structure is in the expanded configuration may include at least three spaced apart locations along the first axis.

Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including a device that includes a plurality of elongate members and at least a first coupler arranged to physically couple each elongate member of the plurality of elongate members together with each other of the elongate members of the plurality of elongate members. Each elongate member of the plurality of elongate members includes a proximal end, a distal end, an intermediate portion positioned between the proximal end and the distal end, a respective length between the proximal end and the distal end, and a thickness. Each intermediate portion includes a front surface and a back surface opposite across the thickness of the elongate member from the front surface.

proximal end and the distal end, a respective length between the proximal end and the distal end, and a thickness. Each intermediate portion includes a front surface and a back surface opposite across the thickness of the elongate member from the front surface. A portion of the device is selectively moveable between an unexpanded configuration in which at least the respective intermediate portions of the elongate members of the plurality of elongate members are arranged with respect to each other front surface-toward-back surface in a stacked array sized for delivery through a bodily opening leading to a bodily cavity, each elongate member of the plurality of elongate members arranged to be advanced distal end first into the bodily cavity, and an expanded configuration in which at least a first elongate member of the plurality of elongate members is positioned to cross a second elongate member of the plurality of elongate members in an X configuration at a first location spaced along the respective length of the second elongate member from a location of at least the first coupler. The first location may be positioned between at least the first coupler and the respective distal end of the second elongate member. The first location may be spaced from the respective distal end of the second elongate member.

At least the first elongate member of the plurality of elongate members may be positioned to cross the second elongate member of the plurality of elongate members in an X configuration at a second location spaced from the first location along the respective length of the second elongate member of the plurality of elongate members when the portion of the device is in the expanded configuration. The medical system may further include a second coupler arranged to physically couple each elongate member of the plurality of elongate members together with each other of the elongate members of the plurality of elongate members. The first location may be spaced along the respective length of the second elongate member from a location of the second coupler and the first location may be positioned between at least the first coupler and the second coupler when the portion of the device is in the expanded configuration.

The respective intermediate portions of each of at least some of the plurality of elongate members may be angularly spaced, like lines of longitude, with respect to one another about a first axis extending through the first location when the portion of the device is in the expanded configuration. At least one elongate member of the plurality of elongate members may be twisted about an axis extending along a portion of the respective length of the at least one elongate member of the plurality of elongate members.

Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including a structure that includes a plurality of elongate members. Each elongate member of the plurality of elongate members includes a proximal end, a distal end, an intermediate portion positioned between the proximal end and the distal end, a respective length between the proximal end and the distal end, and a thickness. Each intermediate portion includes a front surface and a back surface opposite across the thickness of the elongate member from the front surface. Each intermediate portion further includes a respective pair of side edges that define a portion of a periphery of at least one of the front surface and the back surface, the side edges of each pair of side edges opposed to one another across at least a portion of the length of the respective elongate member. The structure is selectively moveable between an unexpanded configuration in which at least the respective intermediate portions of the elongate members of the plu-

rality of elongate members are arranged with respect to one another front surface-toward-back surface in a stacked array sized for delivery through a bodily opening leading to a bodily cavity, and an expanded configuration in which the structure is sized too large for delivery through the bodily opening leading to the bodily cavity. At least a first elongate member of the plurality of elongate members is positioned such that one of the side edges of the pair of side edges of the first elongate member crosses one of the side edges of the pair of side edges of a second elongate member of the plurality of elongate members at each of a plurality of spaced apart locations along the respective length of the second elongate member as viewed normally to each of a respective one of a plurality of portions of the front surface of the respective intermediate portion of the second elongate member over which each of the plurality of spaced apart locations along the respective length of the second elongate member is positioned when the structure is in the expanded configuration.

The respective intermediate portions of at least some of the plurality of elongate members may be fanned with respect to one another about an axis when the structure is in the expanded configuration. At least some of the plurality of elongate members may be fanned with respect to the second elongate member about one or more axes when the structure is in the expanded configuration, the second elongate member arranged such that the one or more axes passes through the second elongate member at each of two or more locations, each location of the two or more locations spaced from another location of the two or more locations along the respective length of the second elongate member. The plurality of spaced apart locations along the respective length of the second elongate member may include at least three spaced apart locations along the respective length of the second elongate member.

The device may further include at least one coupler arranged to physically couple at least some of the plurality of elongate members together with the second elongate member, the at least one coupler spaced along the respective length of the second elongate member from at least one of the plurality of spaced apart locations along the respective length of the second elongate member when the structure is in the expanded configuration. The at least one coupler may be positioned along the respective length of the second elongate member relatively closer to one of the respective proximal end and the respective distal end of the second elongate member than each of at least two of the plurality of spaced apart locations along the respective length of the second elongate member when the structure is in the expanded configuration. Each elongate member of the plurality of elongate members may be arranged to be advanced distal end first into the bodily cavity when the structure is in the unexpanded configuration, and the at least one coupler may be positioned along the respective length of the second elongate member relatively closer to the respective distal end of the second elongate member than at least one of the plurality of spaced apart locations along the respective length of the second elongate member when the structure is in the expanded configuration.

At least one elongate member of the plurality of elongate members may be twisted about an axis extending along a portion of the respective length of the at least one elongate member of the plurality of elongate members. The back surface of the respective intermediate portion of at least the first elongate member may, or may not be separated from the front surface of the respective intermediate portion of the second elongate member at each of at least one of the

plurality of spaced apart locations along the respective length of the second elongate member when the structure is in the expanded configuration.

The one of the side edges of the pair of side edges of the first elongate member may be opposed to the one of the side edges of the pair of side edges of the second elongate member in the stacked array when the structure is in the unexpanded configuration. The first elongate member of the plurality of elongate members may be positioned such that the other one of the side edges of the pair of side edges of the first elongate member crosses the other one of the side edges of the pair of side edges of the second elongate member at each of one or more locations along the respective length of the second elongate member as viewed normally to each of a respective one of one or more portions of the front surface of the respective intermediate portion of the second elongate member over which each of the one or more locations along the respective length of the second elongate member is positioned when the structure is in the expanded configuration.

Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including a structure that includes a plurality of elongate members and at least one coupler arranged to physically couple at least a first elongate member of the plurality of elongate members together with a second elongate member of the plurality of elongate members. Each elongate member of the plurality of elongate members includes a proximal end, a distal end, an intermediate portion positioned between the proximal end and the distal end, and a thickness. Each intermediate portion includes a front surface and a back surface opposite across the thickness of the elongate member from the front surface, a respective geodesic extending along a portion of each of the elongate members between a location at least proximate the proximal end and another location at least proximate the distal end of the elongate member. Each geodesic is located at least on the front surface of the respective intermediate portion of the elongate member. The structure is selectively moveable between an unexpanded configuration in which at least the respective intermediate portions of the elongate members of the plurality of elongate members are arranged with respect to one another front surface-toward-back surface in a stacked array sized for delivery through a bodily opening leading to a bodily cavity, each elongate member of the plurality of elongate members arranged to be advanced distal end first into the bodily cavity, and an expanded configuration in which the structure is sized too large for delivery through the bodily opening to the bodily cavity. At least the first elongate member is positioned such that the respective geodesic of the first elongate member crosses the respective geodesic of the second elongate member at a first location along the geodesic of the second elongate member as viewed normally to a respective portion of the front surface of the intermediate portion of the second elongate member over which the first location along the respective geodesic of the second elongate member is positioned. The first location is spaced from a location of the at least one coupler along the second elongate member, and the first location may be positioned between the at least one coupler and the respective distal end of the second elongate member when the structure is in the expanded configuration.

The respective intermediate portions of at least some of the plurality of elongate members may be fanned with respect to one another about an axis when the structure is in the expanded configuration. At least some of the plurality of

elongate members may be fanned with respect to the second elongate member about one or more axes when the structure is in the expanded configuration, the second elongate member curved such that the one or more axes pass through the second elongate member at each of two or more locations, each location of the two or more locations spaced from each other between the respective proximal and distal ends of the second elongate member. The respective intermediate portions of at least some of the plurality of elongate members may be angularly spaced with respect to one another about a first axis, like lines of longitude, when the structure is in the expanded configuration, each of the least some of the plurality of elongate members including a curved portion arranged to extend along at least a portion of a respective curved path that intersects the first axis at each of a respective at least two spaced apart locations along the first axis.

At least one elongate member of the plurality of elongate members may be twisted about an axis extending along a portion of the at least one elongate member of the plurality of elongate members located between the respective proximal and distal ends of the at least one elongate member of the plurality of elongate members.

The structure may include at least one other coupler arranged to physically couple at least the first elongate member together with the second elongate member, the at least one other coupler positioned relatively closer to the respective distal end of the second elongate member than the at least one coupler, and the first location may be positioned between the at least one coupler and the at least one other coupler along the second elongate member when the structure is in the expanded configuration.

The structure may include at least one other coupler arranged to physically couple at least the first elongate member together with the second elongate member, the at least one other coupler spaced from the at least one coupler along the second elongate member, and the first location may be positioned along the second elongate member relatively closer to the respective distal end of the second elongate member than each of the at least one coupler and the at least one other coupler when the structure is in the expanded configuration.

The at least one coupler may include a flexible line arranged to pass through an opening provided in each of at least one of the first elongate member and the second elongate member. The back surface of the respective intermediate portion of at least the first elongate member may contact the front surface of the respective intermediate portion of the second elongate member at the first location when the structure is in the expanded configuration. The back surface of the respective intermediate portion of at least the first elongate member may be separated from the front surface of the respective intermediate portion of the second elongate member at the first location when the structure is in the expanded configuration.

Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including a structure that includes a plurality of elongate members, each elongate member of the plurality of elongate members including a proximal end, a distal end, and a respective intermediate portion positioned between the proximal end and the distal end. The structure is selectively moveable between a delivery configuration in which the structure is suitably sized to allow the structure to be intravascularly or percutaneously delivered to a bodily cavity, and a deployed configuration in which the structure is expanded to have a size too large to allow the structure to be intravascularly or

percutaneously delivered to the bodily cavity. The plurality of elongate members include a first set of the elongate members and a second set of the elongate members, at least the respective intermediate portions of the elongate members in each of the first and the second sets of the elongate members pivoting about at least one axis when the structure is moved into the deployed configuration, each of the respective intermediate portions of the elongate members in the first set of the elongate members pivoting along a first angular direction and each of the respective intermediate portions of the elongate members in the second set of the elongate members pivoting along a second angular direction opposite to the first angular direction. At least the respective intermediate portion of at least one of the elongate members in the first set of the elongate members is positioned between the respective intermediate portions of at least two of the elongate members in the second set of the elongate members when the structure is in the delivery configuration.

In some embodiments each elongate member of the plurality of elongate members includes a thickness, and the respective intermediate portion of each elongate member of the plurality of elongate members includes a front surface and a back surface opposite across the thickness of the elongate member from the front surface. At least one portion of the respective front surface of each elongate member of the plurality of elongate members may be positioned to directly face an interior tissue surface of the bodily cavity when the structure is moved into the deployed configuration within the bodily cavity, and the respective front surface of the at least one of the elongate members in the first set of the elongate members may be positioned to directly face the respective back surface of one of the at least two of the elongate members in the second set of the elongate members when the structure is in the delivery configuration. The respective intermediate portions of the elongate members of the plurality of elongate members may be arranged with respect to one another front surface-toward-back surface in a stacked array when the structure is in the delivery configuration. At least the respective intermediate portions of the elongate members in the first set of the elongate members may be interleaved with at least the respective intermediate portions of the elongate members in the second set of the elongate members in a stacked array when the structure is in the delivery configuration.

In some embodiments each elongate member of the plurality of elongate members includes a respective length between the respective proximal and distal ends of the elongate member, and at least a first elongate member of the plurality of elongate members crosses a second elongate member of the plurality of elongate members in an X configuration at each of at least one location along the respective length of the second elongate member of the plurality of elongate members when the structure is in the deployed configuration.

In some embodiments each elongate member of the plurality of elongate members includes a respective length between the respective proximal and distal ends of the elongate member, and at least one elongate member of the plurality of elongate members is arranged such that the at least one axis passes through the at least one elongate member of the plurality of elongate members at each of two or more locations, each location of the two or more locations spaced from another location of the two or more locations along the respective length of the at least one elongate member of the plurality of elongate members when the structure is in the deployed configuration. The two or more locations may include at least three spaced apart locations

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along the respective length of the at least one elongate member of the plurality of elongate members.

Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including at least one transducer controller; and a device that includes a plurality of transducer elements and a plurality of flexible circuit structures. Each of the flexible circuit structures includes at least one flexible substrate and a set of one or more electrical conductors carried by the at least one flexible substrate, at least some of the electrical conductors in the set of one or more electrical conductors providing at least a portion of a signal path between the at least one transducer controller and at least some of the transducer elements. At least one portion of each of the plurality of flexible circuit structures is positionable within a bodily cavity. A portion of the device is selectively moveable between an unexpanded configuration in which at least the respective at least one portions of the plurality of flexible circuit structures are arranged successively along a first direction in a stacked arrangement, the stacked arrangement sized to be intravascularly or percutaneously delivered through a bodily opening leading to the bodily cavity, and an expanded configuration in which the respective at least one portions of the plurality of flexible circuit structures are angularly spaced with respect to one another about at least one axis. The respective at least one portion of each of at least some of the flexible circuit structures may pivot about the least one axis when the portion of the device is moved between the unexpanded configuration and the expanded configuration.

At least one of the plurality of flexible circuit structures may be arranged such that the at least one axis passes through the at least one of the plurality of flexible circuit structures at each of two or more spaced apart locations when the portion of the device is in the expanded configuration. The two or more spaced apart locations may include at least three spaced apart locations. At least a first one of the plurality of flexible circuit structures may cross a second one of the plurality of flexible circuit structures in an X configuration when the portion of the device is in the expanded configuration.

The respective at least one flexible substrate of each of at least some of the plurality of flexible circuit structures may include a plurality of material layers, at least one of the material layers bonded to at least one other of the material layers with an adhesive. The respective at least one portion of at least one of the plurality of flexible circuit structures may include a different number of material layers than at least another portion of the at least one of the plurality of flexible circuit structures. At least one of the plurality of transducer elements may be carried by the respective at least one portion of each of the at least some of the plurality of flexible circuit structures. Each of the plurality of flexible circuit structures may be a printed flexible circuit structure. At least one of the plurality of flexible circuit structures includes a twist about a twist axis.

Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including a device that includes a plurality of elongate members. Each elongate member of the plurality of elongate members includes a first end, a second end, an intermediate portion positioned between the first end and the second end, and a thickness. Each intermediate portion includes a front surface and a back surface opposite across the thickness of the elongate member from the front surface. A portion of the device is selectively moveable between a delivery configu-

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ration in which at least the respective intermediate portions of the elongate members of the plurality of elongate members are arranged with respect to one another front surface-toward-back surface in a stacked array sized for delivery through a bodily opening leading to a bodily cavity, and a deployed configuration in which at least the respective intermediate portion of each elongate member of at least some of the plurality of elongate members is arranged within the bodily cavity to position a first portion of the front surface of the respective intermediate portion of the elongate member of the at least some of the plurality of elongate members to face a first portion of an interior tissue surface within the bodily cavity and to position a second portion of the front surface of the respective intermediate portion of the elongate member of the at least some of the plurality of elongate members to face a second portion of the interior tissue surface, where the second portion of the interior tissue surface is opposed across the bodily cavity from the first portion of the interior tissue surface.

20 The at least some of the plurality of elongate members may be bent about a bending axis into an arcuate stacked array when the portion of the device is in the deployed configuration.

At least the respective intermediate portions of the elongate members of the at least some of the plurality of elongate members may be fanned with respect to at least one elongate member of the plurality of elongate members about each of one or more axes when the portion of the device is in the deployed configuration. In some embodiments each elongate member of the plurality of elongate members includes a respective length between the respective first end and the respective second end of the elongate member, and the one or more axes pass through the at least one elongate member of the plurality of elongate members at two or more locations when the portion of the device is in the deployed configuration, each location of the two or more locations spaced from another location of the two or more locations along the respective length of the at least one elongate member of the plurality of elongate members. The two or more locations may include at least three spaced apart locations along the respective length of the at least one elongate member of the plurality of elongate members.

In some embodiments each elongate member of the plurality of elongate members includes a respective length between the respective first end and the respective second end of the elongate member, and at least a first elongate member of the at least some of the plurality of elongate members crosses a second elongate member of the at least some of the plurality of elongate members in an X configuration at each of one or more locations along the respective length of the second elongate member of the at least some of the plurality of elongate members when the portion of the device is in the deployed configuration. At least one location of the one or more locations may be spaced along the respective length of the second elongate member of the at least some of the plurality of elongate members from each of the respective first end and the respective second end of the second elongate member. The at least one location of the one or more locations may be located along the respective length of the second elongate member of the at least some of the plurality of elongate members between the respective first and second portions of the front surface of the respective intermediate portion of the second elongate member of the at least some of the plurality of elongate members. The one or more locations along the respective length of the second elongate member of the at least some of the plurality of elongate members may include at least two spaced apart

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locations along the respective length of the second elongate member of the at least some of the plurality of elongate members. The device may further include at least one coupler that physically couples at least the first and the second elongate members of the at least some of the plurality of elongate members together. The at least one location of the one or more locations may be spaced along the respective length of the second elongate member of the at least some of the plurality of elongate members from a location of the at least one coupler when the portion of the device is in the deployed configuration. The device may further include a plurality of couplers which each physically couples at least the second elongate member of the at least some of the plurality of elongate members together with at least one other elongate member of the plurality of elongate members, each coupler of the plurality of couplers spaced from another of the plurality of couplers along the respective length of the second elongate member of the at least some of the plurality of elongate members. The at least one location of the one or more locations may be located along the respective length of the second elongate member of the at least some of the plurality of elongate members between the respective locations of at least two of the plurality of couplers when the portion of the device is in the deployed configuration. The at least one location of the one or more locations may be located along the respective length of the second elongate member of the at least some of the plurality of elongate members relatively closer to the respective first end of the second elongate member than a respective location of each of at least two of the plurality of couplers when the portion of the device is in the deployed configuration, the respective first end of each elongate member of the plurality of elongate members arranged to be advanced into the bodily cavity before the respective second end of the elongate member of the plurality of elongate members when the portion of the device is in the delivery configuration.

Each elongate member of the at least some of the plurality of elongate members may have a volute shape profile when the portion of the device is in the deployed configuration.

Each of the first and the second portions of the front surface of the respective intermediate portion of the elongate member of the at least some of the plurality of elongate members may include respective ones of one or more transducers which face a respective one of a pair of diametrically opposed portions of the interior tissue surface within the bodily cavity when the portion of the device is in the deployed configuration in use.

Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including a structure that includes a plurality of elongate members. Each elongate member of the plurality of elongate members includes a proximal end, a distal end, and a respective intermediate portion positioned between the proximal end and the distal end. The structure is selectively moveable between a delivery configuration in which the structure is suitably sized to be intravascularly or percutaneously delivered to a bodily cavity, and a deployed configuration in which the structure has a size too large to be intravascularly or percutaneously delivered to the bodily cavity. The respective intermediate portions of at least two of the plurality of elongate members are angularly spaced with respect to one another about a first axis, similar to lines of longitude, and each of the at least two of the plurality of elongate members includes a curved portion that extends along at least a portion of a respective curved path that intersects the first axis at each of a respective at least two spaced apart

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locations along the first axis when the structure is in the deployed configuration. The medical system further includes a handle portion, and a shaft member. A portion of the shaft member sized and arranged to deliver the structure intravascularly or percutaneously to the bodily cavity. The shaft member includes a first end positioned at least proximate to the handle portion and a second end physically coupled to the structure at one or more locations on the structure. Each of the one or more locations on the structure to which the second end is physically coupled is positioned to one side of at least one spatial plane coincident with the first axis when the structure is in the deployed configuration.

At least one of the one or more locations on the structure to which the second end is physically coupled may be at least proximate to the respective proximal ends of at least some of the plurality of elongate members. Each of the at least two of the plurality of elongate members may extend tangentially from the second end of the shaft member when the structure is in the deployed configuration. Each of the proximal ends of the elongate members of the plurality of elongate members may be positioned to one side of the at least one spatial plane coincident with the first axis when the structure is in the deployed configuration. Each of the distal ends of the elongate members of the plurality of elongate members may be positioned to one side of the at least one spatial plane coincident with the first axis when the structure is in the deployed configuration. The shaft member may be arranged to avoid intersection by the first axis when the structure is in the deployed configuration. The shaft member may be arranged to avoid intersection of the second end of the shaft member by the first axis when the structure is in the deployed configuration.

The respective intermediate portion of each elongate member of the plurality of elongate members may include a front surface and a back surface opposite across a thickness of the elongate member from the front surface, and at least the respective intermediate portions of the elongate members of the plurality of elongate members may be arranged with respect to one another front surface-toward-back surface in a stacked array when the structure is in the delivery configuration.

In some embodiments each elongate member of the plurality of elongate members includes a respective length between the respective proximal end and the respective distal end of the elongate member, and the first axis passes through each of at least one elongate member of the plurality of elongate members at two or more locations when the structure is in the deployed configuration, each location of the two or more locations spaced from another location of the two or more locations along the respective length of the at least one elongate member of the plurality of elongate members. The two or more locations may include at least three locations spaced along the respective length of the at least one elongate member of the plurality of elongate members.

In some embodiments each elongate member of the plurality of elongate members includes a respective length between the respective proximal end and the respective distal end of the elongate member, and at least a first elongate member of the plurality of elongate members crosses a second elongate member of the plurality of elongate member in an X configuration at a location along the respective length of the second elongate member spaced from each of the respective proximal end and the respective distal end of the second elongate member when the structure is in the deployed configuration. Each elongate member of

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at least some of the plurality of elongate members may have a volute shape profile when the structure is in the deployed configuration.

Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including a device that includes a plurality of elongate members. Each elongate member of the plurality of elongate members includes a proximal end, a distal end, an intermediate portion positioned between the proximal end and the distal end, and a thickness. Each intermediate portion includes a front surface and a back surface opposite across the thickness of the elongate member from the front surface. A portion of the device is selectively moveable between a delivery configuration in which at least the respective intermediate portions of the elongate members of the plurality of elongate members are arranged with respect to one another front surface-toward-back surface in a stacked array sized for delivery through a bodily opening leading to a bodily cavity, and a deployed configuration in which the respective intermediate portion of each elongate member of at least some of the plurality of elongate members has a volute shape profile.

At least the respective intermediate portions of the elongate members of the at least some of the plurality of elongate members may be fanned with respect to at least one elongate member of the plurality of elongate members about at least one axis when the portion of the device is in the deployed configuration. In some embodiments each elongate member of the plurality of elongate members includes a respective length between the respective proximal end and the respective distal end of the elongate member, and the at least one axis passes through the at least one elongate member of the plurality of elongate members at two or more locations when the portion of the device is in the deployed configuration, each location of the two or more locations spaced from another location of the two or more locations along the respective length of the at least one elongate member of the plurality of elongate members. The two or more locations may include at least three spaced apart locations along the respective length of the at least one elongate member of the plurality of elongate members.

In some embodiments each elongate member of the plurality of elongate members includes a respective length between the respective proximal end and the respective distal end of the elongate member, and at least a first elongate member of the plurality of elongate members crosses a second elongate member of the plurality of elongate member in an X configuration at each of one or more locations along the respective length of the second elongate member spaced from each of the respective proximal end and the respective distal end of the second elongate member when the portion of the device is in the deployed configuration. The device may further include a plurality of couplers which each physically couples at least the second elongate member of the plurality of elongate members together with at least one other elongate member of the plurality of elongate members, each coupler of the plurality of couplers spaced from another of the plurality of couplers along the respective length of the second elongate member of the plurality of elongate members. At least one location of the one or more locations may be located along the respective length of the second elongate member of the plurality of elongate members between the respective locations of at least two of the plurality of couplers when the portion of the device is in the deployed configuration. Each elongate member of the plurality of elongate members in the stacked

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array may be arranged to be advanced distal end first into the bodily cavity when the portion of the device is in the delivery configuration, and at least one location of the one or more locations may be located along the respective length of the second elongate member of the plurality of elongate members relatively closer to the respective distal end of the second elongate member than a respective location of each of at least two of the plurality of couplers when the portion of the device is in the deployed configuration.

10 Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including a catheter sheath that includes a first end, a second end and a lumen therebetween. The medical system further includes a 15 device that includes a plurality of elongate members. Each elongate member of the plurality of elongate members includes a proximal end, a distal end, an intermediate portion positioned between the proximal end and the distal end, and a thickness. Each intermediate portion includes a 20 front surface and a back surface opposite across the thickness of the elongate member from the front surface. A portion of the device is selectively moveable between a first configuration in which at least the respective intermediate portions of the elongate members of the plurality of elongate members are arranged with respect to one another front surface-toward-back surface in a stacked array sized for 25 delivery through the lumen of the catheter sheath, each elongate member of the plurality of elongate members arranged to be advanced distal end first out from the lumen 30 of the catheter sheath, and a second configuration in which the respective distal end of each of at least some of the plurality of elongate members moves along a respective coiled path as the elongate members advance out of the lumen of the catheter sheath, the respective intermediate 35 portions of each elongate member of the at least some of the plurality of elongate members bent about a respective bending axis into an arcuate stacked array sized too large for delivery though the lumen of the catheter sheath.

At least part of the coiled path may extend along a volute 40 path. At least the respective intermediate portion of each elongate member of the at least some of the plurality of elongate members may have a volute shape profile when the portion of the device is in the second configuration.

In some embodiments each elongate member of the 45 plurality of elongate members includes a respective length between the respective proximal end and the respective distal end of the elongate member, and the portion of the device is further selectively moveable between at least the second configuration and a third configuration in which at 50 least the respective intermediate portions of the elongate members of the at least some of the plurality of elongate members are fanned with respect to at least one elongate member of the plurality of elongate members about each of one or more axes. The one or more axes may pass through 55 the at least one elongate member of the plurality of elongate members at two or more locations when the portion of the device is in the third configuration, each location of the two or more locations spaced from another location of the two or more locations along the respective length of the at least one elongate member of the plurality of elongate members. The two or more locations may include at least three spaced apart 60 locations along the respective length of the at least one elongate member of the plurality of elongate members.

In some embodiments each elongate member of the 65 plurality of elongate members includes a respective length between the respective proximal end and the respective distal end of the elongate member, and the portion of the

device is further selectively moveable between at least the second configuration and a third configuration in which at least a first elongate member of the plurality of elongate members crosses a second elongate member of the plurality of elongate members in an X configuration at each of one or more locations along the respective length of the second elongate member spaced from each of the respective proximal end and the respective distal end of the second elongate member. The device may further include a plurality of couplers which each physically couples at least the second elongate member of the plurality of elongate members together with at least one other elongate member of the plurality of elongate members, each coupler of the plurality of couplers spaced from another of the plurality of couplers along the respective length of the second elongate member. At least one location of the one or more locations may be located along the respective length of the second elongate member between the respective locations of at least two of the plurality of couplers when the portion of the device is in the third configuration. At least one location of the one or more locations may be located along the respective length of the second elongate member relatively closer to the respective distal end of the second elongate member than a respective location of each of at least two of the plurality of couplers when the portion of the device is in the third configuration.

At least one elongate member of the at least some of the plurality of elongate members may have an annular shape profile in the second configuration, the annular profile interrupted by a separation. The respective intermediate portion of each elongate member of the at least some of the plurality of elongate members may be preformed to autonomously bend about the respective bending axis of the elongate member of the at least some of the plurality of elongate members as the respective intermediate portion is advanced out from the lumen of the catheter sheath. The medical system may further include a bending unit that acts on at least one of the plurality of elongate members to bend the respective intermediate portion of each elongate member of the at least some of the plurality of elongate members about the respective bending axis of the elongate member of the at least some of the plurality of elongate members when the portion of the device is moved between the first configuration and the second configuration.

Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including a device that includes a plurality of elongate members. Each elongate member of the plurality of elongate members includes a first end and a second end, an intermediate portion between the first end and the second end, and a respective length between the first end and the second end. The device further includes a plurality of couplers that includes a proximal coupler, a distal coupler and at least one intermediate coupler. Each coupler of the plurality of couplers is spaced from another of the plurality of couplers along the respective length of at least a first elongate member of the plurality of elongate members with the at least one intermediate coupler positioned between the proximal coupler and the distal coupler. Each coupler of the plurality of couplers is arranged to couple at least the first elongate member together with least one other elongate member of the plurality of elongate members. A portion of the device is selectively moveable between an unexpanded configuration in which at least the respective intermediate portions of the elongate members of the plurality of elongate members are sized and arranged to be delivered through a bodily opening

leading to a bodily cavity within a body, the bodily cavity having an interior tissue surface interrupted by a port of the bodily opening, and the plurality of couplers arranged to be advanced distal coupler first into the bodily cavity, and an expanded configuration in which at least the respective intermediate portions of at least some of the plurality of elongate members are arranged such that at least the distal coupler is located within the bodily cavity at a respective location positioned relatively closer to the port of the bodily opening than a respective location of the at least one intermediate coupler within the bodily cavity.

When the portion of the device is in the expanded configuration, the proximal coupler may be positioned relatively closer to the port of the bodily opening than the distal coupler within the bodily cavity. When the portion of the device is in the expanded configuration, the distal coupler may be positioned relatively closer to the port of the bodily opening than the proximal coupler. At least the respective intermediate portions of the at least some of the plurality of elongate members may be arranged such that the proximal coupler is located within the body at a location outside of the bodily cavity when the portion of the device is in the expanded configuration.

At least the respective intermediate portions of the elongate members of the plurality of elongate members may be arranged successively with respect to one another along a first direction in a stacked arrangement when the portion of the device is in the unexpanded configuration.

The respective intermediate portion of each elongate member of the plurality of elongate members may include a thickness, a front surface and a back surface opposite across the thickness from the front surface. At least the respective intermediate portions of the elongate members of the plurality of elongate members may be arranged with respect to one another front surface-toward-back surface in a stacked array sized for delivery through the bodily opening leading to the bodily cavity when the portion of the device is in the unexpanded configuration, and the respective intermediate portion of each elongate member of the at least some of the plurality of elongate members may be bent about a respective bending axis when the portion of the device is in the expanded configuration. The respective intermediate portion of each elongate member of the at least some of the plurality of elongate members may be preformed to autonomously bend about the respective bending axis of the elongate member of the at least some of the plurality of elongate members when the respective intermediate portion of the elongate member of the at least some of the plurality of elongate members is advanced into the bodily cavity.

At least the respective intermediate portions of the elongate members of the at least some of the plurality of elongate members may be fanned with respect to at least one elongate member of the plurality of elongate members about each of one or more axes, and the one or more axes may pass through the at least one elongate member of the plurality of elongate members at two or more locations when the portion of the device is in the expanded configuration. Each location of the two or more locations may be spaced from another location of the two or more locations along the respective length of the at least one elongate member of the plurality of elongate members. The two or more locations may include at least three spaced apart locations along the respective length of the at least one elongate member of the plurality of elongate members. At least a second elongate member of the plurality of elongate members may cross the first elongate member at a location along the respective length of the first

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elongate member spaced from each of the proximal coupler and the distal coupler when the portion of the device is in the expanded configuration.

Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including a device that includes a plurality of elongate members. Each elongate member of the plurality of elongate members includes a proximal end, a distal end, an intermediate portion positioned between the proximal end and the distal end, and a thickness. Each intermediate portion includes a front surface and a back surface opposite across the thickness of the elongate member from the front surface. A respective geodesic defined for each elongate member extends along the respective elongate member between a first location at least proximate the proximal end and a second location at least proximate the distal end of the elongate member, each geodesic defined at least on the front surface of the respective intermediate portion of the elongate member. A portion of the device is selectively moveable between an unexpanded configuration in which at least the respective intermediate portions of the elongate members of the plurality of elongate members are arranged front surface-toward-back surface in a stacked array sized to be delivered through a bodily opening leading to a bodily cavity having an interior tissue surface interrupted by a port of the bodily opening, each elongate member of the plurality of elongate members arranged to be advanced distal end first into the bodily cavity, and an expanded configuration in which at least a first elongate member of the plurality of elongate members is positioned to cross a second elongate member of the plurality of elongate members at each of one or more crossing locations within the bodily cavity. Each of the one or more crossing locations is located on the front surface of the second elongate member at a respective one of one or more locations along the respective geodesic of the second elongate member that is crossed by the respective geodesic of the first elongate member as viewed normally to a respective one of one or more portions of the front surface of the second elongate member over which each respective one of the one or more locations along the respective geodesic of the second elongate member is located. The elongate members of the plurality of elongate members are arranged such that the respective distal end of each elongate member of at least some of the plurality of elongate members is positioned within the bodily cavity at a respective location located relatively closer to the port of the bodily opening than at least one crossing location of the one or more crossing locations within the bodily cavity when the portion of the device is in the expanded configuration.

The one or more crossing locations within the bodily cavity may include at least one other crossing location, the least one other crossing location located within the bodily cavity relatively closer to the port of the bodily opening than the respective location within the bodily cavity of the respective distal end of each elongate member of the at least some of the plurality of elongate members when the portion of the device is moved between the unexpanded configuration and the expanded configuration.

The respective intermediate portion of each elongate member of the at least some of the plurality of elongate members may be arranged within the bodily cavity to position a first portion of the front surface of the respective intermediate portion of the elongate member of the at least some of the plurality of elongate members to face a first portion of an interior tissue surface within the bodily cavity and to position a second portion of the front surface of the

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respective intermediate portion of the elongate member of the at least some of the plurality of elongate members to face a second portion of the interior tissue surface when the portion of the device is in the expanded configuration, the second portion of the interior tissue surface positioned diametrically opposite to the first portion of the interior tissue surface.

The device may further include a plurality of couplers which each physically couples at least the second elongate member together with at least one other elongate member of the plurality of elongate members, each coupler of the plurality of couplers spaced from another coupler of the plurality of couplers along the second elongate member. The location of the at least one crossing location along the respective geodesic of the second elongate member may be positioned along the second elongate member between the respective locations of two of the plurality of couplers when the portion of the device is in the expanded configuration. The location of the at least one crossing location along the respective geodesic of the second elongate member may be located along the second elongate member relatively closer to the respective distal end of the second elongate member than a respective location of each of at least two of the plurality of couplers when the portion of the device is in the expanded configuration.

The respective intermediate portion of each elongate member of the at least some of the plurality of elongate members may be preformed to autonomously bend about a respective bending axis as the respective intermediate portion of the elongate member of the at least some of the plurality of elongate members is advanced into the bodily cavity. The medical system may further include a bending unit that acts on at least one of the plurality of elongate members to bend each elongate member of the at least some of the plurality of elongate members about a respective bending axis within the bodily cavity when the portion of the device is moved between the unexpanded configuration and the expanded configuration.

Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including a catheter sheath that includes a first end, a second end and a lumen therebetween. The medical system further includes a structure that includes a plurality of elongate members, each elongate member of the plurality of elongate members including a proximal end, a distal end, and an intermediate portion positioned between the proximal and the distal ends. The structure is selectively moveable between an unexpanded configuration in which the elongate members of the plurality of elongate members are arranged successively with respect to one another along a first direction in a stacked arrangement, the stacked arrangement sized to be delivered through the lumen of the catheter sheath from the first end of the catheter sheath towards the second end of the catheter sheath, a portion of at least one elongate member of the plurality of elongate members in the stacked arrangement positioned to be advanced from the second end of the catheter sheath prior to each of the other elongate members of the plurality of elongate members in the stacked arrangement as the stacked arrangement is delivered through the lumen of the catheter sheath from the first end of the catheter sheath towards the second end of the catheter sheath, and an expanded configuration in which the structure is expanded to have a size too large to be delivered through the lumen of the catheter sheath.

In some embodiments each elongate member of the plurality of elongate members includes a respective length

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between the proximal and the distal ends of the elongate member, and the respective length of the at least one elongate member of the plurality of elongate members is longer than each of the respective lengths of the other elongate members of the plurality of elongate members. The portion of the at least one elongate member of the plurality of elongate members may be cantilevered from the stacked arrangement when the structure is in the unexpanded configuration. The at least one elongate member of the plurality of elongate members may include an outermost elongate member in the stacked arrangement when the structure is in the unexpanded configuration. The at least one elongate member of the plurality of elongate members may include an elongate member located between two outermost elongate members in the stacked arrangement when the structure is in the unexpanded configuration. The at least one elongate member of the plurality of elongate members may include at least two elongate members of the plurality of elongate members.

In some embodiments each elongate member of the plurality of elongate members includes a respective length between the proximal and the distal ends of the elongate member, and at least a first elongate member of the plurality of elongate members crosses a second elongate member of the plurality of elongate members in an X configuration at each of one or more locations along the respective length of the second elongate member when the structure is in the expanded configuration, each of the one or more locations spaced from each of the respective proximal end and the respective distal end of the second elongate member.

The respective intermediate portion of each elongate member of at least some of the plurality of elongate members may be preformed to autonomously bend about a respective bending axis as the respective intermediate portion of the elongate member of the at least some of the plurality of elongate members is advanced from the second end of the catheter sheath as the stacked arrangement is delivered through the lumen of the catheter sheath from the first end of the catheter sheath towards the second end of the catheter sheath. The medical system may further include a bending unit that acts on at least one of the plurality of elongate members to bend each elongate member of at least some of the plurality of elongate members about a respective bending axis when the respective intermediate portion of the elongate member of the at least some of the plurality of elongate members is advanced from the second end of the catheter sheath.

Each elongate member of the plurality of elongate members may be arranged to be advanced distal end first as the stacked arrangement is delivered through the lumen of the catheter sheath from the first end of the catheter sheath towards the second end of the catheter sheath.

Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including a structure that includes a plurality of elongate members. Each elongate member of the plurality of elongate members includes a proximal end, a distal end, a respective intermediate portion positioned between the proximal end and the distal end, and a respective length between the proximal and the distal ends. A method employing the medical system may be summarized as including intravascularly or percutaneously delivering at least a portion of the structure to a location within an intra-cardiac cavity formed at least in part by a tissue wall having an interior tissue surface, each elongate member of the plurality of elongate members introduced distal end first into the intra-cardiac cavity and

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the distal end of each elongate member of the plurality of elongate members curling away from the interior tissue surface as the distal end of the elongate member of the plurality of elongate members is advanced along a respective path within the intra-cardiac cavity during the intravascular or percutaneous delivery. The method further includes fanning at least some of the plurality of elongate members with respect to at least one elongate member of the plurality of elongate members about each of one or more axes within the intra-cardiac cavity. The one or more axes pass through the at least one elongate member of the plurality of elongate members at two or more locations, each location of the two or more locations spaced from another location of the two or more locations along the respective length of the at least one elongate member of the plurality of elongate members.

In some embodiments the respective intermediate portion of each elongate member of the plurality of elongate members includes a front surface and a back surface opposite across a thickness of the elongate member from the front surface, and the method further includes positioning a first portion of the front surface of the respective intermediate portion of at least a first elongate member of the plurality of elongate members to face a first portion of the interior tissue surface and positioning a second portion of the front surface of the respective intermediate portion of at least the first elongate member of the plurality of elongate members to face a second portion of the interior tissue surface, the second portion of the interior tissue surface positioned diametrically opposite to the first portion of the interior tissue surface.

In some embodiments, the respective intermediate portion of each elongate member of the plurality of elongate members may include a front surface and a back surface opposite across a thickness of the elongate member from the front surface, and at least the respective intermediate portions of the elongate members of the plurality of elongate members may be arranged with respect to one another front surface-toward-back surface in a stacked array when intravascularly or percutaneously delivering at least the portion of the structure to the location within the intra-cardiac cavity.

The method may further include crossing a second elongate member of the plurality of elongate members with a first elongate member of the plurality of elongate members in an X configuration at each of one or more locations along the respective length of the second elongate member, each of the one or more locations spaced from each of the respective proximal end and the respective distal end of the second elongate member.

Various methods may include combinations and subsets of those summarized above.

A medical system may be summarized as including a structure that includes a plurality of elongate members. Each elongate member includes a first end, a second end, and an intermediate portion positioned between the first and the second ends. Each intermediate portion includes a thickness, a front surface and a back surface opposite across the thickness from the front surface. The structure further includes a proximal portion and a distal portion, each of the proximal and the distal portions of the structure including a respective part of each of at least some of the plurality of elongate members. The structure is selectively moveable between a delivery configuration in which the structure is sized for delivery through a bodily opening leading to a bodily cavity, at least the respective intermediate portions of the elongate members of the plurality of elongate members arranged front surface-toward-back surface in a stacked array when the structure is in the delivery configuration, and

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a deployed configuration in which the structure is sized too large for delivery through the bodily opening leading to the bodily cavity, the proximal portion of the structure forming a first domed shape and the distal portion of the structure forming a second domed shape when the structure is in the deployed configuration.

At least one of the first domed shape and the second domed shape may have a first radius of curvature in a first spatial plane and a second radius of curvature in a second spatial plane that intersects the first spatial plane, a magnitude of the second radius of curvature different than a magnitude of the first radius of curvature.

Each elongate member of the at least some of the plurality of elongate members may cross at least one other elongate member of the plurality of elongate members at least at one location between the proximal and the distal portions of the structure when the structure is in the deployed configuration.

In some embodiments each elongate member of the plurality of elongate members includes a respective length between the first end and the second end of the elongate member, and each elongate member of the at least some of the plurality of elongate members crosses at least one other elongate member of the plurality of elongate members at each of a plurality of spaced apart locations along the respective length of at least the one other elongate member of the plurality of elongate members when the structure is in the deployed configuration. At least some of the plurality of elongate members may be fanned with respect to at least one of the plurality of elongate members about an axis passing through a location between the proximal and the distal portions of the structure when the structure is in the deployed configuration.

In some embodiments, the medical system further includes at least one flexible line arranged to physically couple the proximal and the distal portions of the structure together, the at least one flexible line manipulable to vary a distance between the proximal and the distal portions of the structure when the structure is in the deployed configuration.

Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including a structure that includes a plurality of elongate members. Each elongate member of the plurality of elongate members includes a proximal end, a distal end, and a respective intermediate portion positioned between the proximal end and the distal end. The structure is selectively moveable between a delivery configuration in which the structure is suitably sized to be intravascularly or percutaneously delivered to a bodily cavity, and a deployed configuration in which the structure is expanded to have a size too large to be intravascularly or percutaneously delivered to the bodily cavity. The respective intermediate portions of at least some of the plurality of elongate members are angularly spaced with respect to one another about a first axis, similar to lines of longitude, when the structure is in the deployed configuration. The medical system further includes a handle portion and a shaft member, a portion of the shaft member sized and arranged to deliver the structure intravascularly or percutaneously to the bodily cavity. The shaft member includes a first end positioned at least proximate to the handle portion and a second end physically coupled to the structure. In the deployed configuration the structure and the shaft member have a projected outline in the shape of the Greek letter rho, where a point where a loop of the letter would intersect a tail of the letter may be open or not closed. Such outline may be either without, or with, an opening defined by a loop portion of the letter represented.

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Each of the at least some of the plurality of elongate members may include a curved portion that extends along at least a portion of a respective curved path that intersects the first axis at each of a respective at least two spaced apart locations along the first axis when the structure is in the deployed configuration.

In some embodiments the respective intermediate portion of each elongate member of the plurality of elongate members includes a front surface and a back surface opposite across a thickness of the elongate member, and at least the respective intermediate portions of the elongate members of the plurality of elongate members are arranged with respect to one another front surface-toward-back surface in a stacked array when the structure is in the delivery configuration.

In some embodiments each elongate member of the plurality of elongate members includes a respective length between the respective proximal end and the respective distal end of the elongate member, and the first axis passes through each of at least one elongate member of the plurality of elongate members at two or more locations when the structure is in the deployed configuration, each location of the two or more locations spaced from another location of the two or more locations along the respective length of the at least one elongate member of the plurality of elongate members. The two or more locations may include at least three locations spaced along the respective length of the at least one elongate member of the plurality of elongate members.

In some embodiments each elongate member of the plurality of elongate members includes a respective length between the respective proximal end and the respective distal end of the elongate member, and at least a first elongate member of the plurality of elongate members crosses a second elongate member of the plurality of elongate member in an X configuration at each of one or more locations along the respective length of the second elongate member spaced from each of the respective proximal end and the respective distal end of the second elongate member when the structure is in the deployed configuration. The medical system may further include a plurality of couplers which each physically couples at least the second elongate member of the plurality of elongate members together with at least one other elongate member of the plurality of elongate members, each coupler of the plurality of couplers spaced from another of the plurality of couplers along the respective length of the second elongate member of the plurality of elongate members. At least one location of the one or more locations may be located along the respective length of the second elongate member of the plurality of elongate members between the respective locations of at least two of the plurality of couplers when the structure is in the deployed configuration. Each elongate member of the plurality of elongate members may be arranged to be

advanced distal end first into the bodily cavity when the structure is in the delivery configuration, and at least one location of the one or more locations may be located along the respective length of the second elongate member of the plurality of elongate members relatively closer to the respective distal end of the second elongate member than a respective location of each of at least two of the plurality of couplers when the structure is in the deployed configuration.

Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including a structure that includes a proximal portion and a distal portion. The structure is selectively movable between a

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delivery configuration in which the structure is sized for delivery through a bodily opening leading to a bodily cavity, the structure arranged to be advanced distal portion first into the bodily cavity, and a deployed configuration in which the structure is sized too large for delivery through the bodily opening leading to the bodily cavity. The proximal portion of the structure forms a first domed shape and the distal portion of the structure forms a second domed shape when the structure is in the deployed configuration. The proximal and the distal portions of the structure are arranged in a clam shell configuration when the structure is in the deployed configuration.

At least one of the first domed shape and the second domed shape may have a first radius of curvature in a first spatial plane and a second radius of curvature in a second spatial plane that intersects the first spatial plane. A magnitude of the second radius of curvature may be different than a magnitude of the first radius of curvature. The proximal and the distal portions of the structure may be physically coupled together to pivot with respect to one another when the structure is in the deployed configuration. The proximal and the distal portions of the structure may be pivotably coupled together by a flexure portion of the structure when the structure is in the deployed configuration.

The medical system may further include at least one actuator operably coupled to the structure to selectively pivot the proximal and the distal portions of the structure with respect to one another when the structure is in the deployed configuration. In some embodiments, the medical system further includes at least one flexible line arranged to physically couple the proximal and the distal portions of the structure together, the at least one flexible line manipulable to vary a distance between the proximal and the distal portions of the structure when the structure is in the deployed configuration.

The medical system may further include at least one actuator selectively operable to act on at least one of the proximal and the distal portions of the structure to distort a respective one of the first domed shape and the second domed shape when the structure is in the deployed configuration. Each of the first domed shape and the second domed shape may have a respective volume therein, and the medical system may further include at least one actuator selectively operable to act on the structure to vary the respective volume of at least one of the first domed shape and the second domed shape when the structure is in the deployed configuration. The medical system may further include at least one actuator selectively operable to act on at least one of the proximal and the distal portions of the structure to vary a difference between the respective volumes of the first and the second domed shapes when the structure is in the deployed configuration.

Each of the proximal and the distal portions of the structure may be arranged to pivot with respect to one another about a pivot location when the structure is in the deployed configuration. Each of the first domed shape and the second domed shape may include a respective apex and a respective height extending normally from a respective spatial plane to the respective apex, each respective spatial plane positioned to intersect the pivot location. The medical system may further include at least one actuator selectively operable to act on at least one of the proximal and the distal portions of the structure to vary at least one of a magnitude of the respective height of the first domed shape and a magnitude of the respective height of the second domed shape when the structure is in the deployed configuration.

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The structure may further include a plurality of elongate members, each of the proximal and the distal portions of the structure comprising a respective portion of each elongate member of the plurality of elongate members. Each elongate member of at least some of the plurality of elongate members may cross at least one other elongate member of the plurality of elongate members at least at one location between the proximal and the distal portions of the structure when the structure is in the deployed configuration. Each 10 elongate member of the plurality of elongate members may include a first end, a second end, and a respective length between the first end and the second end. Each elongate member of at least some of the plurality of elongate members may cross at least one other elongate member of the 15 plurality of elongate members at each of a plurality of spaced apart locations along the respective length of at least the one other elongate member of the plurality of elongate members when the structure is in the deployed configuration. The plurality of spaced apart locations along the 20 respective length of at least the one other elongate member of the plurality of elongate members may include at least one location between the respective portion of the one other elongate member of the plurality of elongate members comprised by the proximal portion of the structure and the 25 respective portion of the one other elongate member of the plurality of elongate members comprised by the distal portion of the structure. At least some of the plurality of elongate members may be fanned with respect to one another about an axis that passes through a location between the proximal and the distal portions of the structure when the 30 structure is in the deployed configuration.

Each elongate member of the plurality of elongate members may include a first end, a second end, an intermediate portion positioned between the first end and the second end, 35 and a thickness, the respective intermediate portion of each elongate member including a front surface and a back surface opposite across the thickness from the front surface. The respective intermediate portions of the plurality of elongate members may be arranged front surface-toward- 40 back surface in a stacked array when the structure is in the delivery configuration. The respective intermediate portion of each elongate member of at least some of the plurality of elongate members may include a slotted opening between the respective first and the second ends of the elongate member, at least two of the slotted openings arranged to 45 cross one another when the structure is in the deployed configuration. The medical system may further include at least one actuator selectively operable to act on the structure to change a location where the at least two slotted openings cross one another when the structure is in the deployed configuration.

Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including a 55 structure that includes a plurality of elongate members. Each elongate member of the plurality of elongate members includes a plurality of ends including a proximal end and a distal end. Each elongate member of the plurality of elongate members further includes a respective intermediate portion positioned between the proximal and the distal ends of the elongate member, and a respective length between the proximal and the distal ends of the elongate member. The structure further includes a plurality of couplers arranged to 60 physically couple each elongate member of the plurality of elongate members together with at least one other elongate member of the plurality of elongate members at each of at least two spaced apart locations along the respective length

of the elongate member of the plurality of elongate members. A method employing the medical system may be summarized as including providing a catheter sheath that includes a first end, a second end and a lumen extending therebetween, and arranging the structure to have a size suitable for delivery through the lumen of the catheter sheath, each of the elongate members in the structure arranged to be advanced distal end first out from the lumen of the catheter sheath. The method includes expanding the structure to have a size too large for delivery through the lumen of the catheter sheath. The method includes providing at least one of a) relative movement between at least some of the ends in a first set of the proximal ends of the elongate members of the plurality of elongate members to reduce an end-to-end distance between the at least some of the ends in the first set during the expanding or b) relative movement between at least some of the ends in a second set of the distal ends of the elongate members of the plurality of elongate members to reduce an end-to-end distance between the at least some of the ends in the second set during the expanding.

The method may further include providing the relative movement between the at least some of the ends in the first set or between the at least some of the ends in the second set while restraining relative movement between at least some of the ends in the other of the first set and the second set along at least one direction during the expanding. The method may further include providing the relative movement between the at least some of the ends in the first set or between the at least some of the ends in the second set while restraining relative movement between the respective intermediate portions of at least some of the plurality of elongate members along at least one direction during the expanding.

The method may further include providing the relative movement between the at least some of the ends in the first set or between the at least some of the ends in the second set while decreasing a distance between the respective distal end and the respective proximal end of each of at least some of the plurality of elongate members during the expanding.

The method may further include arranging the respective intermediate portions of at least some of the plurality of elongate members to cross one another at a crossing location, and varying a respective distance between the crossing location and each of the at least some of the ends in the first set or each of the at least some of the ends in the second set. The method may further include arranging the respective intermediate portions of at least some of the plurality of elongate members to cross one another at a crossing location, and providing the relative movement between the at least some of the ends in the first set while varying a respective distance between the crossing location and each of the at least some of the ends in the first set or providing the relative movement between the at least some of the ends in the second set while varying a respective distance between the crossing location and each of the at least some of the ends in the second set. The method may further include arranging the respective intermediate portions of at least some of the plurality of elongate members to cross one another at a crossing location; varying a respective distance between the crossing location and at least a first one of the ends of the respective at least some of the ends in one of the first set and the second set by a first amount; and varying a respective distance between the crossing location and at least a second one of the ends of the respective at least some of the ends in the one of the first set and the second set by a second amount different from the first amount.

The method may further include arranging at least the respective intermediate portions of at least some of the

plurality of elongate members to be angularly spaced with respect to one another about a first axis. The respective intermediate portion of each elongate member of the plurality of elongate members may include a thickness, a front surface and a back surface opposite across the thickness from the front surface, and arranging the structure to have the size suitable for delivery through the lumen of the catheter sheath may include arranging the respective intermediate portions of the elongate members with respect to one another front surface-toward-back surface in a stacked array.

Various methods may include combinations and subsets of those summarized above.

A medical system may be summarized as including a structure that includes a plurality of elongate members. Each elongate member of the plurality of elongate members includes a proximal end, a distal end, a respective intermediate portion positioned between the proximal and the distal ends, and a respective length between the proximal and the distal ends. The structure is selectively moveable between a delivery configuration in which the structure is sized to be delivered through a bodily opening leading to a bodily cavity, and a deployed configuration in which the structure is expanded to have a size too large to be delivered through the bodily opening leading to the bodily cavity. The respective intermediate portions of at least some of the plurality of elongate members are angularly spaced with respect to one another about a first axis and each of the at least some of the plurality of elongate members further includes a curved portion arranged to extend along at least a portion of a respective curved path that intersects the first axis at each of a respective at least two spaced apart locations along the first axis when the structure is in the deployed configuration. A portion of the structure is radially spaced from the first axis by a first dimension when the structure is in the deployed configuration. The medical system further includes at least one actuator operably coupled to the structure to selectively reduce a curvature of the respective curved portion of at least one of the at least some of the plurality of elongate members to increase the first dimension when the structure is in the deployed configuration.

The structure may include a second dimension along the first axis when the structure is in the deployed configuration, and the at least one actuator may be operably coupled to the structure to selectively reduce the curvature of the respective curved portion of the at least one of the at least some of the plurality of elongate members to increase the second dimension when the structure is in the deployed configuration. The at least one actuator may be operably coupled to the structure to selectively reduce the curvature of the respective curved portion of the at least one of the at least some of the plurality of elongate members to concurrently increase each of the first and the second dimensions. The second dimension may be an overall dimension of the structure along the first axis when the structure is in the deployed configuration. The first axis may pass through the at least one of the at least some of the plurality of elongate members at each of a first location and a second location spaced along the respective length of the at least one of the at least some of the plurality of elongate members from the first location when the structure is in the deployed configuration. The second dimension may be a dimension between the first location and the second location along the first axis.

The portion of the structure may include the respective curved portion of the at least one of the at least some of the plurality of elongate members when the structure is in the deployed configuration. The first axis may pass through the

at least one of the at least some of the plurality of elongate members at a first location spaced along the respective length of the at least one of the at least some of the plurality of elongate members from one of the respective proximal end and the respective distal end of the at least one of the at least some of the plurality of elongate members, and the at least one actuator may be operably coupled to the structure to selectively reduce the curvature of the respective curved portion of the at least one of the at least some of the plurality of elongate members to reduce a distance between the first location and the one of the respective proximal end and the respective distal end of the at least one of the at least some of the plurality of elongate members when the structure is in the deployed configuration.

The respective intermediate portion of each elongate member of the plurality of elongate members may include a front surface and a back surface opposite across a thickness of the elongate member. At least the respective intermediate portions of the elongate members of the plurality of elongate members may be arranged with respect to one another front surface-toward-back surface in a stacked array when the structure is in the delivery configuration.

The first axis may pass through at least a first elongate member of the plurality of elongate members at two or more locations when the structure is in the deployed configuration. Each location of the two or more locations may be spaced from another location of the two or more locations along the respective length of at least the first elongate member of the plurality of elongate members. The two or more locations may include at least three locations spaced with respect to one another along the respective length of the first elongate member of the plurality of elongate members.

At least a first elongate member of the plurality of elongate members may cross a second elongate member of the plurality of elongate members in an X configuration at one or more locations along the respective length of the second elongate member spaced from each of the respective proximal end and the respective distal end of the second elongate member when the structure is in the deployed configuration. The structure may further include a plurality of couplers, each coupler of the plurality of couplers arranged to physically couple at least the second elongate member of the plurality of elongate members together with at least one other elongate member of the plurality of elongate members, each coupler of the plurality of couplers spaced from another of the plurality of couplers along the respective length of the second elongate member of the plurality of elongate members. At least one location of the one or more locations may be located along the respective length of the second elongate member of the plurality of elongate members between the respective locations of at least two of the plurality of couplers when the structure is in the deployed configuration. Each elongate member of the plurality of elongate members may be arranged to be advanced distal end first into the bodily cavity when the structure is in the delivery configuration, and at least one location of the one or more locations may be located along the respective length of the second elongate member of the plurality of elongate members relatively closer to the respective distal end of the second elongate member than a respective location of each of at least two of the plurality of couplers when the structure is in the deployed configuration.

Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including a device that includes a plurality of elongate members. Each elongate member of the plurality of elongate members

includes a first end, a second end, a respective length between the first end and the second end, a thickness, a respective front surface and a respective back surface opposite across the thickness. The plurality of elongate members include at least one elongate member that has a unitary or single piece structure having a plurality of portions arranged between the respective first end and the respective second end of the at least one elongate member. The plurality of portions include at least a first portion, a second portion and a third portion positioned between the first portion and the second portion. Each of the plurality of portions further includes a respective pair of side edges that form a portion of a periphery of at least one of the respective front surface and the respective back surface of the at least one elongate member. The third portion of the at least one elongate member includes a twist about a twist axis extending across at least part of the third portion of the at least one elongate member. The twist in the third portion of the at least one elongate member angularly offsets the second portion of the at least one elongate member from the first portion of the at least one elongate member about the twist axis. In the absence of the twist in the third portion of the at least one elongate member, the plurality of portions of the at least one elongate member are arranged such that the second portion of the at least one elongate member is laterally offset from the first portion of the at least one elongate member across at least a portion of the respective length of the at least one elongate member. At least part of the device is selectively moveable between a delivery configuration in which the elongate members of the plurality of elongate members are arranged in a first arrangement sized for intravascular or percutaneous delivery to a bodily cavity, and a deployed configuration in which the elongate members of the plurality of elongate members are arranged in a second arrangement sized too large for intravascular or percutaneous delivery to the bodily cavity.

The first portion of the at least one elongate member may be bent about a first axis having a directional component extending transversely across at least one of the respective pair of side edges of the first portion of the at least one elongate member when the at least part of the device is in the deployed configuration. The second portion of the at least one elongate member may be bent about a second axis having a directional component extending transversely across at least one of the respective pair of side edges of the second portion of the at least one elongate member when the at least part of the device is in the deployed configuration.

The twist in the third portion of the at least one elongate member may bias the at least one elongate member to autonomously fan with respect to at least one other elongate member of the plurality of elongate members when the plurality of elongate members are advanced into the bodily cavity. The first portion of the at least one elongate member may be preformed to autonomously bend about a first axis to urge the at least one elongate member to fan with respect to at least one other elongate member of the plurality of elongate members when the plurality of elongate members are advanced into the bodily cavity. The second portion of the at least one elongate member may be preformed to autonomously bend about a second axis when the plurality of elongate members are advanced into the bodily cavity. The first axis and the second axis may be non-parallel axes.

In use a first portion of the respective front surface of the at least one elongate member may face towards a first portion of an interior tissue surface within the bodily cavity and a second portion of the respective front surface of the at least one elongate member may face towards a second

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portion of the interior tissue surface within the bodily cavity when the at least part of the device is moved into the deployed configuration within the bodily cavity, the second portion of the interior tissue surface positioned diametrically opposite to the first portion of the interior tissue surface within the bodily cavity.

At least the second portion of the at least one elongate member may include a volute shape profile when the at least part of the device is in the deployed configuration. The at least one elongate member may include at least a first elongate member and a second elongate member. The respective second portion of the first elongate member may be laterally offset from the respective first portion of the first elongate member by a first distance across at least the portion of the respective length of the first elongate member in the absence of the twist in the respective third portion of the first elongate member, and the respective second portion of the second elongate member may be laterally offset from the respective first portion of the second elongate member by a second distance across at least the portion of the respective length of the second elongate member in the absence of the twist in the respective third portion of the second elongate member. The second distance may be different from the first distance.

The at least one elongate member may include multiple elongate members of the plurality of elongate members. The respective first portions of the elongate members of the multiple elongate members may be arranged front surface-toward-back surface along a first direction in a first stacked array when the at least part of the device is in the delivery configuration. The respective second portions of the elongate members of the multiple elongate members may be arranged front surface-toward-back surface along a second direction in a second stacked array when the at least part of the device is in the delivery configuration. The first direction and the second direction may be non-parallel directions.

The respective pair of side edges of each portion of the plurality of portions of the at least one elongate member may include a respective first side edge portion arranged on a first side of the at least one elongate member and a respective second side edge portion arranged on a second side of the at least one elongate member, the second side opposite to the first side. At least one of the first side edge portion and the second side edge portion of the second portion of the at least one elongate member may be laterally offset from the corresponding one of the first side edge portion and the second side edge portion of the first portion of the at least one elongate member across at least the portion of the respective length of the at least one elongate member in the absence of the twist in the third portion of the at least one elongate member. The respective first side edge of one of the first portion and the second portion of the at least one elongate member may converge with the respective first side edge of the third portion of the at least one elongate member to enclose an obtuse angle therebetween in the absence of the twist in the third portion of the at least one elongate member. The obtuse angle may extend across the at least one of the respective front surface and the respective back surface of the at least one elongate member towards the respective second side edge of at least one portion of the plurality of portions of the at least one elongate member.

The at least one elongate member may include a flexible circuit structure that includes at least one base layer and at least one electrically conductive layer patterned to provide at least one electrically conductive trace supported directly or indirectly by the at least one base layer, the at least one electrically conductive trace extending along a path across

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each of at least the first, the third and the second portions of the at least one elongate member. The at least one electrically conductive trace may include at least one jogged portion as viewed perpendicularly to a portion of the surface of the at least one base layer located at least proximate to a location on the surface of the at least one base layer where the path extends across the third portion of the at least one elongate member.

Various systems may include combinations and subsets of those summarized above.

A method for forming a portion of a medical system may be summarized as including providing a plurality of elongate members, each elongate member of the plurality of elongate members including a first end, a second end, a respective length between the first end and the second end, a thickness, a respective front surface and a respective back surface opposite across the thickness. Each elongate member of the plurality of elongate members further includes a plurality of portions arranged between the respective first end and the respective second end of the elongate member. The plurality of portions includes at least a first portion, a second portion and a third portion positioned between the first portion and the second portion. Each of the plurality of portions further includes a respective pair of side edges that form a portion of a periphery of at least one of the respective front surface and the respective back surface of the elongate member. The respective second portion of each elongate member of at least some of the plurality of elongate members is laterally offset from the respective first portion of the elongate member of the at least some of the plurality of elongate members across at least a portion of the respective length of the elongate member of the at least some of the plurality of elongate members. The method includes for each elongate member in the provided plurality of elongate members, distorting the respective third portion of the elongate member to rotationally offset the respective second portion of the elongate member from the respective first portion of the elongate member along the respective length of the elongate member. The method includes arranging each elongate member in the provided plurality of elongate members into an arrangement, the arrangement configurable to a size suitable for intravascular or percutaneous delivery through an opening in a tissue wall leading to a bodily cavity.

Distorting the respective third portion of the elongate member to rotationally offset the respective second portion of the elongate member from the respective first portion of the elongate member along the respective length of the elongate member may cause the respective third portion of the elongate member to have a twisted shape. Distorting the respective third portion of the elongate member to rotationally offset the respective second portion of the elongate member from the respective first portion of the elongate member along the respective length of the elongate member may include forming at least one twist in the respective third portion of the elongate member about a respective twist axis extending across at least part of the respective third portion of the elongate member.

The at least some of the plurality of elongate members that are provided may include at least a first elongate member and a second elongate member, and the method may further include forming at least one twist in the respective third portion of each of the provided first elongate member and the provided second elongate member about the respective twist axis of each of the provided first elongate member and the provided second elongate member to rotationally offset the respective second portion of the provided first elongate member from the respective first portion of the

provided first elongate member along the respective length of the provided first elongate member by a first angular amount and to rotationally offset the respective second portion of the provided second elongate member from the respective first portion of the provided second elongate member along the respective length of the provided second elongate member by a second angular amount. The second angular amount may be different from the first angular amount.

The at least some of the plurality of elongate members that are provided may include at least a first elongate member and a second elongate member, the respective second portion of the provided first elongate member laterally offset from the respective first portion of the provided first elongate member by a first distance across at least the portion of the respective length of the provided first elongate member, and the respective second portion of the provided second elongate member laterally offset from the respective first portion of the provided second elongate member by a second distance across at least the portion of the respective length of the provided second elongate member. The second distance may be different from the first distance.

The method may further include selecting a set of the elongate members from the provided plurality of elongate members and forming at least one twist in the respective third portion of each elongate member in the set of the elongate members to at least in part cause at least the respective second portions of the elongate members in the set of the elongate members to be fanned with respect to one another when at least the respective first portions of each elongate member in the provided plurality of elongate members are arranged into the arrangement. The method may further include selecting a set of the elongate members from the provided plurality of elongate members and bending the respective first portion of each elongate member in the set of the elongate members about a respective bending axis to at least in part cause at least the respective second portions of the elongate members in the set of the elongate members to be fanned with respect to one another when at least the respective first portions of each elongate member in the provided plurality of elongate members are arranged into the arrangement. Each respective bending axis may be skewed with respect to at least one of the pair of side edges of the respective first portion of the associated elongate member in the set of the elongate members.

The method may further include selecting a set of the elongate members from the provided plurality of elongate members and bending the respective second portion of each elongate member in the set of the elongate members about a respective bending axis such that a first portion of the respective back surface of each elongate member of the set of the elongate members is positioned diametrically opposite to a second portion of the respective back surface of the elongate member in the set of the elongate members.

Arranging each elongate member in the provided plurality of elongate members in the arrangement may include arranging the respective first portions of each elongate member in the provided plurality of elongate members front surface-toward-back surface in a stacked array. The method may further include physically coupling the respective first portions of at least two of the elongate members in the provided plurality of elongate members together and physically coupling the respective second portions of the at least two of the elongate members in the provided plurality of elongate members together. The method may include providing a plurality of flexible circuit structures, each flexible circuit structure of the plurality of flexible circuit structures

including at least one base layer and at least one patterned electrically conductive layer. The method may further include interleaving a portion of each flexible circuit structure of the provided plurality of flexible circuit structures with the respective first portions of each elongate member in the provided plurality of elongate members in the array. The respective at least one patterned electrically conductive layer of at least one of the provided plurality of flexible circuits may include at least one electrically conductive trace having at least one jogged portion formed by a patterning process. The method may further include securing each of the at least one of the provided plurality of flexible circuits to a respective one of the provided plurality of elongate members such that the at least one electrically conductive trace extends along a path across each of the first, the third and the second portions of the respective one of the provided plurality of elongate members with the at least one jogged portion of the at least one electrically conductive trace positioned at least proximate to the third portion of the respective one of the provided plurality of elongate members.

The respective pair of side edges of each portion of the plurality of portions of at least one elongate member of the plurality of elongate members may include a respective first side edge arranged on a first side of the at least one elongate member of the plurality of elongate members and a respective second side edge arranged on a second side of the at least one elongate member of the plurality of elongate members, the second side opposite to the first side. Providing the plurality of elongate members may include providing the plurality of elongate members such that at least one of the first side edge and the second side edge of the second portion of the at least one elongate member of the plurality of elongate members is laterally offset from the corresponding one of the first side edge and the second side edge of the first portion of the at least one elongate member of the plurality of elongate members. Providing the plurality of elongate members may include providing the plurality of elongate members such that the at least one elongate member of the plurality of elongate members includes at least one corner formed by a convergence of the respective first side edge of one of the first portion and the second portion of the at least one elongate member of the plurality of elongate members with the respective first side edge of the third portion of the at least one elongate member of the plurality of elongate members. The at least one corner may enclose an angle extending across the at least one of the respective front surface and the respective back surface of the at least one elongate member of the plurality of elongate members towards the respective second edge of at least one portion of the plurality of portions of the at least one elongate member of the plurality of elongate members.

Various methods may include combinations and subsets of those summarized above.

A medical system may be summarized as including a device that includes a plurality of transducer element sets and a plurality of flexible circuit structures. Each transducer element set includes one or more transducer elements. Each flexible circuit structure includes a respective at least one base layer, each at least one base layer including a first end, a second end, a respective length between the first end and the second end, a thickness, a respective front surface and a respective back surface opposite across the thickness, and a respective plurality of portions arranged between the first end and the second end. Each portion of the plurality of portions further includes a respective pair of side edges that form a portion of a periphery of at least one of the respective front surface and the respective back surface of the at least

one base layer. Each respective plurality of portions further includes at least a first portion, a second portion and a third portion positioned between the first portion and the second portion. The respective third portion of each at least one base layer further includes a twist arranged to rotationally offset the second portion of the at least one base layer from the first portion of the at least one base layer along the respective length of the at least one base layer. Each flexible circuit structure further includes a respective at least one patterned electrically conductive layer. Each at least one patterned electrically conductive layer is arranged to provide at least one electrically conductive trace supported at least indirectly by the respective at least one base layer of the flexible circuit structure. Each at least one electrically conductive trace is electrically connected to a respective one of the plurality of transducer element sets, and each at least one electrically conductive trace extends along a path across each of the first, the third and the second portions of the respective at least one base layer of the flexible circuit structure. For each of at least some of the plurality of flexible circuit structures, the respective at least one electrically conductive trace includes at least one jogged portion as viewed normally to a portion of the front surface of the respective at least one base layer located at least proximate to a location on the front surface of the respective at least one base layer where the path extends across the respective third portion of the respective at least one base layer. At least part of the device is selectively moveable between an unexpanded configuration in which the flexible circuit structures of the plurality of flexible circuit structures are arranged in a first arrangement sized for delivery through a bodily opening leading to a bodily cavity, and an expanded configuration in which the flexible circuit structures of the plurality of flexible circuit structures are arranged in a second arrangement sized too large for delivery through the bodily opening leading to the bodily cavity.

The flexible circuit structures in the plurality of flexible circuit structures may be arranged such that the respective first portions of each at least one base layer are arranged front surface-toward-back surface in a first stacked array and the respective second portions of each at least one base layer are arranged front surface-toward-back surface in a second stacked array when the at least part of the device is in the unexpanded configuration. The flexible circuit structures in the plurality of flexible circuit structures may be arranged such that at least the respective second portions of each at least one base layer are arranged in a fanned array when the at least part of the device is in the expanded configuration. The twist in the respective third portion of the at least one base layer of each flexible circuit structure of the at least some of the plurality of flexible circuits may bias the respective second portion of the at least one base layer of the flexible circuit structure of the at least some of the plurality of flexible circuit structures into the fanned array as the plurality of flexible circuit structures are advanced into the bodily cavity.

The respective first portion of the at least one base layer of each flexible circuit structure of the at least some of the plurality of flexible circuit structures may be preformed to bend about a respective bending axis to bias the respective second portion of the at least one base layer of the flexible circuit structure of the at least some of the plurality of flexible circuit structures into the fanned array as the plurality of flexible circuit structures are advanced into the bodily cavity.

The respective second end of the at least one base layer of each of the at least some of the plurality of flexible circuit

structures may move along a curved path that bends back on itself when the at least part of the device is selectively moved from the unexpanded configuration to the expanded configuration. At least part of the curved path may be a volute path. The respective second portion of the at least one base layer of each flexible circuit structure of the at least some of the plurality of flexible circuit structures may include a volute shape profile when the at least part of the device is in the expanded configuration. A first portion of the respective front surface of the at least one base layer of at least one of the plurality of flexible circuit structures may face towards a first portion of an interior tissue surface within the bodily cavity and a second portion of the respective front surface of the at least one base layer of the at least one of the plurality of flexible circuit structures may face towards a second portion of the interior tissue surface within the bodily cavity when the at least part of the device is moved into the expanded configuration within the bodily cavity, the second portion of the interior tissue surface positioned diametrically opposite to the first portion of the interior tissue surface within the bodily cavity.

Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including a structure including a plurality of elongate members, each elongate member of the plurality of elongate members including a proximal end, a distal end and a respective intermediate portion positioned between the proximal and the distal ends, the structure selectively moveable between an unexpanded configuration in which the structure is suitably sized to be percutaneously delivered to a bodily cavity and an expanded configuration in which the structure has a size too large to be percutaneously delivered to the bodily cavity, each of the respective intermediate portions of the plurality of elongate members radially arranged with respect to one another about a first axis when the structure is in the expanded configuration, and each of the respective intermediate portions of the plurality of elongate members radially spaced from the first axis when the structure is in the expanded configuration; a flexible shaft member, a portion of the flexible shaft member sized to be percutaneously delivered to the bodily cavity, the flexible shaft member including a first end portion and a second end portion spaced from the first end portion across an elongated portion of the flexible shaft member, the structure physically coupled to the flexible shaft member at least proximate the second end portion of the flexible shaft member; and at least one actuator selectively operable to concurrently rotate the intermediate portions of all of the plurality of elongate members at least partially about at least the first axis when the structure is in the expanded configuration, the intermediate portions of all of the plurality of elongate members moved relative to at least the second end portion of the flexible shaft member by the at least one actuator when the structure is in the expanded configuration.

One of the respective proximal and distal ends of each of the elongate members may be fixedly coupled to the flexible shaft member. The respective proximal end, the respective distal end, or each of the respective proximal and distal ends of each of the elongate members may be fixedly coupled to the flexible shaft member. The structure may be rotationally coupled to the second end portion of the flexible shaft member. The second end portion of the flexible shaft member may include a surface, a portion of the surface positioned at an end of the flexible shaft member, the portion of the surface circumferentially arranged about a second axis, and wherein the intermediate portions of all of the plurality of

elongate members may be concurrently rotated at least partially about the second axis by the at least one actuator when the structure is in the expanded configuration. The second end portion of the flexible shaft member may include a surface, a portion of the surface positioned at an end of the flexible shaft member, the portion of the surface circumferentially arranged about a second axis, and wherein the intermediate portions of all of the plurality of elongate members are not rotated, even partially, about the second axis by the at least one actuator when the structure is in the expanded configuration. The second end portion of the flexible shaft member may include a surface, a portion of the surface positioned at an end of the flexible shaft member, the portion of the surface circumferentially arranged about a second axis, the second axis parallel to the first axis when the structure is in the expanded configuration. The second end portion of the flexible shaft member may include a surface, a portion of the surface positioned at an end of the flexible shaft member, the portion of the surface circumferentially arranged about a second axis, the second axis not parallel to the first axis when the structure is in the expanded configuration. The medical system may further include a biasing device that opposes rotation of the intermediate portions of all of the plurality of elongate members about at least the first axis when the structure is in the expanded configuration. The biasing device may be provided at least in part by a respective resilient portion of each of at least some of the elongate members. Each of at least some of the plurality of elongate members may include a respective length between the respective proximal and distal ends, and a plurality of portions arranged between the respective proximal and distal ends, each respective plurality of portions further including at least a first elongate member portion, a second elongate member portion and a twisted elongate member portion positioned between the first elongate member portion and the second elongate member portion, the respective twisted elongate member portion of each elongate member of the at least some of the plurality of elongate members arranged to rotationally offset the second elongate member portion from the first elongate member portion along the respective length of the elongate member of the at least some of the plurality of elongate members. Each first elongate member portion may be adjacent the corresponding twisted elongate member portion, and the medical system may further include a biasing device that opposes rotation of the intermediate portions of all of the plurality of elongate members about at least the first axis when the structure is in the expanded configuration, wherein the biasing device is provided at least in part by the respective first elongate member portion of each elongate member of the at least some of the plurality of elongate members. The medical system may further include a biasing device that opposes rotation of the intermediate portions of all of the plurality of elongate members about at least the first axis when the structure is in the expanded configuration, wherein the biasing device is provided at least in part by the respective twisted elongate member portion of each elongate member of the at least some of the plurality of elongate members. The expanded configuration may be a first expanded configuration in which the respective intermediate portion of each of at least some of the plurality of elongate members is radially spaced from the first axis by a respective first radial distance, the structure further selectively moveable between the first expanded configuration and a second expanded configuration in which the respective intermediate portion of each of the at least some of the plurality of elongate members is radially spaced from the first axis by a respective second radial distance, each second

radial distance having a greater magnitude than a magnitude of the corresponding first radial distance. The intermediate portions of the plurality of elongate members may be circumferentially arranged about the first axis when the structure is in the expanded configuration. Each location on the structure to which the flexible shaft member is physically coupled to may be positioned to a same side of at least one plane when the structure is in the expanded configuration, and each plane of the at least one plane may be coincident with the first axis. The medical system may further include a plurality of transducer elements, at least some of the plurality of transducer elements located on each of at least some of the plurality of elongate members. Each of the plurality of transducer elements may include an electrode, wherein energy is selectively transmittable from each electrode, the energy sufficient for tissue ablation. At least a portion of the flexible shaft member may be directly manipulable by a user to percutaneously deliver the structure to the bodily cavity when the structure is in the unexpanded configuration. The at least a portion of the flexible shaft member may include at least part of the elongated portion of the flexible shaft member. At least part of the flexible shaft member may be moved through a lumen of a catheter sheath when the structure is percutaneously delivered to the bodily cavity, a surface of the flexible shaft member arranged to contact a surface of the lumen during at least part of the percutaneous delivery of the structure. The respective intermediate portion of each elongate member of the plurality of elongate members may include a thickness, a front surface, and a back surface opposite across the thickness from the front surface, and wherein the respective intermediate portions of the plurality of elongate members may be arranged front surface-toward-back surface in a stacked array when the structure is in the unexpanded configuration. The structure may further include a proximal portion and a distal portion, each of the proximal and the distal portions including a respective part of each of the plurality of elongate members, the proximal portion of the structure forming a first domed shape and the distal portion of the structure forming a second domed shape when the structure is in the deployed configuration. The structure may include a proximal portion and a distal portion, the structure arranged to be advanced distal portion first into the bodily cavity in the unexpanded configuration, the proximal portion of the structure forming a first domed shape and the distal portion of the structure forming a second domed shape when the structure is in the expanded configuration, and the proximal and the distal portions of the structure arranged in a clam shell configuration when the structure is in the expanded configuration. The plurality of elongate members may include a first set of the elongate members and a second set of the elongate members, the second set of the elongate members different than the first set of the elongate members, and wherein when the structure is moved between the unexpanded configuration and the expanded configuration, the respective intermediate portion of each elongate member in the first set of the elongate members is rotated in a first rotational direction and the respective intermediate portion of each elongate member in the second set of the elongate members is rotated in a second rotational direction, the second rotational direction opposite to the first rotational direction. The at least one actuator may be selectively operable to rotate the intermediate portions of all of the plurality of elongate members about at least the first axis in at least one of the first or the second rotational directions when the structure is in the expanded configuration.

Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including a structure including a plurality of elongate members including a first set of the elongate members and a second set of the elongate members, the second set of the elongate members different than the first set of the elongate members, each elongate member of the plurality of elongate members including a proximal end, a distal end and a respective intermediate portion positioned between the proximal and the distal ends, the structure selectively moveable between: an unexpanded configuration in which the structure is sized to be percutaneously delivered to a bodily cavity, and an expanded configuration in which the structure has a size too large to be percutaneously delivered to the bodily cavity, each of the respective intermediate portions of the plurality of elongate members radially arranged with respect to one another about a first axis and each of the respective intermediate portions of the plurality of elongate members radially spaced from the first axis when the structure is in the expanded configuration, at least one elongate member of the plurality of elongate members further including a respective curved portion arranged to extend along at least a portion of a respective curved path that intersects the first axis at each of a respective at least two spaced apart locations along the first axis when the structure is in the expanded configuration, wherein: when the structure is moved between the unexpanded configuration and the expanded configuration, the respective intermediate portion of each elongate member in the first set of the elongate members is rotated in a first rotational direction and the respective intermediate portion of each elongate member in the second set of the elongate members is rotated in a second rotational direction, the second rotational direction opposite to the first rotational direction.

The structure may be moved between the unexpanded configuration and the expanded configuration, the respective intermediate portion of each elongate member in the first set of the elongate members may be rotated at least partially about the first axis in the first rotational direction and the respective intermediate portion of each elongate member in the second set of the elongate members may be rotated at least partially about the first axis in the second rotational direction. The medical system may further include at least one actuator selectively operable to rotate the intermediate portion of each of at least some of the plurality of elongate members about at least the first axis in at least one of the first rotational direction or the second rotational direction when the structure is in the expanded configuration, the at least some of the plurality of elongate members including each elongate member in the first set of the elongate members and each elongate member in the second set of the elongate members. The medical system may further include at least one actuator selectively operable to rotate the intermediate portion of each of at least some of the plurality of elongate members about at least the first axis between two modes when the structure is in the expanded configuration, the two modes including a first mode in which the intermediate portion of each elongate member of the at least some of the plurality of elongate members is rotated about at least the first axis in the first rotational direction, and a second mode in which the intermediate portion of each of at least some of the plurality of elongate members is rotated about at least the first axis in the second rotational direction, the at least some of the plurality of elongate members including each elongate member in the first set of the elongate members and each elongate member in the second set of the elongate members.

The medical system may further include a flexible shaft member, a portion of the flexible shaft member sized to be percutaneously delivered to the bodily cavity, the flexible shaft member including a first end portion and a second end portion spaced from the first end portion across an elongated portion of the flexible shaft member, the structure physically coupled to the flexible shaft member at least proximate the second end portion of the flexible shaft member, the second end portion of the flexible shaft member including a surface, 5 a portion of the surface positioned at an end of the flexible shaft member, the portion of the surface circumferentially arranged about a second axis, wherein when the structure is moved between the unexpanded configuration and the expanded configuration, the respective intermediate portion of each elongate member in the first set of the elongate members is moved away from the second axis in a first direction and the respective intermediate portion of each elongate member in the second set of the elongate members is moved away from the second axis in a second direction, 10 the second direction opposite to the first direction. The second axis may not be parallel to the first axis when the structure is in the expanded configuration. The first direction may include a first rotational direction component and the second direction may include a second rotational direction component opposite to the first rotational direction component, and the medical system may further include at least one actuator selectively operable to rotate the intermediate portion of each of at least some of the plurality of elongate members about at least the first axis in at least one of the first 15 rotational direction component or the second rotational direction component when the structure is in the expanded configuration, the at least some of the plurality of elongate members including each elongate member in the first set of the elongate members and each elongate member in the second set of the elongate members. The first direction may include a first rotational direction component and the second direction may include a second rotational direction component opposite to the first rotational direction component, and the at least one actuator may be selectively operable to rotate 20 the intermediate portion of each of at least some of the plurality of elongate members about at least the first axis between two modes when the structure is in the expanded configuration, the two modes including a first mode in which the intermediate portion of each of at least some of the plurality of elongate members is rotated about at least the first axis in the first rotational direction component, and a second mode in which the intermediate portion of each of at least some of the plurality of elongate members is rotated about at least the first axis in the second rotational direction component, the at least some of the plurality of elongate members including each elongate member in the first set of the elongate members and each elongate member in the second set of the elongate members. The intermediate portions of the plurality of elongate members may be 25 circumferentially arranged about the first axis when the structure is in the expanded configuration. The at least one elongate member of the plurality of elongate members may include all of the plurality of elongate members, the respective curved portions of the plurality of elongate members circumferentially arranged about the first axis when the structure is in the expanded configuration. The at least one elongate member of the plurality of elongate members may include at least two of the plurality of elongate members, at least some of the respective curved portions of the at least two of the plurality of elongate members arranged on each side of a plane when the structure is in the expanded 30 configuration, the plane coincident with the first axis.

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Various systems may include combinations and subsets of those summarized above.

A medical system may be summarized as including a structure including a plurality of elongate members, each elongate member of the plurality of elongate members including a proximal end, a distal end and a respective intermediate portion positioned between the proximal and the distal ends, the structure selectively moveable between an unexpanded configuration in which the structure is suitably sized to be percutaneously delivered to a bodily cavity and an expanded configuration in which the structure has a size too large to be percutaneously delivered to the bodily cavity, each of the respective intermediate portions of the plurality of elongate members radially arranged with respect to one another about a first axis when the structure is in the expanded configuration, and each of the respective intermediate portions of the plurality of elongate members radially spaced from the first axis when the structure is in the expanded configuration; a flexible shaft member, a portion of the flexible shaft member sized to be percutaneously delivered to the bodily cavity, the flexible shaft member including a first end portion and a second end portion spaced from the first end portion across an elongated portion of the flexible shaft member, the structure physically coupled to the flexible shaft member at least proximate the second end portion of the flexible shaft, the second end portion of the flexible shaft member including a surface positioned at an end of the flexible shaft member, the portion of the surface circumferentially arranged about a second axis; and at least one actuator selectively operable to rotate the intermediate portion of each of at least some of the plurality of elongate members about at least the first axis when the structure is in the expanded configuration, the intermediate portion of each of the at least some of the plurality of elongate members rotating about each of the first axis and the second axis by different respective angular amounts when the at least one actuator rotates the intermediate portion of each of the at least some of the plurality of elongate members about at least the first axis when the structure is in the expanded configuration.

The intermediate portion of each of the at least some of the plurality of elongate members may be rotated about the first axis by a respective first angular amount and may be rotated about the second axis by a respective second angular amount when the at least one actuator rotates the intermediate portion of each of the at least some of the plurality of elongate members about at least the first axis when the structure is in the expanded configuration, each first angular amount being greater than the corresponding second angular amount. The intermediate portion of each of the at least some of the plurality of elongate members may not be rotated about the second axis when the at least one actuator rotates the intermediate portion of each of the at least some of the plurality of elongate members about at least the first axis when the structure is in the expanded configuration. The second axis may not be parallel to the first axis when the structure is in the expanded configuration. The second axis may not be collinear with the first axis when the structure is in the expanded configuration. The at least some of the plurality of elongate members may include all of the plurality of elongate members.

Various systems and methods may include combinations and subsets of all those summarized above.

In any of the above systems, at least some of the elongate members may each include respective ones of one or more transducers.

#### BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, identical reference numbers identify similar elements or acts. The sizes and relative positions of elements in the drawings are not necessarily drawn to scale. For example, the shapes of various elements and angles are not drawn to scale, and some of these elements are arbitrarily enlarged and positioned to improve drawing legibility. Further, the particular shapes of the elements as drawn are not intended to convey any information regarding the actual shape of the particular elements, and have been solely selected for ease of recognition in the drawings.

FIG. 1 is a cutaway diagram of a heart showing a medical device according to one illustrated embodiment percutaneously placed in a left atrium of the heart.

FIG. 2 is a partially schematic diagram of a medical system according to one illustrated embodiment, including a control unit, a display and a medical device having an expandable frame and an assembly of elements.

FIG. 3A is an isometric view of a frame in a first or unexpanded configuration according to one illustrated embodiment.

FIG. 3B is an isometric view of an example of the frame of FIG. 3A in a second or bent configuration.

FIG. 3C is an isometric view of an example of the frame of FIG. 3A in a third or expanded configuration.

FIG. 3D is an exploded isometric view of an elongate member including a flexible circuit structure employed in the frame of FIG. 3A.

FIG. 3E is a cross-sectional view of the frame of FIG. 3A in a catheter sheath.

FIGS. 4A, 4B, 4C, 4D and 4E are sequential elevation views of a portion of a device positioned within a bodily cavity at five successive intervals of time according to an illustrated embodiment, including a control unit illustrated in FIGS. 4B-4E.

FIG. 4F is a partially exploded isometric view of an elongate member of FIGS. 4A, 4B, 4C, 4D and 4E including a flexible circuit structure.

FIG. 4G is a cross-section view of a first set and a second set of various ones of the elongate members of FIGS. 4A, 4B, 4C, 4D and 4E arranged in a second or bent configuration.

FIG. 4H is a cross-section view of the first set and the second set of the elongate members of FIG. 4G arranged in a third or expanded configuration.

FIG. 5A is an isometric view of a portion of a device that includes an arrangement of elongate members in a first/unexpanded configuration received via a catheter sheath, according to one example embodiment.

FIG. 5B is an isometric view of an elongate member of the device of FIG. 5A.

FIG. 5C is an isometric view of the portion of the device of FIG. 5A extending from the catheter sheath positioned in a second/bent configuration.

FIGS. 5D and 5E are isometric views of the portion of the device of FIG. 5A extending from the catheter sheath in a third/expanded or fanned configuration.

FIGS. 5F and 5G are respective top plan views of the isometric views of a portion of the device extending from the catheter sheath shown in the configurations of FIGS. 5D and 5E, respectively.

FIG. 5H is a schematic representation of an elongate member of the device of FIG. 5A crossed by various portions of another elongate member in the third/expanded or fanned configuration.

FIG. 6A is a side elevation view a portion of a device that includes a number of elongate members extending from a catheter sheath and in an initial configuration according to another example embodiment.

FIG. 6B is an isometric view of a representative one of the elongate members of the device of FIG. 6A, and a projection of that elongate member.

FIGS. 6C, 6D, 6E, and 6F are various side elevation views of a portion of the device in FIG. 6A positioned within a bodily cavity at four successive intervals of time according to an example embodiment.

FIGS. 6G and 6H are various perspective views of the elongate members of the device of FIG. 6A extending from the catheter sheath, the elongate members arranged in a first expanded or fanned array.

FIG. 6I is a sectioned side elevation view of the elongate members of the device of FIG. 6A extending from the catheter sheath, the elongate members arranged in a first expanded or fanned array.

FIG. 6J is a partially sectioned end elevation view of the elongate members of the device of FIG. 6A extending from the catheter sheath, the elongate members arranged in a first expanded or fanned array.

FIGS. 6K and 6L are various isometric views of the elongate members of the device of FIG. 6A extending from the catheter sheath, the elongate members arranged in a second expanded or fanned array.

FIG. 6M is a sectioned side elevation view of the elongate members of the device of FIG. 6A extending from the catheter sheath, the elongate members arranged in a second expanded or fanned array.

FIG. 6N is a schematic representation of an elongate member of the device of FIG. 6A crossed by various portions of another elongate member in a first expanded or fanned array.

FIG. 6O is a schematic representation of an elongate member of the device of FIG. 6A crossed by various portions of another elongate member in a second expanded or fanned array.

FIG. 7A is an isometric view of a portion of a device that includes a number of elongate members extending from a catheter sheath in an initial configuration according to another example embodiment.

FIG. 7B is an isometric view of a representative one of the elongate members of the device of FIG. 7A.

FIGS. 7C, 7D, 7E, and 7F are various isometric views of the portion of the device of FIG. 7A extending at least partially from the catheter sheath and positioned at four successive intervals of time according to an example embodiment.

FIG. 7G is a plan view of various elongate members that are provided to form at least a portion of respective ones of the elongate members employed by the device of FIG. 7A.

FIG. 7H is an isometric view of a representative flexible circuit structure provided to form at least a portion of a respective one of the elongate members employed by the device of FIG. 7A.

FIG. 7I is an isometric view of one of the provided elongate members of FIG. 7G distorted by a first distorting process according to an example embodiment.

FIG. 7J is an isometric view of an assemblage of a portion of a flexible circuit structure and the provided elongate member of FIG. 7I.

FIG. 7K is an isometric view of the assemblage of the flexible circuit structure and the provided elongate member of FIG. 7J distorted by a second distorting process according to an example embodiment.

FIG. 7L is a side view of a portion of an arrangement of elongate members as per an example embodiment.

FIGS. 7L (A-A), 7L (B-B) and 7L (C-C) are various cross-sectional views of the arrangement of elongate members of FIG. 7L taken along section lines A-A, B-B and C-C, respectively.

FIG. 7M are respective side and end elevation views of each elongate member of the arrangement of elongate members of FIG. 7L.

10 FIG. 8 is a flow diagram representing a method according to one example embodiment.

FIG. 9A is an isometric view of a portion of a device that includes a number of elongate members extending from a catheter sheath in a deployed configuration according to another example embodiment.

FIG. 9B is a partially sectioned plan view of the portion of the device of FIG. 9A.

FIG. 9C is an isometric view of the portion of device of FIG. 9A extending from the catheter sheath after undergoing an additional manipulation in the deployed configuration.

20 FIG. 9D is a partially sectioned plan view of the portion of the device of FIG. 9C.

FIG. 10A is a view of a structure in an unexpanded configuration according to various embodiments.

25 FIG. 10B is a view of an example of the structure of FIG. 10A in an expanded configuration according to various embodiments.

FIG. 11A is a partially schematic isometric view of a structure that includes a plurality of elongate members, the structure in an unexpanded configuration according to various embodiments.

30 FIG. 11B is an isometric view of an example of the structure of FIG. 11A in an expanded configuration according to various embodiments.

FIG. 11C is a plan view of the structure of FIG. 11B in the expanded configuration.

FIG. 11D is a plan view of the structure of FIG. 11C, an intermediate portion of each of a number of the plurality of elongate members rotated in a first rotational direction according to various embodiments.

40 FIG. 11E is a plan view of the structure of FIG. 11C, an intermediate portion of each of a number of the plurality of elongate members rotated in a second rotational direction opposite the first rotational direction according to various embodiments.

## DETAILED DESCRIPTION

In the following description, certain specific details are set forth in order to provide a thorough understanding of various embodiments of the invention. However, one skilled in the art will understand that the invention may be practiced without these details. In other instances, well-known structures associated with Radio Frequency (RF) ablation and electronic controls such as multiplexers have not been shown or described in detail to avoid unnecessarily obscuring descriptions of the embodiments of the invention.

50 The word "ablation" should be understood to mean any disruption to certain properties of the tissue. Most commonly, the disruption is to the electrical conductivity and is achieved by heating, which can be generated with resistive or of Radio Frequencies (RF) techniques for example. Other properties, such as mechanical or chemical, and other means of disruption, such as optical, are included when the term "ablation" is used.

60 The word "fluid" should be understood to mean any fluid that can be contained within a bodily cavity or can flow into

or out, or both into and out of a bodily cavity via one or more bodily openings positioned in fluid communication with the bodily cavity. In the case of cardiac applications, fluid such as blood will flow into and out of various intra-cardiac cavities (e.g., the left atrium and the right atrium).

The words “bodily opening” should be understood to be a naturally occurring bodily opening or channel or lumen; a bodily opening or channel or lumen formed by an instrument or tool using techniques that can include, but are not limited to, mechanical, thermal, electrical, chemical, and exposure or illumination techniques; a bodily opening or channel or lumen formed by trauma to a body; or various combinations of one or more of the above. Various elements having respective openings, lumens or channels and positioned within the bodily opening (e.g., a catheter sheath) may be present in various embodiments. These elements may provide a passageway through a bodily opening for various devices employed in various embodiments.

The word “tissue” should be understood to mean any tissue that is used to form a surface within a bodily cavity, a surface of a feature within a bodily cavity or a surface of a feature associated with a bodily opening positioned in fluid communication with the bodily cavity. The tissue can include part or all of a tissue wall or membrane that includes a surface that defines a surface of the bodily cavity. In this regard, the tissue can form an interior surface of the cavity that surrounds a fluid within the cavity. In the case of cardiac applications, tissue can include tissue used to form an interior surface of an intra-cardiac cavity such as a left atrium or right atrium.

The term “transducer element” in this disclosure should be interpreted broadly as any device capable of distinguishing between fluid and tissue, sensing temperature, creating heat, ablating tissue and measuring electrical activity of a tissue surface, or any combination thereof. A transducer element can convert input energy of one form into output energy of another form. Without limitation, a transducer element can include an electrode or a sensing device. A transducer element may be constructed from several parts, which may be discrete components or may be integrally formed.

Reference throughout this specification to “one embodiment” or “an embodiment” or “an example embodiment” or “an illustrated embodiment” means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, the appearances of the phrases “in one embodiment” or “in an embodiment” or “in an example embodiment” or “in this illustrated embodiment” in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures or characteristics may be combined in any suitable manner in one or more embodiments.

Various embodiments of percutaneously or intravascularly deployed medical devices are described herein. Many of the described devices are moveable between a delivery or unexpanded configuration in which a portion of the device is sized for passage through a bodily opening leading to cavity within a body, and a deployed or expanded configuration in which the portion of the device has a size too large for passage through the bodily opening leading to the cavity. In some example embodiments, the device senses characteristics (e.g., convective cooling, permittivity, force) that distinguish between fluid (e.g., blood) and tissue forming an interior surface of the bodily cavity. Such sensed characteristics allow a medical system to map the cavity, for example using positions of openings or ports into and out of the

cavity to determine a position or orientation (i.e., pose), or both a position and orientation of the portion of the device in the bodily cavity. In some example embodiments, the devices are capable of ablating tissue in a desired pattern within the bodily cavity. In some example embodiments, the devices are capable of sensing characteristics (e.g., electrical activity) indicative of whether an ablation has been successful. In some example embodiments, the devices are capable of providing stimulation (e.g., electrical stimulation) to tissue within the bodily cavity. Electrical stimulation may include pacing.

An example of the mapping performed by devices according to various embodiments would be to locate the position of various bodily openings leading to the pulmonary veins as well as the mitral valve on the interior surface of the left atrium. In some example embodiments, the mapping is based at least on locating such bodily openings by differentiating between fluid and tissue. There are many ways to differentiate tissue from a fluid such as blood or to differentiate tissue from a bodily opening in case a fluid is not present. By the way of example, three approaches may include:

1. The use of convective cooling of heated transducer elements by the blood. A slightly heated arrangement of transducer elements that is positioned adjacent to the tissue that forms the interior surface(s) of the atrium and across the ports of the atrium will be cooler at the areas which are spanning the ports carrying blood flow. For example, commonly assigned U.S. Patent Application Publication 2008/0004534 A1, which is herein incorporated by reference in its entirety, describes a heart chamber mapping system based on the convective cooling effect of blood flow.
2. The use of the differing change in dielectric constant as a function of frequency between blood and tissue. An arrangement of transducer elements positioned around the tissue that forms the interior surface(s) of the atrium and across the ports of the atrium monitors the ratio of the dielectric constant from 1 KHz to 100 KHz. Such can be used to determine which of those transducer elements are not proximate to tissue, which is indicative of the locations of the ports.
3. The use of transducer elements that sense force (i.e., force sensors). A set of force detection transducer elements positioned around the tissue that forms the interior surface of the atrium and across the ports of the atrium can be used to determine which of the transducer elements are not in contact with the tissue, which is indicative of the locations of the ports.

FIG. 1 shows a device 100 useful in investigating or treating, or both investigating and treating a bodily organ, for example a heart 102, according to one illustrated embodiment.

Device 100 can be percutaneously or intravascularly inserted into a portion of the heart 102, such as an intra-cardiac cavity like left atrium 104. In this example, the device 100 is part of a catheter 106 inserted via the inferior vena cava 108 and penetrating through a bodily opening in transatrial septum 110 from right atrium 112. In other embodiments, other paths may be taken.

Catheter 106 includes an elongated flexible rod or shaft member appropriately sized to be delivered percutaneously or intravascularly. Catheter 106 may include one or more lumens (not shown). The lumen(s) may carry one or more communications or power paths, or both communications and power paths, for example one or more electrical conductors 116. Electrical conductors 116 provide electrical

connections to device 100 that are accessible externally from a patient in which device 100 is inserted.

As discussed in more detail herein, device 100 includes a structure or frame 118 which assumes an unexpanded configuration for delivery to left atrium 104. Frame 118 is expanded (i.e., shown in an expanded configuration in FIG. 1) upon delivery to left atrium 104 to position a plurality of transducer elements 120 (only three called out in FIG. 1) proximate the interior surface formed by tissue 122 of left atrium 104. In this example embodiment, at least some of the transducer elements 120 are used to sense a physical characteristic of a fluid (i.e., blood) or tissue 122, or both, that may be used to determine a position or orientation (i.e., pose), or both of a portion of a device 100 within, or within respect to left atrium 104. For example, transducer elements 120 may be used to determine a location of pulmonary vein ostia (not shown) and/or a mitral valve 126. In this example embodiment, at least some of the transducer elements 120 may be used to selectively ablate portions of the tissue 122. For example, some of the elements may be used to ablate a pattern around the bodily openings, ports or pulmonary vein ostia, for instance to reduce or eliminate the occurrence of atrial fibrillation.

FIG. 2 schematically shows a system that includes a device 200 according to one illustrated embodiment. Device 200 includes a plurality of flexible strips 204 (three called out in FIG. 2) and a plurality of transducer elements 206 (three called out in FIG. 2) arranged to form a two- or three-dimensional grid or array capable of mapping, ablating, stimulating, or combinations thereof, an inside surface of a bodily cavity or lumen without requiring mechanical scanning. The flexible strips 204 are arranged in a framed structure 208 that is selectively movable between an unexpanded configuration and an expanded configuration that may be used to force flexible strips 204 against a tissue surface within the bodily cavity or position the flexible strips in the vicinity of the tissue surface. The flexible strips 204 can form part of a flexible circuit structure (i.e., also known as a flexible printed circuit board (PCB) circuit). The flexible strips 204 can include a plurality of different material layers. The expandable frame 208 can include one or more resilient members. The expandable frame 208 can include one or more elongate members. Each of the one or more elongate members can include a plurality of different material layers. Expandable frame 208 can include a shape memory material, for instance Nitinol. Expandable frame 208 can include a metallic material, for instance stainless steel, or non-metallic material, for instance polyimide, or both a metallic and non metallic material by way of non-limiting example. The incorporation of a specific material into expandable frame 208 may be motivated by various factors including the specific requirements of each of the unexpanded configuration and expanded configuration, the required position or orientation (i.e., pose), or both of expandable frame 208 in the bodily cavity or the requirements for successful ablation of a desired pattern.

Expandable frame 208, as well as flexible strips 204 can be delivered and retrieved via a catheter member, for example a catheter sheath introducer 210, which in some embodiments may have a diameter of about 24 French or smaller while in other embodiments may have a diameter of 16 French or smaller. In some instances, devices deliverable via larger or smaller sized catheter sheets may be employed. Flexible strips 204 may include one or more material layers. Flexible strips 204 may include one or more thin layers of Kapton® (polyimide), for instance 0.1 mm thick. Transducer elements (e.g., electrodes or sensors, or both) 206 may

be built on the flexible strips 204 using conventional printed circuit board processes. An overlay of a thin electrical insulation layer (e.g., polyimide about 10-20 microns thick) may be used to provide electrical insulation, except in areas needing electrical contact to blood and tissue. In some embodiments, flexible strips 204 can form a portion of an elongated cable 216 of control leads 218, for example by stacking multiple layers, and terminating at a connector 220. In some example embodiments, flexible strips 204 are formed from flexible substrates onto which electrically conductive elements (e.g., conductive lines or traces) are provided. In some example embodiments flexible strips 204 form flexible circuit structures. In some example embodiments, a portion of device 200 is typically disposable.

Device 200 can communicate with, receive power from or be controlled by a control system 222, or combinations thereof. The control system 222 may include a controller 224 having one or more processors 226 and one or more non-transitory storage mediums 228 that store instructions that are executable by the processors 226 to process information received from device 200 or to control operation of device 200, or both. For example, controller 224 can control activating selected transducer elements 206 to ablate tissue. Controller 224 may include one or more controllers. Control system 222 may include an ablation source 230. The ablation source 230 may, for example, provide electrical current or power, light or low temperature fluid to the selected transducer elements 206 to cause ablation. The ablation source may include an electrical current source or an electrical power source. Control system 222 may also include one or more user interface or input/output (I/O) devices, for example one or more displays 232, speakers 234, keyboards, mice, joysticks, track pads, touch screens or other transducers to transfer information to and from a user, for example a care provider such as a physician or technician. For example, output from the mapping process may be displayed on a display 232.

In some embodiments, a frame provides expansion and contraction capabilities for a portion of the medical device (e.g., arrangement or array of transducer elements) used to distinguish between blood and tissue. The transducer elements used to sense a parameter or characteristic to distinguish between a fluid such as blood and tissue may be mounted or otherwise carried on a frame, or may form an integral component of the frame itself. The frame may be flexible enough to slide within a catheter sheath in order to be deployed percutaneously or intravascularly. FIG. 2, discussed previously, showed one embodiment of such a frame.

FIGS. 3A, 3B and 3C show a portion of the medical device 1400 in various configurations. Specifically, FIG. 3A shows that the portion of the device 1400 includes a structure or frame 1402 made from a plurality of elongate members 1404a, 1404b, 1404c, 1404d, 1404e and 1404f (collectively 1404). The elongate members 1404 can be selectively arranged in one of a plurality of different arrangements. The elongate members 1404 can be selectively moved between various different configurations. The portion of the device 1400 (i.e., including frame 1402) is shown in a first, or an unexpanded configuration suitably sized for delivery within a catheter sheath 1406 of a catheter system 1408 in FIG. 3A. In some embodiments, employed catheter sheaths may be steerable devices with a portion thereof deflected by an actuator contained in a control portion (e.g., a handle portion). Various levers, knobs, wheels, pulleys, sheathes, etcetera may be employed to steer a deflectable portion of a catheter sheath. Catheter system 1408 is employed to percutaneously or intravascularly deliver a

portion of device 1400 through a bodily opening leading to a bodily cavity such as an intra-cardiac cavity (not shown) by way of non-limiting example. FIG. 3B shows the portion of device 1400 including frame 1402 in a second or bent or expanded and unfanned configuration. In this embodiment, the second/bent configuration is assumed as various portions of frame 1402 are advanced from catheter sheath 1406. FIG. 3C shows the portion of device 1400 including frame 1402 in a third, or expanded configuration. In this illustrated embodiment, the third or expanded or fanned configuration is also alternatively referred to in this application as a fanned configuration, expanded configuration or expanded fanned configuration. The portion of device 1400 including frame 1402 can assume either of the second/bent or the third/expanded or fanned configuration when positioned within the bodily cavity (not shown) by way of example. In this illustrated embodiment, the first configuration is an example of a delivery configuration in which a portion of frame 1402 is suitably sized for delivery through a bodily opening leading to a bodily cavity. In this illustrated embodiment, each of the second and the third configurations is an example of a deployed configuration in which various portions of frame 1402 are manipulated to have a size too large for delivery through the opening leading to the bodily cavity. The portion of device 1400 including frame 1402 is moved into the third/expanded or fanned configuration from the second/bent configuration in this embodiment. In this illustrated embodiment, frame 1402 is sized too large for delivery through catheter sheath 1406 when frame 1402 is in either of the second/bent configuration or the third/expanded or fanned configuration.

In a manner similar to that described in some previous embodiments, various transducer elements may be carried into a bodily cavity by various ones of elongate members 1404. In some embodiments, various transducer elements can be provided on, or by, various flexible circuit structures made up of various flexible substrates which can include by way of non-limiting example, elongate member 1404 itself. FIG. 3D shows an exploded view of an elongate member 1404 and a flexible circuit structure 1480. Flexible circuit structure 1480 can include one or more flexible substrates 1482 (i.e., two in this illustrated embodiment) and at least one electrically conductive layer 1484. In this example embodiment, the at least one conductive layer 1484 has been patterned to form a plurality of transducer elements 1490 (three called out). In this embodiment, the at least one conductive layer 1484 has been patterned to form a plurality of electrodes. Various ones of the at least one conductive layers can be patterned to form other features and elements including conductive traces or lines by way of non-limiting example. For clarity, various transducer elements 1490 associated with device 1400 are not shown in FIGS. 3A, 3B and 3C. For clarity, various flexible circuit structures 1480 associated with device 1400 are not shown in FIGS. 3A, 3B and 3C.

The elongate members 1404 may be transported by a transporter through catheter sheath 1406. In this embodiment, the elongate members 1404 are transported by shaft member 1410 through catheter sheath 1406. Shaft member 1410 is typically sized to extend along a path that leads from a location outside the body to a destination at least proximate to the cavity within the body. Shaft member 1410 is typically a flexible member. Shaft member 1410 can include various lumens and passageways (not shown) some of which can be employed as conduits for various control lines, actuators, force transmitters, irrigation channels, suction channels, etcetera. In this embodiment, wrist coupler 1412 articulably

couples the frame 1402 to shaft member 1410. In other example embodiments, other articulated or non-articulated couplers can be employed to couple the frame 1402 to shaft member 1410. In some example embodiments, a handle (not shown) can be provided at an end of shaft member 1410 opposite to wrist coupler 1412. The handle may be employed by a care provider to help manipulate the shaft member 1410 through catheter sheath 1406 in some embodiments. The handle may include various controls or actuators, or both, employed for manipulation of various portions of device 1400. In some embodiments, shaft member 1410 may be a steerable device with a portion thereof deflected by an actuator contained in a control portion (e.g., a handle portion). Various levers, wheels, pulleys, sheathes may be employed to steer a deflectable portion of shaft member 1410.

While six (6) elongate members 1404 are shown in this illustrated embodiment, some embodiments may employ a greater or a fewer number of elongate members 1404. The present inventors have built devices having fewer than six (6) elongate members (e.g., three (3) elongate members) in some embodiments and more than six (6) elongate members (e.g., eleven (11) elongate members) in other embodiments by way of non-limiting example.

As best shown in FIG. 3D, each of the elongate members 1404 includes a respective distal or first end 1405, a respective proximal or second end 1407, a respective intermediate portion 1409 positioned between the first end 1405 and the second end 1407, and respective length 1411 between the first end 1405 and the second end 1407. In this embodiment, various ones of the elongate members 1404 has a different respective length 1411 than the respective length 1411 of another of the elongate members 1404. In other embodiments, two or more of the elongate members 1404 may have substantially equal lengths 1411. In this embodiment, each of the elongate members 1404 is compliant about at least one axis. Various embodiments can include elongate members 1404 that are pliable, flexible or resilient elongate members. Various embodiments can include elongate members 1404 that have a different bending stiffness when bent about each of a plurality of differently oriented axes.

As shown in FIG. 3A, the elongate members 1404 are arranged successively with respect to one another in a stacked arrangement 1415 when the portion of device 1400 is in the first/unexpanded configuration. In this embodiment, the arrangement of the elongate members 1404 in the stacked arrangement 1415 is an orderly one with each of the elongate members arranged successively with respect to one another along a first direction (i.e., a stacking direction) represented by arrow 1416. It is understood that the first direction need not be a vertical or “up-down” direction but can also include other orientations. For instance in some embodiments, elongate members 1404 which are successively adjacent one another along the first direction 1416 may be stepped with respect to one another in one or more other directions. Thus, the set of elongate members 1404 may be arranged in a non-stepped stacked arrangement fitting in a rectangular parallelepiped or may be arranged in a stepped stacked arrangement for instance fitting in a non-rectangular parallelepiped.

In the illustrated example embodiment, each of the elongate members 1404 is a strip-like member. In this example embodiment, the intermediate portion 1409 of each of the elongate members 1404 includes a set of two opposing surfaces or major faces 1418 made up of a first surface 1418a (i.e., also referred to as front surface 1418a) (one called out in FIG. 3A) and a second surface 1418b (i.e., also

referred to as back surface **1418b**) (three called out in FIG. 3A). In this example embodiment, the two opposing surfaces **1418** are separated from one another across a thickness **1417** (only one called out in FIG. 3A) of the elongate member **1404**. In this illustrated example, the two opposing surfaces **1418** are joined by a set of two opposing edge surfaces **1420a** and **1420b** (collectively **1420**) (only one set called out in FIG. 3A) and hence spaced from each other by the thickness of the edge surfaces **1420a**, **1420b**. In this illustrated embodiment, the surfaces **1418** are arranged successively with respect to one another in the stacked arrangement **1415**. In this embodiment, the elongate members **1404** are successively arranged in an arrayed arrangement sized to be delivered through a lumen of catheter sheath **1406**, with each elongate member **1404** positioned in the arrayed arrangement such that the first surface **1418a** of the elongate member **1404** is towards the second surface **1418b** of an additional elongate member **1404** in the arrayed arrangement, or the second surface **1418b** of the elongate member **1404** is towards the first surface **1418a** of the additional elongate member **1404** in the arrayed arrangement, or both. For example, one of the outermost elongate members in the arrayed arrangement (i.e., elongate member **1404a**) is positioned in the arrayed arrangement such that its first surface **1418a** is towards the second surface **1418b** of elongate member **1404b**. Outermost elongate member **1404f** is positioned in the arrayed arrangement such that its second surface **1418b** is towards the first surface **1418a** (not called out) of elongate member **1404e**. An inboard elongate member in the arrayed arrangement such as elongate member **1404d** is positioned such that its first surface **1418a** (not called out) is positioned towards the second surface **1418b** (not called out) of elongate member **1404e** and the second surface **1418b** (not called out) of elongate member **1404d** is towards the first surface **1418a** (not called out) of elongate member **1404c**. In this example embodiment, the first and the second surfaces **1418a**, **1418b** of the elongate members **1404** are interleaved in the stacked arrangement **1415**.

In various embodiments, each of the elongate members **1404** has at least one surface that has a common characteristic with, or corresponds to, at least one surface of each of the other elongate members **1404**, and the elongate members **1404** are arranged in an arrayed arrangement or stacked arrangement such that at least one surfaces of the elongate members **1404** are successively arranged along the first direction of stacked arrangement **1415**. In this respect, it is noted that the stacked arrangement does not require that the individual elongated members **1404** actually rest on one another. In many instances of the stacked arrangement, the elongated members or portions thereof may be separated from successively adjacent elongate members, for instance by space, such as in an embodiment of an interleaved arrangement. In some of these various embodiments, each at least one surface is a first surface that is positionable adjacent to a tissue surface in the bodily cavity when the portion of device **1400** is in the third/expanded configuration within the bodily cavity. In some of these various embodiments, each at least one surface is a first surface that is positionable to face or contact a tissue surface in the bodily cavity when the portion of device **1400** is moved into the third/expanded configuration within the bodily cavity. In some of these various embodiments, each at least one surface is a first surface that includes, or supports (i.e., directly or indirectly) one or more transducer elements. In some of these various embodiments, each at least one surface is a first surface that includes, or supports (i.e., directly or indirectly) one or more transducer elements (e.g.,

an electrode) that are positionable adjacent to a tissue surface in the bodily cavity when the portion of device **1400** is in the third/expanded configuration within the bodily cavity. In some of these various embodiments, each at least one surface is a first surface that includes, or supports (i.e., directly or indirectly) a flexible circuit structure. In some of these various embodiments, each at least one surface is a second surface that is positionable to face away from a tissue surface in the bodily cavity when the portion of device **1400** is in the third/expanded configuration within the bodily cavity. In some of these various embodiments, each at least one surface is arranged to face away from an axis about which the elongate members **1404** are angularly spaced when the portion of device **1400** is in the third/expanded configuration.

In some embodiments, the elongate members **1404** are arranged successively adjacent to one another. In some embodiments, partial or full separations or gaps can be present between two elongate members **1404** of various ones of the successive pairs of elongate members **1404** in stacked arrangement **1415**. Substantially uniform separations or varying sized separations between the two elongate members **1404** of each successive pair of the elongate members **1404** in the stacked arrangement **1415** can be present. In some example embodiments, various other elements may be disposed between two elongate members **1404** of various ones of the successive pairs of the elongate members **1404** in the stacked arrangement **1415**. For example, various transducer elements may be positioned between two elongate members **1404** of various ones of the successive pairs of the elongate members **1404** in the stacked arrangement **1415**. The elongate members **1404** can be linearly arrayed along the first direction (i.e., as represented by arrow **1416**) in the stacked arrangement **1415**. In some embodiments, at least three elongate members **1404** are linearly arrayed along a first direction (i.e., as represented by arrow **1416**) in an arrayed arrangement. In some embodiments, at least three elongate members **1404** are successively arranged with respect to one another along a first direction (i.e., as represented by arrow **1416**) in the stacked arrangement **1415**.

Elongate members **1404** may be substantially planar members or may have some initial curvature when the portion of device **1400** is in the first/unexpanded configuration. At least one of surfaces **1418a** and **1418b** need not be a flat surface. In this example embodiment, elongate members **1404** have a shape that allows them to be successively stacked in stacked arrangement **1415**. FIG. 3E shows a cross-section view of stacked arrangement **1415** in a lumen **1403** of catheter sheath **1406** as viewed through lumen **1403**. Stacked arrangement **1415** advantageously allows elongate members **1404** to be arranged in a substantially spatially efficient manner to allow for delivery through catheter sheaths **1406**, enabling a reduced dimension (e.g., a diameter dimension) of catheter sheath **1406**. FIG. 3E shows that additional space **1414** within lumen **1403** is also advantageously provided for control lines, actuators and force transmission members (all not shown). Various conventional “basket-type” catheter systems that include resilient members that “spring” outwardly when they are advanced from a catheter sheath into a bodily typically are arranged in a relatively bulky and random or quasi-random arrangement when they are delivered within a catheter sheath which can disadvantageously require the use of larger catheter sheaths. Larger catheter sheaths can also be required for conventional “basket-type” catheter systems that employ buckling mechanisms that outwardly buckle an arrangement of members. Larger catheter sheaths can also be required for conventional

ablator systems that employ a substrate that is required to fold upon itself for delivery though the catheter sheath as is the case with various conventional inflatable balloon or bladder based catheter systems.

Advantageously, the strip-like elongate members 1404 in this embodiment additionally allows for a reduced bending stiffness about a bending axis arranged perpendicularly to the first or stacking direction of the elongate members 1404 in stacked arrangement 1415, especially when the elongate members are allowed to slide relatively with respect to one another during the bending. A reduced bending stiffness can facilitate the delivery of the stacked arrangement 1415 through catheter sheath 1406 especially when catheter sheath 1406 extends along a tortuous path to a bodily cavity. The members in many conventional basket-type catheter systems are coupled together in a manner that typically disadvantageously limits sliding movement between the members in a manner that can adversely impact delivery through a catheter sheath. As shown in FIG. 3A, a portion of elongate member 1404a is cantilevered from stacked arrangement 1415 in this embodiment. In this illustrated embodiment, the second end 1407 of elongate member 1404a is positioned between the respective first and the second ends 1405, 1407 of each of the other elongate members 1404 in stacked arrangement 1415. In this illustrated embodiment, the length 1411 of elongate member 1404a is greater than each of the respective lengths 1411 of the other elongate members 1404 in stacked arrangement 1415.

The elongate members 1404 may be constructed from various materials including, but not limited to, various metal and non-metal compositions, composite materials such as carbon fiber, or flexible PCB substrates with a fiberglass or Nitinol backing. The elongate members 1404 can include one or more material layers. The elongate members 1404 may form an integral component of the transducer elements 1490. When the transducer elements (e.g., transducer elements 1490) form an integral component of the frame 1402, various material components used in the frame may require various mechanical and electrical properties. If the device 1400 is distinguishing between blood and tissue by sensing convective cooling associated with a moving fluid (i.e., the blood), the material used for at least part of each of various ones of the elongate members 1404 preferably has a measurable change in resistance with temperature that is independent of elongate member 1404 deformation. In some embodiments, a resistance of several ohms per centimeter or higher is preferable as it will reduce the amount of current needed to heat the transducer element. The elongate members 1404 may also act as a support for a secondary assembly that carries the sensing and ablation transducer elements. An example of this is a stainless steel or Nitinol structure used to support transducer elements made with a flexible PCB circuit structure. In this embodiment, elongate members 1404 are resilient metallic elongate members. In this example embodiment, each of elongate members 1404b, 1404c, 1404d, 1404e and 1404f and are made from 17-7 stainless steel while elongate member 1404a is made from Nitinol. The use of Nitinol may be advantageous when a portion of an elongate member 1404 is to be subjected to relative tighter bending conditions or greater angular deflections.

In various embodiments, one or more couplers or joints are employed to physically couple some or all of the elongate members 1404 together in stacked arrangement 1415. In various embodiments, two or more couplers or joints are employed to physically couple some or all of the

elongate members 1404 in stacked arrangement 1415. In some example embodiments, at least one of the couplers or joints is employed to pivotally or articulably or articulatably (used interchangeably herein) couple at least some of the elongate members 1404 together in stacked arrangement 1415. In this illustrated embodiment, a first coupler 1422 and a second coupler 1424 couple various ones of the elongate members 1404 together. In this example embodiment, second coupler 1424 pivotally couples some of the elongate members 1404 (i.e., 1404b, 1404c, 1404d, 1404e and 1404f) together at a location proximate the respective second ends 1407 of these elongate members 1404. In this embodiment, first coupler 1422 pivotally couples each of the elongate members 1404 (i.e., 1404a, 1404b, 1404c, 1404d, 1404e and 1404f) together at a location spaced from second coupler 1424 along the respective lengths 1411 of each of the elongate members 1404. In this embodiment, all of the elongate members 1404 are pivotally coupled together directly by first coupler 1422 while only some, but not all of the elongate members 1404 are directly pivotally coupled together by second coupler 1424. It is noted however, that in this illustrated embodiment, elongate member 1404a is fixedly coupled to elongate member 1404f by offset member 1428 and is thereby indirectly pivotally coupled to another of the elongate members 1404 by second coupler 1424. In some example embodiments, each of the elongate members in a stacked arrangement is directly pivotally or articulably coupled to another of the elongate members in the stacked arrangement by each of at least two couplers or joints.

In this illustrated embodiment, each of the first and the second couplers 1422, 1424 respectively include first pivot member 1423 and second pivot member 1425 arranged to pivotally couple various ones of the elongate members 1404 together in stacked arrangement 1415. Second pivot member 1425 is spaced apart from first pivot member 1423 along a respectively coupled one of the elongate members 1404 by a respective length 1426 (only one called out in FIG. 3A) along the elongate member 1404. Each length 1426 can vary as the stacked arrangement 1415 is moved between the first/unexpanded configuration and the second/bent configuration or between the second/bent configuration and the third/expanded or fanned configuration. In this example embodiment, each of the first pivot member 1423 and the second pivot member 1425 takes the form of a pin about which various ones of the elongate members 1402 is configured to turn, revolve or rotate about when the stacked arrangement 1415 is moved to or from the third/expanded or fanned configuration shown in FIG. 3C. In this embodiment, each of the pivot members 1423, 1425 includes two opposing ends and a longitudinal axis extending between the opposing ends. Specifically, first longitudinal axis 1423a is associated with first pivot member 1423 and second longitudinal axis 1425a is associated with second pivot member 1425. In this embodiment, each of the first and the second pivot members 1423, 1425 is sized to be received in a respective opening provided in various ones of the elongate members 1404. Each of the first and the second pivot members 1423, 1425 can include restraining features (not shown) that additionally restrain the elongate members 1404 from axially escaping from the pivot members. Suitable restraining features can be formed by welding operations, heading operations, machining operations or assembly operations in which additional components are physically coupled to the pivot members 1423, 1425.

In other embodiments, other forms of couplings can be employed to physically couple two or more of the elongate members 1404 together. For example, various articulated

joints including flexure-type joints can be employed. In some example embodiments, one or more flexible lines are employed to physically couple at least two of the elongate members 1404 together. In some embodiments, each elongate member 1404 has a portion that is positioned between a set of at least two spaced apart articulated joints, the portion being articulable about each of the at least two articulated, articulable or articulation (used interchangeably herein) joints when the stacked arrangement 1415 is in the third/expanded configuration. In this example embodiment, if the elongate members 1404 are arranged successively with respect to one another to form a planar or flat stacked arrangement of the elongate members 1404, each elongate member 1404 is restrained from turning about each of the first pivot member 1423 and the second pivot member 1425. In this example embodiment, the orientation of the first and second pivot members 1423 and 1425 and the inherent continuous structure of the elongate members 1404 restrain the elongate members 1404 from turning about each of the first and second pivot members 1423 and 1425 if the elongate members 1404 were to be arranged in a planar or flat stacked arrangement.

FIG. 3B shows the portion of the device 1400 including the plurality of elongate members 1404 positioned in the second/bent configuration. This configuration may be established within a bodily cavity in accordance with various embodiments. In this illustrated embodiment, various ones of the elongate members 1404 have been bent by a bending action created by bender 1430. In this embodiment, each elongate member 1404 in the stacked arrangement 1415 is bent about a respective bending axis 1431 (only one shown), each bending axis 1431 extending along a direction having a directional component transversely oriented to the respective length 1411 (not called out in FIG. 3B) of the elongate member 1404. In this embodiment, bender 1430 includes at least one control element 1432 configured to alter a curvature or shape of one or more of the elongate members 1404. In this illustrated embodiment, control element 1432 includes a control line sized to be received by a number of pulleys 1434 (i.e., three called out) that are physically coupled to stacked arrangement 1415. In this embodiment, each of the pulleys 1434 is physically coupled to elongate member 1404a, while in other embodiments, one or more of the pulleys can be physically coupled to other ones of the elongate members 1404. Pulleys 1434 can be employed to reduce the frictional effects and facilitate the bending of various ones of the elongate members 1404 when a tensile force is applied to control element 1432. In some embodiments, one or more control elements 1432 are directly coupled to various ones of the elongate members 1404. In this embodiment, each of the pulleys 1434 is coupled to an elongate member 1404 by a respective control line 1436 (i.e., three called out). The control lines 1436 are, in turn, coupled together by control element 1432. Various arrangements of control elements 1432 and control lines 1436 can be employed to impart a desired curvature or shape change to various portions of selective ones of the elongate members 1404. Different shape changes can be achieved by changing a location on an elongate member 1404 to which a shape-changing force is applied to by a given one of the control lines 1436. A relative movement between various ones of the control elements 1432 or an activation timing of various ones of the control elements 1432, or both can be controlled to impart a desired shape change to a given one of the elongate members 1404 in stacked arrangement 1415. Control elements 1432 other than control lines can be employed in other example embodiments. For example, a

control element 1432 can include a push member configured to apply a compressive force. In this example embodiment, bender 1430 has altered a curvature of each of the elongate members 1404 in stacked arrangement 1415. In this example embodiment, bender 1430 has coiled elongate member 1404a.

In this embodiment, each of the bent elongate members 1404 assumes a respective arcuate shape between the respective first and second ends 1405, 1407 of the elongate member. The arcuate shape can include circular, elliptical arcuate or parabolic forms by way of non-limiting example. In various embodiments, the coupling locations of various control elements 1432 to stacked arrangement 1415 can be selectively chosen to impart a particular curvature or shape to various ones of the elongate members 1404 when the stacked arrangement is moved into the second/bent configuration.

FIG. 3C shows a portion of device 1400 in a third expanded configuration. In this illustrated embodiment, the portion of the device 1400 is moved from the second/bent configuration shown in FIG. 3B to the third/expanded configuration shown in FIG. 3C. In this illustrated embodiment, at least some of the elongate members 1404 are repositioned. In this example embodiment, various ones of the elongate members 1404 are moved to space the intermediate portions 1409 of at least some of the elongate members 1404 apart from one another. In this example embodiment, the respective intermediate portions 1409 of elongate members 1404b, 1404c, 1404d, 1404e and 1404f are angularly spaced with respect to one another about a first axis 1465. In this example embodiment, the respective intermediate portions 1409 of elongate members 1404b, 1404c, 1404d, 1404e and 1404f are radially oriented about first axis 1465. In this embodiment, the respective intermediate portions 1409 of elongate members 1404b, 1404c, 1404d, 1404e and 1404f spread out in a ray-like manner from first axis 1465. In this illustrated embodiment, each of the respective intermediate portions 1409 of elongate members 1404b, 1404c, 1404d, 1404e and 1404f is at a different radial distance from first axis 1465. In this embodiment, the radial distance from first axis 1465 that each of the respective intermediate portions 1409 of elongate members 1404b, 1404c, 1404d, 1404e and 1404f is positioned at, varies at least in part, based on a positioning of the elongate member 1404 in the bent stacked arrangement shown in FIG. 3B. In this illustrated embodiment, each of the respective intermediate portions 1409 of elongate members 1404b, 1404c, 1404d, 1404e and 1404f has a different curvature. In this example embodiment, various portions of each of the elongate members 1404b, 1404c, 1404d, 1404e and 1404f are arranged to form a structure having a domed shape 1419 when the portion of device 1400 is in the third/expanded or fanned configuration. In this example embodiment, the dome-shaped structure is positioned opposite from a portion of at least one of the elongate members 1404 (i.e., elongate member 1404a). In some example embodiments the domed-shaped structure may have a generally hemi-spherical shape. In other example embodiments, the domed shape structure may have a different shape. For example, the structure's domed shape may have a first radius of curvature in a first spatial plane and a second radius of curvature in a second spatial plane that intersects the first spatial plane, a magnitude of the second radius of curvature different than a magnitude of the first radius of curvature.

In this illustrated embodiment, various ones of the elongate members 1404 are fanned with respect to one another about a fanning axis in a fanned array when the portion of

the device 1400 is in the third/expanded configuration. The fanning axis extends along a direction that has a directional component that is transversely oriented to the bending axis 1431 shown in FIG. 3B. In this illustrated embodiment, various ones of the elongate members 1404 turn, revolve, or rotate (used interchangeably herein) about each of a respective pivot axis associated with each of first coupler 1422 and second coupler 1424 when the portion of the device 1400 is moved into the third/expanded configuration. In this illustrated embodiment, various ones of elongate members 1404 turn about pivot axis 1462a and pivot axis 1462b. In this illustrated embodiment, various ones of elongate members 1404 turn about each of first pivot member 1423 and second pivot member 1425 as the elongate members 1404 are fanned. The respective openings in various ones of the elongate members 1404 in which each of the first and the second pivot members 1423, 1425 is located can be appropriately sized to accommodate misalignment between the pivot members 1423, 1425 and respective ones of the pivot axes 1462a, 1462b. In this illustrated embodiment, the respective intermediate portions 1409 of various ones of the elongate members 1404 are angularly spaced about first axis 1465 when the portion of the device 1400 is moved into third/expanded configuration. In this example embodiment, the front surface 1418a of each of the elongate members 1404 is positioned to face away from the first axis 1465 when the portion of the device 1400 is in the third/expanded or fanned configuration.

In this example embodiment, separator 1452 moves various ones of the elongate members 1404 to move the portion of device 1400 into the third/expanded or fanned configuration. In this example embodiment, separator 1452 includes two crank members 1454, each crank member 1454 physically coupled to one of two flexible rotary shafts 1456. Various articulated joints pivotally couple each of crank members 1454 to a respective one of flexible rotary shafts 1456 to allow the crank members 1454 to assume one configuration suitable for delivery through catheter sheath 1406 and another configuration suitable for applying sufficient force to move various ones of elongate members 1404. Selectively applied torque to each of the crank members 1454 via a respective one of flexible rotary shafts 1456 can be applied by various actuators (not shown). In this embodiment, oppositely oriented torques are applied to crank members 1454 to fan different ones of the elongate members 1404 in different directions. In this illustrated embodiment, one of the crank members 1454 is physically coupled to elongate member 1404b while the other crank member 1454 is physically coupled to elongate member 1404c. In this example embodiment, each of the crank members 1454 is physically coupled to a respective one of the elongate members 1404 by a flexible line. The application of sufficient torque to each of the crank members 1454 causes respective ones of the elongate members 1404b and 1404c to move. Other separators may be employed additionally or alternatively in other example embodiments. For example, various elements (e.g., flexible lines) may be physically coupled to at least some of the elongate members 1404 to apply a force suitable for fanning various ones of the elongate members 1404 with respect to one another.

Various coupling members 1458 (four called out) physically couple various ones of the elongate members 1404 together. In this example embodiment, each coupling member 1458 allows movement of one of the elongate members 1404 coupled by the coupling member 1458 to also cause movement of another of the elongate members 1404 coupled by the coupling member 1458. In this example embodiment,

the coupling members 1458 are arranged to restrict or limit an amount of movement that an elongate member 1404 undergoes as the portion of the device is moved into the third/expanded configuration. In this embodiment, each coupling member 1458 is a flexible line. For clarity, bender 1430 is not shown in FIG. 3C. For clarity, separator 1452 is not shown in FIG. 3B. For clarity, bender 1430 and separator 1452 are not shown in FIG. 3A.

FIGS. 4A, 4B, 4C, 4D and 4E show various elevation views of a portion of a device 1700 positioned within a bodily cavity at five successive intervals of time according to an example embodiment. In this illustrated embodiment, the bodily cavity is a left atrium 1762 of a heart 1760 which is showed sectioned for clarity. Device 1700 includes a structure or frame 1702 that includes a plurality of elongate members 1704a, 1704b, 1704c, 1704d, 1704e and 1704f (collectively 1704) as best shown in FIGS. 4D, 4E. In a manner similar to the embodiment illustrated in FIGS. 3A, 3B, and 3C, and as best exemplified in FIG. 4F, each of the elongate members 1704 includes a respective distal or first end 1705, a respective proximal or second end 1707, a respective intermediate portion 1709 positioned between the first end 1705 and the second end 1707, and a respective length 1711 between the first end 1705 and the second end 1707. FIG. 4F shows an exploded view of an elongate member 1704 and a flexible circuit structure 1780.

As best shown in FIG. 4A, each of the elongate members 1704 has a different respective length 1711 in this example embodiment. In some embodiments, two or more of the elongate members 1704 may have substantially equal lengths 1711. As shown in FIG. 4F, each elongate member 1704 includes a front surface 1718a and a back surface 1718b positioned opposite to the first surface 1718a across a thickness 1717 of the elongate member 1704. In a manner similar to that described in some previous embodiments, various transducer elements can be carried into a bodily cavity by various ones of elongate members 1704. In some embodiments, various transducer elements can be provided on, or by various flexible circuit structures made up of various flexible substrates which can include by way of non-limiting example, elongate member 1704 itself. Flexible circuit structure 1780 shown in FIG. 4F can include one or more flexible substrates 1782 (i.e., two in this illustrated embodiment) and at least one electrically conductive layer 1784. In this example embodiment, the at least one conductive layer 1784 has been patterned to form a plurality of transducer elements 1790 (three called out). In this embodiment, the at least one conductive layer has been patterned to form a plurality of electrodes. Various ones of the at least one conductive layers can be patterned to form other features and elements including conductive traces or lines by way of non-limiting example. For clarity, various transducer elements 1790 associated with device 1700 are not shown in FIGS. 4A, 4B, 4C, 4D, 4E, 4G and 4H. For clarity, various flexible circuit structures 1780 associated with device 1700 are not shown in FIGS. 4A, 4B, 4C, 4D, 4G and 4H.

In this embodiment, the elongate members 1704 are arranged successively with respect to one another in stacked arrangement 1715 when the portion of device 1700 is in the first or unexpanded configuration shown in FIG. 4A. In this embodiment, the arrangement of the elongate members 1704 in the stacked arrangement 1715 is an orderly one with each of the elongate members 1704 arranged successively with respect to one another along a first direction (i.e., a stacking direction) represented by arrow 1716. In this example embodiment, the elongate members 1704 are arranged with one another front surface 1718a-toward-back surface 1718b

in an array. In some example embodiments, the elongate members 1704 can be interleaved with one another front surface 1718a-toward-back surface 1718b in an array. In this illustrated embodiment, the elongate members 1704 are arranged in a stacked array (i.e., stacked arrangement 1715) when delivered through catheter sheath 1706 (shown sectioned in FIG. 4A for clarity) which gains access to left atrium 1762 via bodily opening 1764. Catheter sheath 1706 includes a first end 1706a, a second end 1706b and a lumen 1703 extending between the first and the second ends 1706a, 1706b. In this example embodiment, catheter sheath 1706 is typically positioned such that the second end 1706b of the catheter sheath 1706 is positioned at least proximate to a bodily cavity such as left atrium 1762 when catheter sheath 1706 is employed to provide at least part of a percutaneous or intravascular delivery channel. In this example embodiment, each of the elongate members 1704 is arranged to be delivered through the lumen 1703 of catheter sheath 1706 from the first end 1706a of catheter sheath 1706 to the second end 1706b of catheter sheath 1706. In this embodiment, each of the elongate members 1704 is arranged in stacked arrangement 1715 such that its respective first end 1705 (i.e., also referred to as the distal end) is advanced out from lumen 1703 from the second end 1706b of catheter sheath 1706 before the respective second end 1707 (i.e., also referred to as the proximal end) is advanced out from lumen 1703. In this example embodiment, the elongate members are arranged to be advanced out from lumen 1703 into left atrium 1762. In this illustrated embodiment, elongate member 1704a is an outermost elongate member in stacked arrangement 1715. In some embodiments, elongate member 1704a is positioned between two of the outermost elongate members 1704 in stacked arrangement 1715. In this illustrated embodiment, the elongate members 1704 are sized and positioned in stacked arrangement 1715 so that a portion of elongate member 1704a is advanced into left atrium 1762 prior to a portion of each of the other ones of the elongate members 1704 in stacked arrangement 1715. In this illustrated embodiment, the elongate members 1704 are sized and positioned in stacked arrangement 1715 so that a portion of elongate member 1704a is advanced from the second end 1706b of catheter sheath 1706 prior to a portion of each of the other ones of the elongate members 1704 in stacked arrangement 1715. In some example embodiments, a respective portion of each of at least two of the elongate members is advanced from the second end 1706b of catheter sheath 1706 prior to a portion of each of the other ones of the elongate members 1704 in stacked arrangement 1715. In this example embodiment, a portion of elongate member 1704a is cantilevered from stacked arrangement 1715. In this illustrated embodiment, the elongate members 1704 are sized and positioned in stacked arrangement 1715 so that the first end 1705 of elongate member 1704a is advanced into left atrium 1762 prior to each respective first end 1705 of each of the other ones of the elongate members 1704 in stacked arrangement 1715. In this example embodiment, the length 1711 of elongate member 1704a is greater than each of the respective lengths of each of the other elongate members 1704 in stacked arrangement 1715. In some example embodiments, a portion of each of at least two elongate members 1704 of a plurality of elongate members 1704 can be advanced into a bodily cavity prior to a portion of any other elongate member 1704 in the plurality of elongate members 1704.

In this illustrated embodiment, a first coupler 1722 and a second coupler 1724 physically couple various ones of the elongate members 1704 together. In this example embodiment,

ment, second coupler 1724 pivotally couples at least some of the elongate members 1704 (i.e., 1704b, 1704c, 1704d, 1704e and 1704f) together at location proximate the respective second ends 1707 of these elongate members 1704. First 5 coupler 1722 pivotally couples various ones of the elongate members 1704 (i.e., 1704a, 1704b, 1704c, 1704d, 1704e and 1704f) together at a location spaced apart from second coupler 1724 along the respective lengths 1711 of each of these elongate members 1704. As shown in FIG. 4A each of 10 the first coupler 1722 and the second coupler 1724 respectively include first pivot member 1723 and second pivot member 1725 arranged to pivotally couple various ones of the elongate members 1704 together in stacked arrangement 1715 in this embodiment. In this example embodiment, each 15 of the first pivot member 1723 and the second pivot member 1725 takes the form of a pin about which various ones of the elongate members 1704 is configured to turn, revolve or rotate about when the stacked arrangement 1715 is moved to, or from, the third/expanded configuration shown in FIG. 20 4E. In this embodiment, each of the pivot members 1723, 1725 includes two opposing ends and a longitudinal axis extending between the opposing ends. Specifically, first longitudinal axis 1723a is associated with first pivot member 1723 and second longitudinal axis 1725a is associated with 25 second pivot member 1725. In this embodiment, each of the first and the second pivot members 1723, 1725 is sized to be received in a respective opening provided in various ones of the elongate members 1704. Other embodiments may employ other forms of couplers or joints.

As shown in FIGS. 4B to 4D, various portions of stacked arrangement 1715 are bent within the left atrium 1762 by bender 1730. Bender 1730 includes a control element 1732, which in this illustrated embodiment includes a control line that is coupled to various control lines 1736 that are each 30 coupled to an elongate member 1704. In this example embodiment, each control line 1736 is coupled to control element 1732 via a pulley 1734. Control element 1732 is coupled to a control unit 1740 (i.e., schematically shown) that is typically positioned outside of the body. In some 35 embodiments, control unit 1740 is included as part of a catheter system, for example a handle portion of the catheter system that is directly controlled or manipulated by a care provider. In this embodiment, control element 1732 is provided to bending unit 1742. In this embodiment, control 40 element 1732 is controlled by tensioner 1743 that selectively applies and controls tension provided to control element 1732. Tensioner 1743 can include various tensioning devices 45 such as cams by way of non limiting example.

In this illustrated embodiment, a portion of the stacked arrangement 1715 is bent within left atrium 1762 by bender 1730 as the portion of the stacked arrangement 1715 is advanced into left atrium 1762. In this embodiment, each of the elongate members 1704 in each portion of the stacked arrangement 1715 bent by bender 1730 is bent about at least one bending axis 1731 (shown in FIG. 4C) within left atrium 1762. In this embodiment, the direction that at least one bending axis 1731 extends along has a directional component transversely oriented to the first or stacking arrangement represented by arrow 1716. In this embodiment, each 50 of the elongate members 1704 in each portion of the stacked arrangement 1715 bent by bender 1730 is bent in a same direction. FIGS. 4B, 4C and 4D show successive portions of stacked arrangement 1715 bending as each portion is advanced into left atrium 1762. In some embodiments, 55 various portions of stacked arrangement 1715 are each bent by a substantially same angular amount as the portions are advanced into left atrium 1762. In some embodiments, 60 various portions of stacked arrangement 1715 are each bent by a substantially same angular amount as the portions are advanced into left atrium 1762. In some embodiments,

various portions of the stacked arrangement 1715 are bent by different angular amounts as the portions are advanced into left atrium 1762. Each angular amount can be predetermined based at least on various factors including, but not limited to, a measured or estimated dimension of left atrium 1762. As shown in FIG. 4D, the various elongate members 1704 have been bent into an arcuate stacked array. In this illustrated embodiment, the elongate members 1704 are still arranged front surface 1718a-toward-back surface 1718b in the arcuate stacked array.

In this example embodiment, advancing unit 1744 is employed to advance a portion of device 1700 including stacked arrangement 1715 into left atrium 1762. Advancing unit 1744 can include various manual or powered actuators suitable for delivering a portion of device 1700 through catheters sheath 1706 into left atrium 1762. In this embodiment, coordinating unit 1746 coordinates the bending of various portions of stacked arrangement 1715 under the influence of bending unit 1742 with the advancement of the portions of stacked arrangement 1715 into left atrium 1762 under the influence of advancing unit 1744. Coordinating unit 1746 can include various drive components including gears, pulleys, sprockets and timing belts, etcetera suitably arranged to provide the desired coordinated movement. In various embodiments, coordinating unit 1746 may control bending unit 1742 based on various information (e.g., positional information) associated with, or provided by an operation of advancing unit 1744.

As shown in FIGS. 4B, 4C and 4D, bender 1730 directly bends various portions of elongate member 1704a as these portions are advanced into left atrium 1762 in this illustrated embodiment. Elongate member 1704a is suitably arranged and coupled with the other elongate members 1704 in stacked arrangement 1715 to cause the other elongate members 1704 to also bend in a desired manner. In this embodiment, the respective first end 1705 of each of the elongate members 1704 moves from bodily opening 1764 into left atrium 1762 along a respective path in left atrium 1762 during the bending and advancement of various portions of stacked arrangement 1715. In various embodiments, a portion of each of the respective paths extends along an arcuate trajectory. In this example embodiment, the respective path of the first end 1705 of elongate member 1704a is longer than each of the respective paths within the left atrium 1762 of the first ends 1705 of the other ones of the elongate members 1704. In this embodiment, the second end 1707 of elongate member 1704a is advanced into left atrium 1762 prior to the respective second ends 1707 of the other elongate members 1704 in stacked arrangement 1715. In this embodiment, elongate member 1704a is coiled in left atrium 1762.

The advancement and bending of various portions of stacked arrangement 1715 into left atrium 1762 moves stacked arrangement 1715 into a second or bent configuration shown in FIG. 4D. Each of the elongate members 1704 has a generally compact form (e.g., a curled form) when the stacked arrangement 1715 is positioned in the second/bent configuration shown in FIG. 4D. In this embodiment, the respective first ends 1705 and the respective second ends 1707 of each elongate member 1704 is positioned within left atrium 1762 when stacked arrangement 1715 is in the second/bent configuration. Each of the elongate members 1704 has a respective end-to-end dimension between the respective first end 1705 and the respective second end 1707 of the elongate member 1704. In this embodiment, elongate member 1704a has a smaller end-to-end dimension 1750a than the end-to-end dimension of the other elongate mem-

bers 1704 (e.g., the end-to-end dimension 1750f of elongate member 1704f) in the second/bent configuration. In this embodiment, each of the elongate members 1704 has a smaller end-to-end dimension when the portion of the device 1700 is in the second/bent configuration than when the portion of the device is in the first/unexpanded configuration. In some embodiments, the end-to-end dimension of each elongate member 1704 may be approximately equal to the respective length 1711 of the elongate member when the portion of the device 1700 is in the first/unexpanded configuration. In various embodiments, the bent stacked arrangement 1715 assumes a shape in the second/bent configuration having dimensions suitably sized to allow the bent stacked arrangement 1715 to be positioned at one or more locations within left atrium 1762 with reduced or no contact between the elongate members 1704 and a tissue surface within left atrium 1762.

Advantageously, in this embodiment, stacked arrangement 1715 is bent as it is advanced from bodily opening 1764 into left atrium 1762 to reduce physical interactions between stacked arrangement 1715 and a tissue surface within left atrium 1762. A reduction of contact and other physical interaction with the tissue surface within left atrium 1762 during this positioning can reduce occurrences of, or the severity of, damage inflicted to various tissue structures within left atrium 1762 during this positioning. Some conventional “basket-type” catheter systems include resilient members that “spring” outwardly or employ buckling mechanisms that outwardly buckle an arrangement of members, typically have longitudinal lengths (i.e., lengths generally oriented along a direction of advancement from a bodily opening into a left atrium) that are too large to be directly accommodated within the atrium (i.e., the lengths must be sufficiently sized to allow the members to spring outwardly or buckle laterally within the atrium). Typically, these systems require that the arrangement of members be guided within the atrium to position part of the arrangement into another bodily opening leading to the left atrium (e.g., a pulmonary vein opening) to accommodate their excess length prior to expansion of the portion of device 1700 within the left atrium. This can potentially inflict damage to the pulmonary vein and other structures within the atrium. In various embodiments, catheter sheath 1706 is preferably oriented to allow stacked arrangement 1715 to be introduced generally tangentially to an interior tissue surface of left atrium 1762. As various portions of stacked arrangement 1715 are subsequently advanced and bent within the left atrium 1762, the generally tangential orientation with the interior tissue surface of left atrium 1762 is substantially maintained to accommodate the overall length of stacked arrangement 1715 while advantageously reducing occurrences of contact with the tissue surface and allowing the stacked arrangement 1715 to be subsequently positioned in a desired expanded or third configuration as shown in FIG. 4E. In this example embodiment, elongate member 1704a moves along a coiled path within left atrium 1762 to advantageously reduce occurrences of contact with the tissue surface. In this example embodiment, elongate member 1704a curls away from an interior tissue surface with left atrium 1762 as the elongate member 1704a is advanced into left atrium 1762.

FIG. 4E shows the portion of the device 1700 in a third or expanded configuration in left atrium 1762. In this illustrated embodiment, the elongate members 1704 were moved from the second/bent configuration shown in FIG. 4D to the third/expanded or fanned configuration shown in FIG. 4E. In this illustrated embodiment, at least some of the

elongate members 1704 are repositioned in left atrium 1762. In this example embodiment, various ones of the elongate members 1704 are moved to space the intermediate portions 1709 of at least some of the elongate members 1704 apart from one another within left atrium 1762. In this example embodiment, the respective intermediate portions 1709 of elongate members 1704b, 1704c, 1704d, 1704e and 1704f are angularly spaced with respect to one another about a first axis 1765 within left atrium 1762. In this example embodiment, the respective intermediate portions 1709 of elongate members 1704b, 1704c, 1704d, 1704e and 1704f are radially oriented about first axis 1765 within left atrium 1762. In this illustrated embodiment, various ones of the elongate members 1704 are fanned with respect to one another about at least one fanning axis into a fanned array. Each fanning axis extends along a direction that has a directional component that is transversely oriented to the bending axis 1731 shown in FIG. 4C. In this embodiment, elongate member 1704a is positioned inboard within the fanned array. In this illustrated embodiment, various ones of the elongate members 1704 are fanned about each a respective pivot axis associated with each of first coupler 1722 and second coupler 1724. In this illustrated embodiment, various ones of elongate members 1704 turn about each of first pivot member 1723 and second pivot member 1725 as the elongate members 1704 are moved into the fanned arrangement. Spacings between various ones of the elongate members can be adjusted in various manners to facilitate the fanning of the elongate members 1704. In this example embodiment, the front surfaces 1718a of each of the elongate members is positioned to face a tissue surface within left atrium 1762 when the portion of the device 1700 is in the third/expanded or fanned configuration.

Various ones of the elongate members 1704 can be moved in various ways as the portion of device 1700 is moved into the third/expanded configuration. As shown in the cross-section views shown in FIGS. 4G and 4H, a first set of elongate members 1704 made up of elongate members 1704b and 1704d is moved, pivoted, rotated, turned or revolved (used interchangeably herein) along an angular direction represented by arrow 1768 while a second set of the elongate members 1704 made up of elongate members 1704c and 1704e is moved along an angular direction represented by arrow 1766 when the portion of device 1700 is moved, pivoted, rotated, turned or revolved (used interchangeably herein) from the second/bent configuration shown in FIG. 4G to the third/expanded configuration shown in FIG. 4H. In this illustrated embodiment, the first set of elongate members 1704 is moved along an angular direction that is opposite to the angular direction that the second set of elongate members 1704 is moved along.

In this example embodiment, a portion of at least a one of the elongate members 1704 in the first set of the elongate members 1704 (e.g., elongate member 1704d) is positioned between respective portions of at least two of the elongate members 1704 in the second set of elongate members 1704 (i.e., elongate members 1704c and 1704e) when the portion of the device 1700 is at least in the first/unexpanded configuration. In this example embodiment, the elongate members 1704b and 1704d in the first set of elongate members 1704 are interleaved in the bent stacked arrangement 1715 with the elongate members 1704c and 1704e when the portion of device 1700 is in the second/bent configuration as shown in FIG. 4G and when the portion of the device 1700 is in the first/unexpanded configuration (not shown). It is understood that the elongate members 1704 can be arranged differently in other embodiments. For example, the elongate

members 1704b and 1704d in the first set of elongate members 1704 can be arranged successively adjacent to one another in the stacked arrangement 1715 and the elongate members 1704c and 1704e in the second set of elongate members 1704 can be arranged successively adjacent to one another in the stacked arrangement 1715 when the portion of the device 1700 is in the first/unexpanded configuration or the second/bent configuration. In other embodiments, each of the first and the second sets of elongate members 1704 can have different numbers of elongate members than shown in FIGS. 4G and 4H. For clarity, elongate member 1704a is not shown in FIGS. 4G and 4H. In some embodiments, an elongate member 1704 that is introduced first in left atrium 1762 (e.g., elongate member 1704a) can be positioned between at least two of the elongate members 1704 in the fanned arrangement of the elongate members 1704. In some embodiments, an elongate member 1704 that is introduced first in left atrium 1762 (e.g., elongate member 1704a) can be positioned as an outboard elongate member 1704 in the fanned arrangement of the elongate members 1704.

As shown in FIG. 4E, separator 1752 moves various ones of the elongate members 1704 to move the portion of device 1700 including stacked arrangement 1715 into the third/expanded configuration. In this example embodiment, separator 1752 includes two crank members 1754, each crank member 1754 physically coupled to one of two flexible rotary shafts 1756. Various articulated joints (not shown) pivotally couple each of crank members 1754 to a respective one of flexible rotary shafts 1756 to allow the crank members 1754 to assume a first configuration suitable for delivery through catheter sheath 1706 and a second configuration within left atrium 1762 suitable for applying sufficient force to move various ones of elongate members 1704. Flexible rotary shafts 1756 are coupled to separating unit 1748 provided by control unit 1740. Separating unit 1748 is selectively controllable to selectively apply torque to each of the crank members 1754 via a respective one of flexible rotary shafts 1756. In this embodiment, oppositely oriented torques are applied to crank members 1754 to fan different ones of the elongate members 1704 in different directions. In this illustrated embodiment, one of the crank members 1754 is physically coupled to elongate member 1704b while the other crank member 1754 is physically coupled to elongate member 1704c. The application of sufficient torque to each of the crank members 1754 causes respective ones of the elongate members 1704b and 1704c to move. Various coupling members 1758 (three called out) physically couple various ones of the elongate members 1704 together. In this example embodiment, each coupling member 1758 allows movement of one of the elongate members 1704 coupled by the coupling member 1758 to also cause movement of another of the elongate members 1704 coupled by the coupling member 1758. In this example embodiment, the coupling members 1758 are arranged to restrict or limit an amount of movement that an elongate member 1704 undergoes as the portion of the device is moved into the third/expanded configuration. In this embodiment, each coupling member 1758 is a flexible line. In this example embodiment, coordinating unit 1746 restricts separator 1752 from being operated to cause movement of various ones of elongate members 1704 until the portion of the device 1700 is in the second/bent configuration. For clarity, various ones of bender 1730 and separator 1752 are not shown in FIGS. 4A, 4D and 4E.

In this example embodiment, once the portion of device 1700 has been appropriately positioned at a given location within left atrium 1762, determination of the locations of

various components of device 1700 (e.g., transducer elements 1790 including sensors or electrodes or related support structures such as elongate members 1704) or the locations of various anatomical features within left atrium 1762 can be determined. In this example embodiment, after the portion of device 1700 has been appropriately positioned at a given location within left atrium 1762, ablation of various regions of a tissue surface within left atrium 1762 can commence.

Typically, when the elongate members 1704 arranged in an arcuate stacked array (i.e., as shown in FIG. 4D) are repositioned into a fanned array (i.e., as shown in FIG. 4E), the elongate members 1704 are preferably arranged away from various tissue surfaces within the left atrium 1762 to avoid obstructions that could hinder repositioning or to reduce occurrences in which damage may be inflicted on the tissue surfaces, or both. In some example embodiments, portions of each of some of the elongate members 1704 can be positioned away from a tissue surface within a bodily cavity such as left atrium 1762 when the portion of the device 1700 is in the third/expanded or fanned configuration. In some example embodiments, additional manipulation of a portion of device 1700 including elongate members 1704 within a bodily cavity such as left atrium 1762 is initiated when the portion of the device 1700 is moved into the third/expanded or fanned configuration. In some example embodiments, some of the elongate members 1704 are further manipulated to conform to a shape of a tissue surface with a bodily cavity such as left atrium 1762 when the portion of the device 1700 is moved into the third/expanded or fanned configuration. In some example embodiments, a tissue surface within a bodily cavity such as left atrium 1762 is further manipulated to conform to a shape of a number of the elongate members 1704 when the portion of the device 1700 is moved into the third/expanded or fanned configuration. In some example embodiments, a portion of the elongate members 1704 and a tissue surface within a bodily cavity such as left atrium 1762 are each further manipulated to create conformance between a number of the elongate members 1704 and a portion of the tissue surface when the portion of the device 1700 is moved into the third/expanded configuration. In some example embodiments, bending unit 1742 is operated to further manipulate various ones of the elongate members 1704 when the portion of the device 1700 is moved into the third/expanded or fanned configuration. For example, bending unit 1742 can be operated to adjust tension on control element 1732 to release stored potential energy from various ones of the elongate members 1704. In some example embodiments, an adjustment in tension will cause a resilient elongate member 1704 to uncoil or unbend and bear against a proximate tissue surface within left atrium 1762 by an amount sufficient to bias the remaining elongate members 1704<sub>b</sub>, 1704<sub>c</sub>, 1704<sub>d</sub>, 1704<sub>e</sub> and 1704<sub>f</sub> towards portions of the tissue surface proximate these elongate members. A location of various transducer elements (e.g., sensors or electrodes, or both) carried by various ones of the elongate members 1704 relative to a tissue surface within left atrium 1762 can also be adjusted by this or other manipulations of the elongate members 1704.

FIG. 5A is an isometric view of a portion of a device 2400 according to one example embodiment. Device 2400 includes a structure or frame 2402 that includes an arrangement of elongate members 2404<sub>a</sub>, 2404<sub>b</sub>, 2404<sub>c</sub>, 2404<sub>d</sub>, and 2404<sub>e</sub> (collectively 2404) illustrated in FIG. 5A in a first/unexpanded configuration suitably sized for delivery through catheter sheath 2406 (i.e., showed sectioned). The

elongate members 2404 are physically coupled to shaft member 2410 which is employed to convey the elongate members 2404 through catheter sheath 2406. Each of the elongate members 2404 includes a respective distal end 2405 (only one called out), a respective proximal end 2407 (only one called out), a respective intermediate portion 2409 (only one called out) positioned between the distal end 2405 and the proximal end 2407. In this example embodiment, each elongate member 2404 is arranged in frame 2402 to be advanced distal end 2405 first into a bodily cavity (not shown).

FIG. 5B is an isometric view of one of the elongate members 2404 (i.e., elongate member 2404<sub>b</sub>). Each of the elongate members 2404 includes a respective length 2411 between the distal end 2405 and the proximal end 2407. As shown in FIG. 5A, each of various ones of the elongate members 2404 has a different respective length 2411 (not called out) than the respective length 2411 (not called out) of another of the elongate members 2404. In a manner similar to that described in some previous embodiments, various transducer elements can be carried into a bodily cavity by various ones of elongate members 2404. In some embodiments, various transducer elements can be provided on, or by various flexible circuit structures made up of various flexible substrates which can include by way of non-limiting example, elongate member 2404 itself. As exemplified in FIG. 5B, each of the elongate members 2404 includes a plurality of transducer elements 2490 (two called out in each of FIGS. 5A and 5B) distributed along the respective length 2411 of the elongate member in this example embodiment. For clarity, various transducer elements 2490 associated with device 2400 are not shown in FIGS. 5C, 5D, 5E, 5F, 5G, and 5H.

In some previously described embodiments, various elongate members had respective lengths that were sized to be substantially less than a circumference of a portion of an interior surface of a bodily cavity to which the elongate member was to be positioned at least proximate to when in a deployed configuration. The circumference of the portion of the interior tissue surface may have a measured or anticipated value. For example, in the deployed configuration of device 1700 of the embodiment shown in FIG. 4E, various ones of the elongate members 1704 have a respective length 1711 that is sized to be equal to approximately half an internal circumference of left atrium 1762. In the embodiment shown in FIG. 4E, elongate members 1704<sub>b</sub>, 1704<sub>c</sub>, 1704<sub>d</sub>, 1704<sub>e</sub> and 1704<sub>f</sub> in the deployed configuration are arranged in a generally domed-shaped structure. In the deployed configuration of device 1700 of the embodiment shown in FIG. 4E, the domed shape structure enclosing a volume sized to be on the order of a volume of a hemispherical half of left atrium 1762. Various transducer elements (e.g., sensors or electrodes, or both) (not shown) carried by various ones of the elongate members 1704<sub>b</sub>, 1704<sub>c</sub>, 1704<sub>d</sub>, 1704<sub>e</sub> and 1704<sub>f</sub> are essentially distributed across a first region of the interior tissue surface of left atrium 1762 and not across a second region separate from the first region like a region diametrically opposed to the first region. If investigation, sensing or treatment of the second region of the interior tissue surface of left atrium 1762 is additionally required, further operations or manipulations to redeploy device 1700 such that at least a portion of elongate members 1704<sub>b</sub>, 1704<sub>c</sub>, 1704<sub>d</sub>, 1704<sub>e</sub> and 1704<sub>f</sub> are essentially distributed across the second region of the interior tissue surface of left atrium 1762 may be required. This can impose additional requirements when the investigation, sensing or treatment of one region of the interior tissue

surface of left atrium 1762 is dependent on a previous investigation, sensing or treatment of another region of the interior tissue surface of left atrium 1762. For example, in mapping applications, the mapping of features on one region of the interior tissue surface of left atrium 1762 may need to be registered with the mapping of features on another region of the interior tissue surface of left atrium 1762 to provide a global map of the interior surface. In ablation treatment applications, the formation of an ablation lesion extending continuously across both these interior tissue regions may need to employ various stitching techniques to ensure continuity of the ablation lesion.

Unlike some previously described embodiments, each of the elongate members 2404 has a respective length 2411 (not called out in FIGS. 5A, 5C, 5D, 5E, 5F and 5G) that is at least approximately equal to, or greater than a circumference of a portion of a interior tissue surface of a bodily cavity (again not shown) to which the elongate member 2404 is to be positioned at least proximate to when the portion of the device 2400 is in a deployed configuration. The circumference of the portion of the interior tissue surface may have a measured or anticipated value. In this example embodiment, transducer elements 2490 carried by a given one of elongate members 2404 can be distributed across approximately the entirety of the circumference of a region of an interior tissue surface of a bodily cavity (again, not shown) over which the given one of the elongate members 2404 is positioned at least proximate to in a deployed configuration. In some embodiments, two or more of the elongate members 2404 may have substantially equal lengths 2411.

As shown in FIG. 5A, at least the respective intermediate portions 2409 of each of the elongate members 2404 are arranged successively with respect to one another in a stacked arrangement 2415 when the portion of device 2400 is in the first/unexpanded configuration. In this embodiment, the arrangement of the respective intermediate portions 2409 in the stacked arrangement 2415 is an orderly one with each of respective intermediate portions 2409 arranged successively with respect to one another along a first direction (i.e., a stacking direction) represented by arrow 2416. In the illustrated example embodiment, each of the elongate members 2404 is a strip-like member. As shown in FIG. 5B, the intermediate portion 2409 of each of the elongate members 2404 includes a set of two opposing major faces or surfaces or 2418 made up of a front surface 2418a and a back surface 2418b. In this example embodiment, the two opposing surfaces 2418 are separated from one another by a thickness 2417 of the elongate member 2404. In this illustrated example, the intermediate portion 2409 of each of the elongate members 2404 further includes a pair of side edges 2420a, 2420b (collectively 2420) of at least one of the front surface 2418a and the back surface 2418b, the side edges of each pair of side edges 2420 opposed to one another across at least a portion of the length 2411 of the respective elongate member 2404. As used herein and in the claims, the term stacked and variations thereof (e.g., stack) refers to an orientation and does not necessarily require that any one member be carried directly on or supported directly by a next successively adjacent elongate member 2404 in the stack.

As best shown in FIG. 5B, each elongate member includes a geodesic 2414 (i.e., represented by a broken line) extending along a portion of the respective length 2411 between a first location at least proximate the respective proximal end 2407 and a second location at least proximate the distal end 2405 of the elongate member 2404. As used herein and in the claims the term "geodesic" should be

understood to mean the shortest line extending between two points on a given surface (e.g., planar surface, curved surface) of an elongate member employed in various embodiments. In some example embodiments, a geodesic 5 may extend over or bridge a localized opening or other local disruption in the surface of the elongate member as that shortest line extends along the surface between the two points. In this example embodiment, each geodesic 2414 is located at least on the front surface 2418a of the intermediate portion 2409 of a respective elongate member 2404. Each geodesic 2414 is the shortest line on the front surface 2418a of the intermediate portion 2409 of a respective elongate member 2404 extending between a first location on the front surface 2418a at least proximate the respective proximal end 2407 and a second location on the front surface 2418a at least proximate the respective distal end 2405 of the elongate member 2404. In various embodiments, the distal end 2405 is the portion of the elongate member 2404 is advanced first into a bodily cavity. In some example embodiments, each geodesic 2414 is parallel to a midline, center line, longitudinal axis, etcetera, of a respective major surface 2418 of the elongate members 2404. In some example embodiments, each geodesic 2414 is a midline, center line, longitudinal axis, etcetera of a respective major surface 2418 of the elongate members 2404. In some example embodiments, various ones of the elongate members 2404 may be shaped to have a plurality of geodesics 2414 (i.e., each equally sized) extending between locations at least proximate the respective proximal end 2407 and the 10 respective distal end 2405 of the elongate member 2404. For example, in this illustrated embodiment, the relatively "blunt" or "square" proximal and distal ends 2407, 2405 of various ones of the elongate members 2404 allow for a plurality of equally sized geodesics 2414 to be defined 15 across the front surface 2418a of each respective elongate member 2404, each geodesic 2414 spaced from each of the opposing side edges 2420 of the respective elongate member 2404 and each geodesic extending between respective locations at least proximate the proximal and the distal ends 20 2407, 2405 of the respective elongate member 2404. In this illustrated embodiment, a single geodesic 2414 is shown on a respective front surface 2418a at a location spaced from the side edges 2420a 2420b of the front surface 2418a for clarity. Some of the other geodesics 2414 that are not shown 25 but having the same length as the illustrated geodesic 2414 may extend over a continuous portion of the front surface 2418a between locations at least proximate the respective proximal end 2407 and the respective distal end 2405 of a given elongate member 2404.

As shown in FIG. 5A, the elongate members 2404 are arranged in a delivery configuration in this example embodiment. The elongate members 2404 are arranged with respect to one another front surface 2418a-toward-back surface 2418b in a stacked array sized to be delivered through a 30 bodily opening (i.e., via a lumen of catheter sheath 2406) leading to a bodily cavity. In various embodiments, the front surface 2418a is positionable adjacent to an interior tissue surface in the bodily cavity (not shown) when the portion of device 2400 is in a deployed configuration within the bodily cavity. In some embodiments, each front surface 2418a is positionable to face an interior tissue surface in the bodily cavity when the portion of device 2400 is in a deployed configuration within the bodily cavity. In this embodiment, each front surface 2418a includes, or supports a transducer element 2490 that is positionable adjacent to an interior tissue surface in the bodily cavity when the portion of device 2400 is in a deployed configuration within the bodily cavity.

As shown in FIG. 5B, various ones of elongate members 2404 each includes a plurality of openings 2419 including first opening 2419a, second opening 2419b and third opening 2419c in this example embodiment. Each of first opening 2419a, second opening 2419b and third opening 2419c provides a passageway through a respective elongate member 2404. Each of first opening 2419a, second opening 2419b and third opening 2419c are spaced from one another along the length 2411 of a respective elongate member 2404.

In various example embodiments, various ones of the elongate members 2404 are physically coupled together by at least one coupler. In this example embodiment, the at least one coupler includes coupler 2422 (i.e., not shown in FIG. 5B) which forms part of an articulable joint and includes a pivot member 2423 in the form of a pin sized to be received in the first opening 2419a. In this embodiment, each of various ones of the elongate members 2404 is configured to turn, revolve, pivot or rotate about pivot member 2423. The at least one coupler can include other articulated or non-articulated joints in various embodiments.

FIG. 5C is an isometric view of the portion of the device 2400 including the plurality of elongate members 2404 illustrated as positioned in a second/bent configuration (i.e., an example of one deployed configuration). This configuration can be established within a bodily cavity in accordance with various embodiments. In this example embodiment, each elongate member 2404 in the stacked array shown in FIG. 5A is bent about a respective bending axis 2431 (only one shown) into an arcuate stacked array as shown in FIG. 5C. Each bending axis 2431 extends along a direction having a directional component transversely oriented to the respective length 2411 (not called out in FIG. 5C) of the elongate member 2404. In this example embodiment, each elongate member 2404 in the stacked array/stacked arrangement 2415 shown in FIG. 5A is coiled or curved back on itself about a respective bending axis 2431 into a coiled stacked array 2430 as shown in FIG. 5C.

In this example embodiment, each elongate member 2404 in frame 2402 is bent to have a generally annular or ring-like profile, with each annular or ring-like profile interrupted by a separation. When positioned in the second/bent configuration, a first portion 2421a of the front surface 2418a of the respective intermediate portion 2409 of each elongate member 2404 is positioned diametrically opposite to a second portion 2421b of the front surface 2418a in the annular shaped frame 2402. When positioned in the second/bent configuration, the coiled arrangement of elongate members 2404 is sized too large for delivery through a lumen of catheter sheath 2406. In some example embodiments, various ones of the elongate members 2404 are bent by a bending action or force created by a bender (i.e., not shown but similar in function to that of benders 1430 and 1730) that may include at least one control element configured to alter a curvature or shape of one or more of the elongate members 2404.

FIGS. 5D and 5F show a portion of device 2400 in a third/expanded or fanned configuration (i.e., an example of a deployed configuration), according to one embodiment. FIGS. 5E and 5G show a portion of device 2400 in a third/expanded or fanned configuration, (i.e., an example of a deployed configuration) according to another embodiment.

The third/expanded or fanned configuration can be established within a bodily cavity (not shown) in accordance with various embodiments. In one embodiment, the portion of the device 2400 is moved from the second/bent configuration

shown in FIG. 5B to the third/expanded or fanned configuration shown as exemplified by either FIGS. 5D and 5F or by FIGS. 5E and 5G.

In this illustrated embodiment, at least some of the elongate members 2404 are repositioned with respect to at least one other elongate member 2404 in the coiled stacked array 2430. In some embodiments, various ones of the elongate members 2404 are fanned, pivoted or turned with respect to at least one other elongate member 2404 about each of one or more axes, the one or more axes positioned to pass through the at least one other elongate member 2404 at two or more locations, each of the two or more locations spaced from another of the two or more locations along the respective length 2411 (not called out in FIGS. 5D, 5E, 5F and 5G) of the at least one other elongate member 2404. For example, as shown in FIGS. 5D and 5E, various ones of elongate members 2404b, 2404c, 2404d and 2404e are rotated about the one or more axes 2435 which is or are arranged to pass through elongate member 2404a at each of three spaced apart locations 2436a, 2436b and 2436c along the respective length 2411 of elongate member 2404a. Various ones of locations 2436b and 2436c are not easily seen in each of FIGS. 5D and 5E because of the overlapping elongate members 2404 and are called out along with location 2436a. It is understood that locations 2436a, 2436b and 2436c are each respectively spaced apart from one another along the one or more axes 2435. For clarity, the locations 2436a, 2436b and 2436c are represented by a respective "x" in FIG. 5A which shows elongate member 2404a in the first/unexpanded configuration.

In this example embodiment, various ones of elongate members 2404b, 2404c, 2404d and 2404e can be fanned with respect to elongate member 2404a along a first rotational direction (i.e., represented by first arrow 2437a) as shown in FIG. 5D, and along a second rotational direction (i.e., represented by second arrow 2437b) as shown in FIG. 5E that is opposite to the first rotational direction. When the portion of device 2400 is positioned in the second/bent configuration, location 2436b would be located along the respective length 2411 of elongate member 2404a between the respective first portion 2421a (i.e., called out in FIG. 5C) and the respective second portion 2421b (i.e., called out in FIG. 5C) of the front surface 2418a of elongate member 2404a. For clarity, various ones of elongate members 2404a, 2404b, 2404c, 2404d and 2404e have been called out twice in each of FIGS. 5D and 5E to illustrate their annular or quasi-annular or ring-like profile in the third/expanded configuration.

As best illustrated in FIG. 5F, various elongate members 2404 sweep out two opposing fanned sectors 2438a about the one or more axes 2435 (i.e., shown by an "x") when rotated in the first rotational direction (i.e., represented by first arrow 2437a). As best illustrated in FIG. 5G, the various elongate members 2404 sweep out two opposing fanned sectors 2438b about one or more axes 2435 (i.e., shown by an "x") when rotated in the second rotational direction (i.e., represented by second arrow 2437b). In this example embodiment, each fanned sector 2438a and 2438b forms a quadrant of an approximately spherical fanned envelope created by a combination of the two oppositely fanned rotations. A separator (i.e., not shown, but similar in function to that of separators 1452 and 1752) may be employed to fan the various elongate members 2404.

In one example embodiment, elongate member 2404a is manipulated separately from the other elongate members 2404 to unbend and bear against a proximate interior tissue surface within the bodily cavity by an amount sufficient to

hold elongate member 2404a relatively fast to the interior tissue surface of the bodily cavity. This can be accomplished, for example, by the use of a bending unit (i.e., not shown but similar in function to that of benders 1430 and 1730) which increases or releases stored potential energy in elongate member 2404a independently from the other elongate members 2404. With elongate member 2404a substantially fixed with respect to the interior surface of the bodily cavity, various ones of elongate members 2404b, 2404c, 2404d and 2404e can be fanned with respect to elongate member 2404a along the first rotational direction (i.e., represented by first arrow 2437a) to distribute transducer elements 2490 (not shown in FIGS. 5D, 5E, 5F, and 5G) across a first set of two opposing regional quadrants of an interior tissue surface within the bodily cavity.

With elongate member 2404a substantially fixed with respect to the interior surface of the bodily cavity, various ones of elongate members 2404b, 2404c, 2404d and 2404e can be fanned with respect to elongate member 2404a along the second rotational direction (i.e., represented by second arrow 2437b) to distribute the transducer elements 2490 (again not shown in FIGS. 5D, 5E, 5F, and 5G) across another set of two opposing regional quadrants of interior tissue surface within the bodily cavity. After each of the first and the second rotational movements, an investigational, sensing or treatment action may be undertaken on the respective two opposing quadrants of interior surface region of the bodily cavity associated with each of the first and the second rotational movements. Preferably, elongate members 2404b, 2404c, 2404d and 2404e are positioned to reduce contact between the elongate members and an interior tissue surface of the bodily cavity during each of the first and the second rotational movements to reduce occurrences of damage to the interior tissue surface during these movements. After each of the first and the second rotational movements, various ones of elongate members 2404b, 2404c, 2404d and 2404e may be additionally manipulated to engage with, or be positioned at least proximate to, the interior tissue surface within the bodily cavity using a same or different mechanism employed to cause the engagement of elongate member 2404a with the interior tissue surface.

Advantageously, the substantial fixing of elongate member 2404a to the tissue surface can reduce the burden of a registration requirement associated with the investigation, sensing or treatment of each of the two sets of two opposing quadrants of the interior tissue surface region within the bodily cavity. Specifically, in mapping applications, the mapping of features on one set of opposing regional quadrants of the interior surface of the bodily cavity can be readily registered with mapping of features on the other set of opposing regional quadrants of the interior surface of the bodily cavity to provide a greater contiguous area map or even a global map of the interior tissue surface. In ablation treatment applications, the formation of an ablation lesion extending continuously across both adjacent regional quadrants of the interior surface of the bodily cavity can reduce stitching burdens to better ensure continuity of the ablation lesion.

Advantageously, the number of elongate members 2404 employed in this embodiment allows for the investigating, sensing or treatment of a larger region of the interior tissue surface of a bodily cavity while reducing a need to add additional elongate members 2404 that would increase the stacked size of stacked arrangement 2415 and possibly necessitate a use of a larger diameter catheter sheath 2406. This is possible since each elongate member 2404 has a respective length 2411 approximately equal or greater than

a circumference of a portion of an interior tissue surface of a bodily cavity to which the elongate member 2404 is positioned at least proximate to when the portion of the device 2400 is in a deployed configuration. This allows for a greater region of the tissue surface to be investigated, sensed or treated while providing a stacked arrangement 2415 having a relatively small stacked size along the first direction (i.e., as represented by arrow 2416). It is additionally noted that the greater respective lengths 2411 of the elongate members 2404 can increase their flexibility to further facilitate their delivery through catheter 2406 when the portion of the device is in the first/unexpanded configuration. The respective length 2411 of each elongate member 2404 may be preselected to be greater than a circumference of a portion of an interior tissue surface of a bodily cavity to which the elongate member 2404 is positioned to account for variances in the actual circumference of the portion of the interior tissue surface. The circumference of the portion of the interior tissue surface may have a measured or anticipated value.

Referring back to FIGS. 5D and 5E, the one or more axes 2435 is or are represented as a single axis arranged to pass through at least elongate member 2404a at each of three spaced apart locations 2436a, 2436b and 2436c along the respective length 2411 of elongate member 2404a in this embodiment. Again, the three spaced apart locations 2436a, 2436b and 2436c are best seen in FIG. 5A. In some embodiments, the one or more axes 2435 may include two or more axes, each of the two or more axes passing through a respective one of at least one of the locations 2436a, 2436b and 2436c that are spaced along the respective length 2411 of at least elongate member 2404a. In some embodiments, at least a first axis of the two or more axes is collinear with a second axis of the two or more axes. In some embodiments, at least a first axis of the two or more axes is not collinear with a second axis of the two or more axes. Minor distortions in the elongate members 2404 or various pivot clearances may allow for some degree of non-collinearity between the axes during the fanning.

In this illustrated embodiment, each of the elongate members 2404b, 2404c, 2404d and 2404e cross elongate member 2404a in an "X" configuration at location 2436b in the third/expanded configuration. In various example embodiments, a first elongate member 2404 may cross a second elongate member 2404 in an "X" configuration at two or more locations spaced apart from one another along the respective length 2411 of the second elongate member 2404 in the third/expanded configuration. In some example embodiments, a first elongate member 2404 may cross a second elongate member 2404 in an "X" configuration at least at three locations spaced apart from one another along the respective length 2411 of the second elongate member 2404 in the third/expanded configuration. As used herein and in the claims, when a first elongate member crosses a second elongate member in an X configuration at each of one or more locations, a respective portion of the first elongate member crosses a respective portion of the second elongate member at each location of the one or more locations in a crossed configuration similar in form to the letter "X" as viewed or projected perpendicularly from one of the elongate members at the portion, location or point of the crossing. It is understood that a crossing angle between respective pairs of crossed first and second elongate members may vary within a given embodiment or between different embodiments.

In this example embodiment, one of the respective side edges 2420 of at least a first elongate member 2404 crosses

one of the respective side edges 2420 of a second elongate member 2404 at each of a plurality of spaced apart locations along the respective length 2411 of the second elongate member 2404 as viewed normally to each of a respective one of a plurality of portions of the front surface 2418a of the second elongate member 2404 over which each of the plurality of spaced apart locations along the respective length 2411 of the second elongate member 2404 is positioned in the third-expanded configuration. In this example embodiment, one of the respective side edges 2420a and 2420b of at least a first elongate member 2404 crosses an opposite or opposed one of the respective side edges 2420a and 2420b of a second elongate member 2404 at each of a plurality of spaced apart locations along the respective length 2411 of the second elongate member 2404 as viewed normally to each of a respective one of a plurality of portions of the front surface 2418a of the second elongate member 2404 over which each of the plurality of spaced apart locations along the respective length 2411 of the second elongate member 2404 is positioned in the third-expanded configuration. That is, the one of the respective side edges 2420a and 2420b of the first elongate member 2404 and the crossed one of side edges 2420a and 2420b of the second elongate member 2404 are on opposing sides of the stacked arrangement 2415 during the first/unexpanded configuration. For example, as shown in FIG. 5D, the side edge 2420b of elongate member 2404a crosses the side edge 2420a of elongate member 2404b at each of a plurality of spaced apart locations along the respective length 2411 of elongate member 2404b as viewed normally to each of a respective one of a plurality of portions of the front surface 2418a of elongate member 2404b over which each of the spaced apart locations along the respective length 2411 of elongate member 2404b is positioned when the various elongate members 2404 are fanned along the first rotational direction (i.e., as represented by first arrow 2437a). Conversely, the side edge 2420a of elongate member 2404a crosses the side edge 2420b of elongate member 2404b at each of a plurality of spaced apart locations along the respective length 2411 of elongate member 2404b as viewed normally to each of a respective one of a plurality of portions of the front surface 2418a of elongate member 2404b over which each of the spaced apart locations along the respective length 2411 of elongate member 2404b is positioned when the various elongate members 2404 are fanned along the second rotational direction (i.e., as represented by second arrow 2437b) as shown in FIG. 5E. The various side edges 2420 of elongate member 2404a cross the side edges 2420 of the other elongate members 2404c, 2404d and 2404e in a similar manner in this illustrated embodiment. It is additionally noted in this illustrated embodiment that each of the respective side edges 2420a and 2420b of at least a first elongate member 2404 crosses a same one (i.e., edges on a same side of stacked arrangement 2415) of the respective side edges 2420a and 2420b of a second elongate member 2404 at each of a respective plurality of spaced apart locations along the respective length 2411 of the second elongate member 2404 as viewed normally to each of a respective one of a plurality of portions of the front surface 2418a of the second elongate member 2404 over which each of the respective plurality of spaced apart locations along the respective length 2411 of the second elongate member 2404 is positioned when the portion of device 2400 is in the third-expanded configuration.

In this example embodiment, the back surface 2418b of elongate member 2404a contacts the front surface 2418a of elongate member 2404b at each of at least one of the spaced

apart locations along the respective length 2411 of elongate member 2404b where a side edge 2420 of elongate member 2404a crosses a side edge 2420 of elongate member 2404b. In this example embodiment, the back surface 2418b of elongate member 2404a is separated or spaced from the front surface 2418a of each of elongate members 2404c, 2404d and 2404e at each of at least one of the spaced apart locations along the respective length 2411 of each of elongate members 2404c, 2404d and 2404e where a side edge 2420 of elongate member 2404a crosses a side edge 2420 of each of elongate members 2404c, 2404d and 2404e.

In this example embodiment, each of locations 2436b and 2436c passed through by one or more axes 2435 is spaced along the respective length 2411 of elongate member 2404a from a location of coupler 2422. In this example embodiment, coupler 2422 forms part of an articulable joint comprising a pivot axis that is generally coincident with the one or more axes 2435 at location 2436a in the third-expanded or fanned configuration. In this example embodiment, coupler 2422 is located relatively closer to the proximal end 2407 of elongate member 2404a than each of locations 2436b and 2436c as best exemplified in FIG. 5A. Additional couplers may be employed in other example embodiments. For example, an additional coupler may be employed to couple various ones of the elongate members 2404 together to cause the elongate members 2404 to cross or fan with respect to each other at location 2436c in the third-expanded or fanned configuration or maintain a crossed or fanned state at location 2436c in the third-expanded or fanned configuration. Additionally, a coupler may be employed to couple the elongate members 2404 at a location at least proximate to location 2436b. It is noted that various shearing translational movements typically are present between adjacent ones of the elongate members 2404 in stacked arrangement 2415 when the stacked arrangement 2415 is moved from the first/unexpanded configuration to the third-expanded or fanned configuration especially when the stacked arrangement 2415 is coiled within a bodily cavity. In some example embodiments, couplers employing obliquely oriented pivot members may be employed to allow for the shearing movement. In various embodiments, an employed pivot member may be a relatively rigid member or a relatively flexible member. In this example embodiment, each opening 2419b and 2419c is sized to receive at least one flexible line 2440 (called out twice) arranged to pass through each of the opening 2419b (i.e., shown in broken lines) and 2419c (not called out) provided in each of the elongate members 2404 as shown in FIG. 5C. A tubular member 2442 having a lumen sized to receive the at least one flexible line 2440 is additionally provided. Tubular member 2442 is partially sectioned to show flexible line 2440. Upon the application of tension to flexible line 2440 after the stacked arrangement 2415 has been coiled within a bodily cavity, the various elongate members 2404 can be drawn together to align respective ones of the openings 2419b together and respective ones of the openings 2419c together. Tubular member 2442 is provided to control or impede undesired movement of various portions of the elongate members 2404 towards one another along the at least one axis 2435 (not shown in FIG. 5C) under the influence of the tension in flexible line 2440 when the portion of the device 2400 is in the third-expanded or fanned configuration. In the first/unexpanded configuration, little tension is typically provided in flexible line 2440 and tubular member 2442 is conveyed along with the stacked arrangement 2415 through catheter sheath 2406. For clarity, flexible line 2440 and tubular member 2442 are not shown in FIGS. 5A, 5B, 5D, 5E, 5F, 5G and 5H.

The respective geodesics 2414 of the elongate members 2404 may also cross themselves in the third-expanded or fanned configuration. As best shown in FIGS. 5D and 5E, the respective geodesic 2414 of elongate member 2404a crosses the respective geodesic 2414 of at least one other elongate member 2404 (i.e., elongate member 2404b in this exemplary case) at various locations along the respective length 2411 of the at least one other elongate member 2404 as viewed normally to a respective portion of the front surface 2418a of the at least one other elongate member 2404 over which each respective location is positioned in the third-expanded or fanned configuration. For clarity of illustration, the respective geodesics 2414 of other ones of the elongate members 2404 are not shown in FIGS. 5D and 5E.

FIG. 5H is a schematic representation of elongate member 2404b crossed by various portions of elongate member 2404a in the third-expanded or fanned configuration. For clarity, each of elongate members 2404b and 2404a are shown in a “flattened” state and it is understood that these elongate members comprise respective arcuate profiles as exemplified in FIGS. 5D and 5E. In this example embodiment, elongate member 2404b is crossed by various portions of elongate member 2404a in an X configuration. In this example embodiment, the respective geodesic 2414 of elongate member 2404a advantageously crosses the respective geodesic 2414 of elongate member 2404b at three spaced apart locations including a first location 2444b positioned between two other locations 2444a and 2444c along the respective geodesic 2414 of elongate member 2404b in the third-expanded or fanned configuration. In this illustrated embodiment, each of the three spaced apart locations 2444a, 2444b and 2444c is positioned at least proximate to one of locations 2436a, 2436b and 2436c (i.e., marked by an “X” in FIG. 5H) on elongate member passed though by the one or more axes 2435 (not shown in FIG. 5H). It is noted that other geodesics 2414 defined on each of elongate members 2404a and 2404b may also cross each other in a similar manner. Other embodiments may employ other spatial relationships between the geodesic crossing locations and the locations 2436a, 2436b and 2436c passed through by the one or more axes 2435. In some embodiments, various ones of the geodesic crossing locations or various ones of the locations 2436a, 2436b and 2436c passed through by the one or more axes 2435 may not coincide with a location of a coupler (e.g., coupler 2422) employed to couple an elongate member 2404 with at least one other elongate member 2404.

In this example embodiment, various ones of the three spaced geodesic crossing locations including geodesic crossing location 2444b are located along the respective length 2411 of elongate member 2404b between a location of the coupler 2422 and the respective distal end 2405 of elongate member 2404b. In this example embodiment, geodesic crossing location 2444b is also located along the respective length 2411 of elongate member 2404b between coupler 2422 and a second coupler comprising flexible line 2440 (not shown in FIG. 5H) passing through opening 2419c in elongate member 2404b.

FIG. 6A is a side elevation view of a portion of a device 2500 according to one example embodiment. Device 2500 includes a structure or frame 2502 that includes an arrangement of elongate members 2504a, 2504b, 2504c, 2504d, 2504e, 2504f, 2504g, 2504h, and 2504i (collectively 2504). Various ones of the elongate members 2504 are physically coupled to shaft member 2510 which is sized to convey the elongate members 2504 through catheter sheath 2506. Shaft member 2510 includes a first end portion 2510a physically coupled to a handle portion 2503 and a second end portion

2510b physically coupled to frame 2502. In this example embodiment, the second end portion 2510b of shaft member 2510 is coupled to frame 2502 at one or more locations proximate to the respective proximal ends 2507 (only one called out) of various ones of the elongate members 2504. In this example embodiment, the second end portion 2510b of shaft member 2510 is physically coupled to frame 2502 at a location proximate the respective proximal end 2507 of elongate member 2504a.

FIG. 6B is an isometric view of a representative one of the elongate members 2504. Each of the elongate members 2504 includes a respective distal end 2505, a respective proximal end 2507 and an intermediate portion 2509 positioned between the proximal end 2507 and the distal end 2505. Each elongate member 2504 includes a respective length 2511 between the respective proximal and distal ends 2507, 2505 of the elongate member. In this example embodiment, each of various ones of the elongate members 2504 has a different respective length 2511 than the respective length 2511 of another of the elongate members 2504. In some embodiments, two or more of the elongate members 2504 may have substantially equal lengths 2511. In a manner similar to the respective length of various previously described elongate members, each of the elongate members 2504 has a respective length 2511 (not called out in FIGS. 6A, 6C, 6D, 6E, 6F, 6G, 6H, 6I, 6J, 6K, 6L, and 6M) that is at least approximately equal or greater than a circumference of a portion of an interior tissue surface of a bodily cavity (not shown) to which the elongate member 2504 is positioned at least proximate to when the portion of the device 2500 is in a deployed configuration. In a manner similar to other described embodiments, transducer elements (not shown) may be distributed along the respective length 2511 of various ones of the elongate members 2504. Transducer elements carried by a given one of elongate members 2504 can be distributed around a circumferential region of the interior tissue surface of a bodily cavity (again not shown) over which the given one of the elongate members 2504 is positioned at least proximate to in a deployed configuration.

Referring back to FIG. 6B, the intermediate portion 2509 of each of the elongate members 2504 includes a set of two opposing major faces or surfaces 2518 made up of a front surface 2518a and a back surface 2518b. In this example embodiment, the two opposing surfaces 2518 are separated from one another by a thickness 2517 of the elongate member 2504. In this illustrated example, the intermediate portion 2509 of each elongate member 2504 further includes a pair of side edges 2520a, 2520b (collectively 2520) of at least one of the front surface 2518a and the back surface 2518b (i.e., front surface 2518a in this embodiment), the side edges of each pair of side edges 2520 opposed to one another across at least a portion of the length 2511 of the respective elongate member 2504. In this example embodiment, the pair of side edges 2520 defines a portion of a periphery of the front surface 2518a of the elongate member 2504. A geodesic 2514 (i.e., shown as a broken line) is definable for each elongate member 2504. Each geodesic 2514 extends along a portion of the elongate member 2504 between a first location at least proximate the proximal end 2507 and a second location at least proximate the distal end 2505 of the elongate member 2504. In this embodiment, each geodesic 2514 extends across the respective front surface 2518a of the elongate member 2504. A portion of geodesic 2514 is shown on the back surface 2518b of elongate member 2504b in FIG. 6B for clarity only. It is understood that the geodesic 2514 in FIG. 6B extends across the front surface 2518a of elongate member 2504. Each

elongate member 2504 includes a plurality of openings including first opening 2519a, second opening 2519b and third opening 2519c. In this embodiment, each of first opening 2519a, second opening 2519b and third opening 2519c provides a passageway through the intermediate portion 2509 of a respective elongate member 2504. Each of first opening 2519a, second opening 2519b and third opening 2519c is spaced from one another along the length 2511 of a respective elongate member 2504.

In this example embodiment, at least the respective intermediate portions 2509 (one called out in FIG. 6A) of various ones of the elongate members 2504 are preformed to have a substantially bent, arcuate or curved profile in an initial state (i.e., a low energy state). As best shown in FIG. 6A, each of various ones of the elongate members 2504 has a coiled profile (e.g., a profile that curves back on itself) in the initial or low energy state. In some example embodiments, various ones of the elongate members 2504 are coiled in the initial or low energy state. In this particular embodiment, each of the elongate members 2504 includes a scrolled or volute shape profile in the initial configuration. As shown in FIG. 6A, each of the respective intermediate portions 2509 of the elongate members 2504 are arranged with respect to one another front surface 2518a-toward-back surface 2518b in an initial stacked array 2516 in the initial configuration. In this illustrated embodiment, the initial stacked array 2516 is an arcuate stacked array. In this illustrated embodiment, the initial stacked array 2516 is a coiled stacked array. In this illustrated embodiment, each of the elongate members 2504 has a different curvature along its respective length 2511 in the initial stacked array 2516. In this example embodiment, each of the elongate members 2504 makes at least one full turn within the initial stacked array 2516.

In various example embodiments, each of various ones of the elongate members 2504 is physically coupled together with at least one other elongate member 2504 by at least one coupler. In this illustrated embodiment, device 2500 includes a plurality of couplers 2522 including a proximal coupler 2522a, a distal coupler 2522c and at least one intermediate coupler 2522b. In various example embodiments, each of proximal coupler 2522a, distal coupler 2522c and at least one intermediate coupler 2522b is arranged to couple at least a first one of the elongate members 2504 with at least one other of the elongate members 2504. In this illustrated embodiment, proximal coupler 2522a forms part of a pivotable joint and includes a pivot member 2523. In this embodiment pivot member 2523 is in the form of a pin sized to be received in the respective first opening 2519a (i.e., first opening 2519a shown in FIG. 6B) provided in each of the elongate members 2504. Each of various ones of the elongate members 2504 is configured to turn, revolve, pivot or rotate (i.e., used interchangeably herein) about a pivot axis associated with pivot member 2523.

In this example embodiment, distal coupler 2522c includes a first portion 2541a of a flexible line 2540c sized and arranged to be received in the respective third opening 2519c (i.e., best seen in FIG. 6B) of each of the elongate members 2504 thereby physically coupling each of the elongate members 2504 together. In this example embodiment, at least a second portion 2541b of flexible line 2540c forms part of a control member of an elongate member manipulator 2550, a portion of which may extend along a path through catheter sheath 2506. Elongate member manipulator 2550 may include various actuators (not shown) operably coupled to various control members to transmit force via the various control members. Suitable actuators may include powered or passive actuators. Suitable actua-

tors may include a handle, knob, lever, etcetera (not shown) manipulated by a care provider to cause force to be transmitted via a control member. In some embodiments, a separate control member is coupled to the first portion 2541a of flexible line 2540c. In this example embodiment, intermediate coupler 2522b includes a flexible line 2540b sized and arranged to be received in the respective second opening 2519b (i.e., best seen in FIG. 6B) of each of the elongate members 2504 thereby physically coupling each of the elongate members together. Various knots, ferrules, bushings, etcetera may be employed to restrain a flexible line positioned in at least one of second and third openings 2519b, 2519c from escaping from the openings. It is noted that alternative or additional couplers 2522 can be employed in some embodiments. For example, couplers such as coupling members 1458, 1758 may be employed to couple various ones of the elongate members 2504 together. It is noted that the number of couplers 2522 is not limited to three and may include a number less than or greater than three. In some example embodiments only proximal coupler 2522a and distal coupler 2522c are employed. Various ones of the proximal coupler 2522a, distal coupler 2522c and at least one intermediate coupler 2522b may each couple some or all of the elongate members 2504 in various example embodiments.

In this example embodiment, FIGS. 6C, 6D, 6E, and 6F are various side elevation views of a portion of device 2500 positioned within a bodily cavity at four successive intervals of time according to an example embodiment. In this illustrated embodiment, the bodily cavity is a left atrium 2562 of a heart 2560 which is shown sectioned for clarity. As shown in FIG. 6C, the elongate members 2504 (only one called out) are interleaved with one front surface 2518a toward another's back surface 2518b (not called out in FIG. 6C) in a stacked array 2515 sized to be delivered through a bodily opening 2564 (i.e., via a lumen 2506c of catheter sheath 2506 shown sectioned in FIG. 6C) when a portion of device 2500 is in a delivery configuration also known as a first or unexpanded configuration. In this example embodiment, the bodily opening 2564 leads to left atrium 2562 which includes an interior tissue surface 2562a that is interrupted by a port 2564a of opening 2564. In this example embodiment, the respective intermediate portions 2509 (only one called out) of the elongate members 2504 are arranged in stacked array 2515 such that each elongate member 2504 is advanced distal end 2505 first into left atrium 2562 in the first/unexpanded configuration. In this example embodiment, the plurality of couplers 2522 are arranged to be advanced distal coupler 2522c first into left atrium 2562 in the delivery configuration. For clarity, flexible lines 2540b and 2540c associated with respective ones of intermediate coupler 2522b and distal coupler 2522c are not shown in FIGS. 6C, 6D, 6E, 6F, 6G, 6H, 6I, 6K, 6L, 6N and 6O.

In this example embodiment, the respective intermediate portions 2509 of various ones of the elongate members 2504 in the initial stacked array 2516 have been stressed into a higher energy state from their initial or low energy state shown in FIG. 6A. In this example embodiment, the elongate members 2504 in the initial stacked array 2516 have been stressed into a higher energy state suitable for unbending them sufficiently enough for delivery through catheter sheath 2506 during the delivery configuration as shown in FIG. 6C. In this example embodiment, the initial stacked array 2516 is stressed into a higher energy state by retracting the initial stacked array 2516 into catheter sheath 2506 prior to inserting catheter sheath 2506 into a body. In some example embodiments, the initial stacked array 2516 is

stressed into a higher energy state by uncoiling the initial stacked array 2516 and inserting the initial stacked array into catheter sheath 2506. In some example embodiments, the arrangement of elongate members 2504 is reconfigured from the initial configuration shown in FIG. 6A to the delivery configuration shown in FIG. 6C at a point-of-use. In some example embodiments, the arrangement of elongate members 2504 is reconfigured from the initial configuration shown in FIG. 6A to the delivery configuration shown in FIG. 6C at a place of manufacture, assembly or distribution. In various embodiments, various devices including various guides or manipulators may be employed to reconfigure the arrangement of elongate members 2504 from the initial configuration shown in FIG. 6A to the delivery configuration shown in FIG. 6C. In some of these various embodiments, the devices form part of device 2500. In some of these various embodiments, the devices are extraneous to device 2500. Preferably, the higher energy states are controlled to not cause damage to device 2500 or catheter sheath 2506 during delivery therethrough.

In this example embodiment, potential energy is imparted into the various elongate members 2504 in the stacked array 2515 by the higher energy state, the potential energy sufficient to return the arrangement of elongate members 2504 generally back to their initial energy state when released from the confines of catheter sheath 2506. In this example embodiment, the lumen 2506c is positioned between a first end 2506a of catheter sheath 2506 and a second end 2506b of catheter sheath 2506. In some embodiments, catheter sheath 2506 may include a plurality of lumens. In this embodiment, each of the elongate members 2504 is arranged to be delivered through the lumen 2506c of the catheter sheath from the first end 2506a toward the second end 2506b in the delivery configuration. In this example embodiment, each of the elongate members 2504 is arranged to be advanced distal end 2505 first out from the lumen 2506c of the catheter sheath 2506 in the delivery configuration.

FIG. 6D shows the portion of the device 2500 including the plurality of elongate members 2504 positioned in a deployed configuration also known as a second or bent configuration within left atrium 2562. In this example embodiment, each elongate member 2504 (only one called out) is bent about a respective bending axis 2531 (only one shown) into an arcuate stacked array 2532. In some embodiments, a portion of each of various ones of the elongate members 2504 is bent with a substantially constant curvature about a respective bending axis 2531. In some embodiments, a portion of each various ones of the elongate members 2504 is bent with a varying curvature about a respective bending axis 2531. Each bending axis 2531 extends along a direction having a directional component transversely oriented to the respective length 2511 (not called out in FIG. 6D) of the elongate member 2504. In this example embodiment, each elongate member 2504 in the arcuate stacked array 2532 is coiled about a respective bending axis 2531 into a coiled stacked array. In this example embodiment, each elongate member 2504 is bent to have a volute shape profile within the left atrium 2562. In this example embodiment, each elongate member is bent to have a curvature within the left atrium that varies at least once along the respective length 2511 of the elongate member 2504. When positioned in the second/bent configuration, a first portion 2521a of the front surface 2518a of the respective intermediate portion 2509 (only one called out) of each elongate member 2504 is positioned diametrically opposite to a second portion 2521b of the front surface 2518a in the volute shaped frame 2502. When positioned in

the second/bent configuration, the coiled arrangement of elongate members 2504 is sized too large for delivery through the lumen 2506c of catheter sheath 2506.

In this illustrated embodiment, the respective intermediate portions 2509 of various ones of the elongate members 2504 have been preformed to autonomously bend when the intermediate portions 2509 are advanced into a bodily cavity such as left atrium 2562. As the respective intermediate portions 2509 are advanced into left atrium 2562, they are freed of the confines of catheter sheath 2506 and return to their low energy state (i.e., their initial coiled configuration). In this example embodiment, the respective distal end 2505 of various ones of the elongate members 2504 moves along a coiled path (e.g., a path that curves back on itself) within the left atrium 2562 when the portion of the device 2500 is moved between the first/unexpanded configuration and the second/bent configuration. In this example embodiment, the coiled path makes at least one full turn within left atrium 2562. In some embodiments, at least part of the coiled path may extend along a volute path. In this example embodiment, the elongate members 2504 in the second/bent configuration are arranged in an arcuate stacked array 2532 that is similar to the initial stacked array 2516 that elongate members 2504 are arranged in their initial state (i.e., as shown in FIG. 6A). In this example embodiment, shaft member 2510 and frame 2502 have a projected outline generally in the shape of the Greek letter rho ( $\rho$ ) in the second/bent configuration, which letter may be open at point where a loop of the letter would intersect a tail of the letter, and either without, or with, an opening defined by the loop portion of the letter represented in the projected outline.

In this embodiment, various elongate members 2504 are preformed to cause stacked array 2515 to autonomously coil as it is advanced into left atrium 2562 in a manner that may advantageously reduce physical interactions between stacked arrangement 2515 and interior tissue surface 2562a within left atrium 2562 since the respective distal ends 2505 (only one called out) of the elongate members 2504 continuously bend or curl away from the interior tissue surface 2562a as the elongate members 2504 are advanced into left atrium 2562. A reduction of contact and other physical interaction with the interior tissue surface 2562a can reduce occurrences of, or the severity of, damage inflicted to various tissue structures within left atrium 2562 during this positioning. In this illustrated embodiment, the arcuate stacked array 2532 is preferably sized to be positionable within left atrium 2562 with at most, minor amounts of contact with the interior tissue surface 2562a of left atrium 2562. This illustrated embodiment may additionally reduce potential damage to various tissue structures within left atrium 2562 over embodiments employing benders (e.g., benders 1430, and 1730) that bend the elongate members as they are advanced into a bodily cavity. Many benders can impart potential energy into the elongate members during the bending of various portions of the elongate members within a bodily cavity. A failure of either the bender or the elongate member itself can release at least a portion of the potential energy and possibly damage various tissue structures in the bodily cavity. Unlike those embodiments, the elongate members 2504 in the arcuate stacked array 2532 have little potential energy since they are substantially already in their low energy state.

FIG. 6E shows the portion of the device 2500 in a deployed configuration also referred to as a third or expanded or fanned configuration in left atrium 2562. In this illustrated embodiment, the elongate members 2504 (only one called out) were moved from the second/bent configu-

ration shown in FIG. 6D to the third/expanded or fanned configuration shown in FIG. 6E. In this illustrated embodiment, at least some of the elongate members 2504 in the arcuate stacked array 2515 shown in FIG. 6E are repositioned in left atrium 2562. In this example embodiment, various ones of the elongate members 2504 are moved to angularly space various portions of at least some of the elongate members 2504 with respect to one another within left atrium 2562. In this illustrated embodiment, various ones of the elongate members 2504 are fanned with respect to one another about one or more fanning axes (not shown in FIG. 6E) into a first fanned array 2570.

As shown in FIGS. 6G, 6H, 6I and 6J, at least one of the elongate members 2504 crosses another of the elongate members 2504 in an X configuration at a location proximate a first axis 2535. As shown in FIGS. 6G, 6H, 6I and 6J, various ones of the elongate members 2504 are fanned about first axis 2535. In this example embodiment, first axis 2535 passes through a plurality of spaced apart locations along the respective length 2511 of each of at least some of the elongate members 2504 when the portion of the device is in the third/expanded or fanned configuration. In this example embodiment, the respective intermediate portions 2509 of each of at least some of the elongate members 2504 are angularly spaced with respect to one another about first axis 2535. In this illustrated embodiment, each of the at least some of the plurality of elongate members 2504 includes a curved portion 2509a (i.e., shown in FIGS. 6G, 6H, and 6I) arranged to extend along at least a portion of a respective curved path that intersects the first axis 2535 at each of a respective at least two spaced apart locations along first axis 2535 in the third/expanded configuration. In various embodiments, a curved portion 2509a of an elongate member 2504 can extend entirely along, or at least partway along a respective curved path that intersects the first axis 2535 at each of a respective at least two spaced apart locations along first axis 2535 in the third/expanded configuration. In various embodiments, the curved path is an arcuate path. In various embodiments, at least the portion of the curved path extended along by curved portion 2509a is arcuate. In this embodiment, at least a first elongate member 2504 crosses a second elongate member 2504 in an X configuration at each of at least one of the respective at least two spaced apart locations along the first axis 2535 intersected by at least the portion of the respective curved path extended along by the curved portion 2509a of the second elongate member 2504 in the third/expanded configuration. In this example embodiment, the first axis 2535 is shown as a single axis. It is understood that first axis 2535 can include one or more axes in various embodiments. As shown in FIG. 6I, in this example embodiment a portion of frame 2502 is radially spaced from first axis 2535 by a first dimension 2580a in the third/expanded configuration. In various example embodiments, the portion of frame 2502 that is radially spaced from first axis 2535 by first dimension 2580a may include the respective curved portion 2509a of at least one of the elongate members 2504.

In this illustrated embodiment, the second end portion 2510b of shaft member 2510 is not physically coupled or connected to frame 2502 at various locations on frame 2502 that are symmetrically positioned about first axis 2535 as viewed along first axis 2535 in the third/expanded configuration. Rather, in this example embodiment, the second end portion 2510b of shaft member 2510 is physically coupled or connected to frame 2502 at one or more locations on frame 2502, each of the one or more locations on the structure to which the second end portion 2510b is coupled

positioned to one side of at least one spatial plane (not shown) that is coincident with first axis 2535. In this example embodiment, the second end portion 2510b of shaft member 2510 is physically coupled or connected at least proximate to the proximal ends 2507 of various ones of the elongate members 2504 in frame 2502. In this illustrated embodiment, the positioning between frame 2502 and the second end portion 2510b of shaft member 2510 results at least in part from the coiling of various ones of the elongate members 2504 within left atrium 2562. In this example embodiment, shaft member 2510 is positioned to avoid intersection by first axis 2535 in the third/expanded configuration. In this example embodiment, shaft member 2510 is positioned to avoid intersection of the second end portion 2510b by first axis 2535 in the third/expanded configuration. In some example embodiments, each of at least some of the plurality of elongate members 2504 may extend generally tangentially from the second end portion 2510b of shaft member 2510 in the third/expanded or fanned configuration. In this example embodiment, shaft member 2510 and frame 2502 have a projected outline in the shape of the Greek letter rho ( $\rho$ ) in the third/expanded configuration. As noted above, the Greek letter rho may be represented as open at a point where a loop of the letter would intersect a tail of the letter if closed or not open, and either without or with an opening defined by a loop portion of the letter represented.

Various ones of the elongate members 2504 can be moved in various ways as the portion of the device 2500 is moved into the third/expanded or fanned configuration. In this example embodiment, elongate members 2504 are fanned in a manner similar to that illustrated in FIGS. 4G and 4H when the portion of device 2500 is moved from the second/bent configuration shown in FIG. 6D to the third/expanded configuration shown in FIG. 6E. In this example embodiment, a first set of "even" elongate members 2504 (i.e., elongate members 2504b, 2504d, 2504f and 2504h) in the sequential arrangement of elongate members 2504 in the arcuate stacked arrangement 2532 are fanned along an opposite direction than a second set of the "odd" elongate members 2504 (i.e., elongate members 2504c, 2504e, 2504g and 2504i) in the sequential arrangement of elongate members 2504 in the arcuate stacked arrangement 2532 are fanned along. In this context, the words "even" and "odd" relate to a position of a respective one of the elongate members 2504 in the arcuate stacked array 2532. In this example embodiment, the elongate members 2504 in the "even" set are interleaved with the elongate member 2504 in the "odd" set in the arcuate stacked array 2532. In this example embodiment, various fanning mechanisms (not shown) can be employed to move various ones of the elongate members 2504 into the third/expanded configuration. In some example embodiments, various separators similar to previously described separators 1452 and 1752 may be employed to partially or fully fan at least some of the elongate members 2504.

In this example embodiment, when the portion of the device 2500 is moved into the third/expanded configuration, a portion of the front face 2518a (not called out in FIG. 6E) of each of at least some of the elongate members 2504 in the arcuate stacked array 2532 that faces the back surface 2518b (not called out in FIG. 6E) of another elongate member 2504 in the arcuate stacked array 2532 is repositioned in left atrium 2562 such that the portion of the front face 2518a of each of the at least some of the elongate members 2504 in the first fanned array 2570 directly faces a portion of the interior tissue surface 2562a within left atrium 2562. FIGS. 6G and 6H are respective detailed isometric views of the

elongate members 2504 arranged in the first fanned array 2570 during the third/expanded or fanned configuration, each of the views showing one of two opposing sides of the first fanned array 2570. Elongate member 2504a and the set of “odd” elongate members 2504c, 2504e, 2504g and 2504i are called out in FIG. 6G while elongate member 2504a and the set of “even” elongate members 2504b, 2504d, 2504f and 2504h are called out in FIG. 6H. In this example embodiment, each of a first portion 2521a (one called out) of the front surface 2518a of each elongate member 2504 is positioned diametrically opposite to a second portion 2521b (only one called out) of the front surface 2518a (i.e., as compared between FIGS. 6G and 6H) when the portion of device 2500 is in the third/expanded configuration.

In this embodiment, frame 2502 is a structure that includes a proximal portion 2502a and a distal portion 2502b, each of the proximal and distal portions 2502a, 2502b made up of a respective portion of each elongate member 2504 of the plurality of elongate members 2504. As best seen in FIG. 6C, frame 2502 is arranged to be advanced distal portion 2502b first into left atrium 2562 when the portion of the device 2500 is in the first/unexpanded configuration. As best seen in each of the FIGS. 6G and 6H, the proximal portion 2502a of frame 2502 defines a first domed shape 2508a and the distal portion 2502b of frame 2502 defines a second domed shape 2508b when the portion of the device is in the third/expanded or fanned configuration. In this example embodiment, first domed shape 2508a has a respective apex 2512a (i.e., shown in FIG. 6H) and second domed shape 2508b has a respective apex 2512b (i.e., shown in FIG. 6G). In some example embodiments, apex 2512b associated with the distal portion 2502b of frame 2502 is positioned relatively closer to the port 2564a of opening 2564 than apex 2512a associated with the proximal portion 2502a of frame 2502 when the portion of the device is in the third/expanded or fanned configuration. In some example embodiments, apex 2512b associated with the distal portion 2502b of frame 2502 is positioned between port 2564a and apex 2512a associated with the proximal portion 2502a of frame 2502 when the portion of device 2500 is in the third/expanded or fanned configuration. In some example embodiments, apex 2512b associated with the distal portion 2502b of frame 2502 is positioned between second end 2506b of catheter sheath 2506 and apex 2512a associated with the proximal portion 2502a of frame 2502 when the portion of device 2500 is in the third/expanded or fanned configuration. In some example embodiments, apex 2512b associated with the distal portion 2502b of frame 2502 is positioned between a portion of shaft member 2510 and apex 2512a associated with the proximal portion 2502a of frame 2502 when the portion of device 2500 is in the third/expanded or fanned configuration.

In various example embodiments, either of the first and the second domed shapes 2508a, 2508b need not be substantially hemispherical. For example, at least one of the first domed shape 2508a and the second domed shape 2508b may have a first radius of curvature in a first spatial plane and a second radius of curvature in a second spatial plane that intersects the first spatial plane, a magnitude of the second radius of curvature different than a magnitude of the first radius of curvature. In this example embodiment, each elongate member 2504 of at least some of the plurality of elongate members 2504 crosses at least one other elongate member 2504 of the plurality of elongate members 2504 at a location between the proximal and the distal portions 2502a, 2502b of frame 2502 when the portion of the device 2500 is in the third/expanded configuration. In this example

embodiment, the proximal and the distal portions 2502a, 2502b of frame 2502 are arranged in a clam shell configuration in the third/expanded configuration.

FIG. 6I is a sectioned side elevation view of the detailed isometric view of the first fanned array 2570 shown in FIG. 6G. Each of FIGS. 6G, 6H, 6I and 6J additionally shows a respective portion of shaft member 2510 and catheter sheath 2506 as well as a portion of the port 2564a interrupting the interior tissue surface 2562a (not called out in FIG. 6H) of left atrium 2562. In this illustrated embodiment, each of the elongate members 2504 includes a scrolled or a volute shape profile in the third/expanded configuration as best exemplified by elongate member 2504a in FIG. 6I. In this illustrated embodiment, various portions of the elongate members 2504 are fanned such that the second opening 2519b (only one called out in each of FIGS. 6G, 6H, 6I and 6J) and third opening 2519c (only one called out in each of FIGS. 6G, 6H, 6I and 6J) of each of various ones of elongate members 2504 is not aligned with a respective one of the second opening 2519b and third opening 2519c of another of the elongate members 2504. For clarity, each of flexible line 2540b and the first portion 2541a of flexible line 2540c that form part of a respective one of intermediate coupler 2522b and distal coupler 2522c and which are arranged to pass through a respective one of the second opening 2519b and the third opening 2519c in each of the elongate members 2504 are not shown in each of FIGS. 6G, 6H and 6I.

FIG. 6J is a partially sectioned end elevation view of the first fanned array 2570 showing the respective distal ends 2505 (two called out) of the elongate members 2504. Various ones of the elongate members 2504 are partially sectioned in FIG. 6J to better show the respective distal ends 2505 of the elongate members 2504. FIG. 6J shows the first portion 2541a of flexible line 2540c follows a winding, zig-zag or serpentine path through the third openings 2519c (i.e., only one called out) of alternating ones of the “even” elongate members 2504b, 2504d, 2504f and 2504h and the “odd” elongate members 2504c, 2504e, 2504g and 2504i. Flexible line 2540b (not shown) may follow a similar path through the second openings 2519b (i.e., only one called out). The second portion 2541b of flexible line 2540c is also shown in FIG. 6J.

As best shown in FIGS. 6G and 6H, the respective geodesic 2514 of elongate member 2504g crosses the respective geodesic 2514 of at least one other elongate member 2504 (i.e., elongate member 2504i in this exemplary case) at various locations along the respective length 2511 (not called out) of the at least one other elongate member 2504 as viewed normally to a respective portion of the front surface 2518a of the at least one other elongate member 2504 over which each respective location is positioned in the third/expanded configuration. For clarity of illustration, the respective geodesics 2514 of various ones of the elongate members 2504 are not shown in FIGS. 6G and 6H.

FIG. 6N schematically shows a portion of the first fanned array 2570 that includes second elongate member (i.e., elongate member 2504i) with various portions of a first elongate member (i.e., elongate member 2504g) crossing the second elongate member 2504i in an X configuration at various locations in the third/expanded or fanned configuration. For clarity, each of elongate members 2504i and 2504g are shown in a “flattened” state and it is understood that these elongate members include respective arcuate profiles as exemplified in FIGS. 6G and 6H. The respective geodesic 2514 of the first elongate member 2504g crosses the respective geodesic 2514 of the second elongate member

**2504*i*** at a plurality of spaced apart locations (i.e., each represented by an "X" in FIG. 6N) including a first location **2544*c*** positioned relatively closer to the respective distal end **2505** of the second elongate member **2504*i*** than two other locations **2544*a*** and **2544*b*** along the respective geodesic **2514** of second elongate member **2504*i*** in the third/expanded or fanned configuration. It is understood that each of the crossing locations **2544*a***, **2544*b*** and **2544*c*** is located on the front surface **2518*a*** of the second elongate member **2504*i*** and is overlapped by first elongate member **2504*g*** in FIG. 6N. In this illustrated embodiment, the first location **2544*c*** is positioned between the location of the proximal coupler **2522*a*** and the respective distal end **2505** of the second elongate member **2504*i***. In this illustrated embodiment, the first location **2544*c*** is positioned along the respective length **2511** of the second elongate member **2504*i*** between the respective locations of distal coupler **2522*c*** (i.e., the first portion **2541*a*** of flexible line **2540*c*** which is not shown but whose location in FIG. 6N is represented by third opening **2519*c***) and the intermediate coupler **2522*b*** (i.e., flexible line **2540*b*** whose location in FIG. 6N is represented by second opening **2519*b***). In this example embodiment, the first location **2544*c*** is positioned along the respective length **2511** of second elongate member **2504*i*** relatively closer to the respective distal end **2505** of second elongate member **2504*i*** than a respective location of each of the intermediate coupler **2522*b*** and the proximal coupler **2522*a***. In this example embodiment, the first location **2544*c*** is spaced apart from the respective distal end **2505** of second elongate member **2504*i***. In this example embodiment, the first elongate member **2504*g*** crosses the second elongate member **2504*i*** in an X configuration at each of locations **2544*b*** and **2544*c***.

In this example embodiment, additional manipulation of a portion of device **2500** including elongate members **2504** within a bodily cavity such as left atrium **2562** is initiated when the portion of the device **2500** is moved into the third/expanded or fanned configuration. Typically, when the elongate members **2504** arranged in arcuate stacked array **2532** are repositioned into a fanned array (i.e., first fanned array **2570** in this example embodiment), the elongate members **2504** are preferably arranged generally away from various tissue surfaces within the left atrium **2562** to avoid obstructions that could hinder repositioning or to avoid inflicting damage to the tissue surfaces. Referring to FIG. 6E, various portions of each of some of the elongate members **2504** are positioned away from the interior tissue surface **2562*a*** within left atrium **2562** when the portion of the device **2500** is in the third/expanded configuration. As compared between FIGS. 6G and 6H, the first portions **2521*a*** (only one called out) and the second portions **2521*b*** (only one called out) of the front surface **2518*a*** of each of least some of the elongate members **2504** in the first fanned array **2570** are angularly spaced about first axis **2535** when the portion of the device **2500** is in the third/expanded configuration. In this illustrated embodiment, at least some of the elongate members **2504** are further manipulated in the third/expanded configuration to vary a radial spacing between the first axis **2535** and at least one of the first portion **2521*a*** and the second portion **2521*b*** of the front surface **2518*a*** of various ones of the elongate members **2504**.

As shown in FIG. 6F, at least some of the elongate members **2504** (only one called out) are further manipulated in the third/expanded configuration to form a second fanned array **2572**. In this example embodiment, at least some of the elongate members **2504** are further manipulated to increase

a radial distance between the first axis **2535** and at least one of the first portion **2521*a*** (not called out in FIG. 6F) and the second portion **2521*b*** (not called out in FIG. 6F) of the front surface **2518*a*** of various ones of the elongate members **2504**. In this example embodiment, at least some of the elongate members **2504** are further manipulated to increase first dimension **2580*a*** (not called out in FIG. 6F).

Further manipulation of the at least some of the elongate members **2504** may be motivated for various reasons. For example, the at least some of the elongate members **2504** may be further manipulated to adjust a positioning between various transducer elements carried by the elongate members **2504** and a tissue surface within a bodily cavity. The at least some of the elongate members **2504** may be further manipulated to create conformance with a tissue surface with a bodily cavity such as left atrium **2562** when the portion of the device **2500** is moved into the third/expanded or fanned configuration. In some example embodiments, a tissue surface within a bodily cavity such as left atrium **2562** is further manipulated to conform to a shape of a number of the elongate members **2504** when the portion of the device **2500** is moved into the third/expanded or fanned configuration. In some example embodiments, a portion of the elongate members **2504** and a tissue surface within a bodily cavity such as left atrium **2562** are each further manipulated to create conformance between a number of the elongate members **2504** and a portion of the tissue surface when the portion of the device **2500** is moved into the third/expanded or fanned configuration. In this example embodiment, shaft member **2510** and frame **2502** have a projected outline in the shape of the Greek letter rho ( $\rho$ ), as noted above, when the elongate members **2504** are further manipulated into the second fanned array **2572**.

FIGS. 6K and 6L are respective detailed isometric views of the elongate members **2504** arranged in the second fanned array **2572** shown in FIG. 6F, each of the views showing one of two opposing sides of the second fanned array **2572**. In some example embodiments, the proximal and the distal portions **2502*a***, **2502*b*** of frame **2502** are additionally manipulated when the portion of the device is moved into the third/expanded or fanned configuration. In some example embodiments, the respective dome shaped structures (i.e., first and second domed shapes **2508*a***, **2508*b***) of the proximal and the distal portions **2502*a***, **2502*b*** of frame **2502** are physically coupled together to pivot with respect to one another when the structure is in the third/expanded configuration. In this example embodiment, the respective dome shaped structures (i.e., first and second domed shapes **2508*a***, **2508*b***) of the proximal and the distal portions **2502*a***, **2502*b*** of frame **2502** may be pivoted with respect to one another about a region of reduced bending stiffness in frame **2502**. In some example embodiments, portions of various ones of the elongate members **2504** provide a flexure portion of the frame **2502** between the proximal and the distal portions **2502*a***, **2502*b*** that pivotably couples the proximal and the distal portions **2502*a***, **2502*b*** together. In some example embodiments, the proximal and the distal portions **2502*a***, **2502*b*** are pivoted with respect to one another to change a distance therebetween. For example, the proximal and the distal portions **2502*a***, **2502*b*** may be pivoted apart to create conformance between frame **2502** and a portion of a tissue surface within a bodily cavity. In some example embodiments, the proximal and the distal portions **2502*a***, **2502*b*** are pivoted with respect to one another to change a distance between apex **2512*a*** and apex **2512*b***.

In this example embodiment, at least one of the proximal and the distal portions **2502*a***, **2502*b*** of frame **2502** is

additionally manipulated to distort a respective one of the first domed shape **2508a** and the second domed shape **2508b** to move between the first fanned array **2570** and the second fanned array **2572**. Each of the first domed shape **2508a** and the second domed shape **2508b** has a respective volume therein. In some example embodiments, at least one of the proximal and the distal portions **2502a**, **2502b** of frame **2502** is acted upon to reduce a difference between the respective volumes of the first and the second domed shapes **2508a**, **2508b**. In some example embodiments, frame **2502** is acted upon to vary the respective volume of at least one of the first and the second domed shapes **2508a**, **2508b**. In this example embodiment, a respective volume associated with at least the second domed shape **2508b** is increased to move between the first fanned array **2570** and the second fanned array **2572**. In some example embodiments, each of the proximal and the distal portions **2502a**, **2502b** of frame **2502** are pivotable with respect to one another at a pivot location (e.g., near a crossing location of the elongate members) and each of the first and the second domed shapes **2508a**, **2508b** may be characterized at least in part by a respective height (not shown) extending normally from a respective spatial plane (not shown) to the respective apex (i.e., apex **2512a** or apex **2512b**) of the domed shape. Frame **2502** may be acted upon to vary at least one of a magnitude of the respective height of the first domed shape **2508a** and a magnitude of the respective height of the second domed shape **2508b** to move between the first fanned array **2570** and the second fanned array **2572**.

FIG. 6M shows a sectioned elevation view of the detailed isometric view of FIG. 6K. Each of FIGS. 6K, 6L and 6M additionally includes a respective portion of shaft member **2510** and catheter sheath **2506** as well as the port **2564a** interrupting the interior tissue surface **2562a** (not called out in FIG. 6L) within left atrium **2562**. As shown in FIGS. 6K and 6L, the respective intermediate portions **2509** (only one called out) are still fanned or angularly spaced about first axis **2535** in this example embodiment, albeit the first axis **2535** passes through at least some locations through various ones of the elongate members **2504** that are different than the respective locations passed through by the first axis **2535** in the first fanned array **2570** shown in FIGS. 6G and 6H. In this respect, the angular arrangement is similar to an arrangement of lines of longitude about a body of rotation, which may or may not be a spherical body of rotation. In this illustrated embodiment, each of at least some of the plurality of elongate members **2504** continues to include a curved portion **2509a** arranged to extend along at least a portion of a respective curved path that intersects the first axis **2535** at each of a respective at least two spaced apart locations along first axis **2535** after the additional manipulation. As shown in FIGS. 6K and 6L, the first portions **2521a** (only one called out) and the second portions **2521b** (only one called out) of the front surfaces **2518a** of the elongate members **2504** are circumferentially arranged about the first axis **2535**, similar to lines of longitude about an axis of rotation of a body of revolution, which body of revolution may, or may not, be spherical. Use of the word circumference in the application, and derivatives thereof, such as circumferential, circumscribe, circumlocute and other derivatives, refers to a boundary line of a shape, volume or object which may, or may not, be circular or spherical. The terms “radially arranged”, and “angularly arranged” are used interchangeably herein and in the claims, to refer to an arrangement similar to lines of longitude distributed at least partially (e.g., hemispherical) about an axis (e.g., polar axis) of a body (e.g., body of revolution). In this example embodiment, the first portion

**2521a** of the front surface **2518a** of each elongate member **2504** is positioned to face a first portion of the interior tissue surface **2562a** (not shown) within left atrium **2562** and the second portion **2521b** of the front surface **2518a** of the elongate member **2504** is positioned to face a second portion of the interior tissue surface **2562a** (not shown) within left atrium **2562**, the second portion of the interior tissue surface **2562a** positioned diametrically opposite from the first portion of the interior tissue surface **2562a** in the third/expanded or fanned configuration.

As shown in the sectioned view of FIG. 6M, the distal coupler **2522c** is located with left atrium **2562** at a respective location positioned relatively closer to port **2564a** than a respective location of intermediate coupler **2522b** within the left atrium **2562** when the portion of the device **2500** is in the third/expanded or fanned configuration. In this example embodiment, the distal coupler **2522c** is located within left atrium **2562** at a respective location positioned relatively closer to the proximal coupler **2522a** than a respective location of intermediate coupler **2522b** in the third/expanded or fanned configuration. In this example embodiment, the distal coupler **2522c** is located within left atrium **2562** at a respective location positioned relatively closer to the proximal coupler **2522a** in the third/expanded or fanned configuration than when each of the proximal coupler **2522a** and the distal coupler **2522c** are located within lumen **2506c** of catheter **2506** in the first/unexpanded configuration (e.g., as shown in FIG. 6C).

As shown in FIG. 6M, proximal coupler **2522a** is located within the left atrium **2562** at a respective location positioned relatively closer to port **2564a** than the respective location of intermediate coupler **2522b** in this illustrated embodiment. In some example embodiments, the respective location of the proximal coupler **2522a** is located relatively closer to port **2564a** than the respective location of distal coupler **2522c** within the left atrium **2562** when the portion of the device **2500** is in the third/expanded or fanned configuration shown in FIG. 6F. In some example embodiments, the respective location of the distal coupler **2522c** is located relatively closer to port **2564a** than the respective location of the proximal coupler **2522a** within the left atrium **2562** when the portion of the device **2500** is in the third/expanded or fanned configuration shown in FIG. 6F. In this illustrated embodiment, the proximal coupler **2522a** is positioned within the left atrium **2562** when the portion of the device **2500** is in the third/expanded or fanned configuration shown in FIG. 6F. In some example embodiments, the proximal coupler **2522a** is positioned in the bodily opening **2564** when the portion of the device **2500** is in the third/expanded or fanned configuration shown in FIG. 6F. In some example embodiments, the proximal coupler **2522a** is positioned within the body at a respective location outside of the left atrium **2562** when the portion of the device **2500** is in the third/expanded or fanned configuration shown in FIG. 6F.

In this illustrated embodiment, various ones of the elongate members **2504** cross others of the elongate members **2504** at various crossing locations within left atrium **2562** when the portion of the device is in the third/expanded or fanned configuration shown in each of the FIGS. 6F, 6K, 6L and 6M. For example as best shown in FIGS. 6K and 6L, at least the first elongate member (i.e., elongate member **2504g**) is positioned to cross the second elongate member (i.e., elongate member **2504i**) at each of a number of crossing locations **2546** within the left atrium **2562**. In this example embodiment, at least the first elongate member **2504g** is positioned to cross the second elongate member **2504i** in an X configuration at some of the crossing locations

**2546.** In this embodiment, each of the crossing locations **2546** is located on the front surface **2518a** of second elongate member **2504i** at a respective one of a number of locations along the respective geodesic **2514** of second elongate member **2504i** that is crossed by the respective geodesic **2514** of first elongate member **2504g** as viewed normally to a respective one of a number of portions of the front surface **2518a** of the second elongate member **2504i** over which each of the respective ones of the number of locations along the respective geodesic **2514** of second elongate member **2504i** is located.

The crossing locations **2546** are best shown in FIG. 6O which is a schematic representation of a portion of the second fanned array **2572** that includes second elongate member **2504i** with various portions of first elongate member **2504g** crossing second elongate member **2504i** in the third/expanded or fanned configuration. For clarity, each of elongate members **2504g** and **2504i** are shown in a “flattened” state and it is understood that these elongate members include respective arcuate profiles as exemplified in FIGS. 6K and 6L. Each crossing location **2546** is represented by an “X” in FIG. 6O. In this illustrated embodiment, the plurality of crossing locations **2546** include a proximal crossing location **2546a**, an intermediate crossing location **2546b** and a distal crossing location **2546c**. It is understood that each of the crossing locations **2546a**, **2546b** and **2546c** is located on the front surface **2518a** of the second elongate member **2504i** and is overlapped by the first elongate member **2504g** in FIG. 6O.

In this illustrated embodiment, the proximal crossing location **2546a** is located on the front surface **2518a** of the second elongate member **2504i** at least proximate to proximal coupler **2522a**, the intermediate crossing location **2546b** is located on the front surface **2518a** of the second elongate member **2504i** at least proximate to intermediate coupler **2522b** (i.e., whose location is represented by second opening **2519b** in FIG. 6O) and the distal crossing location **2546c** is located on the front surface **2518a** of the second elongate member **2504i** at least proximate to the distal coupler **2522c** (i.e., whose location is represented by third opening **2519c** in FIG. 6O). In this example embodiment, a location of the intermediate crossing location **2546b** along the respective geodesic **2514** of the second elongate member **2504i** is positioned along the respective length **2511** of the second elongate member **2504i** between the respective locations of the proximal coupler **2522a** and the distal coupler **2522c** when the portion of the device **2500** is in the third/expanded or fanned configuration shown in each of the FIGS. 6F, 6K, 6L, and 6M. In this embodiment, a location of the distal crossing location **2546c** along the respective geodesic **2514** of the second elongate member **2504i** is positioned along the respective length **2511** of the second elongate member **2504i** relatively closer to the respective distal end **2505** of the second elongate member **2504i** than a respective location of each of proximal coupler **2522a** and intermediate coupler **2522b** when the portion of the device **2500** is in the third/expanded or fanned configuration shown in each of the FIGS. 6F, 6K, 6L and 6M.

In this example embodiment, the back surface **2518b** of the respective intermediate portion **2509** of the first elongate member **2504g** is separated from the front surface **2518a** of the respective intermediate portion **2509** of second elongate member **2504i** at each of the crossing locations **2546** along the respective geodesic **2514** of the second elongate member **2504i** when the portion of the device **2500** is in the third/expanded or fanned configuration shown in each of the FIGS. 6F, 6K, 6L and 6M. In some example embodiments,

the back surface **2518b** of the respective intermediate portion **2509** of a first elongate member **2504** contacts the front surface **2518a** of the respective intermediate portion **2509** of a second elongate member **2504** at each of at least one of the crossing locations **2546** along the respective geodesic **2514** of the second elongate member **2504** when the portion of the device **2500** is in the third/expanded or fanned configuration shown in each of the FIGS. 6F, 6K, 6L and 6M. As best seen in FIG. 6M, the respective distal end **2505** (only one called out) of each elongate member **2504** is positioned within the left atrium **2562** at a respective location positioned relatively closer to port **2564a** than at least one of the crossing locations **2546** (e.g., intermediate crossing locations **2546b** in this example embodiment) when the portion of the device **2500** is in the third/expanded or fanned configuration shown in each of the FIGS. 6F, 6K, 6L and 6M. In this example embodiment, at least one or more of the other crossing locations **2546** (i.e., each of proximal crossing location **2546a** and distal crossing location **2546c** in this embodiment) are positioned within left atrium **2562** relatively closer to port **2564a** than the intermediate crossing location **2546b** when the portion of the device **2500** is in the third/expanded or fanned configuration shown in each of the FIGS. 6F, 6K, 6L and 6M. In this example embodiment, the respective proximal end **2507** (only one called out) of various ones of the elongate members **2504** is positioned within left atrium **2562** at a respective location located relatively closer to port **2564a** than at least the intermediate crossing location **2546b** when the portion of the device **2500** is in the third/expanded or fanned configuration shown in each of the FIGS. 6F, 6K, 6L and 6M.

In this embodiment, an actuator (not shown) associated with elongate member manipulator **2550** is employed in the third/expanded configuration to further manipulate various elongate members **2504** to reconfigure the first fanned array **2570** shown in FIG. 6E into the second fanned array **2572** shown in FIG. 6F. In this example embodiment, a suitable tension is applied to the second portion **2541b** of flexible line **2540c** in the third/expanded or fanned configuration to further manipulate first fanned array **2570** shown in FIG. 6E into the second fanned array **2572** shown in FIG. 6F. As shown in FIG. 6M the tension applied to the second portion **2541b** of flexible line **2540c** is sufficient to change the volute shaped profile of each of at least some of the elongate members **2504** in the first fanned array **2570** into a generally more uniform annular or ring-like profile as shown in the second fanned array **2572** of FIG. 6M. As compared between FIGS. 6I and 6M, the tension applied to the second portion **2541b** of flexible line **2540c** is sufficient to reduce a curvature of the curved portion **2509a** of each of at least some of the elongate members **2504** along their respective lengths **2511** to manipulate the first fanned array **2570** into the second fanned array **2572**. In this example embodiment, the curvature of at least one portion of an elongate member **2504** that is located between a respective distal end **2505** and a respective location passed through by the first axis **2535** is reduced when a suitable tension is applied to the second portion **2541b** of flexible line **2540c**. In this example embodiment, the reduction in curvature of the curved portion **2509a** of each of at least some of the elongate members **2504** advantageously increases the first dimension **2580a** associated with the first fanned array **2570** shown in FIG. 6I to have a larger magnitude as represented by the first dimension **2580b** associated with the second fanned array **2572** shown in FIG. 6M. As used herein, the word “curvature” should be understood to mean a measure or amount of curving. In some example embodiments, the word “curva-

ture" is associated with a rate of change of the angle through which the tangent to a curve turns in moving along the curve.

In some example embodiments, the first fanned array 2570 includes a second dimension along first axis 2535 (not shown) in the third/expanded or fanned configuration and elongate member manipulator 2550 is employed to reduce the curvature of the curved portion 2509a of each of at least some of the elongate members 2504 to increase the second dimension in the third/expanded or fanned configuration. For example, the second dimension may be an overall dimension 2581 of frame 2502 along the first axis 2535 that is increased as the curvature of various ones of the curved portions 2509a is reduced. In some example embodiments, the second dimension is a dimension between a first location where the first axis 2535 passes through at least one of the elongate members 2504 and a second location where the first axis 2535 passes through the at least one of the elongate members 2504. In some example embodiments, the curvature of each of at least some of the curved portions 2509a is reduced to concurrently increase the first dimension 2580a and the second dimension.

As compared between FIGS. 6I and 6M, a reduction in curvature of each of at least some of the curved portions 2609a results in the first axis 2535 passing through an elongate member 2504 at a location spaced relatively closer to the respective distal end 2505 of the elongate member 2504 when the first fanned array 2570 is additionally manipulated into the second fanned array 2572.

As compared between FIGS. 6N and 6O, tension applied to the second portion 2541b of flexible line 2540c causes at least one of the locations 2544 along the respective geodesic of the second elongate member 2504i that is crossed by the respective geodesic 2514 of the first elongate member 2504g in the first fanned array 2570 to be repositioned along the respective geodesic 2514 of the second elongate member 2504i to assume a position in the second fanned array 2572 as shown by the corresponding crossing locations 2546. In various embodiments, at least one of the first elongate member 2504g and the second elongate member 2504i is repositioned by the elongate member manipulator 2550 (not shown in FIGS. 6N and 6O) to cause a least one of the locations 2544 along the respective geodesic of the second elongate member 2504i that is crossed by the respective geodesic 2514 of the first elongate member 2504g in the first fanned array 2570 to be repositioned along the respective geodesic 2514 of the second elongate member 2504i into the second fanned array 2572. In this illustrated embodiment, the elongate member manipulator 2550 causes the first location 2544c along the respective geodesic 2514 of the second elongate member 2504i as shown in FIG. 6N to be repositioned relatively closer to the respective distal end 2505 of the second elongate member 2504i as shown by distal crossing location 2546c in FIG. 6O. In this illustrated embodiment, the respective distal ends 2505 of various ones of elongate members 2504 are spaced apart with respect to one another in the first fanned array 2570 as best shown in FIG. 6J by a first end-to-end distance 2585 (only one called out). In this embodiment, elongate member manipulator 2550 is employed to vary a distance between at least some of the distal ends 2505 and at least one of the crossing locations to manipulate the first fanned array 2570 into the second fanned array 2572. In this embodiment, elongate member manipulator 2550 is employed to reduce an end-to-end distance 2585 between the respective distal ends 2505 of at least some of the elongate members 2504 to manipulate the first fanned array 2570 into the second fanned array 2572. In this example embodiment, elongate

member manipulator 2550 is employed to reduce an end-to-end distance 2585 between the respective distal ends 2505 of at least some of the elongate members 2504 while varying a respective distance between at least one of the crossing locations and each of the distal ends 2505 of the at least some of the elongate members 2504. It is noted that in some embodiments, the respective distance between the at least one of the crossing locations and each of the distal ends 2505 of the at least some of the elongate members 2504 may be varied by a different amount for each of the at least some of the elongate members while the respective end-to-end distance 2585 is reduced. For example, the respective distance between the at least one crossing location and a first one of the distal ends 2505 may be varied by a first amount and the respective distance between the at least one crossing location and a second one of the distal ends 2505 may be varied by a second amount different than the first amount. In some embodiments, the first and second amounts vary to expand frame 2502 by different amounts in different directions.

It is noted that relative movement between the ends need not be limited to the distal ends 2505. In various example embodiments, relative movement may be provided between at least some of the ends in a first set of the proximal ends 2507 of the elongate members 2504 to reduce an end-to-end distance between the at least some of the ends in the first set while expanding frame 2502 to have a size too large for delivery through the lumen 2506c of catheter sheath 2506. In various example embodiments, relative movement may be provided between at least some of the ends in a second set of the distal ends 2505 of the elongate members 2504 to reduce an end-to-end distance 2585 between the at least some of the ends in the second set while expanding frame 2502 to have a size too large for delivery through the lumen 2506c of catheter sheath 2506. In some of these various embodiments, the relative movement between the at least some of the ends in the first set or between the at least some of the ends in the second set is provided while restraining relative movement between at least some of the ends in the other of the first set and the second set along at least one direction during the expanding of frame 2502. In some of these various embodiments, the relative movement between the at least some of the ends in the first set or between the at least some of the ends in the second set is provided while restraining relative movement between the respective intermediate portions 2509 of at least some of elongate members 2504 during the expanding of frame 2502. In some of these various embodiments, the relative movement between the at least some of the ends in the first set or between the at least some of the ends in the second set is provided while decreasing a distance between the respective distal end 2505 and the respective proximal end 2507 of each of at least some of the plurality of elongate members 2504 during the expanding of frame 2502. For example, as compared between FIGS. 6I and 6M, a distance between the respective distal end 2505 and the respective proximal end 2507 of each of various ones of the elongate members 2504 is reduced as the end-to-end distance 2585 between the distal ends 2505 is reduced.

As shown in FIG. 6M, the second portion 2541b of the flexible line 2540c is manipulated to more substantially align the respective third openings 2519c of the elongate members 2504 in the second fanned array 2572. In this example embodiment, the second portion 2541b of the flexible line 2540c is manipulated to more substantially align the respective second openings 2519b of the elongate members 2504 in the second fanned array 2572. It is

understood that alignment between the respective third openings 2519c and the alignment between the respective second openings 2519b in the second fanned array 2572 need not be a collinear one as shown in FIG. 6M. In embodiments in which the first fanned array 2570 is manipulated to cause the front surfaces 2518a of the various elongate members 2504 in the second fanned array 2572 to contact the interior tissue surface 2562a, variances in a local or global size of the left atrium 2562 may cause varying degrees of alignment between the respective groupings of openings 2519b, 2519c. Flexible line couplings (e.g., flexible lines 2540b and 2540c) may be employed to advantageously physically couple the elongate members 2504 together while having a reduced sensitivity to misalignments between the respective third openings 2519c and the respective second openings 2519b. Other embodiments may employ other types of couplings.

As shown in FIG. 6M, the respective intermediate portion 2509 of each of the various elongate members 2504 has a generally annular or ring-like profile interrupted by a separation in the third/expanded configuration. The separation may not be present in other embodiments. Device 2500 may further include at least one bridging portion arranged to bridge the separation in some embodiments. A bridging portion can include by way of non-limiting example, a portion of an elongate member 2504, a portion of a coupler (e.g., first coupler 2522a), a portion of shaft member 2510 or a portion of catheter sheath 2506.

In various example embodiments, once frame 2502 is deployed within atrium 2562, a sensing, investigation or treatment procedure may be undertaken. In this embodiment, each front surface 2518a includes, carries or supports a transducer element (i.e., not shown, e.g., transducer element 2490) that is positionable adjacent to a tissue surface in the bodily cavity when the first fanned array 2570 is manipulated into the second fanned array 2572. In this example embodiment, once the second fanned array 2572 has been appropriately positioned at a given location within left atrium 2562, determination of the locations of various components of device 2500 (e.g., transducer elements including sensors or electrodes, or related support structures such as elongate members 2504), or the locations of various anatomical features within left atrium 2562 may be determined by various methods. In this example embodiment, after the portion of the device 2500 has been appropriately positioned at a given location within left atrium 2562, ablation of various regions of a tissue surface within left atrium 2562 may commence. The portion of the device 2500 may be removed from the left atrium 2652 by reconfiguring the portion of the device 2500 back into the second/bent configuration and then further back into the first/unexpanded configuration.

FIG. 7A is an isometric view of a portion of a device 2600 in an initial configuration according to one example embodiment. Device 2600 includes a structure or frame 2602 that includes an arrangement of elongate members 2604a, 2604b, 2604c, 2604d, 2604e, 2604f, and 2604g, (collectively 2604). Various ones of the elongate members 2604 are physically coupled to shaft member 2610 which is employed to transport the elongate members 2604 through a catheter sheath 2606 (shown in FIGS. 7C, 7D, 7E and 7F) arranged for delivery through a bodily opening (not shown) leading to a bodily cavity (also not shown). The bodily cavity can include an intra-cardiac cavity by way of non-limiting example.

FIG. 7B is an isometric view of a representative one of the elongate members 2604 in the initial configuration. Each of

the elongate members 2604 includes a respective first or distal end 2605 and a respective second or proximal end 2607. Each elongate member 2604 includes a respective length 2611 (i.e., called out only in FIGS. 7B and 7G) between the respective proximal and distal ends 2607, 2605 of the elongate member 2604. In various embodiments, two or more of the elongate members 2604 may have substantially equal lengths 2611 or substantially unequal lengths 2611. In this example embodiment, a respective portion of each of the elongate members 2604 has a length that is at least approximately equal to or greater than a circumference of a portion of an interior tissue surface of a bodily cavity (not shown) into which the elongate member 2604 is to be positioned at least proximate to when the portion of the device 2600 is in a deployed configuration. The circumference of the portion of the interior tissue surface may have a measured or anticipated value. In a manner similar to other described embodiments, transducer elements 2690 (two called out) are distributed along a surface of each of various ones of the elongate members 2604. Transducer elements 2690 arranged on a given one of elongate members 2604 may be circumferentially distributed along a region of the interior tissue surface of a bodily cavity (again not shown) over which the given one of the elongate members 2604 is positioned at least proximate to in a deployed configuration. In this example embodiment, each elongate member 2604 includes at least a portion of a flexible circuit structure 2680 (not shown or called out in FIGS. 7A, 7B, 7C, 7D, 7E and 7F for clarity) that at least provides an electrically communicative path to various ones of the transducer elements 2690.

Each of the elongate members 2604 includes a set of two opposing major faces or surfaces 2618 denominated as a front surface 2618a and a back surface 2618b. In this example embodiment, the two opposing surfaces 2618 are separated from one another by a thickness 2617 of the elongate member 2604. In this illustrated example, each elongate member 2604 includes a plurality of various portions 2609 arranged between the respective proximal and distal ends 2607, 2605 of the elongate member 2604. In this example embodiment, the portions 2609 include a first portion 2609a, a second portion 2609b and a third portion 2609c positioned between the first and the second portions 2609a, 2609b. In this example embodiment, first portion 2609a is positioned relatively closer to proximal end 2607 than to distal end 2605 and second portion 2609b is positioned relatively closer to distal end 2605 than to proximal end 2607. In this example embodiment, the various portions 2609 are combined in a unitary structure. In this example embodiment, each of the portions 2609 includes a pair of side edges including first side edge 2620a and second side edge 2620b (collectively 2620), the side edges of each pair of side edges 2620 are opposed to one another across at least a portion of the length 2611 of the respective elongate member 2604. In this example embodiment, each pair of side edges 2620 defines a portion or at least some of a periphery of the front surface 2618a of the elongate member 2604.

In this example embodiment, a number of the respective portions 2609 of various ones of the elongate members 2604 include various distortions or deformations. In this example embodiment, the words "distortion" or deformation are used interchangeably herein to mean modification in shape away from an elongated strip-like form that prior to any distortion or deformation predominately a body with a relatively small thickness as compared to a length or width, although major faces of the body may not necessarily have smooth planar

surfaces. For example, the respective second portion **2609b** of the representative elongate member **2604** shown in FIG. 7B has a coiled profile (e.g., a profile that curves back on itself). In this particular embodiment, the respective second portion **2609b** includes a volute shaped profile in the initial configuration. Also for example, the respective third portion **2609c** of the representative elongate member **2604** shown in FIG. 7B includes a twisted profile about a respective twist axis **2633** extending across at least a part of the third portion **2609c** of the elongate member **2604**, the twist in the third portion **2609c** arranged to rotationally offset (e.g., angularly rotated or twisted out of plane about an axis that may extend generally along a length of the elongate member prior to any distortion of deformation thereof) the respective second portion **2609b** of the elongate member **2604** from the respective first portion **2609a** of the elongate member **2604** along a portion of the length **2611** of the elongate member **2604**. In this example embodiment, the respective first portion **2609a** of the representative elongate member **2604** includes a bent profile about a respective bending axis **2631**.

In FIG. 7A, each of the elongate members **2604** is arranged in an arrangement having an initial configuration in which each elongate member **2604** is provided essentially in its distorted form. In this example embodiment, the initial configuration is representative of an initial or low energy state. In this example embodiment, each elongate member **2604** is a resilient member and further distortion of various portions **2609** of the elongate member **2604** can increase spring or potential energy of the elongate member **2604** and thereby bring it into a higher energy state.

As shown in FIG. 7A, at least the respective second portions **2609b** of various ones of the elongate members **2604** each has a coiled profile (e.g., a profile that curves back on itself) in the initial or low energy state. In this example embodiment, at least the respective second portions **2609b** (two called out) of various ones of the elongate members **2604** are fanned into a fanned array in the initial or low energy state. As shown in FIG. 7A, each of the respective first portions **2609a** of the elongate members **2604** are arranged front surface **2618a**-toward-back surface **2618b** with respect to one another in the initial configuration. In this example embodiment, the bent profiles of the respective first portions **2609a** (one called out) of various ones of the elongate members **2604** are arranged to fan or partially fan at least the respective second portions **2609b** of various ones of elongate members **2604** into the fanned array in the initial configuration. In this embodiment, various ones of the second portions **2609b** are fanned along a direction to increase a relative distance between the respective side edges **2620** (two respective sets of edges **2620a** and **2620b** called out) of adjacent ones of the second portions **2609b** in the initial configuration. In this example embodiment, parts of the first portions **2609a** are also fanned in the initial configuration. In this embodiment, various ones of the first portions **2609a** are fanned along a direction to increase a relative front surface **2618a**-to-back surface **2618b** distance between adjacent ones of the first portions **2609a** in the initial configuration.

In some example embodiments, the respective twist axis **2633** (FIG. 7B) about which one of the third portions **2609c** (one called out) is twisted is arranged to rotationally offset a respective second portion **2609b** from a respective first portion **2609a** as well as to fan the respective second portion **2609b** into the fanned array in the initial configuration as exemplified in FIG. 7A. It is noted however that relatively limited fanning angles **2619** (only one called out in FIG. 7A) are typically achieved between a respective pair of the first

and the second portions **2609a**, **2609b** by positional adjustments of the twist axis **2633**. Fanning angles **2619** generally greater than 45 degrees associated with at least some of the elongate members **2604** (e.g., elongate members **2604a** and **2604g**) in FIG. 7A may be difficult to achieve solely by a positional adjustment of various ones of the twist axes **2633**. Greater fanning angles **2619** are typically associated with relatively large numbers of elongate members **2604** as shown in FIG. 7A. It is also noted that when various ones of the third portions **2609c** are twisted to additionally fan the respective second portions **2609b** into a fanned array as shown in FIG. 7A, the twisted third portions **2609c** typically do not nest well together when the various portions **2609** are arranged in an arrayed arrangement suitable for intravascular or percutaneous delivery (e.g., as shown in FIG. 7C). Nesting difficulties may arise because each of the respective third portions **2609c** of various ones of the elongate members **2604** has a different twisted form in accordance with the particular fanning angle that the each of the various ones of the elongate members **2604** must be fanned by. Difficulties with the nesting of the respective third portions **2609c** typically increase with increased fanning angles **2619**. Nesting difficulties can require larger catheter sheaths to be employed to accommodate a bulkier arrangement of at least the third portions **2609c** when delivered percutaneously. In some example embodiments, each of the respective second portions **2609b** of various ones of the elongate members **2604** are fanned in the initial configuration based at least in part by a configuration of the twisted profile of a respective third portion **2609c** and based at least in part by a configuration of the bent profile of a respective first portion **2609a**.

In various example embodiments, various ones of the elongate members **2604** are physically coupled together with at least one other elongate member **2604** by at least one coupler. In this illustrated embodiment, device **2600** includes at least one coupler **2622** arranged to couple at least the respective first portions **2609a** of the elongate members **2604** together in the initial array. In this example embodiment, coupler **2622** includes a pin member **2622a** arranged to secure the first portions **2609a** together. Other forms of couplers may be employed in other example embodiments. For example, in embodiments where various ones of the elongate members **2604** includes a flexible printed structure having a relatively large number of electrically conductive traces, a coupling that couples at least the side edges **2620** of the first portions **2609a** may be better suited than a pin-type coupling that is arranged to pass through the flexible circuit structures in a manner that possibly imposes undesired space constraints on the placement of the electrically conductive traces. In various example embodiments, additional couplers (e.g., couplers **2522b**, **2522c**) may also be employed to couple various other portions **2609** of various ones of the elongate members **2604** together.

Figs. 7C, 7D, 7E, and 7F are various side elevation views of a portion of the device **2600** positioned at four successive intervals of time as the portion of the device **2600** is selectively reconfigured according to an example embodiment. For clarity, transducer elements **2690** are not shown in FIGS. 7C, 7D, 7E, and 7F. As shown in FIG. 7C, the respective first portions **2609a** (only one called out) of the elongate members **2604** (only one called out) are arranged with respect to one another front surface **2618a**-toward-back surface **2618b** along a first direction represented by arrow **2616a** in a first stacked array **2615a** sized to be delivered through lumen **2506c** of catheter sheath **2606** that is positionable within a bodily opening (again, not shown) leading to a bodily cavity (also not shown) when a portion of the

device 2600 is in a delivery configuration also known as a first or unexpanded configuration. As shown in FIG. 7C, the respective second portions 2609b (only one called out) of the elongate members 2604 are arranged with respect to one another front surface 2618a-toward-back surface 2618b along a second direction as represented by arrow 2616b in a second stacked array 2615b sized to be delivered through the lumen of catheter sheath 2606 when the portion of the device 2600 is in the delivery configuration. In this example embodiment, the first direction (i.e., arrow 2616a) and the second direction (i.e., arrow 2616b) are non-parallel directions. In this example embodiment, the elongate members 2604 are arranged within catheter sheath 2606 such that each elongate member 2604 is to be advanced distal end 2605 first into a bodily cavity. In this example embodiment, the elongate members 2604 are arranged within catheter sheath 2606 such that each elongate member 2604 is to be advanced out distal end 2605 first from an end of catheter sheath 2606 arranged to be positioned at least proximate to the bodily cavity.

Notably, as used herein and in the claims, the term stacked does not necessarily require the elongate members 2604 rest directly or even indirectly upon one another, but rather refers to an ordered arrangement which may include spaces or gaps between immediately adjacent or most immediate neighboring pairs of elongate members 2604. It is also noted that while illustrated in FIG. 7C as a plurality of substantially parallel stacked plates or strips, the elongate members 2604 are not perfectly rigid so there may be some flex, sag or curvature even when the catheter sheath 2606 is essentially straight. It is further noted that in use, the catheter sheath 2606 will often curve or even twist to follow a bodily lumen. The elongate members 2604 may adopt or conform to such curvatures or twists as the elongate members 2604 are advanced. In either of these situations, the elongate members 2604 maintain the relative positions to one another as a stacked arrangement.

In this example embodiment, the respective first, second and third portions 2609a, 2609b and 2609c (only one of each called out) of various ones of the elongate members 2604 in the initial configuration have been stressed into a higher energy state from their initial or low energy state shown in FIG. 7A. In this example embodiment, the respective second portions 2609b of various ones of the elongate members 2604 in the initial configuration (i.e., as shown in FIG. 7A) have been stressed into a higher energy state suitable for unbending or uncoiling them sufficiently enough to allow the elongate members 2604 to be delivered through catheter sheath 2606 in the delivery configuration as shown in FIG. 7C. In this example embodiment, the at least one of the respective first portions 2609a and the third portions 2609c of each of various ones of the elongate members 2604 (i.e., as shown in FIG. 7A) have been stressed into a higher energy state suitable for un-fanning at least the second portions 2609b of the elongate members 2604 sufficiently enough to allow the elongate members 2604 to be introduced into, and delivered though catheter sheath 2606. In this example embodiment, potential energy is imparted to the various elongate members 2604 in the delivery configuration by the higher energy state, the potential energy sufficient to return the arrangement of elongate members 2604 generally back to their initial energy state when released from the confines of catheter sheath 2606. In some example embodiments, the arrangement of elongate members 2604 is stressed into a higher energy state by retracting the arrangement of elongate members 2604 into catheter sheath 2606 prior to inserting catheter sheath 2606 into a

body. In some example embodiments, the arrangement of elongate members 2604 is stressed into a higher energy state by uncoiling the elongate members 2604 and inserting the arrangement of elongate members 2604 into catheter sheath 2606. In some example embodiments, the arrangement of elongate members 2604 is reconfigured from the initial configuration shown in FIG. 7A to the delivery configuration shown in FIG. 7C at a point-of-use. In some example embodiments, the arrangement of elongate members 2604 is reconfigured from the initial configuration shown in FIG. 7A to the delivery configuration shown in FIG. 7C at a place of manufacture, assembly or distribution. In various embodiments, various devices including various guides or manipulators may be employed to reconfigure the arrangement of elongate members 2604 from the initial configuration shown in FIG. 7A to the delivery configuration shown in FIG. 7C. In some of these various embodiments, the devices form part of device 2600. In some of these various embodiments, the devices are extraneous to device 2600. Preferably, the higher energy states are controlled to not cause damage to device 2600 or catheter sheath 2606 during delivery therethrough.

FIG. 7D shows a portion of the device 2600 including the plurality of elongate members 2604 positioned in a deployed configuration also referred to as a second or bent configuration. In this example embodiment, the respective second portions 2609b (only one called out) of various ones of the elongate members 2604 have cleared the confines of catheter sheath 2606 while other portions 2609 of the elongate members 2604 remain within the confines of catheter sheath 2606. In this example embodiment, at least the respective second portions 2609b of each elongate member 2604 are bent about a respective bending axis 2634 (only one shown) into an arcuate stacked array 2632. Each bending axis 2634 extends along a direction having a directional component transversely oriented to the respective length 2611 (not called out in FIG. 7D) of the elongate member 2604. In this example embodiment, each of the respective second portions 2609b of various ones of the elongate members 2604 in the arcuate stacked array 2632 is coiled about a respective bending axis 2634 into a coiled stacked array. In this example embodiment, each respective second portion 2609b is bent to have a scrolled or volute shaped profile. In this example embodiment, each second portion 2609b is bent to have a curvature that varies at least once along the respective length 2611 of the elongate member 2604. When positioned in the second/bent configuration, a first portion 2621a of the front surface 2618a (only one called out) of the respective second portion 2609b of each elongate member 2604 is positioned diametrically opposite to a second portion 2621b of the front surface 2618a in the volute shaped frame 2602. When positioned in the second/bent configuration, the coiled arrangement of elongate members 2604 is sized or dimensioned too large for delivery through a lumen of catheter sheath 2606.

In this illustrated embodiment, the respective second portions 2609b of various ones of the elongate members 2604 have been preformed to autonomously bend when the second portions 2609b are advanced out of catheter sheath 2606. As the respective second portions 2609b are advanced from the confines of catheter sheath 2606, they are urged or biased to seek their low energy state (i.e., their initial coiled configuration). In this example embodiment, the respective distal ends 2605 of various ones of the elongate members 2604 moves along a coiled path (e.g., a path that curves back on itself) when the portion of the device 2600 is moved between the first/unexpanded configuration and the second/bent configuration. In this example embodiment, the coiled

path makes at least one full turn. In some embodiments, at least part of the coiled path may extend along a volute path.

In this embodiment, the respective second portions **2609b** of various ones of the elongate members **2604** are preformed to autonomously coil as they are advanced into a bodily cavity (not shown) in a manner that may advantageously reduce physical interactions between elongate members **2604** and an interior tissue surface within the bodily cavity. In a manner similar to the elongate members **2504** shown in FIG. 6D, the respective distal ends **2605** (only one called out) of the elongate members **2604** are arranged to continuously bend or curl away from an interior tissue surface within a bodily cavity (not shown) into which they are introduced. A reduction of contact and other physical interaction with an interior tissue surface within a bodily cavity can reduce occurrences of, or the severity of, damage inflicted to various tissue structures during the positioning. In various embodiments, the arcuate stacked array **2632** is arranged to have a predetermined size that will allow the arcuate stacked array **2632** to be positioned within a bodily cavity with at most relatively minor amounts of contact with an interior tissue surface within the bodily cavity.

FIG. 7E shows the portion of the device **2600** in deployed configuration also referred to as a third or expanded configuration. In this illustrated embodiment, the elongate members **2604** were moved from the second/bent configuration shown in FIG. 7D to the third/expanded configuration shown in FIG. 7E. In this example embodiment, the portion of the device **2600** is further advanced through catheter sheath **2606** so that at least the respective third portions **2609c** (only one called out) of various ones of the elongate members **2604** are clear of the confines of catheter sheath **2606**. In this example embodiment, the portion of the device **2600** is further advanced through catheter sheath **2606** so that at least the respective first portions **2609a** (only one called out) of various ones of the elongate members **2604** are clear of the confines of catheter sheath **2606**. As shown in FIG. 7E, the respective second portions **2609b** (only one called out) of various ones of the elongate members **2604** are spaced apart from one another in the third/expanded configuration. In this illustrated embodiment, at least the respective second portions **2609b** of various ones of the elongate members **2604** are angularly spaced with respect to one another about an axis when the portion of the device **2600** is in the third/expanded configuration. In this illustrated embodiment, at least the respective second portions **2609b** of at least some of the elongate members **2604** are fanned with respect to one another about one or more fanning axes **2635** into a first fanned array **2670** when the portion of the device **2600** is in the third/expanded configuration. As shown in FIG. 7E, in this example embodiment the one or more fanning axes **2635** are arranged to pass through a plurality of spaced apart locations along the respective length **2611** (not called out) of each of the at least some of the elongate members **2604** when the portion of the device **2600** is in the third/expanded or fanned configuration. In this example embodiment, the one or more fanning axes **2635** are shown as a single axis (i.e., also referred to as fanning axis **2635**) for clarity. It is understood that one or more axes **2635** can include two or more axes in various embodiments. In this illustrated embodiment, each of the at least some of the plurality of elongate members **2604** includes a curved portion arranged to extend along at least a portion of a respective curved path that intersects fanning axis **2635** at each of a respective at least two spaced apart locations along fanning axis **2635** in the third/expanded or fanned configuration.

In this example embodiment, the respective first portions **2609a** of various ones of the elongate members **2604** have been preformed to autonomously bend when the first portions **2609a** are advanced out of catheter sheath **2606**. As the respective first portions **2609a** are advanced from the confines of catheter sheath **2606**, stored potential energy is released and the first portions **2609a** are urged or biased to assume a lower energy state (i.e., similar to their initial configuration shown in FIG. 7A) and cause at least the respective second portions **2609b** of various ones of the elongate members **2604** to autonomously fan at least in part, with respect to one another into the third/expanded or fanned configuration. In some example embodiments, as the respective third portions **2609c** are advanced from the confines of catheter sheath **2606**, stored potential energy is released and the respective third portions **2609c** are urged or biased into a lower energy state to cause at least the respective second portions **2609b** of various ones of the elongate members **2604** to autonomously fan, at least in part, with respect to one another into the third/expanded or fanned configuration. In some example embodiments, as both the respective third portions **2609c** and the respective first portions **2609a** of various ones of the elongate members **2604** are advanced from the confines of catheter sheath **2606**, stored potential energy is released and the respective first and third portions **2609a**, **2609c** are urged or biased into respective lower energy states to cause at least the respective second portions **2609b** of various ones of the elongate members **2604** to autonomously fan at least in part, with respect to one another into the third/expanded or fanned configuration.

In some example embodiments, additional fanning mechanisms (not shown) may be employed to assist in the fanning of, or to promote an additional fanning of, various ones of the elongate members **2604** as the elongate members **2604** are moved into the third/expanded or fanned configuration. In some example embodiments, various separators similar to previously described separators **1452** and **1752** may be employed to further fan, or to assist in the fanning of, at least some of the elongate members **2604**. In this example embodiment, the elongate members **2604** are fanned in a different manner than previously described elongate members **2504**. In this example embodiment a first set made up elongate members **2604a**, **2604b**, and **2604c** are fanned along an opposite direction from a second set made up of elongate members **2604e**, **2604f** and **2604g**. Unlike the described embodiment employing elongate members **2504**, the elongate members **2604** in the first set of elongate members **2604** are not interleaved with the elongate members **2604** in the second set of elongate members **2604** in this example embodiment.

FIG. 7E shows that various parts of the respective second portions **2609b** of various ones of the elongate members **2604** cross one another at various crossing locations in the third/expanded configuration in a manner similar to that previously described for the elongate members **2504** shown in their respective third/expanded or fanned configurations in FIGS. 6E, 6G, 6H and 6I. In this example embodiment at least a first one of the plurality of elongate members **2604** crosses a second one of the plurality of elongate members **2604** in an X configuration at each of a plurality of locations spaced from one another along the respective length **2611** of the second one of the plurality of elongate members **2604** when a portion of device **2600** is moved into the third/expanded or fanned configuration. In this example embodiment, additional manipulation of a portion of device **2600** including elongate members **2604** may be initiated when the portion of the device **2600** is moved into the third/expanded

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configuration. Typically, when the elongate members 2604 are arranged within a bodily cavity in the third/expanded or fanned configuration, the arrangement of the elongate members 2604 is preferably sized sufficiently small enough to reduce occurrences where damage may be inflicted to the tissue surfaces within the bodily cavity by the arrangement of elongate members 2604. As shown in FIG. 7E, first portions 2621a (only one called out) and the second portions 2621b (only one called out) of the respective front surface 2618a (only one called out) of each of at least some of the elongate members 2604 in the first fanned array 2670 are angularly arranged about fanning axis 2635 when the portion of the device 2600 is in the third/expanded configuration. In this illustrated embodiment, at least some of the elongate members 2604 are further manipulated in the third/expanded or fanned configuration to vary a radial spacing between fanning axis 2635 and at least one of the first portion 2621a and the second portion 2621b of the respective front surface 2618a of each of various ones of the elongate members 2604. In this embodiment, frame 2602 includes a proximal portion 2602a having a first domed shape 2608a and a distal portion 2602b having a second domed shape 2508b, the proximal and distal portions 2602a, 2602b arranged in a clam shell configuration.

In FIG. 7F, at least some of the elongate members 2604 are further manipulated in the third/expanded configuration to form a second fanned array 2672. In this example embodiment, at least some of the elongate members 2604 are further manipulated to increase a radial spacing between fanning axis 2635 and at least one of the first portion 2621a (only one called out) and the second portion 2621b (only one called out) of the respective front surface 2618a (only one called out) of each of various ones of the elongate members 2604. In some example embodiments, at least some of the elongate members 2604 are further manipulated to distort at least one of the first and the second domed shapes 2608a, 2608b of a respective one of the proximal and the distal portion 2602a, 2602b of frame 2602. Further manipulation of the at least some of the elongate members 2604 may be motivated for various reasons. For example, the at least some of the elongate members 2604 may be further manipulated to create a conformance with a tissue surface with a bodily cavity (not shown in FIGS. 7C, 7D, 7E and 7F) when the portion of the device 2600 is moved into the third/expanded or fanned configuration. In some example embodiments, the at least some of the elongate members 2604 may be further manipulated to position various transducer elements 2690 (again not shown in FIGS. 7C, 7D, 7E and 7F) relatively closer to an interior tissue surface within a bodily cavity.

In this example embodiment, an end portion of shaft member 2610 is physically coupled or connected to frame 2602 at one or more locations on frame 2602, each of the one or more locations on the structure to which the end portion is coupled positioned to one side of at least one spatial plane (not shown) that is coincident with fanning axis 2635. In this example embodiment, shaft member 2610 and frame 2602 have a projected outline in the shape of the Greek letter rho ( $\rho$ ) in the third/expanded or fanned configuration, as indicated above.

In this example embodiment, various ones of the elongate members 2604 cross at least one other of the elongate members 2604 at various crossing locations when the portion of the device 2600 is in the third/expanded or fanned configuration shown FIG. 7E. In this example embodiment, a number of the elongate members 2604 are additionally manipulated to vary at least one of the crossing locations to

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arrange the elongate members 2604 in the second fanned array 2672 shown in FIG. 7F. In some example embodiments, an elongate member manipulator (e.g., elongate member manipulator 2550) is employed to further manipulate the various elongate members 2604 to reconfigure the first fanned array 2670 shown in FIG. 7E into the second fanned array 2672 shown in FIG. 7F in the third/expanded or fanned configuration. It is noted that if a flexible line similar to the flexible line 2540c of elongate member manipulator 2550 is employed to further manipulate the first fanned array 2670 shown in FIG. 7E into the second fanned array 2672 shown in FIG. 7F, the flexible line may be arranged to follow a path less tortuous than the zig-zag path that the flexible line 2540c follows in FIG. 6J. A less tortuous path may be achieved at least in part because the elongate members 2604 in the first set of elongate members 2604 are not interleaved with the elongate members 2604 in the second set of elongate members 2604 in this example embodiment.

Other techniques may be employed to additionally manipulate or expand a structure of elongate members (e.g., frame 2602) in the deployed configuration. For example, FIGS. 9A and 9B respectively show an isometric view and a partially sectioned plan view of a portion of a device 2800 according to one example embodiment in a deployed configuration also known as third or expanded configuration similar to that employed by device 2600 in FIG. 7E. Device 2800 includes a structure or frame 2802 physically coupled to a shaft member 2810. Frame 2802 includes a plurality of elongate members 2804 that include elongate members 2804a, 2804b, 2804c, 2804d, 2804e, 2804f and 2804g. In this embodiment, each of the elongate members 2804 includes a distal end 2805, a twisted portion 2809c and a bent portion 2809a positioned proximate to shaft member 2810. Each of the elongate members 2804 includes a front surface 2818a that is positionable to face an interior tissue surface within a bodily cavity (not shown) and a back surface 2818b opposite the front surface 2818a. In some embodiments, each of the elongate members 2804 is arranged front surface 2818a-toward-back surface 2818b in a stacked array during a delivery configuration similar to that employed by other described embodiments. In this embodiment, each of the elongate members 2804 is arranged in a first fanned array 2870 that is similar to the first fanned array 2670 of elongate members 2604 shown in FIG. 7E. In this example embodiment, each elongate member 2804 includes a respective slot 2820. As best seen in the partially sectioned plan view of FIG. 9B, the slots 2820 of various ones of the elongate members 2804 cross one another at a crossing location 2825 in the first fanned array 2870. In some embodiments each of at least some of the slots 2820 are positioned to one side of a midline or centerline of a respective one of the elongate members 2804.

FIGS. 9C and 9D respectively show an isometric view and a partially sectioned plan view of a portion of device 2800 which has been additionally manipulated from the first fanned array 2870 shown in FIGS. 9A, 9B to form a second fanned array 2872. As compared between FIGS. 9B and 9D, a change in the positioning where various ones of the slots 2820 cross one another accompanies a manipulation between the first fanned array 2870 and the second fanned array 2872. In this example embodiment, a movement of the respective distal ends 2805 of the elongate members 2804 generally along a direction toward crossing location 2825 accompanies a movement between the first fanned array 2870 and the second fanned array 2872. In this example embodiment, the respective distal ends 2805 of the elongate

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members **2804** are moved generally along a radial direction toward crossing location **2825**. In this example embodiment, at least one flexible line **2821** (shown and called out only in FIGS. 9B and 9D for clarity) is employed to further manipulate between the first fanned array **2870** shown in FIGS. 9A, 9B and the second fanned array **2872** shown in FIGS. 9C, 9D. In this example embodiment, at least one flexible line **2821** is sized for passage through holes **2812** in various ones of the elongate members **2804**. As compared with the embodiment shown in FIG. 6J, flexible line **2821** follows a less tortuous path than the flexible line **2540c** of elongate member manipulator **2550**. In various example embodiments, various ones of the elongate members **2804** may be physically coupled together by one or more coupling members (not shown for clarity) arranged to be slidably received in respective slots **2820** of the various ones of the elongate members **2804**. In some embodiments, the one or more coupling members may include a relatively rigid member while in other embodiments, the one or more coupling members may include a relatively flexible member. In some example embodiments, the one or more coupling members may be employed to assist in establishing generally radial movement of various portions of the elongate members **2804** towards crossing location **2825**. In some example embodiments, one or more flexible lines are sized and arranged to be received in the respective slots **2820** of various ones of the elongate members **2804**.

As shown in FIGS. 9A and 9C, frame **2802** includes a proximal portion **2802a** having a first domed shape **2808a** and a distal portion **2802b** having a second domed shape **2808b**. In this example embodiment, the proximal and the distal portions **2802a**, **2802b** are arranged in a clam shell configuration in the third/expanded configuration. In this example embodiment, frame **2802** is additionally manipulated to distort a respective one of the first domed shape **2808a** and the second domed shape **2808b** to accompany a movement between the first fanned array **2870** and the second fanned array **2872**. In this example embodiment, various ones of the slots **2820** have different longitudinal dimensions. In some example embodiments, various ones of the slots **2804** are sized differently to vary amounts of movement between various portions of respective elongate member **2804** during the manipulating. In some example embodiments, each of various ones of the slots **2804** is sized to vary amounts of distortion imparted to their respective elongate members **2804** during the manipulating. In this embodiment, the slots **2820** have been selectively sized to distort distal portion **2802b** to have a more prolate second domed shape **2808b** than the first domed shape **2808a** of the proximal portion **2802a** during the manipulating.

In this example embodiment, various ones of the elongate members **2804** are physically coupled together by coupling members **2858** (two called out in each of FIGS. 9A, 9B, 9C and 9D). In various example embodiments, each coupling member **2858** may allow movement of one of the elongate members **2804** coupled by the coupling member **2858** to also cause movement of another of the elongate members **2804** coupled by the coupling member **2858**. In some example embodiments, the coupling members **2858** are arranged to restrict or limit an amount of movement that an elongate member **2804** undergoes as the portion of the device is moved into the third/expanded configuration. In this example embodiment, coupling members **2858** are positioned to extend across the back surfaces **2818b** of the elongate members **2804** in the third/deployed configuration. In this embodiment, two quasi-circumferential arrangements

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of coupling members **2858** are provided. Different arrangements of coupling members **2858** may be employed in other embodiments.

In this embodiment, device **2800** includes separator **2852** arranged to manipulate various ones of the elongate members **2804**. In this embodiment, separator **2852** includes a first flexible line **2853a** and a second flexible line **2853b** (collectively flexible lines **2853**). In this example embodiment, each of the flexible lines **2853** is physically coupled to elongate member **2804g**. Each of the flexible lines **2853** is sized to be slidably received in a lumen of a respective one of tubular members **2854a** and **2854b** (collectively tubular members **2854**). Tubular member **2854b** is not shown in each of FIGS. 9A and 9C. Tubular members **2854** are physically coupled to elongate member **2804a** at respective spaced apart locations along a length of elongate member **2804a**.

In this example embodiment, the flexible lines **2853** may be manipulated to move a portion of device **2800** into the third/expanded or fanned configuration. For example, flexible lines **2853** may be manipulated to move device **2800** from a second/bent configuration (e.g., similar to that shown by device **2600** in FIG. 7D) into the third/expanded or fanned configuration. In this example embodiment, the flexible lines **2853** may be manipulated to fan at least some of the elongate members **2804**. In this example embodiment, the flexible lines **2853** may be manipulated to further fan at least some of the elongate members **2804** which have been initially fanned under an influence of a biasing action provided by one or more portions (e.g., the twisted portion **2809c** or the bent portion **2809a**, or both) of each of various ones of the at least some of the elongate members **2804**. In some embodiments, the flexible lines **2853** are manipulated to vary a distance between the proximal and the distal portions **2802a**, **2802b** in the third/expanded configuration. In some embodiments, the flexible lines **2853** may be manipulated to vary a distance between adjacent elongate members (e.g., elongate members **2804a**, **2804g**) in the third/expanded configuration. In some embodiments, the flexible lines **2853** are manipulated to distort at least one of the first domed shape **2808a** and the second domed shape **2808b**. For example, when the portion of device **2800** is moved into the second fanned array **2872**, flexible line **2853** may be manipulated to reduce a deviation in a shape of frame **2802** (e.g., a “radial step” between elongate members **2804a**, **2804g** as compared between FIGS. 9B and 9D). Reducing deviations in the shape of frame **2802** may be motivated by various reasons including providing a more uniform distribution in an arrangement of transducers (not shown) that may be carried by the device **2800**. In various example embodiments, manipulation of the flexible lines **2853** may include relatively sliding the flexible lines **2853** within their respective tubular members **2854**. In some example embodiments, manipulation of the flexible lines **2853** includes tensioning the flexible lines **2853**. Other numbers of flexible lines **2853** may be employed in other embodiments.

Various embodiments in this disclosure include various systems or devices that are each selectively movable from an unexpanded or delivery configuration in which a portion of the device is suitably sized for percutaneous delivery to a bodily cavity and an expanded or deployed configuration in which the portion of the device or system is sized too large for percutaneous delivery to the bodily cavity. In some embodiments, additional positioning (e.g., repositioning) of a system or device that is selectively moved from an unexpanded configuration to an expanded configuration

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occurs after the system or device has been moved into the expanded configuration and/or while the system or device is in the expanded configuration. For example, a portion of a medical system or device **2900** is shown in an unexpanded configuration in FIG. 10A and in an expanded configuration in FIG. 10B according to various embodiments. System or device **2900** includes a frame or structure **2902** that includes a plurality of elongate members **2904**. Each of the elongate members **2904** includes a proximal end **2907**, a distal end **2905** and a respective intermediate portion **2909** between the proximal end **2907** and the distal end **2905**. Each of the elongate members **2904** includes a front surface **2918a** (i.e., called out in FIG. 10B) that is positionable to face an interior surface of a bodily cavity (not shown) into which the structure **2902** may be deployed. Each of the elongate members **2904** includes a back surface **2918b** (i.e., called out in FIG. 10B) opposite the corresponding front surface **2918a** across a thickness of the elongate member **2904**.

In various embodiments, a set of one or more transducer elements **2990** is located on each of at least some of the elongate members **2904**. As in other embodiments described in this disclosure, each transducer element **2990** may include an electrode by way of non-limiting example. In various embodiments, a transducer element **2990**, or a component thereof may be located on (a) the front surface **2918a**, (b) the back surface **2918b**, or both (a) and (b) of a corresponding elongate member **2904**. For example, an electrode may be located on one, or both of the front surface **2918a** and back surface **2918b** of a given elongate member **2904** in some embodiments. In various embodiments, energy may be selectively transmittable from an electrode. In some of these various embodiments, the energy is sufficient for tissue ablation. In some of the various embodiments, the energy is insufficient for tissue ablation.

In FIG. 10A, the structure **2902** is in an unexpanded configuration suitably sized for delivery through catheter sheath **2906** (i.e., showed sectioned), for example for percutaneous delivery. The structure **2902** is physically coupled to a shaft member **2910** which is appropriately sized to convey structure **2902** through catheter sheath **2906** during the delivery. In some embodiments, shaft member **2910** is typically sufficiently flexible to allow for percutaneous delivery of structure **2902** through a tortuous path. Percutaneous delivery typically includes moving or otherwise conveying a structure (e.g., structure **2902**) through a bodily opening leading to a bodily cavity. In various embodiments, shaft member **2910** includes a first end portion **2910a** and a second end portion **2910b** spaced from the first end portion **2910a** across an elongated portion **2910c** of the shaft member **2910**. In FIGS. 10A and 10B, structure **2902** is physically coupled to the shaft member **2910** at least proximate the second end portion **2910b** of the shaft member **2910**.

In some embodiments, a handle portion **2903** is physically coupled to the shaft member **2910** at a location at least proximate the first end portion of **2910a** of shaft member **2910**. In various embodiments, handle portion **2903** is directly manipulable by a user to percutaneously deliver structure **2902** to a bodily cavity when structure **2902** is in the unexpanded configuration. In some example embodiments, at least a portion of the shaft member **2910** is directly manipulable by a user to percutaneously deliver structure **2902** to a bodily cavity. For example, the directly manipulable portion of shaft member **2910** may include at least part of the elongated portion **2910c** of the shaft member **2910**. The phrase "directly manipulable" and variants thereof (e.g., directly manipulated) employed herein in this disclosure may include grasping, gripping, or other similar handling

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performed directly on a particular entity (e.g., handle portion **2903**, elongated portion **2910c**) by a user or operator (for example, by a hand of a user or operator).

In some embodiments, a surface of shaft member **2910** contacts a lumen of catheter sheath **2906** when structure **2902** is percutaneously delivered through catheter sheath **2906**. In various example embodiments, each elongate member **2904** is arranged in structure **2902** to be advanced distal end **2905** first into a bodily cavity (not shown).

In FIG. 10B, structure **2902** is positioned in an expanded configuration. Shaft member **2910** is shown partially sectioned in FIG. 10B for clarity of illustration of various components. For clarity, catheter sheath **2906** is not shown.

In various embodiments, each of the respective intermediate portions **2909** of the plurality of elongate members **2904** is radially or angularly arranged with respect to one another at least partially about or around a first axis **2935** when the structure **2902** is in the expanded or deployed configuration. That is, each of the intermediate portions **2909** is radially or angularly distributed at least partially about or around the first axis **2935** (i.e., when looking along a direction that the first axis **2935** extends along), for instance like lines of longitude about a rotational or polar axis. In various embodiments, each of the respective intermediate portions **2909** of the elongate members **2904** is radially spaced from the first axis **2935** when structure **2902** is in the expanded configuration. In various embodiments, the intermediate portions **2909** may be circumferentially arranged about the first axis **2935** when the structure **2902** is in the expanded configuration.

In some embodiments, each of the elongate members **2904** includes a curved portion **2923** (only two called out) having a curvature configured to cause the curved portion **2923** to extend along at least a portion of a curved path, the curvature configured to cause the curved path to intersect the first axis **2935** at each of a respective at least two spaced apart locations along the first axis **2935** when structure **2902** is in the expanded configuration. In some embodiments, the curved path is defined to include an imagined extension of the curved portion along the curved portion's extension direction while maintaining the curved portion's curvature (e.g., radius of curvature or change in radius of curvature). In some embodiments, each curved portion **2923** may extend entirely along, or at least part way along the respective curved path to physically intersect at least one of the respective at least two spaced apart locations along the first axis **2935**. In some particular embodiments, no physical portion of a given elongate member of an employed structure intersects any of the at least two spaced apart locations along the first axis intersected by the respective curved path associated with the curved portion of the given elongate member. For example, the end portion of the given elongate member **2904** may be physically separated from the first axis **2935** by a hub device (e.g., hub **2965**) employed to physically couple or align the given elongate member **2904** to another elongate member **2904**. Additionally or alternatively, a given elongate member **2904** may include a recurve portion arranged to physically separate the given elongate member **2904** from the first axis **2935**. In some embodiments, various ones of the elongate members **2904** cross one another at a location on the structure **2902** passed through by the first axis **2935** when the structure **2902** is in the expanded configuration. In various embodiments, the curved path is an arcuate path. In various embodiments, at least the portion of the curved path extended along by corresponding curved portion **2923** is arcuate.

In some embodiments, each of the elongate members 2904 is a resilient member that stores potential or spring energy when confined in a confining structure (e.g., catheter sheath 2906) in the unexpanded configuration. Upon being advanced from the confining structure, at least some of the potential or spring energy is released to cause the structure 2904 to assume a lower energy state defined by the expanded configuration. In FIG. 10B, each of at least some of the elongate members 2904 is physically coupled to control member 2960a of an expansion control actuator 2960, a portion of which may, in some embodiments, extend along a path through shaft member 2910 or catheter sheath 2906. In some embodiments, the expansion control actuator 2960 is located on handle portion 2903. In some embodiments, the expansion control actuator 2960 is operable to impart force (e.g., tensile force) to control member 2960a sufficient to cause the intermediate portions 2909 of various ones of the elongate members 2904 to buckle outwardly from the first axis 2935 to move structure 2902 into the expanded configuration. In various embodiments, control member 2960a can include a flexible control line/wire/cable, a control rod or other force transmission members by way of non-limiting example. In some embodiments, the respective distal end 2905 of each of at least some of the elongate members 2904 is physically coupled (i.e., directly or indirectly) to control member 2960a. In some embodiments, the control member 2960a is physically coupled (i.e., directly or indirectly) to each of various ones of the elongate members 2904 at a location between the respective proximal and distal ends 2907, 2905 of each of the various ones of the elongate members 2904. For example, a single elongate member 2904 may form two diametrically opposed portions of the structure 2902, with the control member 2960a physically coupled (i.e., directly or indirectly) at a location on the elongate member 2904 between the two diametrically opposed portions. Other embodiments may employ other mechanisms or modes of operation for moving a structure (e.g., structure 2902) from an unexpanded configuration to an expanded configuration.

In various embodiments, structure 2902 is rotationally coupled to the second end portion 2910b of the shaft member 2910. In FIG. 10B, each of the elongate members 2904 is physically coupled to a hub 2965 (shown partially sectioned), the hub 2965 rotationally coupled to the second end portion 2910 of shaft member 2910. In some embodiments, the respective proximal end 2907 of each of the elongate members 2904 is directly coupled to hub 2965. In various embodiments, the structure 2902 is operably coupled to at least one actuator, the at least one actuator selectively operable to rotate the intermediate portion 2909 of each of at least some of the plurality of elongate members 2904 at least partially about or around the first axis 2935 when or while structure 2902 is in the expanded configuration. In various embodiments, the structure 2902 is operably coupled to at least one actuator, the at least one actuator selectively operable to concurrently rotate the intermediate portions 2909 of all of the plurality of elongate members 2904 about the first axis 2935 when or while structure 2902 is in the expanded configuration. In various embodiments, the intermediate portion 2909 of each of at least some of the plurality of elongate members is moved with respect to, or relatively to, at least the second end portion 2910b of the shaft member 2910 by the at least one actuator when or while the structure is in the expanded configuration. In various embodiments, the intermediate portions 2909 of all of the plurality of elongate members are moved with respect to, or relatively to, at least the second end portion 2910b of

the shaft member 2910 by the at least one actuator when or while the structure is in the expanded configuration. For example, in FIG. 10B, hub 2965 is physically coupled to a control member 2970a (shown sectioned) of at least one actuator that includes a rotation actuator 2970, a portion of which may, in some embodiments, extend along a path through shaft member 2910 or catheter sheath 2906 (again not shown in FIG. 10B). In some embodiments, the rotation actuator 2970 is located on handle portion 2903. In various embodiments, the rotation actuator 2970 is operable to manipulate control member 2970a to cause the intermediate portions 2909 of all of the plurality of elongate members 2904 to concurrently rotate about the first axis 2935 and move with respect to, or relatively to, at least the second end portion 2910b of the shaft member 2910. In some embodiments, the rotation actuator 2970 is operable to impart rotational movement (e.g., movement associated with an applied torque) to control member 2970a sufficient to cause the intermediate portions 2909 of all of the plurality of elongate members 2904 to rotate concurrently about the first axis 2935 and move with respect to, or relatively to, at least the second end portion 2910b of the shaft member 2910. In various embodiments, the intermediate portions 2909 of all of the plurality of elongate members 2904 are configured to concurrently move with respect to, or relatively to, the second end portion 2910b of the shaft member 2910 and to concurrently rotate about the first axis 2935. In various embodiments, the intermediate portions 2909 of all of the plurality of elongate members 2904 are configured to concurrently move throughout the duration of their movement with respect to, or relative to, the second end portion 2910b of the shaft member 2910 and throughout the duration of their rotation about the first axis 2935. In various embodiments, the intermediate portions 2909 of all of the plurality of elongate members 2904 are configured to concurrently move throughout only a portion of the duration of their movement with respect to, or relatively to, the second end portion 2910b of the shaft member 2910 and throughout only a portion of the duration of their rotation about the first axis 2935. Thus, as used herein and in the claims, the terms concurrently, and similar terms (e.g., current), means at least partially overlapping in time, even if not starting and ending at the same time.

Rotation of various ones and sometimes all of the intermediate portions 2909 of the elongate members 2904 about the first axis 2935 when or while structure 2902 is in the expanded configuration may be motivated by various reasons. For example in some embodiments when structure 2902 is deployed in the expanded configuration in a bodily cavity, various ones of the transducer elements 2990 may not be able to effectively interact with bodily tissue in the cavity, and an additional rotation of a portion of the structure 2902 on which the transducer elements 2990 are located may be required to increase the effectiveness of the interaction of with the bodily tissue. In FIG. 10B, the respective transducer elements 2990a and 2990b of a first adjacent pair of transducers 2990 are circumferentially spaced with respect to each other (i.e., about first axis 2935) by a greater amount than a circumferential spacing between the respective transducer elements 2990c and 2990d of a second pair of transducer elements 2990. In FIG. 10B, each of transducer elements 2990a and 2990b are radially spaced from first axis 2935 by a greater radial distance than each of the transducer elements 2990c and 2990d. In some embodiments, a circumferential distance between an adjacent pair of transducer elements (e.g., various transducer elements 2990) may be too large to effectively ablate tissue between the two trans-

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ducer elements of the adjacent pair, thereby necessitating an additional rotation in accordance with various embodiments. For example, a rotation of a portion of structure 2902 may occur after at least the two transducer elements 2990a and 2990b are activated to ablate respective tissue regions, the rotation sufficient to position one of the transducer elements 2990a and 2990b to ablate a tissue region between the two previously ablated tissue regions. In various embodiments, the rotation of the portion of the structure 2902 about first axis 2935 when or while the structure 2902 is in the expanded configuration rotates all the transducer elements 2990 about first axis 2935. In various embodiments, the rotation of the portion of the structure 2902 about first axis 2935 when or while the structure 2902 is in the expanded configuration rotates the intermediate portions 2909 of all of the plurality of elongate members 2904 about first axis 2935. The intermediate portions 2909 of all of the plurality of elongate members 2904 may be controlled to rotate about the first axis 2935 by other angular amounts in various other embodiments.

In FIG. 10B, control member 2960a is arranged in a lumen provided in control member 2970a. In various embodiments, control member 2970a is arranged in a lumen provided in control member 2960a. In some embodiments control member 2960a may be arranged to transmit an axially compressive force to move structure 2902 from the unexpanded configuration to the expanded configuration. For example, an axially compressive force may be applied to buckle the intermediate portions 2909 of at least some of the elongate members 2904 as structure 2902 is moved from the unexpanded configuration to the expanded configuration. In some embodiments, control member 2960a is arranged to concurrently rotate as the intermediate portion 2909 of each of at least some or all of the plurality of elongate members 2904 is rotated about the first axis 2935 by rotation actuator 2970. In other embodiments, control member 2960a is arranged to not concurrently rotate as the intermediate portion 2909 of each of at least some or all of the plurality of elongate members 2904 is rotated about the first axis 2935 by rotation actuator 2970. In some embodiments, control member 2970a is physically coupled (i.e., directly or indirectly) to the respective proximal end 2907, the respective distal end 2905, or each of the respective proximal and distal ends 2907, 2905 of each of at least some of the elongate members 2904. In various embodiments, rotation of the intermediate portion 2909 of each of at least some or all of the elongate members 2904 by rotation actuator 2970 when or while structure 2902 is in the expanded configuration is accompanied by a concurrent rotation of each of the corresponding respective proximal and distal ends 2907 and 2905. In various embodiments, rotation of the intermediate portion 2909 of each of at least some or all the elongate members 2904 by rotation actuator 2970 when or while structure 2902 is in the expanded configuration is accompanied by a concurrent rotation of one, but not both, of the respective proximal and distal ends 2907 and 2905. In some of these various embodiments, various ones of the elongate members 2904 assume a helical form around first axis 2935 when the intermediate portion 2909 of each of at least some or all the elongate members 2904 is rotated about the first axis 2935 by rotation actuator 2970 when or while structure 2902 is in the expanded configuration. In some embodiments, rotation of the intermediate portion 2909 of each of at least some or all the elongate members 2904 by rotation actuator 2970 when or while structure 2902 is in the expanded configuration.

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expanded configuration is not accompanied by a concurrent rotation of any of the respective proximal and distal ends 2907 and 2905.

In FIG. 10B, the second end portion 2910b of shaft member 2910 includes a surface 2912, a portion of the surface 2912 positioned at an end 2913 of flexible shaft member 2910, the portion of the surface 2912 being circumferentially arranged about a second axis 2937. End 2913 defines an end or terminus of flexible shaft member 2910, and in particular, an end of second end portion 2910b. In various embodiments, an extent of the portion of surface 2912 is defined at least in part by end 2913. In various embodiments, the second axis 2937 is parallel to the first axis 2935. In some embodiments, the second axis 2937 and the first axis 2935 are substantially collinear. In various embodiments, the intermediate portion 2909 of each of at least some or all of the plurality of elongate members 2904 is rotated about the second axis 2937 by rotation actuator 2970.

In various embodiments, the expanded configuration is a first expanded configuration in which the respective intermediate portion 2909 of each of at least some of the elongate members 2904 is radially spaced from the first axis 2935 by a respective first radial distance. In some of these various embodiments, the structure 2902 is further selectively moveable between the first expanded configuration and a second expanded configuration in which the respective intermediate portion 2909 of each of the at least some of the plurality of elongate members 2904 is radially spaced from the first axis 2935 by a second radial distance, each second radial distance having a greater magnitude than a magnitude of the corresponding or respective first radial distance. This may be motivated by various reasons. For example, the at least some of the elongate members 2904 may be further manipulated to adjust a positioning between various transducer elements 2990 located on the elongate members 2904 and a tissue surface within a bodily cavity in which the structure 2902 is positioned. The at least some of the elongate members 2904 may be further manipulated to create conformance with a tissue surface of the bodily cavity when structure 2902 is moved from the first expanded configuration to the second expanded configuration. In some embodiments, a size of the structure 2902 in the first expanded configuration is configured to reduce contact between the structure 2902 and an interior tissue surface of the bodily cavity in which the structure 2902 is positioned. This may be motivated by different reasons including reducing occurrences of damage to the interior tissue surface during the rotation of the intermediate portions 2909 of at least some or all of the elongate members 2904 by rotation actuator 2970. After the rotational movement, the structure 2902 may be selectively moved into the second expanded configuration to engage with, or be positioned at least proximate to, the interior tissue surface within the bodily cavity.

FIGS. 11A and 11B show a system including a medical system or device 3000 according to various embodiments. System or device 3000 includes a frame or structure 3002 that comprises a plurality of elongate members 3004. System or device 3000 may include a plurality of transducer elements located on the structure 3002 (i.e., not shown for clarity, but similar to transducer elements 120, 206, 1490, 2490, 2690 and 2990), the plurality of transducer elements positionable within a bodily cavity (not shown). In some embodiments, the plurality of transducer elements are arrangeable to form a two- or three-dimensional distribution, grid or array of the transducer elements capable of mapping, ablating or stimulating an inside surface of a bodily cavity

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or lumen without requiring mechanical scanning. In various example embodiments, at least some of the transducer elements include respective electrodes, each electrode including a respective energy transmission surface configured for transferring energy to tissue, from tissue, or both to and from tissue.

In a manner similar to other embodiments described in this disclosure, structure 3002 is selectively movable between an unexpanded or delivery configuration (e.g., as shown in FIG. 11A) and an expanded or deployed configuration (e.g., as shown in FIG. 11B) that may be used to position elongate members 3004 against a tissue surface within the bodily cavity or position the elongate members 3004 in the vicinity of the tissue surface. In some embodiments, structure 3002 has a size in the unexpanded or delivery configuration suitable for percutaneous delivery through a bodily opening (e.g., via catheter sheath 3012) to the bodily cavity. In some embodiments, structure 3002 has a size in the expanded configuration too large for percutaneous delivery through a bodily opening (e.g., via catheter sheath 3012, not shown in FIG. 11B) to the bodily cavity. The elongate members 3004 may form part of a flexible circuit structure (i.e., also known as a flexible printed circuit board (PCB) circuit). In some embodiments, the elongate members 3004 include a plurality of different material layers. In some embodiments, each of the elongate members 3004 includes a plurality of different material layers.

In FIG. 11A, each of the elongate members 3004 includes a respective distal end 3005 (only one called out), a respective proximal end 3007 (only one called out) and an intermediate portion 3009 (only one called out) positioned between the proximal end 3007 and the distal end 3005. The respective intermediate portion 3009 of each elongate member 3004 includes a first or front surface 3018a that is positionable to face an interior tissue surface within a bodily cavity (not shown) and a second or back surface 3018b opposite across a thickness of the intermediate portion 3009 from the front surface 3018a. In various embodiments, the intermediate portion 3009 of each of the elongate members 3004 includes a respective pair of side edges of the front surface 3018a, the back surface 3018b, or both the front surface 3018a and the back surface 3018b, the side edges of each pair of side edges opposite to one another, the side edges of each pair of side edges extending between the proximal end 3007 and the distal end 3005 of the respective elongate member 3004. In some embodiments, each pair of side edges includes a first side edge 3027a (only one called out in FIG. 11A) and a second side edge 3027b (only one called out in FIG. 11A). In some embodiments, each of the elongate members 3004, including each respective intermediate portion 3009, is arranged front surface 3018a-toward-back surface 3018b in a stacked array during an unexpanded or delivery configuration. In many cases, a stacked array allows the structure 3002 to have a suitable size for percutaneous or intravascular delivery. In some embodiments, the elongate members 3004 are arranged to be introduced into a bodily cavity (again not shown) distal end 3005 first. For clarity, not all of the elongate members 3004 of structure 3002 are shown in FIG. 11A. In some embodiments, each of at least some of the elongate members includes a bent portion 3009a (i.e., similar to portions 2609a, 2809a) as called out in FIG. 11B. In some embodiments, each of at least some of the elongate members includes a twisted portion 3009c (i.e., similar to twisted portions 2609c, 2809c) as called out in FIG. 11B.

Each of the elongate members 3004 is arranged in a fanned arrangement 3080 in FIG. 11B. Elongate members

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3004 are identified as elongate members 3004a, 3004b, 3004c, 3004d, 3004e, 3004f, 3004g, 3004h, 3004i and 3004j in FIG. 11B. In some embodiments, the fanned arrangement 3080 is formed during the expanded or deployed configuration in which structure 3002 is manipulated to have a size too large for percutaneous or intravascular delivery. In some embodiments, structure 3002 includes a proximal portion 3002a having a first domed shape 3008a and a distal portion 3002b having a second domed shape 3008b when structure 3002 is in the expanded configuration. In some embodiments, the proximal and the distal portions 3002a, 3002b include respective portions of elongate members 3004. In some embodiments, the structure 3002 is arranged to be delivered distal portion 3002b first into a bodily cavity (again not shown) when the structure 3002 is in the unexpanded or delivery configuration as shown in FIG. 11A. In some embodiments, the proximal and the distal portions 3002a, 3002b are arranged in a clam shell configuration in the expanded or deployed configuration shown in FIG. 11B. In various example embodiments, each of the front surfaces 3018a (three called out in FIG. 11B) of the intermediate portions 3009 of the plurality of elongate members 3004 face outwardly from the structure 3002 when the structure 3002 is in the expanded configuration. In various embodiments, each of the front surfaces 3018a of the intermediate portions 3009 of the plurality of elongate members 3004 are positioned adjacent an interior tissue surface of a bodily cavity (not shown) in which the structure 3002 (i.e., in the expanded configuration) is located. In various example embodiments, each of the back surfaces 3018b (two called out in FIG. 11B) of the intermediate portions 3009 of the plurality of elongate members 3004 face an inward direction when the structure 3002 is in the expanded configuration.

In various embodiments, the respective intermediate portions 3009 of various ones of the elongate members 3004 are angularly arranged with respect to one another about a first axis 3035 when structure 3002 is in the expanded configuration. In various embodiments, each of the respective intermediate portions 3009 of the plurality of elongate members 3004 are radially arranged with respect to one another at least partially about or around a first axis 3035 when the structure 3002 is in the expanded configuration. That is, each of the intermediate portions 3009 is radially distributed at least partially about or around the first axis 3035 (i.e., when looking along a direction that the first axis 3035 extends along), for example like lines of longitude about a rotational or polar axis. Thus, in various embodiments, each of the respective intermediate portions 3009 of the elongate members 3004 may be described as being radially spaced from the first axis 3035 when structure 3002 is in the expanded configuration. In various embodiments, the intermediate portions 3009 of various ones of the elongate members 3004 may be described as being circumferentially arranged about first axis 3035 when structure 3002 is in the expanded configuration, similar to lines of longitude about an axis of rotation of a body of revolution, which body of revolution may, or may not be spherical.

In some embodiments, each of the elongate members 3004 includes a curved portion 3023 (two called out in FIG. 11B) having a curvature configured to cause the curved portion 3023 to extend along at least a portion of a curved path, the curvature configured to cause the curved path to intersect the first axis 3035 at each of a respective at least two spaced apart locations along the first axis 3035 when structure 3002 is in the expanded configuration. In some embodiments, the curved path is defined to include an imagined extension of the curved portion along the curved

portion's extension direction while maintaining the curved portion's curvature (e.g., radius of curvature or change in radius of curvature). In some embodiments, each curved portion 3023 may extend entirely along, or at least part way along the respective curved path to physically intersect at least one of the respective at least two spaced apart locations along the first axis 3035. In some particular embodiments, no physical portion of a given elongate member of an employed structure intersects some of the at least two spaced apart locations along the first axis 3035 intersected by the respective curved path associated with the curved portion 3023 of the given elongate member. In some embodiments, various ones of the elongate members 3004 cross one another at a location on the structure 3002 passed through by the first axis 3035 when the structure 3002 is in the expanded configuration. In various embodiments, the curved path is an arcuate path. In various embodiments, at least the portion of the curved path extended along by corresponding curved portion 3023 is arcuate or volute. In some embodiments, structure 3002 is selectively movable between a first expanded configuration and a second expanded configuration similar to various embodiments described above in this disclosure (e.g., selective manipulation of frame 2502 from a first fanned array 2570 to a second fanned array 2572 or selective manipulation of frame 2802 from a first fanned array 2870 to a second fanned array 2872). In various embodiments, the curved portions 3023 are circumferentially arranged about the first axis 3035 when the structure 3002 is in the expanded configuration.

In various embodiments, a shaft member 3010 is used to deliver structure 3002 through catheter sheath 3012. In some embodiments, shaft member 3010 is typically sufficiently flexible to allow for percutaneous delivery of structure 3002 through a tortuous path. In FIGS. 11A and 11B, structure 3002 is physically coupled to shaft member 3010. In various embodiments, shaft member 3010 includes a first end portion 3010a and a second end portion 3010b spaced from the first end portion 3010a across an elongated portion 3010c of the shaft member 3010. In FIGS. 11A and 11B, structure 3002 is physically coupled to the shaft member 3010 at least proximate the second end portion 3010b of the shaft member 3010. In some embodiments, a handle portion 3003 is physically coupled to the shaft member 3010 at a location at least proximate the first end portion 3010a of shaft member 3010. In various embodiments, handle portion 3003 is directly manipulable by a user to percutaneously deliver structure 3002 to a bodily cavity when structure 3002 is in the unexpanded configuration. In some example embodiments, at least a portion of the shaft member 3010 is directly manipulable by a user to percutaneously deliver structure 3002 to a bodily cavity. For example, the directly manipulable portion of shaft member 3010 may include at least part of the elongated portion 3010c of the shaft member 3010. In various embodiments, an external surface of shaft member 3010 is positioned for contact with a surface of a lumen of a catheter sheath (e.g., catheter sheath 3012) through which a portion of shaft member 3010 is passed through when structure 3002 is percutaneously delivered in the unexpanded configuration. Various communication paths (e.g., transducer element data paths, energy transmission paths, etcetera, not shown) may be provided through a portion of shaft member 3010. In some embodiments, various control paths, communication paths or data transmission paths (not shown) may be provided between shaft member 3010 and a controller (e.g., controller 224).

In some embodiments, structure 3002 is fixedly coupled to shaft member 3010. In various embodiments, the respec-

tive proximal end 3007, the respective distal end 3005, or each of the respective proximal and distal ends 3007, 3005 of each of the elongate members 3004 is fixedly coupled to shaft member 3010. For example, in FIGS. 11A and 11B, the respective proximal end 3007 of each of the elongate members 3004 is fixedly coupled to shaft member 3010. In some example embodiments, each location on the structure 3002 to which shaft member 3010 is physically coupled is positioned to one side (i.e., a same or a common one of the sides) of at least one plane (also referred to as a spatial plane) when the structure 3002 is in the expanded configuration, each plane of the at least one plane coincident with the first axis 3035. For example, in FIG. 11B, a plane 3039 is coincident with first axis 3035 when structure 3002 is in the expanded configuration. In FIG. 11B, each location on the structure 3002 to which shaft member 3010 is physically coupled is positioned to one or a same side of plane 3039. It is understood that other planes may also be positioned in a similar relationship with shaft member 3010. Plane 3039 is depicted as having boundaries merely for purposes of clarity of illustration in FIG. 11B. In some embodiments, at least some of the respective curved portions 3023 of at least two of the elongate members 3004 are arranged on each side of a plane positioned coincident with first axis 3035 (e.g., plane 3039) when the structure 3002 is in the expanded configuration. In some embodiments, at least some of the respective intermediate portions 3009 of at least two of the elongate members 3004 are arranged on each side of a plane positioned coincident with first axis 3035 (e.g., plane 3039) when the structure 3002 is in the expanded configuration. FIG. 11C is a plan view of structure 3002 in the expanded configuration of FIG. 11B. The plan view of FIG. 11C has an orientation such that first axis 3035 is viewed along the axis in this particular embodiment. The plan view of FIG. 11C has an orientation such that plane 3039 is viewed 'on edge' to its respective planar surface. It is noted in various embodiments, plane 3039 is an imaginary spatial plane (i.e., not itself a physical structure) and has no or infinitesimal thickness, and 'on edge' is intended to refer to an 'on edge' perspective assuming that the plane had an edge of infinitesimal or minimal thickness. Plane 3039 is represented by a respective 'heavier' line in FIG. 11C. First axis 3035 is represented by a " symbol in FIG. 11C. It is understood that each of the depicted lines or symbols " used to represent any corresponding plane, or axis in this disclosure do not impart any size attributes on the corresponding plane or axis.

In FIGS. 11B and 11C, the second end portion 3010b of shaft member 3010 includes a surface 3014, a portion of the surface 3014 positioned at an end 3013 of shaft member 3010 being circumferentially arranged about a second axis 3037. End 3013 defines an end of shaft member 3010, and in particular, an end of second end portion 3010b. In various embodiments, an extent of the portion of surface 3012 is defined at least in part by end 3013. In various embodiments, the second axis 3037 is not parallel to the first axis 3035 when structure 3002 is in the expanded configuration. In various embodiments, the second axis 3037 is not collinear with first axis 3035 when structure 3002 is in the expanded configuration.

Structure 3002 may be selectively moved between the unexpanded configuration and the expanded configuration by the use of various methods and devices such as those employed with structures or frames 2702, 2802 by way of non-limiting example. In some example embodiments, at least the respective intermediate portions 3009 of at least some of the plurality of elongate members 3004 are fanned

as the structure 3002 is moved between the unexpanded configuration and the expanded configuration. At least a portion of the fanning may include autonomous fanning as described above in this disclosure. In some example embodiments, at least the respective intermediate portions 3009 of at least some of the plurality of elongate members 3004 are rotated about an axis as the structure 3002 is moved between the unexpanded configuration and the expanded configuration. In some example embodiments, when the structure 3002 is moved between the unexpanded configuration and the expanded configuration, at least the respective intermediate portion 3009 of each elongate member 3004 of a first set of the elongate members 3004 is rotated in a first rotational direction (e.g., a clockwise rotational direction), and at least the respective intermediate portion 3009 of each elongate member 3004 of a second set of the elongate members 3004 different than the first set is rotated in a second rotational direction (e.g., a counter-clockwise rotational direction) opposite to the first rotational direction. For example in some embodiments, the respective intermediate portions of each of a first set of the elongate members and a second set of the elongate members are rotated in opposite directions in a manner similar to the elongate members 1704b, 1704c, 1704d, 1704e, 1704f in FIGS. 4G and 4H as an associated structure that includes the first and the second sets is moved between an unexpanded configuration and an expanded configuration. In some example embodiments, the respective intermediate portions of each of a first set of the elongate members and a second set of the elongate members are rotated in opposite directions in a manner similar to the elongate members 2604a, 2604b, 2604c, 2604e, 2604f and 2604g in various ones of FIG. 7 as an associated structure that includes the first and the second sets is moved between an unexpanded configuration and an expanded configuration. Rotations may have differential rotational speeds, or the rotational speeds may be the same across some or all elongate members.

As represented in FIG. 11C, when structure 3002 has been moved into the expanded configuration from the unexpanded configuration (e.g., as shown in FIG. 11A), at least the respective intermediate portions 3009 (only two called out) of the elongate members 3004 in a first set of the elongate members 3004 (i.e., elongate members 3004a, 3004b, 3004c, 3004d, and 3004e) each have been rotated in a first rotational direction (e.g., a clockwise rotational direction represented by arrow 3090a) and at least the respective intermediate portions 3009 (only two called out) of the elongate members 3004 in a second set of the elongate members 3004 (i.e., elongate members 3004f, 3004g, 3004h, 3004i and 3004j) each have been rotated in a second rotational direction (e.g., a counter-clockwise rotational direction represented by arrow 3090b) opposite to the first rotational direction. In some embodiments, when the structure 3002 is moved between the unexpanded configuration and the expanded configuration, at least the respective intermediate portion 3009 of each elongate member 3004 in the first set is rotated in a first rotational direction about the first axis 3035, and at least the respective intermediate portion 3009 of each elongate member 3004 in the second set is rotated in a second rotational direction about the first axis 3035, the second rotational direction opposite to the first rotational direction. As represented in FIG. 11C, when structure 3002 has been moved into the expanded configuration from the unexpanded configuration (i.e., as best visualized in FIG. 11A), at least the respective intermediate portion of each elongate member 3004 in the first set of elongate members 3004 has been moved away from the

second axis 3037 in a first direction (e.g., represented by arrow 3092a) and at least the respective intermediate portion of each elongate member 3004 in the second set of elongate members 3004 has been moved away from the second axis 3037 in a second direction (e.g., represented by arrow 3092b). In some embodiments, the first and the second directions are different directions. In some embodiments, the second direction is opposite to the first direction. In some embodiments, the first direction includes a first rotational direction component (e.g., a clockwise rotational direction component represented by arrow 3094a) and the second direction includes a second rotational direction component (e.g., a counter-clockwise rotational direction component represented by arrow 3094b) opposite to the first rotational direction component.

In various embodiments, the structure 3002 is operably coupled to at least one actuator, the at least one actuator selectively operable to rotate the intermediate portion 3009 of each of at least some or all of the plurality of elongate members 3004 at least partially about or around at least the first axis 3035 when or while structure 3002 is in the expanded configuration. In various embodiments, the intermediate portion 3009 of each of at least some of the plurality of elongate members 3004 is moved with respect to, or relatively to, at least the second end portion 3010b of the shaft member 3010 by the at least one actuator when or while structure 3002 is in the expanded configuration. In various embodiments, the intermediate portions 3009 of all of the plurality of elongate members 3004 are moved with respect to, or relatively to at least the second end portion 3010b of the shaft member 3010 by the at least one actuator when structure 3002 is in the expanded configuration. For example, in FIGS. 11B and 11C, at least one actuator that includes a rotation actuator 3070 is employed in some embodiments to rotate at least the intermediate portion 3009 of each of at least some or all of the plurality of elongate members 3004 about the first axis 3035 when or while structure 3002 is in the expanded configuration. In various embodiments, at least the intermediate portion 3009 of each of at least some or all of the plurality of elongate members 3004 is moved with respect to, or relatively to, at least the second end portion 3010b of the shaft member 3010 by rotation actuator 3070. In some embodiments, the rotation actuator 3070 is located on handle portion 3003. In various embodiments, the intermediate portions 3009 of all of the plurality of elongate members 3004 are configured to concurrently move with respect to, or relatively to, the second end portion 3010b of the shaft member 3010 and to concurrently rotate about the first axis 3035. In various embodiments, the intermediate portions 3009 of all of the plurality of elongate members 3004 are configured to concurrently move throughout at least a portion of the duration of their movement with respect to the second end portion 3010b of the shaft member 3010 and throughout at least a portion of the duration of their rotation about the first axis 3035.

In various embodiments, rotation actuator 3070 is selectively operable to rotate the intermediate portion 3009 of each of at least some of the plurality of elongate members 3004 at least partially about or around at least the first axis 3035 when or while structure 3002 is in the expanded configuration. In some of these embodiments, the intermediate portion 3009 of each of at least some of the plurality of elongate members 3004 rotates at least partially about or around each of the first axis 3035 and the second axis 3037 by different respective angular amounts when the rotation actuator 3070 rotates the intermediate portion 3009 of each of at least some of the plurality of elongate

members 3004 about at least the first axis 3035 when or while structure 3002 is in the expanded configuration. For example, when the intermediate portion 3009 of each of the at least some of the plurality of elongate members 3004 is rotated partially about the first axis 3035 by a respective first angular amount by the rotation actuator 3070 when or while structure 3002 is in the expanded configuration, a secondary rotation of the intermediate portion 3009 of each of the at least some of the plurality of elongate members 3004 by a second angular amount about the second axis 3037 may also occur. In various embodiments, each first angular amount is typically much greater than the corresponding second angular amount. In some embodiments, the intermediate portion 3009 of each of the at least some of the plurality of elongate members 3004 is not rotated about the second axis 3037 when rotation actuator 3070 rotates the intermediate portion 3009 of each of the at least some of the plurality of elongate members 3004 about at least the first axis 3035 when or while structure 3002 is in the expanded configuration.

In various embodiments, the rotation actuator 3070 is operable to manipulate various control members to cause at least the intermediate portion 3009 of each of at least some or all of the plurality of elongate members 3004 to at least partially rotate about the first axis 3035 and move with respect to, or relative to, the second end portion 3010b of the shaft member 3010. For example, in FIGS. 11B and 11C, two control members 3070a and 3070b are manipulable by rotation actuator 3070 to cause the intermediate portion 3009 of each of at least some or all of the plurality of elongate members 3004 to partially rotate about the first axis 3035 and move with respect or relative to the second end portion 3010b of the shaft member 3010. It is noted that although each of control members 3070a and 3070b is directly physically coupled to a respective one of elongate members 3004a and 3004j in FIGS. 11B and 11C, movement of any of elongate members 3004a and 3004j under the influence of corresponding ones of control members 3070a and 3070b may also result in movement of others of the elongate members 3004 in various embodiments. For example, each of the elongate members 3004 may be physically coupled together by various coupling members (not shown but sometimes similar to coupling members 2858 used in various embodiments associated with device 2800). In various embodiments, coupling members such as coupling members 2858 may be employed to cause a movement of at least one elongate member 3004 on the basis of a movement of at least another elongate member 3004.

Control members 3070a, 3070b may take different forms in various embodiments. For example, control members 3070a, 3070b can include tension force transmission members or compression force transmission members by way of non-limiting example. In various embodiments, a portion of each of at least one of control members 3070a, 3070b may be conveyed through shaft member 3010 or catheter sheath 3012 to rotation actuator 3070. In FIGS. 11B and 11C, rotation actuator 3070 is operable to selectively apply force (e.g., a tension force) to various ones of the control members 3070a, 3070b to cause the intermediate portion 3009 of each of at least some or all of the plurality of elongate members 3004 to at least partially rotate about the first axis 3035 and move with respect to, or relative to, the second end portion 3010b of the shaft member 3010 when or while structure 3002 is in the expanded configuration. For example, in various embodiments, rotation actuator 3070 may be selectively operable to partially rotate the intermediate portion 3009 of each of at least some or all of the plurality of elongate members 3004 about or around the first axis 3035

in a particular rotational direction when or while structure 3002 is in the expanded configuration. In some of these various embodiments, the particular rotational direction is one of a first rotational direction (e.g., rotational direction represented by arrow 3090a or rotational direction component represented by arrow 3094a) or a second rotational direction (e.g., rotational direction represented by arrow 3090b or rotational direction component represented by arrow 3094b) associated with the movement of structure 3002 between the unexpanded configuration and the expanded configuration.

FIG. 11D is similar to the plan view of FIG. 11C in which structure 3002 is in the expanded configuration, but in which rotation actuator 3070 has been operated in a first mode in which the intermediate portion 3009 of each of at least some (i.e., all in FIG. 11D) of the elongate members 3004 have been partially rotated about or around the first axis 3035 in a first rotational direction (e.g., a clockwise rotational direction represented by arrow 3096a) according to various embodiments. In some of these various embodiments, the first rotational direction represented by arrow 3096a is the same as a first rotational direction (e.g., rotational direction 3090a or rotational direction component 3094a) associated with a movement of a portion of the structure 3202 between the unexpanded configuration and the expanded configuration. In various embodiments, rotation actuator 3070 may be configured to operate in various ways in the first mode. For example in some embodiments, rotation actuator 3070 may be operated to cause the intermediate portion 3009 of each of at least some (i.e., all in FIG. 11D) of the elongate members 3004 to partially rotate about or around the first axis 3035 in the first rotational direction represented by arrow 3096a by causing control member 3070a to apply a greater amount of force (e.g., tension-based force) to elongate member 3004a than a force (e.g., tension-based force) applied to elongate member 3004j by control member 3070b. In some embodiments, rotation actuator 3070 may be operated to cause the intermediate portion 3009 of each of at least some (i.e., all in FIG. 11D) of the elongate members 3004 to partially rotate about or around the first axis 3035 in the first rotational direction represented by arrow 3096a by causing control members 3070a, 3070b to apply a suitable force couple or moment to structure 3202. In some embodiments, a biasing device (e.g., spring, resilient member) is employed to oppose a rotation, when structure 3002 is in the expanded configuration, of the intermediate portion 3009 of each of at least some or all of the elongate members 3004 about the first axis 3035 under the influence of rotation actuator 3070. For example, a biasing device as described above may be provided at least in part by a respective resilient portion of each of at least some of the elongate members 3004. In FIGS. 11B and 11C, a first portion (e.g., bent portion 3009a) of each of at least some of the elongate members 3004 is adjacent a corresponding twisted portion 3009c. In various embodiments, a biasing device as described above may be provided at least in part by each bent portion 3009a. It is noted each twisted portion 3009c may also provide at least part of the biasing device. However, since each twisted portion 3009c is typically stiffer than a corresponding bent portion 3009a, each bent portion 3009 will preferentially bend during the application of the biasing action in various embodiments.

FIG. 11E is similar to the plan view of FIG. 11C in which structure 3002 is in the expanded configuration, but in which rotation actuator 3070 has been operated in a second mode in which the intermediate portion 3009 of each of at least some (i.e., all in FIG. 11E) of the elongate members 3004

have been rotated about the first axis 3035 in a second rotational direction (e.g., counter-clockwise rotational direction represented by arrow 3096b) according to various embodiments. In various embodiments, the second rotational direction represented by arrow 3096b is opposite to the first rotational direction represented by arrow 3096a. In some of these various embodiments, the second rotational direction represented by arrow 3096b is the same as a second rotational directional rotation (e.g., rotational direction represented by arrow 3090b or rotational direction component represented by arrow 3094b) associated with a movement of a portion of the structure 3002 between the unexpanded configuration and the expanded configuration. In various embodiments, rotation actuator 3070 may be configured to operate in various ways in the second mode. For example in some embodiments, rotation actuator 3070 may be operated to cause the intermediate portion 3009 of each of at least some (i.e., all in FIG. 11E) of the elongate members 3004 to partially rotate about or around the first axis 3035 in the second rotational direction represented by arrow 3096b by causing control member 3070b to apply a greater amount of force (e.g., tension-based force) to elongate member 3004j than a force (e.g., tension-based force) applied to elongate member 3004a by control member 3070a. In some embodiments, rotation actuator 3070 is selectively operable in each of the first mode (e.g., represented in FIG. 11D) and the second mode (e.g., represented in FIG. 11E). The intermediate portion 3009 of each of at least some or all of the plurality of elongate members 3004 may be controlled to at least partially rotate about or around the first axis 3035 by other angular amounts than those depicted in FIGS. 11D and 11E in other embodiments.

Referring back to embodiments represented in FIGS. 7, each front surface 2618a includes, carries or supports (i.e., directly or indirectly) at least one transducer element 2690 (i.e., not shown) that is positionable adjacent to an interior tissue surface in when the first fanned array 2670 is manipulated into the second fanned array 2672 within a bodily cavity having the interior tissue surface. In these example embodiments, once the second fanned array 2672 has been appropriately positioned at a given location within a bodily cavity, determination of the locations of various components of device 2600 (e.g., transducer elements including sensors or electrodes or related support structures such as elongate members 2604), or the locations of various anatomical features within the bodily cavity can be determined by various methods. In these example embodiments, after the portion of the device 2600 has been appropriately positioned at a given location within a bodily cavity, ablation of various regions of a tissue surface within bodily cavity can commence. The second fanned array 2672 may be removed from the bodily cavity by reconfiguring the portion of the device 2600 back into the second/bent configuration and then further back into the first/unexpanded configuration. In this example embodiment, the wedged or tapered form of the fanned first portions 2609a of the elongate members 2604 allows the elongate members 2604 to be readily drawn into a lumen of catheter sheath 2606 facilitating movement from the deployed configuration to the delivery configuration.

FIG. 8 is a flow diagram representing a method 2700 for forming, fabricating or manufacturing various elongate members employed in various embodiments. For convenience, the various procedures or acts described in method 2700 are made with reference to the elongate members 2604 shown in FIGS. 7A through 7M. It is understood that method 2700 may be applied to produce other elongate members employed in other embodiments.

Method 2700 begins with block 2702 in which a plurality of elongate members are provided. For example, FIG. 7G includes a respective plan view of each of various elongate members including elongate members 2604<sub>a<sub>int</sub></sub>, 2604<sub>b<sub>int</sub></sub>, 2604<sub>C<sub>int</sub></sub>, 2604<sub>d<sub>int</sub></sub>, 2604<sub>e<sub>int</sub></sub>, 2604<sub>f<sub>int</sub></sub>, and 2604<sub>g<sub>int</sub></sub> (collectively 2604<sub>int</sub>) that are provided to form at least a portion of respective ones of the elongate members 2604 employed by the example embodiment shown in FIG. 7A. In this example embodiment, provided elongate member 2604<sub>a<sub>int</sub></sub> corresponds to elongate member 2604a, provided elongate member 2604<sub>b<sub>int</sub></sub> corresponds to elongate member 2604b, provided elongate member 2604<sub>C<sub>int</sub></sub> corresponds to elongate member 2604c, provided elongate member 2604<sub>d<sub>int</sub></sub> corresponds to elongate member 2604d, provided elongate member 2604<sub>e<sub>int</sub></sub> corresponds to elongate member 2604e, provided elongate member 2604<sub>f<sub>int</sub></sub> corresponds to elongate member 2604f, and provided elongate member 2604<sub>g<sub>int</sub></sub> corresponds to elongate member 2604g. As shown in FIG. 7G, the respective proximal end 2607, the respective distal end 2605, the respective length 2611, and the respective front surface 2618a of each one of elongate members 2604a, 2604b, 2604c, 2604d, 2604e, 2604f, and 2604g is also represented in a respective one of provided elongate members 2604<sub>a<sub>int</sub></sub>, 2604<sub>b<sub>int</sub></sub>, 2604<sub>C<sub>int</sub></sub>, 2604<sub>d<sub>int</sub></sub>, 2604<sub>e<sub>int</sub></sub>, 2604<sub>f<sub>int</sub></sub>, and 2604<sub>g<sub>int</sub></sub>. Accordingly, the same reference numbers have been employed.

In this example embodiment, each of the elongate members 2604<sub>int</sub> is provided in a strip-like form. In some embodiments, each elongate member 2604<sub>int</sub> is provided in a generally planar form or with material or geometric properties that allow the elongate member 2604<sub>int</sub> to be deformed into assuming a generally planar or flat form under the influence of modest forces. Without limitation, various ones of the provided elongate members 2604<sub>int</sub> may include various metallic compositions, non-metallic compositions or combinations thereof. In some embodiments, the provided elongate members 2604<sub>int</sub> may include a shape memory material, for instance Nitinol. The incorporation of a specific material into various ones of the elongate members 2604<sub>int</sub> may be motivated by various factors. In this example embodiment, various portions of each provided elongate member 2604<sub>int</sub> include material properties and geometric dimensions suitable for undergoing a distortion or deformation process employed by method 2700. By way of non-limiting example, the distortion or deformation process can include a plastic deformation process. By way of non-limiting example, the distortion or deformation process can include a non-reversible distortion or deformation process in which a given one of the provided elongate members 2604<sub>int</sub> that is distorted or deformed by the application of force does not generally return back to its original shape upon removal of the applied force. In this example embodiment, each provided elongate member 2604<sub>int</sub> includes material properties and geometric dimensions that have been pre-selected to allow for a subsequent manipulation (e.g., during an actual use of device 2600) of the respective elongate member 2604 that is formed at least in part, from the provided elongate member 2604<sub>int</sub>. Manipulation of various portions 2609 of each resulting elongate member 2604 can include bending, flexing, twisting and combinations thereof by way of non-limiting example. Manipulation of various portions 2609 of each resulting elongate member 2604 can include relatively few manipulations or a relatively large number of manipulations. In some example embodiments, various ones of the provided elongate members 2604<sub>int</sub> are made from a material whose material properties and geometric dimensions have been preselected so that the resulting elongate

members **2604** can withstand cyclic manipulation. In some example embodiments, various ones of the provided elongate members **2604<sub>int</sub>** are made from a material having material properties and geometric dimensions that have been preselected such that the resulting elongate members **2604** can withstand anticipated conditions that can lead to possible fatigue failure. The present inventors have employed methods similar to method **2700** that employ provided elongate members **2604<sub>int</sub>** made from stainless steel (e.g., 17-7 SS) and having maximum cross-sectional dimensions of 0.127 millimeters by 4 millimeters by way of non-limiting example.

In this example embodiment, each provided elongate member **2604<sub>int</sub>** includes a plurality of different portions **2609** including first portion **2609a<sub>int</sub>**, second portion **2609b<sub>int</sub>** and a third portion **2609C<sub>int</sub>** positioned between the first and the second portions **2609a<sub>int</sub>** and **2609b<sub>int</sub>**. Each of the various portions **2609** corresponds to one of the various portions **2609** of elongate member **2604** that results from processing of the provided elongate member **2604<sub>int</sub>** under various processes undertaken in accordance with method **2700**. Accordingly, the respective side edges of each of the portion **2609<sub>int</sub>** are identified by the same part numbers of the side edges **2620** of the corresponding portions **2609**. In some embodiments, at least one of the first portion **2609a<sub>int</sub>**, second portion **2609b<sub>int</sub>** and a third portion **2609C<sub>int</sub>** of a provided elongate member **2604<sub>int</sub>** may undergo one or more processes to transform the at least one of the first portion **2609a<sub>int</sub>**, second portion **2609b<sub>int</sub>** and third portion **2609C<sub>int</sub>** into a corresponding one of one of the first portion **2609a**, second portion **2609b** and third portion **2609c** of the elongate member **2604** produced by method **2700**. It is noted that in some embodiments, not all of the various portions **2609<sub>int</sub>** including first portion **2609a<sub>int</sub>**, second portion **2609b<sub>int</sub>** and third portion **2609C<sub>int</sub>** of a provided elongate member **2604<sub>int</sub>** may undergo a process as specified by method **2700** and may be provided substantially unaltered or undergo an alternate process to form the final elongate member **2604**.

In this example embodiment, the respective second portion **2609b<sub>int</sub>** of each provided elongate member **2604<sub>int</sub>** of at least some of the plurality of provided elongate members **2604<sub>int</sub>** (e.g., provided elongate members **2604a<sub>int</sub>**, **2604b<sub>int</sub>**, **2604c<sub>int</sub>**, **2604e<sub>int</sub>**, **2604f<sub>int</sub>** and **2604g<sub>int</sub>**) is laterally offset from the respective first portion **2609a<sub>int</sub>** of the provided elongate member **2604<sub>int</sub>** across at least a portion of the respective length **2611** of the provided elongate member **2604<sub>int</sub>**. In this example embodiment, a center line or midline **2612b** of the respective second portion **2609b<sub>int</sub>** of each provided elongate member **2604<sub>int</sub>** of at least some of the plurality of provided elongate members **2604<sub>int</sub>** (e.g., elongate members **2604a<sub>int</sub>**, **2604b<sub>int</sub>**, **2604c<sub>int</sub>**, **2604e<sub>int</sub>**, **2604f<sub>int</sub>** and **2604g<sub>int</sub>**) is laterally offset from a center line or midline **2612a** of the respective first portion **2609a<sub>int</sub>** of the provided elongate member **2604<sub>int</sub>** across at least a portion of the respective length **2611** of the provided elongate member **2604<sub>int</sub>**. In some example embodiments, various ones of the midlines **2612a** and **2612b** form a line of symmetry of a respective one of the portions **2609<sub>int</sub>**. In some example embodiments, various ones of the midlines **2612** extend across a centroid of a respective one of the portions **2609<sub>int</sub>**. In this example embodiment, the respective pair of side edges **2620** of each of the first portion **2609a<sub>int</sub>** and second portion **2609b<sub>int</sub>** of each provided elongate member **2604<sub>int</sub>** includes a respective first side edge **2620a** (only one called out for each provided elongate member **2604<sub>int</sub>**) arranged on a first side of the provided elongate

member **2604<sub>int</sub>** and a respective second side edge **2620b** (only one called out for each provided elongate member **2604<sub>int</sub>**) arranged on a second side of the provided elongate member **2604<sub>int</sub>**. In various example embodiments, at least one of the first side edge **2620a** and the second sided edge **2620b** of the respective second portion **2609b<sub>int</sub>** of at least one of the provided elongate members **2604<sub>int</sub>** (i.e., both of the first and the second side edges **2620a**, **2620b** in this illustrated embodiment) is laterally offset from the corresponding one of the first side edge **2620a** and the second sided edge **2620b** of the respective first portion **2609a<sub>int</sub>** of the at least one of the provided elongate members **2604<sub>int</sub>** across at least a portion of the respective length **2611** of the at least one of the provided elongate members **2604<sub>int</sub>**.

In this example embodiment, various ones of the provided elongate members **2604<sub>int</sub>** have different amounts of lateral offset between their respective second and first portions **2609b<sub>int</sub>**, **2609a<sub>int</sub>**. For example, the respective second portion **2609b<sub>int</sub>** of provided elongate member **2604a<sub>int</sub>** is laterally offset from the respective first portion **2609a<sub>int</sub>** of provided elongate member **2604a<sub>int</sub>** by a first distance **2623a** over a portion of the respective length **2611** of provided elongate member **2604a<sub>int</sub>**. The respective second portion **2609b<sub>int</sub>** of provided elongate member **2604b<sub>int</sub>** is laterally offset from the respective first portion **2609a<sub>int</sub>** of provided elongate member **2604b<sub>int</sub>** by a second distance **2623b** over a portion of the respective length **2611** of provided elongate member **2604b<sub>int</sub>**. In this example embodiment, the second distance **2623b** is different than the first distance **2623a**. In this example embodiment, the second distance **2623b** is less than the first distance **2623a**. In this example embodiment, the amount of lateral offset between their respective second and first portions **2609b<sub>int</sub>**, **2609a<sub>int</sub>** of the various provided elongate members **2604<sub>int</sub>** arranged as shown in FIG. 7G reduces from top-to-middle and from middle-to-top in the illustrated arrangement. In this example embodiment, the respective second portion **2609b<sub>int</sub>** of each of provided elongate members **2604C<sub>int</sub>** and **2604e<sub>int</sub>** has relatively little lateral offset from the respective first portion **2609a<sub>int</sub>** of each of provided elongate members **2604C<sub>int</sub>** and **2604e<sub>int</sub>**. In this example embodiment, the respective second portion **2609b<sub>int</sub>** of each of provided elongate members **2604a<sub>int</sub>** and **2604g<sub>int</sub>** has the greatest amount of lateral offset from the respective first portion **2609a<sub>int</sub>** of each of the provided elongate members **2604a<sub>int</sub>** and **2604g<sub>int</sub>**. In this example embodiment, the respective second portion **2609b<sub>int</sub>** of provided elongate member **2604d<sub>int</sub>** is not laterally offset from the respective first portion **2609a<sub>int</sub>** of provided elongate member **2604d<sub>int</sub>**. Rather, the respective first, second and third portions **2609a<sub>int</sub>**, **2609b<sub>int</sub>** and **2609C<sub>int</sub>** of provided elongate member **2604d<sub>int</sub>** are all aligned along a substantially straight path.

As best seen in FIG. 7G, at least one of the provided elongate members **2604<sub>int</sub>** includes at least one corner **2630a** (only one called out as shown in provided elongate member **2604a<sub>int</sub>**) formed by a convergence of the respective first side edge **2620a** of the third portion **2609C<sub>int</sub>** of the at least one of the provided elongate members **2604<sub>int</sub>** and the respective first side edge **2620a** of the second portion **2609b<sub>int</sub>** of the at least one of the provided elongate members **2604<sub>int</sub>**, the at least one corner **2630a** enclosing a respective angle “ $\alpha$ ” extending across the front surface **2618a** of the at least one of the provided elongate members **2604<sub>int</sub>**. In this example embodiment, the enclosed angle  $\alpha$  extends towards at least part of the respective second side edge **2620b** of at least one of the portions **2609<sub>int</sub>** of the at least one of the provided elongate members **2604<sub>int</sub>**. In this example

embodiment, at least one of the provided elongate members **2604<sub>int</sub>** includes at least one corner **2630b** (only one called out as shown in provided elongate member **2604a<sub>int</sub>**) formed by a convergence of the respective second side edge **2620b** of the third portion **2609c<sub>int</sub>** of the at least one of the provided elongate members **2604<sub>int</sub>**, and the respective second side edge **2620b** of the first portion **2609a<sub>int</sub>** of the at least one of the provided elongate members **2604<sub>int</sub>**. In this example embodiment at least one corner **2630b** encloses an angle "B" extending across the front surface **2620a** of the provided at least one of the provided elongate members **2604<sub>int</sub>**. In this example embodiment, each respective enclosed angle  $\beta$  extends towards the respective first side edge **2620a** of at least one of the portions **2609<sub>int</sub>** of the at least one of the provided elongate members **2604<sub>int</sub>**. In this example embodiment each of corners **2630a**, **2630b** encloses an obtuse angle. It is understood that other angles may be enclosed by various ones of corners **2630a**, **2630b** in other example embodiments. In this example embodiment, each of corners **2630a** and **2630b** is a filleted corner. Other shapes or forms may be employed by various ones of the corners **2630a** and **2630b** in other example embodiments.

In some embodiments, various flexible circuit structures are employed to provide at least a signal path between a plurality of transducers employed by a medical device and a transducer controller. In some example embodiments, at least some of the transducer elements are used to sense a physical characteristic of a fluid (i.e., blood) or tissue, or both, that may be used to determine a position or orientation (i.e., pose), or both, of a portion of a device in a bodily cavity (e.g., a left atrium). For example, some transducer elements may be used to determine a location of pulmonary vein ostia or a mitral valve in a left atrium. In some example embodiments, at least some of the transducer elements may be used to selectively ablate portions of a tissue surface within a bodily cavity. For example, some of the transducer elements may be used to ablate a pattern around various bodily openings, ports or pulmonary vein ostia, for instance to reduce or eliminate the occurrence of atrial fibrillation. In various embodiments, transducer elements can include at least one of an electrode and a sensing element. In various embodiments, at least some of the transducer elements are provided on, or by various ones of the flexible circuit structures. The flexible circuit structures may be mounted or otherwise carried on a frame, or may form an integral component of the frame itself. The frame may be flexible enough to slide within a catheter sheath in order to be deployed percutaneously. FIGS. 1, 2, 3, 4, 5, 6, 7 and 9 discussed previously show various example embodiments of such a frame.

In various example embodiments, the flexible circuit structures form part of a framed structure that is selectively movable between an unexpanded configuration in which respective portions of each of the flexible circuit structures are arranged successively along a first direction in a stacked arrangement sized to be percutaneously delivered through a bodily opening leading to a bodily cavity, and an expanded or fanned configuration in which the respective portions of the flexible circuit structures are angularly spaced with respect to one another about at least one axis. In some of these embodiments, each of the respective portions of at least some of the flexible printed circuit structures revolve, rotate, pivot or turn (used interchangeably herein) about at least one axis when the structure is moved between the unexpanded configuration and the expanded configuration.

In block **2706**, a plurality of flexible circuit structures **2680** are provided and a portion of each of the flexible

circuit structures **2680** is secured to a respective one of the plurality of provided elongate members **2604<sub>int</sub>**. In this example embodiment, each flexible circuit structure **2680** is a flexible printed circuit board (PCB) structure. FIG. 7H is an isometric view of a representative one of the flexible circuit structures **2680**. Each flexible circuit structure **2680** includes at least one flexible material layer **2682**. In this example embodiment, each at least one flexible material layer **2682** includes an electrical insulator layer (e.g., polyimide). In a manner similar to each of the provided elongate members **2604<sub>int</sub>**, the at least one material layer **2682** includes a first end **2687**, a second end **2685**, a respective length **2681** between the first and the second ends, **2687**, **2685**, a thickness **2683** and a front surface **2684a** and a back surface **2684b** opposite across the thickness **2683**. The at least one flexible material layer **2682** further includes a plurality of portions **2689** including a first portion **2689a**, a second portion **2689b** and a third portion **2689c** positioned between the first and the second portions **2689a**, **2689b**. In this example embodiment, the second portion **2689b** is laterally offset from the first portion **2689a** along at least a portion of the respective length **2681** of the at least one material layer **2682**. In this example embodiment, each of the plurality of portions **2689** includes a respective pair of side edges **2686** including a first side edge **2686a** (only one called out) arranged on a first side of the at least one material layer **2682** and a second side edge **2686b** (only one called out) arranged on second opposite side of the at least one material layer **2682**. Each of the pair of side edges **2686** forms a portion of a periphery of at least one of the front surface and the back surface **2684a** and **2684b** of the at least one material layer **2682**. In this example embodiment, a portion of the periphery of at least one of the front surface and the back surface **2684a**, **2684b** of the at least one material layer **2682** is similar in shape to the periphery of at least one of the front surface and the back surface **2618a**, **2618b** of the provided elongate member **2604<sub>int</sub>** to which the flexible circuit structure **2680** is to be secured. In this example embodiment, each of the second and the third portions **2689b**, **2689c** of the at least one material layer **2682** have a size and shape substantially similar to the second and the third portions **2609b**, **2609c** of the provided elongate member **2604<sub>int</sub>** to which the flexible circuit structure **2680** is to be secured. In this example embodiment, the first portion **2689a** of the at least one material layer **2682** is longer than the first portion **2609a** of the provided elongate member **2604<sub>int</sub>** to which the flexible circuit structure **2680** is to be secured. In other example embodiments, the at least one material layer **2682** may have different shapes and/or sizes than those illustrated. In this example embodiment, the lateral offset between the respective second and first portions **2689b**, **2689a** of each of the plurality of flexible circuit structures **2680** is generally similar to the lateral offset between the respective second and first portions **2609b<sub>int</sub>**, **2609a<sub>int</sub>** of a respective one of the provided elongate members **2604<sub>int</sub>** to which the flexible circuit structure **2680** is to be secured.

Transducer elements (e.g., electrodes or sensors, or both) may be built on the flexible circuit structure **2680** using conventional printed circuit board processes. In this example embodiment, each of the flexible circuit structures **2680** includes at least one electrically conductive layer **2692**. In this example embodiment, the at least one electrically conductive layer **2692** is patterned to provide a portion of each of a set of transducer elements **2690** (two called out) and at least one electrically conductive trace **2694** on, or carried by (i.e., directly or indirectly) a surface of the at least one

material layer 2682. In this example embodiment, the at least one electrically conductive trace 2694 is electrically connected to various ones of the transducer elements 2690 (i.e., only one in this illustrated embodiment). It is understood that other electrical traces, each connected to one or more of the plurality of transducer elements 2690 can be present in various embodiments. In this example embodiment, the at least one electrically conductive trace 2694 extends on the front surface 2684a of the at least one material layer 2682 along a path across parts of each of the first portion 2689a, the third portion 2689c and the second portion 2689b of the at least one material layer 2682. In this example embodiment, the at least one electrically conductive trace 2694 includes various jogged portions 2694a (one called out) as viewed perpendicularly to a portion of the front surface 2684a of the at least one material layer 2682 located at least proximate to a location on the front surface 2684a where the path extends across the third portion 2689c of the at least one material layer 2682. In this example embodiment, the jogged portions 2694a are formed by a patterning process. In this example embodiment, the jogged portions 2694a are formed by employing flexible circuit patterning techniques. In other example embodiments, other techniques may be employed to form a jogged portion 2694a in the at least one electrically conductive trace 2694. By way of non-limiting example, other techniques can include manipulation of the at least one material layer 2682 before, during or after the formation of the at least one electrically conductive trace 2694.

Each of the flexible circuit structures 2680 can be secured to a respective one of the provided plurality of elongate members 2604<sub>int</sub> by various techniques. For example, in some embodiments, fasteners or fastening devices are employed. In some example embodiments, a flexible circuit structure 2680 is bonded to a respective one of the provided plurality of elongate members 2604<sub>int</sub> with an adhesive. The present inventors have created various assemblages by bonding polyimide and 17-7 stainless steel layers using LOCTITE® 4081 or LOCTITE® 435 medical device adhesives. Various factors such as, but not limited to, sterilization considerations, particulate generation, fastening reliability, etcetera can motivate the selection of a particular securement technique.

In block 2704, at least one of the provided elongate members 2604<sub>int</sub> undergoes a first distortion or deformation process. In this particular embodiment, at least one of the provided elongate members 2604<sub>int</sub> is distorted or deformed prior to the securing of a flexible circuit structure 2680 to the at least one of the provided elongate members 2604<sub>int</sub> in block 2706. The at least one of the provided elongate members 2604<sub>int</sub> may be distorted or deformed in various ways. In this example embodiment, the respective second portion 2609b of each of the provided elongate members 2604<sub>int</sub> is distorted or deformed to provide a coiled, scrolled or volute profile as shown in FIG. 7I. Each respective second portion 2609b<sub>int</sub> of the provided elongate members 2604<sub>int</sub> can be distorted or deformed using various bending or coiling mechanisms known in the art. For example, a particular second portion 2609b<sub>int</sub> may be run through a series of rolls arranged to impart a desired profile onto the particular second portion 2609b<sub>int</sub>, especially when the desired profile is a coiled profile.

FIG. 7J shows a portion of a flexible circuit structure 2680 that has been secured to the provided elongate member 2604<sub>int</sub> of FIG. 7I that has been distorted or deformed in accordance with block 2704. In this example embodiment, a portion of the flexible circuit structure 2680 has been bonded

to the provided elongate member 2604<sub>int</sub>. In this example embodiment, a portion of the assemblage of the provided elongate member 2604<sub>int</sub> and flexible circuit structure 2680 provides the second portion 2609b generally with the desired coiled, scrolled or volute profile comprised by a respective one of the resulting elongate members 2604 shown in FIG. 7A. It is noted that when compared with the coiled profile of the provided elongate member 2604<sub>int</sub> shown in FIG. 7I, the assemblage of the provided elongate member 2604<sub>int</sub> and flexible circuit structure 2680 shown FIG. 7J has a larger coiled profile. The process of distorting or deforming the provided elongate member 2604<sub>int</sub> can impart significant stress on the elongate member 2604<sub>int</sub> sometimes deforming the elongate member 2604<sub>int</sub> well beyond a yield point of the elongate member 2604<sub>int</sub>. Various factors may require that the coiled profile that is imparted to the provided elongate member 2604<sub>int</sub> as per block 2704 be made relatively smaller than the coiled profile that the provided elongate member 2604<sub>int</sub> has after the portion of the flexible circuit structure 2680 has been secured to the provided elongate member 2604<sub>int</sub> as shown in FIG. 7J. For example, various material properties of the provided elongate member 2604<sub>int</sub> may have a bearing. The particular material properties of the provided elongate member 2604<sub>int</sub> can impart a certain amount of “spring-back” to the provided elongate member 2604<sub>int</sub>. Soft materials typically have limited spring-back whereas relatively harder materials (e.g., metals employed in medical devices such as stainless steel, Nitinol) can have a substantially more spring-back. If a provided elongate member 2604<sub>int</sub> that included a material having a relatively high spring-back were to be distorted or deformed after the flexible circuit structure 2680 was bonded to the provided elongate member 2604<sub>int</sub>, the small coiled profile (i.e., similar to that shown in FIG. 7I) that would be required to be imparted on the provided elongate member 2604<sub>int</sub>/flexible circuit structure 2680 assemblage to account for the spring-back so as to form the coiled profile shown in FIG. 7J may impart substantially higher stress and strain rates on various features of the flexible circuit structure 2680 (e.g., the at least one electrically conductive trace 2694) than if the provided elongate member 2604<sub>int</sub> was distorted or deformed prior to the bonding of the at least one flexible circuit structure 2680 to the provided elongate member 2604<sub>int</sub> as per block 2706. These higher stress and strain rates may increase the risk of failures of various elements of the flexible circuit structure 2680 such as the at least one electrically conductive trace 2694 and thereby result in a less robust and reliable device. Further, these resulting higher stress and strain rates may increase the chances of bonding failures when an adhesive is employed to secure a portion of the flexible circuit structure 2680 to the provided elongate member 2604<sub>int</sub> prior to distortion or deformation of the provided elongate member 2604<sub>int</sub>. Another possible reason for pre-distorting or pre-deforming the provided elongate member 2604<sub>int</sub> prior to the securement of the flexible circuit structure 2680 is to provide a more uniform coiled profile. In some example embodiments, the stiffness of the flexible circuit structure 2680 may not be consistent along its respective length. For example, regions of the flexible circuit structure 2680 comprising transducer elements 2690 (only one called out in FIG. 7J) may be stiffer than other regions of the flexible circuit structure 2680 that do not include transducer elements 2690. Coiling the provided elongate element 2604<sub>int</sub> after flexible circuit structure 2680 has been secured to the provided elongate element 2604<sub>int</sub> may result in an undesired “step-bent” profile along the length of the assemblage.

In block 2708, at least one of the provided elongate members 2604<sub>int</sub> undergoes at least a second distorting or deforming process after the securing of a flexible circuit structure 2680 to the at least one of the provided elongate members 2604<sub>int</sub>. FIG. 7K shows the provided elongate member 2604<sub>int</sub>/flexible circuit structure 2680 assemblage of FIG. 7J additionally processed as per block 2708. In this example embodiment, the respective third portion 2609C<sub>int</sub> of each of various ones of the provided elongate members 2604<sub>int</sub> is distorted or deformed to rotationally offset the respective second portion 2609b<sub>int</sub> of the respective provided elongate member 2604<sub>int</sub> from the respective first portion 2609a<sub>int</sub> of the respective provided elongate member 2604<sub>int</sub> along the respective length 2611 (not called out) of the provided elongate member 2604<sub>int</sub>. In this example embodiment, the respective third portion 2689c of the flexible printed circuit 2680 is also distorted or deformed to rotationally offset the second portion 2689b from the first portion 2689a of the flexible printed circuit 2680. In various example embodiments, a distortion or deformation of a particular portion of a provided elongate member 2604<sub>int</sub> as per block 2708 can also result in a corresponding distortion or deformation to a portion of an associated one of the provided flexible circuit structures 2680.

In this example embodiment, distorting or deforming the respective third portion 2604C<sub>int</sub> of the provided elongate member 2604<sub>int</sub> to rotationally offset the respective second portion 2609b<sub>int</sub> from the respective first portion 2609a<sub>int</sub> along the respective length 2611 of the provided elongate member 2604<sub>int</sub> causes the respective third portion 2609C<sub>int</sub> of the provided elongate member 2604<sub>int</sub> to have a twisted shape. The twisted shape can be imparted using various methods. In some example embodiments, a stamping or coining operation can be employed to impart the twisted shape onto the third portion 2609C<sub>int</sub> of the provided elongate member 2604<sub>int</sub>. It is noted that care may need to be taken to not damage components such as the flexible printed circuit structure 2680 during the distorting or deforming. In this example embodiment, distorting or deforming the respective third portion 2604C<sub>int</sub> of the provided elongate member 2604<sub>int</sub> to rotationally offset the respective second portion 2609b<sub>int</sub> from the respective first portion 2609a<sub>int</sub> along the respective length 2611 of the provided elongate member 2604<sub>int</sub> includes twisting the respective third portion 2609C<sub>int</sub> of the provided elongate member 2604<sub>int</sub> about a respective twist axis 2633 extending across at least part of the respective third portion 2609C<sub>int</sub>. In this example embodiment, the third portion 2689c of the at least one material layer 2682 of the flexible circuit structure 2680 also has a twisted shape. The twisted shape of the at least one third portion 2689c of the flexible circuit structure 2680 provides a relatively smooth and gradual transition for the at least one electrically conductive trace 2694 to follow along a path extending across the third portion 2689c between the first and the second portions 2689a, 2689b of the at least one material layer 2682. In some example embodiments, the jogged portion 2694a of the at least one electrically conductive trace 2694 is visible when viewed normally to a portion of the front surface 2684a of the at least one material layer 2682 located at least proximate to a location on the front surface 2684a of the at least one material layer 2682 where the path extends across the third portion 2689c.

In some example embodiments, the twist in the third portion 2609C<sub>int</sub> of a provided elongate member 2604<sub>int</sub> can be arranged to cause the second portion 2609b<sub>int</sub> of the provided elongate member 2604<sub>int</sub> to assume a skewed orientation with respect to the first portion 2609b<sub>int</sub> of the

provided elongate member 2604<sub>int</sub> similar to that exemplified by the representative elongate member 2604 shown in FIG. 7B. In some example embodiments, additional or alternate distortions or deformations can also be made to various ones of the provided elongate members 2604<sub>int</sub>. For example, as shown in FIG. 7K, the respective first portion 2609a<sub>int</sub> of the provided elongate member 2604<sub>int</sub> (i.e., including the respective first portion 2689a of the secured flexible circuit structure 2680) is bent about a respective bending axis 2631 to cause the second portion 2609b<sub>int</sub> of the provided elongate member 2604<sub>int</sub> to assume at least in part, a required fanned orientation as exemplified by the representative elongate member 2604 shown in FIG. 7B.

In this example embodiment, each respective bending axis 2631 has a skewed orientation with respect to the respective side edges 2620 of the first portion 2609a<sub>int</sub> of the provided elongate member 2604<sub>int</sub>. Each respective bending axis 2631 is skewed to cause at least the respective second portions 2609b of the resulting elongate members 2604 to fan about the one or more fanning axes 2635 which is/are in turn, oriented to intersect the second portions 2609b of the resulting elongate members 2604 at locations at least proximate to at least some of the number of crossing locations when various ones of the resulting elongate members 2604 are fanned in a manner similar to that shown in FIG. 7E. If the respective bending axes 2631 were not so oriented, additional forces could be required to distort or deform at least a portion of the stacked elongate members 2604 to accommodate possible fanning misalignment. In such a case, some of the elongate members 2604 may be required to undergo additional bending, twisting or combined bending and twisting to correct for misalignment and produce the desired fanned arrangement. The amount of skew of each bending axis 2631 is typically dependent on the various geometric factors including, but not limited to, the relative lengths of various ones of the portions 2609 of each of the elongate members. The present inventors have produced elongate members 2604 whose first portions 2609a are bent about a respective bending axis 2631 skewed by approximately 22 degrees in some example embodiments.

The assemblage of the provided elongate member 2604<sub>int</sub>/flexible circuit structure 2680 shown in FIG. 7K may be processed into an elongate member 2604 as represented in FIG. 7B. In block 2710, various ones of the provided elongate member 2604<sub>int</sub>/flexible circuit structure 2680 assemblages are arranged into an arrangement similar to that shown in FIG. 7A.

In this example embodiment, the twisted shape of the third portion 2609c of each elongate member 2604 arranged in the initial configuration shown in FIG. 7A advantageously allows various transducer elements 2690 (not shown in FIG. 7A) positioned on respective front faces 2618a of the elongate members 2604 to be appropriately oriented to face an interior tissue surface within a bodily cavity (not shown) when the portion of device 2600 is moved into the third/expanded configuration (i.e., FIGS. 7E and 7F). In this example embodiment, the twisted shape of the third portion 2609c of each elongate member 2604 arranged in the initial configuration shown in FIG. 7A advantageously orients the respective first portions 2609a of the elongate members 2604 to act as flexures which allow the respective second portions 2609b of the elongate members 2604 to fan and distribute the transducer elements 2690 across an interior tissue surface when the portion of device 2600 is moved into the third/expanded configuration (i.e., FIGS. 7E and 7F) within a bodily cavity having the interior tissue surface. The bent first portions 2609a further advantageously allow for

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some degree of autonomous fanning capability and may possibly reduce the need for additional fanning mechanisms or the complexity thereof. In this example embodiment, the twisted shape of the third portion **2609c** of each elongate member **2604** arranged in the initial configuration shown in FIG. 7A advantageously allows at least one electrically conductive trace **2694** (not shown in FIG. 7A) to extend along a path having a relatively smooth and gradual transition between the first and the second portions **2609a**, **2609b** of the elongate member **2604** while reducing potentially harmful bending stresses acting on the at least one electrically conductive trace **2694** during the fanning of the elongate member **2604**.

In some example embodiments, each of the third portions **2609c** has a twisted form sufficient to rotationally offset the respective second portion **2609b** from the respective first portion **2609a** by a same angular amount for each of the plurality of the provided elongate members **2604**. In other example embodiments, different ones of the elongate members **2604** employ different rotational offsets along their respective lengths **2611**. The use of different rotational offsets may be motivated by various factors. For example, when skewed bending axes **2631** are employed to cause the fanning of the various portions **2609** as described above, bending about the skewed bending axes **2631** can also impart a twist during the fanning. The twisted form of the respective third portion **2609c** can be adjusted to compensate for the additional twist that arises during fanning. In some example embodiments, the amount of additional twist typically varies based at least on the position of the elongate member **2604** in the arrayed arrangement of elongate members **2604**. In this example embodiment, a first set of elongate members **2604a**, **2604b**, and **2604c** is fanned along an opposite direction from a second set of elongate members **2604e**, **2604f** and **2604g**. However, since the rotational offsets between the respective first and second portions **2609a**, **2609b** of each elongate member **2604** are along the same direction (i.e., each third portion **2609c** is twisted in a same direction), the additional twist created by the bending about the respective skewed bending axes **2631** will decrease the rotational offset of the elongate members **2604** in one of the first set and the second set while increasing the rotational offset of the elongate members **2604** in the other of the first and second set during the fanning. The present inventors have created arrangements of elongate members **2604** with rotational offsets between the respective first and the second portions **2609a**, **2609b** varying from approximately 90 degrees to 70 degrees to compensate for an additional increase or decrease in the rotational offset of each elongate member **2604** that results from bending about the respective skewed bending axes **2631** during fanning.

In this example embodiment, the respective first and second portions **2609a**, **2609b** of the elongate members **2604** are arranged in the delivery configuration illustrated in FIG. 7C by arranging respective first portions **2609a** of the elongate members **2604** front face **2618a**-toward-back face **2618b** along a first direction (i.e., arrow **2616a**) in a first stacked array **2615a** and arranging the respective second portions **2604b** of the elongate members **2604** front surface **2618a**-toward-back surface **2618b** along a second direction (i.e., arrow **2616b**) in a second array **2615b**. The spatially efficient stacked arrays **2615a**, **2615b** advantageously allow for catheter sheaths **2606** of reduced size to be employed while the non-parallel first and second directions (i.e., arrows **2616a**, **2616b**) of the stacked array allow for various benefits including those described above. Ideally, the twisted third portions **2609c** of the elongate members should also be

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efficiently arrayed, stacked or nested so as to not negate the spatial efficiency advantages provided by each of the first and the second stacked arrays **2615a**, **2615b**.

FIG. 7L is a side elevation view of an arrangement of stacked elongate members **2604** (i.e., in a configuration similar to the delivery configuration shown in FIG. 7C) in which the third portions **2609c** (only one called out) of each elongate member **2604** is twisted to allow the third portions **2609c** to be nested in a stacked arrangement with substantially similar overall cross-sectional stack dimensions as those of the first stacked array **2615a** and the second stacked array **2615b**. A cross-sectional view A-A of the stacked elongate members **2604** of FIG. 7L through first stacked array **2615a** is provided by FIG. 7L (A-A). A cross-sectional view B-B of the stacked elongate members **2604** of FIG. 7L through the twisted third portions **2609c** is provided by FIG. 7L (B-B). A cross-sectional view C-C of the stacked elongate members **2604** of FIG. 7L through second stacked array **2615b** is provided by FIG. 7L (C-C). In this example embodiment, second portions **2609b** (only one called out in FIG. 7L (C-C)) are rotationally offset by less than 90 degrees from their respective first portions **2609a** (only one called out in FIG. 7L (A-A)). A comparison of each of FIGS. 7L (A-A), 7L (B-B), and 7L (C-C) shows that a reference circle **2625** representing a catheter sheath **2606** dimension sized to just enclose each of the first and second stacked arrays **2615a**, **2615b** also advantageously encloses the twisted portions **2609c**. Each of the elongate members **2604** are shown spaced from one another in each of FIGS. 7L (A-A), 7L (B-B), and 7L (C-C) for clarity. Ideally, reduced spacings are desired to accommodate the smallest sized catheter sheath possible.

FIG. 7M provides respective side and end elevation views of each of the elongate members **2604** shown in FIG. 7L but separated from one another for clarity. Each of the first portions **2609a** (only one called out) and the second portions **2609b** (only one called out) is additionally shown unbent for clarity. Center **2625a** is provided in the end view of each elongate member **2604** to reference a position of each of the elongate members **2604** when stacked as per FIG. 7L. The respective end views in FIG. 7M show that the respective first and second portions **2609a**, **2609b** of each elongate member **2604** require a different positioning with respect to center **2625a** based on the required position of the elongate member **2604** in the arrayed arrangement shown in FIG. 7L. Accordingly, the twisted form of the third portion **2609c** (only one called out) of each elongate member **2604** will also vary based on the required position of the elongate member **2604** in the arrayed arrangement shown in FIG. 7L. In this example embodiment, each elongate member **2604** of at least some of the elongate members **2604** (i.e., elongate members **2604a**, **2604b**, **2604c**, **2604e**, **2604f** and **2604g**) has a form that in the absence of the twist in the respective third portion **2609c** of the elongate member **2604**, the plurality of portions **2609** of the elongate member **2604** are arranged such that the second portion **2609b** of the elongate member **2604** is laterally offset from the first portion **2609a** of the elongate member **2604** across at least a portion of the respective length **2611** of the elongate member **2604**. This is best visualized in FIG. 7G, in which the respective second portions **2609b<sub>int</sub>** of various ones of the provided elongate members **2604<sub>int</sub>** (i.e., from which the elongate members **2604** are produced from in this example embodiment) are laterally offset from the respective first portions **2609a<sub>int</sub>** of the provided elongate members **2604<sub>int</sub>**. In this example embodiment, the amount of lateral offset varies for each provided elongate member **2604<sub>int</sub>** based at least on the

intended position of the provided elongate member  $2604_{int}$  in the arrayed arrangement shown in FIG. 7L.

Example embodiments in which an inherent lateral offset exists between the respective second and first portions  $2609b$ ,  $2609a$  of various ones of the elongate members  $2604$  in the absence of the required twist in the respective third portion  $2609c$  allow the respective third portions  $2609c$  when actually twisted to be stacked into a stacked array suitably sized to fit within catheters sheaths  $2606$  of reduced size (e.g., with respect to conventional catheter sheaths used for similar procedures) while still properly arranging the respective first and second portions  $2609a$ ,  $2609b$  of the elongate members  $2604$  into the corresponding first and second stacked arrays  $2615a$ ,  $2615b$  which are also suitably sized to fit in the catheter sheaths  $2606$  of reduced size. It is additionally noted that significant departures from these twist forms may cause the third portions  $2609c$  of the elongate members to not nest well and thereby adversely impact the ability to pass the stacked third portions  $2609c$  through catheter sheaths  $2606$  of reduced size.

In some example embodiments, the twisted third portions  $2609c$  of the elongate members  $2604$  may be efficiently nested in a stacked arrangement with substantially similar overall cross-sectional stack dimensions as those of the first stacked array  $2615a$  and the second stacked array  $2615b$  while each twisted third portion  $2609c$  maintains a cross-sectional shape having dimensions on the same order as those of the cross-sectional shape of respective ones of the first and the second portions  $2609a$ ,  $2609b$ . This may be motivated for different reasons including employing twisted third portions  $2609c$  which maintain a required width dimension sufficient to route the electrically conductive traces  $2694$  or that provided sufficient strength to address strength considerations while still allowing the stacked arrangement of the third portions  $2609c$  to fit within catheter sheaths  $2606$  of reduced size. In some example embodiments, the cross-sectional shape of each twisted third portion  $2609c$  remains fairly uniform, but with a different rotational alignment as the length of the twisted third portion  $2609c$  is traversed between the rotationally offset first and second portions  $2609a$ ,  $2609b$ . In some embodiments, each of the twisted third portions  $2609c$  of the elongate members  $2604$  includes a substantially similar twist rate (i.e., turns/unit length). In some embodiments, each of the twisted third portions  $2609c$  of the elongate members  $2604$  is twisted about a respective twist axis  $2633$ , with each respective twist axis  $2633$  being substantially parallel to the each of the other respective twist axes  $2633$ .

In this example embodiment, the provided elongate members  $2604_{int}$  are strip-like members that are twisted to form the respective ones of the elongate members  $2604$ . As shown in FIG. 7G, in the absence of the twist, the respective third portion  $2609C_{int}$  of each of the provided elongate members  $2604_{int}$  has a serpentine or "S" shape whose form varies depending on the geometry of the final stacked arrangement shown in FIG. 7L and the intended position of the provided elongate member  $2604_{int}$  in the arrayed arrangement shown in FIG. 7L. This serpentine or "S" shape allows for reduced strain during the distortion or deformation that accompanies the twisting of the provided elongate member  $2604_{int}$ . If the respective third portion  $2609C_{int}$  of a provided elongate member  $2604_{int}$  included a significantly different shape (e.g., a linear strip with no lateral offset between the respective second and first portions  $2609b_{int}$ ,  $2609a_{int}$ ) and was distorted or deformed to create the required twist shape (i.e., as described above), much higher strains would be imparted onto the provided elongate member  $2604_{int}$  as various addi-

tional bending components perpendicular to various ones of the surfaces  $2618a$ ,  $2618b$  of third portion  $2609C_{int}$  would be required to produce the required twisted shape. In some cases, the resulting increased strains may be greater than the provided elongate member  $2604_{int}$  can tolerate. These distortion or deformation criteria are especially relevant for the provided elongate members  $2604_{int}$  (i.e., elongate members  $2604a_{int}$ ,  $2604b_{int}$ ,  $2604f_{int}$  and  $2604g_{int}$ ) that are provided to form the outermost elongate members  $2604$  in the arrayed arrangement shown in FIG. 7L since each of these provided elongate members  $2604_{int}$  would require the greater amounts of distortion or deformation to form the required twisted shape. In some cases however, the provided elongate members  $2604_{int}$  that are provided to form some of the innermost elongate members  $2604$  in the arrayed arrangement shown in FIG. 7L (e.g., provided elongate members  $2604c_{int}$ ,  $2604d_{int}$ ) may be tolerant to increased strains if the shape of the respective third portions  $2609C_{int}$  of these provided elongate members  $2604_{int}$  deviated from the serpentine or "S" shape described above since little lateral offset is required between the respective first and second portions  $2609a_{int}$ ,  $2609b_{int}$  of these provided elongate members  $2604_{int}$  as shown in FIG. 7G. In some embodiments, some of the innermost elongate members  $2604$  such as elongate members  $2604c$  and  $2604e$  may be formed from relatively straight strip-like members with no lateral offset between their respective second and first portions  $2609b$ ,  $2609a$  as appears to be shown by Redmond et al. in U.S. Pat. Nos. 5,245,987 and 5,390,644. It is noted however that the distortion or deformation of provided elongate members  $2604_{int}$  not having laterally offset second and first portions  $2609b_{int}$ ,  $2609a_{int}$  would not be suitable for the outermost elongate members  $2604$  in various arrangements such as those shown in FIG. 7L. It is noted however that the distortion or deformation of provided elongate members  $2604_{int}$  not having laterally offset second and first portions  $2609b_{int}$ ,  $2609a_{int}$  would not be suitable for the outermost elongate members  $2604$  in stacked arrangements having relatively large number of elongate members (e.g., more than three) when it is desired to reduce the overall cross-sectional size of the arrangements.

In some example embodiments, method  $2700$  employs a subset of the blocks described. In some example embodiments, method  $2700$  may include additional/and or alternate processes. Method  $2700$  describes various processes that distort or deform a shape of the third portion  $2609C_{int}$  of various ones of the provided elongate members  $2604_{int}$  into a desired twisted shape. The twisted shape of the third portions  $2609c$  of elongate members  $2604$  employed in other example embodiments can be formed by other manufacturing processes including, but are not limited to, materials removal processes (e.g., machining), material joining processes (e.g., welding, brazing, bonding), casting or molding processes, or combination thereof. Regardless of the process employed, the resulting elongate members  $2604$  are characterized in that in the absence of the twist in their respective third portions  $2609c$ , their respective first, second and third portions  $2609a$ ,  $2609b$  and  $2609c$  may combine to form a unitary structure in which each respective second portion  $2609b$  is not rotationally offset from the respective first portion  $2609a$  along the respective length  $2611$  of the elongate member  $2604$  but is laterally offset from the first portion  $2609a$  along at least a portion of the respective length  $2611$  of the elongate member  $2604$ .

While some of the embodiments disclosed above are described with examples of cardiac mapping, the same or similar embodiments may be used for mapping other bodily

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organs, for example gastric mapping, bladder mapping, arterial mapping and mapping of any lumen or cavity into which the devices of the present invention may be introduced.

While some of the embodiments disclosed above are described with examples of cardiac ablation, the same or similar embodiments may be used for ablating other bodily organs or any lumen or cavity into which the devices of the present invention may be introduced.

As used herein and in the claims, the term "spatial plane" 10 and variations thereof such as "spatial planes" or "plane" may mean an imaginary plane having either zero or infinitesimal thickness.

Subsets or combinations of various embodiments described above can provide further embodiments. The 15 various embodiments described above can be combined to provide further embodiments. U.S. provisional patent application Ser. No. 61/435,213 filed Jan. 21, 2011; U.S. provisional patent application Ser. No. 61/485,987 filed May 13, 2011; U.S. provisional patent application Ser. No. 61/488, 20 639 filed May 20, 2011; U.S. provisional patent application Ser. No. 61/515,141 filed Aug. 4, 2011; International patent application Serial No. PCT/US2012/022061 with International filing date of Jan. 20, 2012; International patent application Serial No. PCT/US2012/022062 with International filing date of Jan. 20, 2012; U.S. Patent Application Publication 2008/0004534 A1; and U.S. Patent Application Publication 2009/0131930 A1, are each incorporated by reference herein, in their entireties. Aspects of the invention can be modified, if necessary, to employ systems, circuits 30 and concepts of the various patents, applications and publications to provide yet further embodiments of the invention.

These and other changes can be made to the invention in light of the above-detailed description. In general, in the 35 following claims, the terms used should not be construed to limit the invention to the specific embodiments disclosed in the specification and the claims, but should be construed to include all medical treatment devices in accordance with the claims. Accordingly, the invention is not limited by the disclosure, but instead its scope is to be determined entirely by the following claims.

The invention claimed is:

1. A medical system comprising:  
a catheter sheath;  
a catheter shaft member;  
a frame comprising multiple members, each member of the multiple members comprising a proximal end coupled to the catheter shaft member, a distal end, and a respective length extending between the proximal end and the distal end; and  
a plurality of transducer elements, a respective set of at least one transducer element of the plurality of transducer elements forming an integral component of each member of the multiple members of the frame, each transducer element of the plurality of transducer elements selectively activatable to transmit energy sufficient to cause tissue ablation,  
wherein at least part of the catheter shaft member is configured to be moveable through a lumen of the catheter sheath to deliver the frame through the lumen when the frame is percutaneously delivered to an intra-cardiac cavity,  
wherein the frame is configured to be selectively moveable into a delivery configuration in which the frame is arranged and sized to be deliverable through the lumen of the catheter sheath,

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wherein the frame is configured to be selectively moveable into an expanded configuration in which the frame is expanded relative to the delivery configuration, in which each member of the multiple members of the frame is radially arranged with respect to one another about a first axis, and in which each member of the multiple members of the frame is longitudinally arranged with respect to the first axis,

wherein at least some of the transducer elements of the plurality of transducer elements are activatable to perform a first cardiac tissue ablation when the frame is in the expanded configuration,

wherein the frame is configured to be selectively moveable, via at least an actuator, from the expanded configuration into a changed expanded configuration in which the changed expanded configuration is expanded relative to the delivery configuration, and in which each member of the multiple members of the frame is radially arranged with respect to one another about a second axis,

wherein at least some of the transducer elements of the plurality of transducer elements are activatable to perform a second cardiac tissue ablation when the frame is in the changed expanded configuration, and

wherein, when the frame is in the expanded configuration, the changed expanded configuration, or each of the expanded configuration and the changed expanded configuration, each particular member of the multiple members of the frame and an adjacent member of the multiple members of the frame that is adjacent the particular member of the multiple members of the frame diverge and then converge between each pair of a respective set of multiple pairs of adjacent spaced apart locations as the respective length of the particular member of the multiple members of the frame is traversed between the proximal end and the distal end of the particular member of the multiple members of the frame.

## 2. The medical system of claim 1,

wherein each member of the multiple members of the frame comprises a front surface and a back surface opposite across a thickness of the member from the front surface, the front surface of each member of the multiple members of the frame arranged to face outwardly when the frame is in the expanded configuration, the changed expanded configuration, or each of the expanded configuration and the changed expanded configuration, and

wherein, for each particular member of the multiple members of the frame, and when the frame is in the expanded configuration, the changed expanded configuration, or each of the expanded configuration and the changed expanded configuration, the particular member of the multiple members of the frame overlaps, or is overlapped by, the adjacent member of the multiple members of the frame in a front surface-toward-back surface arrangement at least at each of the spaced apart locations of at least a first pair of the respective set of multiple pairs of adjacent spaced apart locations.

3. The medical system of claim 2, wherein, for each particular member of the multiple members of the frame, and when the frame is in the expanded configuration, the changed expanded configuration, or each of the expanded configuration and the changed expanded configuration, a portion of the particular member of the multiple members of the frame between the adjacent spaced apart locations of the first pair of the respective set of multiple pairs of adjacent

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spaced apart locations is laterally separated from the adjacent member of the multiple members of the frame.

**4. The medical system of claim 1,**

wherein each member of the multiple members of the frame comprises a front surface and a back surface opposite across a thickness of the member from the front surface, the front surface of each member of the multiple members of the frame arranged to face outwardly when the frame is in the expanded configuration, the changed expanded configuration, or each of the expanded configuration and the changed expanded configuration,

wherein the multiple members of the frame include a first member, a second member, and a third member, and wherein, when the frame is in the expanded configuration, the changed expanded configuration, or each of the expanded configuration and the changed expanded configuration:

the first member of the multiple members of the frame, the second member of the multiple members of the frame, and the third member of the multiple members of the frame are adjacent members of the multiple members of the frame with the second member of the multiple members of the frame located between the first member of the multiple members of the frame and the third member of the multiple members of the frame;

the second member of the multiple members of the frame is overlapped by the first member of the multiple members of the frame in a front surface-toward-back surface arrangement at least at each of the spaced apart locations of at least a first pair of the respective set of multiple pairs of adjacent spaced apart locations; and the third member of the multiple members of the frame is overlapped by the second member of the multiple members of the frame in a front surface-toward-back surface arrangement at least at each of the spaced apart locations of at least a second pair of the respective set of multiple pairs of adjacent spaced apart locations.

**5. The medical system of claim 4, wherein, when the frame is in the expanded configuration, the changed expanded configuration, or each of the expanded configuration and**

the changed expanded configuration:

a portion of the first member of the multiple members of the frame is laterally separated from the second member of the multiple members of the frame between the adjacent spaced apart locations of the first pair of the respective set of multiple pairs of adjacent spaced apart locations; and

a portion of the second member of the multiple members of the frame is laterally separated from the third member of the multiple members of the frame between the adjacent spaced apart locations of the second pair of the respective set of multiple pairs of adjacent spaced apart locations.

**6. The medical system of claim 1, wherein, for each particular member of the multiple members of the frame, and when the frame is in the expanded configuration, the changed expanded configuration, or each of the expanded configuration and the changed expanded configuration, the particular member of the multiple members of the frame is physically coupled by a respective coupler to the adjacent member of the multiple members of the frame at least at each of the spaced apart locations of at least a first pair of the respective set of multiple pairs of adjacent spaced apart locations.****136**

7. The medical system of claim 6, wherein the respective coupler that physically couples at least a first member of the multiple members of the frame and a second member of the multiple members of the frame comprises a pin, the second member of the multiple members of the frame adjacent the first member of the multiple members of the frame when the frame is in the expanded configuration, the changed expanded configuration, or each of the expanded configuration and the changed expanded configuration.

8. The medical system of claim 6, wherein, for each particular member of the multiple members of the frame, and when the frame is in the expanded configuration, the changed expanded configuration, or each of the expanded configuration and the changed expanded configuration, the particular member of the multiple members of the frame overlaps, or is overlapped by, the adjacent member of the multiple members of the frame at least at each of the spaced apart locations of the first pair of the respective set of multiple pairs of adjacent spaced apart locations.

9. The medical system of claim 8, wherein, for each particular member of the multiple members of the frame, and when the frame is in the expanded configuration, the changed expanded configuration, or each of the expanded configuration and the changed expanded configuration, at least a second pair of the respective set of multiple pairs of adjacent spaced apart locations follows the first pair of the respective set of multiple pairs of adjacent spaced apart locations as the respective length of the particular member of the multiple members of the frame is traversed between the proximal end and the distal end of the particular member of the multiple members of the frame.

10. The medical system of claim 1, wherein, for each particular member of the multiple members of the frame, and when the frame is in the expanded configuration, the changed expanded configuration, or each of the expanded configuration and the changed expanded configuration, the particular member of the multiple members of the frame is physically coupled to the adjacent member of the multiple members of the frame at least at each of the spaced apart locations of the respective set of multiple pairs of adjacent spaced apart locations.

11. The medical system of claim 10, wherein, for each particular member of the multiple members of the frame, and when the frame is in the expanded configuration, the changed expanded configuration, or each of the expanded configuration and the changed expanded configuration, the particular member of the multiple members of the frame overlaps, or is overlapped by, the adjacent member of the multiple members of the frame at least at each of the spaced apart locations of at least a first pair of the respective set of multiple pairs of adjacent spaced apart locations.

12. The medical system of claim 11, wherein, for each particular member of the multiple members of the frame, and when the frame is in the expanded configuration, the changed expanded configuration, or each of the expanded configuration and the changed expanded configuration, the particular member of the multiple members of the frame is physically coupled to the adjacent member of the multiple members of the frame at least by a respective pin at each of the spaced apart locations of the first pair of the respective set of multiple pairs of adjacent spaced apart locations.

13. The medical system of claim 11, wherein, for each particular member of the multiple members of the frame, and when the frame is in the expanded configuration, the changed expanded configuration, or each of the expanded configuration and the changed expanded configuration, at least a second pair of the respective set of multiple pairs of adjacent spaced apart locations follows the first pair of the respective set of multiple pairs of adjacent spaced apart locations as the respective length of the particular member of the multiple members of the frame is traversed between the proximal end and the distal end of the particular member of the multiple members of the frame.

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adjacent spaced apart locations follows the first pair of the respective set of multiple pairs of adjacent spaced apart locations as the respective length of the particular member of the multiple members of the frame is traversed between the proximal end and the distal end of the particular member of the multiple members of the frame.

**14.** The medical system of claim 1, wherein, when the frame is in the expanded configuration, the changed expanded configuration, or each of the expanded configuration and the changed expanded configuration, each member of multiple members of the frame includes a curved portion arranged to extend along at least a portion of a respective curved path that intersects a corresponding one of the first axis, when the frame is in the expanded configuration, and the second axis, when the frame is in the changed expanded configuration, at each of a respective at least two spaced apart locations.

**15.** The medical system of claim 1, comprising a tubular member, wherein the multiple members of the frame are radially arranged about the tubular member when the frame is in the expanded configuration, the changed expanded configuration, or each of the expanded configuration and the changed expanded configuration.

**16.** The medical system of claim 1, wherein the frame is physically coupled to a distal end portion of the catheter shaft member, and wherein a particular angular orientation of a first portion of the frame relative to the distal end portion of the catheter shaft member when the frame is in the expanded configuration is different than a particular angular

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orientation of the first portion of the frame relative to the distal end portion of the catheter shaft member when the frame is in the changed expanded configuration.

**17.** The medical system of claim 1, wherein at least a portion of the frame is configured to undergo a reduction in stored potential energy during a movement of the frame between the expanded configuration and the changed expanded configuration.

**18.** The medical system of claim 1, wherein each member of the multiple members of the frame includes a metal layer.

**19.** The medical system of claim 1, wherein each member of the multiple members of the frame includes a patterned electrically conductive layer.

**20.** The medical system of claim 1, wherein, at least in the changed expanded configuration, each member of the multiple members of the frame is longitudinally arranged with respect to the second axis.

**21.** The medical system of claim 1,  
wherein each member of the multiple members of the frame comprises a front surface and a back surface opposite across a thickness of the member from the front surface, each of the back surface and the front surface having a set of side edges, and  
wherein, for each particular member of the multiple members of the frame, a width of the front surface of the particular member is greater than the thickness of the particular member.

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