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(54) MULTI-ELECTRODE CATHETER

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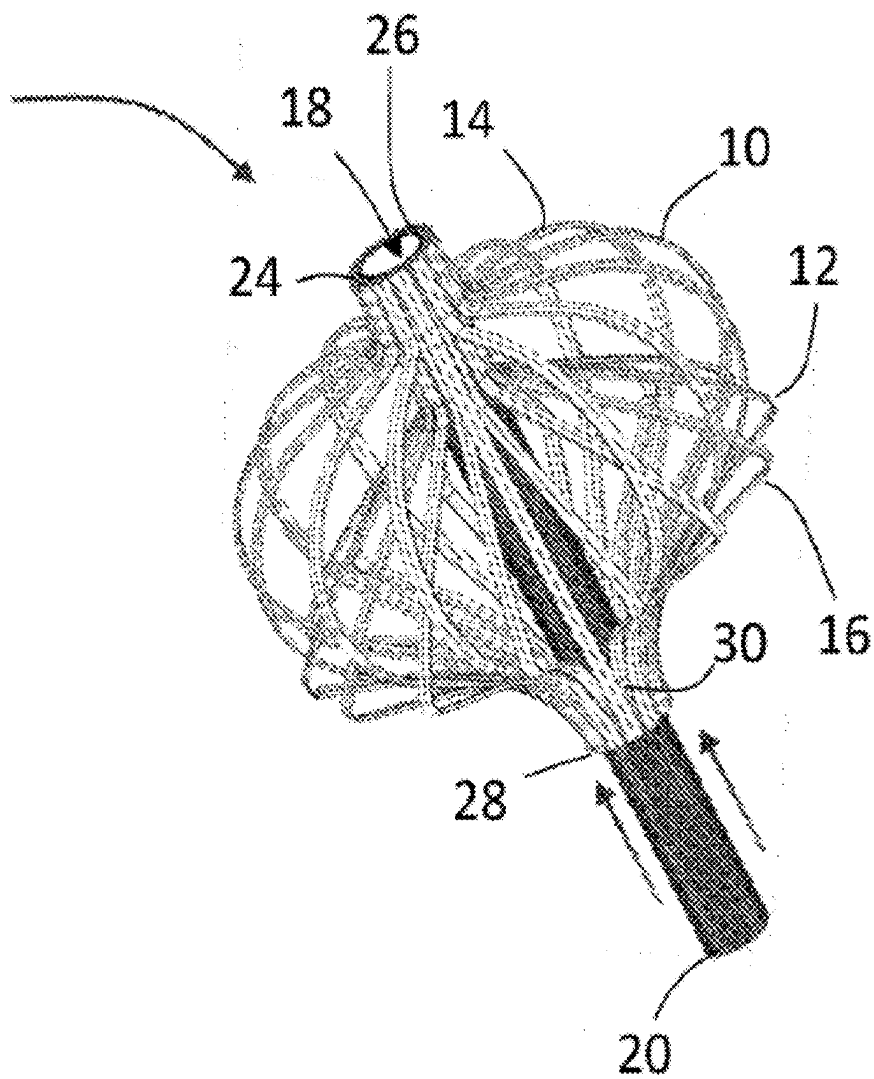
(57) **ABSTRACT**

A multi-electrode surgical probe comprising a basket 10, and a plurality of electrodes supported on the basket, wherein the basket is flexible between a contracted configuration and a deployed configuration, and the probe comprises a bi-stable structure 12 which is stable in both the deployed configuration and the contracted configuration.



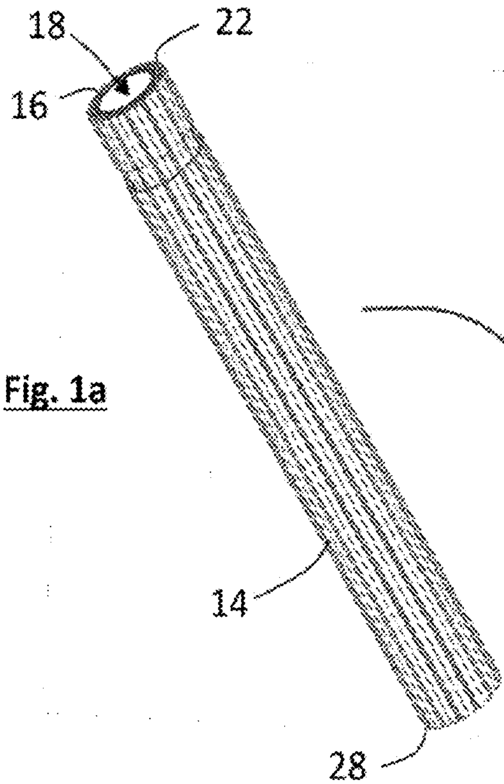


Fig. 1a

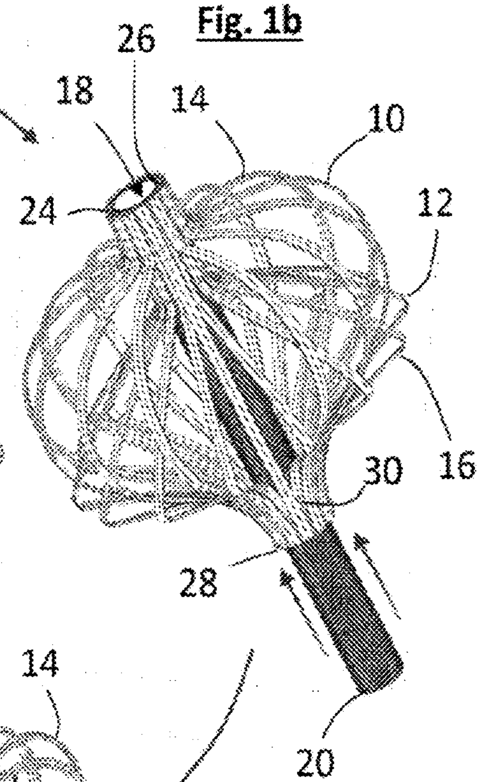


Fig. 1b

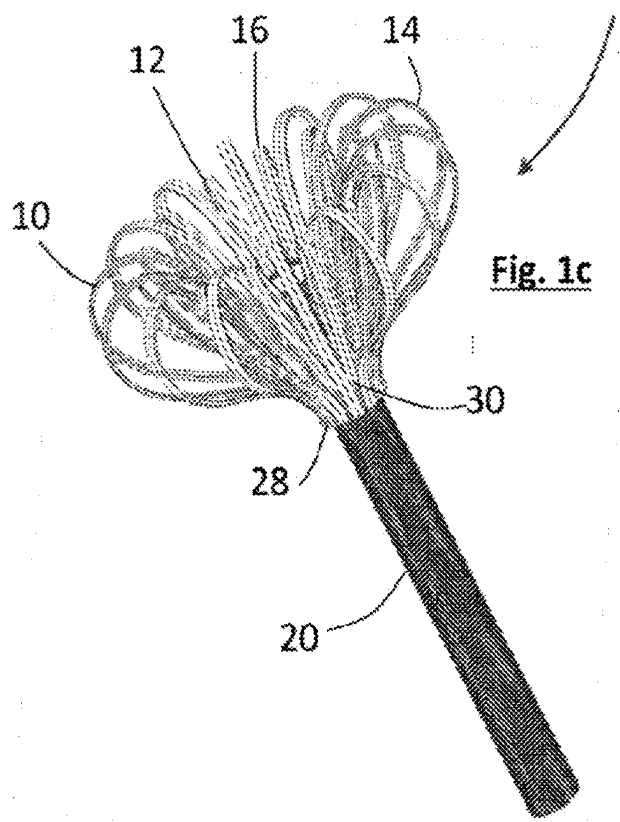


Fig. 1c

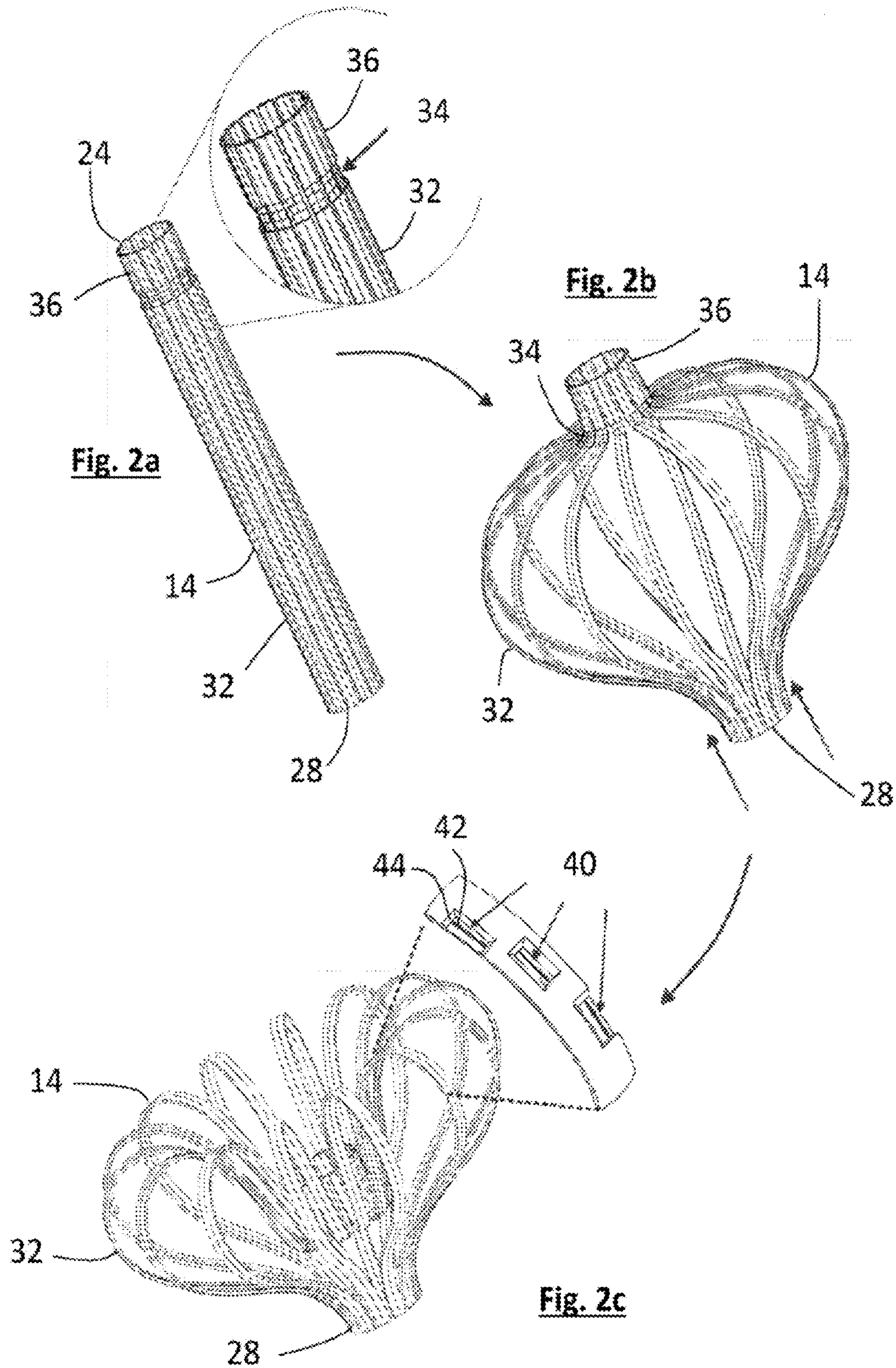

36
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Fig. 2b
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Fig. 2a
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14
32
Fig. 2c
28

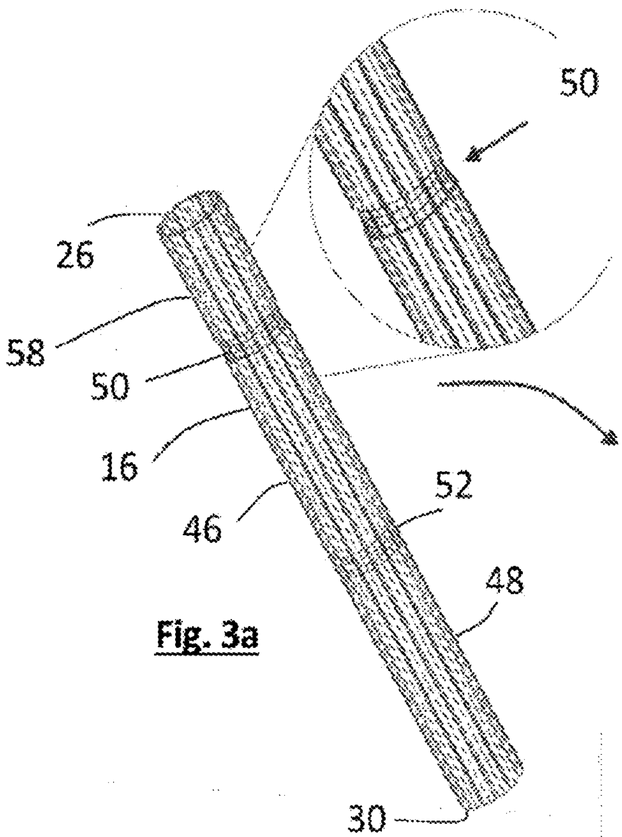


Fig. 3a

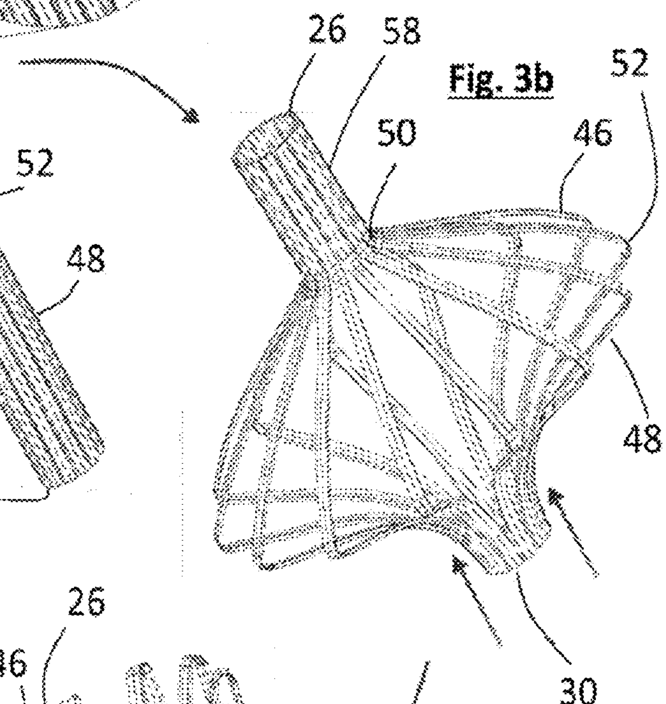


Fig. 3b

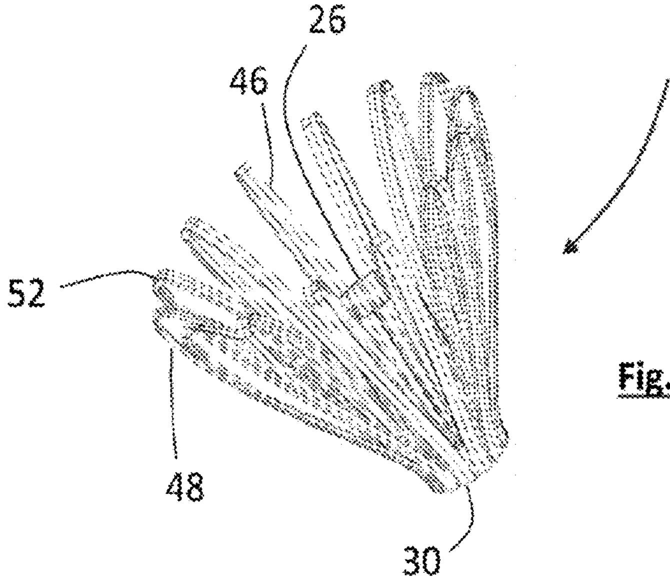


Fig. 3c

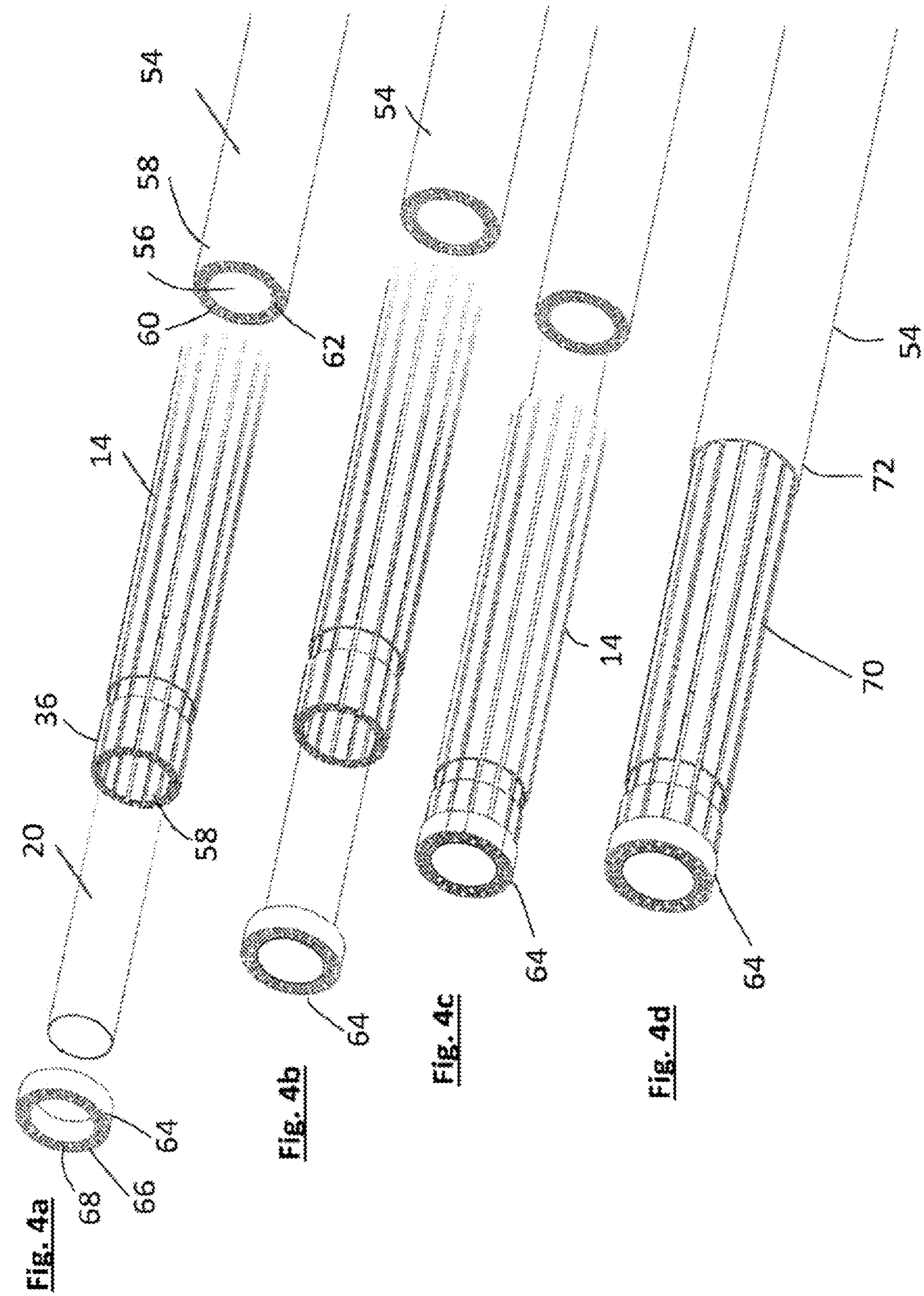


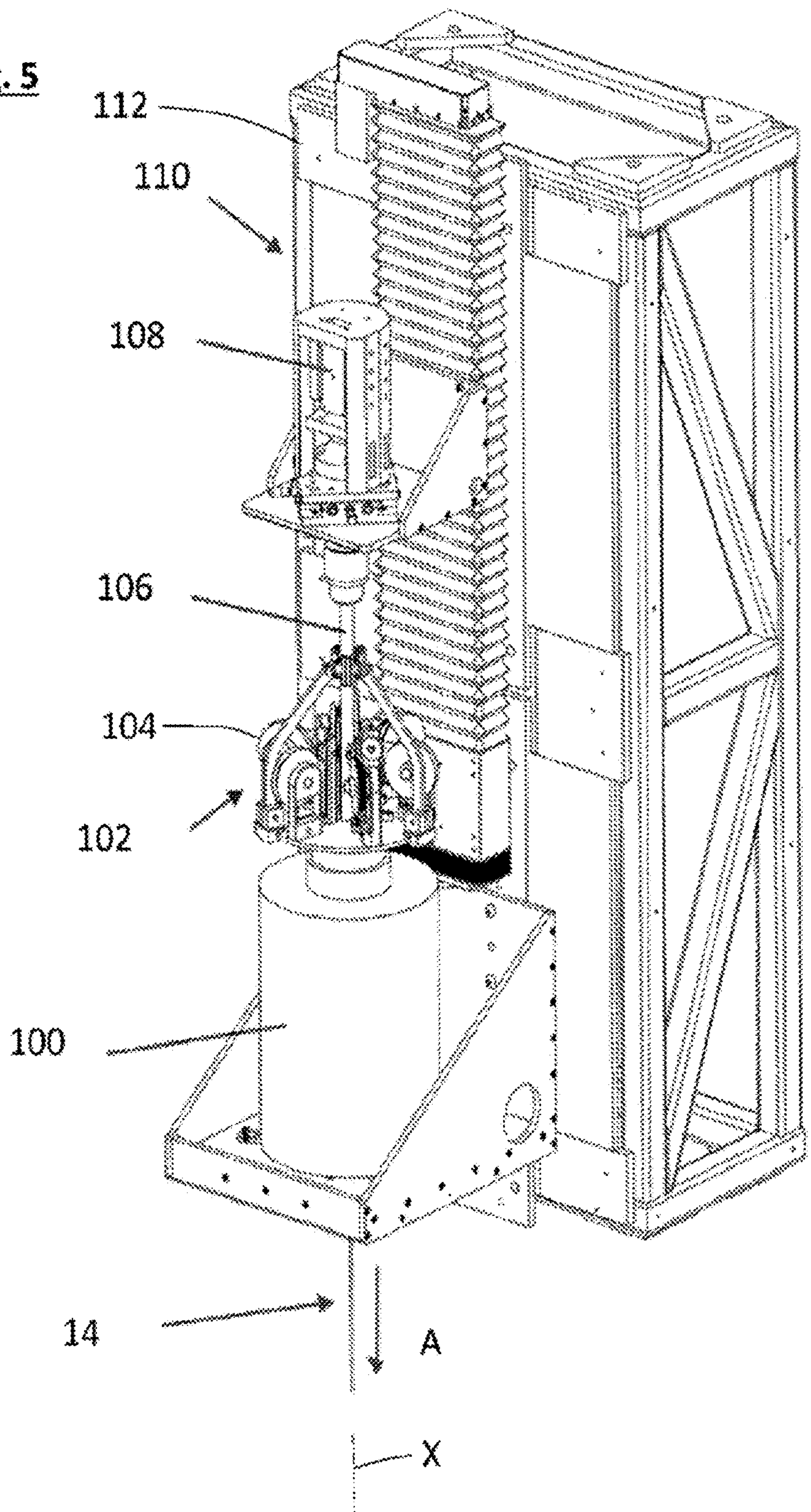
Fig. 4a

Fig. 4b

Fig. 4c

Fig. 4d

Fig. 5



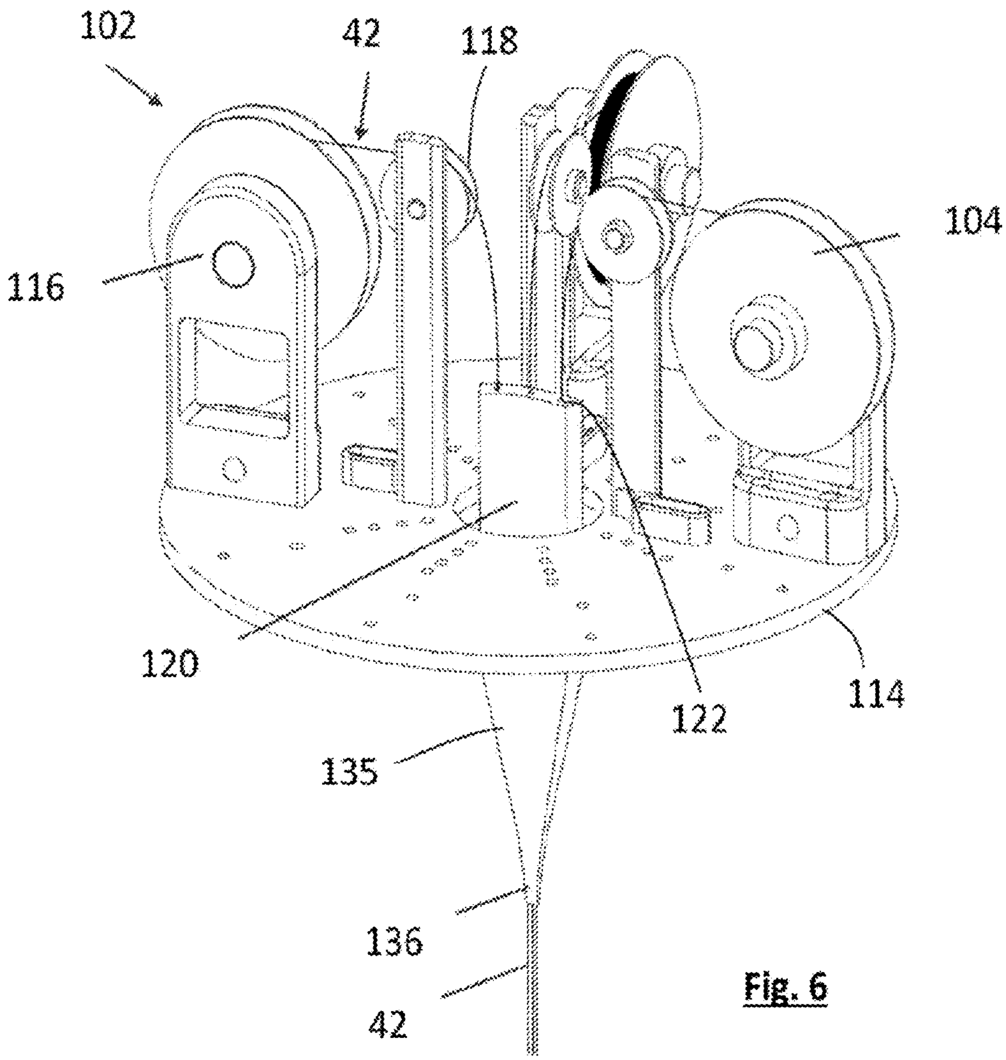


Fig. 6

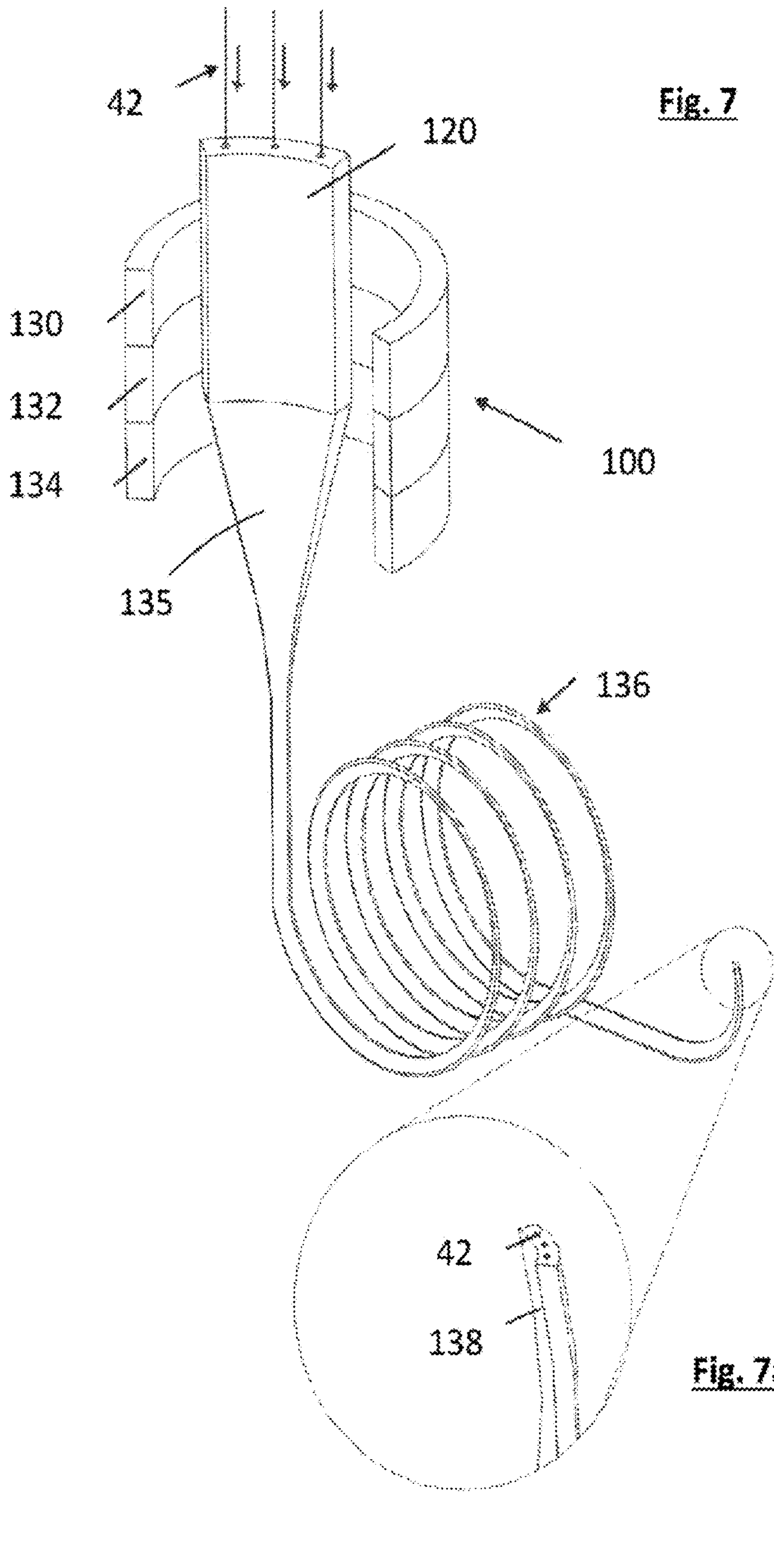


Fig. 7

Fig. 7a

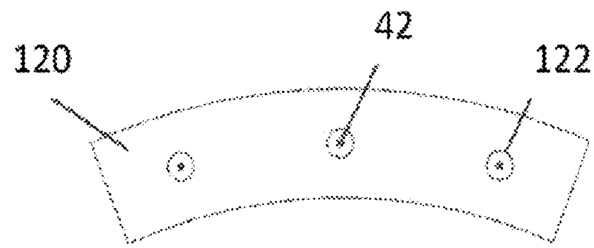


Fig. 8

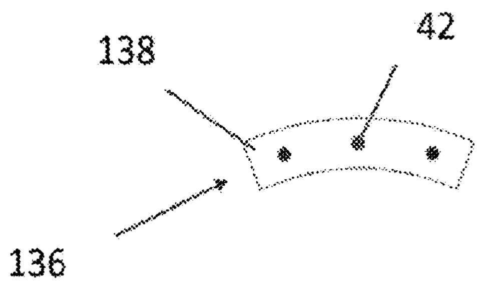


Fig. 9

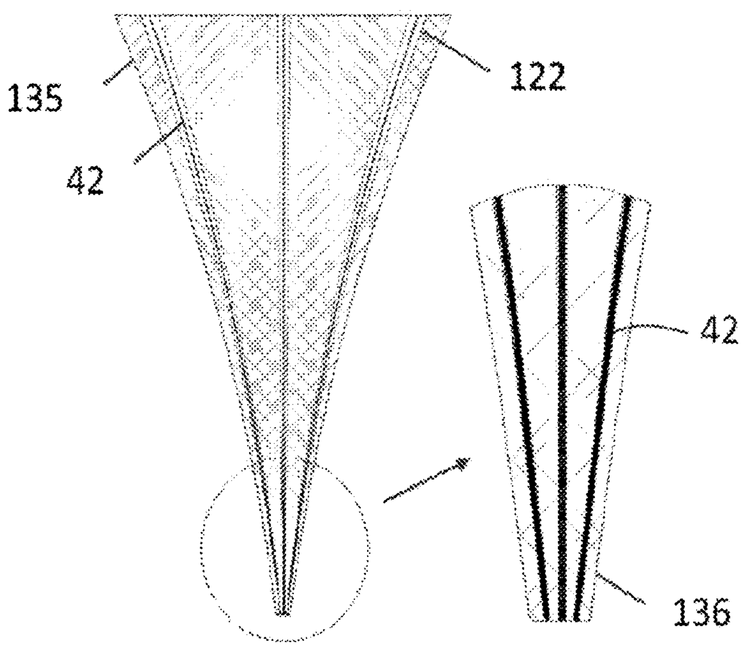


Fig. 10 Fig. 10a

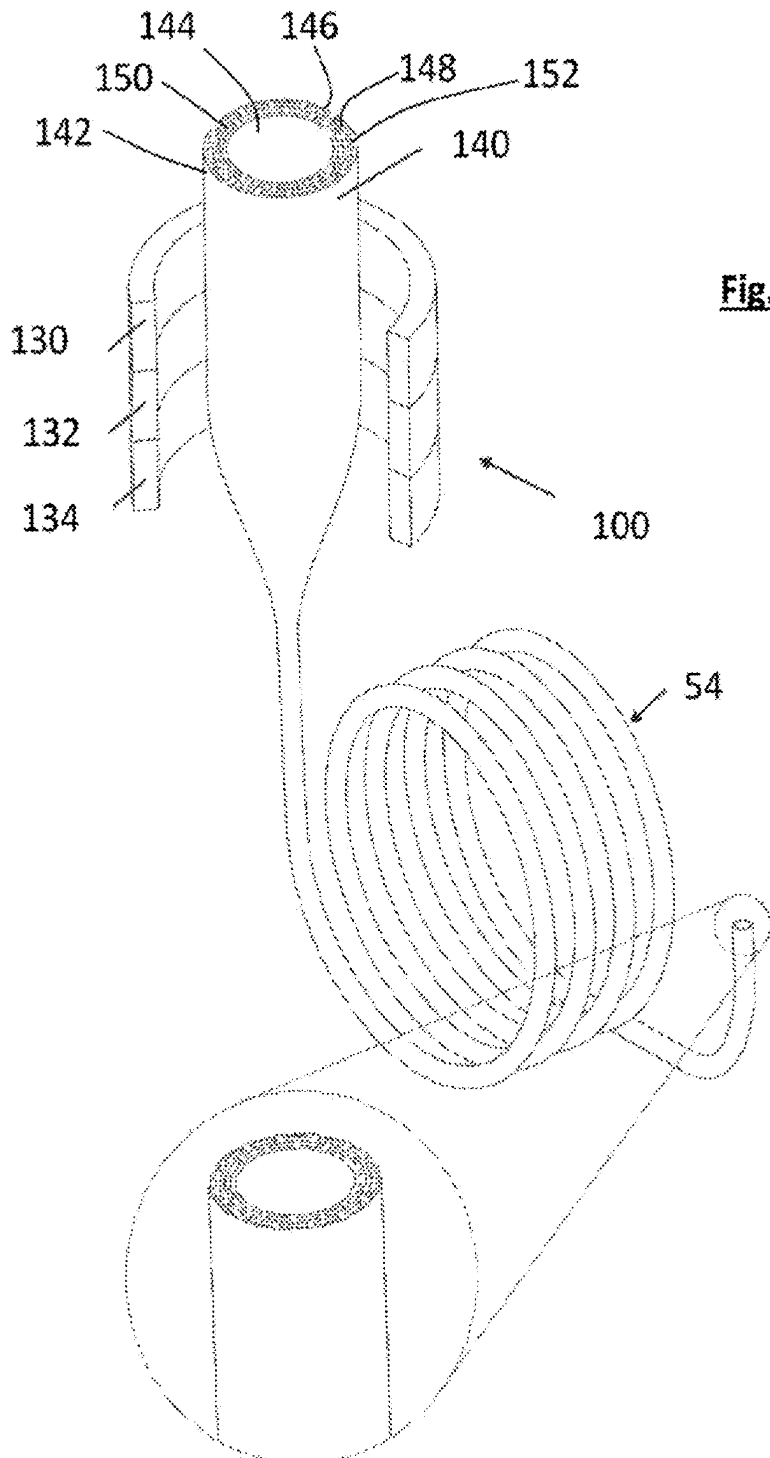
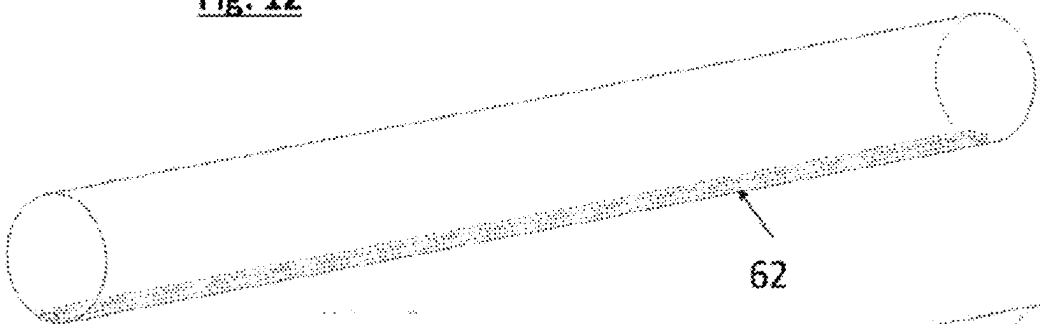


Fig. 11

Fig. 11a

Fig. 12



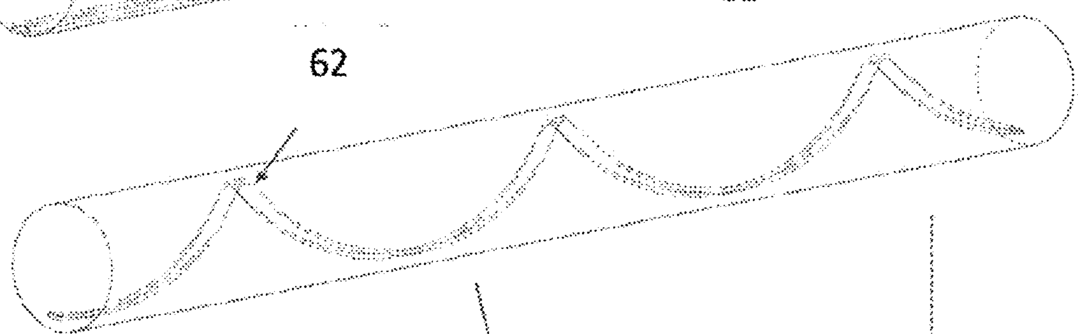


Fig. 13

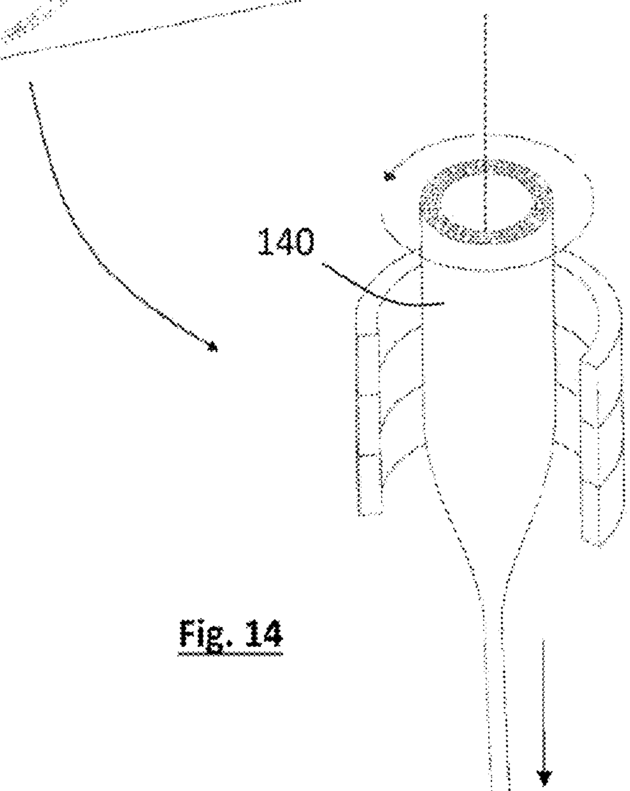


Fig. 14

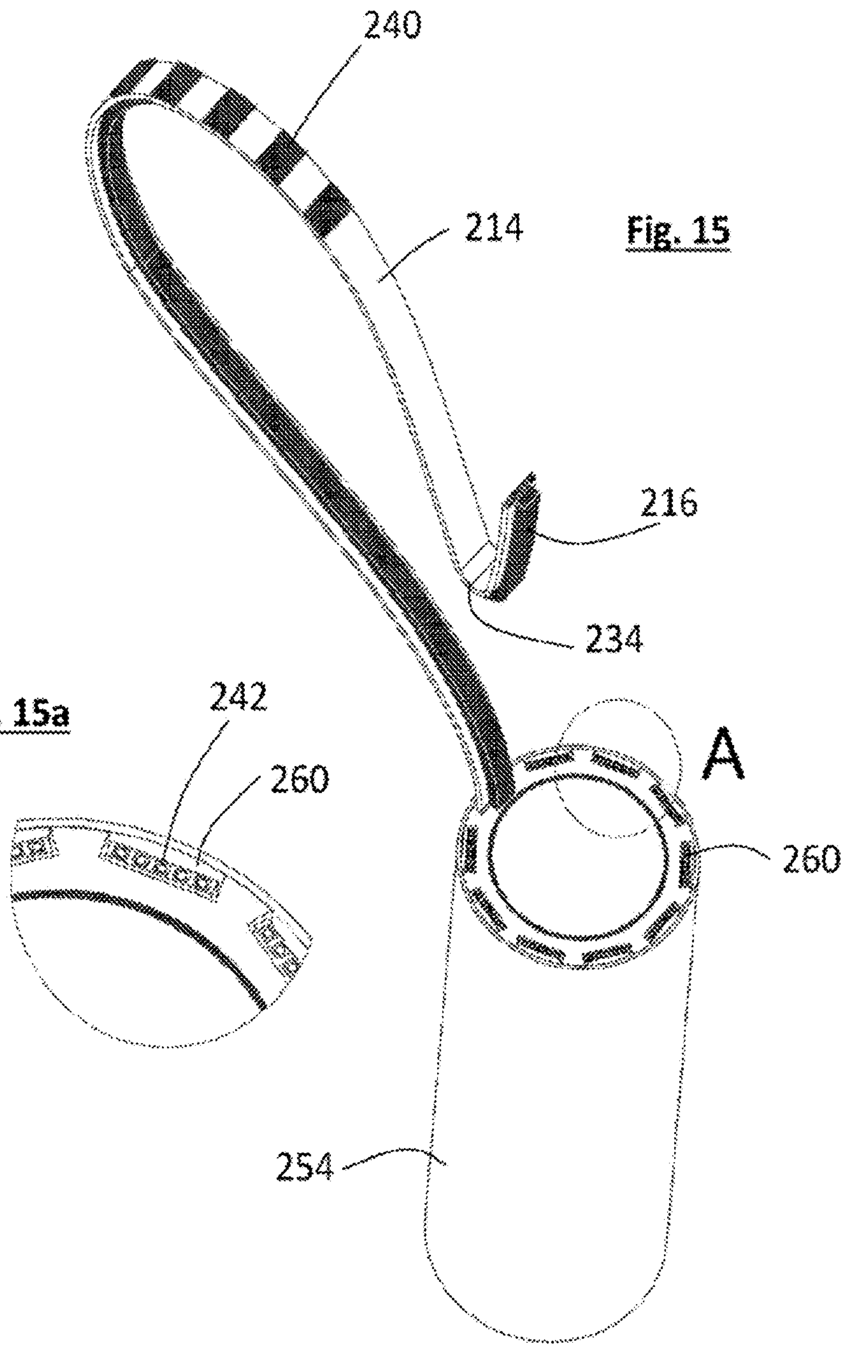


Fig. 15

Fig. 15a

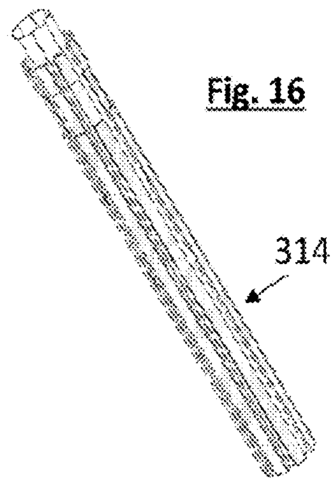


Fig. 16

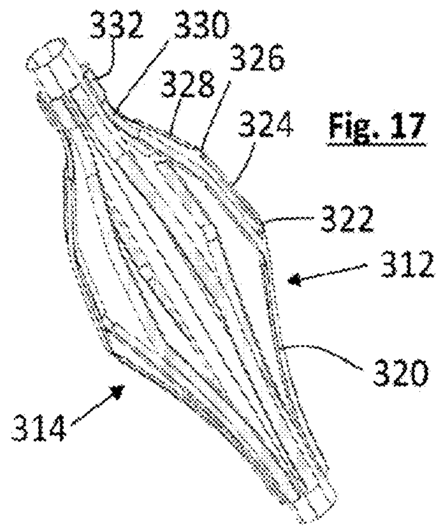


Fig. 17

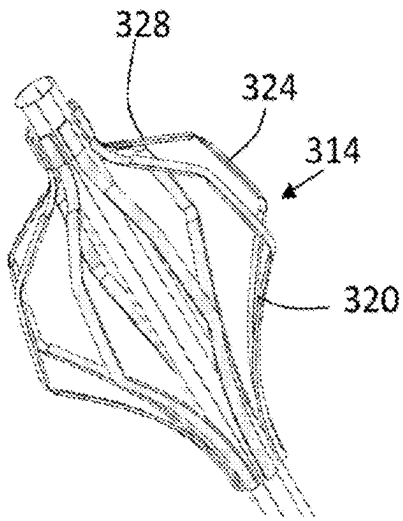


Fig. 18

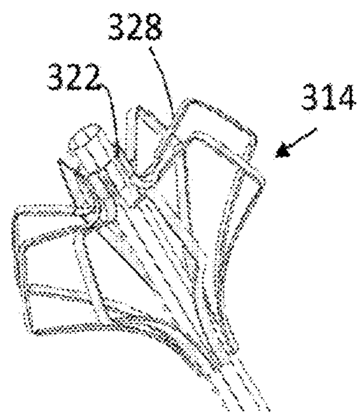


Fig. 19

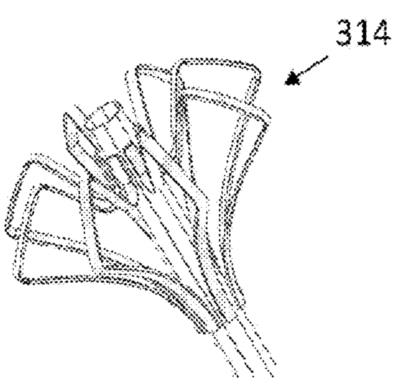


Fig. 20

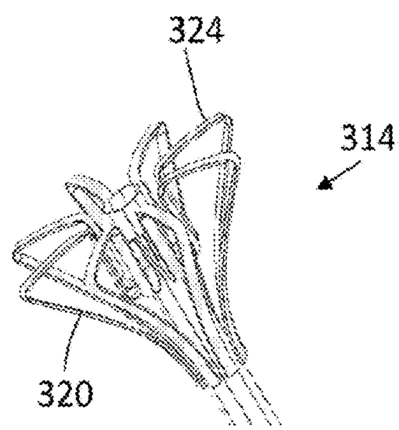


Fig. 21

MULTI-ELECTRODE CATHETER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is the National 1 Stage of International Application No. PCT/GB2023/050989, filed Apr. 13, 2023 which claims priority to GB 2205559.4 filed Apr. 14, 2022, both of which are hereby incorporated in their entireties by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to multi-electrode probes or catheters, in particular for the detection and recordal of electrical signals from the surface of the heart.

BACKGROUND TO THE INVENTION

[0003] Atrial fibrillation (AF) counts amongst the most common heart rhythm disturbances. It is caused by abnormal areas of the heart causing disruption to the normal electrical beats in the heart. These areas can be treated by 'ablation'—a procedure in which parts of the heart are cauterised. In order to locate the areas causing atrial fibrillation it is known to collect electrical information directly from the surface of the heart. Typically this is done using a multi-electrode catheter. Such catheters require design and manufacturing solutions which can present all of the wires to the heart surface and achieve contact at the same. The wires have to be kept fully insulated and connected outside the body to an amplifier system and computer to perform the required analysis.

[0004] A multi-electrode mapping catheter for endocardial contact mapping of a heart chamber typically includes an expandable framework or basket. Known basket designs can generally be defined in two distinct categories: pre-shaped and post-shaped. A pre-shaped basket is movable between a stressed contracted configuration and a pre-shaped deployed configuration. An example of such a catheter is described in WO2016039824A1. In contrast, a post-shaped basket is movable between a stress-free contracted configuration and a deployed configuration that is post-shaped via an external force. An example of such a catheter is described in WO2005112813A1. The pre-shaped basket has a precisely defined deployed shape but fewer wires than the post-shaped basket. An excess of wires concentrates high stress in contracted configuration and leads to high intertwined risks. A post-shaped basket can have many more wires than a pre-shaped one. However existing post-shaped baskets are deployed via large nonlinear wire bending, which requires a rigorously controlled and constantly applied load to keep their expanded shape, and the expanded shape cannot be precisely estimated or accurately controlled onsite. This uncertainty in the deformation, and hence the expanded shape, has a detrimental influence on the signal stability and the mapping accuracy.

SUMMARY OF THE INVENTION

[0005] The present invention provides multi-electrode catheter comprising a basket supporting a plurality of electrodes wherein the basket is flexible between a deployed configuration and a contracted configuration, wherein the probe comprises a bi-stable structure which is stable in both the deployed configuration and the contracted configuration.

[0006] The basket may comprise a plurality of flexible electrode support members. Each of the electrode support members may support at least one of the electrodes. The electrode support members may be arranged to flex between a first shape and a second shape as the basket flexes between the contracted configuration and the deployed configuration. The first shape of the electrode support members may be straight and the second shape may be curved.

[0007] The electrode support members may form a hollow tubular structure when the probe is in the contracted configuration.

[0008] The basket may have a first end and a second end. The probe may further comprise first and second supports each supporting a respective end of the basket. Each of the supports may be tubular defining an opening therethrough. The opening may form an instrument channel through which an instrument can be moved through the probe. The first support may be movable relative to the second support thereby to flex the basket between the contracted configuration and the deployed configuration.

[0009] The probe may comprise a bistable member which is arranged to resist movement of the probe out of both the contracted configuration and the deployed configuration. The bistable member may be flexible. The bistable member may have a folded state and an unfolded state. The bistable member may comprise first and second main portions and a hinge portion connecting the first and second main portions to each other. The bistable member may further comprise a support portion and a further hinge portion connecting the support portion to the second main portion. The bistable member may or may not comprise one of the electrode support members.

[0010] One end of the first main portion may be supported in a first support. The support portion may be supported in a second support. The first and second supports may be moveable relative to each other to move the bistable member between its folded and unfolded states.

[0011] The bistable structure may comprise a plurality of flexible bistable members.

[0012] When the probe is in the contracted state, the bistable member or members may be parallel to the electrode support members.

[0013] Each of the electrodes may be electrically connected to an electrical conductor which extends through one of the electrode support members. One, or each, of the electrodes and its associated conductor may be formed from a single wire. The electrical conductor may be enclosed within the electrode support member. The electrode may be exposed for contact with a subject.

[0014] Each of the electrode support members may support a single electrode, or a plurality of electrodes.

[0015] The probe may further comprise a shaft. The shaft may comprise a tube having a side wall with a plurality of lumens extending along the side wall. Each of the electrode supporting members may extend into a respective one of the lumens. Each of the electrode supporting members may extend along the length of the shaft.

[0016] The tube may have a central lumen. The plurality of lumens may be helical, extending around the central lumen and along the length of the shaft.

[0017] The invention further provides a method of producing a multi-electrode surgical probe, wherein the probe comprises a basket and a plurality of electrodes supported by the basket, and the basket comprises a plurality of composite fibres each comprising a flexible electrode support member and a conductor embedded in the support member, the method comprising providing a preform of polymeric material with a channel extending through it, inserting a conducting wire into the channel, heating the preform, and drawing the wire through the heated preform whereby the polymeric material coats the wire and forms one of the electrode support members.

[0018] The heating may melt a part of the preform. The melted part of the preform may be drawn with the wire. The melted part of the preform may narrow around the wire as it is drawn so as to coat the wire.

[0019] The method may further comprise removing an area of the polymer material so as to expose a part of the wire, thereby forming an electrode.

[0020] The method may further comprise processing a part of the electrode support member to form a hinge.

[0021] The method may further comprise providing a multi-lumen tube having a central lumen surrounded by a side wall, and a plurality of lumens formed in the side wall, and inserting a part of each of the composite fibres into a respective one of the plurality if lumens. The plurality if lumens may be helical, extending around the central lumen as well as along the length of the multi-lumen tube.

[0022] The probe may further comprise, in any workable combination, any one or more further features of the embodiments of the invention as will now be described in more detail with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] FIG. **1***a* is a perspective view of a probe according to an embodiment of the invention in a contracted configuration;

[0024] FIG. **1***b* is a perspective view of the probe of FIG. **1***a* in a partially deployed state;

[0025] FIG. **1***c* is a perspective view of the probe of FIG. **1***a* in a fully deployed state;

[0026] FIG. **2***a* shows detail of the outer basket of the probe of FIG. **1***a* in the contracted configuration;

[0027] FIG. **2***b* is a perspective view of the outer basket of FIG. **2***a* in a partially deployed state;

[0028] FIG. **2***c* is a perspective view of the outer basket of FIG. **2***a* in a fully deployed state;

[0029] FIG. **3***a* shows detail of the inner basket of the probe of FIG. **1***a* in the contracted configuration;

[0030] FIG. **3***b* is a perspective view of the inner basket of FIG. **3***a* in a partially deployed state;

[0031] FIG. **3***c* is a perspective view of the inner basket of FIG. **3***a* in a fully deployed state;

[0032] FIG. **4***a* is an exploded view of the components of the probe of FIG. **1***a;*

[0033] FIGS. **4***b* to **4***d* show the components of FIG. **4***a* at different points during assembly of the probe;

[0034] FIG. **5** is a perspective view of an apparatus for producing parts of the probe of FIG. **1***a;*

[0035] FIG. **6** shows detail of part of the apparatus of FIG. **5**;

[0036] FIG. **7** illustrates operation of the apparatus of FIG. **5**;

[0037] FIG. **7***a* shows detail of part of FIG. **7**;

[0038] FIG. **8** is a cross section through a polymer preform used in the apparatus of FIG. **5**;

[0039] FIG. **9** is a cross section through a flexible member formed from the preform of FIG. **8**;

[0040] FIG. **10** is a longitudinal section through the preform of FIG. **9** with encapsulated wires during drawing;

[0041] FIG. **10***a* shows detail of part of FIG. **10**;

[0042] FIG. **11** illustrates a method of drawing a multi-lumen tubing of the probe of FIG. **1***a;*

[0043] FIG. **12** illustrates the shape of one of the lumens in the tubing of FIG. **11**;

[0044] FIG. **13** illustrates the shape of one of the lumens in an alternative embodiment;

[0045] FIG. **14** shows how the embodiment of FIG. **13** is formed;

[0046] FIG. **15** shows part of a probe according to a further embodiment of the invention;

[0047] FIG. **15***a* is an enlargement of part A of FIG. **15**;

[0048] FIGS. **16** to **21** show the basket of a further embodiment of the invention in various states of deployment, from contracted to fully deployed.

DETAILED DESCRIPTION

[0049] Referring to FIGS. **1***a* to **1***c* a multi-electrode surgical probe comprises a flexible basket **10** supporting electrodes, as will be described below. The basket **10** is flexible between a contracted configuration, as shown in FIG. **1***a*, a partially deployed configuration as shown in FIG. **1***b*, and a deployed configuration as shown in FIG. **1***c*. The probe further comprises a bi-stable structure **12** which is stable in both the deployed configuration and the contracted configuration. The basket **10** is formed of a number of flexible electrode support members **14**. The bistable structure **12** may be in the form of a further basket, for example an inner basket, and may also comprise a number of flexible bistable members **16**, which may be formed of Nitinol or other alloys or materials with similar properties of flexibility and resilience.

[0050] The configuration of the flexible members **14**, **16** may take various forms, but as shown in FIG. **1***a*, when the probe is in the contracted configuration the flexible electrode support members **14** may be in the form of straight splines all extending parallel to each other along the length of the probe, and spaced around the central lumen **18** of the probe to form a generally tubular structure. The flexible bistable members **16** may also be in the form of straight splines all extending parallel to each other along the length of the probe, and spaced around the central lumen **18** of the probe to form a generally tubular structure. The bistable members **16** may be located inside the electrode support members **14**. A central tube **20** may be located within the tubular structures of the electrode supporting members **14** and the bistable members **16**, defining the central lumen **18**. This central lumen **18** is open on both the retracted and deployed states of the probe, and can be used to introduce tools or implements through the probe while the probe is in use. The probe may therefore form the end of a catheter through which, for example, ablation tools can be inserted.

[0051] At the distal end **22** of the probe, the ends **24** of the electrode support members **14**, and the ends **26** of the bistable members **16** are supported and retained in position around the end of the central tube **20**. The proximal ends **28** of the electrode support members **14** and the proximal ends **30** of the bistable members **14** are fixed relative to each other, but are slidable along the central tube **20** towards and away from the distal end **22**.

[0052] To move the probe from the contracted configuration of FIG. **1***a*, the proximal ends of the electrode supporting members **14** are pushed towards the distal end **22** of the probe, so that the electrode supporting members **14** flex outwards as shown in FIG. **1***b* so as to form an approximately spherical structure, and then flex further as shown in FIG. **1***c* so as to form an approximately toroidal structure with their proximal ends **28** close to their distal ends **24**. At the same time, the proximal ends **30** of the bistable members **16** move towards their distal ends **26** and the bistable members flex out of their stable contracted configuration, through an unstable partially deployed configuration as shown in FIG. **1***b*, and then to a stable deployed configuration as shown in FIG. **1***c*. The bistable members **16** thus resist movement of the probe out of the retracted configuration of FIG. **1***a*, and also retain the electrode supporting members **14** in their deployed configuration once that configuration is reached, resisting movement of the probe out of the deployed configuration.

[0053] Referring to FIG. **2***a* the flexing of the electrode support members **14** may be controlled by shaping the members **14**. For example, each of the members **14** may be of constant cross section along a main part **32** of its length, but may have a reduced thickness hinge portion **34** formed in it so as to increase the ease with which it flexes at that hinge portion **34**. For example, as shown in FIG. **2***a*, the hinge portion **34** may be located close to the distal end **24** of the members **14**. The distal end portion **36** of the member **14** beyond the hinge portion **34** may then form a support portion which is arranged to be supported at the distal end of the probe. The main portion **38** of the member **14**, to the proximal side of the hinge portion **34**, can therefore flex outwards by substantial flexing of the hinge portion **34** while the support portion remains substantially straight, and the main portion **38** flexes less than the hinge portion **34**. If there is no hinge portion formed at the proximal end **28** of the members **14**, as the proximal ends **28** are moved towards the distal ends **24**, as shown in FIG. **2***b* the degree of flexing at the proximal ends **28** is less than in the hinge portions **34**, and so the main portions **38** flex outwards and forwards over the distal end portions **36** until the fully deployed configuration is reached, in which the basket formed by the main portions **38** extends forwards beyond the distal ends **24** of the members **14** as shown in FIG. **2***c*. Each of the electrode supporting members **14** supports at least one electrode **40**, and a conductor **42** connected to the electrode and extending along the member **14** towards its proximal end **28**. The conductor **42** may be embedded within the member **14**, which is made of electrically non-conductive material and therefore insulates it from the conductors in the other members. The electrodes **40** may be formed by simply forming an opening **44** in the material of the member **14** to expose a portion of the conductor **42**. Optionally each of the openings **44** may be filled with conducting material so as to form a lager electrode having an outer surface which is flush with the surface of the electrode support member **14**. As shown in FIG. **2***c*, each member **14** may support more than one electrode, for example three, each with its respective conductor **42**.

[0054] Referring to FIGS. **3***a*, **3***b* and **3***c* the flexing of the bistable members **16** may also be controlled by shaping the members **16**. For example, each of the members **16** may be of constant cross section along two main parts **46**, **48** of its length, but may have two reduced thickness hinge portions **50**, **52** formed in it so as to increase the ease with which it flexes at that hinge portions **50**, **52**. For example, as shown in FIG. **3***a*, one of the hinge portions **50** may be located close to the distal end **26** of the members **16**, and one of the hinge portions **52** may be located between the first hinge portion **50** and the proximal end **30** of the member **16** to form the two main portions **46**, **48** on opposite sides of the second hinge portion **52**. The distal end portion **58** of the member **16** beyond the hinge portion **50** may then form a support portion which is arranged to be supported at the distal end of the probe. The main portions **46**, **48** of the member **16**, can therefore flex outwards as the proximal ends **30** are moved towards the distal ends **26**. The more distal main portion **46** can fold outwards relatively easily due to the flexibility of the more distal hinge portion **50**. However the more proximal main portion **46** is flexed outwards as shown in FIG. **3***b*, which provides resistance to movement of the proximal ends **30** towards the distal ends. There is a tipping point when the more distal main portion **46** is extending radially outwards, and so the flexing of the proximal main portions **48** is at a maximum. On further movement of the proximal ends **30** towards the distal ends **26**, the more distal main portions **46** start to fold inwards, and so the more proximal main portions **48** can also flex inwards, reducing their flexing as they return towards a straight configuration, where the probe is in its deployed configuration. This urges the members towards a stable folded condition as shown in FIG. **3***c*. The exact position of the deployed configuration will depend mainly on the balance between the forces from the flexing of the more proximal main portions **48** of the bistable members **16**, and the forces from the flexing of the electrode support members **14**. However, once the probe has been assembled, with the electrode support members **14** and the bistable members **16** connected to each other at their distal and proximal ends as shown in FIGS. **1***a* to **1***c*, the deployed configuration will be fixed, and not dependent on any additional forces applied to the probe.

[0055] Referring to FIG. **4***a*, the proximal ends of the electrode supporting members **14** may be supported in a multi-lumen tube **54**. The multi-lumen tube may have a central lumen **56** in which the central tube **20** is located, and an annular section side wall **58** having an outer ring **60** of lumens and an inner ring **62** of lumens. The outer ring of lumens **60** are each arranged to house the proximal end **28** of one of the electrode support members **14**. In order to provide electrical connection to the electrodes **40**, the proximal ends **28** of the electrode supporting members may extend through the whole length of the multi-lumen tube **54**. A distal spline support **64** may be mounted on the distal end of the central tube **20**. The distal spline support **64** may have an outer ring of support apertures **66** and an inner ring of support apertures **68**, in which the short sections of the outer and inner rings of lumens are arranged to support the support sections **36**, **58** at the distal ends of the electrode support members **14** and the bistable members **16**. The distal spline support **64** may conveniently be formed from a section of the same tubing as the multi-lumen tube **54**. The distal spline support **64** may be mounted on the end of the central tube **20** as shown in FIG. **4***b*, and then the distal ends of the electrode supporting members **14** and the bistable members **16** inserted into the spline support **64** as shown in FIG. **4***c*.

[0056] Once the probe is assembled as shown in FIG. **4***d*, there is a fixed exposed length **70** of the electrode support members **14** and the bistable members **16** extending between the distal end **72** of the multi-lumen tube **54** and the distal spline support **64**. The central tube **20** may be slidable within the multi-lumen tube **54** so as to move the distal spline support **64** towards the end **72** of the multi-lumen tube **54** to move the probe from the retracted configuration shown in FIG. **4*d*** to the deployed configuration as described above.

[0057] It will be appreciated that other embodiments can differ in a variety of ways from the embodiments shown. For example the number and shape of both the electrode support members **14** and the bistable members **16** may be different. Indeed the electrode support members may themselves be bistable, though this can result in a less stable configuration of the electrode array. While the bistable members **16** form part of the basket structure of the probe in the embodiments shown, they may be separate from the basket, and may for example take other forms. For example there may be just one or two bistable members similar to those described above, but thicker so that each of them provides more force than in the embodiment shown. Alternatively the bistable members could take a different form altogether.

[0058] Referring to FIG. **5**, the electrode support elements **14** may be formed by a number of suitable methods, but one suitable method is a drawing process in which the conducting elements **42**, which are typically in the form of electrically conducting wires, are drawn through a preform of the electrically non-conducting polymeric material of the electrode support element **14**, and the preform is heated and drawn into the narrow cross section of the electrode support element **14**, with the conducting elements embedded within it. The apparatus for performing this process may comprise a heater or furnace **100** in which the polymeric preform is held and heated, and a wire feed system **102** from which the conducting elements **42** are fed into the furnace **100** from spools **104**. In general terms, the electrode support element **14** is drawn from the furnace **100** in the direction of the arrow A, as the electrode support element **14** has the conducting elements **42** embedded in it, that also pulls the conducting elements **42** from the spools **104**. The polymeric preform within the furnace **100** is melted and drawn out with the conducting elements forming a coating around them.

[0059] The wire feed system **102** may be rotatably mounted so that it can rotate about a central axis X that is aligned with the drawn electrode support element **14**. The preform, which will be described in more detail below, may be support on a preform holder **106** that extends through the wire feed system **102** along the same axis X. The preform holder may also be rotatable about the same axis X. A single spinning motor **108** may be connected to both the preform holder **106** and optionally also to the wire feed platform **102** so that it can rotate one or both of them about the axis X during the drawing process. The spinning motor **108** may only be used during formation of the multi-lumen tube **54** as will be described below. The furnace **100**, wire feed platform **102**, preform holder **106**, and motor **108** may all be supported on a suitable structure such as a tower **112**.

[0060] Referring to FIG. **6**, the wire feed system **102** may comprise a rotatably mounted platform **114** on which the spools **104** are mounted via respective spool supports **116**, optionally together with guide rollers **118** which guide the conducting elements **42** from the spools **104** into the preform. The preform **120** is supported in the centre of the wire feed system on its axis of rotation X. The preform **120** may have a number of channels **122** formed through it into each of which a respective one of the conducting elements **42** is fed.

[0061] Referring to FIG. **7**, in operation, preform **120** is held within the furnace **100**, which may include a number of heating zones **130**, **132**, **134**. The channels **122** extend through the preform **120** parallel to each other and parallel to the draw axis X. At this point where the preform **120** is still solid and un-melted, the channels **122** are larger in diameter than the conducting elements **42** which therefore extend loosely through them, as shown in FIG. **8**, and can be drawn through them. The drawn polymeric material **135** from the preform **120** with the conducting elements **42** embedded within it form a continuous composite fibre **136** which can be pulled away from the furnace **100** to continue the drawing process. That pulling draws melted polymer from the preform **120**, causing the melted part of the preform to narrow down so that it forms a polymeric coating **138** of the composite fibre **136**, and is significantly narrower than the preform **120**. However the composite fibre retains the cross sectional shape of the preform **120**. Therefore the preform **120** may be of substantially rectangular cross section so that the composite fibre **136** is also of substantially rectangular cross section. At the same time the conducting elements **42** are pulled through the preform **120**, and the channels shrink around them until the polymeric material coats the surface of the conducting elements in the composite fibre **136** as shown in FIGS. **10** and **10*a***. However the conducting elements **42** remain separated by the polymeric coating **138** so that each of them is insulated from the others within the composite fibre **136** as shown in FIG. **9**.

[0062] In order to form the electrode supporting members **14** from the composite fibre, the fibre **136** is cut into lengths, the hinges **34** are formed by cutting a way a portion of the fibre **126** to reduce its thickness, preferably without exposing the conducting elements **42**. The openings **44** are then cut into the fibre **126** to expose regions of the conducting elements **42** thereby forming the electrodes **40**. The rectangular cross section of the composite fibre **136** means that multiple electrodes can be formed on one flat side of the electrode supporting members **14** as shown in FIG. **2*c***. It will be appreciated that other cross sections could be used but if more than one electrode is supported on each of the electrode supporting members **14** then it is preferable for the cross section to be such that there is a single flat or substantially flat surface which can be cut away to form all of the electrodes.

[0063] The bistable members **16** do not need to include the conducting elements **42**, but may be formed form a drawing process similar to that described for the electrode supporting members **14**, but using solid preforms with no channels **122** through them, and without the conducting elements being fed into the drawing process.

[0064] Referring to FIG. **11**, the multi-lumen tube **54** may be formed in a similar manner to the to the bistable members **16**. In this case the preform **140** has the same general cross section as the multi-lumen tube **54**, but with a much larger diameter. It therefore comprises a generally tubular member **142** having a central opening or through bore **144**, and an annular section side wall **146**. The lumens **148** are formed in the side wall **146**, in an inner ring **150** and an outer ring **152**. The preform **140** is heated in the furnace **100** and drawing out to form the multi-lumen tube **54**.

[0065] Referring to FIG. **12**, if the multi-lumen tube **54** is drawn from the preform **140** without use of the spinning motor **108**, the lumens **62**, **64** for the electrode supporting members **14** are straight and parallel to the central axis of the tube **54**. However, referring to FIG. **14**, if the spinning motor **108** is operated to rotate the preform **140** during drawing of the multi-lumen tube **54**, then the lumens **62**, **64** are spiral in form as shown in FIG. **13**, extending around the central lumen **54** as well as along the length of the probe shaft. Therefore when the electrode supporting members **14** are inserted into the lumens **62**, **64**, the conducting elements **42** are also in a spiral configuration. This has the advantage that the shaft of the finished probe, which comprises the multi-lumen tube **54** with the electrode supporting members and the conducting elements **42** extending through it, is more flexible than in the configuration of FIG. **11**, in which the wire conducting elements, which are generally inextensible, prevent easy bending of the probe shaft.

[0066] Referring to FIG. **15**, in a further embodiment, the electrode support members **214** are themselves of a similar structure to those **14** of FIG. **2***c*, each comprising an elastomeric support with conducting elements **242** extending through it and connected to electrodes **240**. However the bistable structure is achieved by attaching one or more flexible stiffening members **216** to each of the electrode support members **214**. The basket is therefore formed of a number of identical flexible members or splines each of which supports a number of electrodes **240** and each of which is bistable. The bistable structure may be achieved by having stiffening members **216** connected to parts of the conducting elements **242** to form stiffer regions, and parts **234** of the conducting elements having no stiffening material connected to them so that they are more flexible and can form hinge portions.

[0067] The electrode supporting elements **214** may be supported in a multi-lumen tube **254**, and may have their distal ends supported in a spline support, which is movable by means of a central tube in the same way as the embodiment of FIGS. **4***a* to **4***d*. However because the electrode support elements **214** themselves form the bistable structure, there is no need for separate lumens in the multi-lumen tube **254** for the separate bistable structure, and so all of the lumens **260** in the multi-lumen tube **254** are used for electrode support elements **214**. As can be seen in FIG. **15**, and in FIG. **15***a*, the stiffening members **216** do not need to extend into the multi-lumen tube **254**, but are attached to the surface, conveniently the inner surface, of the electrode supporting elements **214** between the end of the multi-lumen tube and the spline support. In FIG. **15** only one of the composite bistable electrode supporting members is shown which is in the fully deployed condition. The central tube and distal spline support are also not shown.

[0068] Referring to FIGS. **16** to **21**, in a further embodiment, the structure of the basket **312** is similar to that of FIG. **15**, except for the length and location of the stiffening members **316**. In this case each of the bistable electrode supporting members **314** comprises, from the proximal end where it is supported in the multi-lumen tube, a first stiffened portion **320** to which a stiffening member **316** formed form a length of stiffening material is connected, a first hinge portion **322**, at the distal end of the first stiffened portion **320**, to which no stiffening material is attached, then a second stiffened portion **324**, then a second hinge portion **326**, then a third stiffened portion **328**, then a third hinge portion **330**, and finally a distal support portion **332** which is supported on the distal end of the central tube **340**, for example by means of a spline support.

[0069] In operation, from the fully retracted condition as shown in FIG. **16** in which the splines are all parallel and as the distal support portions **332** of the splines are moved down towards the proximal end, the first stiffened portions **320** and the third hinge portions **330** bend outwards, until over-centre position which is approximately as shown in FIG. **19** is reached in which the third stiffened portions **328** extend approximately radially outwards. On further movement of the distal support portions **322** the third stiffened portions **328** fold inwards towards the distal support portions **322**, the first stiffened portions **320** also flex back inwards, and the second stiffened portions move towards the distal end of the probe. As shown in FIG. **21**, in the fully deployed condition, the third hinge portions **330** are folded through 180° so that the third stiffened portions **328** are approximately parallel to each other and the axis of the probe, and the second stiffened portions extend approximately radially outwards. In this condition the flexing of the first stiffened portions **320** pushes the third stiffened portions inwards into contact with the distal support portions **322**, which prevents further movement and therefore defines the fully deployed condition. To start movement back towards the contracted condition, the distal support portions **322** are moved back towards the distal end of the probe causing folding of the third stiffened portions **328** outwards, which pushes the first stiffened portions **320** outwards causing them to flex back outwards towards their over-centre position.

[0070] All of the electrodes may be located on the second stiffened portion **324** such that, when the basket is in the fully deployed condition, the electrodes are approximately in a single plane perpendicular to the axis of the probe.

1. A multi-electrode surgical probe comprising a basket, and a plurality of electrodes supported on the basket, wherein the basket is flexible between a contracted configuration and a deployed configuration, and the probe comprises a bi-stable structure which is stable in both the deployed configuration and the contracted configuration.

2. A probe according to claim **1** wherein the basket comprises a plurality of flexible electrode support members each of the electrode support members supporting at least one of the electrodes, and the electrode support members are arranged to flex between a first shape and a second shape as the basket flexes between the contracted configuration and the deployed configuration; wherein the first shape of the electrode support members is straight and the second shape is curved.

3. A probe according to claim **2** wherein when the electrode support members form a hollow tubular structure when the probe is in the contracted configuration.

4. A probe according to claim **1** wherein the basket has a first end and a second end and the probe further comprises first and second supports each supporting a respective one of the first and second ends of the basket.

5. A probe according to claim **4** wherein each of the first and second supports is tubular defining an opening therethrough, the probe further comprises an instrument channel through which an instrument can be moved through the probe, and the openings surround the instrument channel.

6. A probe according to claim **4** wherein the first support is movable relative to the second support thereby to flex the basket between the contracted configuration and the deployed configuration.

7. A probe according to claim **1** wherein the probe comprises a bistable member which is arranged to resist movement of the probe out of both the contracted configuration and the deployed configuration; wherein the bistable member is a flexible member having a folded state and an unfolded state; and wherein the bistable member comprises first and second main portions and a hinge portion connecting the first and second main portions to each other.

8. A probe according to claim **7** wherein the bistable member further comprises a support portion and a further hinge portion connecting the support portion to the second main portions.

9. A probe according to claim **8** wherein the probe further comprises first and second supports, the first main portion has a first end which is supported in the first support, and the support portion is supported in the second support, and the first and second supports are moveable relative to each other to move the bistable member between its folded and unfolded states.

10. A probe according to claim **7** wherein the bistable member further comprises a second hinge portion, a third main portion connected to the second main portion by the second hinge portion, and a support portion connected to the third main portion by a third hinge portion.

11. A probe according to claim **10** wherein the probe has an axis, and in the deployed configuration, the second main portion extends radially outwards from the axis of the probe.

12. A probe according to claim **10** wherein the electrodes are supported on the second main portion of the bistable member.

13. A probe according to claim **7** wherein the bistable structure comprises a plurality of bistable members.

14. A probe according to claim **7** wherein the basket comprises a plurality of flexible electrode support members each of the electrode support members supporting at least one of the electrodes, and the electrode support members are arranged to flex between a first shape and a second shape as the basket flexes between the contracted configuration and the deployed configuration, and wherein, when the probe is in the contracted state, the bistable member is parallel to the electrode support members.

15. A probe according to claim **1** further comprising a plurality of electrical conductors each of which extends through a respective one of the electrode support members, wherein each of the electrodes is electrically connected to one of the electrical conductors.

16. A probe according to claim **15** wherein one of the electrodes and its associated electrical conductor are formed from a single wire, the electrical conductor being enclosed within the electrode support member and the electrode being exposed for contact with a subject.

17. A probe according to claim **1** wherein the probe further comprises a shaft, and the shaft comprise a tube having a side wall with a plurality of lumens extending along the side wall, and each of the electrode supporting members extends into a respective one of the lumens and along a length of the shaft.

18. A probe according to claim **17** wherein the tube has a central lumen, and the plurality of lumens are helical extending around the central lumen and along the length of the shaft.

19. A method of producing a multi-electrode surgical probe, wherein the probe comprises a basket and a plurality of electrodes supported by the basket, wherein the basket comprises a plurality of composite fibres each comprising a flexible electrode support member and a conductor embedded in the support member, the method comprising providing a preform of polymeric material with a channel extending through it, inserting a conducting wire into the channel, heating the preform, and drawing the wire through the heated preform whereby the polymeric material coats the wire and forms one of the electrode support members.

20. A method according to claim **19** further comprising removing an area of the polymer material so as to expose a part of the wire, whereby the exposed part of the wire forms an electrode; processing a part of the electrode support member to form a hinge; and providing a multi-lumen tube having a central lumen surrounded by a side wall, and a plurality of lumens formed in the side wall, and inserting a part of each of the composite fibres into a respective one of the plurality if lumens; wherein the plurality if lumens are helical, extending around the central lumen as well as along the length of the multi-lumen tube.

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