



(51) International Patent Classification:

A61B 17/221 (2006.01)

A61B 1/00 (2006.01)

A61B 17/00 (2006.01)

(21) International Application Number:

PCT/EP2020/055708

(22) International Filing Date:

04 March 2020 (04.03.2020)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

1902891.9

04 March 2019 (04.03.2019)

GB

(71) Applicants: CAMBRIDGE MECHATRONICS LIMITED

[GB/GB]; The Westbrook Centre, Building 6, Milton Road, Cambridge Cambridgeshire CB4 1YG (GB). UNIVERSITY OF BIRMINGHAM [GB/GB]; University of Birmingham, Edgbaston, Birmingham West Midlands B15 2TT (GB).

(72) Inventors: BRYAN, Richard; c/o University of Birmingham,

Edgbaston, Birmingham West Midlands B15 2TT (GB). SHEPHERD, Duncan; c/o University of Birmingham, Edgbaston, Birmingham West Midlands B15 2TT (GB). GREEN, Naomi; c/o University of Birmingham,

Edgbaston, Birmingham West Midlands B15 2TT (GB). VAN WYK, Peter; c/o Cambridge Mechatronics Limited, The Westbrook Centre, Building 6, Milton Road, Cambridge Cambridgeshire CB4 1YG (GB). CARR, Joshua; c/o Cambridge Mechatronics Limited, The Westbrook Centre, Building 6, Milton Road, Cambridge Cambridgeshire CB4 1YG (GB). HART, Oliver; c/o Cambridge Mechatronics Limited, The Westbrook Centre, Building 6, Milton Road, Cambridge Cambridgeshire CB4 1YG (GB).

(81) Designated States (unless otherwise indicated, for every

kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every

kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,

(54) Title: SHAPE MEMORY ALLOY CONTROLLED DEVICE FOR A RESECTOSCOPE

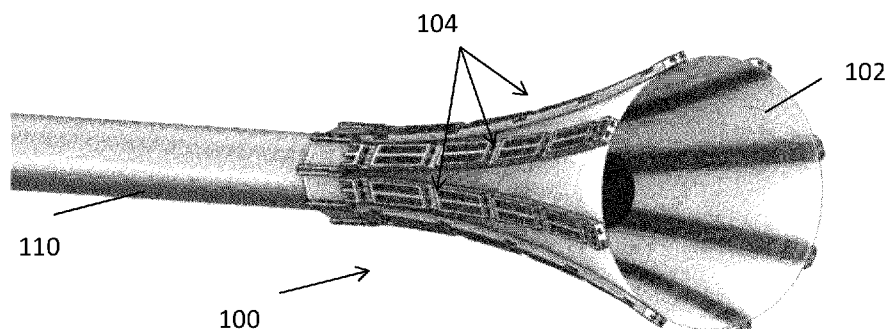


FIG 1

(57) **Abstract:** The application describes a surgical device (100), a resectoscope (110) incorporating the surgical device and a method of making the surgical device. The surgical device comprises a housing (102) which is made from a flexible material; a plurality of flexible arms (104) which are attached to the housing and which are configured to move the housing between a closed configuration and an open configuration; and at least one shape memory alloy (SMA) member attached to each one of the plurality of flexible arms. Contraction of the at least one SMA member causes the flexible arm to which the at least one SMA member is attached to flex and move the housing from the closed configuration to the open configuration.



TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

- *with international search report (Art. 21(3))*
- *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

Shape Memory Alloy Controlled Device for a Resectoscope

The present application generally relates to a shape memory alloy (SMA) based actuator for controlling a device which may be attached to a resectoscope, and in particular to a bladder tumour resectoscope.

As discussed in "Design of an improved surgical instrument for the removal of bladder tumours" by Barnes et al published in Journal of Engineering in Medicine 2016, Vol 230(6) 579 to 587, transurethral resection of bladder tumour (TURBT) is the mainstay of treatment for non-muscle-invasive bladder cancer (NMIBC) and the surgical staging modality of choice for muscle-invasive bladder cancer (MIBC). The equipment for TURBT which may be termed a resectoscope typically comprises a stainless housing for a cutting loop (also termed a diathermy loop) and a cystoscope attached to a video camera head. Current surgical approaches permit spilled tumour cells to disseminate within the bladder, re-implant and cause tumour recurrence. The paper describes an add-on instrument to potentially decrease such recurrence.

In a first approach of the present techniques, there is provided a surgical device comprising a housing which is made from a flexible material; a plurality of flexible arms which are attached to the housing and which are configured to move the housing between a closed configuration and an open configuration; and at least one shape memory alloy (SMA) member attached to each one of the plurality of flexible arms; wherein contraction of the at least one SMA member causes the flexible arm to which the at least one SMA member is attached to flex and move the housing from the closed configuration to the open configuration.

In a second approach of the present techniques, there is a provided a resectoscope comprising the surgical device.

In a third approach of the present techniques, there is provided a method of manufacturing the surgical device. The method comprises assembling a jig comprising a base and a plurality of shaped segments which when supported in the base have an outer surface matched to the shape of the housing in the open configuration; forming the plurality of arms; forming the housing on the jig;

attaching the plurality of arms to the housing; detaching the base from the jig; and removing the shaped segments from within the housing

Preferred features are set out in the appended dependent claims.

5

Implementations of the present techniques will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of a surgical device for a resectoscope;

10

Figure 2 is a perspective view of a plurality of arms in an open configuration;

Figure 3 is a perspective view of an arm which can be used in the surgical device of Figure 1;

15

Figures 4a to 4d are schematic cross-sectional views of a resectoscope incorporating the surgical device of Figure 1 in an insertion position, in an extended position, in a containment position and in a removal position respectively,

20

Figures 5a and 5b are close-up views of the detail of two alternative surgical devices;

Figures 6a and 6b are side and plan schematic views of two separate SMA wires on part of an arm;

25

Figures 6c and 6d are schematic views of the partial and full activation of the arm of Figure 6a respectively;

30

Figure 7 is an exploded perspective view of an alternative design of arm;

Figure 8 is a sketch of a retaining collar for use in a surgical device;

35

Figure 9a is a view of one end of an arm illustrating part of a second arrangement for a retaining collar;

Figure 9b is a view of one end of multiple adjacent arms;

5 Figure 10 is a perspective view of a plurality of arms and another arrangement for a retaining collar in a planar arrangement;

Figures 11a and 11b are perspective view of a plurality of arms in planar or octagonal rolled configurations respectively;

10 Figure 11c is a side view of a mounting base for use in the manufacture of the device;

Figure 11d is a perspective view of the mounting base in use;

15 Figures 12a and 12b are perspective view of alternative devices in the open configuration.

Broadly speaking, embodiments of the present techniques provide a device which is controlled by a shape memory alloy (SMA) based actuator and which is
20 used with another surgical instrument. The device may thus be termed a surgical device. The SMA actuator may comprise any suitably shaped SMA member, e.g. an SMA wire, a rod or a member having a different cross-sectional shape.

The device may be an add-on device which is attached to the other surgical
25 instrument to perform one or more surgical operations. The add-on device may be reusable or may be a single use, discardable device. Alternatively, the surgical instrument and device may be manufactured together as a combined apparatus. For example, the surgical instrument may be a resectoscope, particularly a bladder tumour resectoscope and the surgical device may help to limit the scattering of
30 tumour fragments during the resection process. As explained in more detail below, the surgical device may be deployed once the resectoscope is inserted in a patient, e.g. into the bladder, to form a housing or contained volume which surrounds the tumour during resection.

The flexibility of each arm is designed to provide the required change in shape from the closed to the open configuration based on the force available from the attached SMA member(s). The flexibility may be adjusted by making each arm from a suitable plastics or composite material and/or using a stiffening layer, e.g. a metallic coating. Each arm may comprise at least one hinge, which may be a portion of the arm having reduced thickness or width compared to the adjacent portions of the arm, to reduce the local stiffness of the hinge and thus increase flexibility. One or more of the arms may comprise a first portion and a second portion, wherein the second portion is more flexible than the first portion.

Each arm flexes on contraction of the attached SMA member. Each SMA member may be located within one or more channels on the arm. These channels may be important with regards to reducing the operating power because the channels may provide insulation for the member by providing a local environment and by reducing the amount of heat dissipated to the environment. Each arm may comprise a plurality of guide members comprising at least one channel. The guide members may be separated by hinges where these are used.

The form factor of the surgical device may be important, particularly in the closed configuration. A collar may be included to assist in retaining a low form factor as the surgical device is inserted into a patient. The collar may hold one end of the plurality of arms in a closed configuration and thus prevent the arms opening the housing. The collar may use friction forces to retain the arms together. Using an arm with a tapered portion may also help to reduce the form factor.

It will be appreciated that the features of the different arrangements shown below may be combined. For example, the collar and/or the differently located wire retention members may be used on an arm having first and second portions. Furthermore, in each of the Figures 1 below, there is reference to SMA wire(s) but it will be appreciated that any suitably shaped SMA member may be used, e.g. a wire, a rod or a member having a different cross-sectional shape. Accordingly, throughout the description of the Figures, the term "SMA wire" may be replaced with "SMA member". Similarly, where a more general SMA member is used, the

"wire retention member" and "wire guide member" may be referred to as "retention member" and "guide member"

Figure 1 is a schematic illustration of a surgical device 100 which is attached to a resectoscope 110. The device 100 comprises a plurality of flexible arms 104 which are attached to a housing 102. The device 100 may be considered to resemble an umbrella because it is moveable between a closed configuration and the open configuration shown in Figure 1. The closed configuration may alternatively be termed a compact or relaxed configuration. Similarly, the open configuration may be termed an expanded configuration.

In the example shown in Figure 1, there are equally spaced eight arms but it will be appreciated that this number of arms is merely exemplary. The number and arrangement of arms may be selected to ensure uniform opening of the housing 102. Furthermore, in this arrangement, all the arms are identical but it will be appreciated that different sized arms may be used if it is preferred to provide a non-uniform shape of housing. It may also be possible to create a non-uniform shape by adjusting the flexure of each arm using different amounts of power to each SMA wire within each arm which controls the contraction. It will be appreciated that any suitable control mechanism may be used, for example a feedback mechanism which measures information about the device or a surgeon controlled mechanism. An example of a feedback mechanism is one which uses resistance measurements to obtain the length of the wires.

In the closed configuration, the material of the housing is not taut and is loosely stored in a folded manner. The housing 102 may be made from an elastomeric material, e.g. latex, TPU, TPE, silicone or another similar soft flexible material which is sufficiently flexible to allow the arms to move the device between the closed and open configurations. The material may be selected to be taut in both the closed and open configurations or may be selected to be taut in the open configuration only. The material may be thin, for example in the range of 10 microns to 250 microns thickness. The thickness of the material should be sufficient for the arm to resist tearing and some strength but not too great to prevent movement to the open configuration. The housing 102 may be made from a bio-compatible material or a material coated with a bio-compatible coating.

Similarly, the arms may be made from a bio-compatible material or a material coated with a bio-compatible coating.

The housing 102 may comprise a perforate material comprising a plurality of apertures, i.e. may be a permeable material. The apertures are sized to allow any liquid, but not other debris, e.g. cancer cells, within the location of the resection to circulate through the housing 102. Resection is typically accompanied by irrigation which may be achieved by continually circulating a fluid through the body of the resectoscope into the housing of the surgical device and out through the apertures in the housing. Such a perforate membrane may allow flow through the housing and may thus allow for a pressure differential across the housing without causing leakage around the housing.

Figure 2 shows a plurality of arms 204 in an open configuration as in Figure 1 but without the housing or the resectoscope to highlight the detail of the arms. Each arm 204 comprises a plurality of wire guide members 306 connected by hinges 208. In this arrangement, there are four wire guide members 206 and five hinges 208 but it will be appreciated that any suitable number may be used. The hinges may also be optional if the material and cross-section of the arm is sufficiently flexible. At one end of each arm 204 there is a wire guide 214. At the other end of each arm 204, there is an indentation 202 which supports a crimp (not shown). The arms are held together using a collar 216 which also may assist in positioning the device when in use as explained below.

Figure 3 shows the detail of an arm 304 of the device of Figures 1 or 2. The arm 304 is designed to be flexible so that the device can move between the closed and open configurations as described in more detail below. The arm 304 may be made from any suitable flexible material, e.g. plastics, super elastic alloys or composites. The arm may be manufactured using any suitable technique, e.g. machined or moulded or 3D printed as explained below. A composite metallic skin may be attached to the arm to increase the stiffness. When used in a resectoscope, the open configuration has an overall diameter of between 30 to 60mm which is approximately 20 to 50 mm greater than the closed position depending on the diameter of the resectoscope itself. The arm is designed to be flexible enough to allow this increase in size on contraction of the SMA wire.

The arm 304 comprises a first portion having a plurality of wire guide members 306 with pairs of adjacent wire guide members connected by hinges 308. In this arrangement, there are four wire guide members 306 and five hinges 308 but it will be appreciated that any suitable number may be used. The use of hinges 308 provides greater flexibility in the arm 304 by reducing the force required to bend the arm 304. The hinges may have the same width as the wire guide members but may have a reduced thickness when compared to the wire guide members to give the desired stiffness. Merely as examples, the width may be between approximately 2 to 4mm and the thickness of the hinges may be between 0.3 to 1mm compared to 0.3 to 2mm thickness for the wire guide member. In these examples, the length of the arm is between approximately 50 to 100mm. Each wire guide member 306 comprises a pair of channels 305 through which a shape memory alloy (SMA) wire (not shown) passes.

An optional second portion which is tapered to form of a flexible tip 310 extends from one end of the first portion in this arrangement. It will be appreciated that the flexible tip 310 may also be incorporated in the arrangement shown in Figure 1 (and other arrangements described below). A wire guide 314 may be used to join the first portion and the second portion to guide the wire between the flexible tip and the first portion. The flexible tip may be designed to have greater flexibility than the first portion. This may allow the arm to be designed to control the extent of the opening of the housing and/or to allow the device to better conform to the internal shape of the patient, e.g. the patient's bladder wall during resection. The flexible tip 310 comprises a plurality of loops 312 (which may be termed vertebrae) which hold the wire to the flexible tip. In this arrangement there are eight loops, but it will be appreciated that this is merely exemplary.

At the opposed end of the arm to the flexible tip, there is an indentation 302 which supports a crimp (not shown). Opposed ends of the SMA wire are held in the crimp and the initial portions of the SMA wire which extend from the crimp may be located in channels which extend from the indentation. In one arrangement, the wire is located on the arm by feeding the wire through the channels along one side of the first portion, through the wire guide 314, through

the loops 312 along one side of the flexible tip and looping the wire back through the loops 312 along the opposed side of the flexible tip, through the wire guide 314 and through the channels along the opposed side of the first portion. More detail on the channels is shown below. Alternatively, a first wire may be looped
5 along the first portion, i.e. through the channels along one side of the first portion, through the wire guide 314 and back through the channels along the opposed side of the first portion. A second may be looped on the flexible tip, i.e. looped along one side of the flexible tip and back through the loops 312 along the opposed side of the flexible tip. The two wires may be operated independently as described
10 below in relation to Figure 6a.

The indentation is located on a first end of the arm 304 which may be termed the distal end. The tip of the second portion may be termed the proximal end and in use this is the end which is inserted in a patient. The second portion
15 is in the form of a flexible tip 310 and as shown may be tapered to aid insertion.

Figures 4a to 4d illustrate the apparatus as used in transurethral resection of bladder tumours (TURBT). The apparatus comprises the device 400 with a resectoscope 420 which is housed or inserted within the device 400. Figure 4a
20 shows the closed configuration of the device 400 to allow the device with the resectoscope 420 to be inserted into a patient. In this closed configuration, the device 400 increases the cross-section of the overall apparatus by as minimal an amount as possible so that the apparatus has an overall low form factor to aid insertion. The resectoscope 420 has a coude tip 422 which is at the proximal end
25 of the apparatus and which is the part first inserted into a patient. The collar 416 which holds the arms in place also acts as a positioning collar. SMA wires 430 extend through the arms and to a power source (not shown) which is positioned outside a patient in use. In Figure 4a, the SMA wires are not powered.

In Figure 4b, the resectoscope 420 has been positioned ready for use by extending the diathermy tip 424 to its maximum position protruding from the coude tip 422. The device is still in its closed position with the SMA wires 430 not powered and the arms 412 in their relaxed position. The collar 416 is released as schematically illustrated by the arrows to prepare the device.
35

In Figure 4c, the SMA wires 430 are powered. Powering the SMA wires causes the SMA wires to contract and due to the flexibility of the arms 412, the arms bend outward because of the SMA tensile force on the outer surface of each arm. There is a moment acting around the neutral axis of the arm which causes it to bend (or curl up). As the arms bend, the housing is opened and abuts the patient's bladder wall to form an enclosure (or contained volume) around the diathermy tip and a tumour to be removed. The SMA wires may be individually controlled to set the shape of the housing in the open configuration. In this open configuration of the device, the procedure to remove the tumour can be carried out in a more restricted volume of the bladder and scattering of tumour fragments may be prevented or reduced. The device has a higher form factor in the open configuration than in the closed configuration for insertion or removal.

Figure 4d illustrates the configuration of the apparatus for removal once the resection of the tumour is complete. The SMA wires 430 are powered down. The SMA wires cool and return to their uncontracted state. The arms 412 also return to their original (i.e. relaxed and unbent) state. The removed tumour may be enclosed by the collapsed housing to assist in its removal. Once the apparatus is removed from a patient, the device may be discarded and replaced with a new device to avoid any cross-contamination between patients. Thus, each device may be single use.

Figures 5a and 5b illustrate two alternative mechanisms for attaching the SMA wires to the arms. Figure 5a shows an enlarged view of a hinge 508 between two wire guide members 506a, 506b which may be used in the arm of Figure 3. Each wire guide member 506a, 506b comprises a pair of parallel, open channels 505 which extend along substantially the length of the wire guide member 506a, 506b. At the end of each wire guide member 506a, 506b, there is a wire retention member 509a, 509b. Each wire retention member 509a, 509b comprises a pair of bores 507 which hold a wire passing through each bore to the arm. Each bore is adjacent to an end of a corresponding wire channel and extends through the wire retention member 509a, 509b in a direction which is parallel to the corresponding wire channel. The bores 507 in adjacent wire retention members 509a, 509b are also aligned. The bore may be created after the arm is formed by

a suitable manufacturing method, e.g. injection moulding, and may be undercut from the opposed side.

In use, the SMA wire is located (but not held) within a channel 505 in a first wire guide member 506a and is located in the bore 507 in the retention member 509a at the end of the first wire guide member 506a to hold the wire to the first wire guide member 506a. The wire passes over but is not held to the hinge 508. Similarly, the wire is located in the bore 507 in the retention member 509b at the end of the adjacent wire guide member 506b to hold it to the arm and is located in the channel 505 of the adjacent wire guide member 506b.

Figure 5b shows an enlarged view of a hinge 518 between two wire guide members 516a, 516b which may be used in the arm of Figure 3. Each wire guide member 516a, 516b comprises two pairs of parallel, open channels 513, 515 which are connected by wire retention members 519a, 519b, respectively. Each wire retention member 519a, 519b comprises a pair of bores 517 which hold a wire passing through each bore to the arm. Each bore extends through the wire retention member 519a, 519b in a direction which is parallel to and connects the corresponding adjacent pair of wire channels 513, 515. Each wire retention member 519a, 519b is generally centrally located on the respective wire guide member 516a, 516b.

In use, the SMA wire is located (but not held) within a first channel 513 in a first wire guide member 516a, is located in the bore 517 in the retention member 519a to hold the wire to the first wire guide member 516a and is located (but not held) within a second channel 515 in the first wire guide member 516a. The wire passes over but is not held to the hinge 518. Similarly, is located (but not held) within a first channel 513 in an adjacent wire guide member 516b, is located in the bore 517 in the retention member 519b and is located (but not held) within a second channel 515 in the adjacent wire guide member 516b.

It will be appreciated that the arrangement shown in Figure 5a holds each SMA wire to the arm at the start and end of each hinge whereas in Figure 5b, each SMA wire is only held to the arm at a central point of each wire guide member. In both arrangements, the wire may be considered to be threaded through the bores

in the arm. The arrangement of Figure 5a doubles the number of bores and wire retention members which are required when compared to the arrangement in Figure 5b and thus is more complex. It is also possible that the arrangement in Figure 5b may have a greater mechanical advantage because of the fewer attachment points. However, it is likely that an SMA wire attached using the arrangement in Figure 5a will not protrude from the arm as much as in the arrangement in Figure 5b. The arrangement of wire attachments members can be selected as required to balance the advantages and disadvantages of the two styles of attachment.

Figures 6a and 6b are side and plan views of an arm 604 comprising a dual actuator arrangement having two separate and independent loops of SMA wire that are controllable. The arm 604 comprises a first flexible portion 611 to which a first SMA wire 630 is attached and a second flexible portion 612 to which a second SMA wire 632 is attached. The first SMA wire 630 is held to a surface (upper or lower depending on the arrangement) of the first flexible portion 611 using a plurality of wire retention members 609. As shown, there are nine retention members which are equally spaced along the length of the first flexible portion 611 but it will be appreciated that this number and arrangement is merely exemplary. These retention members 609 may be as described above in relation to Figures 5a and 5b or may be any suitable retention member. At each end of the SMA wire 630, there is a crimp 602 which forms a mechanical and electrical connection to the wire. A single loop of wire is thus arranged on the first portion 611.

Similarly, the second SMA wire 632 is held to a surface (upper or lower depending on the arrangement) of the second flexible portion 612 using a plurality of wire retention members 619. As shown, there are six retention members which are equally spaced along the length of the second flexible portion 612 but it will be appreciated that this number and arrangement is merely exemplary. These retention members 619 may be the same as the retention members 609 used on the first portion or may be the vertebrae described in relation to Figure 3 or may be any suitable retention member. At each end of the SMA wire 632, there is a crimp 622 which forms a mechanical and electrical connection to the wire.

The arrangement shown in Figure 6a and 6b thus incorporates two separately controllable SMA wires; one for each section of the arm 604. The first portion 611 may be considered to form a first (or primary) flexure which may be opened by activating the SMA wire on its surface. The second portion 612 may be considered to form a second (or secondary) flexure which may be opened by activating the SMA wire on its surface. These flexures are operated independently as illustrated in Figures 6c and 6d.

As shown in Figure 6c, the shape change (i.e. bending) of the first portion 611 may be controlled by controlling the contraction of the first SMA wire. In this arrangement, there is no change to the shape of the second portion 612. The shape change of the second portion may be independently controlled by controlling the contraction of the first SMA wire. As shown in Figure 6d, both the primary and secondary flexure may be activated and different amounts of bending may be applied in each portion 611, 612. For example, the shape change of the first portion may be designed to provide the overall desired shape of the device in the open configuration and the shape change of the second portion may be designed to provide a flexible seal to the bladder wall.

Where both primary and secondary flexures are initiated, they may be initiated simultaneously or in any order, e.g. secondary flexure after the primary flexure has taken place (or vice versa). By removing the power in either wire, the wire returns to its original shape and the first and second flexible portions return to their original positions. Such an arrangement may be incorporated in any of the other arrangements described above or below. It will also be appreciated that more than two wires may be located on an arm to increase the amount of control and location of flexing for the arm.

Figure 7 shows an exploded view of an alternative arm 704 which may be incorporated in any of the other arrangements. The arm 704 comprises a first part 738 in which the wire channel 705 is defined and a second part 736 which comprises a plurality of wire retention members 709 and which can be attached to the first part. In this arrangement, each of the wire retention members are

mechanical clips which hold the two parts of the arm together. A pair of bores 734 extends through a first end piece of the first part 738. Adjacent the bores 734, a divider 732 protrudes from a face of the first part 734 which is adjacent the second part 736. The divider 732 physically and electrically separates two crimp locations 702 from each other. In this arrangement, each crimp location 702 is relatively long compared to the end piece and this length may be designed to allow for easy assembly of the crimp. The wire channel 705 extends in an elongate loop from the crimp locations 702 to a sealing edge 730 which is located at the opposed end of the first part 738 to the first end piece. The elongate loop of the wire channel 705 comprises two parallel portions each of which extends substantially along the entire length of the first part 738.

The second part 736 comprises a central rod 740 which is generally equal in length to the wire channel 705. Each of the wire retention members 709 comprises a pair of arms, each of which extends either side of the central rod 740. In use, each arm holds the wire in the respective parallel portion of the channel 705. The arms are also formed with clips 742 which clip around the first part 738. Protrusions 744 on the opposed surface of the first part 738 to the channel 705 engage with the clips 742. In this arrangement, there are six equally spaced wire retention members 709 but it will be appreciated that this is merely an exemplary number and spacing.

The arrangement of Figure 7 provides a two-part arm which may aid speed and ease of assembly. For example, to assemble the arm with the wire, a wire may first be fed through one bore 734 in the end piece of the first part 738. The wire is then placed inside a first portion of the channel 705, looped around into the second half of the channel 705 and out through the second bore 734. Once the wire is in place in the channel, the wire may be crimped at both crimp locations 702. The second part 736 may then be clipped in place to the first part 738 to provide a sealed channel to contain the wire and against which the wire strains to form the open configuration. In this arrangement, the second part 736 may be considered to be on top of the first part 738 and thus the first and second parts may be considered to be lower and upper parts respectively. The arrangement may allow for greater control over the length of the wire and reduce the chance of damaging the wire. The arrangement may also facilitate connection to the

resectoscope by keeping wires out of the way, thus reducing the risk of an electrical short. The arrangement may also decrease the thermal loss from the wires and/or reduce the risk of injury to the patient from accidental contact with heated wires.

5

As shown in Figures 4a to 4d, there is a collar to help retain the device in its closed configuration so that it fits into as small a space as possible during insertion and removal. Figure 8 shows one example of a suitable collar 816 which holds the arms 804 and folded material of the housing 802 together during
10 insertion. As shown in Figure 4b, the collar 816 is slid towards the coude tip 822 once the resectoscope 820 is in location.

Figures 9a and 9b illustrate one arrangement for incorporating the collar within the arms themselves as well as an alternative wire retention member 909.
15 As shown in Figure 9a, the arms are similar to those shown in Figures 1 and 2 and the proximal end of each arm 904 (i.e. the end which is inserted into a patient) comprises a wire guide 914. The wire guide 914 comprises a channel 942 in the form of a loop to retain the looped portion of the wire. A hinge 908 separates the wire guide 914 from the adjacent wire guide member 906. Each arm 904 has a
20 clip 940 which extends from one side of the arm 904 and a retaining protrusion 946 which extends from the opposed side of the arm 904 at a location which is staggered relative to the clip. It will be appreciated that the clips may be incorporated in the other designs of the arms.

As shown in Figure 9b, the clips of each arm are sequentially retained by the retaining protrusion on an adjacent arm by providing a friction force of retention. The clip 940a on a first arm 904a abuts the retaining protrusion 946b on a second arm 904b (which in this arrangement is to the left of the first arm). Similarly, the retaining protrusion 946a on the first arm 904a abuts the clip 940c
30 on a third arm 904c (which in this arrangement is to the right of the first arm). The clips and retaining protrusions could be customised to provide the correct amount of retention force. For example, the clips could be designed to open in a specific order to provide a greater (or lower) retention force and which may allow individual control of the arms in the device.

35

Figure 9a also shows an alternative wire retention member 909. As in the arrangement shown in Figure 5a the wire retention members 909 are located at opposed ends of the wire guide member 906. However, in this arrangement, there is no bore through the wire retention member 909 but the wire is held in place underneath the wire retention member 909. Apertures 907 are provided in the arm on either side of the wire retention member 909 and the wire is passed through a first hole, under the wire retention member and up through the hole on the opposed edge of the wire retention member. Such a design may be easier to injection mould than one with bores.

Figure 10 shows an alternative collar which comprises an elongate clip 1040 which wraps around the plurality of arms 1004 and is held in place by a locking mechanism comprising in this example a pin 1044 which engages in an aperture 1042. The engagement of the pin 1044 in the aperture 1042 is by a friction force of retention and when the force exceeds a retention threshold, the pin 1044 is disengaged from the aperture 1042. The device may then open.

Figures 11a to 11d illustrate different stages which may be used in the manufacturing process and which may increase the ease of manufacture. In this arrangement, the arms 304 correspond to those shown in Figure 3 but it will be appreciated that a similar method could be used for the other types of arms. As shown in Figure 11a, the plurality of arms 304 are in a planar configuration and each arm 304 is attached to one or both adjacent arms 304. The plurality of arms may be printed in this planar configuration. Alternatively, as shown in Figure 11b, the plurality of arms 204 may be printed in octagonal form. As an example, the arms may be printed on an SLS machine in PA nylon. Such a material has good mechanical strength and is able to cope with the large strain and stress that may be experienced. A similarly strong printable material may alternatively be used. Moulding may also be used as an alternative to printing. The arms may be moulded or printed individually or together.

The attachment of the arms to the housing is not trivial due to the complex shape of the device in the open configuration. It may be advantageous to attach the arms when the housing is in its open configuration because this is when the

bonding between the arms and the housing is under its greatest tensile stress. Figures 11c and 11d show a jig 1150 on which the housing may be formed, e.g. by dip moulding, in its open configuration. The housing material is slightly tensioned in the open configuration which creates a relatively high frictional force
5 between the housing material and the jig 1150. This may lead to a difficulty in removing the housing from the jig 1150.

The jig 1150 comprises a base 1152 which holds a plurality of shaped segments 1154 together to define the shape of the housing in the open
10 configuration. Each segment 1154 is curved and tapers towards a tip away from the base. In this arrangement, there are eight segments but a different number may be used. In manufacture, each segment 1154 is placed into the base 1152 to form the jig, the housing is formed on the jig 1150. Each arm may then be attached to the housing. The wires may be attached before the housing and arms
15 are joined. Automating the wiring of the arms is likely to be easier when they are in a planar or other simple arrangement and not in the final 3D arrangement when attached to the housing.

Once the device is assembled, the base 1152 is then removed from the
20 segments 1154 which then fall apart from one another. The segments can then be removed easily from within the housing without shearing or otherwise stressing the housing, the arms and/or the bond between the housing and the arms. It will be appreciated that the use of a plurality of segments held within a base is just one arrangement for creating a collapsing core on which the device can be
25 assembled and other suitable arrangements may be used.

Figures 12a and 12b show alternative designs for the housing 1102, 1202 which may be incorporated in any of the arrangements shown above. In the arrangement shown in Figure 12a, a plurality of the arms 1104 are attached to
30 the housing 1102 as described above. Additionally, the housing 1102 comprises a flange 1122 of material which extends beyond the proximal end of each arm 1104 (i.e. the end of each arm which is inserted in use into a patient). When the device is in the open position as shown in Figure 12a, the flange 1122 of material creates a taut band which in use may better conform to the bladder wall of the
35 patient. This may improve the retention of tumour cells within the housing during

the resection process. Merely as an example, the flange may have a depth (i.e. extent beyond the arm) of 7mm.

The arrangement of Figure 12b is similar to Figure 12a except that the housing 1202 comprises a band 1222 rather than a flange which extends beyond the proximal end of each arm which is attached to the housing 1202. The band 1222 is formed by folding the housing material over the ends of the arms and attaching the fold to a front edge of the housing (e.g. by adhesive). The band 1222 may, merely as an example, be 7mm wide. Accordingly, the housing 1202 may be designed to extend beyond the arms by at least 14mm to allow for the folding and attaching steps. It will be appreciated that other similar extensions to the housing may be used to improve the seal between the housing and the bladder wall.

Those skilled in the art will appreciate that while the foregoing has described what is considered to be the best mode and where appropriate other modes of performing present techniques, the present techniques should not be limited to the specific configurations and methods disclosed in this description of the preferred embodiment. Those skilled in the art will recognise that present techniques have a broad range of applications, and that the embodiments may take a wide range of modifications without departing from any inventive concept as defined in the appended claims.

Claims

1. A surgical device comprising
a housing which is made from a flexible material;
5 a plurality of flexible arms which are attached to the housing and which are configured to move the housing between a closed configuration and an open configuration; and
at least one shape memory alloy (SMA) member attached to each one of the plurality of flexible arms;
10 wherein contraction of the at least one SMA member causes the flexible arm to which the at least one SMA member is attached to flex and move the housing from the closed configuration to the open configuration.
2. The surgical device of claim 1, wherein each arm is made of plastics
15 material.
3. The surgical device of claim 1 or claim 2, wherein each arm comprises at least one hinge.
- 20 4. The surgical device of any one of the preceding claims, wherein each arm comprises a plurality of guide members comprising at least one channel within which the SMA member is located.
5. The surgical device of claim 4, wherein the guide members comprise a
25 retention member which holds the SMA member to the arm.
6. The surgical device of claim 5, wherein the guide member comprises at least one bore for receiving the SMA member.
- 30 7. The surgical device of claim 5 or claim 6, wherein the retention member is centrally located on the guide member.
8. The surgical device of claim 5 or claim 6, comprising a pair of retention
members adjacent opposed ends of each guide member.

9. The surgical device of any one of the preceding claims, wherein at least one of the plurality of flexible arms comprises a first portion and a second portion, wherein the second portion is more flexible than the first portion.

10. The surgical device of claim 9, wherein the second portion comprises at least one loop to attach the at least one SMA member to the second portion.

11. The surgical device of claim 9 or claim 10, wherein the second portion is tapered.

12. The surgical device of any one of claims 9 to 11, comprising a first SMA member attached to the first portion and a second SMA member attached to the second portion wherein contraction of the first SMA member causes the first portion to flex and contraction of the second SMA member causes the second portion to flex.

13. The surgical device of any one of the preceding claims, wherein each arm comprises a first part comprising a channel for locating the SMA member and a second part comprising at least one retention member for holding the SMA member in the channel, wherein the first and second part are attachable to one another.

14. The surgical device of claim 13, further comprising a pair of crimp locations at one end of the channel and a divider for separating the crimp locations.

15. The surgical device of claim 13 or claim 14, wherein the channel is an elongate loop.

16. The surgical device of any one of the preceding claims, further comprising a collar which is adjustable between a first position in which the collar retains the housing in the closed configuration and a second position in which the housing is moveable to the open configuration.

17. The surgical device of claim 16, wherein the collar is configured to slide between the first and second positions.

18. The surgical device of claim 16, wherein the collar is configured to provide a friction force of retention to retain the collar in the first position.

19. The surgical device of claim 18, wherein the collar comprises an elongate clip which in the first position encircles one end of the plurality arms and which comprises a locking mechanism which provides the friction force of retention.

20. The surgical device of claim 18, wherein the collar is formed integrally with the plurality of arms.

21. The surgical device of claim 20, wherein each arm comprises a clip and a retaining protrusion which extends from opposed sides of the arm and wherein in the first position, the clip on each arm engages with the retaining protrusion on the adjacent arm to provide the friction force of retention.

22. The surgical device of any one of the preceding claims, wherein the at least one SMA member is an SMA wire.

23. The surgical device of any one of the preceding claims, wherein the housing is formed from a permeable material.

24. The surgical device of any one of the preceding claims, wherein the housing comprises an extension which acts as a seal when the surgical device is in the open configuration.

25. A resectoscope comprising the surgical device of any one claims 1 to 24.

26. The resectoscope of claim 25 wherein the surgical device is removably mounted to the resectoscope.

27. The resectoscope of claim 25 wherein the surgical device is integrally formed with the resectoscope

28. A method of manufacturing the surgical device of any one claims 1 to 24, the method comprising:

assembling a jig comprising a base and a plurality of shaped segments which when supported in the base have an outer surface matched to the shape of the housing in the open configuration;

forming the plurality of arms;

5 forming the housing on the jig;

attaching the plurality of arms to the housing;

detaching the base from the jig; and

removing the shaped segments from within the housing.

10 29. The method of claim 28, wherein forming the plurality of arms comprises printing or moulding the arms.

30 The method of claim 28 or claim 29, wherein forming the housing comprises dip-moulding the housing.

15

31. The method of any one of claims 28 to 30, wherein forming the plurality of arms comprises attaching the SMA members before attaching the plurality of arms to the housing.

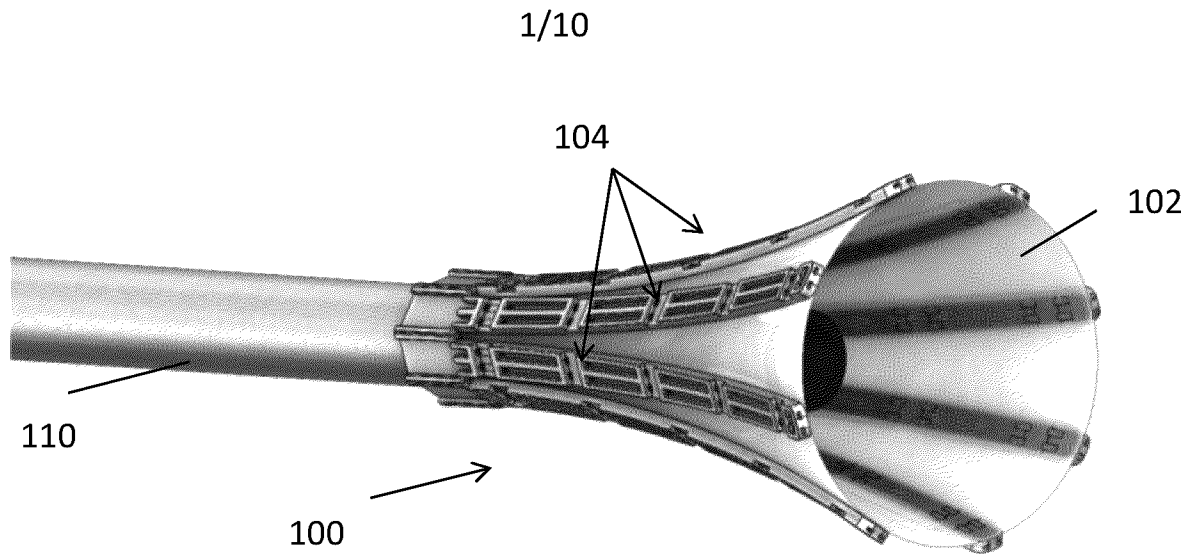


FIG 1

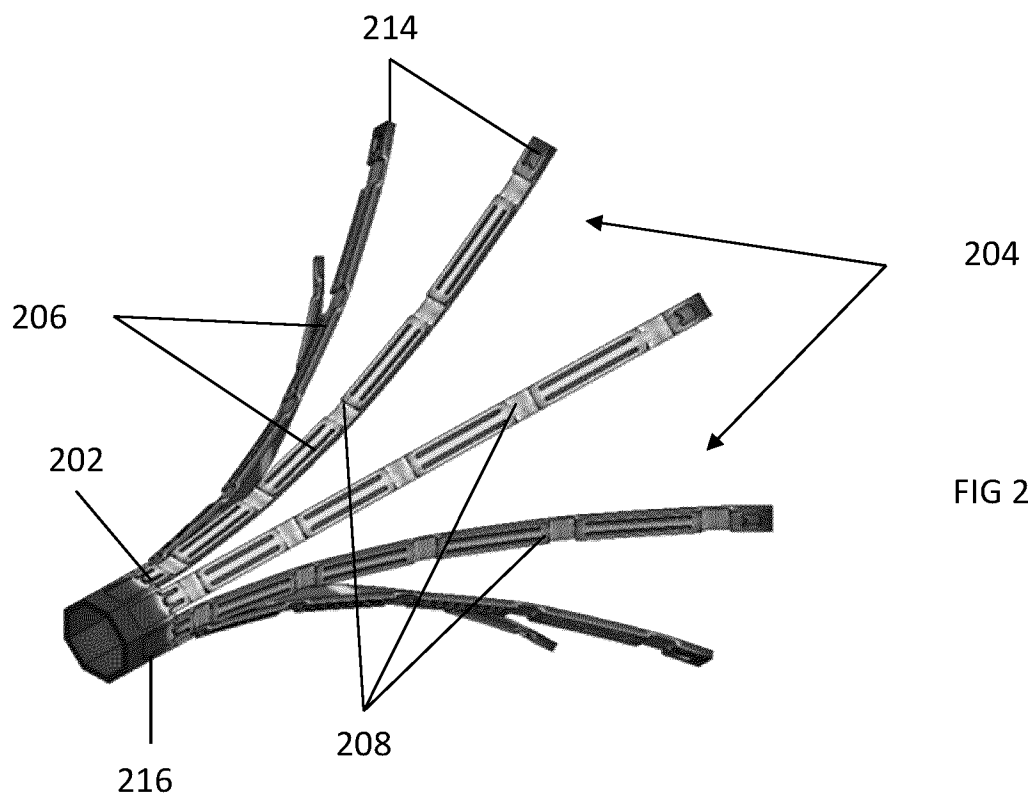


FIG 2

2/10

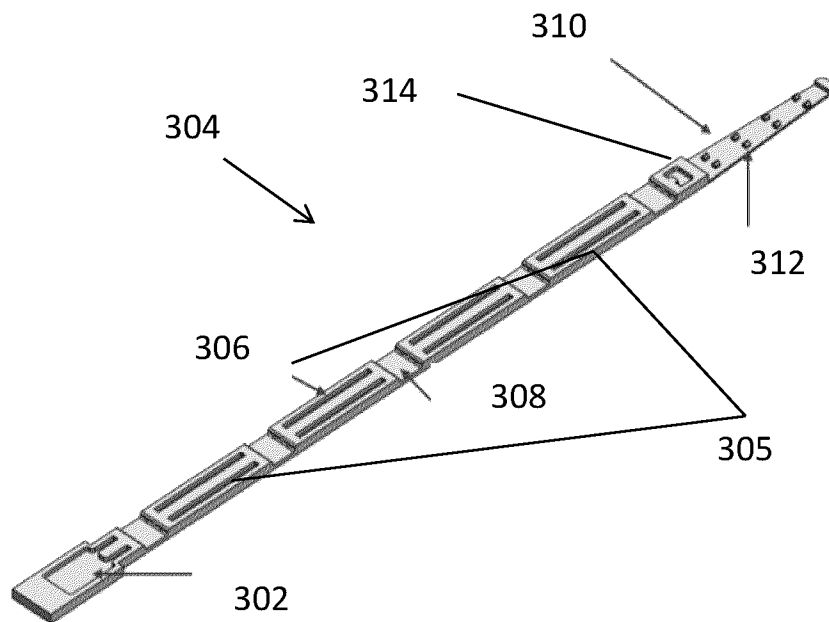


FIG 3

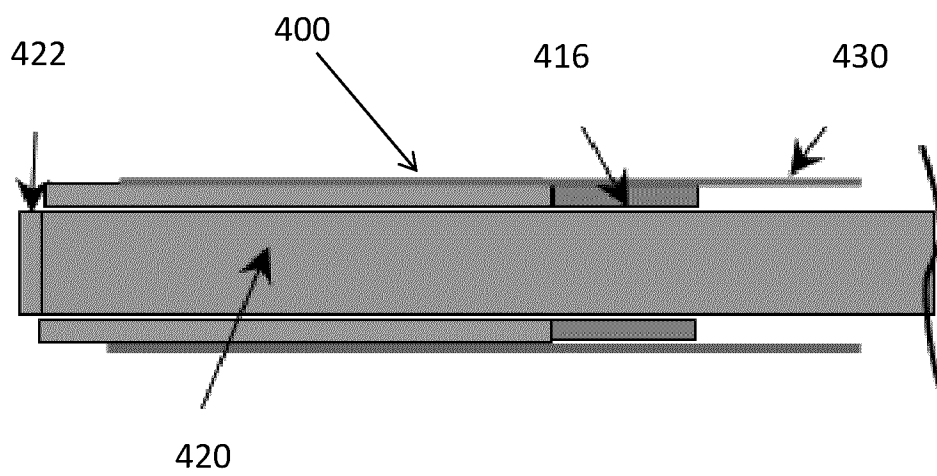


FIG 4a

3/10

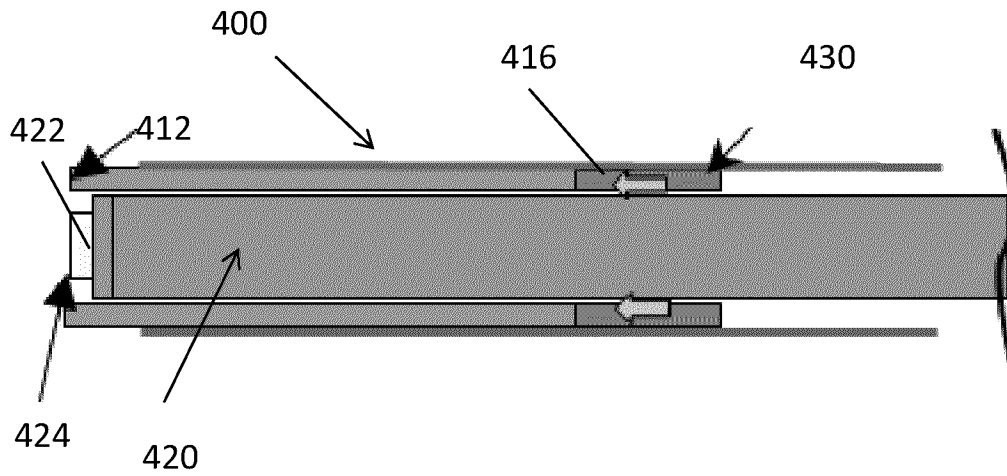


FIG 4b

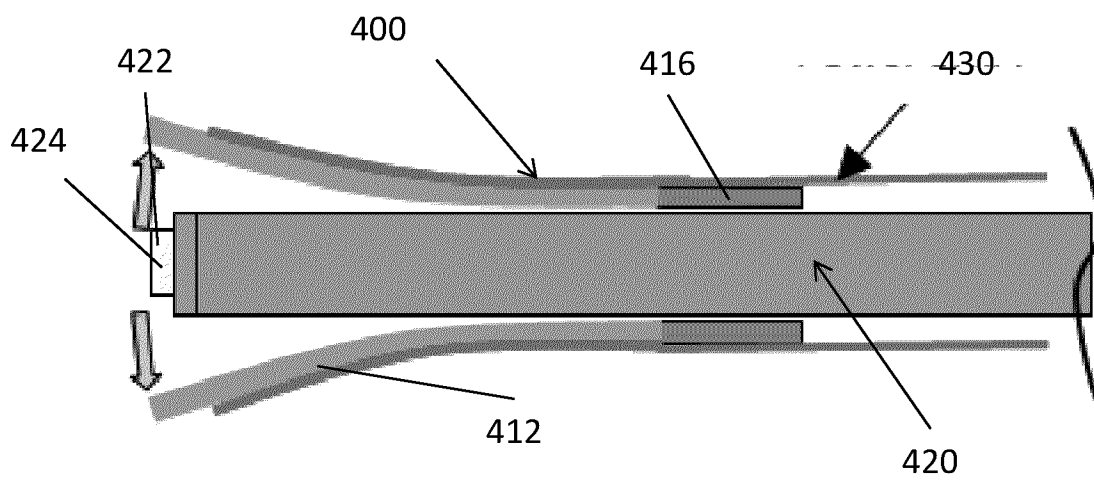


FIG 4c

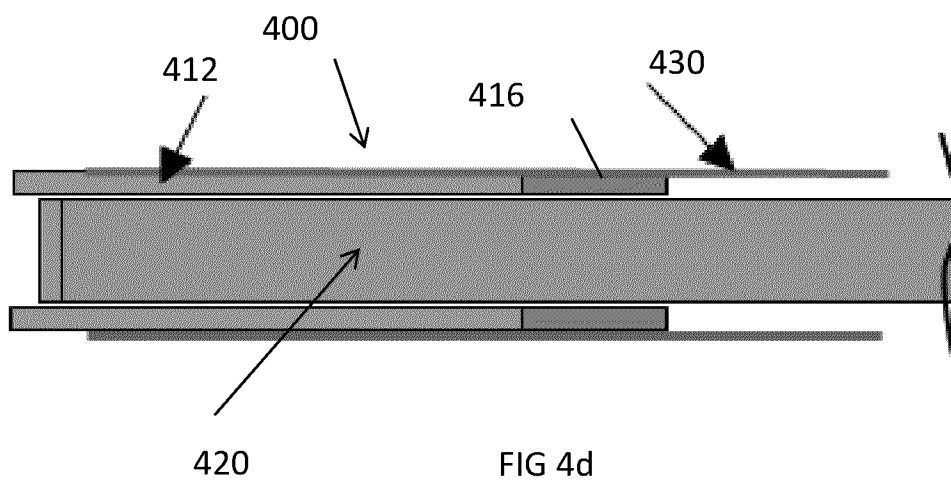


FIG 4d

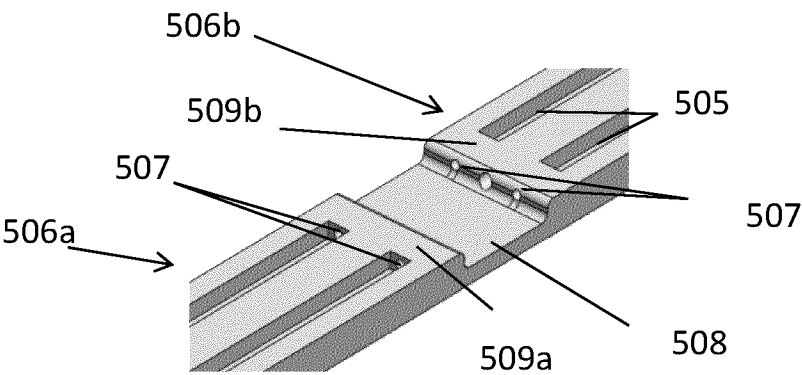


FIG 5a

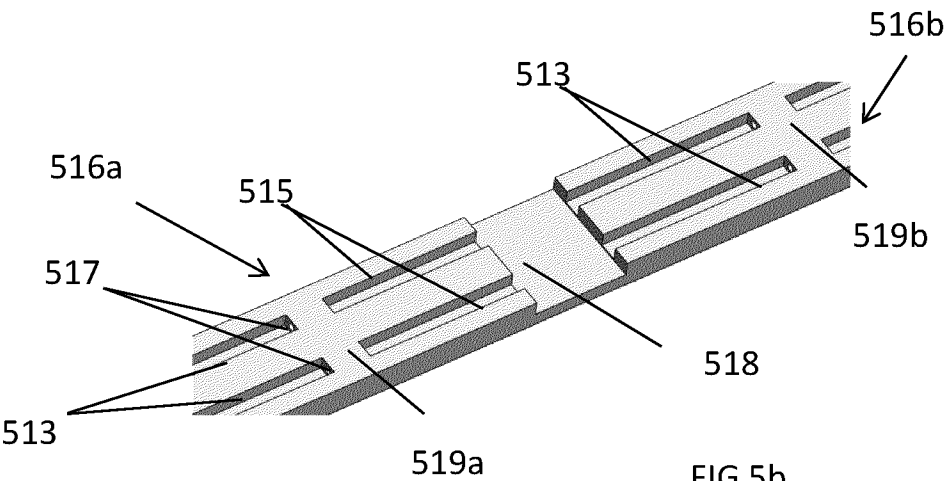


FIG 5b

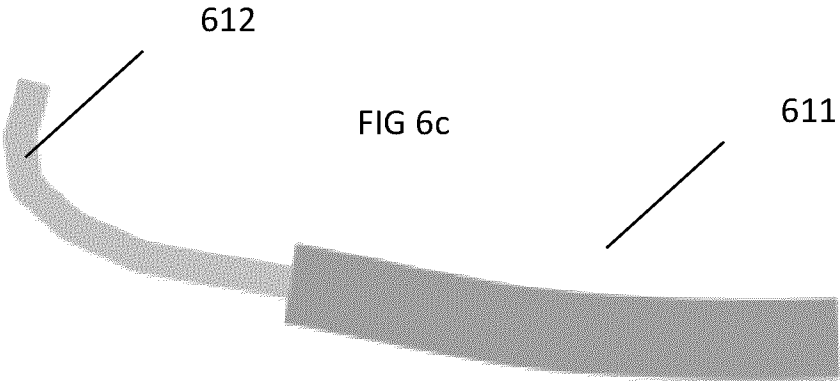
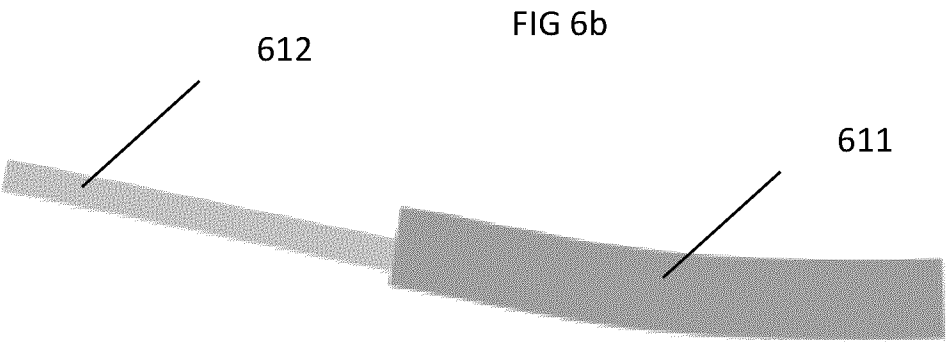
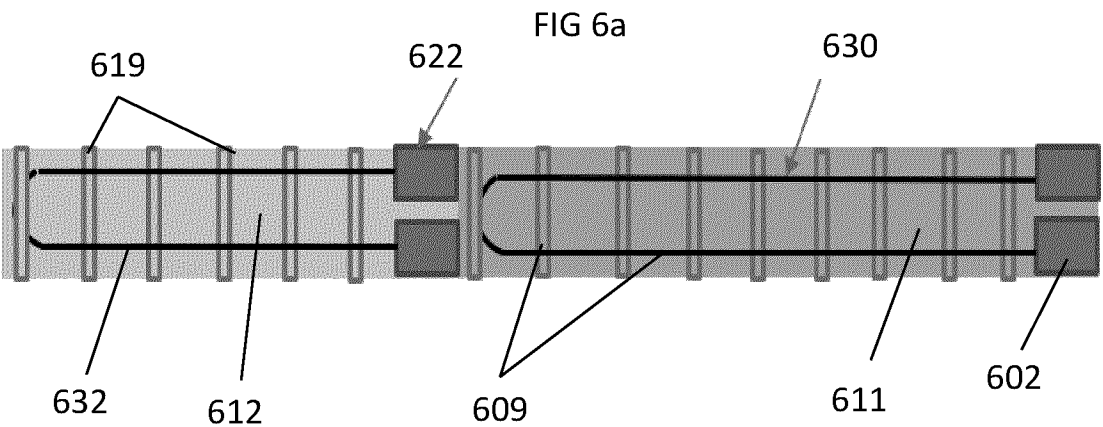
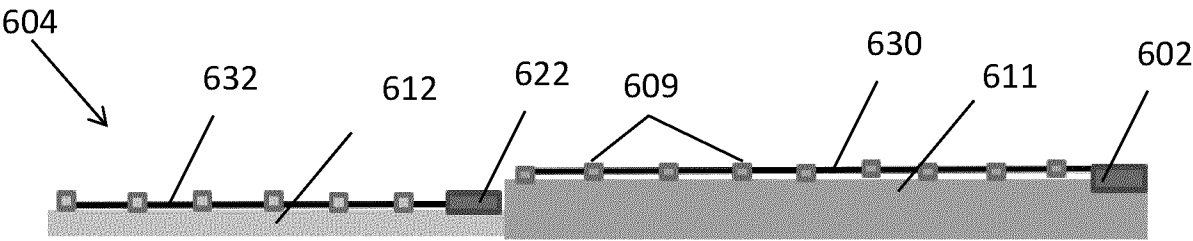
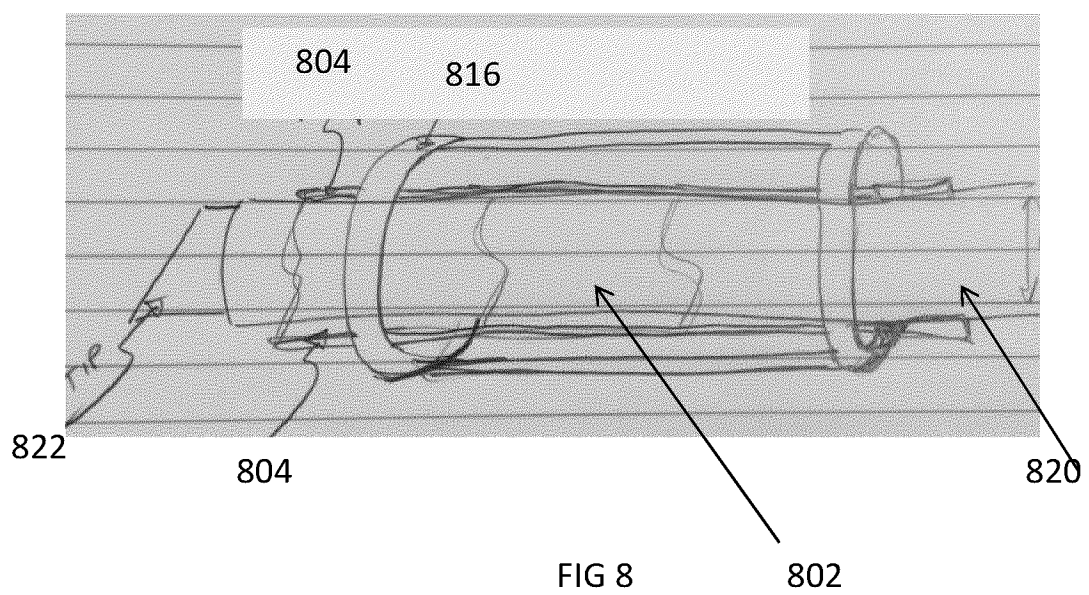
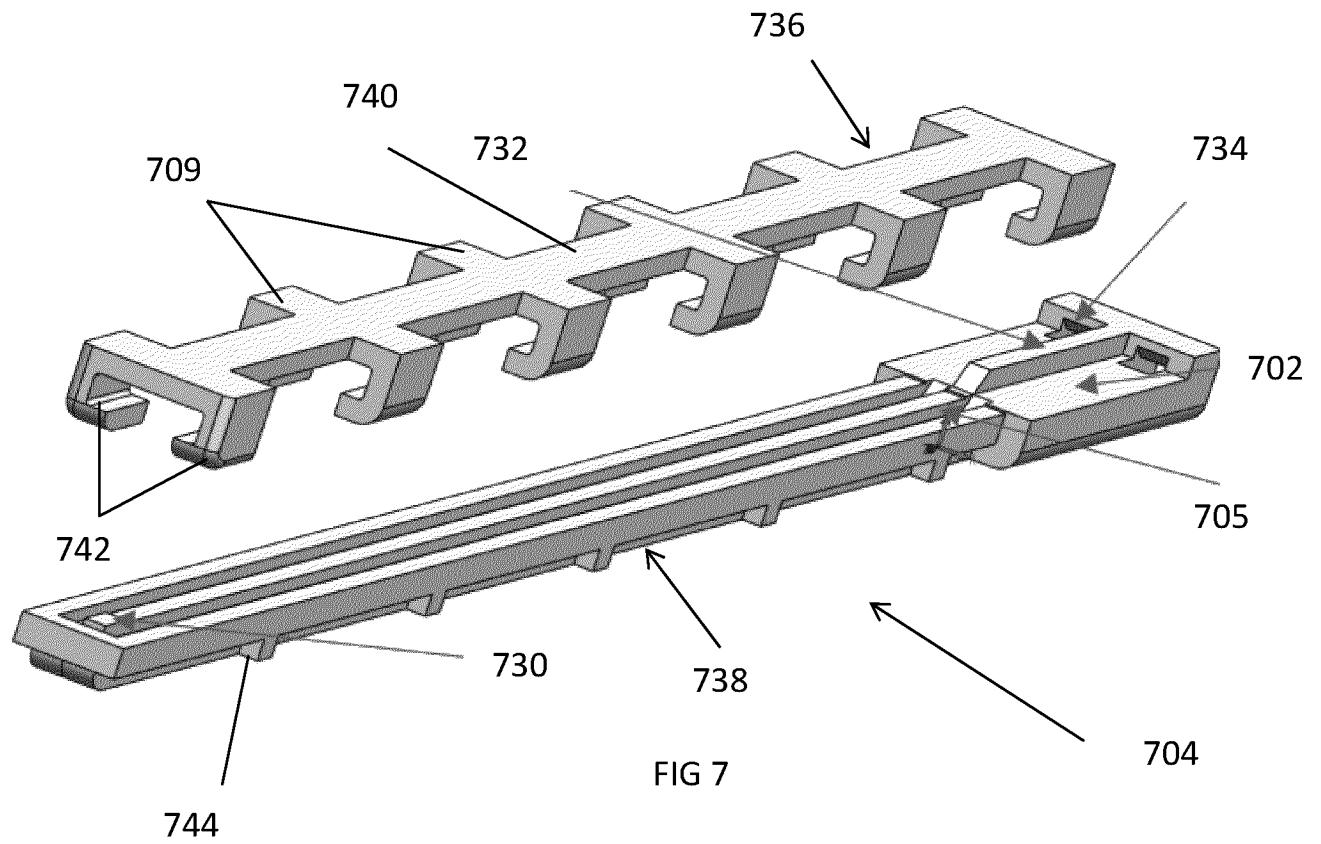


FIG 6d

6/10



7/10

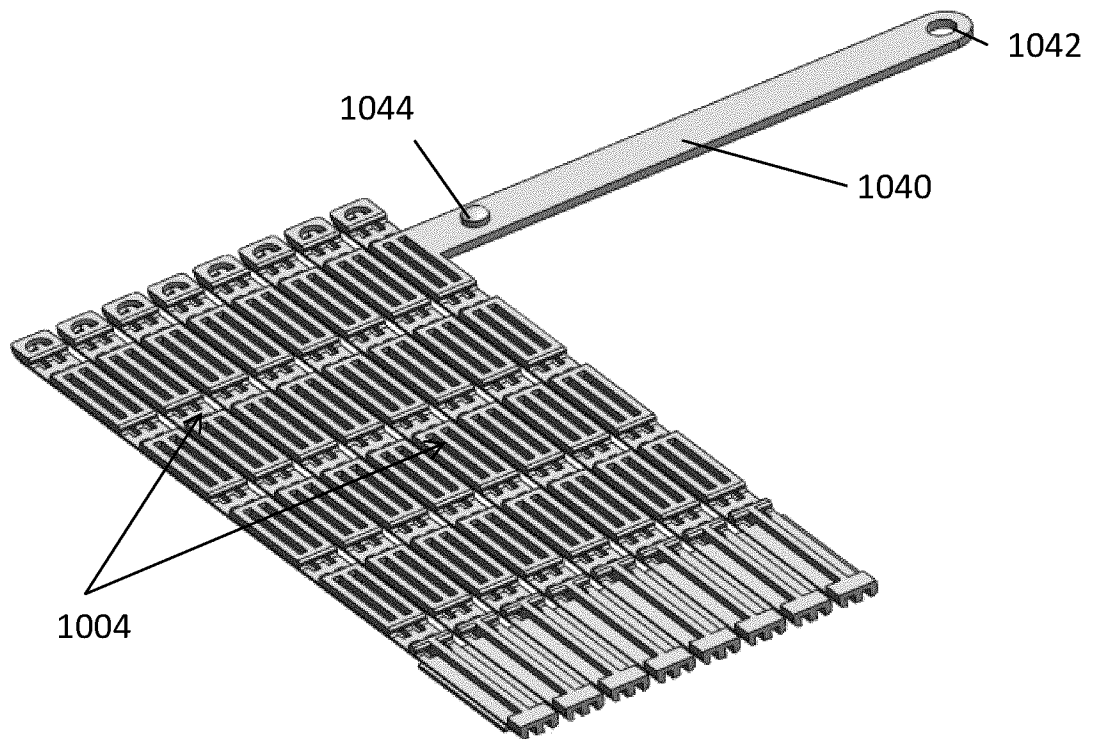
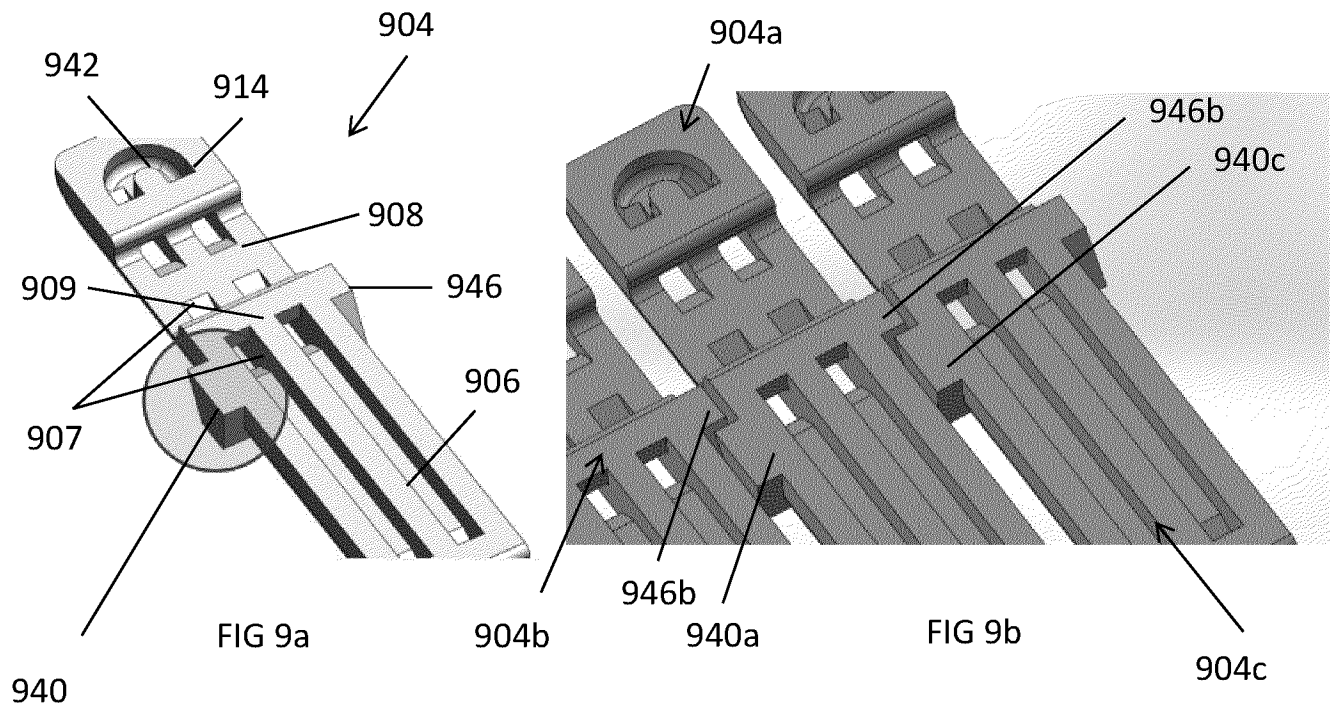


FIG 10

8/10

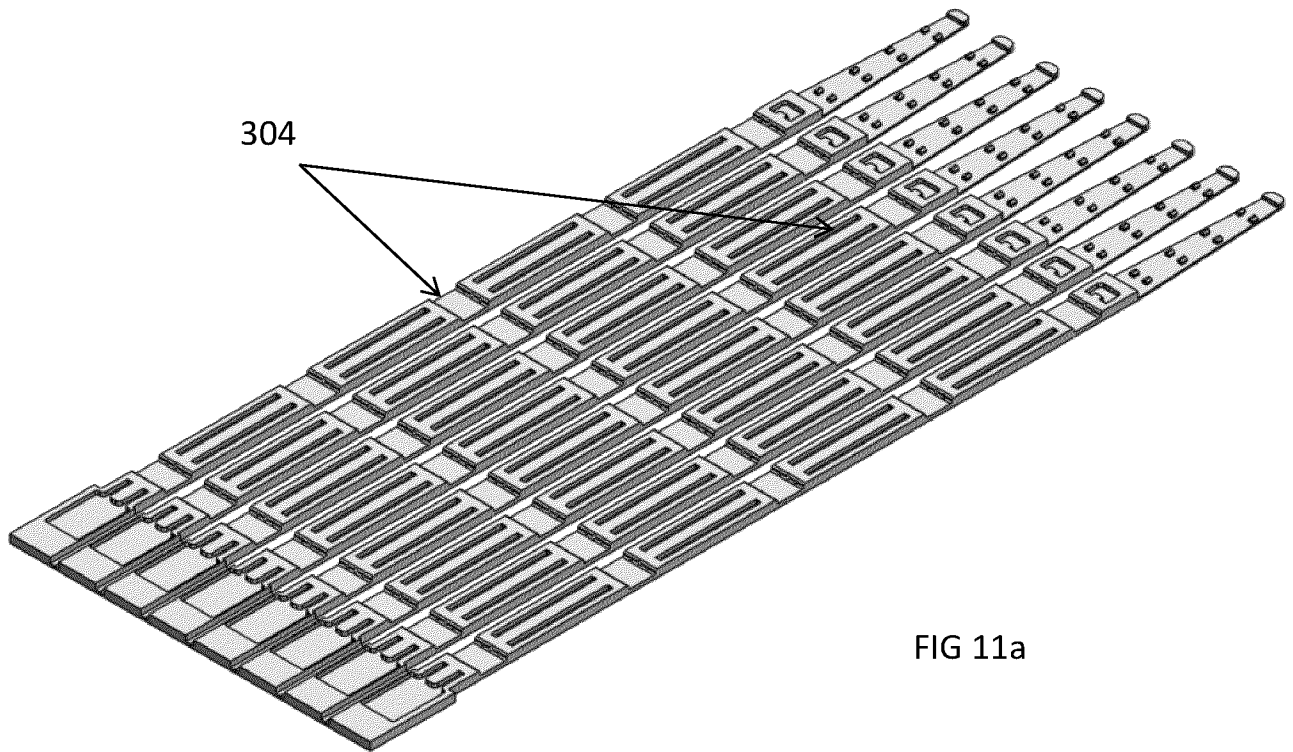


FIG 11a

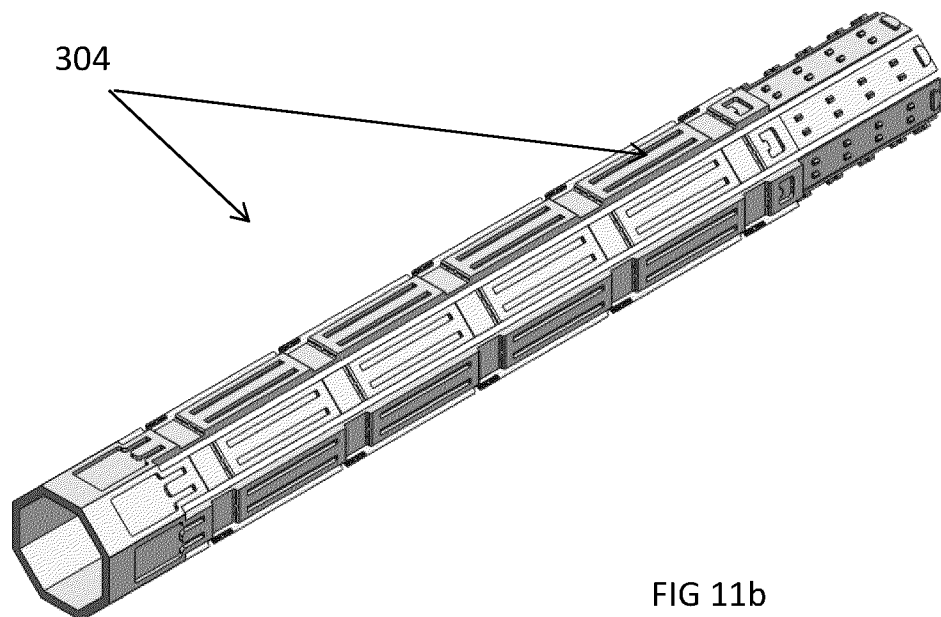
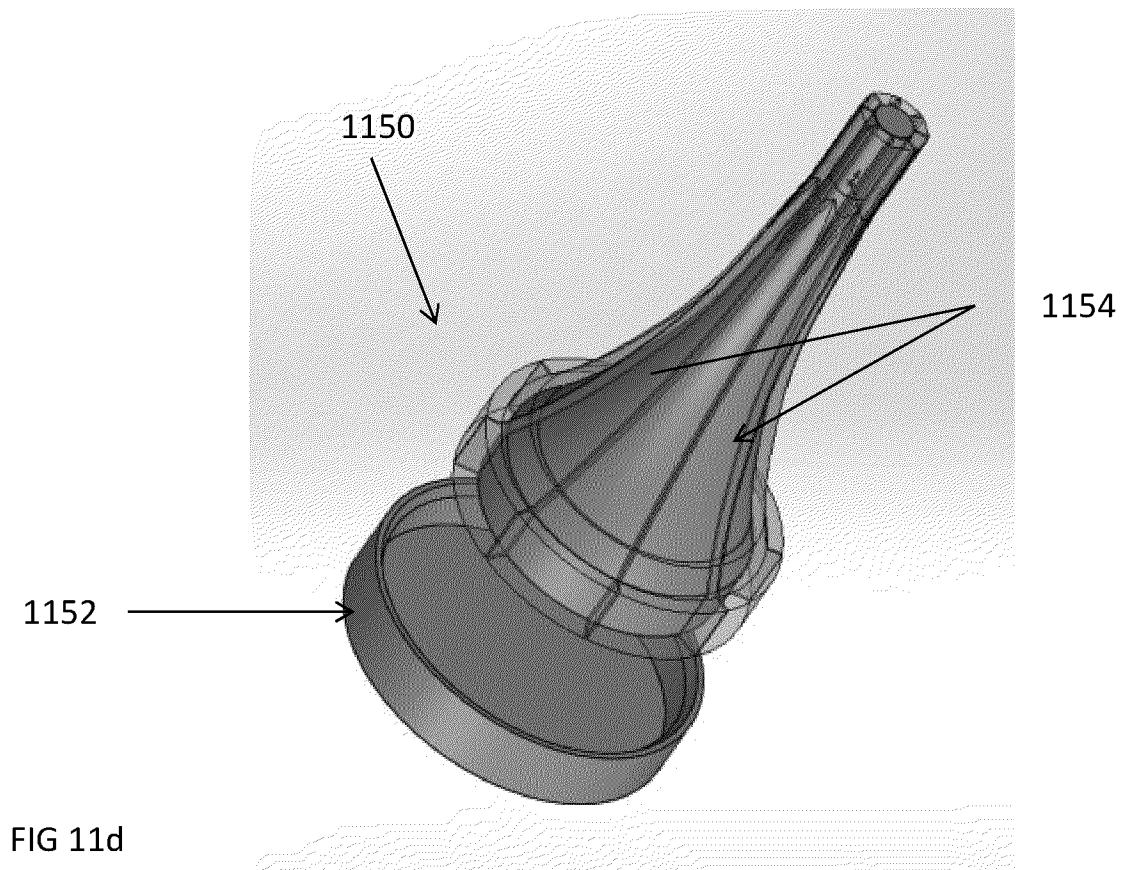
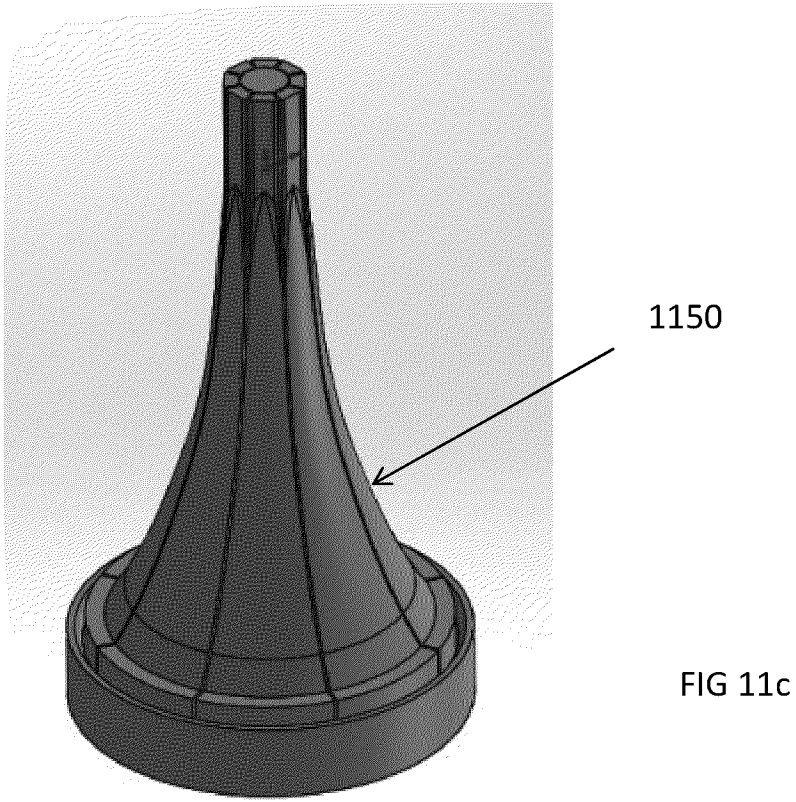


FIG 11b

9/10



10/10

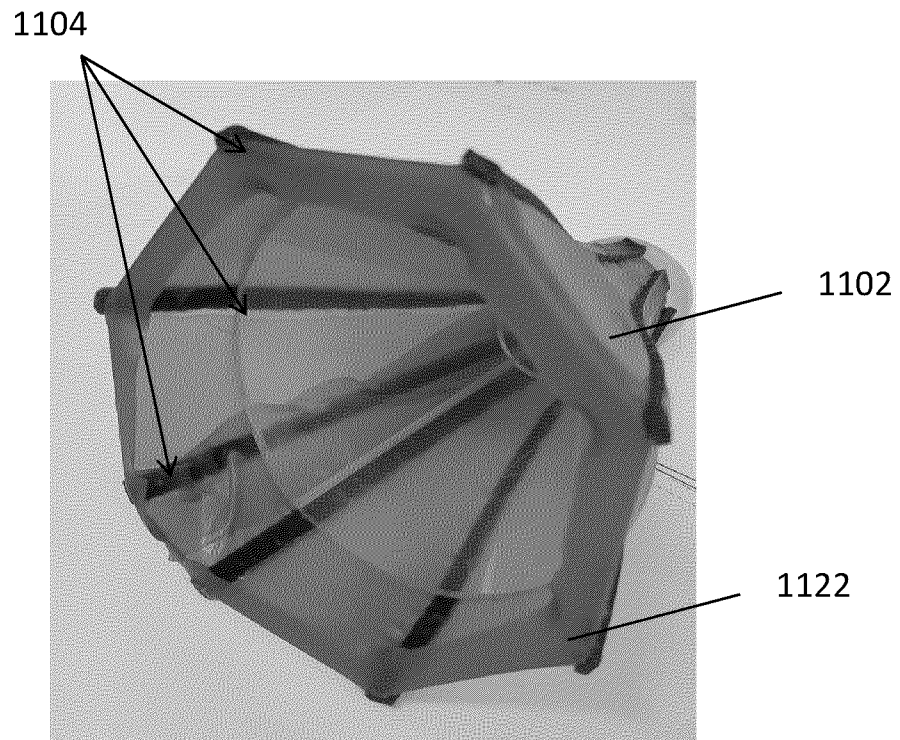


FIG 12a

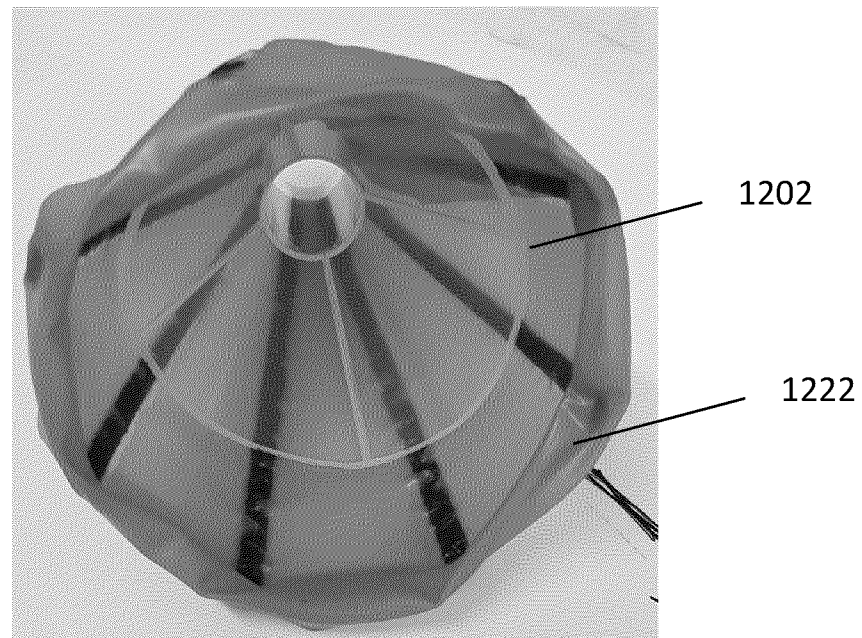


FIG 12b

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/055708

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B17/221 A61B17/00 A61B1/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	SPENCER C BARNES ET AL: "Design of an improved surgical instrument for the removal of bladder tumours", PROCEEDINGS OF THE INSTITUTION OF MECHANICAL ENGINEERS. JOURNAL OF ENGINEERING IN MEDICINE. PART H., vol. 230, no. 6, 12 April 2016 (2016-04-12), pages 579-587, XP055697077, GB ISSN: 0954-4119, DOI: 10.1177/0954411916640580 cited in the application the whole document ----- -/-	1-31



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

19 May 2020

Date of mailing of the international search report

29/05/2020

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Ioanovici, T

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2020/055708

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/087942 A1 (MCGUCKIN JAMES F [US] ET AL) 6 May 2004 (2004-05-06)	1-11, 13-20, 22-24, 28-31
A	abstract paragraphs [0084] - [0110]; figures 1-36 -----	12,21, 25-27
A	WO 00/12011 A1 (HENDLER SHOSHAN [IL]; MAROKO MOSHE [IL]) 9 March 2000 (2000-03-09) abstract page 6, line 3 - page 8, line 20; figures 1-11 -----	1-31
A	US 5 279 548 A (ESSIG MITCHELL N [US] ET AL) 18 January 1994 (1994-01-18) abstract column 2, line 20 - line 26 column 3, line 35 - column 5, line 45; figures 1-3 -----	1-31
A	US 5 871 443 A (EDWARDS STUART D [US] ET AL) 16 February 1999 (1999-02-16) abstract column 8, line 34 - line 58 column 13, line 18 - line 58; figures 15-24 -----	1-31
A	US 3 794 044 A (VENNARD W ET AL) 26 February 1974 (1974-02-26) abstract column 3, line 58 - column 5, line 37; figures 1-10 -----	1-31

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2020/055708

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2004087942	A1	06-05-2004	AU 2002258866 B2 07-12-2006
		CA 2443966 A1	07-11-2002
		EP 1392172 A1	03-03-2004
		ES 2331563 T3	08-01-2010
		JP 4271946 B2	03-06-2009
		JP 2004529708 A	30-09-2004
		US 2001047169 A1	29-11-2001
		US 2004087942 A1	06-05-2004
		US 2006030847 A1	09-02-2006
		WO 02087447 A1	07-11-2002
WO 0012011	A1	09-03-2000	AU 5385199 A 21-03-2000
		IL 125965 A	12-03-2003
		US 6506166 B1	14-01-2003
		WO 0012011 A1	09-03-2000
US 5279548	A	18-01-1994	NONE
US 5871443	A	16-02-1999	US 5309910 A 10-05-1994
		US 5509419 A	23-04-1996
		US 5871443 A	16-02-1999
		US 6052607 A	18-04-2000
		US 6163716 A	19-12-2000
		WO 9407411 A1	14-04-1994
US 3794044	A	26-02-1974	NONE