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(54) Title: DEVICE AND ASSEMBLY TO REPAIR A HEART VALVE

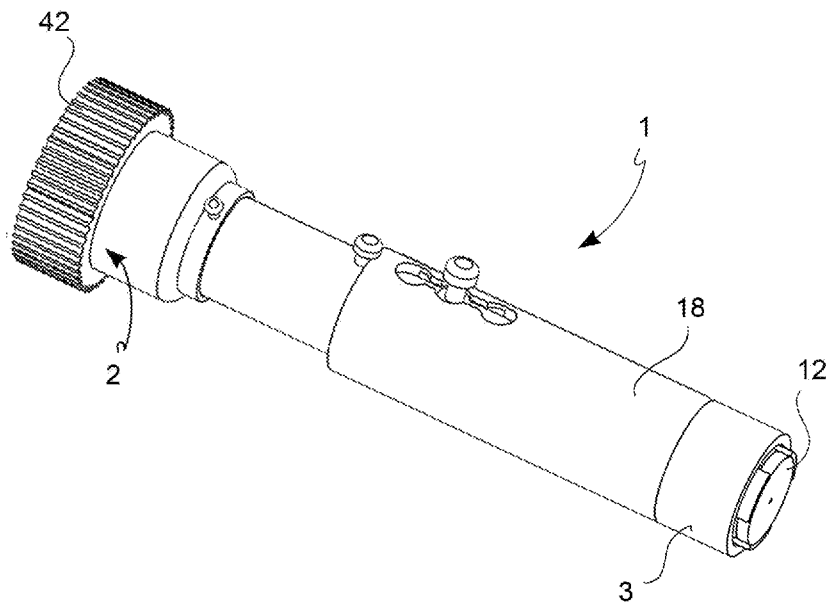


FIG. 4

(57) Abstract: An assembly (1) for reshaping a cardiac ventricle in a patient comprising an implantable device (10) for reshaping a ventricle (10) comprising a tether (16), a non-implantable tool (18, 18') which is detachably connectable to said implantable device (10) and has a proximal portion (2) and a distal portion (3) opposite to said proximal portion (2); the implantable device (10) further comprises an active anchor (12) adapted to be detachably connected to the distal portion (3) of the tool (18, 18'); the active anchor (12) comprises an abutment portion (13) adapted to abut against a structure of the ventricle; the active anchor (12) of the implantable device (10) comprises an adjustment device adapted to adjust the tensional state of the tether (16); the distal portion (3) of the tool (18, 18') comprises an adjustment key (48, 48') adapted to cooperate with the adjustment device of the active anchor (12); the proximal portion (2) of the tool (18, 18') comprises a maneuvering interface (42, 42') which is operatively connectable to said adjustment key (48, 48') for adjusting the tensional state of the tether by acting on the maneuvering interface of the proximal portion (2) of the tool (18, 18').



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“Device and assembly to repair a heart valve”

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DESCRIPTION

[0001]. Field of the invention

[0002]. The present invention relates to the technical domain of heart valve repair systems.

[0003]. In particular, the present invention relates to valve repair according to an approach which includes the relative bringing together of native ventricle structures.

10 [0004]. The present invention relates to an assembly to repair a heart valve.

[0005]. Background art

[0006]. A native atrioventricular heart valve can become damaged and unable to close effectively. A typical type of damage is related to the structural alteration of the ventricle which is dilated; the muscular-fibrous ring forming the passage opening can also be dilated. These alterations cause the inability of the valve leaflets to arrange themselves in the coaptation position and necessarily cause a highly undesirable regurgitation flow from the ventricle towards the atrium which in turn severely limits the effectiveness of the heart pump.

[0007]. Typically, for the repair of an atrioventricular valve, for example the mitral valve, a hoop ring is implanted to reinforce the annulus so as to return the annulus to the original shape thereof, thus allowing the free margin of the leaflets to be brought closer together with the valve closed.

[0008]. Devices which are implantable via trans-catheter have also been proposed in the form of a clip for capturing and bringing the free edge of the valve leaflets closer together, resulting in the formation of a double orifice valve, following the example of the Alfieri suture.

[0009]. A further known approach includes the implantation of devices for bringing the walls of the heart chambers (atria and ventricles) closer together or bringing the papillary muscles forming the anchoring structures of the tendon to the inner side of the ventricle closer together.

[0010]. For example, **US-2017-0086975** shows a solution which includes fixing a tether between two atrial walls near the valve to be repaired. A similar solution is also shown by **US-2005-222488**. **US-2007-203391** shows a tether for bringing the ventricular walls closer together. For example, **US-2019-380699** shows a device which is implantable in the left ventricle via trans-catheter having a pair of rigid plates which are fixed on the outer side of the papillary muscles, i.e., the side facing the ventricular wall, and a thread-like structure, such as a suture filament, extending therebetween.

[0011]. All the solutions of the types described above are intrinsically unsuitable for allowing a precise adjustment of the degree of bringing the ventricular walls together, particularly after

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implantation, and could involve the replacement of the implantable device.

[0012]. **US-2019-0365539** includes the implantation inside the right ventricle of an accordion element coupled to two opposing inner ventricular walls, the device being preloaded with a spring so as to influence the walls to which it is coupled, bringing them together. Although advantageous
5 from some points of view, this solution risks excessively stressing the ventricular walls in the first moments after implantation due to the elastic action exerted by the spring, effectively squeezing the ventricular chamber. Furthermore, the coupling of the device to the inner wall of the heart can fail very early under the elastic action of the spring.

[0013]. The need is therefore felt to provide a solution to repair an atrioventricular valve which is
10 of improved efficacy in both the short and long term.

[0014]. Solution

[0015]. It is an object of the present invention to obviate the previously mentioned drawbacks of the known art.

[0016]. These and other objects are achieved by an assembly according to claim 1.

15 [0017]. Some advantageous embodiments are the subject of the dependent claims.

[0018]. Drawings

[0019]. Further features and advantages of the invention will become apparent from the description provided below of preferred exemplary embodiments thereof, given by way of non-limiting example, with reference to the accompanying drawings, in which:

20 [0020]. - figure 1 diagrammatically shows an implantable device when implanted in a patient, according to an embodiment;

[0021]. - figure 2 diagrammatically shows an assembly comprising a tool and an implantable device when implanted in a patient, according to an embodiment;

25 [0022]. - figure 3 shows an axonometric view of an implantable device, according to an embodiment;

[0023]. - figure 4 shows an axonometric view of an assembly comprising a tool and an implantable device, according to an embodiment;

[0024]. - figures 5 A and 5 B diagrammatically show some steps of the implantation of the implantable device, according to a possible operating method;

30 [0025]. - figure 6 diagrammatically shows a possible step of the implantation of the implantable device, according to a possible operating method;

[0026]. - figures 7 A, 7 B and 7 C diagrammatically show some steps of the implantation of the implantable device subsequent to the steps shown in figures 5-A and 5-B or in figure 6, according to a possible operating method;

35 [0027]. - figure 8 is an isometric view with separated parts of an anchoring element of an

implantable device, according to an embodiment;

[0028]. - figures 9 A - 9 F diagrammatically and sectionally show an adjustment sequence which is achievable by the anchoring element in figure 8;

5 [0029]. - figure 10 A shows an axonometric view with separated parts of an anchoring element, according to an embodiment;

[0030]. - figure 10 B shows an axonometric view of the anchoring element in figure 10 A during a possible adjustment sequence;

[0031]. - figure 11 shows an axonometric view and with assembled parts of the anchoring element in figure 10 A locked on the tether;

10 [0032]. - figures 12 A and 12 B diagrammatically show an adjustment sequence, according to an embodiment;

[0033]. - figures 13 A, 13 B, 13 C and 13 D diagrammatically show an adjustment sequence, according to an embodiment;

[0034]. - figure 14 shows an axonometric view of an assembly, according to an embodiment;

15 [0035]. - figure 15 shows an axonometric view and with separated parts of a portion of an assembly, according to an embodiment;

[0036]. - figure 16 shows an axonometric and sectional view of a portion of an assembly, according to an embodiment;

20 [0037]. - figure 17 shows an axonometric and sectional view of a portion of an assembly, according to an embodiment;

[0038]. - figure 18 shows an axonometric view of a portion of an assembly, according to an embodiment;

[0039]. - figure 19 shows an axonometric and sectional view of a portion of an assembly, according to an embodiment;

25 [0040]. - figures 20 A, B and C show some configurations of an adjustment device in vertical elevation;

[0041]. - figures 21 A - 21 E show some steps of an adjustment sequence.

[0042]. Detailed description of some embodiments

30 [0043]. In accordance with a general embodiment, an implantable device 10 is included for reshaping a ventricle 11, 21 in a patient. The implantable device 10 comprises at least one tether 16 and an active anchor 12 or first anchor 12. Preferably, the implantable device 10 is designed to reshape the right ventricle 11 of a patient's heart 5 for the treatment of the tricuspid valve 15.

35 [0044]. The active anchor 12 comprises an abutment portion 13 adapted to abut against a structure of the ventricle 11, 21. Preferably, the terminology "ventricle structure" means a wall of the heart which delimits or is located inside the ventricle, such as an outer wall 4 of the patient's

heart 5 delimiting the ventricular chamber or a papillary muscle 6 or an interventricular septum 7 of the heart 5. For example, the structure of the ventricle 11 is an outer wall 4 of the patient's heart 5 delimiting the ventricular chamber 11 so that the abutment portion 13 of the active anchor 12 of the implantable device 10 is adapted to abut against the outer wall 4 of the heart 5.

5 **[0045]**. In accordance with an embodiment, when in the conditions of implantable device 10 implanted in the patient's heart 5, the active anchor 12 forms a crossing gate of the outer wall 4 of the heart 5, the abutment portion 13 of the active anchor 12 is outside the right ventricle 11 and abuts against the outer wall 4 of the heart 5, the tether 16 crosses the right ventricle 11 to connect to a second structure of the right ventricle 11, for example a wall of the interventricular septum 7
10 or a wall of a papillary muscle 6 of the right ventricle 11.

[0046]. Those skilled in the art will appreciate that the implantable device 10 can also be implanted in a left ventricle 21 to reshape the left ventricle 21 for the treatment of the mitral valve.

[0047]. In accordance with a preferred embodiment, the implantable device 10 comprises a second further anchor 22, opposite to the active anchor 12 with respect to the body of the tether
15 16. Preferably, the tether 16 is fixed to said second further anchor 22. In accordance with an embodiment, the second anchor 22 also comprises a second abutment portion 23 adapted to abut against a second structure of the ventricle 11, opposite to the first structure of the ventricle 11 where the active anchor 12 abuts, so that the active anchor 12 and the second anchor 22 have
20 respective abutment portions 13, 23 opposite to each other and so that the tether 16 can exert a traction action between the two anchors 12, 22, consequently causing the reshaping of the ventricle 11, 21. In accordance with an embodiment, the second anchor 22 comprises a portion, for example a hook, for coupling to a second ventricle structure. For example, the abutment portion 23 of the second anchor 22 is intended to abut against a wall facing the left ventricle 21 of the interventricular septum 7 so that the second anchor 22 is in the left ventricle 21, the first anchor
25 12 is on the wall 4 of the heart 5 and the tether 16 extends from said first anchor 12 to said second anchor 22. In accordance with an embodiment, the second anchor 22 is different from the first anchor 12. The second further anchor 22 is preferably a passive anchor, and preferably does not comprise any device for adjusting the tensional state of the tether 16.

[0048]. Advantageously, the active anchor 12 of the implantable device 10 comprises an
30 adjustment device adapted to adjust the tensional state of the tether 16. The adjustment of the tensional state of the tether 16 is preferably obtained by varying the useful length of the tether 16, i.e., the working length of the tether 16 between the two anchors 12, 22. Adjusting the tensional state of the tether 16 can lead to a change in the useful length of the tether. Adjusting the tensional state of the tether 16 allows to adjust the traction force between the two anchors 12, 22. Adjusting
35 the tensional state of the tether 16 allows to adjust the relative position of the two anchors 12, 22.

[0049]. The tether 16 can comprise an elastic element, to provide an elastic influence action aimed at bringing the two anchors 12, 22 closer together or aimed at distancing the two anchors 12, 22 away from each other.

[0050]. The tether 16 can comprise at least one section made of shape-memory material.

5 [0051]. At least one anchor 12 or 22 of said two anchors 12, 22 can comprise at least one portion made of shape-memory material.

[0052]. In accordance with a general embodiment, an assembly 1 is included for reshaping a ventricle in a patient comprising at least one implantable device 10 according to any of the previously described embodiments.

10 [0053]. The assembly 1 further comprises a tool 18, which is non-implantable and detachably connectable to said implantable device 10. The tool 18 comprises a proximal portion 2 and a distal portion 3 opposite to said proximal portion 2. A longitudinal axis is defined between said proximal portion 2 and said distal portion 3 of the tool 18.

[0054]. The active anchor 12 of the implantable device 10 is adapted to detachably connect to the
15 distal portion 3 of the tool 18.

[0055]. Advantageously, the distal portion 3 of the tool 18 comprises an adjustment key 48 adapted to cooperate with the adjustment device of the active anchor 12. By operating the adjustment key 48, it is possible to adjust the tensional state of the tether 16 by means of the operation of the adjustment device. The adjustment key 48 can have a distal head 35 with polygonal geometry
20 adapted to engage a proximal portion of the active anchor 12 to perform the adjustment of the tensional state of the tether 16.

[0056]. With further advantage, the proximal portion 2 of the tool 18 comprises a maneuvering interface 42 which is operatively connectable to said adjustment key 48 for adjusting the tensional state of the tether by acting on the maneuvering interface of the proximal portion 2 of the tool 18.
25 Preferably, the maneuvering interface 42 is intended to remain outside the patient's body during the adjustment of the tensional state of the tether 16 while the distal portion 3 of the tool 18 is connected to the active anchor 12 inside the patient's body. The active anchor 12 can be placed on the outer wall 4 of the heart 5, preventing the tool 18 from having to penetrate inside the patient's heart 5 to adjust the tensional state of the tether 16.

30 [0057]. In accordance with a preferred embodiment, the tool 18 also acts as a delivery tool at least for the active anchor 12 of the implantable device 10. In other words, the same tool 18 has the dual function of delivering the active anchor 12 in the implantation site and allowing the adjustment of the tensional state of the tether 16 of the implantable device 10 by activating the adjustment device of the active anchor 12 from outside the heart 5. As shown for example in **figure 7-B**, the
35 active anchor 12 can be delivered on the outer wall 4 of the heart 5 by the tool 18, for example

mounted on the distal end 3 of the tool 18.

[0058]. In accordance with an embodiment, the tool 18 also acts as a delivery tool for the tether 16.

5 [0059]. The inclusion of such a tool 18 allows to adjust the tensional state of the tether 16 both during the implantation of the implantable device 10 and, if necessary, in a step subsequent to the implantation, while avoiding having to access inside the patient's heart 5.

[0060]. In accordance with an embodiment, the assembly 1 further comprises a delivery catheter 46 for delivering at least one portion of the implantable device 10. As shown for example in **figures 5-A and 5-B**, the delivery catheter 46 is intended to deliver the second further anchor 22 to the
10 respective implantation site, for example the wall facing the right ventricle 21 of the atrial septum 7, crossing the interventricular septum 7.

[0061]. In accordance with an embodiment, the assembly 1 further comprises a vascular catheter 45 for delivering at least one portion of the implantable device 10. As shown for example in **figure 6**, the vascular catheter 45 is intended to deliver the second further anchor 22 to the respective
15 implantation site, for example the wall facing the right ventricle 21 of the atrial septum 7 crossing the patient's vascular system.

[0062]. As shown for example in **figure 7-A**, after the second anchor 22 has been delivered to the respective implantation site, the tether 16 can be extended through the ventricle 11.

[0063]. As shown for example in **figures 7-B and 7-C**, the active anchor 12 is then delivered by
20 means of the tool 18 and the tensional state of the tether 16 can be adjusted before the detachment of the active anchor 12 from the tool 18.

[0064]. The tensional state of the tether 16 can be adjusted in various manners.

[0065]. In accordance with a preferred embodiment, the adjustment device of the active anchor 12 of the implantable device 10 comprises two portions 28, 29 rotatably associated with each other.
25 Thereby, by relatively rotating said two portions 28, 29 of the active anchor 12 with each other, it is possible to adjust the tensional state of the tether 16.

[0066]. In accordance with a preferred embodiment, the tool 18 further comprises a shaft 49 fitted onto said adjustment key 48, so that the adjustment key 48 and the shaft 49 are rotatably associated with each other. Preferably, the adjustment key 48 of the tool 18 is integrally
30 connectable to a first portion 28 of the adjustment device of the active anchor 12, and the shaft 49 of the tool 18 is integrally connectable to a second portion 29 of the adjustment device of the active anchor 12. Thereby, it is possible to adjust the tension of the tether by means of rotation impressed on the adjustment key 48, and preferably on the maneuvering interface 42.

[0067]. The inclusion of such a tool 18 allows to adjust the tensional state of the tether 16 by
35 rotating the maneuvering interface 42 both during the implantation of the implantable device 10

and, if necessary, in a step subsequent to the implantation, while avoiding having to access inside the patient's heart 5.

[0068]. According to an embodiment, one portion 28 or 29 of said two portions 28, 29 of the adjustment device of the active anchor 12 is integrally connectable to the tether 16. Thereby, for example, it is possible to wind the tether 16 around a winding shaft 27 which can be included inside the active anchor 12. In accordance with an embodiment shown for example in **figures 9-A to 9-F**, a proximal section 31 of the tether 16 has an enlarged portion, for example a knot 41, which acts as an end-of-stroke for integrally connecting the tether 16 to a first portion 28 of the adjustment device of the active anchor 12, so that a relative rotation of the two portions 28, 29 of the adjustment device causes the winding of a proximal portion of the tether 16 around a winding shaft 27. By virtue of the inclusion of such a winding shaft 27 it is possible to obtain a winch system for adjusting the tensional state of the tether. The winding shaft 27 can be provided in a single piece or integral with the first portion 28. The first portion 28 preferably comprises a termination site 17, for example a through hole of a comparable gauge to that of the tether 16, which is integrally connectable to a portion of the tether 16. The second portion 29 can comprise a central channel 26 which receives the tether 16. Preferably, the central channel 26 of the second portion 29 and the termination site 17 of the first portion 28 are offset from each other, i.e., they are not in axis, to cause the winding of the tether 16 around the winding shaft 27.

[0069]. As shown for example in **figures 9-A and 9-B**, the tether 16 is secured to the termination portion 17 of the anchoring element 12 by forming a knot 41 in the proximal section 31 of the tether 16. As shown for example in **figures 9-C and 9-D**, by opposing the action of the spring 30, the two portions 28, 29 of the anchoring element 12 are released so that they can rotate with respect to each other, causing the proximal portion 31 of the tether 16 to be wound, which consequently tensions the tether 16. As shown for example in **figures 9-E and 9-F**, the action of the spring 30 interlocks the two portions 28, 29 of the anchoring element 12 with each other in a predefined mutual configuration. Preferably, the winch adjustment system comprises one or more radial teeth 32 extending from a first portion 28 to be received in an annular groove 33 of a second portion 29 of the anchoring element 12, when the action of the spring 30 is opposed. When the action of the spring 30 is not opposed, said one or more radial teeth 32 abut against a circumferential abutment 34 which prevents the portions 28, 29 from rotating with respect to each other.

[0070]. As shown for example in **figure 8**, a preload spring 30 can be included between the two portions 28, 29 of the anchoring element 12. Preferably, the spring 30 mutually distances the two portions 28, 29 of the anchoring element 12, interlocking them in a mutual configuration. By opposing the action of the spring 30, it is possible to unlock the configuration and rotate one

portion 28 or 29 of the two portions 28, 29 with respect to the other 29 or 28, causing the tether 16 to be wound around the winding shaft 27. The winch adjustment system formed by said two portions 28, 29 of the anchoring element 12 can comprise a ratchet mechanism adapted to allow the relative rotation of the two portions 28, 29 in a single rotation direction.

5 **[0071]**. The maneuvering interface 42 can comprise a ratchet mechanism adapted to allow the rotation of the maneuvering key 48 with respect to the shaft 49 in a single rotation direction.

[0072]. In accordance with an embodiment, said two portions 28, 29 are rotatably associated with each other by means of threaded coupling. As shown for example in figures **10-A, 10-B and 11**, a portion 29 comprises a passage channel 26 adapted to receive with clearance the tether 16 arranged on a male threaded element 37 so that the tether can slide with respect to the portion 29, and in which the other portion 28 comprises a tightening nut 36 which, when screwed onto the male threaded element 37, causes a narrowing of the gauge of the passage channel 26, stopping the sliding of the tether 16 with respect to the male threaded element 37 of the portion 29 by friction.

15 **[0073]**. In accordance with a preferred embodiment, the active anchor 12 of the implantable device 10 comprises an anchor back 19 opposite to said abutment portion 13, in which the distal portion 3 of the tool 18 is detachably connectable to said anchor back 19. When in operating conditions, the anchor back 19 is adapted to remain outside the ventricle 11. Thereby, the active anchor 12 forms a sort of adjustment gate for the tensional state of the tether 16 having the anchor back 19 placed on the outer wall 4 of the heart 5 so that it can be reached by the access device 18 even after the implantation of the implantable device 10, to adjust the tensional state of the tether 16 post-implantation without requiring an access inside the heart 5.

20 **[0074]**. In accordance with a preferred embodiment, the tool 18 further comprises an outer case 51 slidably associated with said shaft 49 so that the distal portion 3 of the tool 18 can protrude at various distances distally from the outer case 51. When in operating conditions, once the outer case 51 of the access device 18 has been positioned so that the distal end thereof is near the outer wall 4 of the heart 5, it is possible to advance the shaft 49 and the adjustment key 48 in the distal direction so that they can engage the active anchor 12, to adjust the tensional state of the tether 16.

30 **[0075]**. In accordance with a preferred embodiment, the tool 18 comprises said maneuvering key 48 rotatable inside said longitudinally hollow shaft 49 and adapted to engage a first portion 28 of the active anchor, the tool 18 comprising at the distal end of said shaft 49 one or more fingers 52 which extend distally like a crenellation in order to engage, for example in a snap-fit manner, the second portion 29 of the active anchor 12. Preferably, the set of the maneuvering key 48 and shaft 49 are capable of moving forward and backward with respect to the case 51. An

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advancement control 53 can be included in order to cause the relative moving forward and/or backward of the case 51 with respect to the set of the maneuvering key 48 and the shaft 49, formed for example by a longitudinal slot 54 placed on the case 51 which defines a plurality of seats 54-a, 54-b, 54-c adapted to receive a radial pin 55 extending the shaft 51 so as to lock the set of the maneuvering key 48 and shaft 49 in a mutual position with respect to the case of the access device 18. Said seats 54-a, 54-b, 54-c are preferably aligned in the longitudinal direction of the tool 18. An end-of-stroke pin 56 can be included which is integral with the shaft 49, forming a proximal abutment for the case 51.

[0076]. The inclusion of such a pin 55 and such a slot 54 allows to mechanically visualize the relative position in which the set of the maneuvering key 48 and shaft 49 with respect to the case 51 is located.

[0077]. As shown for example in **figures 20-B and 20-C**, by distally advancing the maneuvering key 48 and the shaft 49 with respect to the case 51, the pin 55 is moved from the seat 54-b to the seat 54-c.

[0078]. In accordance with an embodiment, the tool 18 comprises a tether guiding device 57 adapted to guide a proximal portion 31 of the tether 16. For example, the tether guiding device 57 comprises a perforated plate 58 arranged on the case 51, in which the hole 59 of the perforated plate 58 of the tether guiding device 57 receives a proximal portion of the tether 16. By virtue of the inclusion of said tether guiding device 57, it is possible to temporarily lock a proximal section 31 of tether 16 having a predetermined length in order to obtain said knot 41 or said enlarged portion 41 on the proximal section 31 of the tether 16. Furthermore, by virtue of the inclusion of said tether guiding device 57 it is possible to preassemble the active anchor 12 to the distal end 3 of the tool 18, in other words, by virtue of the inclusion of said tether guiding device 57, it is possible to provide an assembly 1 having the active anchor 12 of the implantable device 10 preassembled on the tool 18, avoiding assembling the active anchor 12 on the tool 18 during the operation. For example, as shown in **figure 21-A**, the proximal portion 31 of the tether 16 passes through the active anchor 12, the tool 18 in a proximal direction and exits from the hole 59. As shown in **figure 21-B**, by activating the command 47, the diameter of the hole 59 is reduced, locking the proximal portion 31 of the tether 16 in the hole 59 by friction. As shown in **figures 21-C and 21-D** a knot 41 or an enlarged portion is made on the proximal portion 31 of the tether 16 and the section of the tether 16 proximal to the knot 41 is cut. As shown in **figure 21-E**, the command 47 is deactivated and the section of the hole 59 passes through the tether 16 and the knot 41, so that by distally advancing the knot 41 it abuts the termination portion 17 of the active anchor 12. The inclusion of such a tether guiding device 57 also allows the tether 16 to be kept close to the case 51.

[0079]. In accordance with an embodiment, the adjustment device of the active anchor 12 of the implantable device 10 comprises an expandable element 38, for example an inflatable balloon. By expanding the expandable balloon 38, the termination portion 17 to which the tether 16 is secured is distanced from the abutment portion 13 of the active anchor 12. The abutment portion 13 of the active anchor 12 can be included on the expandable element 38. The expandable element 38 is integrally connectable to the termination portion 17 in a portion thereof. In this case, in order to adjust the tensional state of the tether 16 it is necessary to inflate the expandable element 38, and the inflation of the expandable element 38 can be achieved by using a percutaneous port 18' having a fluid communication duct with the expandable element 38, to expand it, in which the fluid communication duct 48' therefore acts as an adjustment key 48', the percutaneous port 18' being provided with an inflation tank 39 having a maneuvering interface 42', for example a deformable pouch when pressed. By applying pressure to the deformable pouch, which acts as a maneuvering interface 42', the inflation fluid moves from the inflation tank 39 to the expandable element 38 which thereby distancing the tether termination portion 17 from the abutment portion 13 of the active anchor 12 allows to tension the tether 16.

[0080]. In accordance with a preferred embodiment, the active anchor 12 comprises two portions 28, 29 slidingly coupled so that a relative distancing of the two portions allows to adjust the tensional state of the tether 16, acting as an adjustment device. In accordance with a preferred embodiment, the two mutually slidingly coupled portions of the anchoring element 12 can be interlocked with each other, acting as a locking device. The sliding coupling between the two portions 28, 29 can be included in addition to or in place of the rotatable coupling between the two portions 28, 29.

[0081]. According to an embodiment, as shown for example in the **figures 13-A to 13-D**, the adjustment of the tensional state of the tether 16 can occur by means of a cardiac catheter 45' with vascular access which delivers a forceps 60, for example an elastic clip 60, inside the ventricle 11 in order to adjust the tensional state of the tether 16. Thereby the adjustment of the tensional state of the tether 16 can occur either by acting on the active anchor 12 by means of the tool 18 or by means of a trans-catheter action performed with a cardiac catheter 45'. Preferably, the cardiac catheter 45' comprises at the distal end thereof an elastic clip 60, preferably detachably connected to the cardiac catheter 45, so as to deliver it inside the ventricle 11 in order to adjust the tensional state of the tether 16.

[0082]. The adjustment of the tensional state of the tether 16 carried out by means of a trans-catheter approach can be included in place of the adjustment of the tensional state of the tether 16 obtained by means of the active anchor 12.

[0083]. According to a general embodiment, an assembly 1 for reshaping a ventricle in a patient

comprises an implantable device 10 for reshaping a ventricle comprising a tether 16, and a cardiac catheter 45' for adjusting the tensional state of the tether 16. The cardiac catheter 45' is preferably a vascular access catheter adapted to reach the ventricle 11, 21, for example the right ventricle 11, of the patient's heart 5 with a distal portion thereof. The cardiac catheter 45' preferably comprises at the distal end thereof forceps 60 or a clip 60 for adjusting the tensional state of the tether 16 of the implantable device 10, as shown for example in **figures 13-A to 13-D**. The implantable device 10 preferably comprises two opposite anchors at opposite ends of the tether 16. For example, the implantable device 10 is adapted to reshape a ventricle to repair a heart valve, for example to repair the tricuspid valve 15.

10 **[0084]**. By virtue of the features described above provided separately or jointly with each other in particular embodiments, it is possible to obtain a device as well as an assembly which at the same time satisfies the above described requirements, contrasting each other, and the aforementioned desired advantages, and in particular:

15 **[0085]**. - it allows to adjust the tensional state of the tether of an implantable device for reshaping a ventricle, in order to repair a heart valve;

[0086]. - the adjustment can occur with a trans-thoracic tool;

[0087]. - it allows to adjust the tension of the tether by maneuvering a maneuvering interface placed outside the patient's body, at the proximal end of the trans-thoracic tool;

20 **[0088]**. - the trans-thoracic tool can also act as a device for delivering the active anchor of the implantable device;

[0089]. - it allows to adjust the tensional state of the tether after implantation, without requiring direct access to the ventricle;

[0090]. - the active anchor forms an adjustment gate for the tether placed on the outer wall of the heart;

25 **[0091]**. - the active anchor acts as a device for adjusting the tensional state of the tether;

[0092]. - it allows to repair a heart valve by approximating, i.e., by bringing closer together, the structures of the ventricle such as the ventricular walls, the interventricular septum, the papillary muscles, a combination of the above.

30 **[0093]**. Those skilled in the art may make many changes and adaptations to the embodiments described above or may replace elements with others, which are functionally equivalent, in order to meet contingent needs without however departing from the scope of the appended claims.

LIST OF REFERENCE NUMERALS

1	Assembly
2	Proximal portion of the tool
3	Distal portion of the tool
4	Outer wall of the heart
5	Heart
6	Papillary muscle
7	Interventricular septum
10	Implantable device
11	Right ventricle
12	Active anchor or first anchor
13	Abutment portion
15	Tricuspid valve
16	Tether
17	Termination portion
18, 18'	Tool
19	Anchor back
21	Left ventricle
22	Second anchor
23	Second abutment portion
26	Channel
27	Winding shaft
28	First portion of the active anchor
29	Second portion of the active anchor
30	Spring
31	Proximal section of the tether
32	Radial teeth
33	Annular groove
34	Circumferential abutment
35	Distal head of the adjustment key
36	Nut
37	Male threaded element
38	Expandable element
39	Inflation tank

41	Knot, or enlarged portion, of the tether
42, 42'	Adjustment key maneuvering interface
45, 45'	Vascular catheter
46	Delivery catheter
48, 48'	Adjustment key
49	Tool shaft
51	Tool case
52	Distal fingers of the shaft
53	Advancement command
54	Slot
54 a-c	Seats
55	Radial pin
56	End-of-stroke
57	Tether guiding device
58	Perforated plate
59	Hole
60	Forceps or clip

CLAIMS

1. An assembly (1) for reshaping a cardiac ventricle in a patient comprising:
- an implantable device (10) for reshaping a cardiac ventricle comprising a tether (16);
 - a non-implantable tool (18, 18') which is detachably connectable to said implantable device (10)
- 5 and has a proximal portion (2) and a distal portion (3) opposite to said proximal portion (2);
wherein:
- the implantable device (10) further comprises an active anchor (12) adapted to be detachably connected to the distal portion (3) of the tool (18, 18'), and a second anchor (22) opposite to said active anchor (12) with respect to said tether (16).
- 10 - the active anchor (12) comprising an abutment portion (13) adapted to abut against a structure of the cardiac ventricle;
- the active anchor (12) of the implantable device (10) comprises an adjustment device adapted to adjust the tensional state of the tether (16), the adjustment of the tensional state of the tether (16) is preferably obtained by varying the useful length of the tether (16), i.e., the working length
- 15 of the tether (16) between the two anchors (12, 22);
- the distal portion (3) of the tool (18, 18') comprises an adjustment key (48, 48') adapted to cooperate with the adjustment device of the active anchor (12);
 - the proximal portion (2) of the tool (18, 18') comprises a maneuvering interface (42, 42') which is
- 20 operatively connectable to said adjustment key (48, 48') for adjusting the tensional state of the tether by acting on the maneuvering interface of the proximal portion (2) of the tool (18, 18').
2. The assembly (1) according to claim 1, wherein the tool (18, 18') also acts as a delivery tool of the active anchor (12) of the implantable device (10).
3. The assembly (1) according to claim 1 or 2, wherein the tool (18, 18') is a trans-thoracic tool.
4. The assembly (1) according to any one of the preceding claims, wherein a proximal section
- 25 (31) of the tether (16) comprises an enlarged part, for example a knot (41), to stop the adjustment of the tensional state of the tether (16).
5. The assembly (1) according to any one of the preceding claims, wherein the adjustment device of the active anchor (12) of the implantable device (10) comprises two portions (28, 29) rotatably associated with each other.
- 30 6. The assembly (1) according to claim 5, wherein the tool (18, 18') further comprises a shaft (49) fitted onto said adjustment key (48, 48'), so that the adjustment key (48, 48') and the shaft (49) are rotatably associated with each other, and wherein
- the adjustment key (48, 48') is integrally connectable to a first portion (28) of the adjustment device of the active anchor (12), and wherein
- 35 - the shaft (49) is integrally connectable to a second portion (29) of the adjustment device of the

active anchor (12).

7. The assembly (1) according to claim **5** or **6**, wherein a portion (28 or 29) of said two portions (28, 29) of the adjustment device is integrally connectable to the tether (16).

8. The assembly (1) according to claim **5**, **6** or **7**, wherein a portion (28 or 29) of said two portions
5 (28, 29) comprises a winding shaft for winding the tether (16).

9. The assembly (1) according to any one of claims **5** to **8**, wherein said two portions (28, 29) are rotatably associated with each other by means of a threaded coupling.

10. The assembly (1) according to any one of claims **1** to **4**, wherein the adjustment device of the active anchor (12) of the implantable device (10) comprises an expandable element (38), for
10 example an inflatable balloon.

11. The assembly (1) according to any one of the preceding claims, wherein the active anchor (12) of the implantable device (10) comprises an anchor back (19) opposite to said abutment portion (13), wherein the distal portion (3) of the tool (18, 18') is detachably connectable to said anchor back (19); and/or wherein the anchor back (19) is adapted to remain outside the ventricle.

12. The assembly (1) according to any one of the preceding claims, wherein the tool (18, 18')
15 comprises an outer case (51) slidingly associated with said shaft (49) so that the distal portion (3) of the tool (18, 18') can protrude at various distances distally from the outer case (51).

13. The assembly (1) according to any one of the preceding claims, wherein the tool (18, 18')
20 comprises a tether guiding device (57) adapted to guide a proximal section (31) of the tether (16) to allow the pre-assembly of the active anchor (12) of the implantable device (10) on the tool (18, 18').

14. The assembly (1) according to any one of the preceding claims, further comprising a cardiac catheter (45, 45') for the adjustment of the tether (16), wherein the cardiac catheter (45, 45') preferably comprises at the distal end thereof an elastic clip (60) so as to deliver it inside the
25 cardiac ventricle in order to adjust the tensional state of the tether (16).

15. The assembly (1) according to any one of the preceding claims, comprising a vascular catheter for the delivery of at least one portion of the implantable device (10).

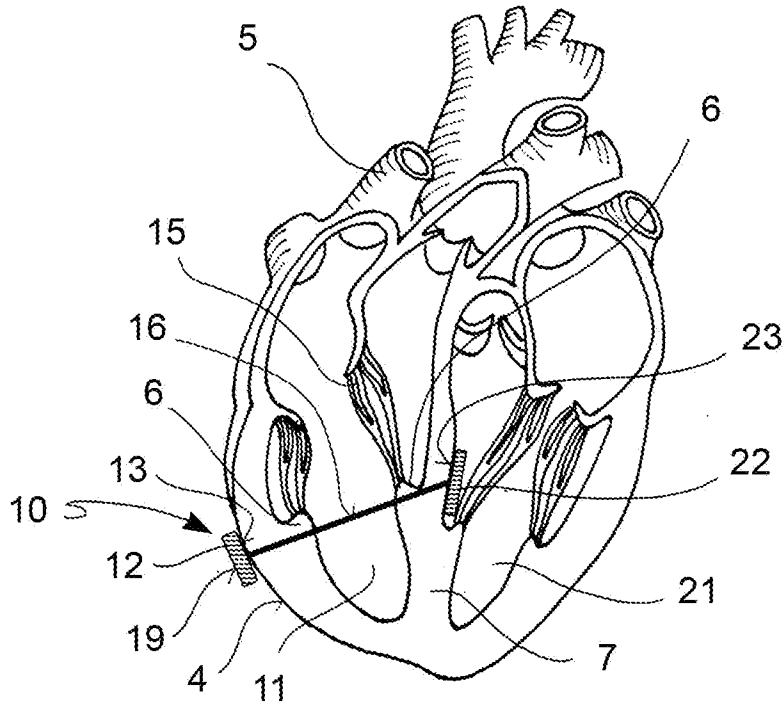


FIG. 1

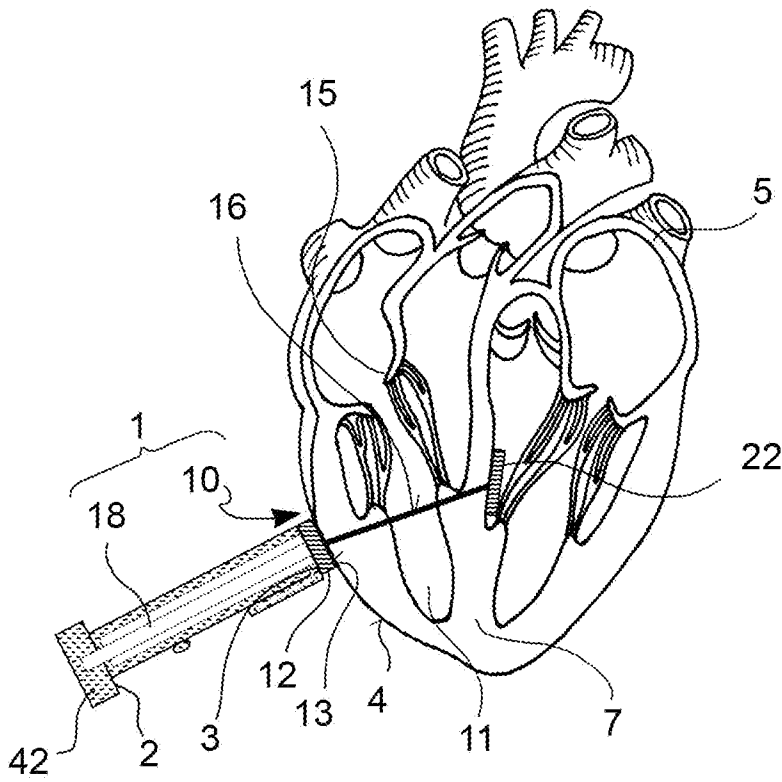


FIG. 2

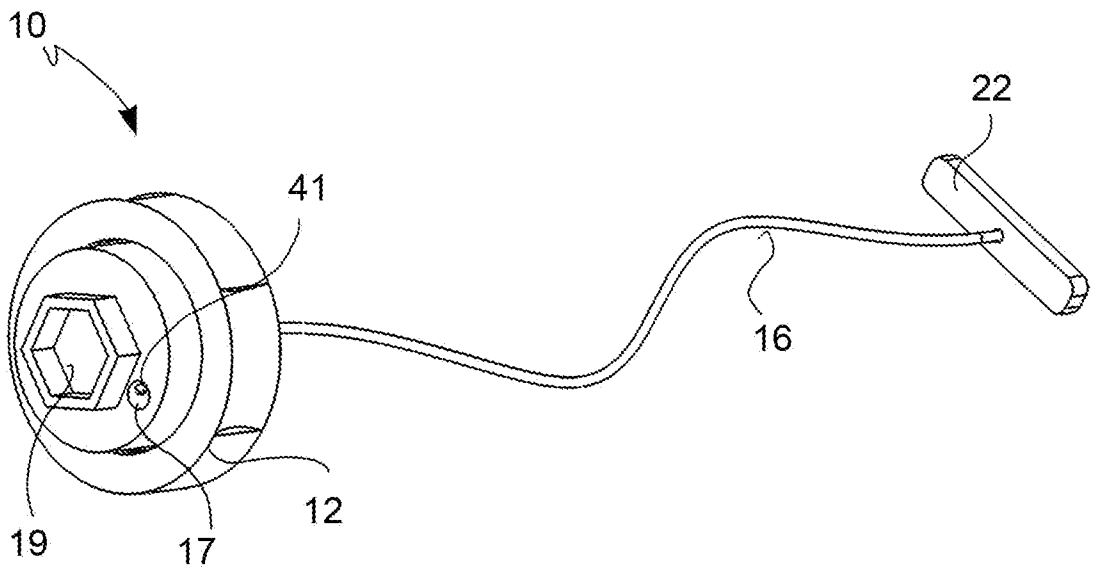


FIG. 3

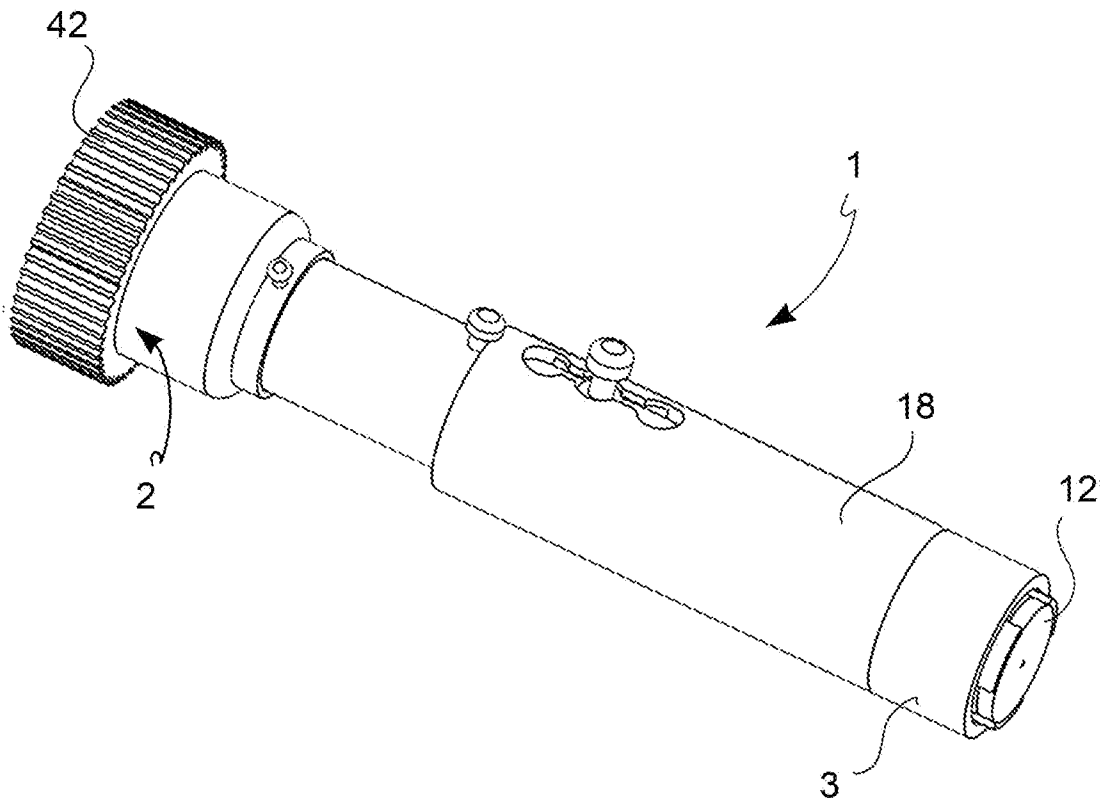


FIG. 4

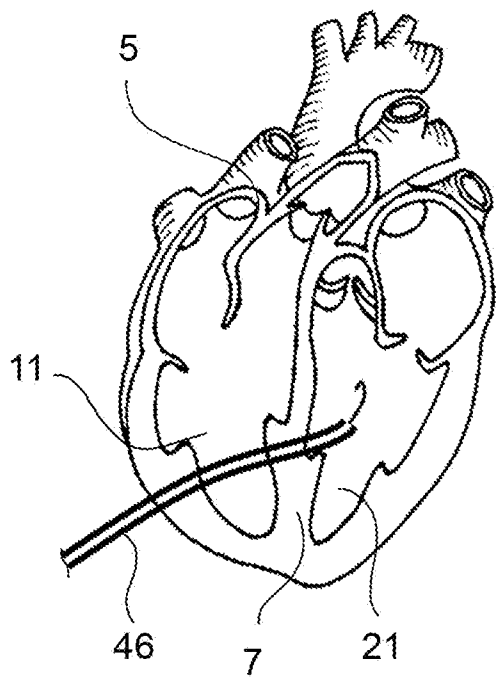


FIG. 5A

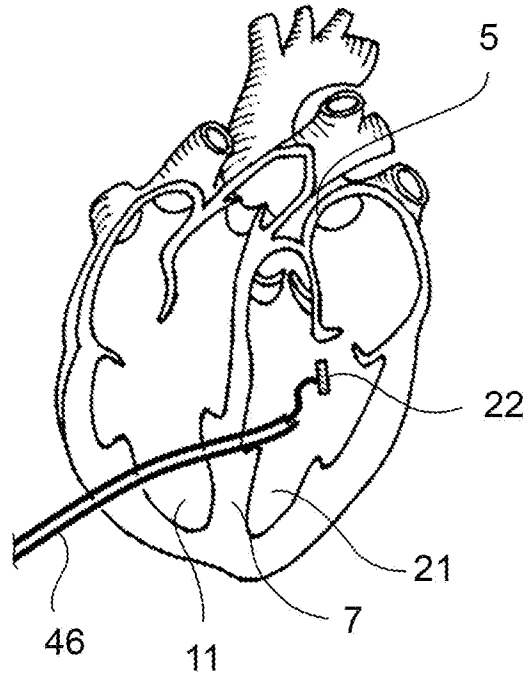


FIG. 5B

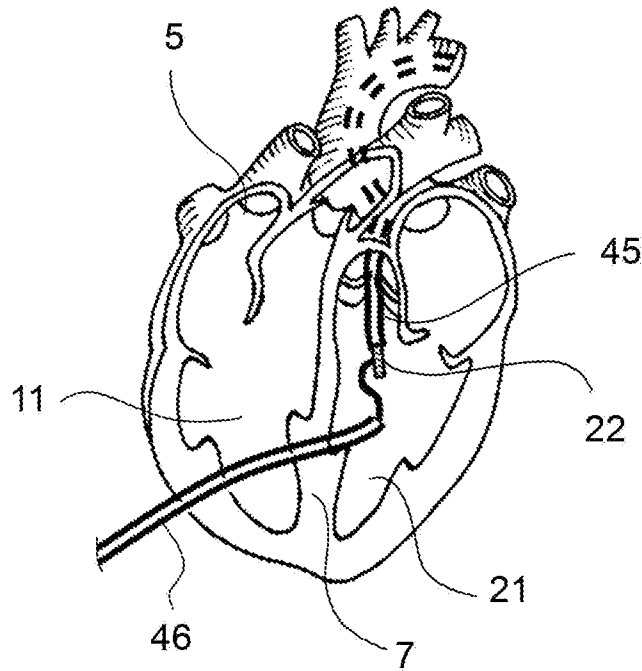


FIG. 6

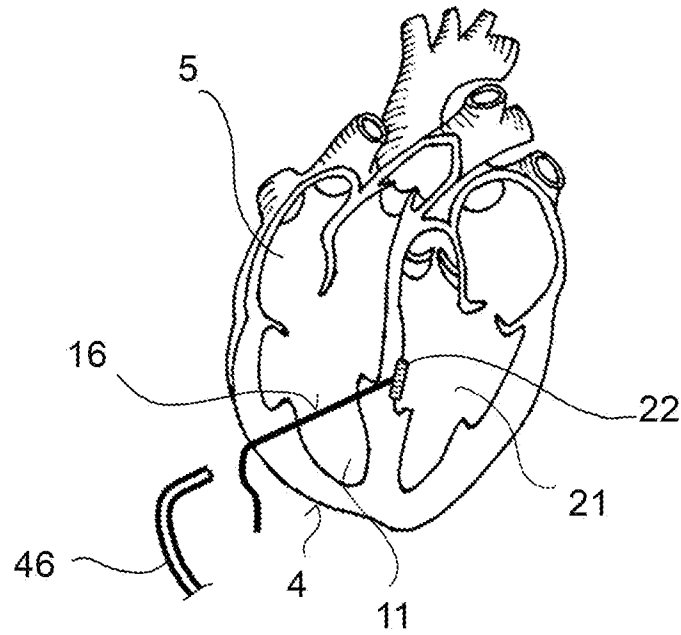


FIG. 7A

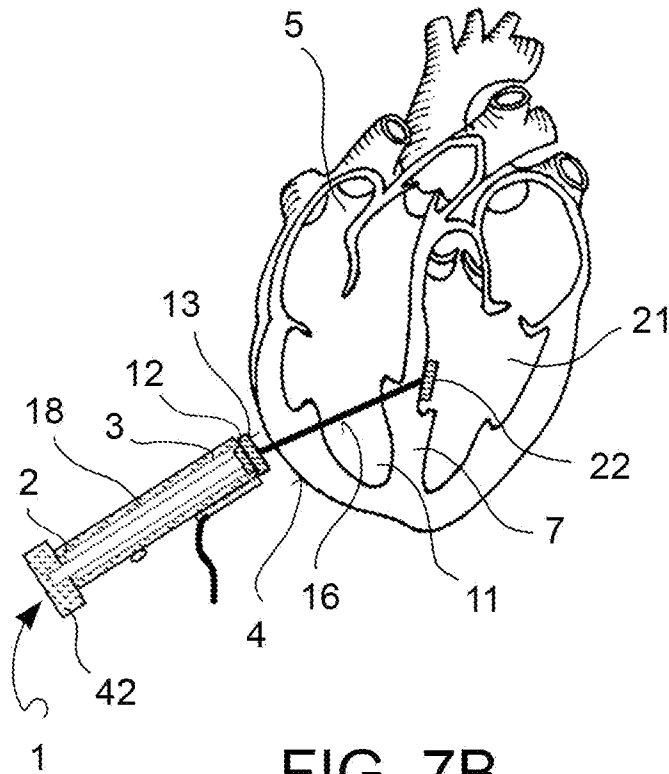


FIG. 7B

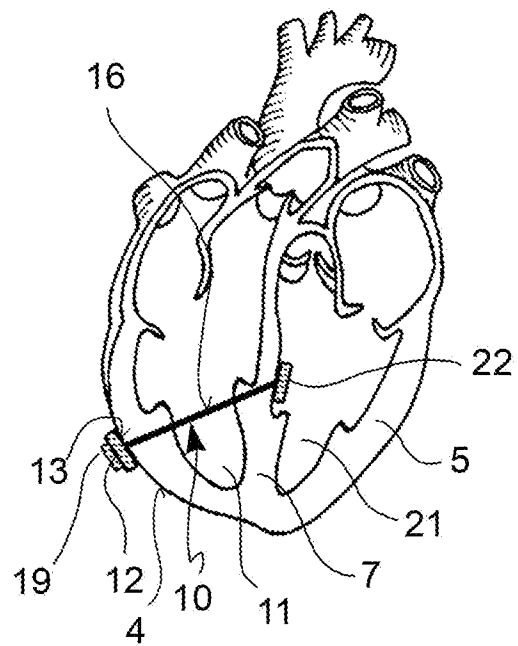


FIG. 7C

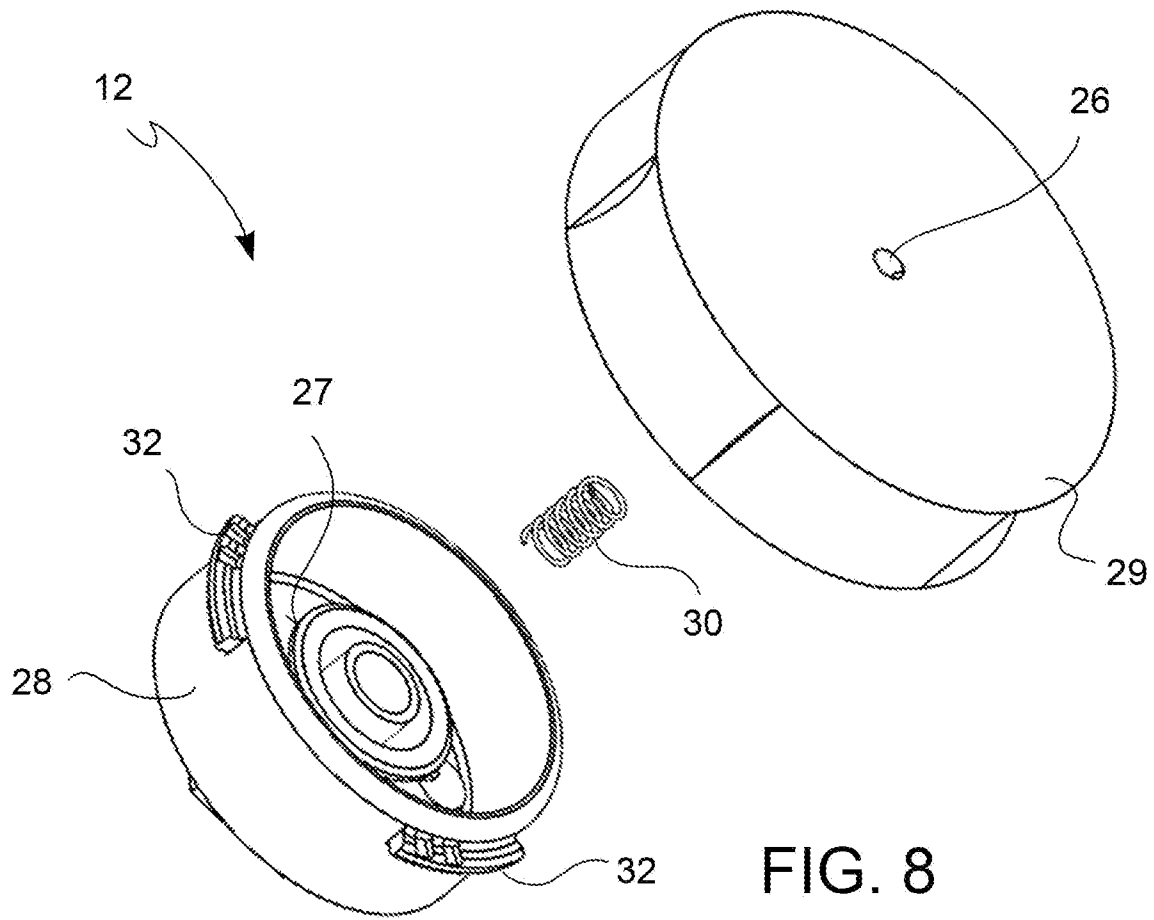


FIG. 8

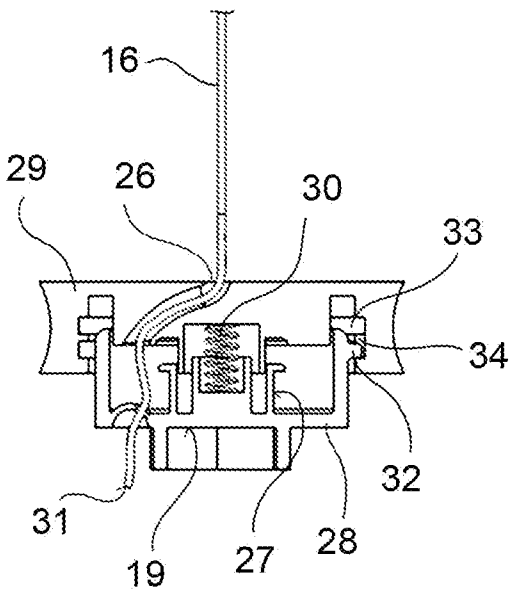


FIG. 9A

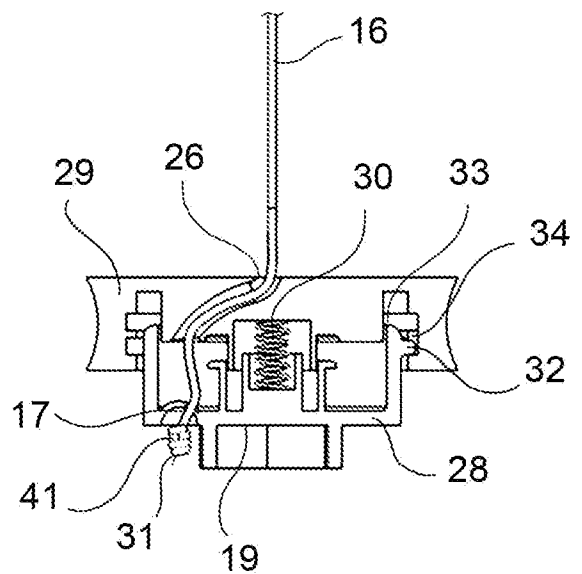


FIG. 9B

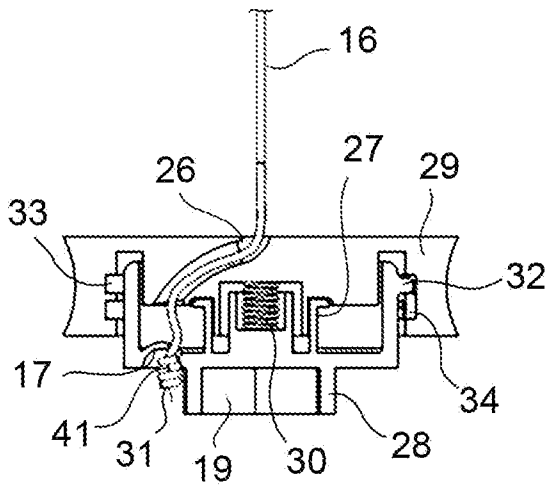


FIG. 9C

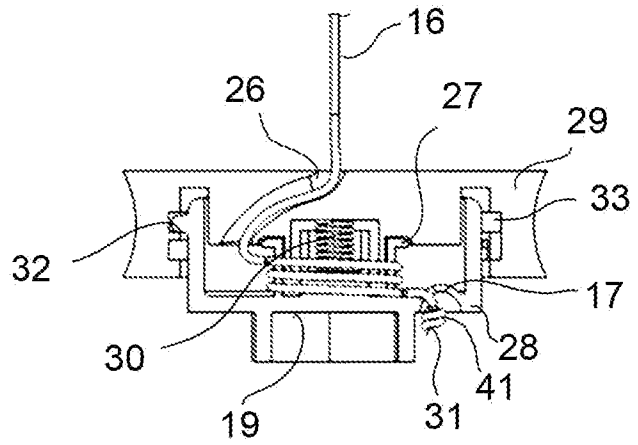


FIG. 9D

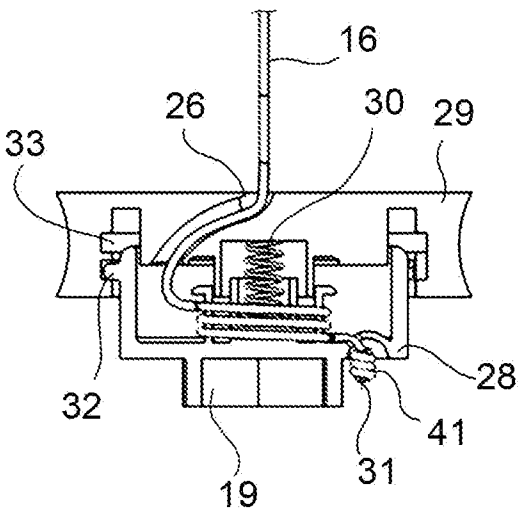


FIG. 9E

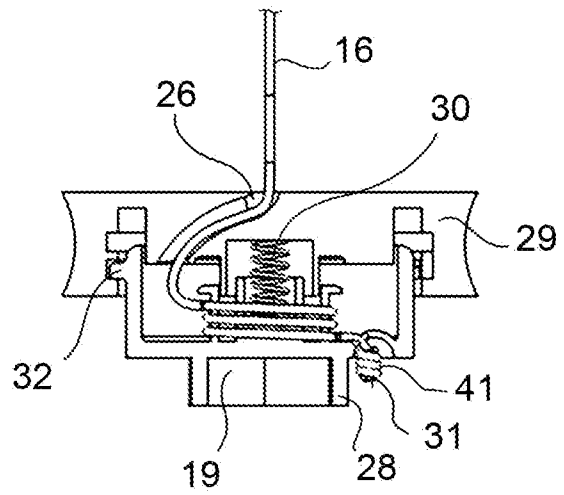


FIG. 9F

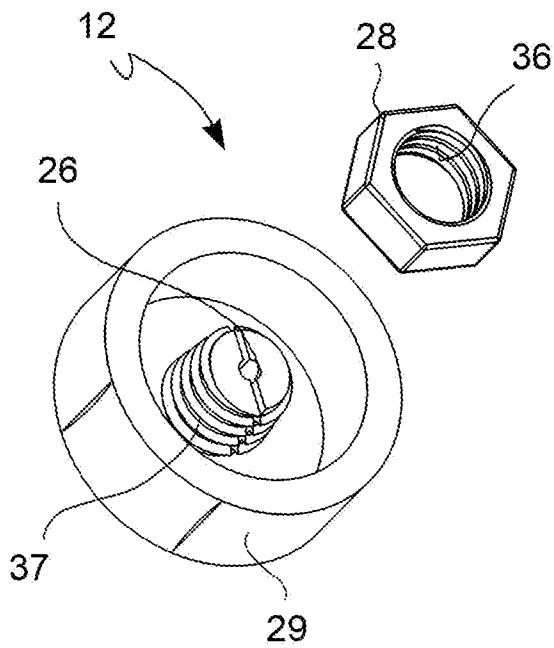


FIG. 10A

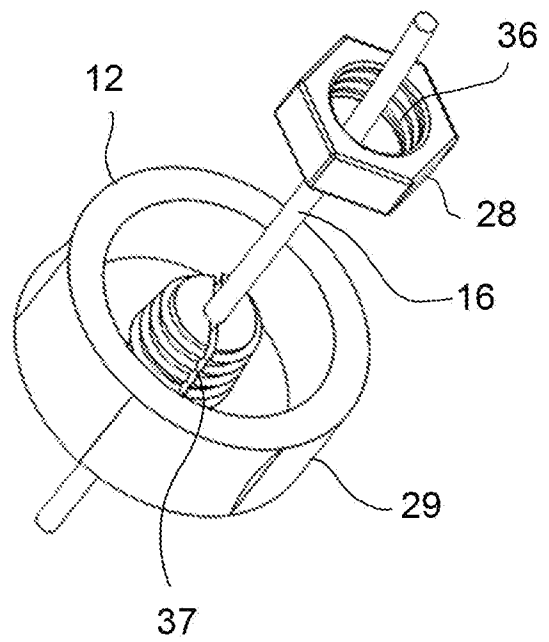


FIG. 10B

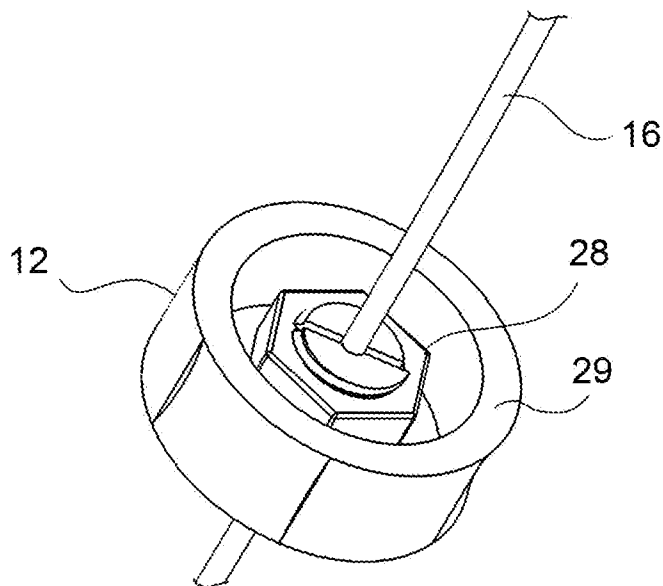


FIG. 11

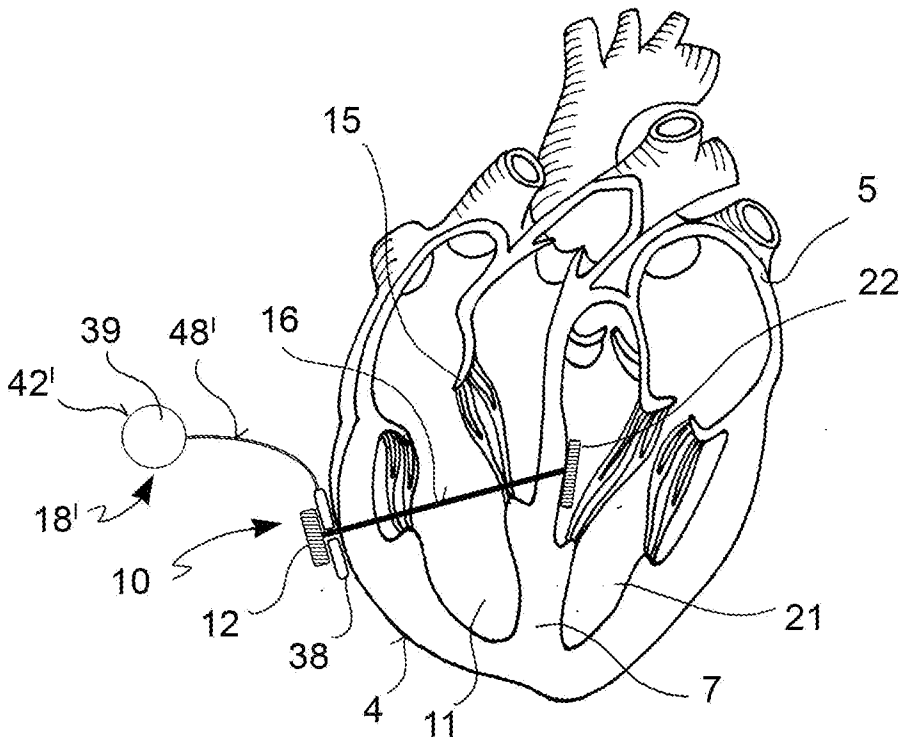


FIG. 12A

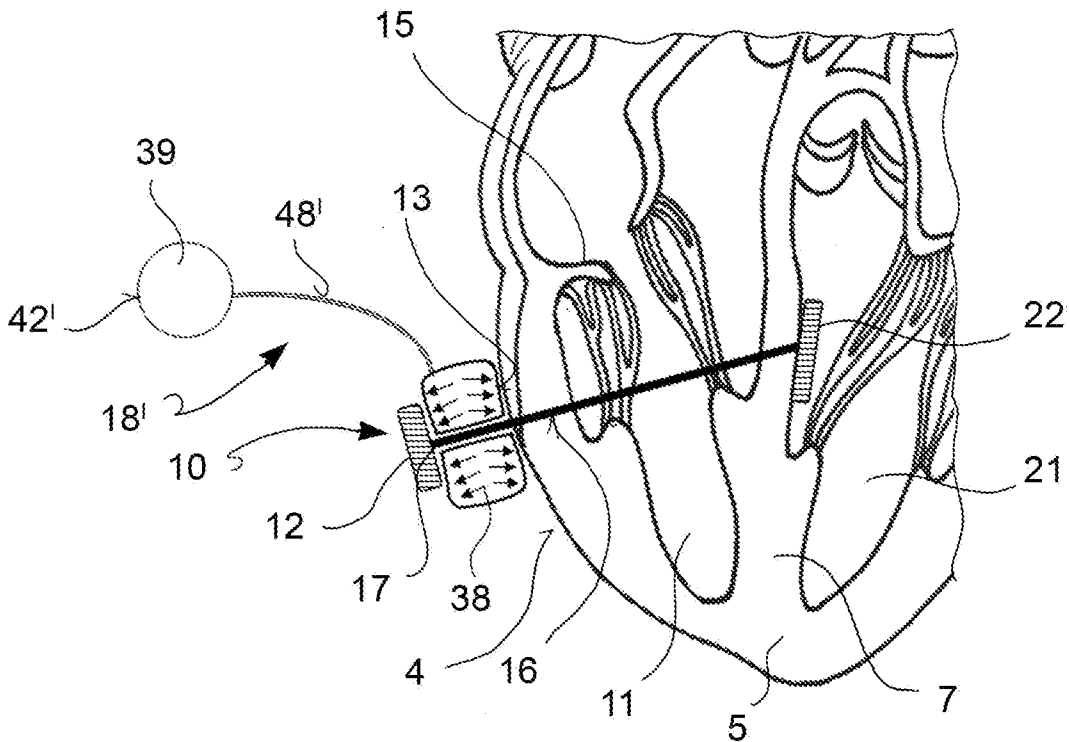


FIG. 12B

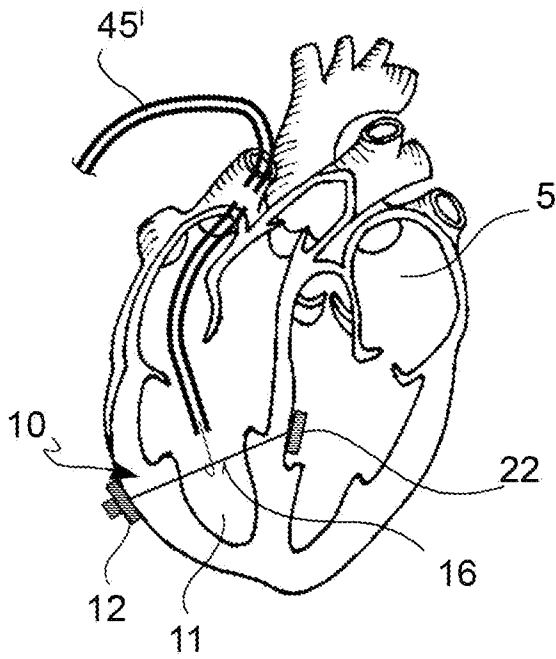


FIG. 13A

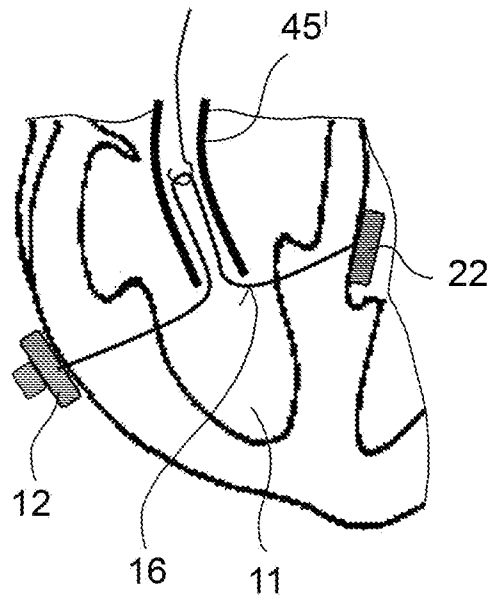


FIG. 13B

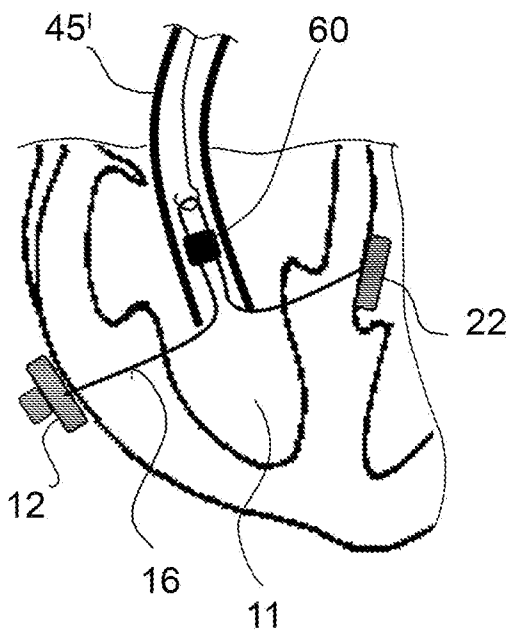


FIG. 13C

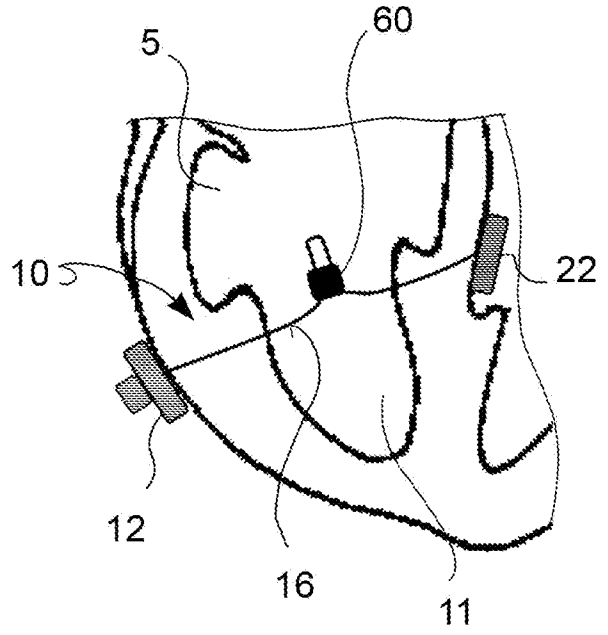


FIG. 13D

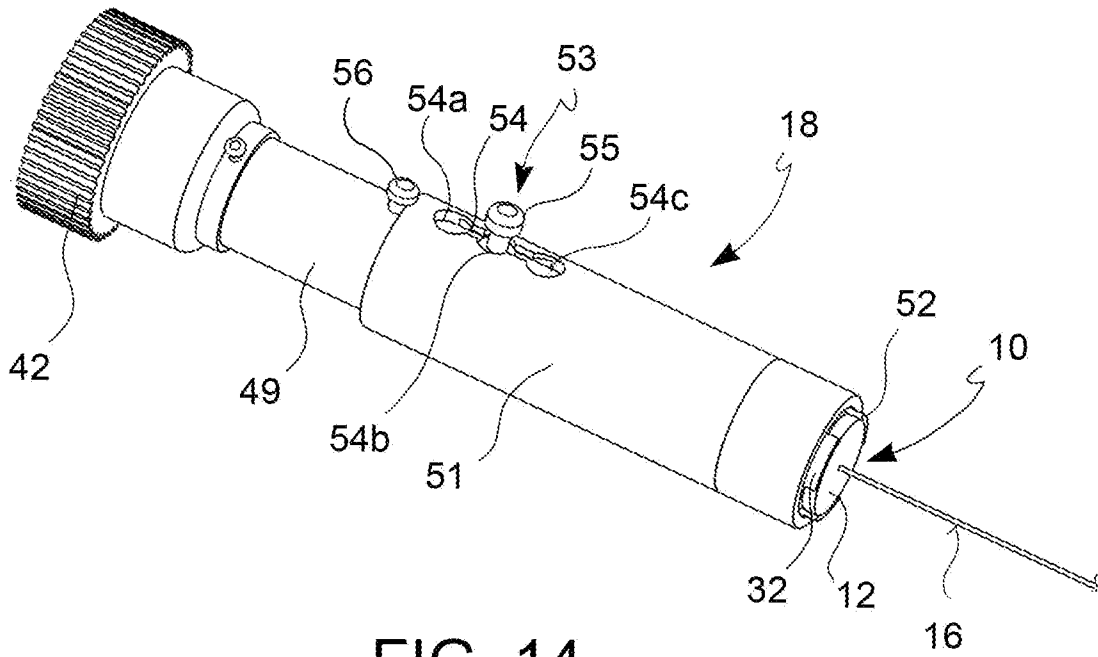


FIG. 14

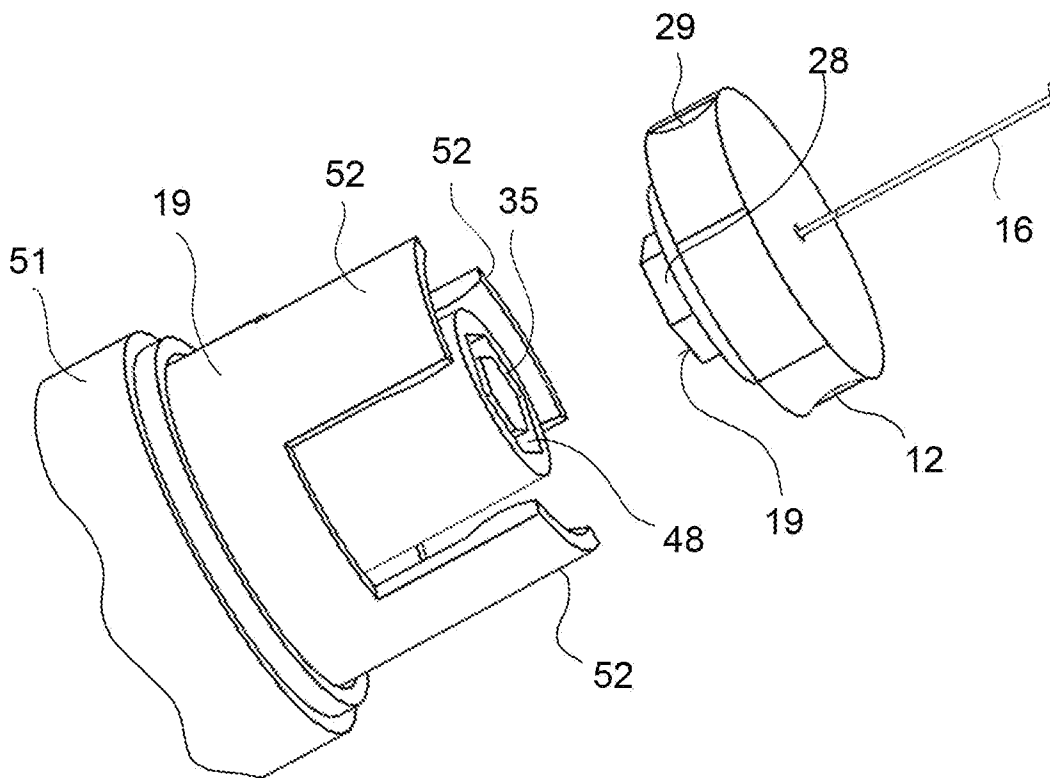


FIG. 15

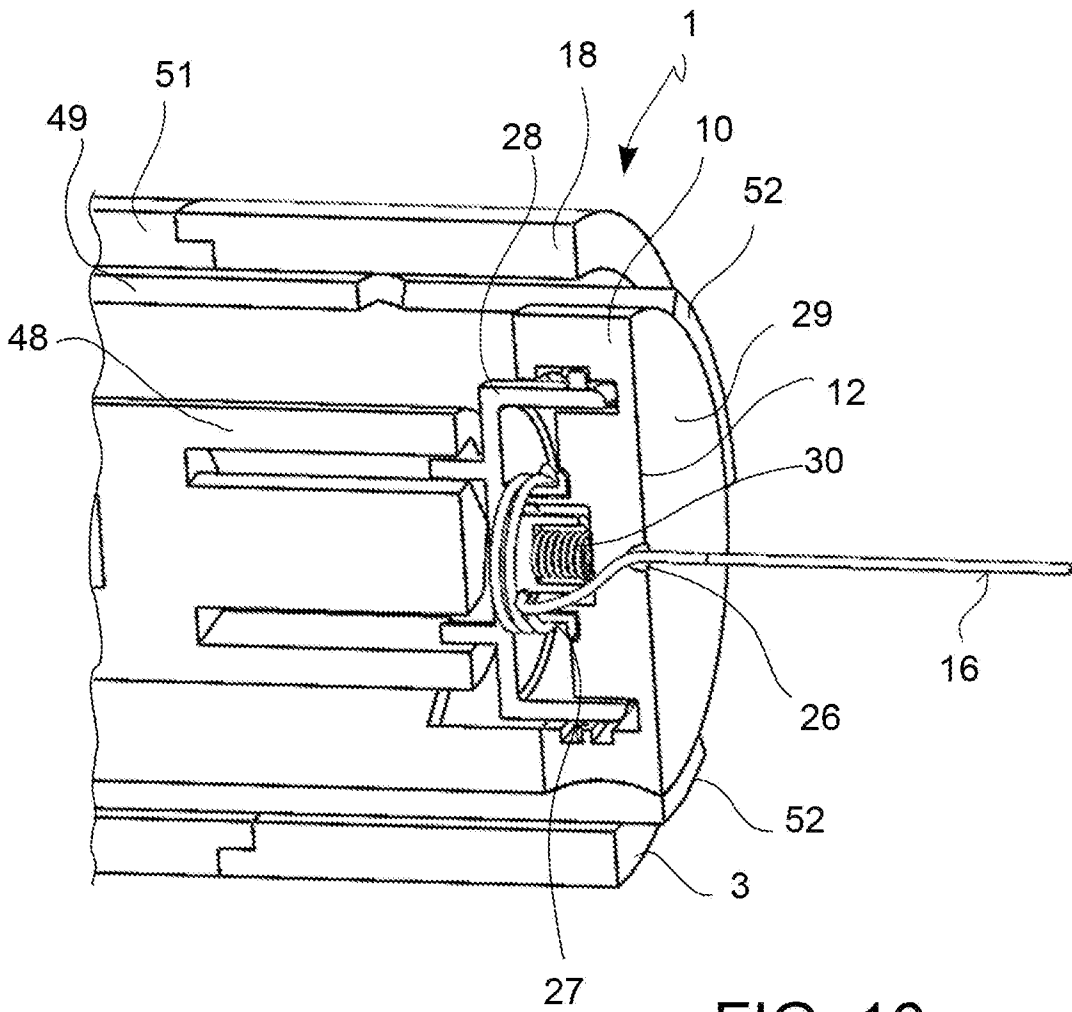


FIG. 16

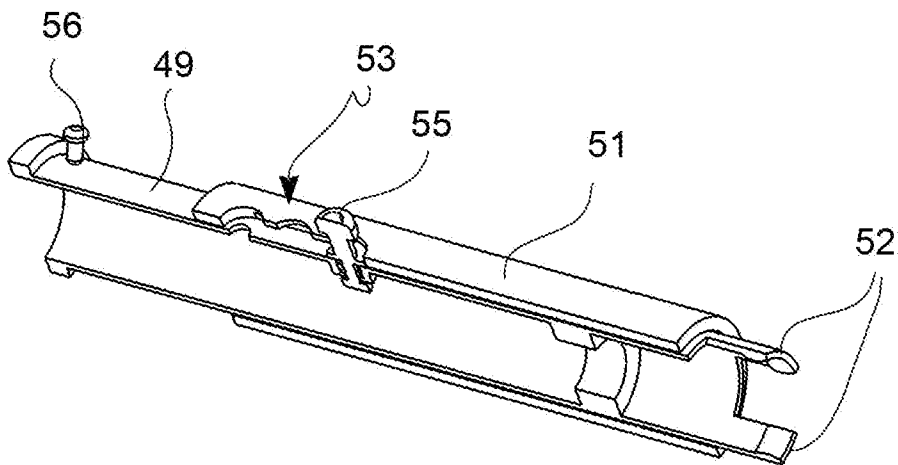


FIG. 17

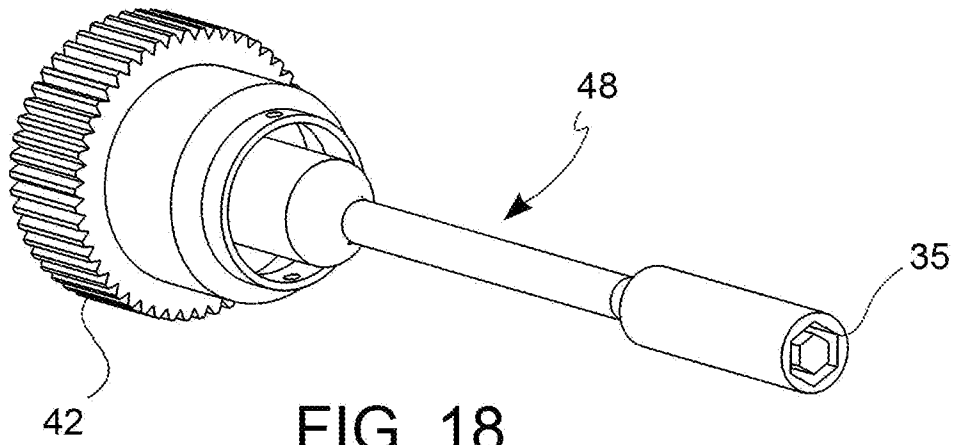


FIG. 18

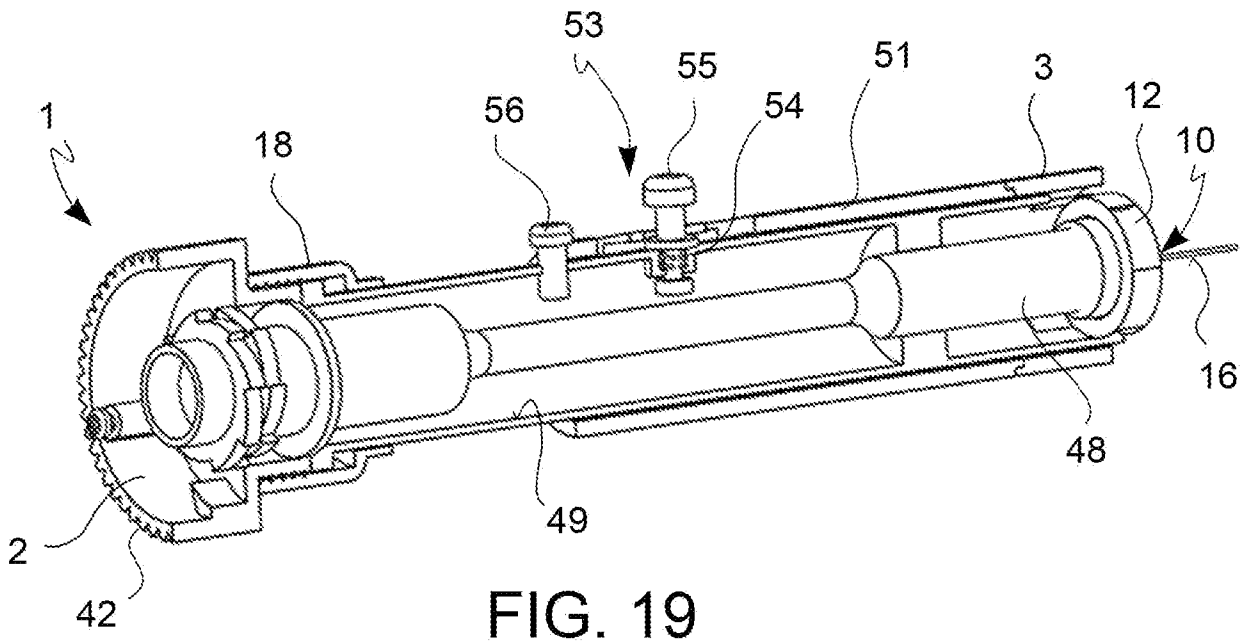


FIG. 19

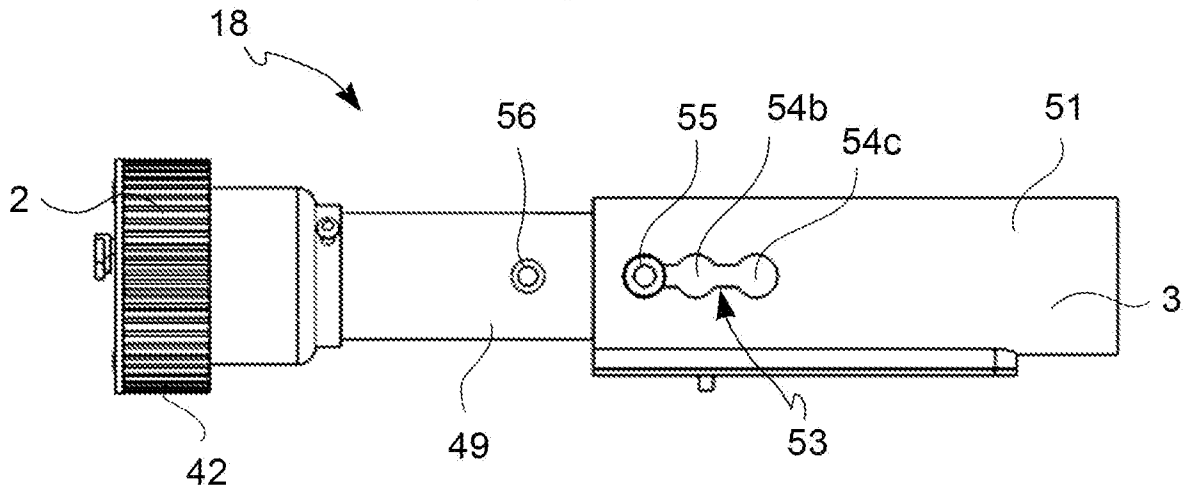


FIG. 20A

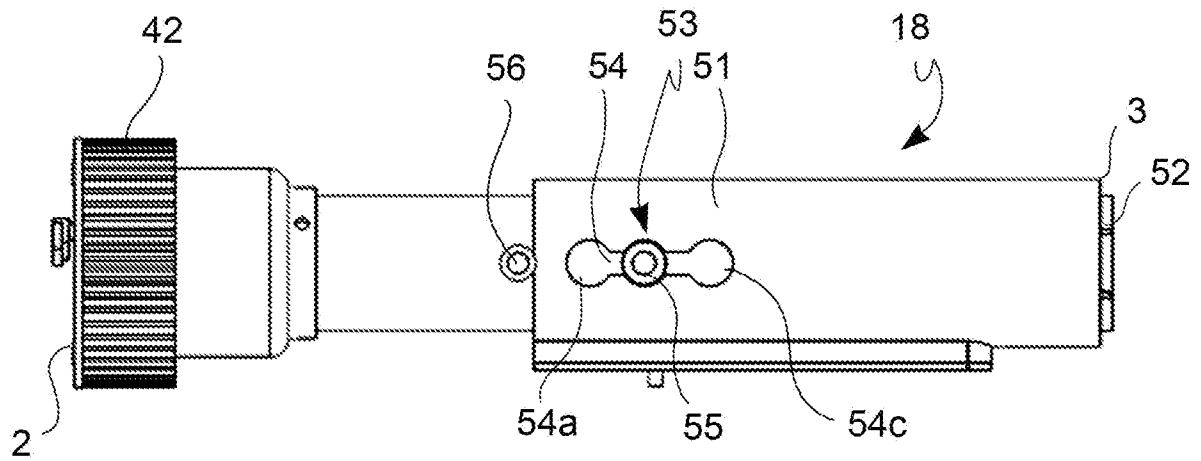


FIG. 20B

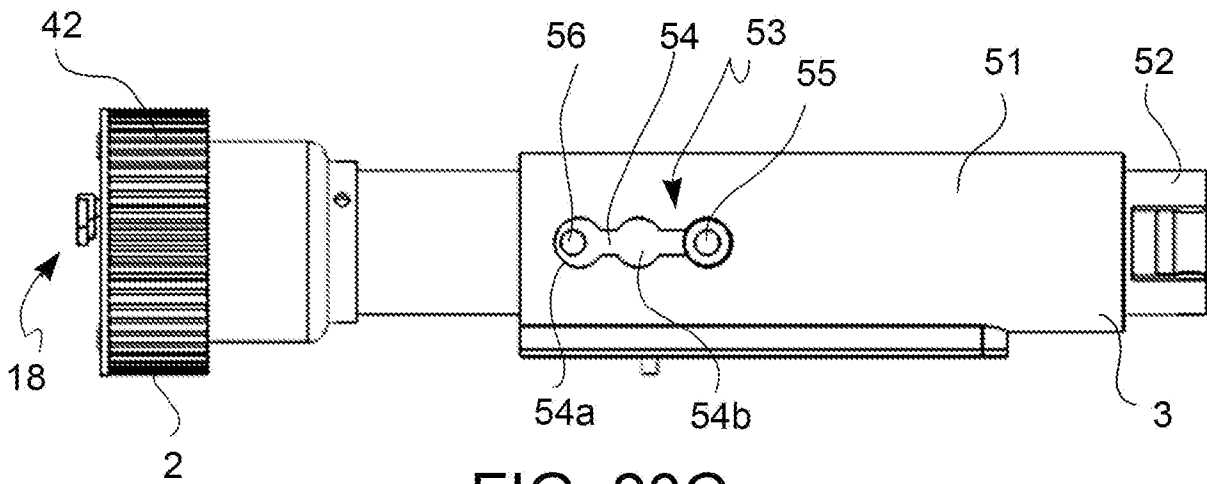


FIG. 20C

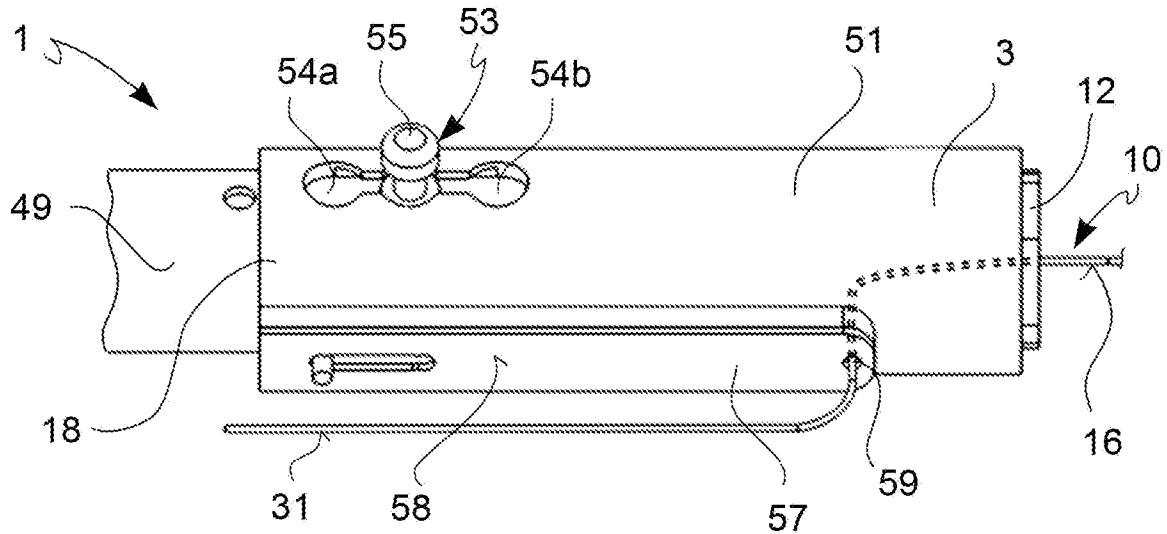


FIG. 21A

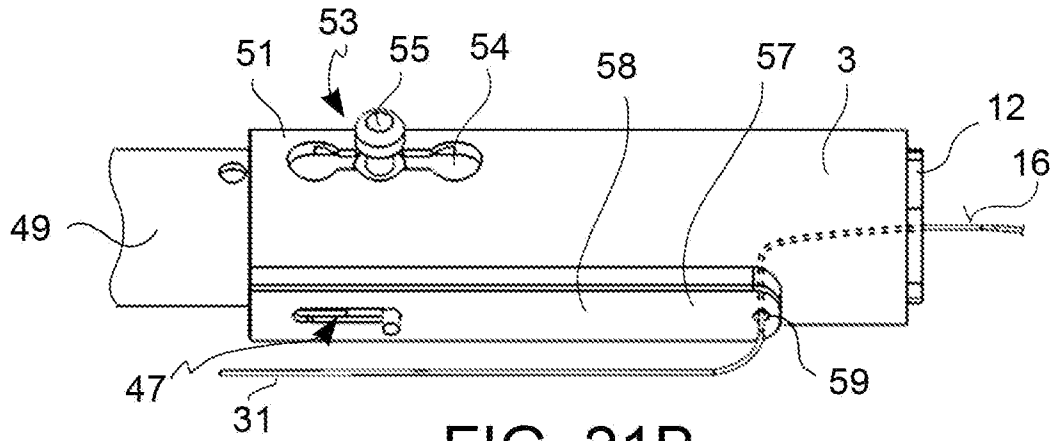


FIG. 21B

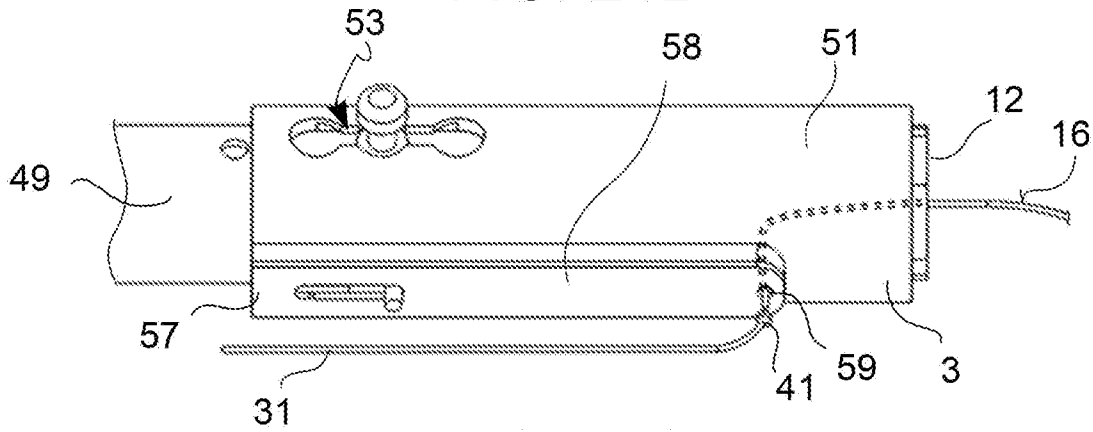


FIG. 21C

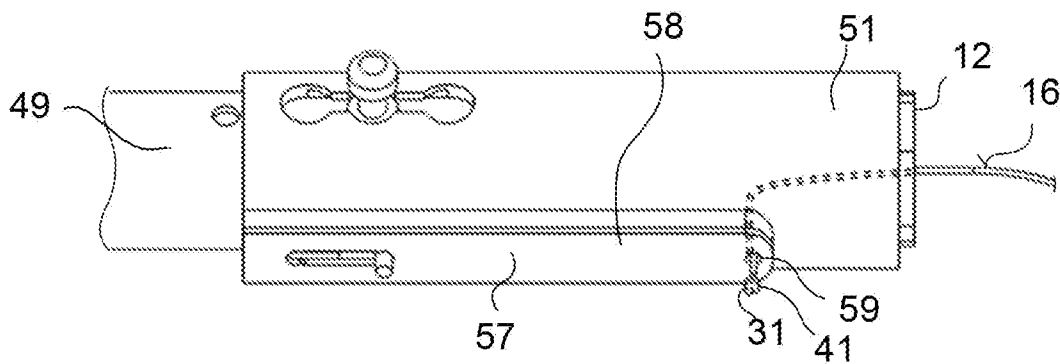


FIG. 21D

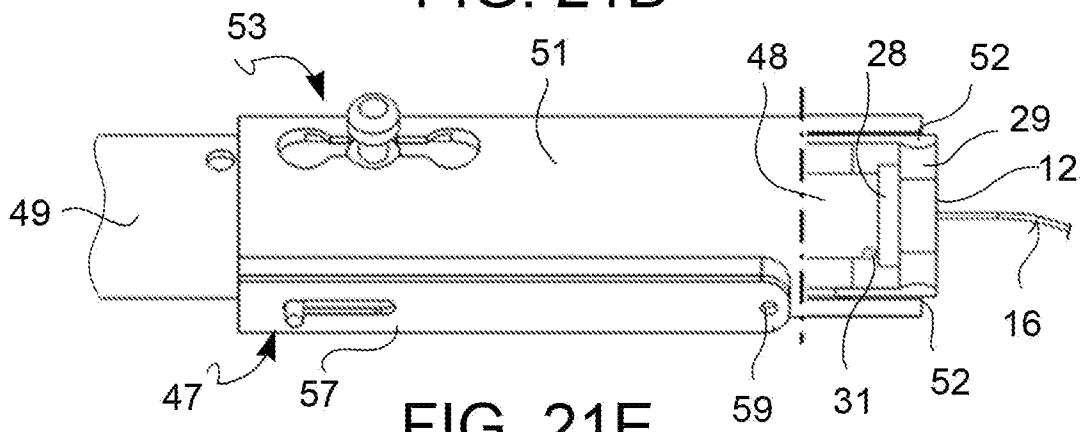


FIG. 21E

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2021/054150

A. CLASSIFICATION OF SUBJECT MATTER
 INV. A61F2/24
 ADD. A61B17/00

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)
 A61F 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	WO 2011/154942 A2 (VALTECH CARDIO LTD [IL]; MILLER ERAN [IL] ET AL.) 15 December 2011 (2011-12-15) page 19, line 14 - page 29, line 18; figures 1-9 page 30, line 27 - page 31, line 22; figure 16	1-15
X	US 2005/222488 A1 (CHANG ROBERT T [US] ET AL) 6 October 2005 (2005-10-06) paragraphs [0124] - [0148]; figures 10A-10C paragraphs [0228], [0229]; figures 47A, 47B	1-15
X A	US 2013/030522 A1 (ROWE STANTON J [US] ET AL) 31 January 2013 (2013-01-31) paragraph [0096] - paragraph [0100]; figures 6A-D	1-4, 10, 15 5-9, 11-14

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"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</p> <p>"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</p> <p>"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</p> <p>"&" document member of the same patent family</p>
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Date of the actual completion of the international search 25 August 2021	Date of mailing of the international search report 02/09/2021
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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 Chevalot, Nicolas
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No PCT/IB2021/054150

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