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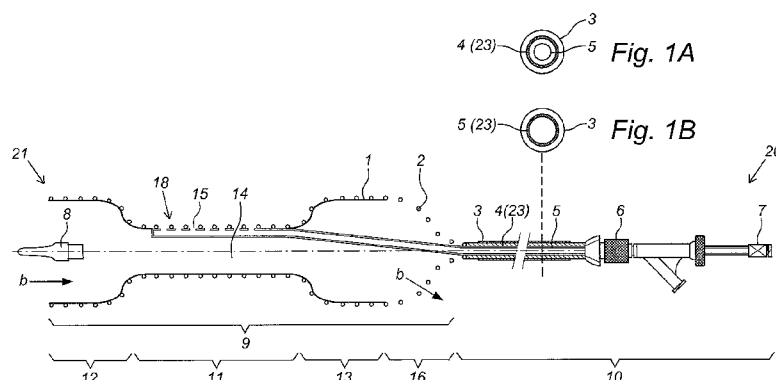


Fig. 1

(57) **Abstract:** The present application provides a retrievable medical device for the delivery of a therapeutic agent to a an organ having a distal end (21), and a proximal end (20); said device comprises a delivery catheter (10) suitable for deploying a self - expanding bell shaped member (9) at the distal end of the catheter; the proximal end of the bell shaped member is attached to the distal end of the catheter; said bell shaped member is configured to expand radially and comprises a liquid permeable carrier (2) which is at least partially bonded to a liquid impermeable liner (1).

Organ perfusion device**Field of the invention**

- 5 The present invention generally relates to the field of medical treatment systems. More particularly, the present invention relates to a device for delivering a therapeutic agent to an organ.

Background

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The lungs are large, multi-lobed organs located in the chest. The main blood inflow into the lungs is from the pulmonary trunk which divides into the left and right pulmonary arteries, which further branch to supply arteries to each of the lobes of the left and right lung, respectively.

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Diseases of the lung may be congenital, or may be induced or exacerbated by environmental factors. Air pollution, cigarette smoke, and other harmful air-borne agents (e. g., asbestos) can contribute to a variety of lung diseases including, without limitation, chronic airflow obstruction, pneumoconiosis, pneumonia, restrictive lung disease (also known as infiltrative lung disease), and primary or metastatic lung cancer. For some diseases, a therapeutic agent should be delivered to one or both lungs. Surgical approaches can be used for the delivery, however, said approaches are traumatic, expensive and cannot be repeated in a short time which lowers the success rate when treating cancers and other diseases for which repetitive treatments is required.

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WO 00/20066 discloses the use of a pulmonary artery catheter and a pulmonary vein catheter in a method for delivering a composition to a lung that includes the steps of inserting a pulmonary artery catheter into a pulmonary artery supplying the lung via a first non-surgical percutaneous route; inserting a pulmonary vein catheter into a pulmonary vein draining the lung via a second non-surgical percutaneous route; and delivering the composition to the lung via at least one of the group consisting of the pulmonary artery catheter and the pulmonary vein catheter. The catheter comprises a deployable means for occluding a blood vessel into which said catheter has been inserted, a lumen that is in communication with a port located proximal to said deployable occluding means, and a deployable arm that is deployed by advancing said arm through said lumen and said port of said catheter. Said catheter further comprises a second lumen that is in communication with a port located distal to said deployable occluding means. The deployable arm, when deployed, comprises a deployable means for occluding a blood vessel into which it is inserted. Said deployable arm, when deployed, further comprises a lumen that is in communication with a port located distal to said deployable occluding means of said deployable arm.

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The presence of two or more lumens in a delivery device considerably reduces the perfusion rate. Furthermore, the occlusion of a vessel using a balloon presents significant risk to the patient. Inflation of the catheter's balloon within the pulmonary artery causes a distinct force to be exerted outwardly against the artery's interior wall. A naturally fragile or otherwise weakened artery may not tolerate this outward force, resulting in rupture of the artery. The ultimate effect of a ruptured artery is catastrophic to the patient; a surgical team has only between about 30 seconds and three minutes to open the patient's chest and clamp the bleeder before the patient bleeds to death into the plural cavity. To compound the problem, pulmonary artery catheters have a tendency to migrate downstream. As the catheter enters smaller and smaller portions of the arterial branch, the chance for rupture of the artery increases.

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Effort has already been made for providing methods, devices and systems for isolating and perfusing lungs with a therapeutic agent. However, all these methods, devices and systems have their limitations and drawbacks, so there is a persistent need for improvement to and/or simplification of the prior art.

The aim of the present invention is to provide a solution for at least part of the above mentioned problems. The present invention aims at providing a device for minimal invasive, less risky and easy delivery of a therapeutic agent (e. g., a drug) to the lung for treating, or at least alleviating the symptoms of, a lung disease.

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Summary of the invention

In a first aspect, the present invention provides a retrievable medical device for the delivery of a therapeutic agent to an organ, said device is provided with a distal end and a proximal end; said device comprises a delivery catheter suitable for deploying a self-expanding bell shaped member at the distal end of the catheter; the proximal end of the bell shaped member is attached to the distal end of the catheter; said bell shaped member is configured to expand radially and comprises a liquid permeable carrier which is at least partially bonded to a liquid impermeable liner. The self-expanding bell shaped member contacts the vessel wall securely in the expanded state, owing to the open structure, creating a plurality of friction points. In an expanded state, the device provides strong sealing against the vessel wall. There is no requirement for applying additional pressure to the vessel walls, for example, from a balloon which reduced the risk of vessel, more specifically of pulmonary artery rupture. Indeed, the expandable member of the device will expand until being in contact with the vessel's walls, thereby applying minimal pressure on said vessel's wall.

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In a preferred embodiment, the carrier is configured to adopt an essentially cylindrical state when compressed and to self-expand radially to form said bell shaped member. In a further preferred embodiment, the carrier is made of a braided wire mesh.

25 In a preferred embodiment, the liquid impermeable liner is bonded to the liquid permeable carrier over the full length of said carrier.

In a preferred embodiment, the liquid permeable carrier is partially bonded to the liquid impermeable liner whereby said liquid impermeable liner is forming an impermeable cup shaped area.

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In a preferred embodiment, the carrier is made from a surgical wire that is: an alloy comprising Cobalt, Chromium, Nickel, Molybdenum and Iron, or nitinol, or a surgical wire in accordance to the standard ASTM F 1058.

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In a preferred embodiment, the liner is made from any of polycarbonate polyurethane formulation, polytetrafluoroethylene, polyurethane, silicone or polyethylene terephthalate polymer.

40 In a preferred embodiment, the catheter comprises (a) an inner tube; (b) an outer tube surrounding at least a portion of the length of the inner tube, and (c) a pusher means for deployment of the bell shaped member, said pusher means being:

- a pusher rod disposed between the inner tube and the outer tube, or formed from the wall of the inner tube,
- the pusher means being adapted for axial movement relative to the outer tube,
- 45 - the proximal end of the bell shaped member being attached to the distal end of the pusher means, and disposed within the outer tube in the compressed state.

In a preferred embodiment, the inner tube is configured for the passage of the therapeutic agent.

50 In a preferred embodiment, the inner tube is configured to receive a guidewire.

In a preferred embodiment, the inner tube of the catheter is in fluid connection with the bell shaped member.

In a second aspect, the present invention provides for the use of a medical device as described above, for minimal invasive and repeatable organ perfusion of a living being.

In a preferred embodiment, said device is introduced in the pulmonary artery of a living being thereby infusing the lung and/or at least one lobe of the lung of said living being. In a further preferred embodiment, the device is withdrawn after perfusion.

The device of the present invention allows organ perfusion with a high perfusion rate. This is due to the expandable bell shaped member of the device in which expansion is not triggered by the flow of perfusate flowing in the lumen of the device. The high perfusion rate reduces the intervention time which is advantageous for the patient. Furthermore, the device of the present invention facilitates the delivery of a therapeutic agent to the lung via a non-surgical, percutaneous approach that utilizes the pulmonary circulation. The device allows minimal invasive perfusion of the lung, thereby providing a less traumatic and less expensive perfusion compared to perfusions performed using devices of the prior art. The perfusion using the device of the present invention can hence be repeated in a relatively short time.

Description of the figures

Fig. 1 illustrates an embodiment of the second medical device of the present invention in the expanded state comprising a tubular member (dumb-bell shaped) attached to a catheter. **FIG. 1A** shows a transverse cross-section across the catheter where the pusher means is a pusher rod. **FIG. 1B** shows a transverse cross-section across the catheter where the pusher means is formed from the wall of the inner tube.

Fig. 1C illustrates another embodiment of the second medical device of the present invention in the expanded state comprising a tubular member (dumb-bell shaped) attached to a catheter. The dumb-bell shaped liner is attached to the inner wall of the cylindrical tubular member.

Fig. 1D illustrates a side view of another embodiment of the second medical device of the present invention wherein the liner has a cup or a spoon shape **Fig. 1E** illustrates a top view of the same embodiment **Fig. 1F** illustrates a cross-section view along A-A shown in **Fig. 1D**.

Fig 1G illustrates another embodiment of the second medical device of the present invention in the expanded state wherein the device is impermeable and has a bell shape.

Fig. 2A illustrates an embodiment of the second medical device of **Fig. 1** where the tubular member is in its collapsed, compressed state and is provided with a closed tip.

Fig. 2B illustrates another embodiment of the second medical device of **Fig. 1** where the tubular member is in its collapsed, compressed state and is provided with a conical closed tip.

Fig. 3 illustrates the second medical device of the present invention have been placed in situ, wherein: **A** illustrates a liner on the exterior of the carrier, and **B** illustrates a liner on the interior of the carrier.

Fig. 3 C and **D** illustrate the use of the second medical device for the delivery of a therapeutic agent to the right and left lung respectively. **Fig. 3 E** and **F** illustrate the use of the second medical device having a bell shape for the delivery of a therapeutic agent to the right and left lung respectively.

Fig. 4 illustrates an embodiment of the kit wherein the first medical device, the second medical device and the separation device are used for delivering a therapeutic agent and removing the therapeutic agent excess from the liver.

Fig. 5 illustrates the second medical device when introduced in the vena cava.

Fig. 6 illustrates an embodiment showing the position of the separation device within the second medical device.

Fig. 7 illustrates another embodiment showing the position of the separation device within the second medical device.

Fig. 8 detailed schematic illustration of the first medical device.

Fig. 9 detailed schematic illustration of an embodiment of the third medical device.

Fig. 10 detailed schematic illustration of another embodiment of the third medical device.

Fig. 11A and **Fig. 11B** illustrates an embodiment of the first medical device.

Fig. 11C, Fig. 11D and **Fig. 11E** illustrate an embodiment of the first medical device wherein each opening allowing fluid communication of the lumen with the interior of the balloon is provided with a valve.

Fig. 12A and **Fig. 12B** longitudinal cross-section view of the first medical device

Fig. 13 illustrates an embodiment of the third medical device.

Fig. 14 is a schematic view of a system that can be used to perfuse a medical treatment through an organ. The system can be controlled by an algorithm.

Fig. 15 is a flowchart of an algorithm that can be used to control the perfusion system of **Fig.14**.

Fig. 16A shows a vessel having a lesion **Fig. 16B** shows the second retrievable medical device introduced in the vessel having a lesion.

Detailed description of the invention

Unless otherwise defined, all terms used in disclosing the invention, including technical and scientific terms, have the meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. By means of further guidance, term definitions are included to better appreciate the teaching of the present invention.

As used herein, the following terms have the following meanings:

"A", "an", and "the" as used herein refers to both singular and plural referents unless the context clearly dictates otherwise. By way of example, "a compartment" refers to one or more than one compartment.

"About" as used herein referring to a measurable value such as a parameter, an amount, a temporal duration, and the like, is meant to encompass variations of +/-20% or less, preferably +/-10% or less, more preferably +/-5% or less, even more preferably +/-1% or less, and still more preferably +/-0.1% or less of and from the specified value, in so far such variations are appropriate to perform in the disclosed invention. However, it is to be understood that the value to which the modifier "about" refers is itself also specifically disclosed.

"Comprise," "comprising," and "comprises" and "comprised of" as used herein are synonymous with "include", "including", "includes" or "contain", "containing", "contains" and are inclusive or open-ended terms that specifies the presence of what follows e.g. component and do not exclude

or preclude the presence of additional, non-recited components, features, element, members, steps, known in the art or disclosed therein.

The recitation of numerical ranges by endpoints includes all numbers and fractions subsumed within that range, as well as the recited endpoints.

The expression "% by weight" (weight percent), here and throughout the description unless otherwise defined, refers to the relative weight of the respective component based on the overall weight of the formulation.

The term "therapeutic agent" is used herein to refer to a treatment fluid or particles delivered to a patient's organ.

The terms "particles", "microspheres" and "beads" are used herein as synonyms and refer to an object that is substantially spherical in shape and has a diameter less than 1 millimeter.

The term "glass" refers to a hard, brittle, non-crystalline, inorganic substance, which is usually transparent; glasses are often made by fusing silicates with soda, as described by Webster's New World Dictionary. Ed. Guralnik, D B 1984.

The terms "inflow" and "outflow" herein refer respectively to the blood flowing into an organ and the blood flowing out from an organ.

The term "lungs" refers to the left lung, right lung and/or to at least one lobe of a living being lung.

The present invention provides a retrievable medical device for the delivery of a therapeutic agent to an organ, said device is provided with a distal end and a proximal end; said device comprises a delivery catheter suitable for deploying a self-expanding bell shaped member at the distal end of the catheter; the proximal end of the bell shaped member is attached to the distal end of the catheter; said bell shaped member is configured to expand radially and comprises a liquid permeable carrier which is at least partially bonded to a liquid impermeable liner.

In another embodiment, the device of the present invention is suitable to be used in a kit for the delivery a therapeutic agent to an organ blood flow and the removal of the excess of said therapeutic agent from said organ blood flow. The kit comprises:

(a) optionally the therapeutic agent,

(b) a first retrievable medical device, for delivering said therapeutic agent into the organ blood flow, preferably into the organ artery blood, comprising a catheter and an injection device such as a syringe, said catheter is provided with a proximal end, a distal end and a lumen; the distal end is in fluid communication with the proximal end via the lumen; said injection device is suitable to be connected to the proximal end of the catheter,

(c) a second retrievable medical device, being the device of the present invention, for isolating the organ outflow blood, having a distal end and a proximal end; said second medical device comprises a catheter at the distal end suitable for deploying a self-expanding hollow tubular member at the proximal end of the device; the proximal end of the tubular member is attached to the distal end of the catheter ; said tubular member is configured to expand radially to form a central part flanked by two annular ridges, a distal annular ridge and a proximal annular ridge; the tubular member comprises a liquid-impermeable area disposed with one or more fluid ports for the collection of organ blood vein or organ outflow and two liquid-permeable regions, one distal to the distal annular ridge and one proximal to the proximal annular ridge so forming a passageway between the distal end and the proximal end of the tubular member for the flow the organ blood devoid of therapeutic agent, whereby the liquid-impermeable area is disposed in an area defined by the region flanked by the annular ridges, the distal annular ridge and at least part of the proximal annular ridge for isolating organ vein blood containing therapeutic agent excess from the organ blood flow devoid of therapeutic agent, and

(d) a separation device comprising at least one filter able to separate the therapeutic agent excess from the organ vein blood, having an inlet for the organ vein blood having a particle excess and an outlet for filtered organ vein blood or organ outflow.

- 5 When used in a kit for treating liver for example, the main blood vessels connected to the liver are occluded: the vena porta (PV, hepatic portal vein) using a third retrievable medical device, hepatic artery (HA) using a first retrievable medical device and hepatic vein (HV) using the second retrievable medical device to achieve site specific blood isolation and collection. The isolation of the liver vascular system makes it possible to reach high local chemotherapy concentration.

10 The kit and the device will be further detailed for a treatment of the liver and/or the lungs. However, any other organ can be treated using the kit and/or the device of the present invention. For liver treatment, the kit is intended to control blood flow in and/or out of the hepatic veins, while maintaining continuous blood flow through the inferior vena cava. The kit is used to collect
15 the hepatic vein outflow in order to filter chemotherapy, particles or a fluid treatment or any other therapeutic agent.

Therapeutic agent

- 20 The therapeutic agent can be a treatment fluid or particles or beads containing said treatment. By treatment fluid, it is referred to any fluid having therapeutic and/or curative effects. Any treatment fluid known to the person skilled in the art might be used. Preferably, the treatment fluid is for chemotherapy purposes.
- 25 Particles are known for the person skilled in the art and for instance described in US2004/197264, the content of which is incorporated herein by reference. The particles comprise a material selected from the group consisting of glass, polymer and resin; a first radioisotope that emits a therapeutic [beta]-particle; and a second radioisotope that emits a diagnostic [gamma]-ray; wherein the atomic number of the first radioisotope is not the same as the atomic number of the second
30 radioisotope. In a preferred embodiment of the present invention, the particles are beads comprising a radioactive element, preferably polymer or glass beads.

Second retrievable medical device

- 35 The device of the present invention is herein also called second retrievable medical device or second medical device.

FIG. 1 illustrates an embodiment of the second medical device according to the present invention. The device comprises a radially, self-expandable tubular member **9**, shown in the expanded state
40 attached to a delivery catheter **10**. **FIG 1A** shows a transverse cross-section of the catheter.

One embodiment of the present invention is medical device having a distal **21** and a proximal **20** end, comprising a hollow, self-expanding tubular member **9** and a catheter **10** suitable for deploying a self-expanding tubular member **9**, wherein:

- 45 - the tubular member **9** is configured to expand radially to form a central part **11** flanked by two annular ridges
- a distal annular ridge **12** and a proximal annular ridge **13**,
- the tubular member **9** comprises a liquid-impermeable area, defined at least by the region flanked by the annular ridges **12,13**,
50 - the tubular member **9** comprises two liquid-permeable regions, one distal to the distal annular ridge **12** and one proximal to the proximal annular ridge **13**, so forming a passageway **14** between the distal end **21** and the proximal end **20** of the tubular member **9** for the flow of vessel fluid,

- the proximal end **20** of the tubular member **9** is attached to the distal end **21** of the delivery catheter **10**, - the liquid impermeable area is disposed with one or more fluid ports **15** for blood passage.

- 5 In a preferred embodiment, the tubular member of the second medical device comprises a liner attached to at least a part of the wall of the tubular member, which provides the liquid impermeable area. This area allows the isolation of the blood flowing in a vessel from blood arising from lateral veins for instance.
- 10 The self-expandable tubular member **9**, called herein 'tubular member', is typically an elastic tube that self-expands after having been compacted. Illustrative examples of self-expandable tubular members are disclosed in the following documents all of which are incorporated herein by reference: US 5,876,445, US 5,366,504, US 5,234,457, US 5,061,275; Watkinson et al: The role of self-expanding metallic endoprostheses in esophageal structures, "Seminars in Interventional
- 15 Radiology", 13(1):17-26 (March 1996).

In a preferred embodiment of the present invention, the tubular member of the second medical device comprises a liquid permeable carrier configured to adopt an essentially cylindrical state when compressed, and to self-expand radially to form a central part flanked by two annular ridges.

- 20 In a further preferred embodiment, the carrier is made of a braided wire mesh. The annular ridges are suitable to contact the vessel of the organ thereby apply a sealing pressure to the vessel wall. Hence, the systemic blood flow of the patient is maintained.

- 25 In a preferred embodiment of the present invention, the catheter of the second medical device comprises an inner tube, an outer tube surrounding at least a portion of the length of the inner tube and a pusher means for the deployment of the tubular member; the distal end of the pusher means is attached to the proximal end of the tubular member.

- 30 In a preferred embodiment of the present invention, the inner tube distal end of the catheter of the second medical device is in fluid connection with the one or more ports of the liquid-impermeable area of the tubular member and the inner tube proximal end is in fluid connection with the separation device inlet.

- 35 In a preferred embodiment, the tubular member **9** comprises, in the expanded state, a central part **11** flanked by two annular ridges - a proximal annular ridge **13** and a distal annular ridge **12**. The central part **11** radially expands to a lesser degree compared to the annular ridges **12**, **13**. The expanded central part **11** typically has a cylindrical shape while the annular ridges **12**, **13** are at least partly conical, so forming a funnel-like structure in the expanded state. By designing the device as such, it is formed partly as an hour-glass or dumb-bell upon expansion. When deployed
- 40 in a bodily vessel, the central part **11** forms an annular lumen **18**, sealed by the annular ridges **12**, **13** for the delivery of a therapeutic agent to the vessel. Said annular lumen can be used for the collection of blood brought to said bodily vessel by other vessels, such as lateral vessels, when the device is used in a kit as described above.

- 45 The skilled person will appreciate the diameters of the tubular member **9** at the annular ridges **12**, **13** and central part **11** in the expanded state may be adapted according to the diameter of the vessel at the deployment site. The diameter of the central part **11** should be wide enough to avoid obstruction of blood flow, but not too wide that flow reaches high levels that will affect leakage resistance and disturb laminar flow. The diameter of the annular ridges **12**, **13** should be selected
- 50 such as to provide a perfect sealing against the vessel's inner wall when the tubular member **9** is in the expended state. The sealing is assured by the pressure applied by the carrier **2** on the vessel's wall and by the fact that the annular ridges **12**, **13** contact the inner vessel over a distance comprised between 15 and 100 mm, preferably between 16 and 80 mm, more preferably between 17 and 60 mm, most preferably between 18 and 40 mm.

In another preferred embodiment, in the expanded state the central part and the annular ridges of the tubular member are designed to expand radially with the same degree. The expanded tubular member has then a cylindrical shape (**Fig. 1C**) with at least one partly conical extremity, so forming a funnel-like structure in the expanded state. The cylindrical shape is obtained by the expansion of the carrier **2**. A liner **1** having an hour-glass or dumb-bell shape is at least partly attached to the walls of the carrier **2** as shown in **Fig. 1C**. When deployed in a bodily vessel, liner **1** forms an annular lumen **18**, for the delivery of a therapeutic agent to the vessel. The straight carrier **2** is made of flexible material such as braided wire mesh. Hence, it is able to follow the vessel curvatures and assure a reliable isolation between the systemic blood flow and the fluid flowing in through both the inner tube **5** and the annular lumen **18**. The continuous cylindrical carrier assures an optimal opening of the vessel during the organ treatment.

In another preferred embodiment, in the expanded state the central part and the annular ridges of the tubular member are designed to expand radially with the same degree. The expanded tubular member has then a cylindrical shape (**Fig. 1D** and **Fig. 1E**) with at least one partly conical extremity, so forming a funnel-like structure in the expanded state. The cylindrical shape is obtained by the expansion of the carrier **2**. The distal end **21** of the inner tube **5** is formed as a cup or a spoon **1'**. In a preferred embodiment, the cup or spoon **1'** of the device is made of an impermeable material, thereby defining a cup or spoon shaped impermeable area. The cup or spoon can be attached in at least two locations to the carrier **2** such as to form an annular lumen **18** as shown in **Fig. 1D**. Said cup or spoon **1'** can be bonded completely to the carrier **2**. To exemplify the latter, the cup lip, defining the cup upper opening, is completely bonded to the carrier and the inner volume of the cup, wherein fluid can be placed, is hanging inside the tubular member as shown in **Fig. 1E** and **Fig. 1F**. The example refers to a regular cup for coffee or thee or any other liquid.

The cup or spoon **1'** of the device is suitable to be in fluid connection with several veins or arteries. For instance when the device is placed in the thoracic arch, the cup or a spoon **1'** is suitable to be in fluid connection with several bronchial branches. **Fig. 1F** shows a cross sectional view along A-A shown in **Fig. 1D** while **Fig. 1E** shows a top view of the second medical device according to the present embodiment. The straight carrier **2** is made of flexible material such as braided wire mesh. Hence, it is able to follow the vessel curvatures and assure a reliable isolation between the systemic blood flow and the fluid flowing in through both the inner tube **5** and the annular lumen **18**. The continuous cylindrical carrier assures an optimal opening of the vessel during the organ treatment. The carrier **2** can be devoid of impermeable liner. Said carrier can also be provided with an impermeable liner over at least part of its length or over its full length.

In another preferred embodiment, the second medical device in expanded state has a bell shape as shown in **Fig. 1G**. The device comprises a carrier **2** and liner **1** which is disposed and bonded at the outer wall of the carrier **2** and is thereby covering said carrier **2**. Said carrier **2** can also be bonded to the inner wall of the carrier or to both the inner and the outer wall of said carrier **2**. The liner **1** is in this embodiment provided over the full length of the carrier **2** of the expandable member of the device as shown in **Fig. 1. G**. The device is mainly used for delivering a therapeutic agent to an organ, preferably to the lungs of a living being. The therapeutic agent flows through the inner tube **5**. For simplicity, only the self-expanding bell shaped member of the device and a part of the catheter **10** is shown in **Fig. 1G**. It is to be understood that in this embodiment, the device comprises the catheter as shown in **Fig. 1** and the self-expanding bell shaped member **9'** shown in **Fig. 1G**.

In another preferred embodiment, the second medical device in expanded state has a bell shape as shown in **Fig. 1G** provided with a cup or spoon as shown in **Fig. 1E** and **Fig. 1F**. Said cup or spoon is made of an impermeable material, thereby defining a cup or spoon shaped impermeable area. The carrier of the bell shaped member can be bonded to an impermeable liner. Preferably said carrier is devoid of impermeable liner. The cup or spoon can be attached in at least two locations to

the carrier **2** such as to form an annular lumen **18** as shown in **Fig. 1D**. Said cup or spoon **1'** can be bonded completely to the carrier **2**. To exemplify the latter, the cup lip, defining the cup upper opening, is completely bonded to the carrier and the inner volume of the cup, wherein fluid can be placed is hanging inside the tubular member as shown in **Fig. 1E** and **Fig. 1F**.

In a preferred embodiment, the cup or spoon **1'** is placed around the inlet or outlet of a side vessel thereby allowing perfusion of said vessel while being isolated from the main flow. This considerably limits side effects to other side vessels. If the perfusion of the bronchial arterial delta is desired, the device allows isolating and perfusion of said delta only. All other arteries leaving the aorta remain open for arterial inflow to prevent serious problems during the local perfusion. The device of the present invention presents the advantage of being flexible and having an uncovered braided wire mesh carrier so it can be easily placed and anchored in tortuous situations, like the ascending/descending aorta or below, or in the pulmonary arteries at the left/right Y split. The cup or spoon shaped impermeable area will assure that we only communicate, and control the flow, with the targeted vessels.

Further, the device of the invention avoids the use of occluding perfusion catheters wherein a balloon is occluding one of the bronchial arteries which leads to spasms and makes it impossible to isolate and perfuse the lungs. Also, the presence of several bronchial take offs in the aorta feeding the bronchial artery, makes it not practicable to have an occluding perfusion catheter provided with a balloon in each of said bronchial take offs.

Using small edging of the cup or spoon of the device of the present invention and placing said edging around the bronchial delta we can inject contrast in the delta, and the radiologist will have visual control of the isolation, thereby allowing optimization of the device position when needed, and start thereafter the isolated perfusion. When the edging of the cup or spoon of the device is optimized for certain side vessels such as the bronchial artery delta, the branching between left or right pulmonary artery or the branching between the internal- and external jugularis; perfusion into/from specific side vessels, without occluding the main flow or interrupting blood flow to other organs in the same area, is then possible.

It is to be understood that the non-permeable area of the device can have any other shape provided said shape is suitable to be positioned in front of one or a group of vessels thereby allowing selective perfusion into selected vessels without communication of the perfusate to other side vessels or to the systemic flow.

The self-expandable bell shaped member **9'**, is typically an elastic tube that self-expands after having been compacted. Illustrative examples of self-expandable tubular members are disclosed in the following documents all of which are incorporated herein by reference: US 5,876,445, US 5,366,504, US 5,234,457, US 5,061,275; Watkinson et al: The role of self-expanding metallic endoprostheses in esophageal structures, "Seminars in Interventional Radiology", 13(1):17-26 (March 1996).

It is to be understood that all the embodiments of the second medical device described above can be used for delivering a therapeutic agent to an organ and/or retrieving a therapeutic agent from an organ. The delivery and/or retrieval of the therapeutic agent can be performed while maintaining the systemic blood flow of the patient. The treated organ is for example liver or lungs.

The use of the second medical device for the delivery of a therapeutic agent to an organ, in particular the lungs, is illustrated in **Fig. 3 C to F**. After being inserted, at least partially, in the left (LPA) or the right (RPA) pulmonary artery (PA), the therapeutic agent is delivered through the inner tube **5**. **Fig. 3 C** illustrates the use of the second medical device having an expandable tubular member for the delivery of a therapeutic agent to the right lung (continued arrow) while the systemic flow (illustrated on the figure by a discontinued arrow) of the left lung is maintained. For simplicity, the device is not shown in details. It is to be understood that the device of **Fig. 1** is

used. Said device is introduced in the vessel such as, after expansion of the tubular member, the proximal annular ridge is positioned in the pulmonary trunk **PT**, the distal annular ridge is positioned in the **LPA** and the annular lumen is positioned at the entrance of the **RPA**. After positioning the device, systemic blood will flow from the **PT** to the **LPA**. The practitioner can then deliver the therapeutic agent to the **RPA** via the inner tube and the annular lumen of the device.

Fig. 3 D illustrates the use of the second medical device having an expandable tubular member for the delivery of a therapeutic agent to the left lung (continued arrow) while the systemic flow (discontinued arrow) of the right lung is maintained. For simplicity, the device is not shown in details. It is to be understood that the device of **Fig. 1** is used. Said device is introduced in the vessel such as, after expansion of the tubular member, the proximal annular ridge is positioned in the pulmonary trunk **PT**, the distal annular ridge is positioned in the **RPA** and the annular lumen is positioned at the entrance of the **LPA**. After positioning the device, systemic blood will flow from the **PT** to the **RPA**. The practitioner can then deliver the therapeutic agent to the **LPA** via the inner tube and the annular lumen of the device.

Fig. 3 E illustrates the use of the second medical device having an expandable bell shaped member for the delivery of a therapeutic agent to the right lung (continued arrow) while the systemic flow (discontinued arrow) of the left lung is maintained. For simplicity, the device is not shown in details. It is to be understood that the device of **Fig. 1G** is used. Said device is introduced in the vessel such as, after expansion, the bell shaped member is positioned in the **RPA**. After introducing the device, systemic blood will flow from the **PT** to the **LPA**. The practitioner can then deliver the therapeutic agent to the **RPA** via the inner tube of the device.

Fig. 3 F illustrates the use of the second medical device having a bell shape for the delivery of a therapeutic agent to the left lung (continued arrow) while the systemic flow (discontinued arrow) of the right lung is maintained. For simplicity, the device is not shown in details. It is to be understood that the device of **Fig. 1G** is used. Said device is introduced in the vessel such as, after expansion, the bell shaped member is positioned in the **LPA**. After introducing the device, systemic blood will flow from the **PT** to the **RPA**. The practitioner can then deliver the therapeutic agent to the **LPA** via the inner tube of the device.

The device of the present invention allows (i) to perfuse one full lung while maintaining the flow in the other lung; (ii) to stop flow in one lung while maintaining flow in the other lung and (iii) to withdraw the infused therapeutic agent to avoid its propagation in the body.

In a preferred embodiment, the device is introduced, by the practitioner, in the pulmonary artery for delivering a high dose or a high concentration of therapeutic agent to at least one lung or lung lobes. The blood inflow of the lung to be perfused is thereby interrupted. After delivering said therapeutic agent, the device will be maintained in the artery for a certain period of time or interaction time which is variable according to the nature of the introduced agent. Said interaction time allows the therapeutic agent to interact with the cells of the perfused lung. The device also prevents the therapeutic agent from flowing into the non-perfused organs of the body as the systemic blood inflow of the perfused lung is stopped by the introduction of said device. The interaction time can vary from few minutes to several hours. It is of from 5 to 180 min, preferably from 15 min to 150 min, more preferably from 30 to 120 min, even more preferably from 45 to 90 min, most preferably about 60 min. After the interaction time has passed, the practitioner can proceed to the withdrawal of the therapeutic agent excess by applying a negative pressure in the device inner tube. Afterwards, the device can be retrieved from the pulmonary artery, thereby restoring the systemic blood flow.

In another preferred embodiment, the device is introduced by the practitioner in the pulmonary artery for delivering a high dose or a high concentration of therapeutic agent to at least one lung or lung lobes. The veins of the lung to be perfused are occluded by the introduction of devices having

at least one occlusion means. By preference, said devices are also designed to allow perfusion via at least one vein of said lung. Said devices are known to the person skilled in the art. The introduction of said devices leads to the isolation of the lung to be perfused. The therapeutic agent is then delivered to the isolated lung via the device of the invention which is introduced in the pulmonary artery. The excess of the therapeutic agent can be withdrawn by the use of the devices introduced in the veins of the isolated lung. Here also, an interaction time can be provided to the therapeutic agent to interact with the lung cell before proceeding to the withdrawal of the therapeutic agent excess.

In a preferred embodiment, the outer diameter of the device having a bell shaped expandable member is of from 15 to 50 mm, preferably from 20 to 40 mm, more preferably from 25 to 30 mm, most preferably about 33 mm. The outer diameter of the device having a tubular shaped expandable member is of from 2 to 50 mm, preferably from 4 to 40 mm, more preferably from 6 to 30 mm, most preferably about 10 mm. The length of each expandable member is of from 10 to 100 mm, preferably from 20 to 80 mm, more preferably from 30 to 60 mm, more preferably about 50 mm.

When the second medical device, having a tubular expandable member, is used for liver treatment, it can be positioned in the vena cava with the proximal extremity just above the inflow of the renal veins. The proximal part of the device occludes collateral inflow from renal veins up to the annular lumen **18** around the hepatic veins. This isolation is assured by an annular ridge that is rounded at the end, preventing possible damage of the entrance of the right atrium even when placed deep into the right atrium. The annular lumen **18** around the hepatic veins is about 15-20 mm long. The practitioner will not encounter difficulties to position the device in front of the hepatic veins. With exception of the annular lumen **18**, the vena cava is in contact with the second medical device: from renal veins up to right atrium.

The minimum diameter of the central part **11** in the expanded state may be 45, 50, 55, 60, 65, 70, 76, 80, 85, 90, or 95% of the internal diameter of the vena cava, or a value between any two of the aforementioned values. Preferably the minimum diameter of the central part **11** in the expanded state is at least 50% of internal diameter of the vena cava. According to one aspect of the invention, the minimum diameter of the central part **11** in the expanded state is between 6, 8, 10, 12, 14, 16, 18, 20, 22 mm or a value in the range between any two of the aforementioned values, preferably 8 to 18 mm diameter.

The maximum diameter of the annular ridges **12,13** in the expanded state may be 5, 10, 15, 20, 25, 30, or 35% larger than the internal diameter of the vena cava, or a value between any two of the aforementioned values. Preferably the maximum diameter of the annular ridges **12,13** in the expanded state is between 10, 15, 20, 25, 30% larger than internal diameter of the vena cava. According to one aspect of the invention, the maximum diameter of the annular ridges **12,13** in the expanded state is between 20, 25, 30, 35, 40, 45 mm or a value in the range between any two of the aforementioned values, preferably 20, 26, 33 or 43 mm diameter.

According to one aspect of the invention, the difference between the maximum diameters of the annular ridges **12, 13** and the minimum diameter of the central part **11** in the expanded state may be 2, 3, 4, 5 or 6 mm or a value in the range between any two of the aforementioned values, preferably 4 to 5 mm diameter.

The region flanked by the annular ridges **12, 13** defines a liquid impermeable area. The skilled person will understand the adaptations to the tubular member **9** necessary to define a liquid-impermeable area that provide sealed annular lumen **18** in the deployed state. Generally, the liquid-impermeable area will extend between the annular ridges **12, 13**, from the region of maximum diameter of the proximal annular ridge **13** to the region of maximum diameter of the distal annular ridge **12**. It is within the practices of the skilled person to determine a lesser or greater area, for example, depending on the patency of the vessel wall.

Through the inner part of the tubular member extends a passageway **14** between the distal end **21** and the proximal end **20** of the tubular member **9**; blood is able to flow there between. The tubular member **9** comprises two liquid-permeable areas, one distal to the distal annular ridge **12** and one proximal to the proximal annular ridge **13**, so blood can flow from through the passageway from the distal end **21** and the proximal end **20** or vice versa. Preferably, the liquid-permeable region of the distal end **21** of the tubular member **9** comprises an open-mouthed region, while the liquid-permeable region of the proximal end **20** comprises a region **16** devoid of liquid-impermeable lining. According to one aspect of the invention the tubular member **9** comprises a carrier **2** and a liquid-impermeable liner **1**.

The carrier part **2** is typically, though not always, the outer most part of the device, and contacts the vessel wall in the deployed state. The carrier **2** expands in the manner mentioned above. The carrier **2** is preferably retractable which means that it normally adopts the hour-glass or dumb-bell shape mentioned above; when retracted into a cylindrical sheath, the carrier can be compressed to adopt an essentially cylindrical state, suitable for introduction into and freely positioning within a vessel. The carrier **2** can be described as being self-expanding. The carrier is attached to the catheter, to a pusher means **23** element therein described below. Preferably, the proximal end **20** of the carrier **2** is attached circumferentially to the distal end **21** of the pusher means **23**, so giving the proximal end **20** of the tubular member **9** and/or the bell shaped member **9'** a conical shape **16**.

The tubular member **9** and/or the bell shaped member **9'** and/or the carrier **2** is attached to the catheter **10** or pusher means **23**. It is configured to remain attached when the tubular member **9** and/or the bell shaped member **9'** and/or the carrier **2** is in the retracted and deployed position. According to one aspect of the invention, it is non-releasably attached; meaning that the tubular member **9** and/or the bell shaped member **9'** and/or the carrier **2** cannot be released, in situ, from the catheter **10** or pusher means **23**. In other words, the device may be devoid of a mechanism for releasing the tubular member in situ. This feature allows the tubular member and/or the bell shaped member to be withdrawn at the same time as the catheter **10**, without the possibility of leaving the tubular member in the vessel. A non-releasable attachment may still allow the member **9** and/or the bell shaped member **9'** and/or the carrier **2**, to be unattached from catheter **10** or pusher means **23** outside by the body, for example, using a screw fitting, a clip, a push fitting or any other secure coupling. A non-releasable attachment would also include the possibility that the member **9** and/or the bell shaped member **9'** and/or the carrier **2**, is permanently attached to the catheter **10** or pusher means **23**.

In the expanded state, the carrier **2** is able to retain its shape without the requirement for an additional source of pressure, for example, from a balloon catheter. The carrier **2** may or may not maintain an essentially constant axial length in the compressed state compared with the expanded state.

The carrier part **2** is preferably made of a braided wire mesh, woven so as to self-expand radially. In an embodiment, the carrier is made from a surgical wire preferably of an alloy comprising Cobalt, Chromium, Nickel, Molybdenum and Iron, and more preferably a surgical wire in accordance to the standard ASTM F 1058. Alternatively, the carrier part **2** may be a knitted mesh of nitinol wire flexible in both the radial and longitudinal axes. Alternatively, other materials, such as shape memory alloy or synthetic material, can be used to produce the carrier. The carrier part **2** may, alternatively, be laser cut. The shape of the central part **11** may be formed by using crimping or heat treatment. The carrier may show a high degree of flexibility and a radial force that assures a good contact with the vessel wall after positioning. The carrier part **2** is liquid permeable, which means that blood can flow there through, without substantial hindrance. This is achieved in the carrier because it is formed from an open wire structure and may comprise an open mouthed end. A liquid permeable region may comprise one or more openings, at least wide enough to avoid capillary action through the opening.

Because the carrier part **2** is preferably formed from an open mesh structure, it contacts the vessel wall securely in the expanded state, owing to the open structure, creating a plurality of friction points. In an expanded state, the device is securely anchored and provides strong sealing against the vessel wall. There is no requirement for applying additional pressure to the vessel walls, for example, from a balloon.

Another component of the tubular member **9** and/or the bell shaped member **9'** is the liner **1**, which is made from a liquid- impermeable material. This is typically attached partly to the walls of the carrier **2**, inside or outside the passageway lumen **14** of the device. The liner **1** is disposed at least in the region of the annular lumen **18**, so that the passageway lumen **14** is liquid-sealed from the annular lumen **18** in the deployed state. Preferably the liner **1** is disposed in an area defined at least by the region flanked by the annular ridges **12, 13**.

The liner **1** may be made from a biocompatible material, preferentially a medical grade expandable material e.g. an elastic material which can expand at the same time as the carrier **2**. The liner may be made from a medical grade polycarbonate polyurethane formulation. The liner may, alternatively, be made from ploytetrafluoroethylene, polyurethane, silicone or polyethylene terephthalate polymers. The most preferred materials are indicated in Table 1 below:

Table 1: Examples of preferred liner materials for use in the present invention. All brand names are registered trademarks.

	Supplier	Brand name	Elastomer
1	Polymer Technology group Inc, Berkeley CA, USA (Licensed by Boston scientific)	Bionate (Corethane)	Thermoplastic Polycarbonate Urethane
2	B.F Goodrich, Cleveland OH, USA	Estane	Thermoplastic Polyesther Urethane
3	Thermedics Inc, Woburn MA, USA	Tecoflex	Thermoplastic PolyetherUrethane
4	CT Biomaterials, Woburn USA	Chronoflex	Thermoplastic Aromatic Polycarbonate Polyurethane
5	Aortech, Sidney, Aus	Elasteon	Siloxane based Macrodiol Aromatic Polyurethane

The liner **1** may be attached to the carrier **2** of the tubular member and/or the bell shaped member by chemical or thermal bonding. The liquid- impermeable area formed by the liner **1** is disposed with one or more fluid ports **15** for blood passage; this is described in more detail further below.

Through the inner part of the tubular member **9** extends a passageway **14** between the distal end **21** and the proximal end **20** of the tubular member **9**; blood is able to flow there between. The tubular member **9** comprises at least two liquid-permeable areas, one distal to the distal annular ridge **12** and one proximal to the proximal annular ridge **13**, so fluid can flow from through the passageway **14** from the distal end **21** and the proximal end **20** or vice versa. A flow is indicated by arrows 'b' in **FIG. 1**. The skilled person will realize that liquid permeable areas should not extend into the liquid impermeable region so that the seal of the annular lumen **18** is breached. Preferably, the distal end **21** of the tubular member is open-mouthed, while the proximal end **20** is closed but is disposed with a liquid-permeable region **16** i.e. a region devoid of liner **1**.

The medical device having a bell shaped member does not allow for the maintain of the systemic blood flow as it occludes a vessel after expansion thanks to the presence of the impermeable liner which covers the carrier of said bell shaped member.

According to one aspect of the device having a tubular member, a region of the carrier **16** towards the proximal end **20** of the proximal annular ridge **13**, is devoid of liner **1**. According to another aspect of the invention, at least part of the carrier **2** between the distal end **21** of the catheter **10**

and proximal end **20** of the proximal annular ridge **13** is devoid of liner **1**. This creates a large liquid passageway **14** inside the tubular member **9** while the catheter **10** is still attached. This configuration has advantages over conventional designs which employ openings and lumens within the narrow confines of the catheter tube to maintain the flow of blood. Conventional lumens are narrow bore, and can cause the buildup of pressure towards the proximal side of the occlusion device. Known devices thus require catheter tubing having larger diameters to accommodate wider a blood lumen, which catheters can then be difficult to navigate along a tortuous path of a blood vessel for example. The present device, by contrast, dispenses with a catheter blood lumen, and maintains blood flow using a wide bore passageway in the expanding tubular member **9**, and with a narrow diameter catheter.

The catheter **10** part of the device is used to introduce and guide the tubular member **9** and/or the bell shaped member into the body vessel. The catheter **10** is also used to restrain, temporarily, the tubular member **9** in a compressed state at the distal end of the catheter. In use, the catheter is introduced to a desired site within a body vessel, the restraint is removed, thereby allowing the tubular member **9** and/or the bell shaped member **9'** to expand by its own elastic and apply sealing pressure to the vessel wall.

Examples of delivery systems for expandable members are described in the following US patents which are all incorporated herein by reference: US 5,484,444, US 4,990,151, and US 4,732,152.

In a preferred embodiment of the invention, the catheter **10** comprises an outer tubing **3**, pusher means **23** for deployment of the tubular member **9** and/or the bell shaped member **9'**, and an inner tube **5**, which extend along the length of the catheter. The pusher means **23** may be a pusher rod (or stick) **4** at least partly co-axially or concentrically disposed around the inner tube **5** (**FIG. 1A**). Alternatively, the pusher means **23** may be formed from the wall of the inner tube **5** (**FIG. 1B**).

The outer tubing **3** may be coaxially or concentrically disposed around the pusher rod **4**. Where the pusher means **23** is formed from the wall of the inner tube **5**, the outer tubing **3** may be coaxially or concentrically disposed around the inner tube **5**. The pusher means **23** is configured to translate axially along the length of the catheter, relative to the outer tubing **3**.

Where the pusher means **23** is formed of the wall of the inner tube **5**, the inner tube **5** may be configured to translate axially along the length catheter, relative to the outer tubing **3**. Movement of the pusher means **23** may be effected by operating a plunger **7** mechanically connected to the pusher rod **5** or inner tubing **5**, at the proximal end **20** of the catheter **10**.

The position of the outer tubing **3** may be maintained or adjusted using a grip area **6**. The distal end **21** of pusher means **23** is mechanically attached to the proximal end of the carrier **2**.

In a preferred embodiment of the invention, the catheter **10** comprises, (a) an inner tube **5**; (b) an outer tube **3**, (c) a pusher means **23**. Said outer tube **3** is surrounding at least a portion of the length of said inner tube **5**. Said pusher rod **4** may be disposed between said inner tube **5** and said outer tube **3**. Alternatively, the pusher means **23** may be formed of the wall of the inner tube **5**, in which case the outer tube **3** surrounds at least a portion of the length of said inner tube **5** whose wall forms the pusher means **23**. The pusher rod **4** is adapted for axial movement relative to said outer tube. The tubular member **9** is attached to the distal end of the pusher means **23**, and may be retracted in the outer tube **3** in the compressed state.

FIG. 2 illustrates the tubular member **9** and/or the bell shaped member **9'**, comprising the liner **1** and carrier **2**, retracted within the outer tubing **3** of the catheter **10**. In the compressed state, the tubular member **9** and/or the bell shaped member **9'** is maintained compressed by inner surface of the outer tube **3**, which acts as a restraint. **FIG. 2A** shows an embodiment wherein a closed tip **8** is provided to the device at the distal end **21**. **FIG. 2B** shows an embodiment wherein a conical

closed tip **8'** is provided at the distal end **21** of the device. Said conical closed tip **8'** acts as a dilator which helps opening and enlarging the vein during the introduction of the second medical device.

- 5 According to one aspect of the invention, the catheter **10** further comprises a restraining member disposed between said outer tube **3** and tubular member **9**, said restraining member being dimensioned to maintain said tubular member **9** and/or said bell shaped member **9'** in a compressed state.
- 10 The aforementioned restraining member may be a braided tube -or any other type of tube- surrounding said tubular member **9** and/or the bell shaped member **9'**, said braided tube preferably being made from a strong, flexible, filamentary material having a low coefficient of friction. Examples of such materials may be a fine polyester or metal wire. The braided tube may be formed directly over the tubular member **9** and/or the bell shaped member **9'**, preferably using
- 15 an automated braiding machine, or may be pre-formed and then inserted over the tubular member **9** and/or the bell shaped member **9'**. Where the braided tube is pre-formed and inserted over the tubular member **9** and/or the bell shaped member **9'**, the system preferably further includes a braid holding sleeve secured to the inner tube **5**, said braid holding sleeve being adapted to receive the proximal end of the braided tube. The distal end of the restraining member is preferably
- 20 mechanically coupled to the distal end of the outer tube **3** so that retraction of the outer tube **3** causes the restraining member to retract from the tubular member **9** and/or the bell shaped member **9'**, thereby allowing the tubular member **9** and/or the bell shaped member **9'** to self-expand. The catheter **10** and tubular member **9** and/or the bell shaped member **9'** may be inserted in a blood vessel and, preferably with the aid of a guide wire, maneuvered to its desired
- 25 position. The guidewire may be disposed with a separate guidewire lumen. Alternatively, the inner tube **5** may act as a guidewire lumen. The tubular member **9** and/or the bell shaped member **9'** may be deployed by moving the pusher means **23** axially in the distal direction, while the outer tubing **3** is held in a fixed position. Preferably, the tubular member **9** and/or the bell shaped member **9'** is deployed by retracting the outer tubing **3** axially in the proximal direction while the
- 30 pusher means **23** is held in a fixed position. The practitioner may position the tubular member appropriately to account for any shortening of the device during deployment. As the restraint of the outer tubing is removed, the tubular member **9** and/or the bell shaped member **9'** self-expands. The catheter may optionally be closed with a tip **8**.
- 35 As seen in **FIG. 1** the second medical device comprising the liner **1** and carrier **2** expands to its dumb-bell or hour-glass shape. Retrieval of the device after treatment is by withdrawing the tubular member **9** into the outer tubing **3**. This may be achieved by drawing the pusher means **23** towards the proximal end **20** while maintaining the position of the outer tubing **3**. Alternatively, the outer tubing **3** may be pushed towards the distal end **21** while maintaining the position of the
- 40 pusher rod **4**. Because the carrier **2** is connected to the pusher means **23**, the tubular member **9** is forced to take its non-expanded state inside the outer tubing **3** again. The device can then be carefully withdrawn from the blood vessel. This is also the case when the device is provided with a bell shaped member **9'**.
- 45 For devices having a tubular member, the inner tube **5** of the catheter **10** is in fluid connection with the one or more ports **15** present in the wall tubular member **9**. Said port **15** is disposed in the wall of the tubular member **9** in the region of the annular lumen **18**. The port **15** may be disposed in the central part **11**, and/or in the parts of the annular ridges **12**, **13** that form the annular lumen **18**. The port **15** allows the lumen of the inner tube **5** to be in fluid contact with the
- 50 annular lumen **18** so that a therapeutic agent can be delivered to the vessel. The port **15** may also act as an entry/exit point for a guidewire. Whether the second medical device is provided with one or more ports, the size of the ports **15** and the diameter of the inner tube **5** should be selected such as they are not obstructed by the particles if the treatment agent is delivered in said particles. Preferably, the ports are at least 1 mm wide and the diameter of the inner tube is at least 5 mm.

For devices having a bell shaped member, the inner tube **5** of the catheter **10** is in fluid connection with said bell shaped member **9'**.

The diameter of the inner tube is preferably > 1mm to prevent the piling up of particles which can occlude the device. The normal blood flow through the liver is about 1.5 – 1.8 liters/minute. The second retrievable medical device have a French size diameter of F18 (= about 6 mm), preferably the diameter is below F16 (= about 5.3 mm), thereby allowing a flow up to 2 liters/minute.

The skilled person will understand that the connection between the inner tube **5** and the ports **15** can be optimized so that expansion of the tubular member **9** does not result in axial tension in the inner tube **5**, or excessive slack along the inner tube **5**. According to one embodiment of the invention, the inner tube **5** of the catheter **10** extends from the outer tubing **3** and is in fluid connection with the annular lumen **18** via one or more ports **15**. In other words, the inner tube **5** may extend from the outer tubing **3** to connect with the ports **15**, as a continuous extension of the inner tube. According to another embodiment of the invention, the inner tube **5** of the catheter **10** is in fluid connection with a port **15** of the tubular member **9** using a bridging tubing.

FIG 5 shows one configuration of the inner tube **5** whereby a rigid bridging tube **19** is employed to connect fluidly a port **15** of the tubular member **9** to the inner tube **5** of the catheter **10**. **FIG 6** shows an alternative configuration of the inner tube **5** whereby an axially expandable bridging tube **19'** is employed to connect fluidly a port **15** of the tubular member **9** to the inner tube **5** of the catheter **10**. The latter bridging tubing **19'** is typically made from a flexible material which can expand by virtue of elastic properties and/or by use of a concertina-like folding of the unexpanded bridging tube **19'**.

FIGS. 3A and **3B** illustrate the device having a tubular member **9** which is deployed within a vessel **30**. The proximal **13** and distal **12** annular ridges contact the wall of the vessel **30**, and the central part **11** forms an annular lumen **18**. Blood (illustrated by arrow **b**) is able to flow freely through the unlined portion of the tubular member **9**. The annular lumen **18** may span the region of branched vessels **31** to **37**, wherein blood with therapeutic agent excess (illustrated by arrows **a**) will flow. Blood with therapeutic agent excess (illustrated by arrows **a**) flows then inside the inner tube **5**.

In **FIG. 3A**, the liner **1** is attached to the carrier **2** such that the liner is on the inside of the carrier **2**. **FIG. 3B** shows an alternative configuration whereby the liner **1** is on the outside of the carrier **2**.

The device having a tubular member is particularly useful for the minimal invasive and repeatable treatment of an organ. After positioning, as mentioned, before the device expands to achieve its dumb-bell or hour-glass shape. The proximal annular ridge **13** and distal annular ridge **12** (i.e. the end parts of the device) expand until they press against the inner wall of the vessel, thereby fixing the device at the selected position and providing a liquid tight seal inside the vessel. The central part **11** of the device expands to a lesser degree, thereby creating an annular lumen **18** between the device and the inner wall of the vessel. Inside the device is a passageway lumen **14** for bypassing the systemic blood past the sealed area. This way the passageway lumen **14** defines a new blood path to allow the continuation of the systemic blood flow during perfusion. The liquid tight sealing of the vessel by the proximal annular ridge **13** and distal annular ridge **12** and the liquid tight liner **1** of the device form a liquid tight barrier maintaining systemic blood flow through the passageway **14**.

The device having a bell shaped member is also particularly useful for the minimal invasive and repeatable treatment of an organ. After positioning, as mentioned, before the device expands to achieve its bell shape which expands pressing against the inner wall of the vessel, thereby fixing the device at the selected position and providing a liquid tight seal inside the vessel.

Depending on the type and positioning of the cells for treatment, the practitioner can decide in which vein to introduce the second medical device. During radioembolization of liver, the second medical device is introduced in the vena cava (VC), thereby isolating the blood brought to the VC by the HV.

5

Although the following describes the use of this system in a retrograde liver perfusion application, the application is only exemplifying. It is clear to a person skilled in the art that this system can also be used for treating other organs than the liver, this orthograde as well as retrograde.

- 10 In a preferred embodiment, for organs like liver and lungs wherein retrograde infusion is possible, the second medical device can be used for delivering the therapeutic agent or for removing its excess from an organ. The therapeutic agent could be delivered through the outflow of the organ, thereby loading it with a retrograde flow, i.e. against systemic pressure, assuring that it will stay in the organ. After some time the flow can be restored again and this will push the non-bonded
15 therapeutic agent out of the organ and can be conveyed by the VCD catheter.

- In a preferred embodiment, the present invention provides for the use of the second retrievable medical device having a tubular member for the repair of vessel's lesions. The second retrievable medical device is used for temporarily isolating a portion of the vasculature from both blood flow
20 and pressure. In the current practice, when a portion of the vasculature needs to be temporarily isolated from both blood flow and pressure in order to repair a damaged vessel or to perform an end-side anastomosis with a synthetic or natural graft, a surgeon needs to place cross-clamps to occlude all blood flow. Occlusion balloons can be placed in the aorta; however, a balloon has a tendency to migrate due to the aortic pressure. For example, when a graft is needed to bypass a
25 chronically occluded iliac artery, a preferred bypass is from the aorta near the bifurcation to the femoral. This is currently performed using an occlusion balloon in the aorta. The problems with using a balloon are that the legs can become ischemic and the balloon has a tendency to migrate due to the aortic pressure. The second medical device can be deployed between in the patient iliac and the aorta and the pressure and blood would be excluded from a portion of the aorta thereby
30 allowing the anastomosis of the bypass graft to be performed without excessive bleeding. The use of the second medical device eliminates both mentioned problems as the blood would be shunted to the legs and there would be no build up of pressure to cause a device to migrate. Cross-clamps can also be used on the aorta. However, cross-clamps can damage the intimae and if there is calcification in the vessel, it can cause an embolization. The second medical device is less
35 traumatic to the vessel.

- Fig. 16A** shows a vessel **131** wherein a lesion **130** is present. In order to repair the vessel **131**, the second medical device with or without the inner tube **5** is introduced in the vessel (**Fig. 16 B**) thereby providing the surgeon with a working space to repair the lesion **130**. The impermeability of
40 the liner results in very small or no blood leakage normal blood flow **BF** is not interrupted.

Although the present invention has been described with reference to preferred embodiments thereof, many modifications and alternations may be made by a person having ordinary skill in the art without departing from the scope of this invention which is defined by the appended claims.

Claims

1. A retrievable medical device for the delivery of a therapeutic agent to an organ, said device is provided with a distal end (21) and a proximal end (20); said device comprises a delivery catheter (10) suitable for deploying a self-expanding bell shaped member (9') at the distal end (21) of the catheter; the proximal end (20) of the bell shaped member (9') is attached to the distal end (21) of the catheter (10); said bell shaped member (9') is configured to expand radially and comprises a liquid permeable carrier (2) which is at least partially bonded to a liquid impermeable liner (1).
2. The medical device according to claim 1, wherein said carrier (2) is configured to adopt an essentially cylindrical state when compressed and to self-expand radially to form said bell shaped member (9').
3. The medical device according to claim 1 or 2, wherein the liquid impermeable liner (1) is bonded to the liquid permeable carrier (2) over the full length of said carrier (2).
4. The medical device according to claim 1 or 2, wherein the liquid permeable carrier (2) is partially bonded to the liquid impermeable liner (1) whereby said liquid impermeable liner (1) is forming an impermeable cup shaped area (1').
5. The medical device according to any of the preceding claims, wherein the carrier (2) of the medical device is made of a braided wire mesh.
6. The medical device according to any of the preceding claims, wherein the carrier (2) is made from a surgical wire that is: an alloy comprising Cobalt, Chromium, Nickel, Molybdenum and Iron, or nitinol, or a surgical wire in accordance to the standard ASTM F 1058.
7. The medical device according to any of the preceding claims, wherein the liner (1) is made from any of polycarbonate polyurethane formulation, ploytetrafluoroethylene, polyurethane, silicone or polyethylene terephthalate polymer.
8. The medical device according to any of the preceding claims, wherein the catheter (10) comprises:
 - (a) an inner tube (5);
 - (b) an outer tube (3) surrounding at least a portion of the length of the inner tube (5), and
 - (c) a pusher means (23) for deployment of the bell shaped member (9'), said pusher means (23) being:
 - a pusher rod disposed between the inner tube and the outer tube, or formed from the wall of the inner tube,
 - the pusher means (23) being adapted for axial movement relative to the outer tube,
 - the proximal end of the bell shaped member (9') being attached to the distal end of the pusher means (23), and disposed within the outer tube (3) in the compressed state.
9. The medical device according to any of the preceding claims, wherein the inner tube (5) is configured for the passage of the therapeutic agent.
10. The medical device according to any of the preceding claims, wherein the inner tube (5) is further configured to receive a guidewire.
11. The medical device according to any of the preceding claims, wherein the inner tube (5) of the catheter is in fluid connection with the bell shaped member (9').
12. Use of a medical device according to any of the preceding claims, for minimal invasive and repeatable organ perfusion of a living being.
13. Use according to claim 11, wherein said device is introduced in the pulmonary artery of a living being thereby infusing the lung and/or at least one lobe of the lung of said living being.
14. Use according to any claim 11 or 12, further comprising the step of withdrawing the device after perfusion.

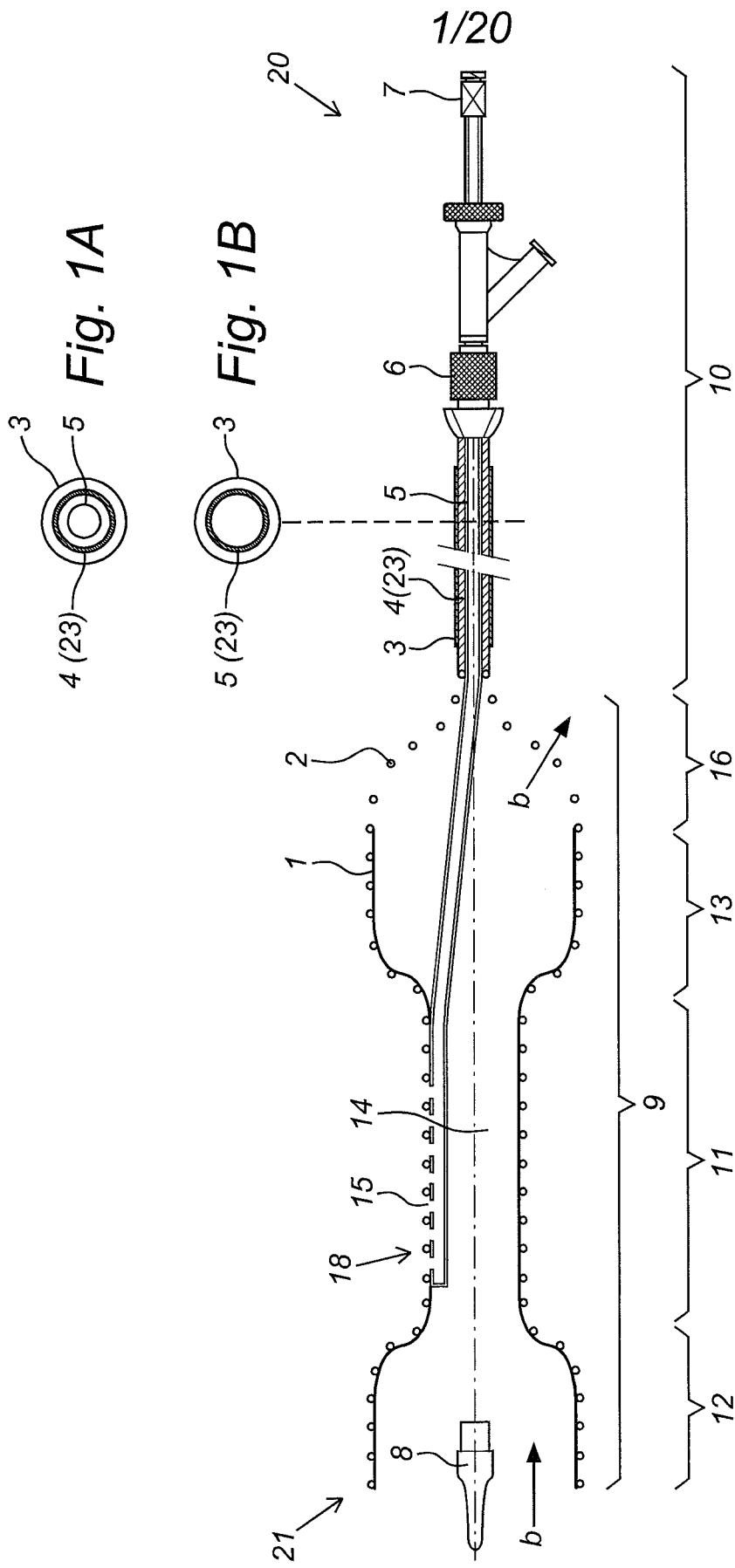


Fig. 1

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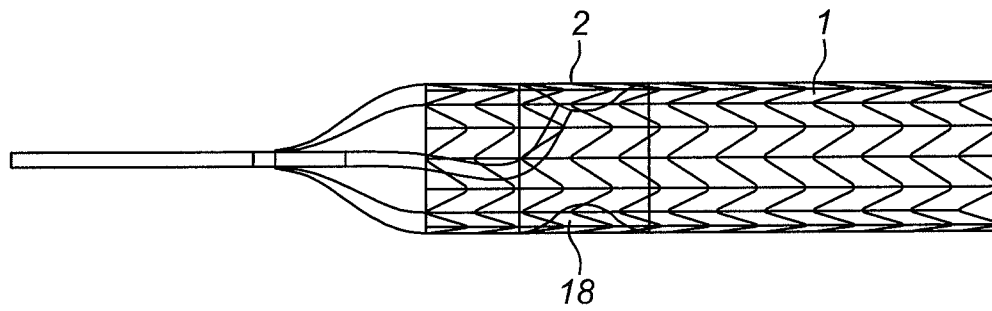


Fig. 1C

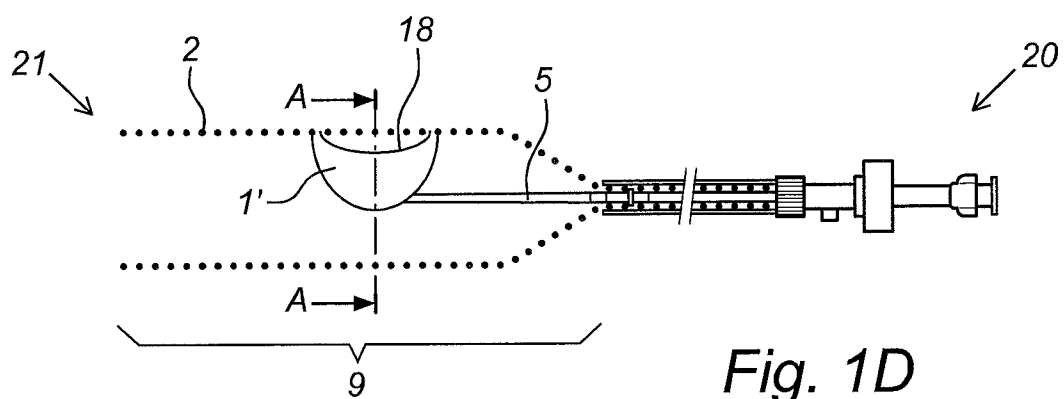


Fig. 1D

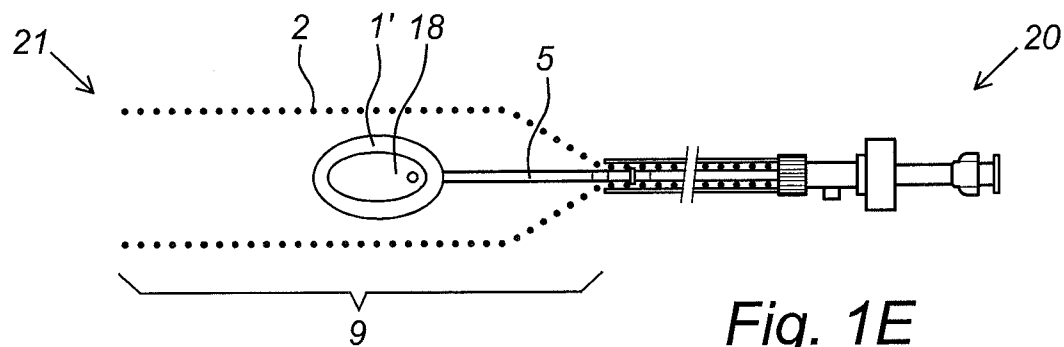


Fig. 1E

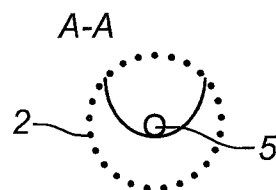


Fig. 1F

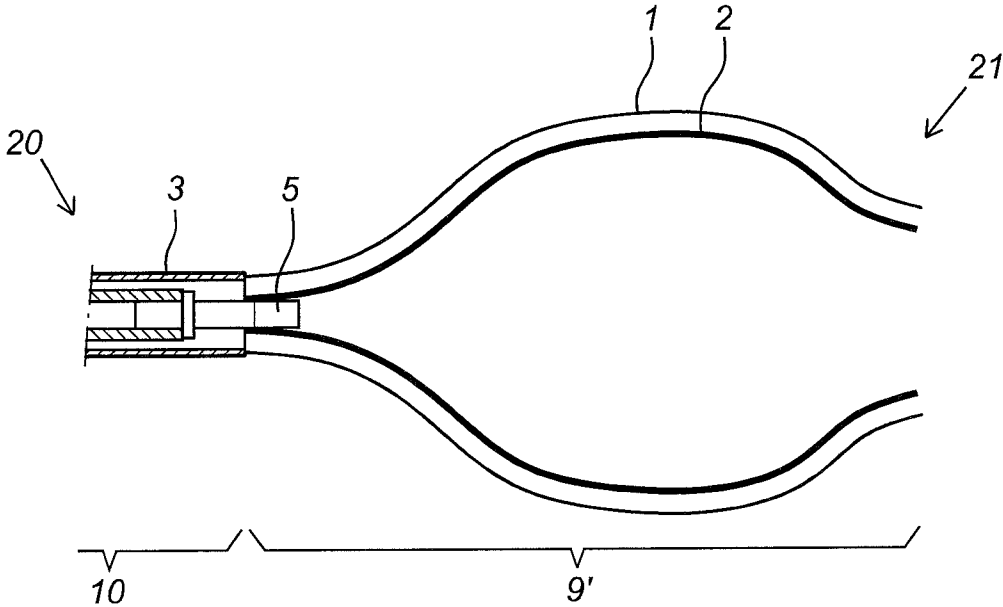


Fig. 1G

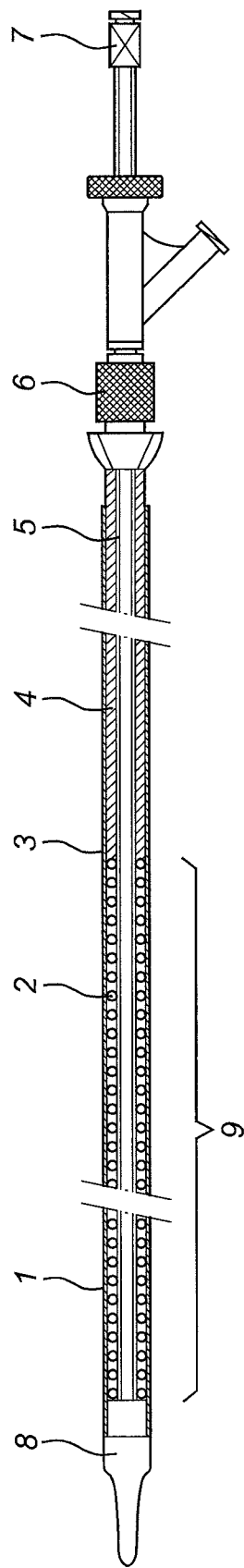


Fig. 2A

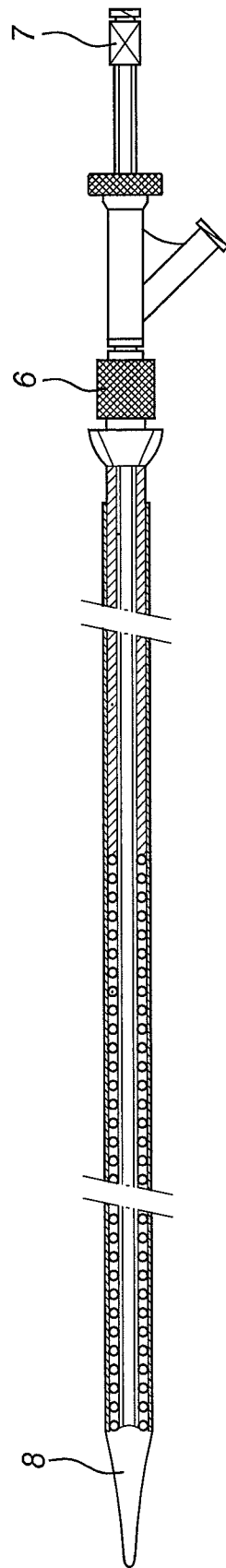


Fig. 2B

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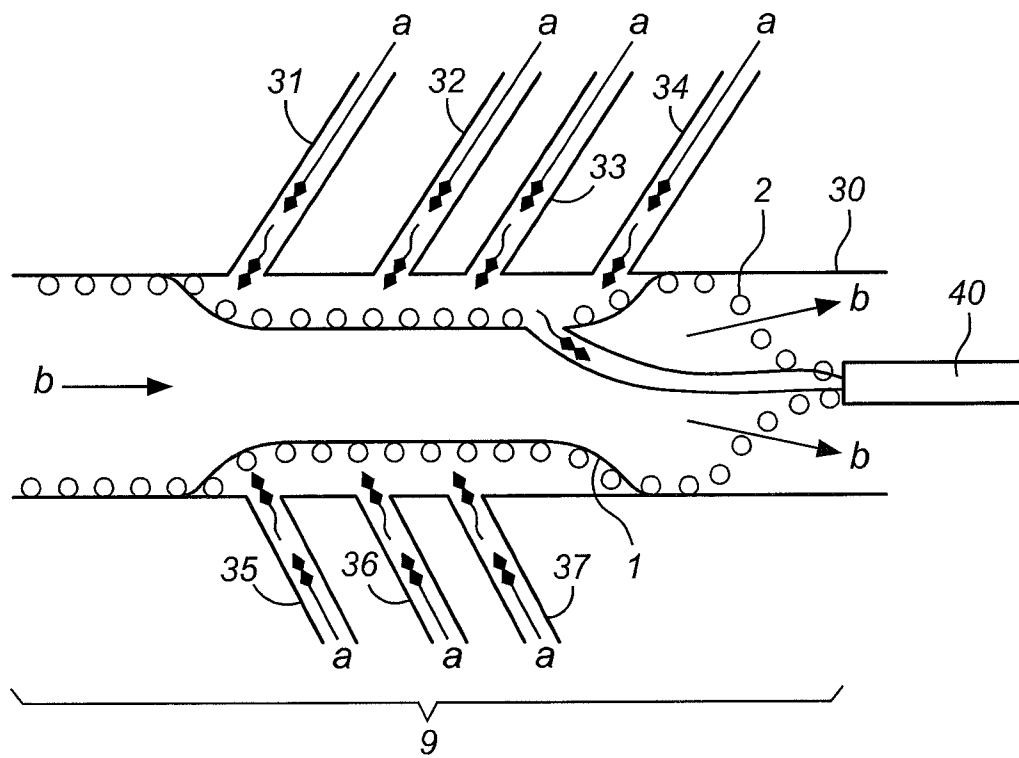


Fig. 3A

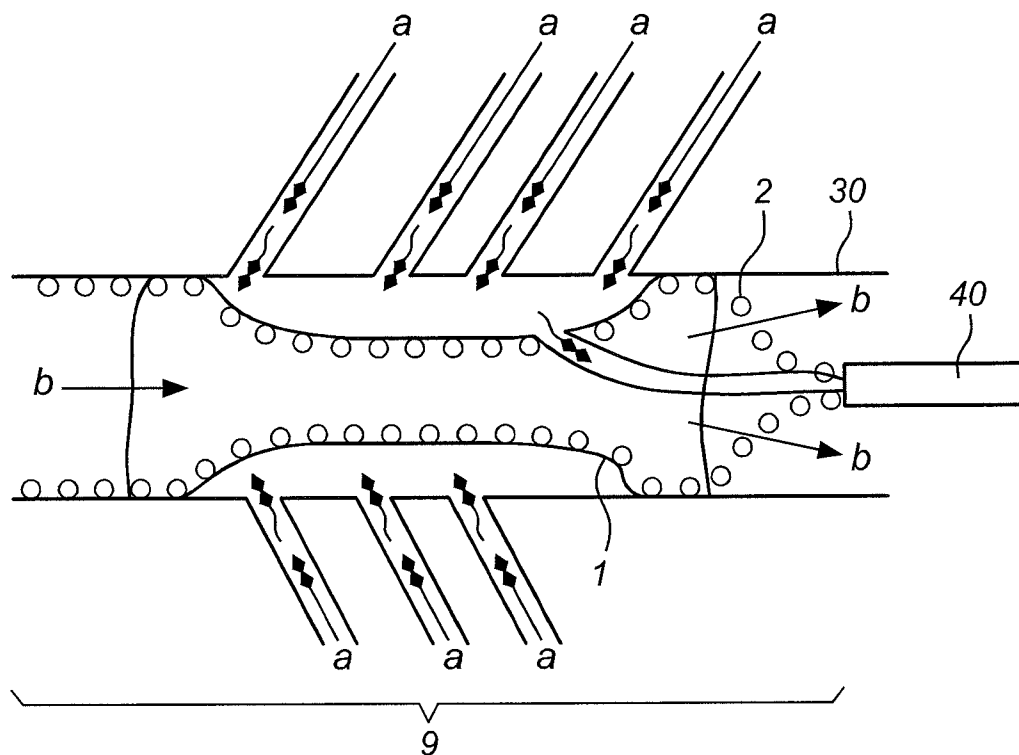
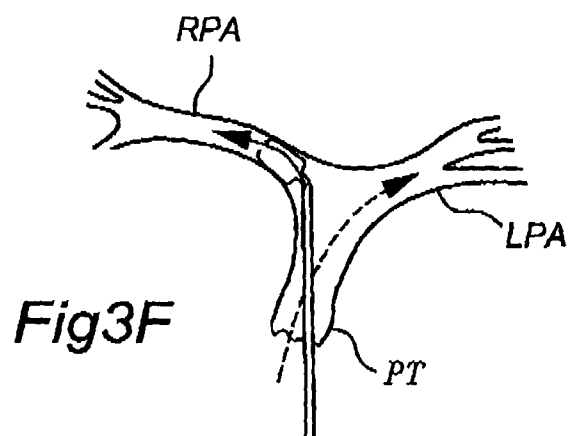
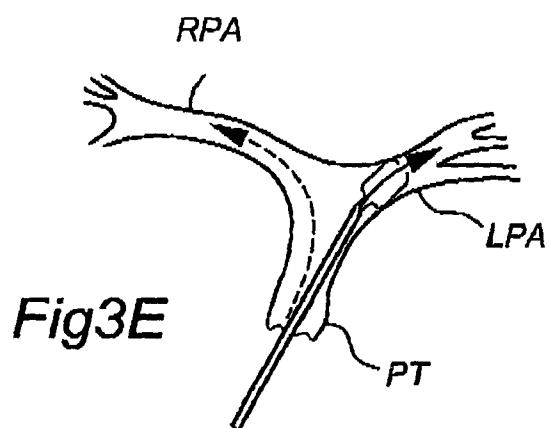
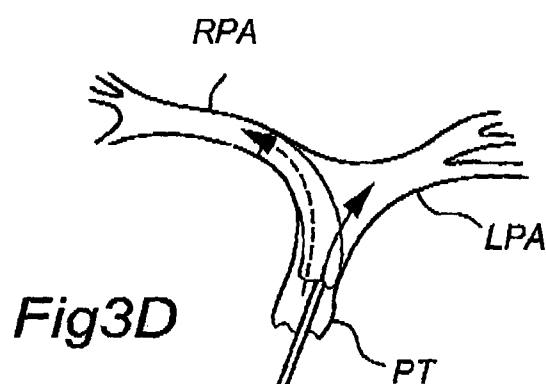
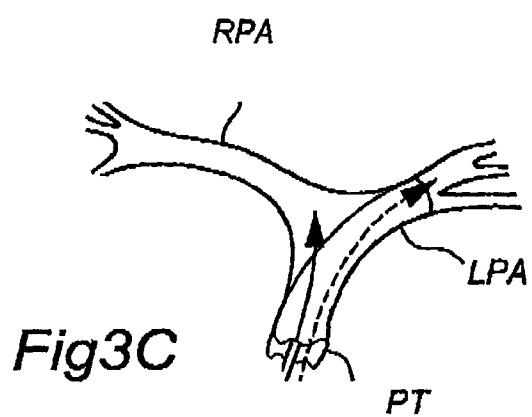


Fig. 3B

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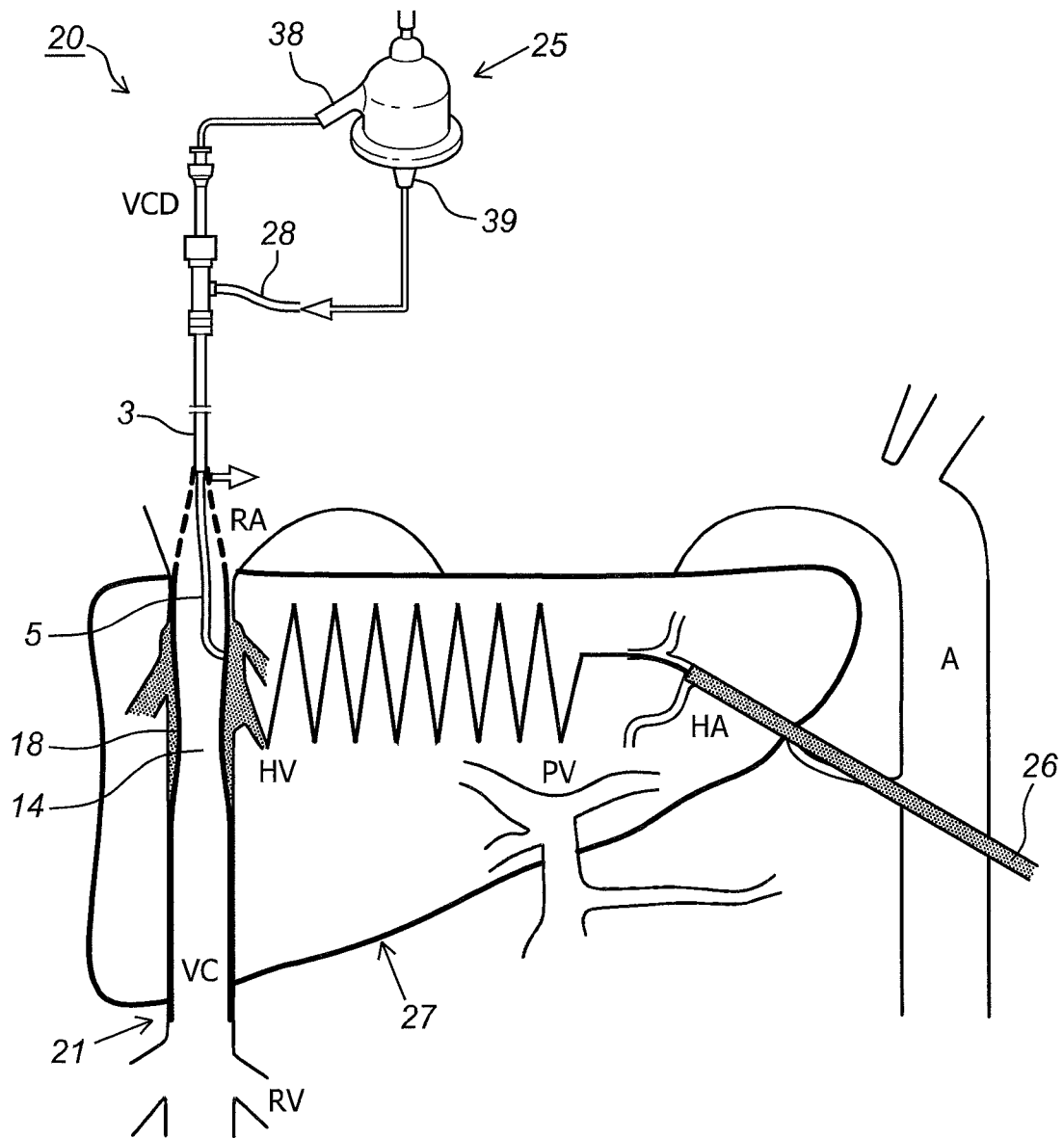


Fig. 4

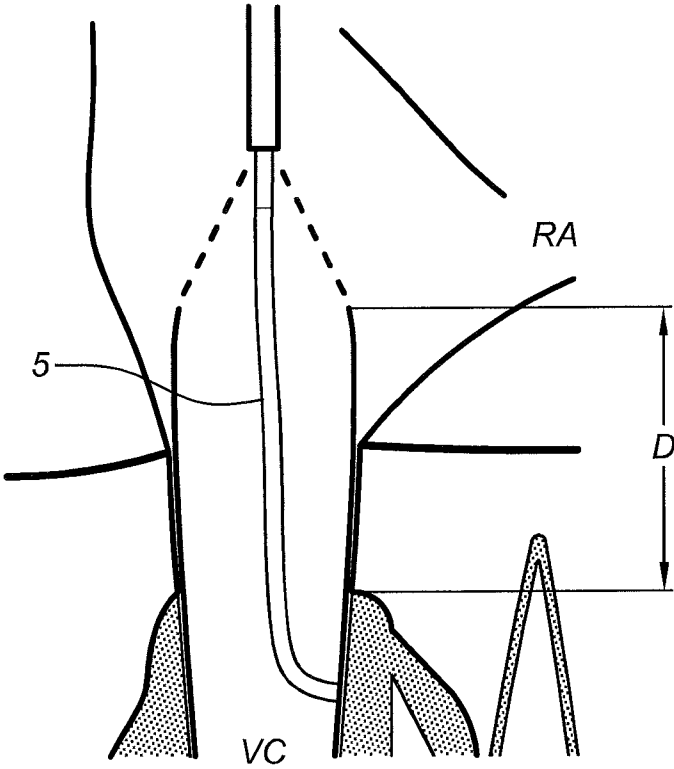


Fig. 5

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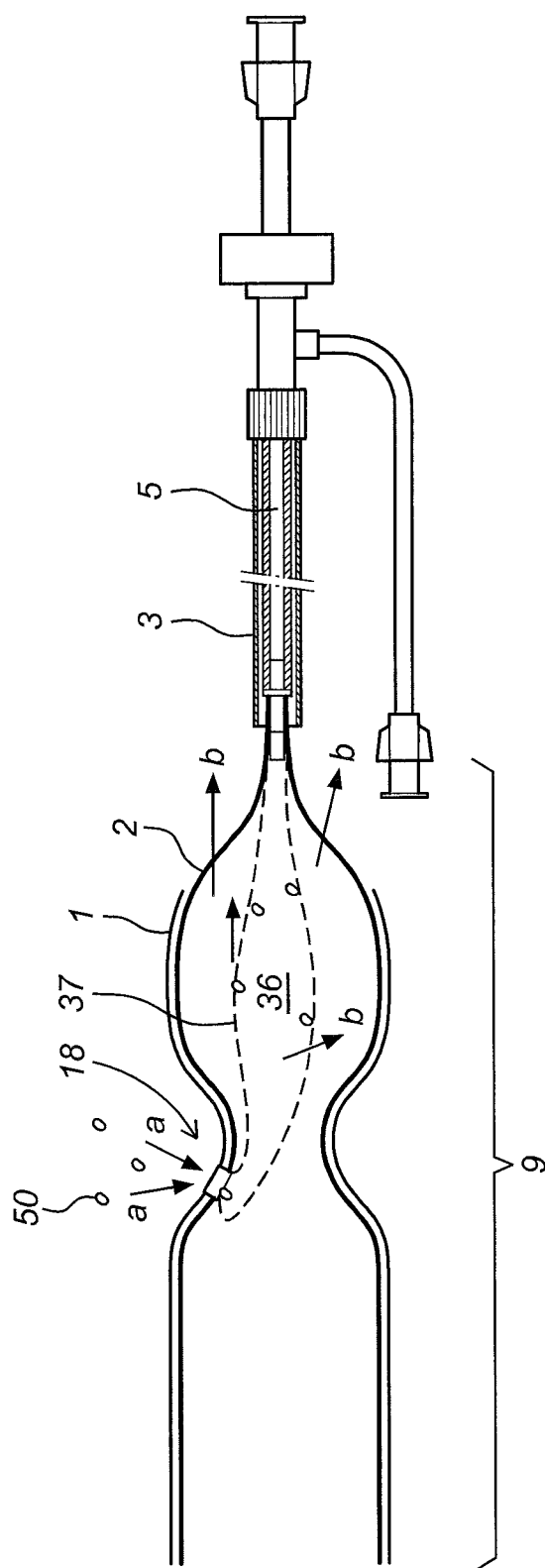


Fig. 6

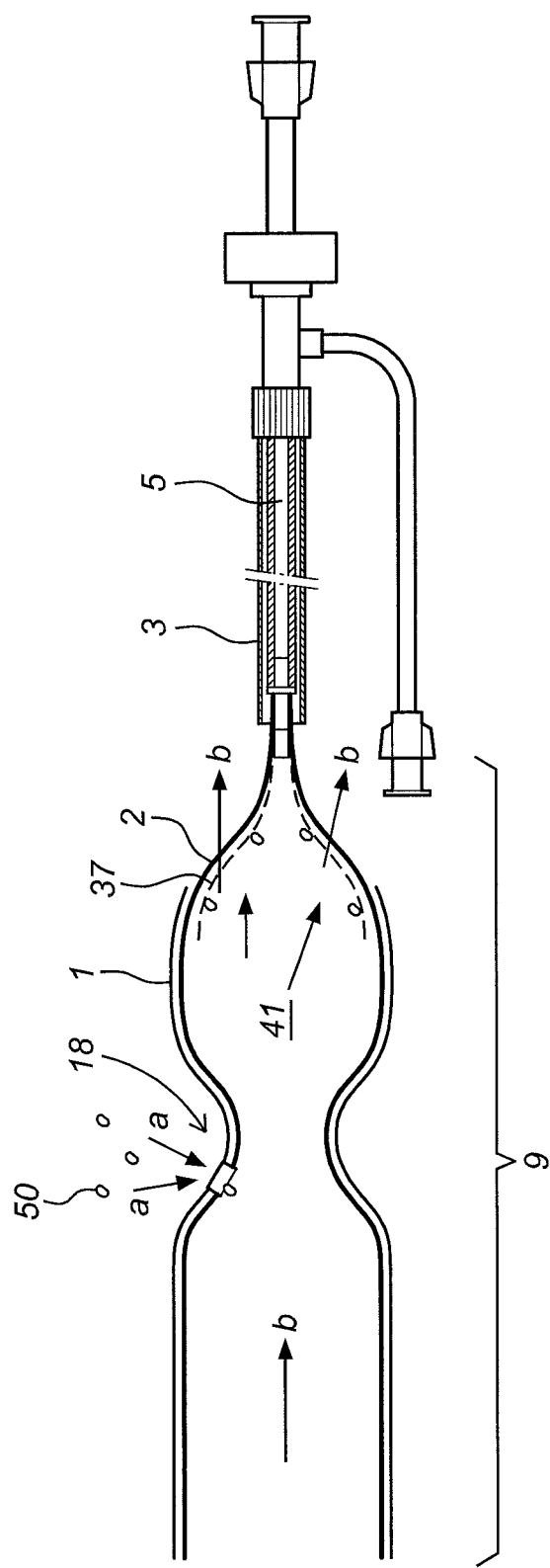


Fig. 7

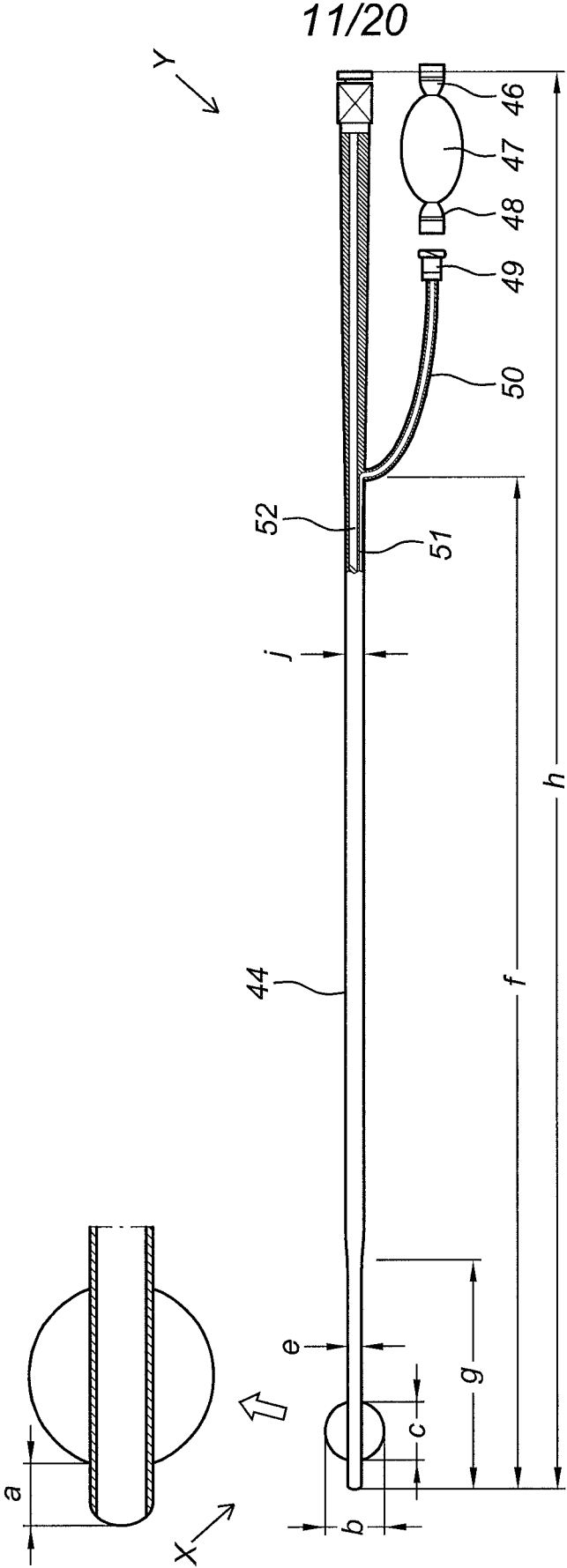


Fig. 8

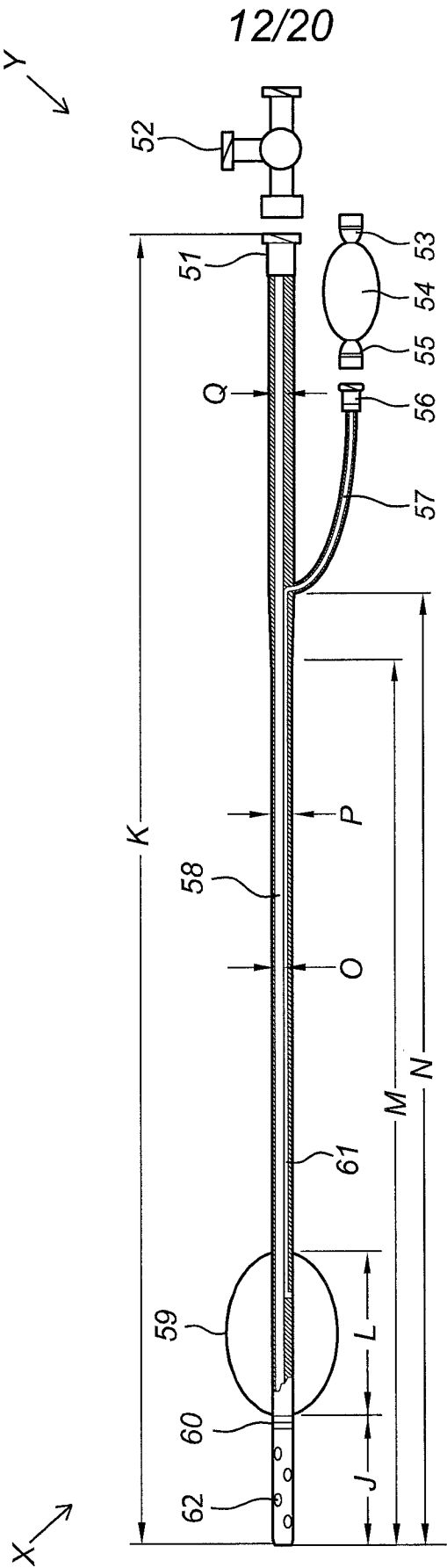


Fig. 9

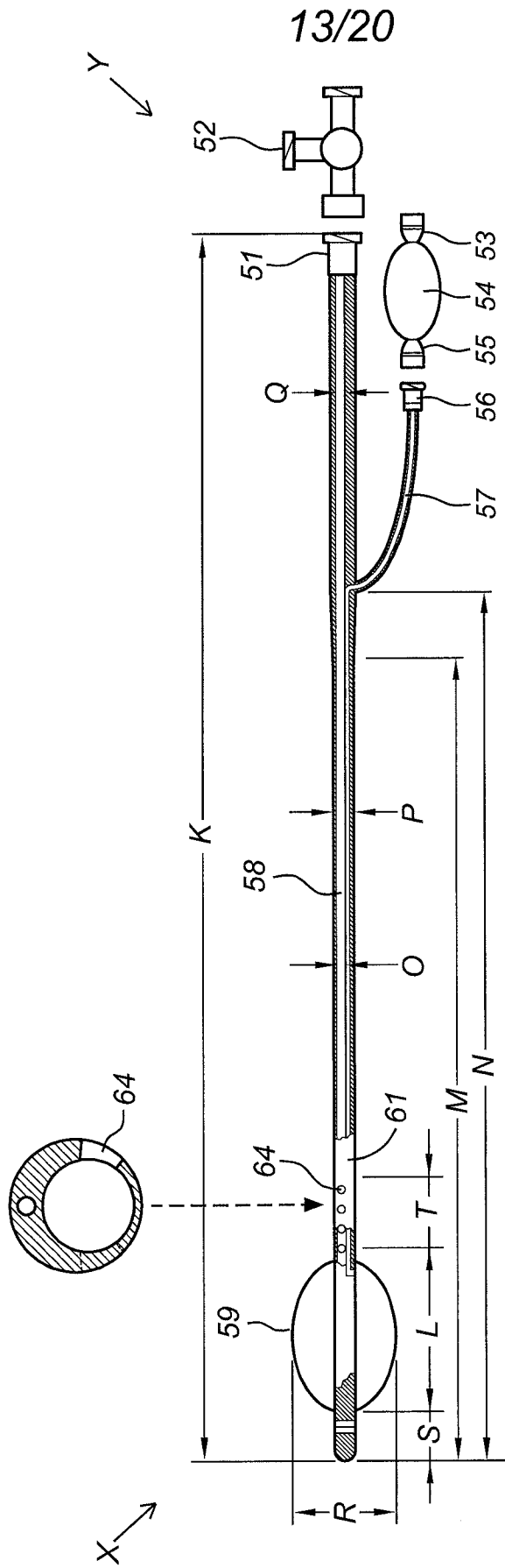


Fig. 10

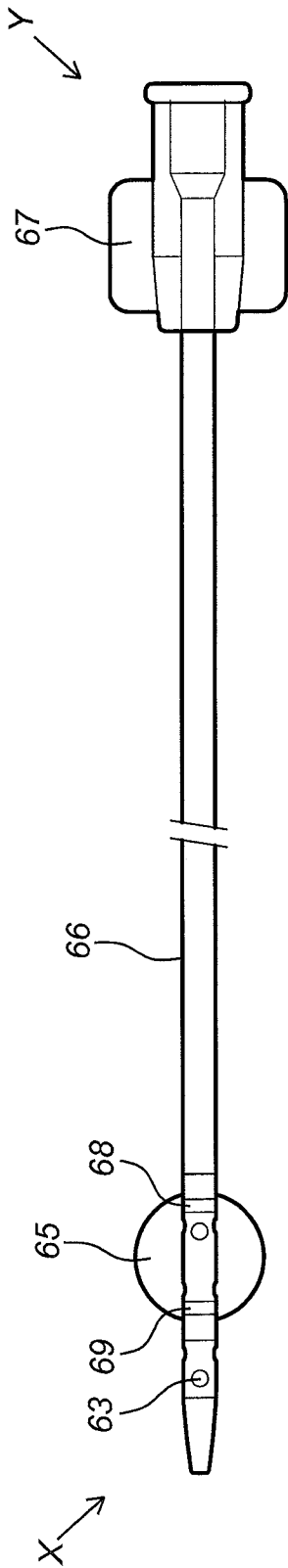


Fig. 11A

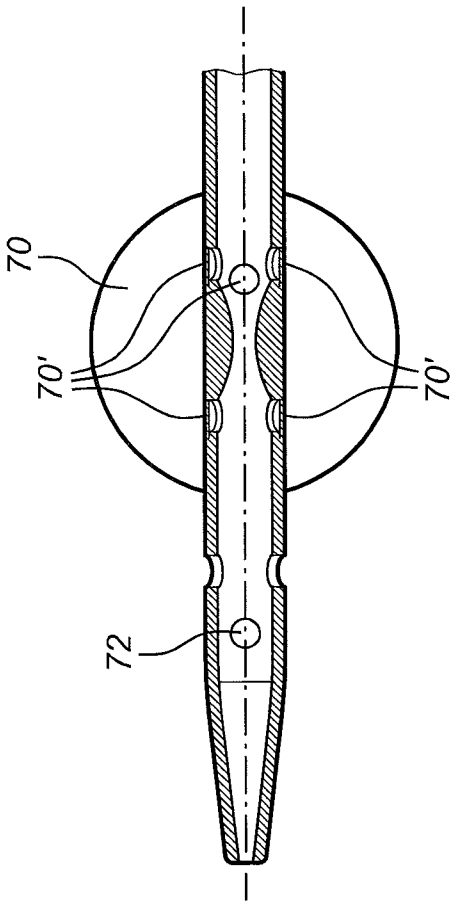


Fig. 11B

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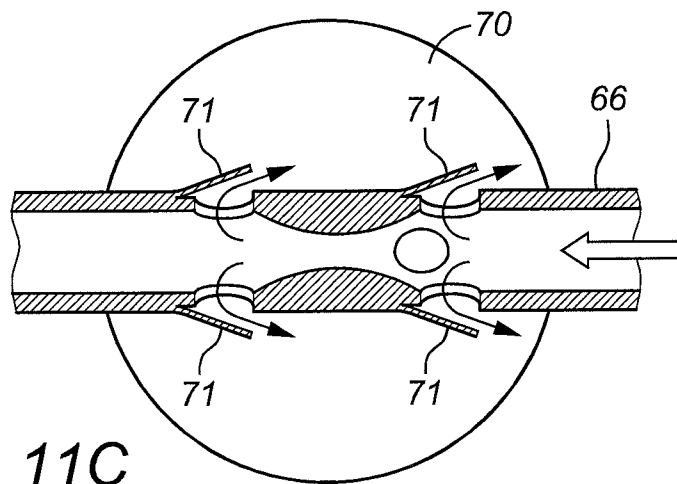


Fig. 11C

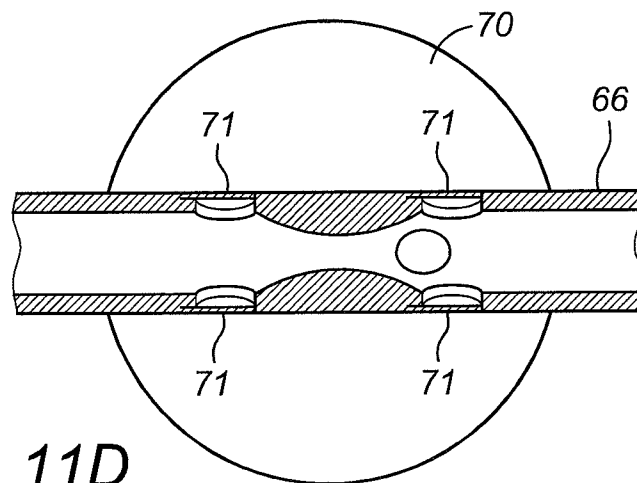


Fig. 11D

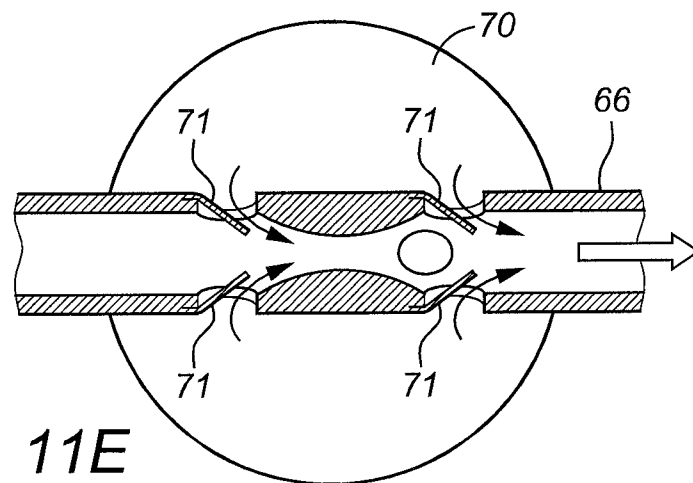


Fig. 11E

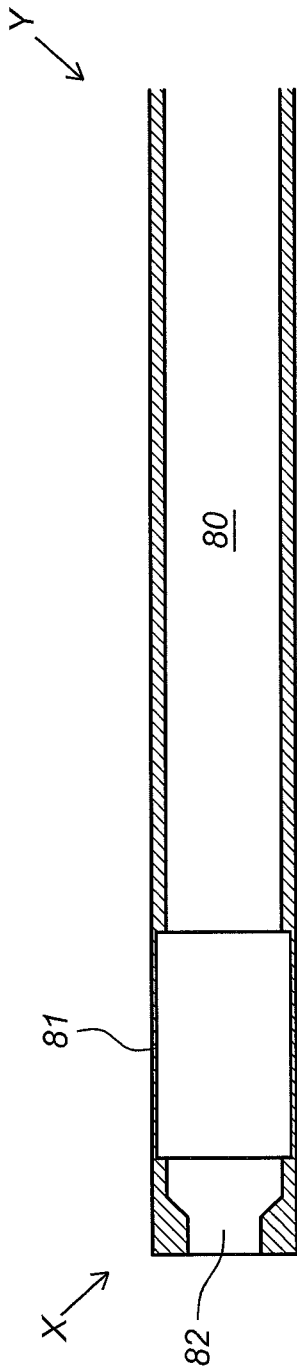


Fig. 12A

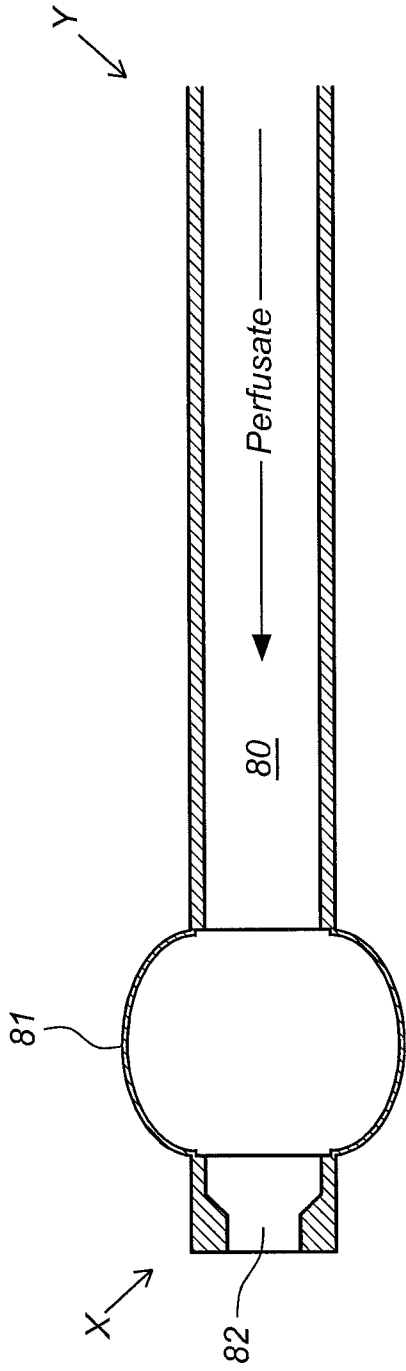


Fig. 12B

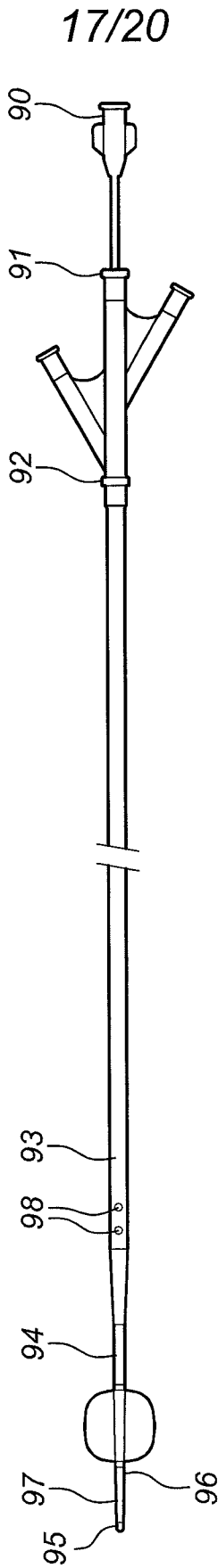


Fig. 13

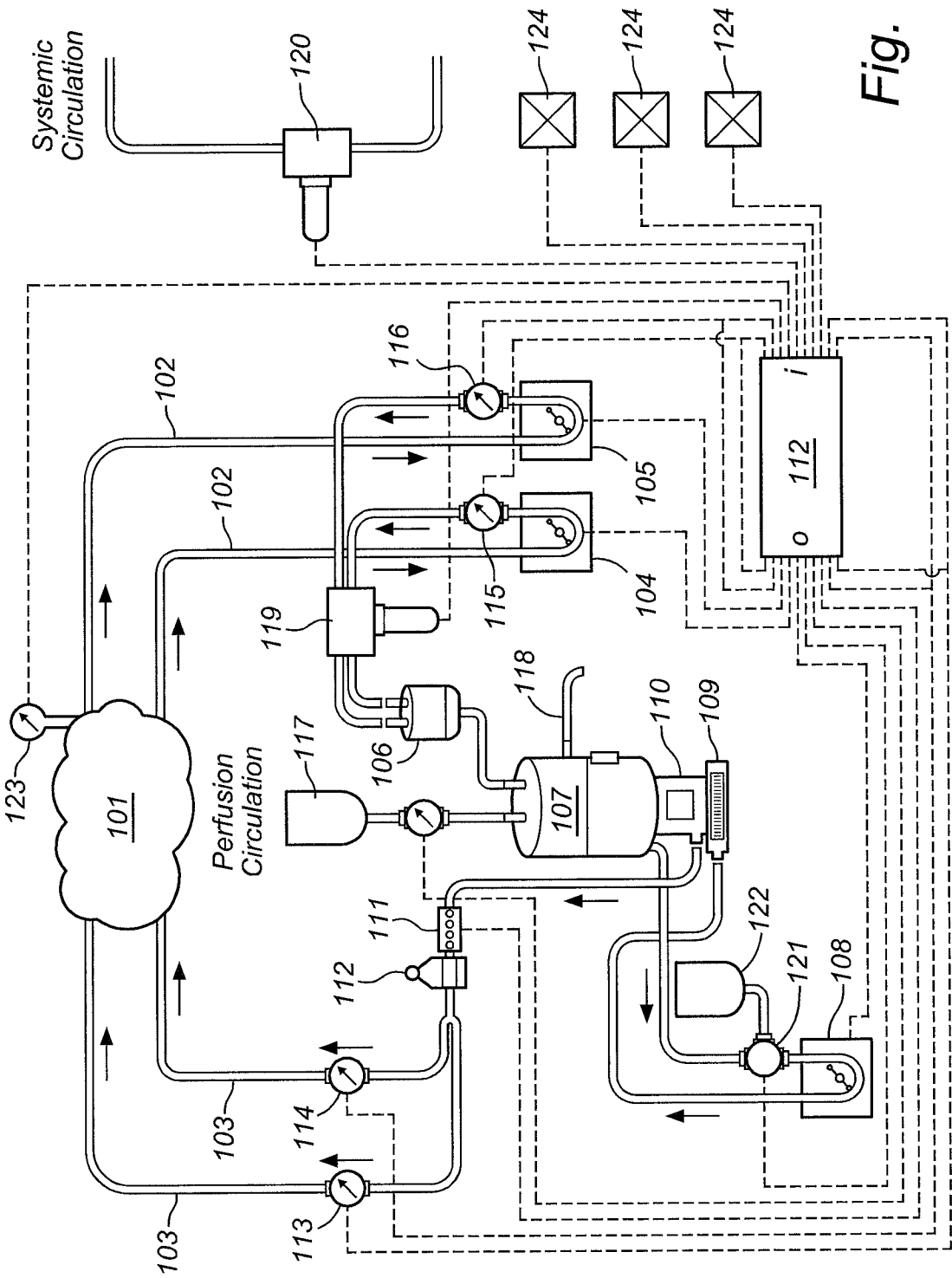
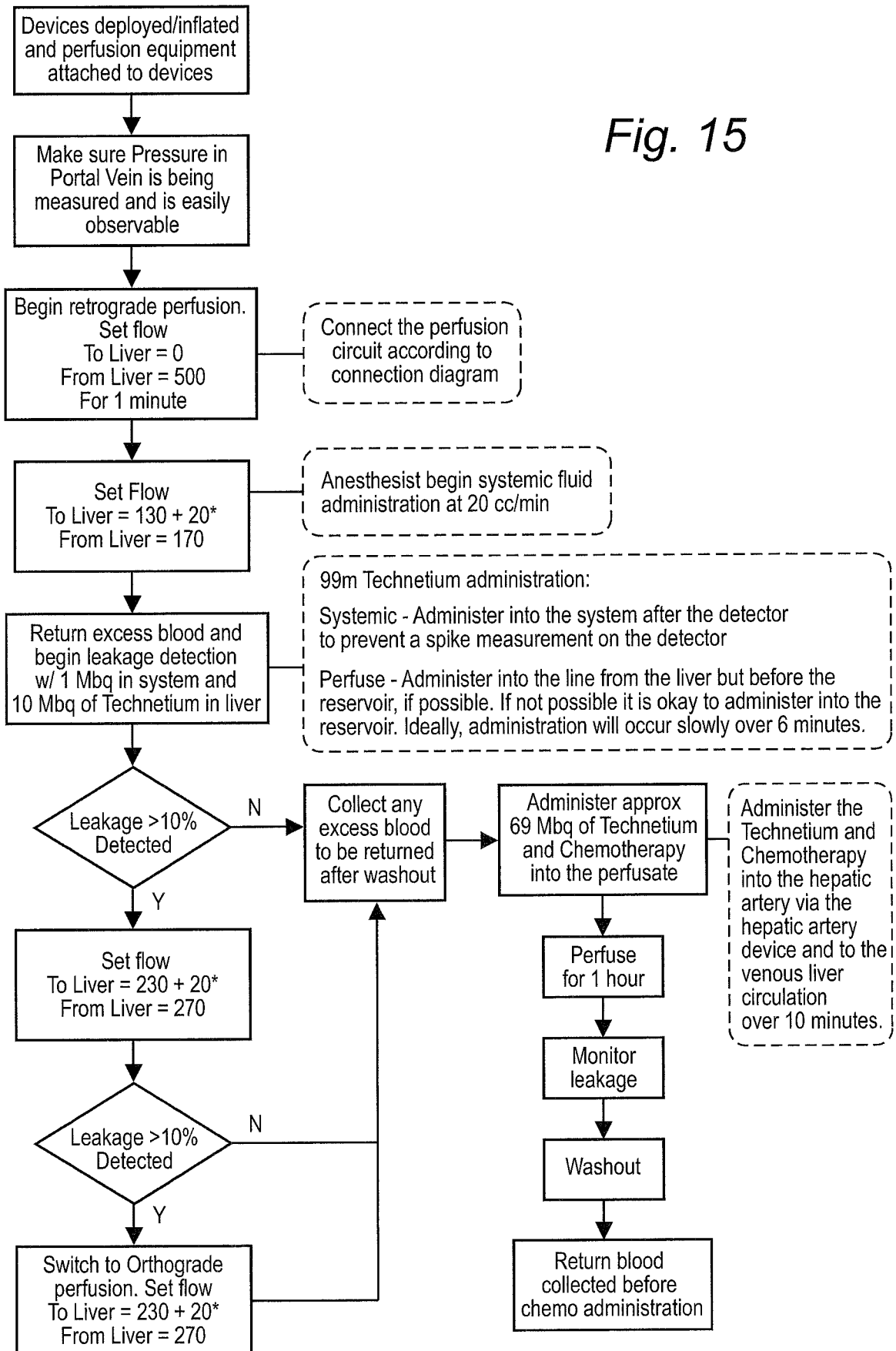


Fig. 14

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Fig. 15



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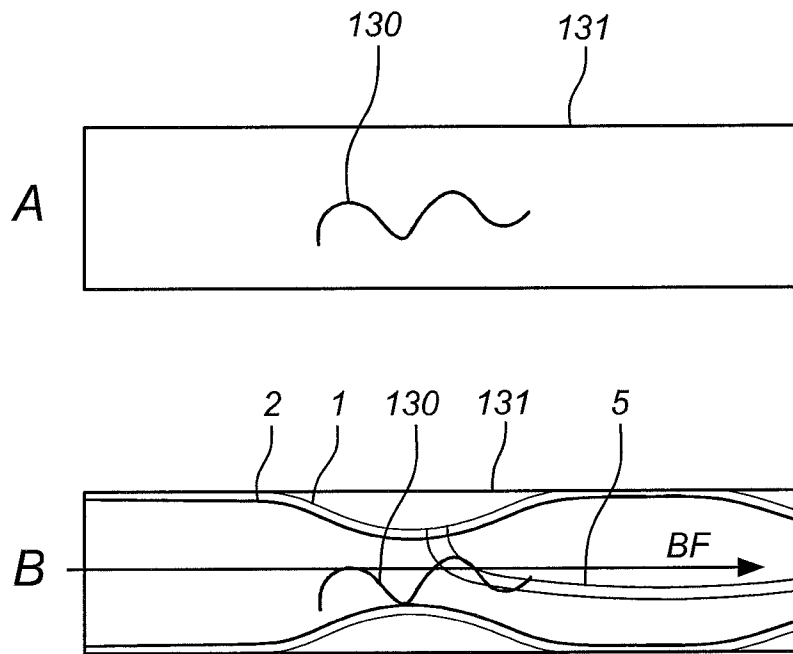


Fig. 16

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/054174

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B17/12 A61F2/82
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 A61F

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)

EP0-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2007/107327 A1 (MEDICAL DEVICE WORKS NV SA [BE]; FIERENS JOOST J [BE]; MARCOUX ERIC [B] 27 September 2007 (2007-09-27) the whole document -----	1-14

☐

Further documents are listed in the continuation of Box C.

☒

See patent family annex.

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"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

12 June 2013

Date of mailing of the international search report

19/06/2013

Name and mailing address of the ISA/

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Authorized officer

Amaro, Henrique

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2013/054174

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