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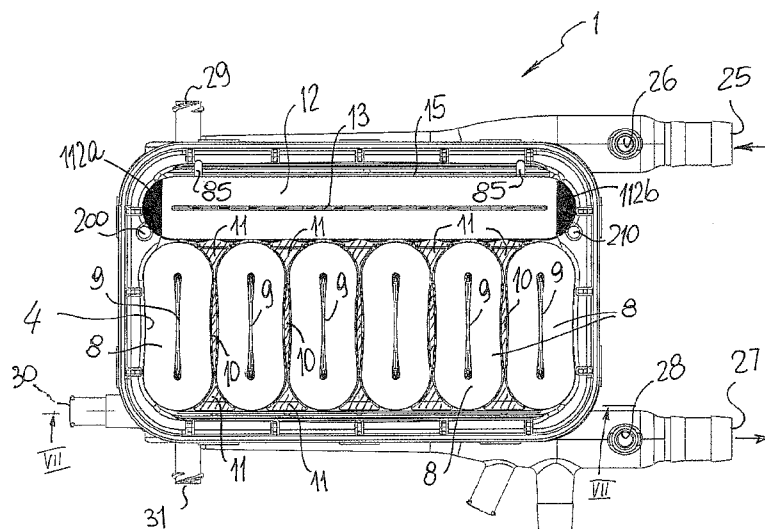


FIG. 2

(57) Abstract: The organic fluid oxygenator for extracorporeal circulation treatment of patients comprises: a three-dimensional container body (2), with an internal treatment compartment (4) bounded by inner walls; a gas exchange unit (12); a thermic-exchange unit (13); the oxygenator further comprises a substantially rigid frame (5) which is designed to be introduced into at least a first seat (6) and a second seat (7), which are contiguous to and separate from each other, in which said gas-exchange unit (8) and thermic-exchange unit (12) can be respectively accommodated, and which have fixed contours.

AN OXYGENATOR OF ORGANIC FLUIDS FOR TREATMENTS OF PATIENTS IN EXTRACORPOREAL CIRCULATION

Field of the invention

The invention relates to an organic fluid oxygenator for extracorporeal circulation treatment of patients, particularly a disposable blood oxygenator, which has a three-dimensional structure and a substantially cylindrical shape, in which blood is submitted to carbon dioxide washout, oxygenation and thermic treatment, as therapeutically needed by patients.

Background art

Disposable oxygen exchanging devices, known as oxygenators, have been long known and used in the medical field, with the purpose of releasing oxygen to blood and removing excess carbon dioxide during extracorporeal circulation treatment of patients.

These prior art devices consist of substantially cylindrical bodies, which enclose an oxygenation chamber with a gas exchange unit arranged therein.

The latter typically consists of a multitude of hollow fibers, which are arranged in parallel relation to each other and to the longitudinal axis of the cylindrical body, each having a lumen as large as a few hundreds of microns.

These hollow fibers are formed of a flexible membrane, which is only gas- and not fluid-permeable.

The ends of the hollow fibers are incorporated in two corresponding solid connection elements, known as "pottings", which are typically formed of polyurethane-based glues, and have the purpose of holding the ends in a fixed position.

In practice, the container bodies of these oxygenator devices, hereinafter simply referred to as oxygenators, have a first blood inlet and outlet pair, with blood being forced to flow in a predetermined path within the oxygenation chamber, and to lap the hollow fibers in a flow direction which,

according to the fluidic geometry of the device, may be substantially perpendicular or substantially longitudinal thereto, thereby becoming richer in oxygen and releasing excess carbon dioxide.

The cylindrical body also has two covers at the top and bottom ends thereof, in which a second inlet and outlet are formed, designed both for supplying oxygen gas, in pure form or diluted with other gases, such as nitrogen, and for discharging the carbon dioxide released to blood during oxygenation.

These oxygenator devices can be typically combined with heat exchangers, which are required for temperature control of the blood flowing in the extracorporeal circuit of the patient to be treated, and which require water "treated" by a heating or cooling device, generally known as "heater" or "cooler" or "heater-cooler", otherwise generally defined as "temperature baths".

In practice, a temperature control device may include, according to its geometry, a series of windings of hollow fibers with a temperature-controlled fluid flowing therein, or a flat plate, possibly knurled at its surface, which is equipped with a series of contiguous pleats, designed to be lapped with blood on one side and water on the other, like in the case of oxygenators, or a metal tube bundle.

The windings of hollow fibers may be accommodated in a special housing body, which may be separate from the oxygenator, but designed to be coupled thereto for connection to a circuit or, according to a more recent technique, the windings may be arranged in a special compartment defined in the oxygenation chamber of the oxygenator.

Typically, for operation of these temperature-controlled oxygenators, after such passage through a temperature control apparatus to reach a desired temperature, the blood to be oxygenated that comes from the patient and is carried by a transport conduit shall enter the oxygenation chamber through the inlet therefor, lap the multitude of hollow fibers having oxygen, or a mixture of oxygen and other diluting gases, flowing therein, receive oxygen

and simultaneously release carbon dioxide as a result of differential concentrations, and flow out of the outlet in an oxygen-enriched state, to finally reach the patient through a return connection line.

Oxygen, or the oxygen-containing gas mixture, enters its inlet and is released to blood while carbon dioxide is released by blood to the depleted oxygen that flows in the hollow fibers and is discharged through the outlet.

The motion of blood flow that comes from the patient, passes through the oxygenator and goes back to the patient is typically generated and maintained using a pump that may be mounted along an extracorporeal circuit that establishes connection between the patient and the oxygenator.

The pump action generates a pressure higher than atmospheric pressure in the oxygenator, which is sufficient to overcome the sum of the mechanical resistances encountered by blood as it flows through the treatment chamber that contains the hollow fibers, through the conduits that connect the various devices and those of the peripheral circulatory system of the patient, and eventually through the temperature control devices, if any, to ensure that circulation is maintained active all along the path defined by the extracorporeal circuit.

One requirement to be met by these temperature-controlled oxygenators is to provide an exchange surface area that is optimized for both oxygenation and temperature control, relative to their overall size, which has to be maintained within strict limits both due to bulk limitation and handling requirements, and because a considerable volume of blood has to be removed from the patient to fill and reach steady-state operation of an oxygenator and a temperature control device and the extracorporeal circuit attached thereto, even though it is diluted with suitable salines.

One oxygenator as described above is known from patent EP 0765683B1.

This patent provides an oxygenator that has a substantially cylindrical hollow body that defines therein a blood treatment chamber, with an exchange unit arranged therein, comprising a plurality of hollow plastic

capillaries spirally wound around an inner cylinder.

A further substantially cylindrical body is precision-mounted to the exterior of this first exchange unit, and has an exchange unit thereon, comprising a plurality of microporous capillaries spirally wound around said cylindrical body, to saturation of the gap between the two cylindrical bodies.

Both windings are embedded in a polyurethane resin, which simultaneously embeds both ends thereof, thereby simplifying the process of making the device, provided that the materials of the impermeable plastic capillaries of the heat exchanger and the micro-porous capillary fibers of the oxygenator are of the same nature.

A top cover and a bottom cover are also provided, with respective blood, oxygen and water supply chambers.

Both top and bottom covers are joined to the body of the device by precision-gluing thereof on such body, the top cover being joined to the edge that delimits the boundary between gas and water and the innermost boundary between water and blood, the bottom cover being precision-bounded to the body, at the edge that delimit the boundary between gas and water.

The box-like body has an outlet for the blood to be treated, including an annular chamber that has the purpose of collecting the blood that flows in from the inlet, through a special lumen, first into the exchange chamber of the heat exchanger in a substantially longitudinal, downward flow direction and then through radial lumens back into the exchange chamber of the oxygenator, in a substantially longitudinal upward direction.

Another oxygenator is known from WO95/26488.

This patent provides an oxygenator whose body is flattened along a first axis, which is formed by successively joining elements having a substantially planar component, with two main containing plates, and three different flow distributing plates or grids.

When the latter are joined together, they define two compartments in which two windings of hollow fibers are precision-mounted.

The first winding defines a blood treatment chamber which accommodates an exchange unit comprising a plurality of hollow, impermeable plastic capillaries, wound in successive layers around a flat element.

The next compartment accommodates an exchange unit comprising a plurality of micro-porous capillaries wound in successive layers around a flat element, and a plurality of capillaries formed of a micro-porous membrane, which form an additional winding.

Both windings are embedded in a polyurethane resin, which simultaneously embeds both ends of the windings, thereby simplifying the process of making the device, provided that the materials of the impermeable plastic capillaries of the heat exchanger and the micro-porous capillary fibers of the oxygenator are of the same nature.

Top and bottom covers, with oxygen and water supply and depleted gas and water discharge chambers respectively, complement the oxygenator.

Both top and bottom covers are joined to the body of the device, by precision-bonding thereof to the structure obtained by coupling the load-bearing elements and their covers on the edges that delimit the boundary between gas and water.

The box-like body defined by the two closing plates has a blood inlet and a blood outlet respectively and a series of secondary blood temperature sensing orifices are formed on the plate designed as the blood outlet side.

Connections are also provided for drawing cardioplegic blood and for micro-bubble discharge.

Blood enters through a connection on the plate and flows through both windings, in an upward flow direction, while being thermally conditioned and while capturing oxygen and releasing carbon dioxide in the second winding.

A further oxygenator is known from patent EP 0346302B1.

This patent discloses an oxygenator whose body is flattened along a first axis, wherein a succession of layers of hollow micro-porous fibers are

wound on an element or grid, in a double layer crossed geometry.

The winding is precision-fitted into a body and the outermost layer is held in contact with the surface of the container body, by means of two opposed longitudinal beams, which are in turn adjacent to the inner surface of the container body or directly formed in the inner surface thereof.

Some compression is exerted on the outermost winding of hollow micro-porous fibers, due to the geometrical interference caused by the difference between the overall size of the winding and the internal space of the body.

Such compression is transferred by the two longitudinal beams to the two lateral areas of the winding, with the purpose of forcing the blood across the above described structure, and throughout its height, with the two beams and the interference mounting arrangement preventing the flowing blood to bypass the above structure without exchanging oxygen and carbon dioxide with the oxygen and gas mixture that flows through the lumens of the micro-porous capillaries of the winding.

The structure of the winding is joined to the body using two polyurethane resin pottings.

The above described prior art suffers from certain drawbacks.

A first drawback is that the increase of pressure losses caused in prior art oxygenators by resistance to blood flow motion damages the red cells membranes and causes hemolysis, i.e. red cell (or erythrocyte) destruction.

A second drawback is that prior art oxygenators require their oxygenation and temperature control chambers to be filled with considerable volumes of blood, to be withdrawn and removed from the patient to fill, as mentioned above, the conduits of an extracorporeal circuit and the oxygenation and temperature control compartments, said volumes requiring compensation with additional adequate volumes of blood compatible diluents.

A third drawback is that prior art oxygenators tend to be exposed to quick deterioration of gas exchange performance.

A fourth drawback is that if prior art oxygenators are not used within a

short time from their fabrication and are not stored using criteria that can ensure stable effectiveness thereof, they tend with time to be exposed to degradation of the components mainly made of plastic materials.

This degradation may generate deformations of components and thus create undesired gaps or apertures that will act as free passages for blood that will flow through them without previously lapping the hollow fibers and without being adequately oxygenated and washed out of excess carbon dioxide, before reaching back the patient.

A fifth drawback is that the bundles of hollow fibers are introduced into their respective housings, both for oxygenation and for temperature control, in a peripherally compressed state, to allow proper fitting thereof without creating gaps through which blood might flow without being adequately treated before reaching back the patient.

This compression considerably affects the perviousness of the lumens of the hollow fibers located in the peripheral areas of the windings, especially those that contact or are contiguous to the walls of the oxygenation and temperature control compartments.

This partial reduction of the flows of blood and temperature control fluid reduces the velocity of such flows, due to an increase of flow resistances and creates, on the other hand, areas for blood stagnation, which may lead to clots, and other areas in which temperature control is imperfect due to the unevenness of the available hydraulic section.

Objects of the invention

An object of the invention is to improve the prior art.

Another object of the invention is to provide an organic flow oxygenator for extracorporeal circulation treatment of patients, that can prevent reduction of blood and temperature control fluid flows.

A further object of the invention is to provide an organic flow oxygenator for extracorporeal circulation treatment of patients, that can incorporate both oxygenation and temperature regulation features for blood or any organic fluid flowing in an extracorporeal circuit, in a single element.

A further object of the invention is to provide an organic flow oxygenator for extracorporeal circulation treatment of patients, that can be easily assembled and can maintain a substantially homogeneous pressure on the hollow fibers all over the windings.

In one aspect, the invention relates to an organic fluid oxygenator for extracorporeal treatment of patients according to the features of claim 1.

Therefore, the invention achieves the following advantages:

maintaining a homogeneous compression in the windings of hollow fibers which form both the gas exchange unit and the temperature control unit of the oxygenator, while maintaining a substantially homogeneous exchange section all over the hollow fibers;

preventing the formation of areas of flow velocity reduction and stagnation;

improving blood flowability in extracorporeal circuits, by reducing mechanical flow resistances in the oxygenation and temperature control area; and

providing an oxygenator that has a small size, with respect to the gas and heat exchange surfaces.

Brief description of the drawings

Further features and advantages of the invention will be more readily apparent upon reading of the description of an embodiment of an organic fluid oxygenator for extracorporeal circulation treatment of patients, which is shown by way of illustration and without limitation by the annexed drawings, in which:

Figure 1 is a perspective view of the oxygenator of the invention;

Figure 2 is a cross-sectional view of the oxygenator of Figure 1, as taken along a plane *II-II* of Figure 1;

Figure 3 is a partially exploded perspective view of the oxygenator of the invention;

Figure 4 is a perspective view of the oxygenator of the invention, with the upper portion partially exploded;

Figure 5 is a cross sectional view of Figure 2, with the windings of hollow fibers omitted;

FIG. 6 is an exploded perspective view of a frame inserted in the oxygenator of the invention;

FIG. 7 is a longitudinal sectional view of the oxygenator of the invention, as taken along a plane VII-VII of Figure 2;

Figure 8 is a perspective view of a top cover of the oxygenator of the invention;

Figure 9 is a bottom perspective view of the top cover of Figure 8;

Figure 10 is a perspective view of a bottom cover of the oxygenator of the invention;

Figure 11 is a top perspective view of the cover of Figure 10;

Figure 12 is a perspective view of a connection element disposed between the top and bottom covers and the body of the oxygenator of the invention;

Figure 13 is a bottom perspective view of the connection element of Figure 12.

Detailed description of a preferred embodiment

Referring to the figures, numeral 1 generally designates an oxygenator having a substantially cylindrical box-like body 2 and stiffening ribs at its periphery.

The body 2 has a plurality of inlet and outlet ports, that will be described in greater detail below.

Referring to Figures 2, 5, 6, it can be noted that the body 2 defines therein an inner treatment compartment 4, with a frame 5 being adapted to be precision-fitted therein, and to divide it into a series of hollow seats 6 and 7, as better shown in Figure 5, which are designed to accommodate an oxygenation unit and a temperature control unit for oxygenation and temperature control of an organic fluid to be treated, namely the blood of a patient that flows in an extracorporeal circuit, not shown, which is designed to have the oxygenator 1 mounted thereto.

The oxygenator assembly comprises a plurality of first hollow fibers 8, which are wound on rigid central ribs 9, to form a multiplicity of first windings 8 whose peripheral size is slightly larger than the inner size of the seats 6, such that they shall be peripherally elastically compressed beforehand to be introduced therein.

As soon as the first windings 8 are introduced into their respective seats 6, they are released and tend to be restored to their normal size, whereby they spontaneously adhere to the walls of the seats 6.

This conditions achieves two goals, i.e. affording a substantially even distribution of the residual peripheral pressure over all the hollow fibers of the hollow fiber windings 8 and removing any gap between these and the walls of the seats 6 and 7.

Still referring to Figures 2, 5, 6, the frame 5 is shown to also define a plurality of generally flat parallel diaphragms 10 that separate the seats 6.

Each diaphragm 10 comprises a substantially sheet-like central body and two enlarged ends 11, which are shaped to deflect blood flows for the latter to enter the first windings 8 of hollow fibers.

The skilled person will understand that the term "hollow fibers" is typically intended to designate a plurality of substantially rectilinear capillaries, which are in parallel integral arrangement, and have open lumens at their ends as small as a few tens of microns.

These hollow fibers are formed from liquid-impervious, gas-pervious membranes, whereby a liquid may flow inside or outside them, without mixing with any gas that would lap the exterior or the interior of them, or vice versa.

As shown in greater detail in Figure 5, the frame 5 only partially fills the treatment compartment 5 and leaves the above mentioned seats 7 clear.

These seats 7 are designed to accommodate a second winding of hollow fibers 12, which are wound around a central rib 13, perpendicular to the ribs 9, and which form the temperature control unit of the oxygenator 1, as better explained hereinafter.

It shall be noted that, for better operation of the oxygenator 1, the

second winding of hollow fibers 12 has an elongate shape and is oriented perpendicular to the ribs 9, thereby forming two opposed ends 12a and 12b having a rounded shape.

These two opposed ends 12a and 12b of the winding of hollow fibers 12 are embedded in respective solid and rigid elements 112a and 112b, known as pottings, which are designed to prevent blood flows from being slowed down at the end areas, as is the case with prior art oxygenators, and to prevent the resulting undesired blood stagnation, which might lead to the formation of solid or semi-solid clots, that may release cell materials injurious to the patient.

The two pottings 112a and 112b are formed by introducing a liquid-state polyurethane resin, that has been mixed but has not been cured yet, into two channels 200 and 210 specially formed in the inner wall of the treatment compartment 4.

The covers 19 and 20 are fixed to their box-like body 2 by using glues or a series of hooking teeth 150, which formed at the periphery of the edge of both ends of the box-like body 2 and are designed to engage with corresponding hooking slots 151 formed at the periphery of the inner contours of the covers 19 and 20.

Referring now to Figures 3 and 4, a seal 50 and a connection element 60 are shown between the covers 19 and 20.

The seal 50 has two stems 51a and 51b, which are designed to be temporarily fitted into the two channels 200 and 210 during preparation of two further solid elements 21 and 22, known as pottings, as better described below, through two special holes 61a and 61b formed in the connection element 60, and axially aligned with the two stems 51a and 51b.

As shown in Figures 4, 6, 7, the walls of the frame 5 have perforations 14 which, according to the use of the oxygenator 1, i.e. according to the type of organic fluid to be temperature-controlled and oxygenated, may have predetermined shapes, orders and sizes, in view of not blocking the flows therethrough.

The central rib 13 also has perforations and the second winding of hollow fibers 12 is contained between the frame 5 and a retaining wall 15, also perforated, which extends parallel to the central rib 13 and is inserted in the treatment compartment 4, between the wall of the latter and the winding of hollow fibers 12.

As shown in Figures 2 and 5, both the retaining wall 15 and the frame 5 have spacer members 16 and 17 respectively, which are designed to abut against the inner walls of the treatment compartment 4 and keep both slightly spaced therefrom, such that two parallel laminar chambers 18 and 18' are defined, and against the larger walls of the treatment chamber 4.

More in detail, the retaining wall 15 has in turn a pair of hooks 85, located proximate to both ends, which are required to structurally hold the retaining wall 15 to the box-like body 2.

Referring now to Figures 1, 3, 7, it will be noted that the body 2 has two respective closing covers 19 and 20 at the top and bottom ends, and also the windings of hollow fibers 8 have the ends embedded in two additional solid elements 21 and 22, known as pottings, with the one designed to be the upper potting, i.e. the element 21, having an inclined inner surface 21a to promote spontaneous outflow of any air collected in the treatment compartment 4.

As still shown in Figure 7, two accumulation chambers 23 and 24 are defined between the two elements 21 and 22 and the inner surfaces of the two covers 19 and 20, whose function will be described below.

More in detail, as shown in Figures 9 and 11, the inner surfaces of the two covers 19 and 20 have raised ribs 100 extending into the treatment compartment 4 and forming both the two accumulation chambers 23 and 24 and two housings 23' and 24' contiguous to the latter, which are designed to receive the ends of the second winding of hollow fibers 12 when the oxygenator 1 is in the assembled state.

As mentioned above, the body 2 has a series of ports for access to the inner treatment compartment 4 from the outside, which include a first inlet

port 25 for the organic fluid (blood) to be oxygenated, shaped as a tube segment in which a second accessory port 26 is formed, through which a parameter of the inflowing organic flow is measured, namely venous blood pressure.

The body 2 also comprises an outlet port 27 for the organic fluid that has undergone oxygenation, such outlet port also having an accessory port 28 for measuring a parameter of the outflowing organic fluid, namely the pressure of the arterial blood sent back to the patient.

In addition to these ports, there are provided three ports for bleeding air from the treatment compartment 4, which are referenced 29, 30, 31 and two additional ports 40 and 41, each formed in one of the covers 19 and 20, and respectively designed for admitting oxygen, or a mixture of oxygen and other gases, into the accumulation chamber 23 and for discharging oxygen or a mixture of oxygen and other gases, once depleted, and the carbon dioxide collected during blood oxygenation in the accumulation chamber 24.

Further ports 32 and 33 are also formed in the covers 19 and 20, for discharging water or temperature control fluid respectively into the chamber 23' for collecting water or temperature control fluid and into the chamber 24' for receiving and distributing water or fluid for blood temperature control.

The skilled person may decide that all the above communication ports be equipped with standard connectors, such as Luer-lock connectors, or Hansen connectors for the temperature control fluid inlets and outlets, to allow connections with the ends of extracorporeal circuit tubes, for the oxygenator 1 to be quickly and easily mounted or removed to or from the circuits.

The operation of the organic fluid oxygenator for extracorporeal circulation treatment of patients is described below concerning blood oxygenation treatment and is as follows: the medical staff first carries out a traditional priming step, i.e. fills the oxygenator 1 and the whole extracorporeal circuit with the patient's blood, possibly after diluting it with a blood-compatible saline.

At the same time, a heating or cooling device, known as "heater-cooler" is connected to the oxygenator 1 through the inlet 33 and outlet 32 ports, for thermally conditioning the patient's blood to be treated.

Then, the venous blood to be treated is directly drawn from the patient through a special drawing line and is introduced into the treatment compartment 4 through the inlet port 25.

When needed, the value of pressure (or another parameter) of the venous blood is detected through the accessory port 26, prior to its entering the treatment compartment 4 of the oxygenator 1.

When blood enters the treatment compartment 4, it fills the accumulation chamber 18 and then flows among the hollow fibers of the second winding 12 of the temperature control unit, in which temperature-controlled water flows, which has the connector 33 and the distribution chamber 24' on the bottom cover 20 as an inlet and the connection 40 and the accumulation chamber 23' on the top cover 19 as an outlet, both adjacent to their respective inlet and outlet chambers for oxygen or a mixture of oxygen and other gases.

The term temperature-controlled water shall be understood by the skilled person as designating water that may have a temperature above or below blood temperature, temperature control being selected by the medical staff, according to the disease and the desired therapy for the patient.

Blood laps and flows past the hollow fibers of the second winding 12, and the central rib 13, through the perforations 14 and towards the first windings of hollow fibers 8.

It shall be noted that the two pottings 112a and 112b prevent the venous blood from flowing through the end areas of the second winding of hollow fibers 12, thereby avoiding any flow velocity reduction in these areas, as well as any resulting formation of undesired accumulations, that might be injurious to the patient.

Oxygen, or a mixture of oxygen and other gases is caused to axially flow in the hollow fibers of the windings of hollow fibers 8, and is introduced

into the oxygenator 1 through the additional port 40, formed in the cover 19, and the accumulation chamber 23.

The heated or cooled venous blood transversely laps the hollow fibers 8 of the first windings, and the differential concentration of oxygen flowing in the windings of hollow fibers 8 and venous blood allows the latter to receive oxygen through the gas-pervious structure of the hollow fibers 8 of the first windings and to release its carbon dioxide thereto, to be purified.

At the same time, the liquid imperviousness of the hollow fibers prevents gases from mixing with blood.

Blood flow is maintained in the extracorporeal circuit and in the oxygenator 1, by means of a pump mounted thereto.

The hollow fibers of the first windings of hollow fibers 8 release the depleted oxygen, or the depleted mixture of oxygen and other gases, as well as the carbon dioxide they have collected, into the accumulation chamber 24, and such gases are carried from the latter, through the port 41, out of the oxygenator 1 and collected in special containers provided in the extracorporeal circuit for this purpose.

It shall be noted that the profiles of the central ribs 9 and diaphragms 10 shall be designed to impart a turbulent-wavy motion to blood flows, which is adapted to promote gas exchange.

Once blood flows have transversely lapped also the first windings of hollow fibers 8 and have become oxygenated and purified from carbon dioxide, the blood turns into arterial blood and accumulates in the laminar chamber 18' from which it is sent back to the patient, after being oxygenated and heated or cooled.

It shall be noted that, in addition to the advantage of combining both organic fluid oxygenation and temperature control features into a single disposable device, the oxygenator 1 also has the characteristic of being easily assembled and to maintain a low and constant pressure on the hollow fibers 8 and 12 that form the first windings and the second winding, thereby avoiding the presence of uneven hydraulic sections in various areas thereof,

which might either slow down and even stop the blood flow or facilitate it to even cause blood to bypass the hollow fibers of the oxygenator and the heat exchanger.

This feature is obtained by insertion of the frame 5, in combination with the central rib 13 and the retaining wall 15 that define the hollow seats 4 and 6 respectively, such seats having substantially constant and unchanging inner dimensions for receiving the windings of hollow fibers, and the seat 7, which is also substantially constant and unchanging, as it is contained between the two end resin pottings 112a and 112b.

The above described invention has been found to fulfill the intended objects.

The invention is susceptible to changes and variants within the inventive concept.

Also, all the details may be replaced by other technical equivalent elements.

In practice, any material, shape and size may be used as needed, without departure from the scope as defined by the following claims.

CLAIMS

1. An oxygenator of organic fluids for treatments of patients in extracorporeal circulation comprising:

- A three-dimensional containing body (2) having an upper lid (19) and a opposite lower lid (20) and wherein a treatment space (4) bounded by inner walls is defined;
- A gas-exchange arrangement (8);
- A thermic-exchange arrangement (12);

characterized in that it comprises a substantially rigid frame (5) designed to be fitted inside said treatment space (4) and which divides it into at least a next and divided first hollow seat (6) and a second hollow seat (7) having fixed outlines and wherein said gas-exchange arrangement (8) and said thermic-exchange arrangement (12) can be respectively housed.

2. An oxygenator according to claim 1, wherein said first hollow seat (6) and second hollow seat (7) are defined between portions of said frame (5) and said inner walls of said treatment space (4).

3. An oxygenator according to claim 1, wherein said first hollow seat (6) and second hollow seat (7) are fluid-dynamically connected.

4. An oxygenator according to claim 1, wherein said gas-exchange arrangement comprises at least a first winding of hollow fibres (8) which are impermeable to said organic fluids and permeable to gases.

5. An oxygenator according to claim 1, wherein said thermic-exchange arrangement comprises at least a second winding of hollow fibres (12) which are fully impermeable.

6. An oxygenator according to claims 1, 4, 5, wherein said second winding of impermeable hollow fibres (12) of said thermic-exchange arrangement has a main axis perpendicularly placed in respect of a longitudinal axis of said first winding of hollow fibres (8).

7. An oxygenator according to claim 5, wherein said second winding of hollow fibres (12) comprises closed portions (112a, 112b) to the passage of said organic fluids.

8. An oxygenator according to claims 5 and 7, wherein said closed portions are obtained in correspondence with opposed ends (12a, 12b) of said second winding of hollow fibres in the form of rigid and solid elements (112a, 112b) of polymeric material.

9. An oxygenator according to one or more of preceding claims, wherein said first winding of hollow fibres (8) and second winding of hollow fibres (12) are restrained between two rigid end elements (21, 22).

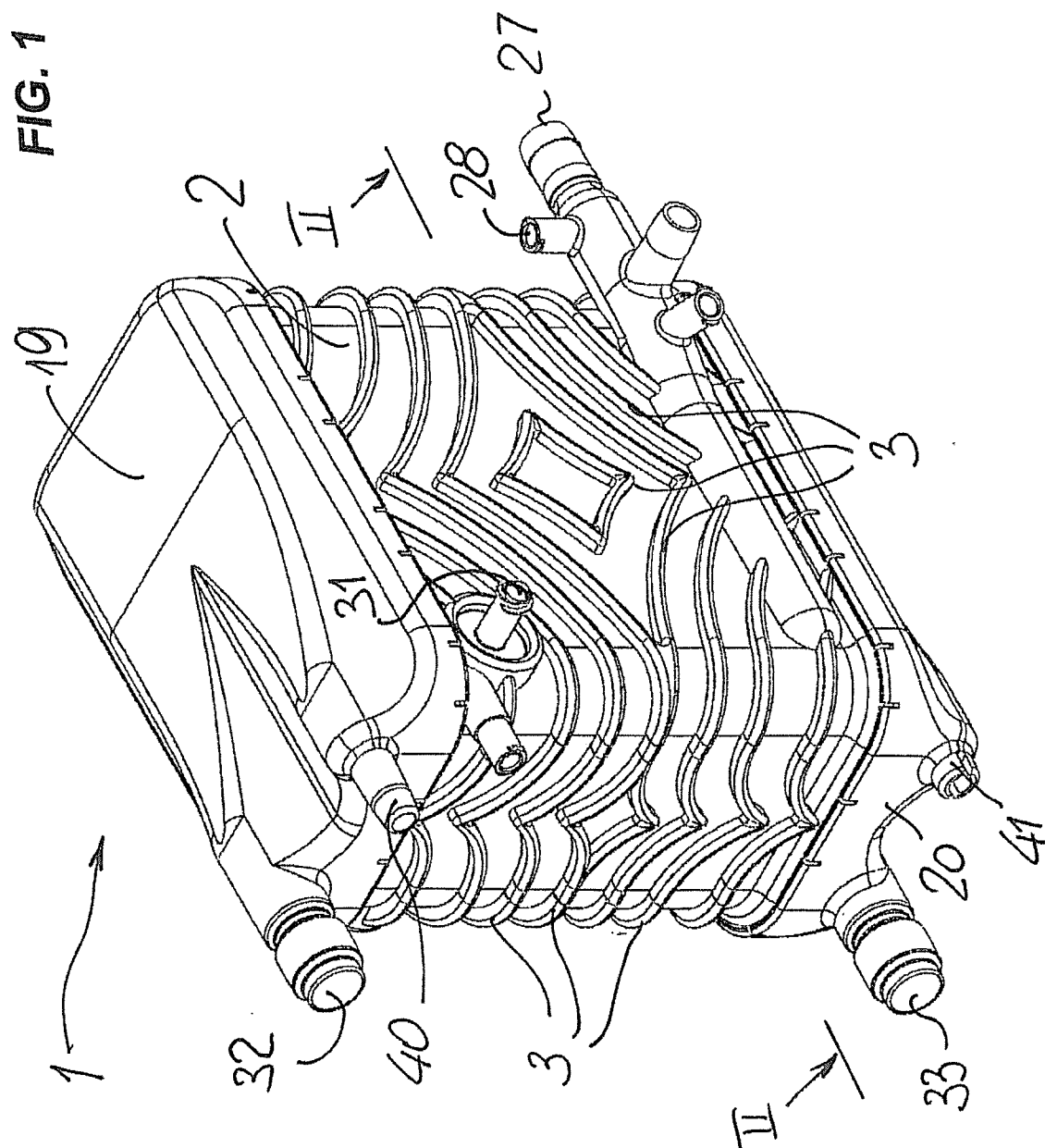
10. An oxygenator according to claim 4, wherein said first winding of hollow fibres (8) comprises one first inner rib (9) on which said first winding of hollow fibres (8) is wound.

11. An oxygenator according to claim 10, wherein said inner rib (9) has a substantially flattened shape and comprises deflecting means to deflect flows of said organic fluids by a turbulent-wave movement.

12. An oxygenator according to claim 5, wherein said second winding of hollow fibres (12) comprises a second inner rib (13) having through openings (149) to allow the through passage of flows of said organic fluids.

13. An oxygenator according to claim 1, wherein said first and second hollow seats (6, 7) have perforated walls by through openings (14).

14. An extracorporeal circuit characterized in that it comprises an oxygenator (1) of organic fluids for treatments of patients in extracorporeal circulation according to one or more of preceding claims.



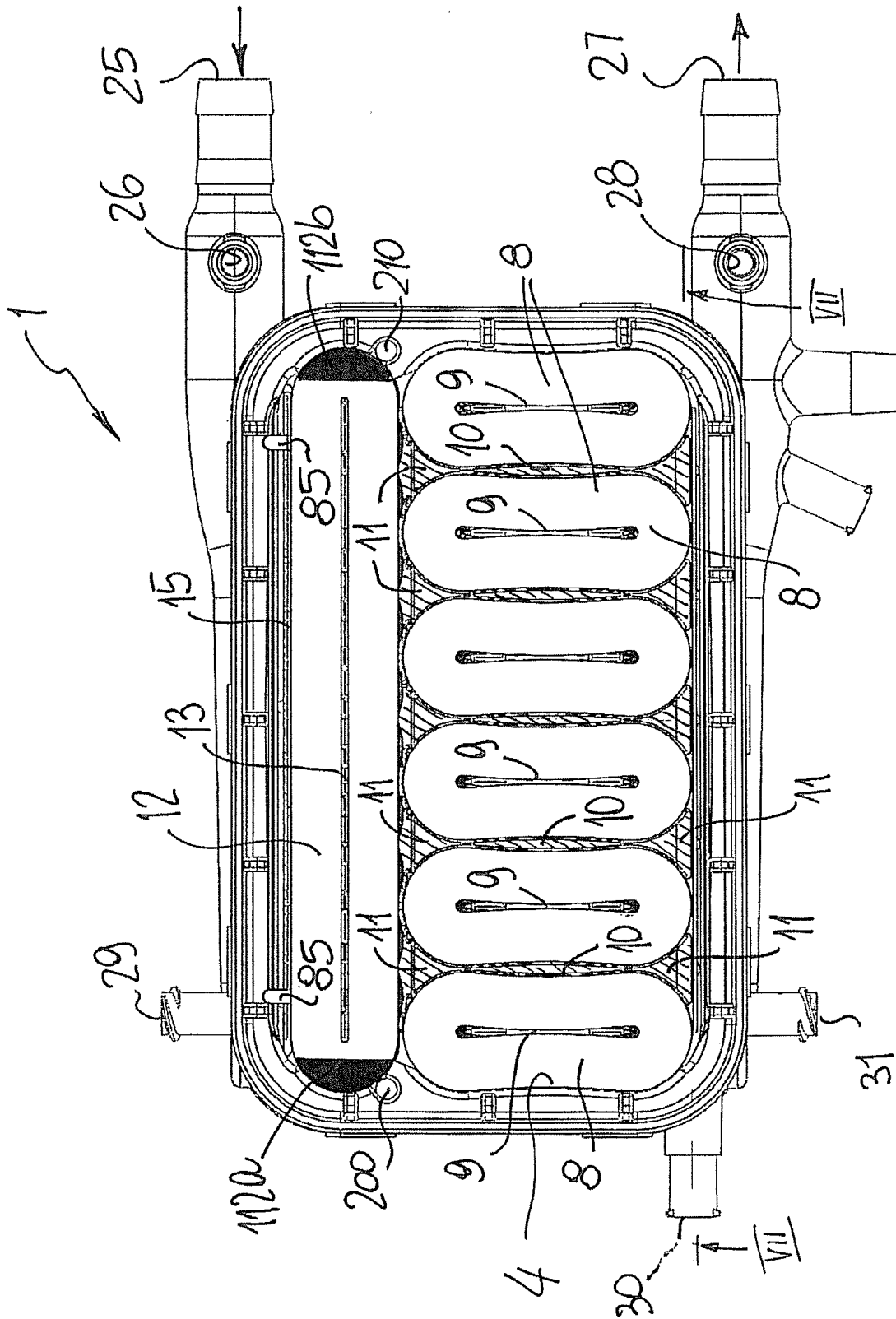


FIG. 2

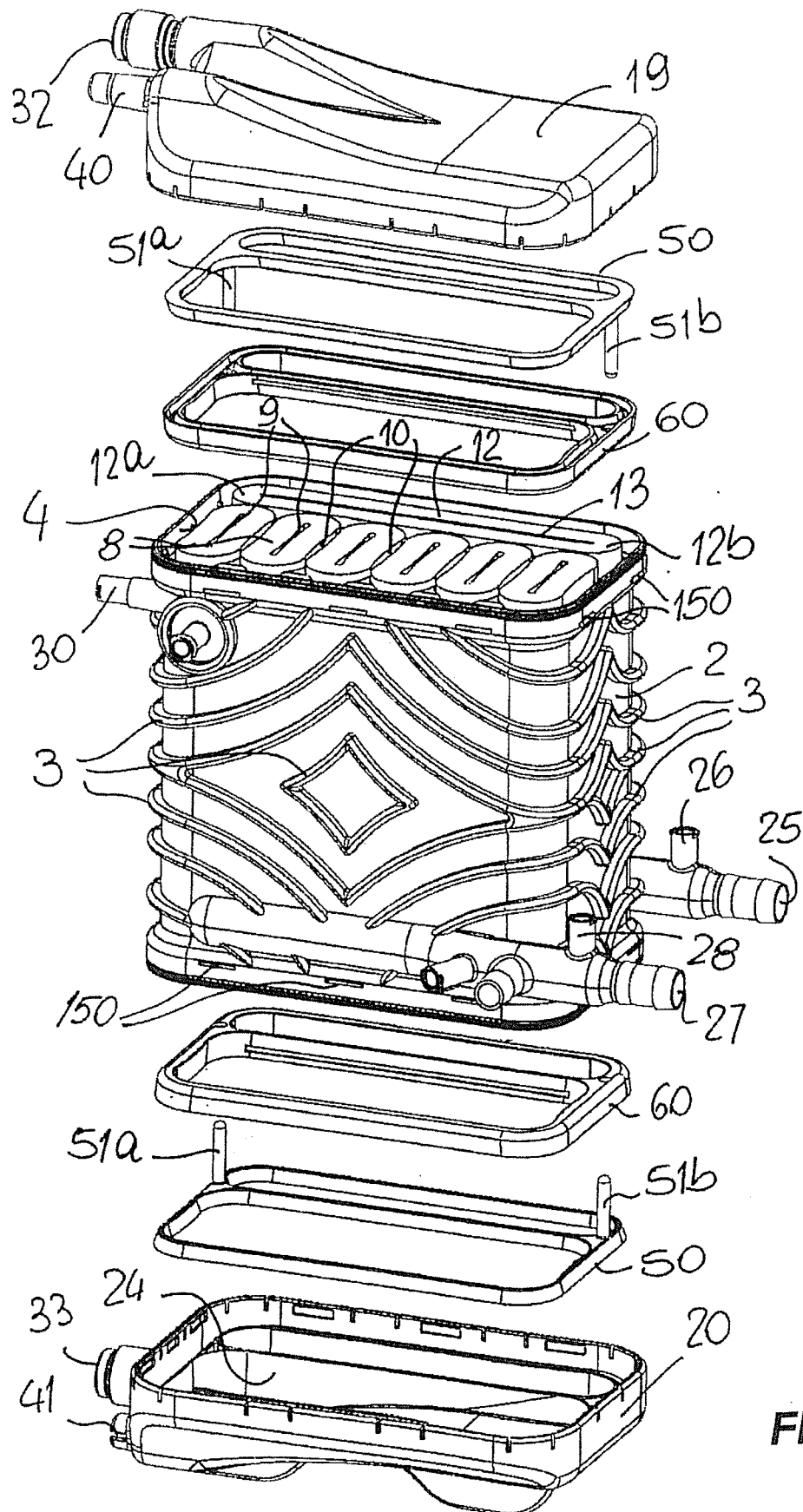


FIG. 3

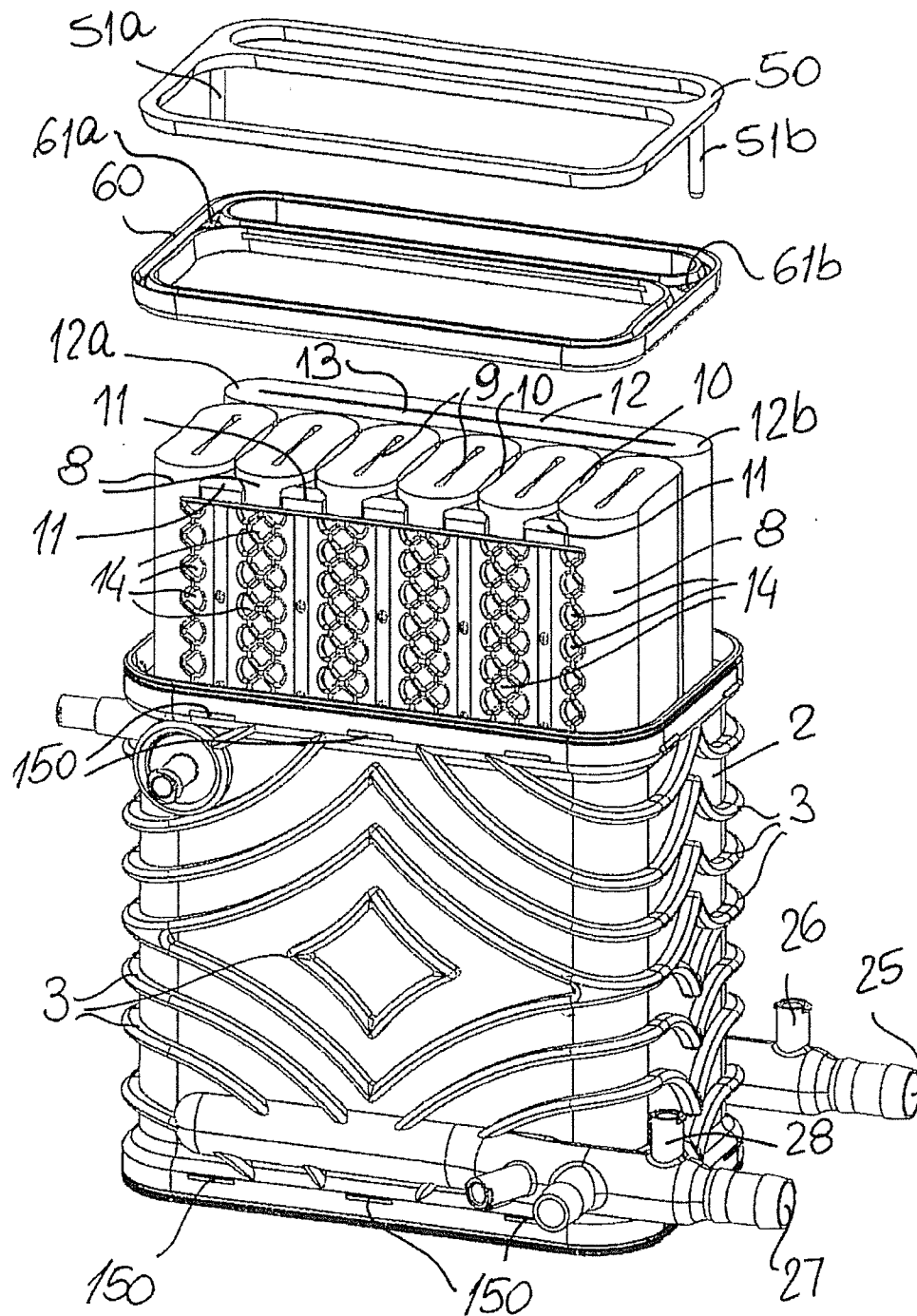
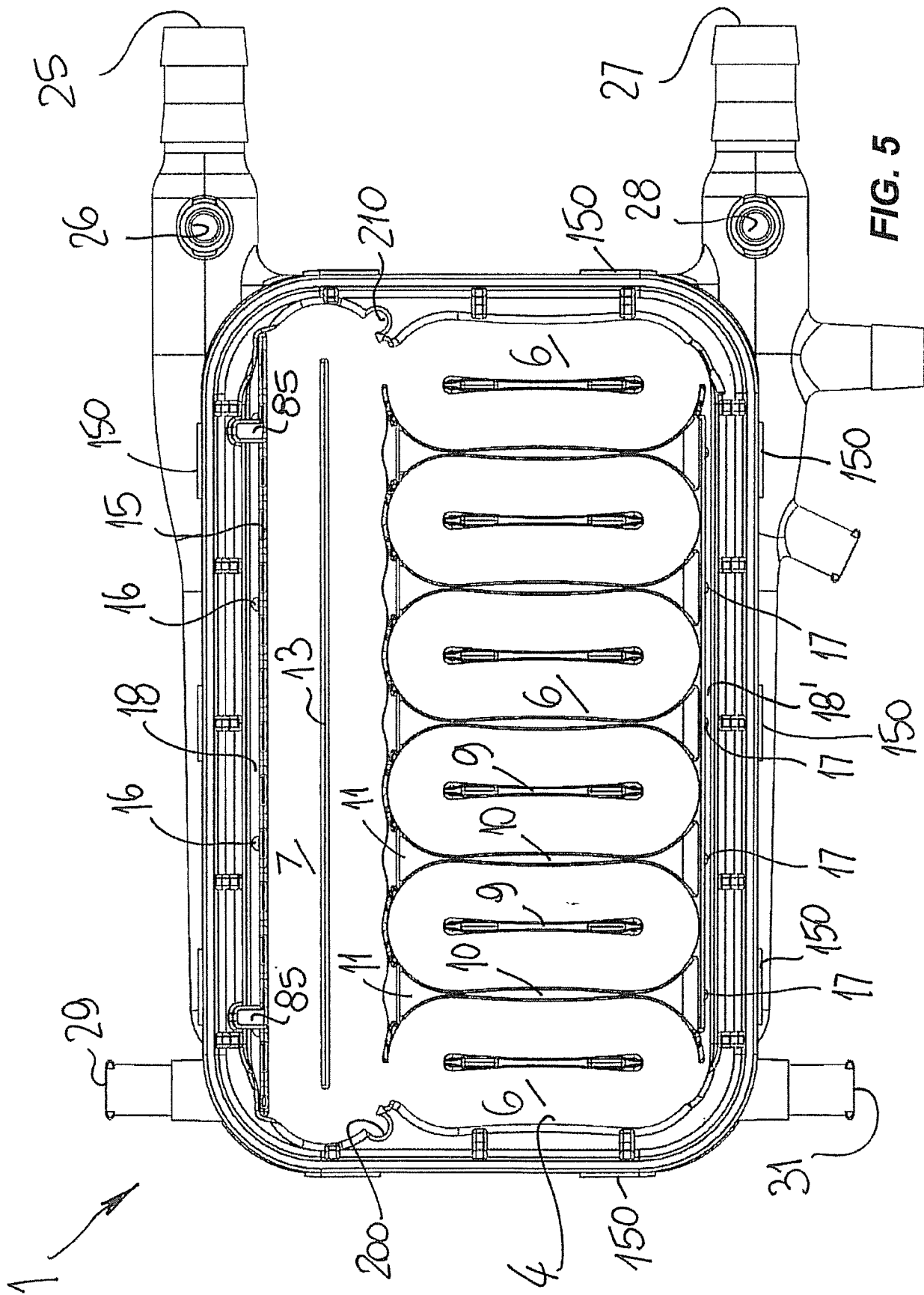
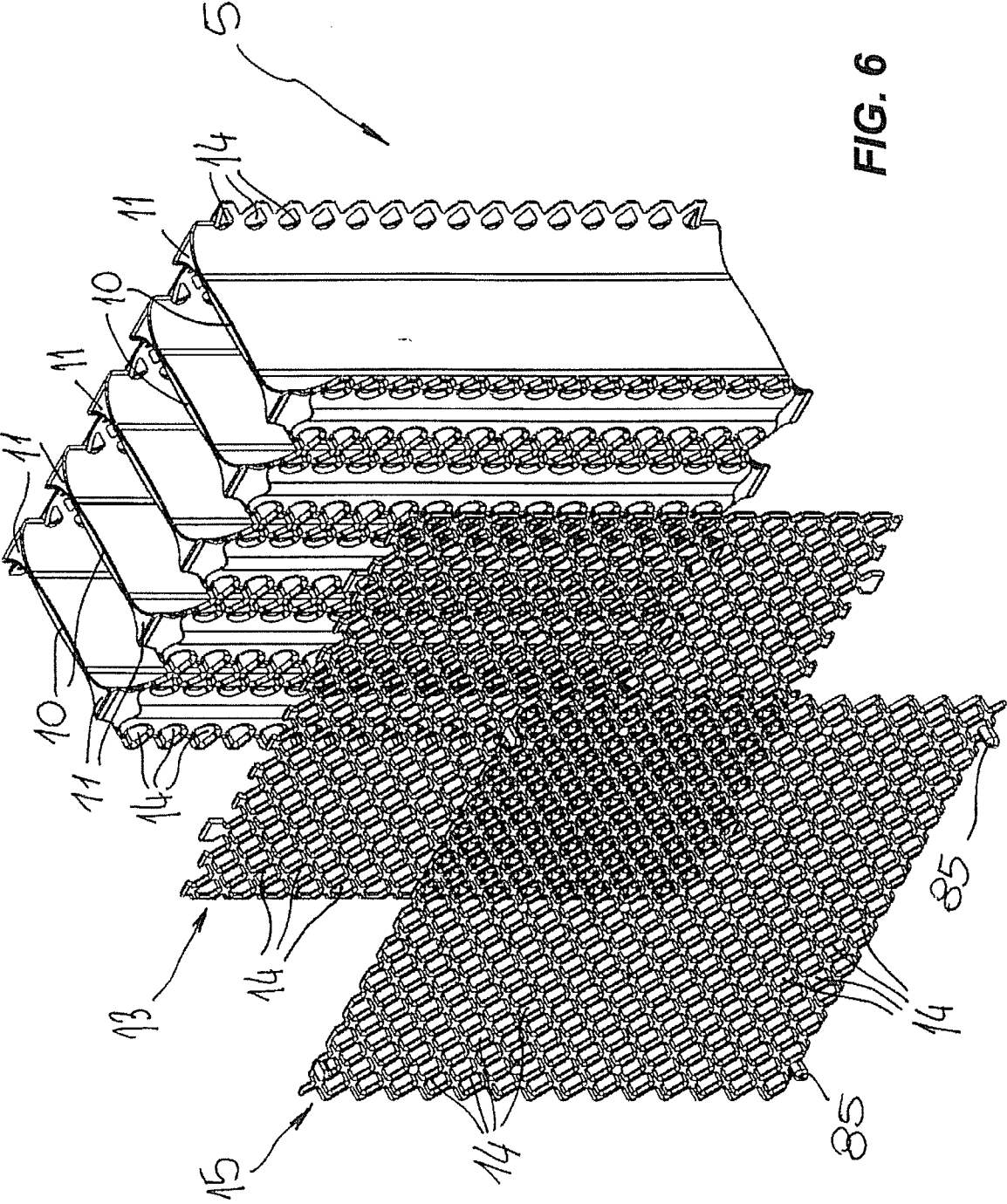


FIG. 4





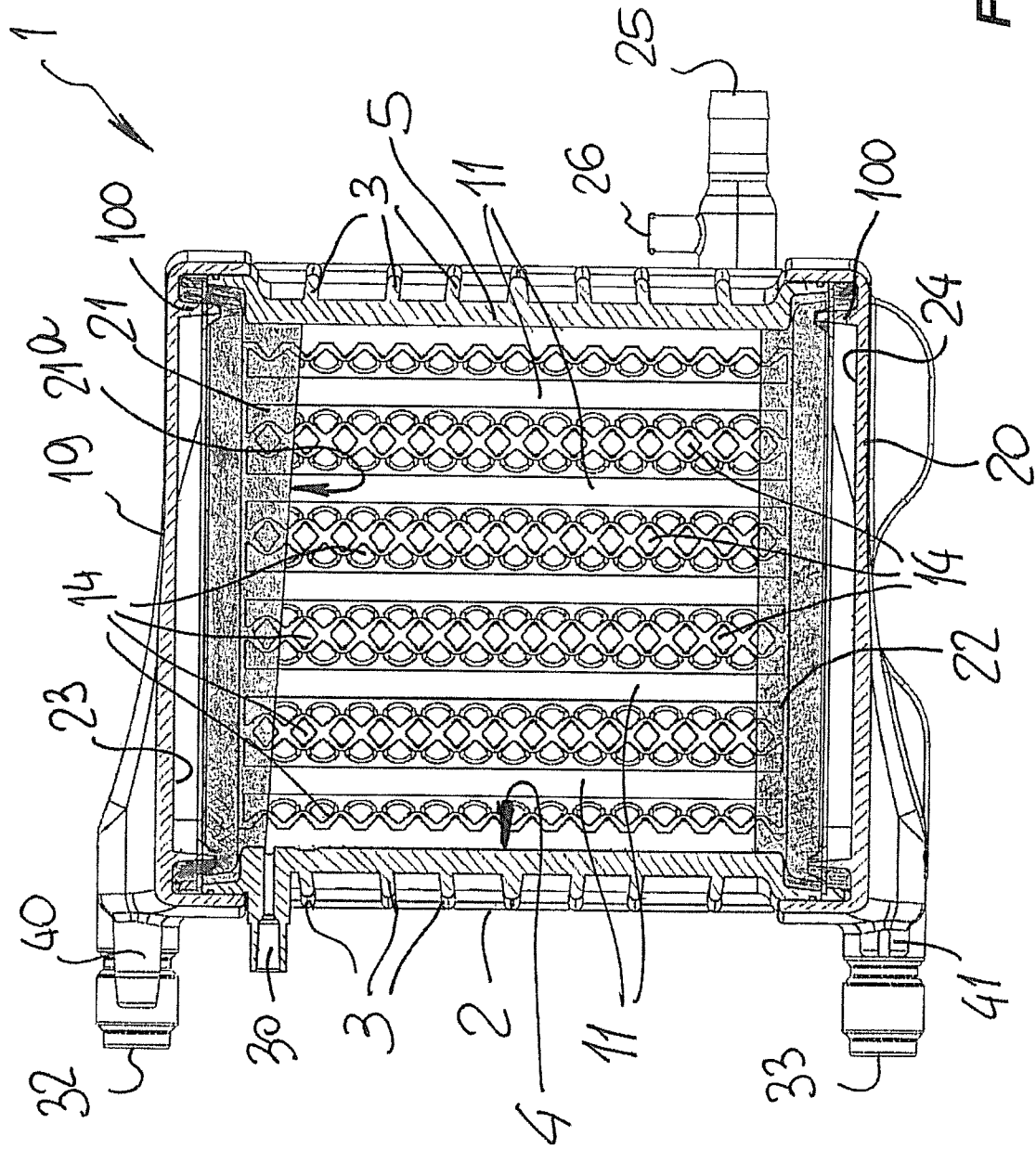
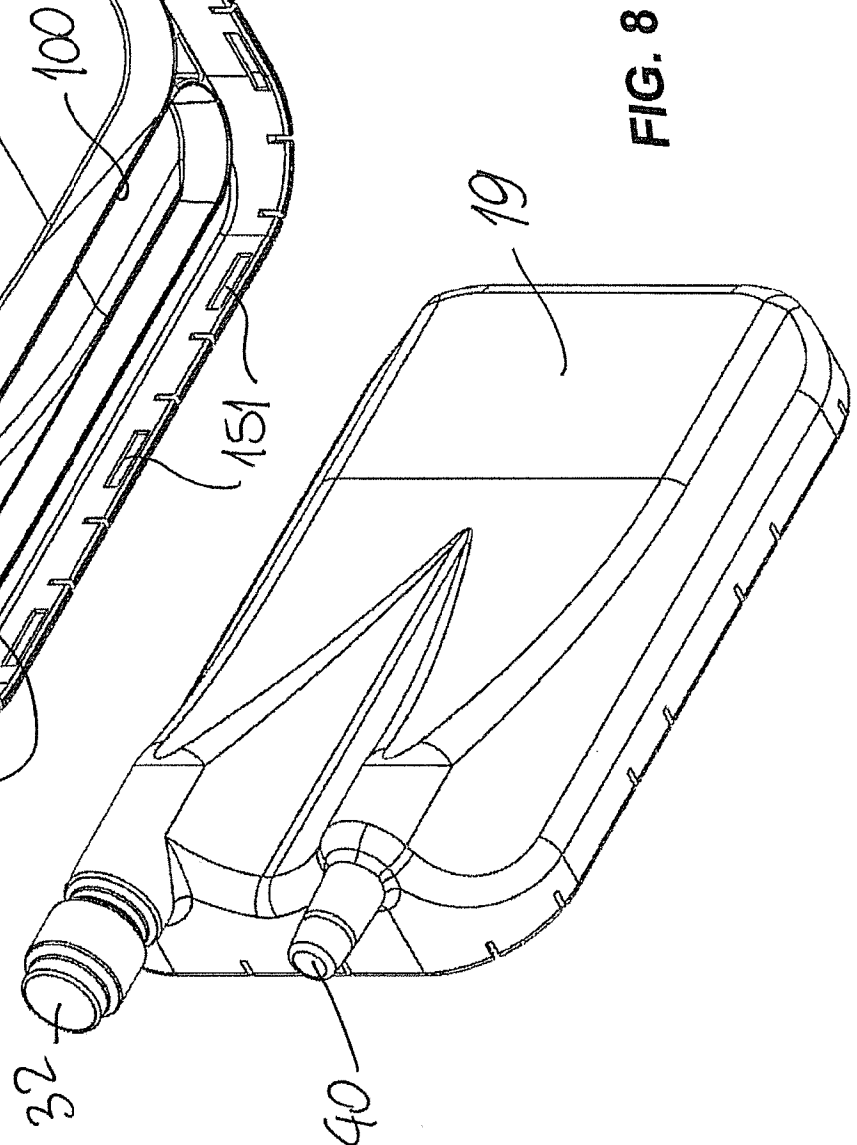
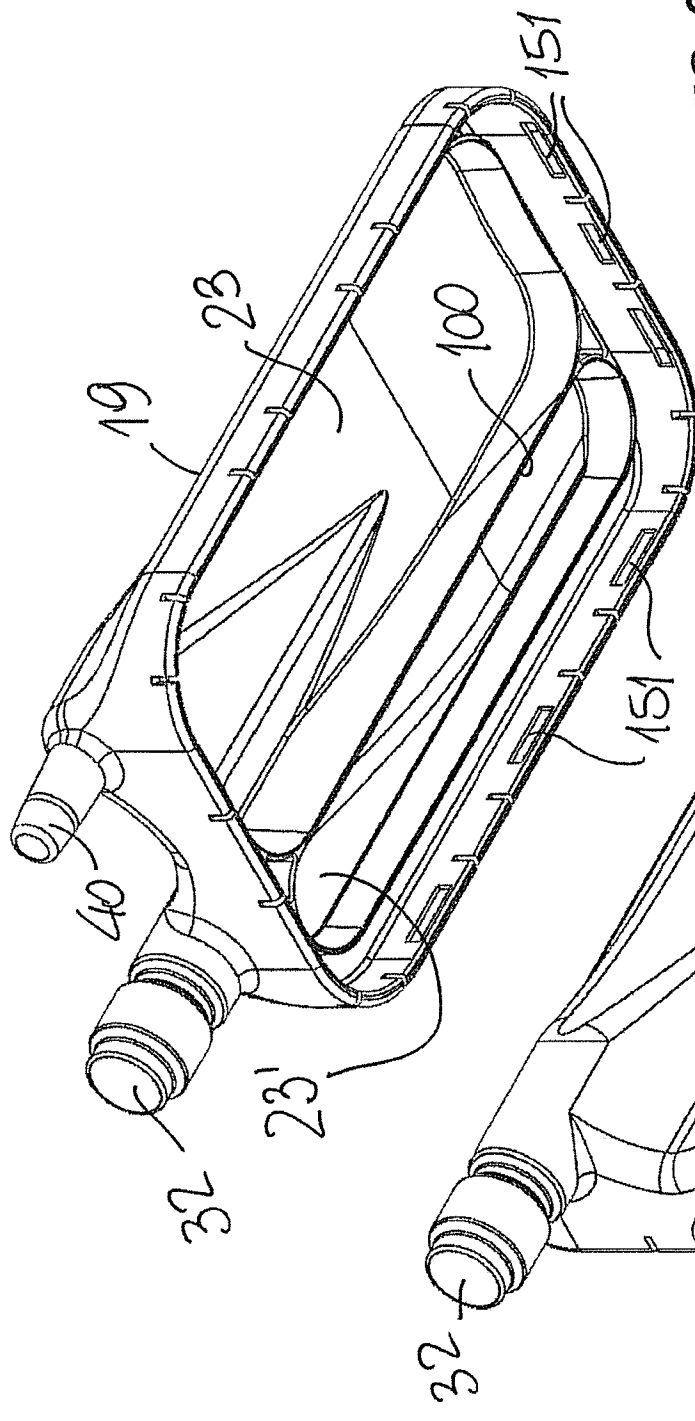
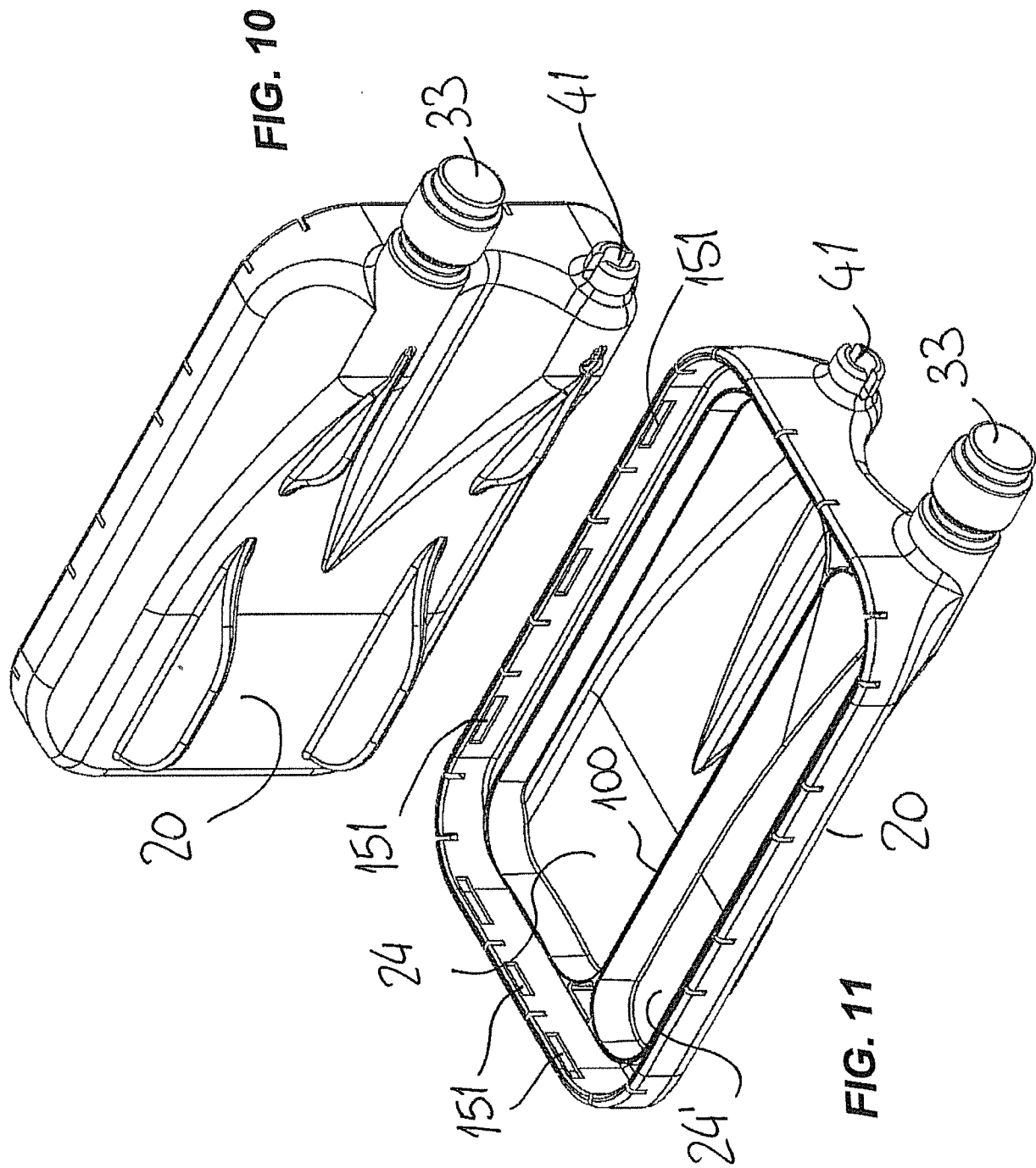
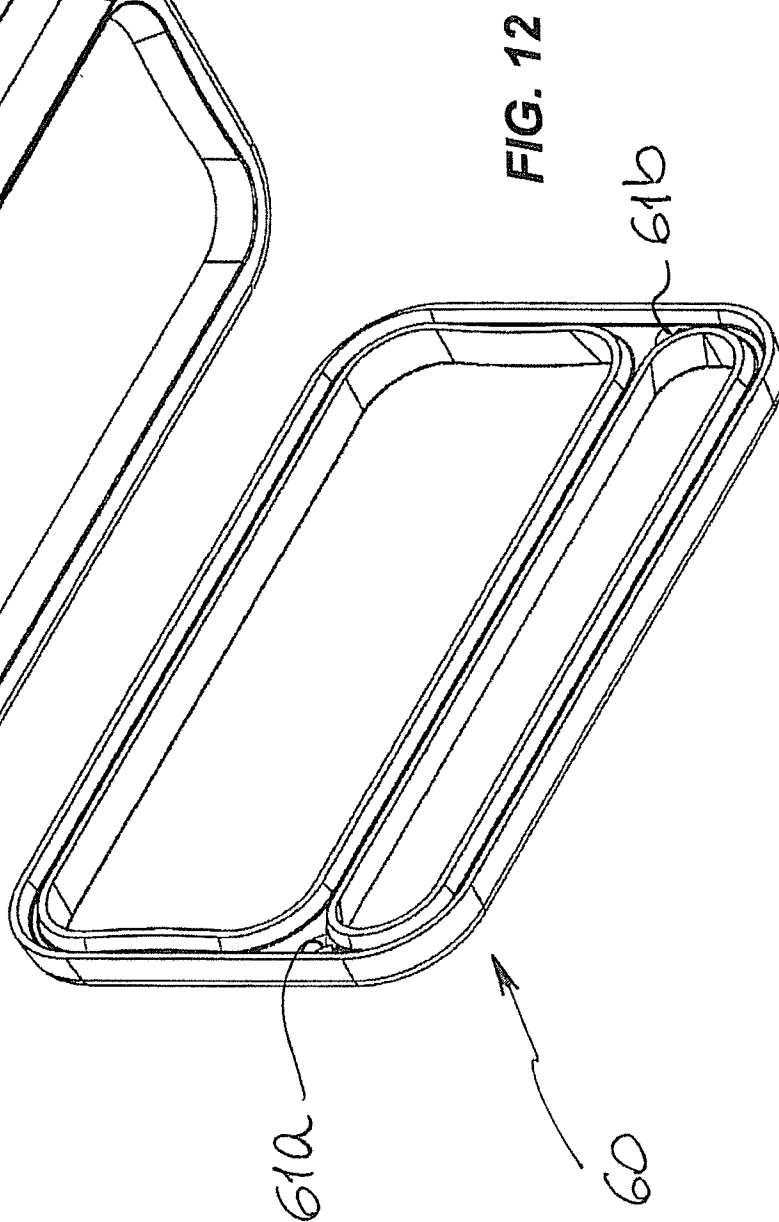
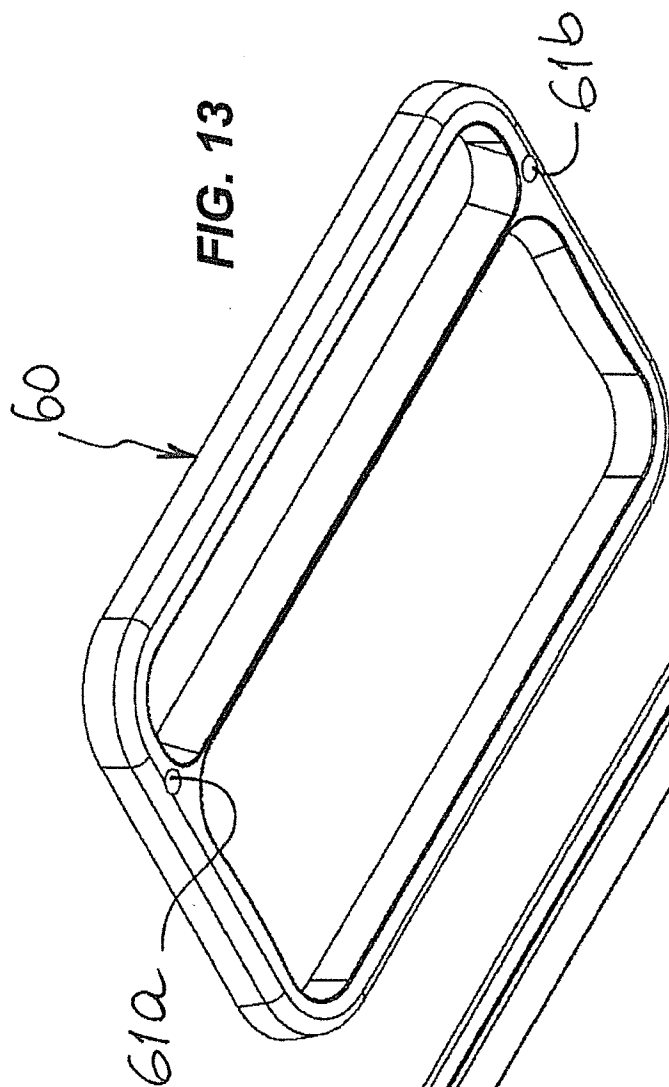


FIG. 7







INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2012/054005

A. CLASSIFICATION OF SUBJECT MATTER

INV. B01D61/28 B01D63/02 A61M1/14
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)

B01D A61M

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, 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	W0 90/07943 A1 (MINNTECH CORP [US]) 26 July 1990 (1990-07-26)	1-9, 12-14
Y	page 9, lines 19-25; figures 1,7,9 page 13 page 17, lines 1-12 page 20, lines 1-15	10,11
X	W0 98/08555 A1 (MINNTECH CORP [US]) 5 March 1998 (1998-03-05)	1-9, 12-14
Y	page 7, line 30 - page 10, line 21; figures 1,2	10,11
X	EP 1 557 185 A1 (RAND S R L [IT]) 27 July 2005 (2005-07-27)	1-11,13, 14
Y	paragraphs [0038] - [0062]; figures 2,4	10,11
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Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

24 October 2012

Date of mailing of the international search report

02/11/2012

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Hennebrüder, K

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2012/054005

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

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International application No

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