(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 January 2013 (10.01.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/005193 A2

(51) International Patent Classification:
B01D 61/28 (2006.01) *A61M 1/14* (2006.01)
B01D 63/02 (2006.01)

(21) International Application Number:
PCT/IB2012/053478

(22) International Filing Date:
6 July 2012 (06.07.2012)

(25) Filing Language: Italian

(26) Publication Language: English

(30) Priority Data:
MO2011A000166 6 July 2011 (06.07.2011) IT

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

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

[Continued on next page]

(54) Title: AN OXYGENATOR FOR OXYGENATING AN ORGANIC FLUID IN AN EXTRACORPOREAL CIRCUIT

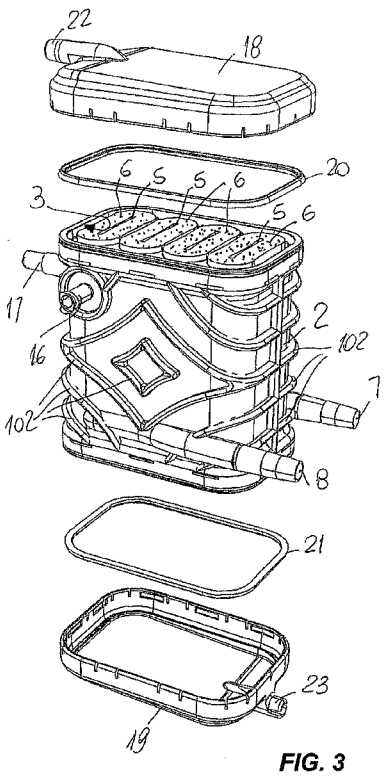

FIG. 3

(57) Abstract: The oxygenator (1) for oxygenating blood during extracorporeal circulation comprises: a box-like body (2) defining therein an oxygenation chamber (3) which has an inlet (7) for the organic fluid to be oxygenated and an outlet (8) for the oxygenated organic fluid; at least one oxygen exchanging unit (4) for exchanging oxygen with said organic fluid, which is arranged in said oxygenation chamber (3) and comprises at least two windings of hollow fibers (6) made from a hydrophobic and gas-permeable microporous membrane which are designed to be lapped by transverse flows of said fluid to be oxygenated and to have oxygen or a mixture of oxygen flowing therethrough, said oxygenator comprising at least one three-dimensional frame (9) which is designed to be accommodated in said oxygenation chamber (3) and defines at least two corresponding housing compartments (1 2) for accommodating said at least two windings (6) in peripherally compressed fashion.

WO 2013/005193 A2

TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

AN OXYGENATOR FOR OXYGENATING AN ORGANIC FLUID IN AN EXTRACORPOREAL CIRCUIT

TECHNICAL FIELD

The invention relates to an oxygenator for oxygenating an organic fluid, such as blood, as it flows in an extracorporeal circuit during treatment of a patient.

BACKGROUND ART

Disposable devices have been long known and used in the medical field, which can exchange a gas, such as oxygen, with an organic fluid, namely blood.

These devices for exchanging oxygen with blood are simply known as oxygenators and are designed to release oxygen to blood and simultaneously remove excess carbon dioxide therefrom during extracorporeal circulation treatments.

These prior art oxygenators consist of substantially cylindrical box-like bodies, which define therein an oxygenation chamber with a gas exchanging unit arranged therein.

Such gas exchanging unit typically consists of a multitude of so-called hollow fibers, which are substantially rectilinear and arranged in line with the longitudinal axis of the cylindrical body.

Each hollow fiber has an inlet lumen and an opposite outlet lumen, which are as large as a few hundreds of microns, and are formed of a flexible membrane, which is only gas- and not liquid-permeable.

The open ends of the hollow fibers are in turn incorporated and retained in two solid connection elements, known as "pottings", which are typically formed of polyurethane-based glued, and are used to hold the ends of the hollow fibers in a stable position, while keeping their inlet and outlet lumens clear.

The bodies of these oxygenators have a first pair of apertures, namely an inlet and an outlet for the fluid to be oxygenated, such as blood, the latter being forced to flow in the oxygenation chamber along a predetermined path defined therein, which forces it to lap the exterior of the hollow fibers in a flow

direction substantially transverse thereto, thereby becoming richer in oxygen and releasing excess carbon dioxide.

The closing covers of both pottings fixed to the cylindrical body of the oxygenator have a second inlet and a second outlet, which are designed both for supplying oxygen gas, in pure form or diluted with other gases, such as nitrogen or air, and for discharging the carbon dioxide released to blood during oxygenation.

These oxygenators are typically functionally or structurally 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 typically use water thermally treated by a heating or cooling device, to add or remove heat from patient's blood, and are generally known as "heaters" or "coolers" or otherwise generally defined as "temperature baths".

Typically, for operation of these 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 eventually 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 blood flow that comes from the patient, passes through the oxygenator and goes back to the patient is typically generated and kept flowing using a pump mounted on the extracorporeal circuit, typically upstream from the oxygenator, in the section that connects the latter with the patient.

The pump action generates a pressure higher than atmospheric pressure in the oxygenator, which is sufficient to overcome the sum of

mechanical resistances to blood flow, i.e. the resistances encountered by blood as it flows through the oxygenation chamber that contains the hollow fibers, and the internal resistances in the conduits that connect the various devices of the extracorporeal circuit with the peripheral circulatory system of the patient, to ensure that circulation is maintained active all along the path defined by the extracorporeal circuit.

One of the most important features required of these oxygenators is an exchange surface area that is optimized relative to their overall size, which has to be maintained within strict limits both due to bulk limitation and handling requirements, and because a volume of blood has to be removed from the patient to fill the oxygenator and the extracorporeal circuit, even though it is diluted with suitable salines.

The term optimized exchange surface area is intended to designate a surface that provides the maximum exchange volume relative to the overall surface area through which exchange occurs.

An oxygenator as described hereinbefore is known from Italian Patent Application MO2010A000192 by the applicant hereof.

This patent provides an oxygenator that comprises a substantially cylindrical hollow box-like body that defines therein a blood treatment, i.e. blood oxygenation chamber, with an exchange unit arranged therein, comprising a plurality of diaphragms wrapped with bundle windings of a plurality of hollow fibers.

The box-like body has an inlet port for the blood to be oxygenated and an opposite outlet port for the oxygenated blood, which is parallel to the inlet port and defines therewith an alignment direction.

In one embodiment of the invention all the diaphragms are arranged parallel to the alignment direction and, as a result, the windings of hollow fibers are also arranged with their greater axes parallel to this direction.

The windings of hollow fibers have partition elements therebetween, which have the purpose of maintaining them separate and, like the diaphragms, have their longitudinal greater axes arranged parallel to the alignment direction.

Compartments are formed between the gas exchanging unit and the inner surface of the oxygenation chamber, a first compartment being designed to receive the inflowing blood to be oxygenated that enters through the inlet port, and a second opposite compartment receiving the oxygenated blood, that is designed to flow out through the outlet.

Some compartments extend along the windings and the hollow fibers that compose the latter have their inlet and outlet ends embedded in two "pottings", as previously discussed.

The body also has upper and lower closing covers that hermetically seal its ends and the compartments, the upper cover being designed to receive the oxygen that flows in the hollow fibers of the microporous capillary windings, and the lower cover being designed to receive the carbon dioxide accumulated after the exchange in the oxygenation chamber, once it is released from blood to the depleted oxygen flowing in the hollow fibers, typically due to differential concentration.

In the oxygenator of the above patent application, both the partition elements and the diaphragms wrapped with the microporous capillaries are substantially parallel and equally spaced.

Therefore, each winding is held between two contiguous partition elements, or between an end partition and the inner surface of the oxygenation chamber of the container body, in the case of the lateral windings.

In an oxygenator as described above, the windings of hollow fibers are introduced into the oxygenation chamber in substantially monolithic form, i.e. in a configuration in which the windings are bundled in a side-by-side arrangement, prepared beforehand.

Nevertheless, in order that they can be fully introduced therein, they must be previously peripherally compressed, to reduce their overall size that, in a disassembled state, i.e. when they are out of the oxygenation chamber, is slightly larger than inner size of the latter.

The compression exerted on the windings of hollow fibers is almost completely elastic and, once they have been fully introduced into the

oxygenation chamber, the bundle of windings tend to almost completely recover its original size.

Nevertheless, some residual peripheral compression remains, because, as mentioned above, the interior size of the oxygenation chamber is slightly smaller than the overall bundle size, and as a result the windings of hollow fibers cannot fully recover their original size and there is still some, though little, peripheral compression.

For this reason, interstices of different sizes are formed between the windings and between the hollow fibers of each winding, to allow the flow of organic fluid.

In practice, the sizes of the interstices were found to be smaller in the areas closer to the outer surface of the bundle of windings, i.e. the ones closer to or in contact with the inner surface of the oxygenation chamber, as compared with those between the hollow fibers of the central areas, i.e. those closer to the diaphragms wrapped therewith.

This condition causes a problem that characterizes this kind of oxygenators, i.e. that, due to the difference of interstice sizes between the peripheral hollow fibers and the inner, central ones of the bundle of windings, the exchanging unit has areas in which the flow of organic flow is hindered and slowed down, and may be even stopped.

As the flow reduces its speed or, in certain conditions, is totally stopped, it may cause, also due to the typical blood density, the interstices of the peripheral areas of the bundle of windings to be progressively obstructed and blood to progressively undesirably stagnate therein, thereby forming blood accumulations, which may lead to clots and platelet aggregates that are dangerous for the patient.

This causes the oxygenator to have an unsatisfactory performance and a reduced life, which add to the above mentioned dangers for the patient's safety.

An additional drawback is that if prior art oxygenators are not used within a predetermined time from their fabrication and are not stored with adequate care, to ensure stable effectiveness thereof, they tend with time to

be exposed to degradation of the components, which are mainly made of plastic materials. Such degradation may cause size changes in the components and thus create undesired additional interstices or apertures that will act as clear passages for blood that will flow through them without previously lapping the hollow fibers and hence without being adequately oxygenated and washed out of excess carbon dioxide, before reaching back the patient.

Another drawback is that prior art oxygenators are required to have a large size to ensure adequate gas exchange even when the latter tends to be reduced due to obstructions and blocks in the interstices between the hollow fibers.

A further drawbacks is that, since prior art oxygenators must have a large size, they require a large volume of blood to be withdrawn from the patient, for both the extracorporeal circuit and the oxygenation chamber to be filled for operation, which requires infusion of additional biocompatible salines to patients, to compensate for the withdrawal of such blood volumes and to avoid health problems to the patients during treatment.

Yet another drawback is that prior art oxygenators require complex and inconvenient assembly procedures, due both to the number of their components and to their instability during assembly.

SUMMARY OF THE INVENTION

It is an object of the invention to improve the prior art.

Another object of the invention is to provide an oxygenator for oxygenating an organic fluid in an extracorporeal circuit, that can provide an exchanging bundle allowing homogeneous flow therethrough over its entire surface, thereby preventing any stagnation danger.

Another object of the invention is to provide an oxygenator for oxygenating an organic fluid in an extracorporeal circuit, that has a construction allowing quick and easy assembly.

A further object of the invention is to provide an oxygenator for oxygenating an organic fluid in an extracorporeal circuit that only requires withdrawal of small amounts of blood from the patient, to be filled and

operate properly.

Yet another object of the invention is to provide an oxygenator for oxygenating an organic fluid in an extracorporeal circuit that can also operate at very low pressures without the risk of creating stagnation areas and promoting turbulence of the flowing organic fluid, while preserving the integrity of both the cells that compose the organic fluid, in the case of blood, and the cell membranes of the red blood cells, by minimizing the shear stresses that cause hemolysis.

Another object of the invention is to provide an oxygenator for oxygenating an organic fluid in an extracorporeal circuit that can adequately and consistently oxygenate the flow of organic fluid that passes through it during use and for the whole life of the device, in spite of progressive and inevitable ageing and degradation of the materials of which it is formed.

In one aspect, the invention provides an oxygenator for oxygenating an organic fluid in an extracorporeal circuit as defined in claim 1.

Therefore, the invention provides the following advantages:

providing a more homogeneous exchange capacity (also known as mass transfer) as compared with prior art oxygenators;

reducing the number of steps required to assemble the oxygenator device of the invention;

prevent undesired blood stagnation;

form a three-dimensional structure, in which the position of the exchanging unit in the oxygenation chamber provides an arrangement of contact areas having predetermined patterns of concave and convex surfaces, for overall improvement of gas exchange between the oxygen that flows in the microporous capillaries, i.e. the hollow fibers, and the blood that laps the outer surface of such capillaries.

placing a three-dimensional structure in the oxygenation chamber, that has such an arrangement of interstices for the flows of organic fluid to be oxygenated, as to allow the organic fluid, such as blood, to lap or flow through it, while opposing very little resistance and also optimizing the blood volume being treated and the gas exchange between oxygen or the oxygen

mixture blown into the capillary fibers and the blood that flows through the oxygenator; and

providing an oxygenator device can be easily coupled both with a heat exchanger, that does not require the use of a temperature-controlling liquid and with a heat exchanger that uses a temperature-controlling liquid.

BRIEF DESCRIPTION OF THE DRAWINGS

Further features and advantages of the invention will be more readily apparent upon reading of the description of a preferred, non-exclusive, embodiment of a device for oxygenating blood during extracorporeal circulation according to the invention, which is shown as a non-limiting example by the annexed drawings, in which:

FIG. 1 is a perspective view of an oxygenator for oxygenating an organic fluid in an extracorporeal circuit according to the invention;

FIG. 2 is a perspective view of the oxygenator of Figure 1, with the upper portion being omitted to provide a partial view of its interior during one of the temporary mounting/assembly steps;

FIG. 3 is an exploded perspective view of the oxygenator of Figure 1;

FIG. 4 is an exploded view of the components of a gas exchanging unit of the oxygenator of the invention;

FIG. 5 is a cross-sectional view of the oxygenator of the invention, as taken along a plane V-V of Fig. 1;

FIG. 6 is a broken and slightly enlarged view of a portion of the sectional view of Figure 5;

FIG. 7 is a perspective view of a three-dimensional frame that forms the gas exchanging unit of the oxygenator of the invention;

FIG. 8 is a perspective, highly enlarged view of a diaphragm which is designed to be wrapped with a bundle of hollow fibers to create a winding;

FIG. 9 is a top view of the oxygenator of the invention;

FIG. 10 is a vertical sectional view of the oxygenator of the invention, as taken along a plane X-X of Figure 9;

FIG. 11 is a highly enlarged view of a winding of hollow fibers accommodated in a compartment within the oxygenation chamber of the

oxygenator of the invention.

DESCRIPTION OF EMBODIMENTS OF THE INVENTION

Referring to the figures, an oxygenator for oxygenating an organic fluid in an extracorporeal circuit is generally referenced 1 and includes a box-like body 2 substantially having the shape of a parallelepiped with rounded edges and in which an oxygenation chamber 3 is defined for oxygenating the organic fluid to be oxygenated which, in the following description is by way of example and without limitation blood.

An exchanging unit, generally referenced 4, is arranged in the oxygenation chamber 3, and comprises a plurality of flat diaphragms 5, wrapped with a plurality of hollow fibers, referenced 6, in bundle winding form.

The box-like body 2 has a series of outer stiffening ribs 102, an inlet port 7 for the blood to be treated and an opposite outlet port 8, which is aligned with the inlet port 7.

As shown in Figures 2, 3, 5, 6, all the diaphragms 5, that will be described in detail below, are arranged parallel to an alignment direction “DA", which is perpendicular to blood inflowing and outflowing directions through the ports 7 and 8, and the windings 6 of hollow fibers are also arranged with their greater axes parallel to this direction.

The exchanging unit 4 also comprises a three-dimensional frame 9 which is preferably formed of one piece and is designed to be inserted in the oxygenation chamber 3.

This frame 9 forms a plurality of ribs 10, or partition elements, which are parallel to one another and to the alignment direction "DA" and are transversely joined by perforated walls 11 which form a mesh grid through which blood may flow to lap the hollow fibers 6.

As particularly shown in Figure 7, innermost compartments 12 are defined between contiguous ribs, which are designed to receive respective windings of hollow ribs 6 therein.

Still referring to Figure 7, it can be also noted that, at the ends of this frame, the perforated walls 11 are discontinued in their longitudinal direction

to abut against the inner end walls of the oxygenation chamber 3 to form therewith two additional end compartments 12 for receiving two additional windings of hollow fibers 6, having substantially the same size as the innermost compartments 12.

Referring to Figure 6, it can be noted that, when the frame 4 is inserted in the oxygenation chamber 3, two narrow chambers 13 and 14 are defined.

The chamber 13 is designed to be used for accumulation of the inflowing blood that has just entered through the inlet port 7 and is waiting to be oxygenated, whereas the chamber 14 is designed to be used for accumulation of the blood that, after flowing through the windings of hollow fibers 6 and being oxygenated and washed out of excess carbon dioxide, is ready to flow out of the outlet port 8 to reach back the patient.

Referring to the figures, it can be noted that lumens, referenced 15, 16, 17, are also formed in the body 2 for connecting the oxygenation chamber 3 with the outside environment, for exhausting any air contained in blood, both before and after oxygenation.

Referring to Figure 3, it can be noted that the body 2 comprises two end covers, an upper cover 18 and a lower cover 19 which, with the oxygenator 1 in the assembled state, are fixed to the ends of the oxygenation chamber 3, with seals 20 and 21 interposed therebetween.

Both covers 18 and 19 have additional lumens 22 and 23.

The lumen 22 may be designed for introduction of oxygen or the mixture of oxygen and other gases, whereas the lumen 23 may be designed for removal of the carbon dioxide washed out of blood during oxygenation.

As shown in Figure 10, two additional collection chambers 24 and 25 are defined between the covers 18 and 19 and the exchanging unit 4, with the chamber 24 being used for accumulation of oxygen or the mixture of oxygen and other gases, that has to longitudinally flow through the windings of hollow fibers 6.

Furthermore, two end "pottings", referenced 26 and 27 are shown in Figure 6, which embed and retain the ends of the hollow fibers 6 while

leaving the inlet and outlet lumens unobstructed.

Particularly, the potting 26 is shown with an inclination of its surface toward the interior of the box-like body 2 for gradually conveying any microbubbles in the oxygenator towards the special debubbling outlets 15, 16 or 17 through the narrow chambers 13 and 14.

Referring to Figures 6 and 7, it can be noted that for each rib 10 the ends 110 extending in the alignment direction "DA" are enlarged and each defines a respective longitudinal rib 210 in the perforated walls 11, from which spacing buttons 29 extend, which are designed to lie against the inner surface of the oxygenation chamber 3, to hold the frame 9 in a firm centered position.

Referring to Figure 8, a diaphragm 5 is shown, which comprises a substantially sheet-like body 105 having the two opposed larger edges shaped to form a series of raised directional baffles 205.

These directional baffles 205 are designed to impart a wavy motion to the blood flow that laps them and laps the surfaces of the diaphragm 5, as shown by way of illustration only by broken arrows "FL".

In greater detail, it shall be noted that in the embodiment of the drawings, the baffles on one side are intentionally not aligned with the baffles of the other side, to prevent the formation of laminar, non-wavy blood flows between the two sides.

Furthermore, the surfaces of the diaphragms 5 have slightly concave profiles in the longitudinal direction, as shown when looking at the ends of the diaphragm as shown in Figure 8, in which two opposed concavities "C1" and "C2" of the two surfaces are found between two projecting teeth 305, that are designed to be embedded in the pottings 26 and 27 of the oxygenator 1.

When the oxygenator 1 is assembled, these concavities are located at transverse enlargements 310 formed in the center areas of the ribs 10.

Referring to Figure 11, the winding of hollow fibers 6 is found to have, in cross sectional view, two end areas 106 in which the compression of the hollow fibers 6, designated by the arrows "CP" is slightly greater than the compression at the median areas 206 interposed between the end areas

106.

As shown in the figures, this is obtained because the cross sections "S1" of the median areas 206 are slightly larger than the cross sections "S2" of the end areas 106.

These compression differences are provided, with the oxygenator 1 in the assembled state, by the opposed profiles of the enlargements 310 and the concavities "C1" and "C2" at the median areas 206 and by the profiles of the directional baffles 205 and the inner walls of the compartment 12.

The operation of the oxygenator of the invention is substantially similar to the operation of a prior art oxygenator.

Typically, the oxygenator 1 is introduced into an extracorporeal circuit for oxygenating an organic fluid, namely for oxygenating the blood of a patient.

The patient's blood to be oxygenated, drained or sucked in by a special pump, enters the oxygenator 1 through the inlet port 7, after completion of a conventional "priming" step, which involves filling and recirculation of a saline or the like, to remove any area from the circuit.

Blood fills the oxygenation chamber 3 and flows through the perforated walls 11 of the three-dimensional frame 9, whereupon it tangentially laps the windings of hollow fibers 6 in which oxygen, or an oxygen mixture, flows, after entering the lumen 22, accumulating in the collection chamber 24 and flowing through the hollow fibers, whereby gas is exchanged with blood, due to differential concentration.

At the same time, a reverse exchange occurs, with carbon dioxide being released from blood into the hollow fibers, also due to differential concentration, and collected, with depleted oxygen, in the collection chamber 25, to be later discharged through the lumen 23.

The oxygenated blood collects in the chamber 14 formed by the inner wall of the oxygenation chamber 3 and the three-dimensional frame 9 and is conveyed back to the patient through the outlet port 8.

Blood is kept flowing by a known type of pump unit, mounted to the extracorporeal circuit.

Any air bubble in blood is vented out of the oxygenator through the lumens 15, 16, 17, to prevent them from accidentally reaching the patient.

Gas exchange between the hollow fibers 6 and blood is substantially complete and homogeneous over the entire available surface of the windings of hollow fibers 6, because the fibers in the areas of the oxygenator 1 close to the walls of the oxygenation chamber or the areas of the compartments 12 defined in the three-dimensional frame 9 have a controlled peripheral compression, which is maintained by the stiffness of the three-dimensional frame 9.

Therefore, blood flows are not subjected to detrimental speed reduction and any undesired accumulation and stagnation are thus prevented.

Furthermore, the profiles of the diaphragms 5 and the baffles 205 impart a wavy motion to blood flows, to avoid any laminar flow and promote turbulent flow, thereby improving contact with the surfaces of the hollow fibers 6 and, as a result, gas exchange.

Such turbulent flow is further facilitated by the profiles of the opposed concavities "C1" and "C2" of the surfaces of the diaphragms 5 and the opposed enlargements 310 formed in the ribs 10.

The oxygenator 1 of the invention can be assembled in a particularly quick and easy manner.

As shown in Figure 2, the windings of hollow fibers 6 are prepared and introduced into the compartments 12 defined in the three-dimensional frame 9 and between the end walls 11 of the latter and the inner walls of the oxygenation chamber 3.

Then, the three-dimensional frame 9, with its windings of hollow fibers 6 is placed in the oxygenation chamber 3 with the spacing buttons 29 holding it in the proper position.

These compartments 12 are substantially non-deformable and prevent undesired crushing of the windings of hollow fibers 6.

Finally, the two end pottings are formed and the covers 18 and 19 are placed, with the interposition of respective seals 20 and 21.

The skilled person may change the number of compartments 12 of the three-dimensional frame 9 according to special requirements and blood volumes to be oxygenated: therefore, the oxygenator 1 may have dimensional configurations designed for adult patients or for pediatric or infant use.

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

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

Furthermore, all the details may be replaced by other technically equivalent elements; the direction of flow of the fluids being used may be reversed without affecting the functionality of the inventive principle.

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 (1) to oxygenate an organic fluid in an extracorporeal circuit, comprising:

- A box-like shaped body (2) internally defining an oxygenation chamber (3) having an inlet (7) for the organic fluid to be oxygenated and an outlet (8) for the oxygenated organic fluid;

- At least an oxygen exchanging arrangement (4) with said organic fluid, fitted inside said oxygenation chamber (3) and comprising at least two hollow fibers windings (6) made of a micro-porous hydrophobic gas-permeable membrane which are designed to be lapped by transversal flows of said fluid to be oxygenated and inside which oxygen or a mixture of oxygen can flow,

characterized in that it comprises at least a three-dimensional frame (9) fittable inside said oxygenation chamber (3) and defining at least two corresponding housing spaces (12) wherein said at least two windings (6) can be housed in a peripherally compressed way.

2. An oxygenator according to claim 1, wherein said housing spaces (12) have fixed and identical volumes.

3. An oxygenator according to claim 1, wherein said housing spaces (12) are fitted side-by-side and have respective longitudinal parallel axes.

4. An oxygenator according to claim 1, wherein said three-dimensional frame (9) has perforated walls (11) to be crossed by flows of said fluid.

5. An oxygenator according to claim 1, wherein said three-dimensional frame (9) has reticulate walls (11) to be crossed by flows of said fluid.

6. An oxygenator according to claim 1, wherein said three-dimensional frame (9) has reticulate walls (11) defining constant dimensioned and pitched cross openings to be crossed by flows of said fluid.

7. An oxygenator according to claim 1, wherein said three-dimensional frame (9) has reticulate walls (11) defining not-constant dimensioned and pitched cross openings to be crossed by flows of said fluid.

8. An oxygenator according to claim 1, wherein said three-dimensional frame (9) has reticulate walls (11) defining opposite cross openings to be crossed by flows of said fluid and aligned on a mutual aligning line.

9. An oxygenator according to claim 1, wherein said three-dimensional frame (9) has reticulate walls (11) defining opposite misaligned cross openings to be crossed by flows of said fluid.

10. An oxygenator according to claim 1, wherein said at least two hollow fibers windings (6) comprise respective centered flat diaphragms (5) each of which shapes two opposite greater surfaces and which have profiles defining two opposite concavities (C1, C2).

11. An oxygenator according to claim 1, wherein said diaphragms (5) have end shelves (205) projecting from longer parallel sides, the shelves of one longer side being aligned with the shelves of the other longer side.

12. An oxygenator according to claim 1, wherein said diaphragms (5) have end shelves (205) projecting from longer parallel sides, the shelves of one longer side being misaligned from the shelves of the other longer side.

13. An oxygenator according to anyone of preceding claims, wherein said three-dimensional frame (9) defines separating ribs (10) of said spaces (12) having central zones (S1) wherein enlargements (310) are obtained in correspondence with said opposing concavities (C1, C2) of said diaphragms (5).

14. An oxygenator according to anyone of preceding claims, wherein in an assembled configuration of said oxygenator, said hollow fibers windings (6) have middle zones (S1) and end zones (S2) pressed by peripheral differable compressions.

15. An oxygenator according to claim 1, wherein said box-like shaped body (2) comprises two end lids (18, 19), two correspondent collecting chambers (24, 25) for collecting respectively oxygen/oxygen mixture to oxygenate said fluid and oxygen/oxygen mixture and carbon dioxide to be eliminated are provided between said lids (18, 19) and said exchanging arrangement (4).

16. An oxygenator according to anyone of preceding claims, wherein said three-dimensional frame (9) comprises spacing means (29) projecting from walls (11) of said three-dimensional frame (9), designed for the stable positioning inside said oxygenation chamber (3).

17. An oxygenator according to anyone of preceding claims, wherein said lids (18, 19) comprise connecting ports (22, 23) with an extracorporeal circuit, respectively an oxygen/oxygen mixture feeding port and oxygen/oxygen mixture and carbon dioxide washed away from said organic fluid eliminating port.

18. An oxygenator according to claim 1, wherein said box-like shaped body (2) further comprises air evacuation ports (15, 16, 17).

19. An oxygenator according to claim 1, wherein said inlet (7) and outlet (8) are aligned.

20. An oxygenator according to claim 1, wherein said inlet (7) and outlet (8) are misaligned.

21. An oxygenator according to anyone of preceding claims, wherein between said exchanging arrangement (4) and internal walls of said oxygenation chamber (3), at least a collecting chamber (13) to collect fluid to be oxygenated and a collecting chamber (14) to collect oxygenated fluid are defined.

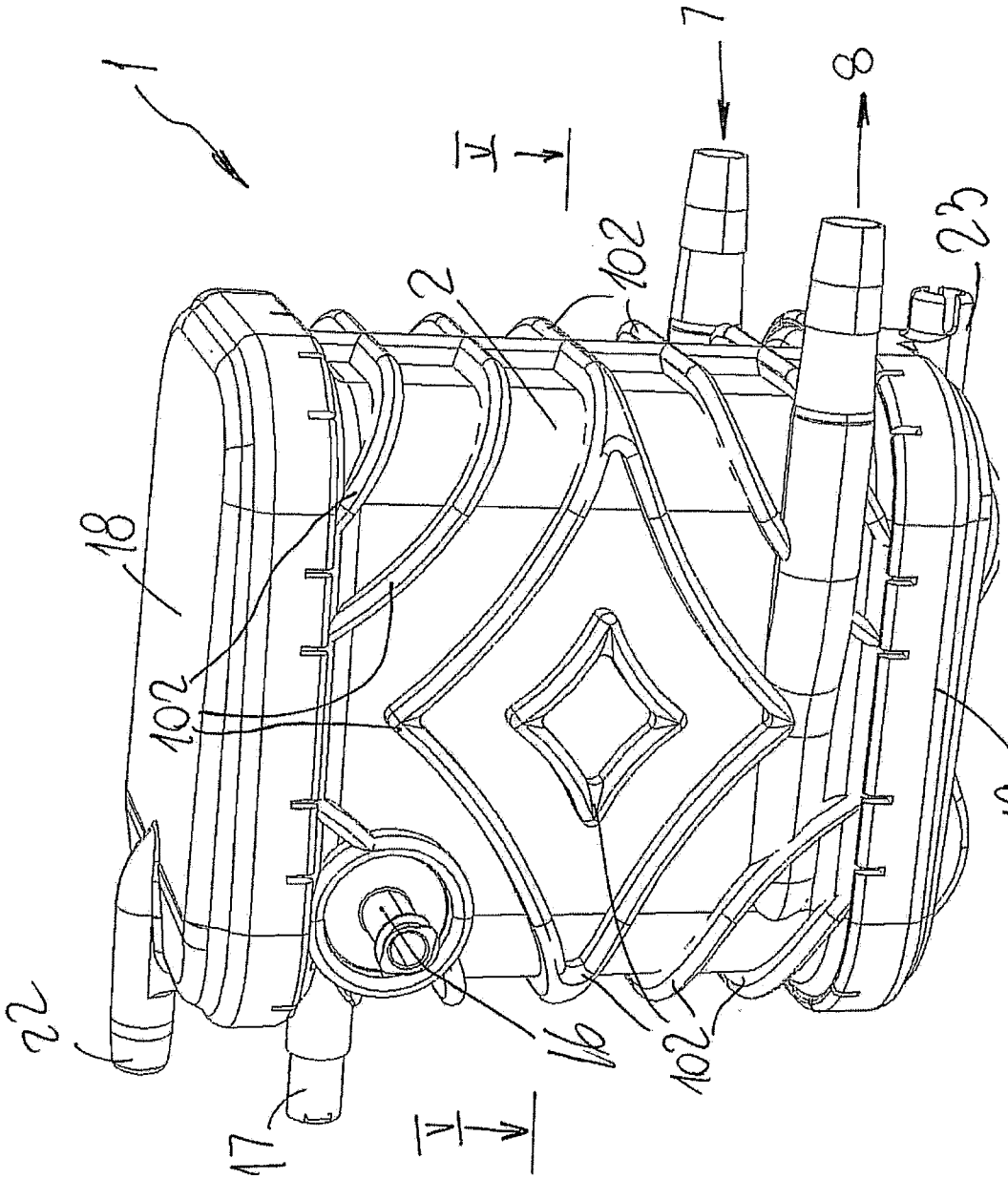

FIG. 1

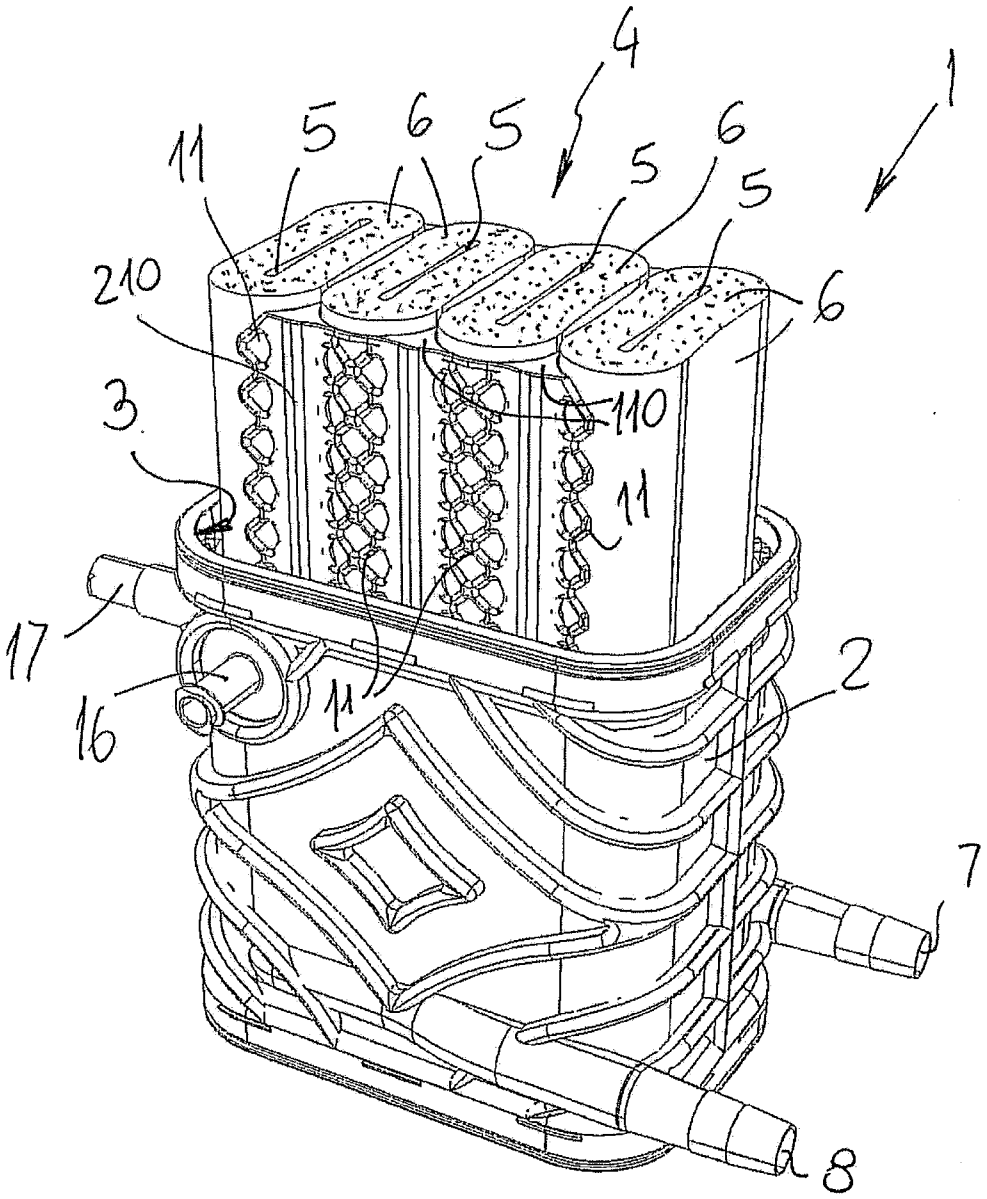

FIG. 2

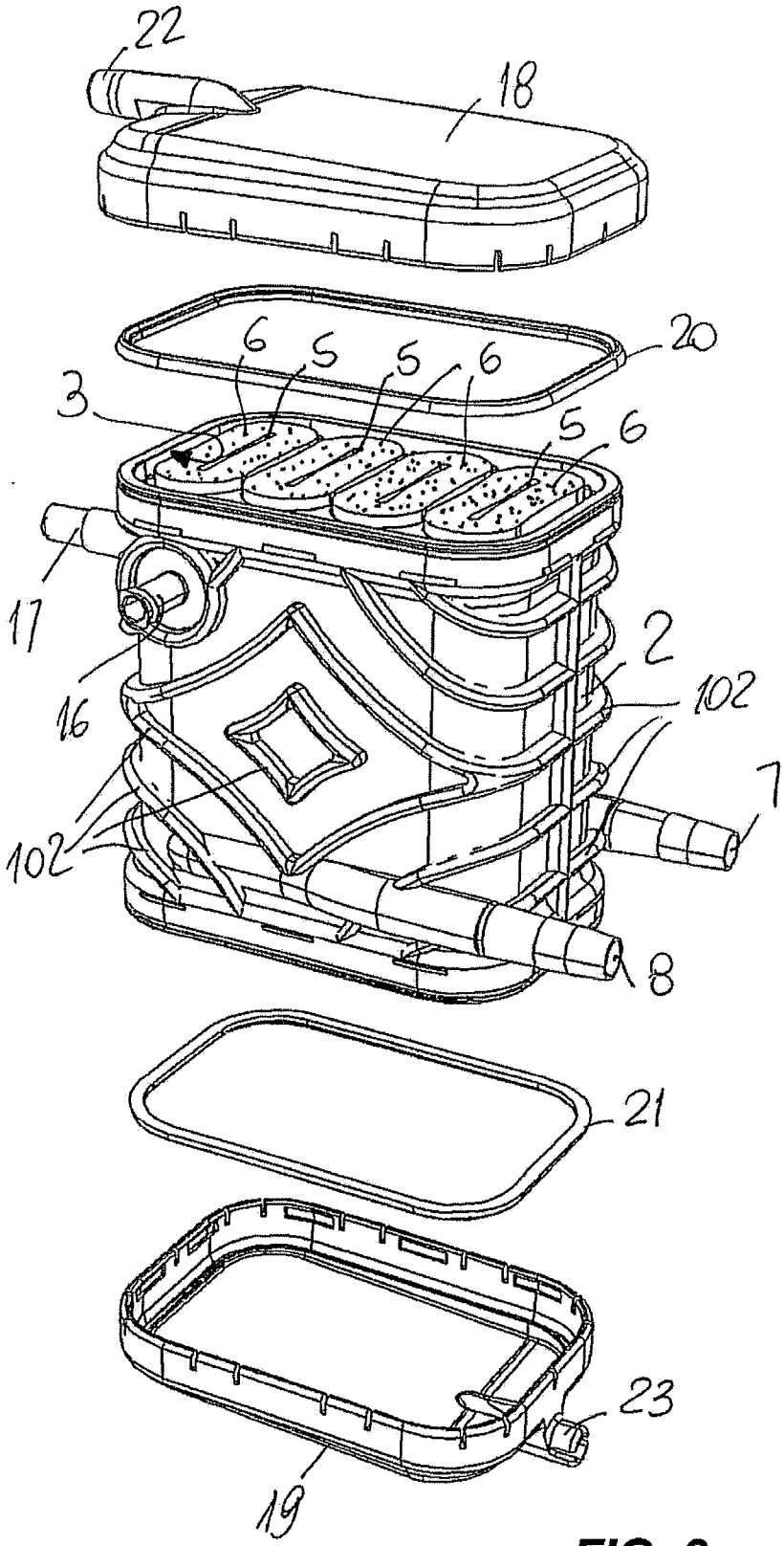

FIG. 3

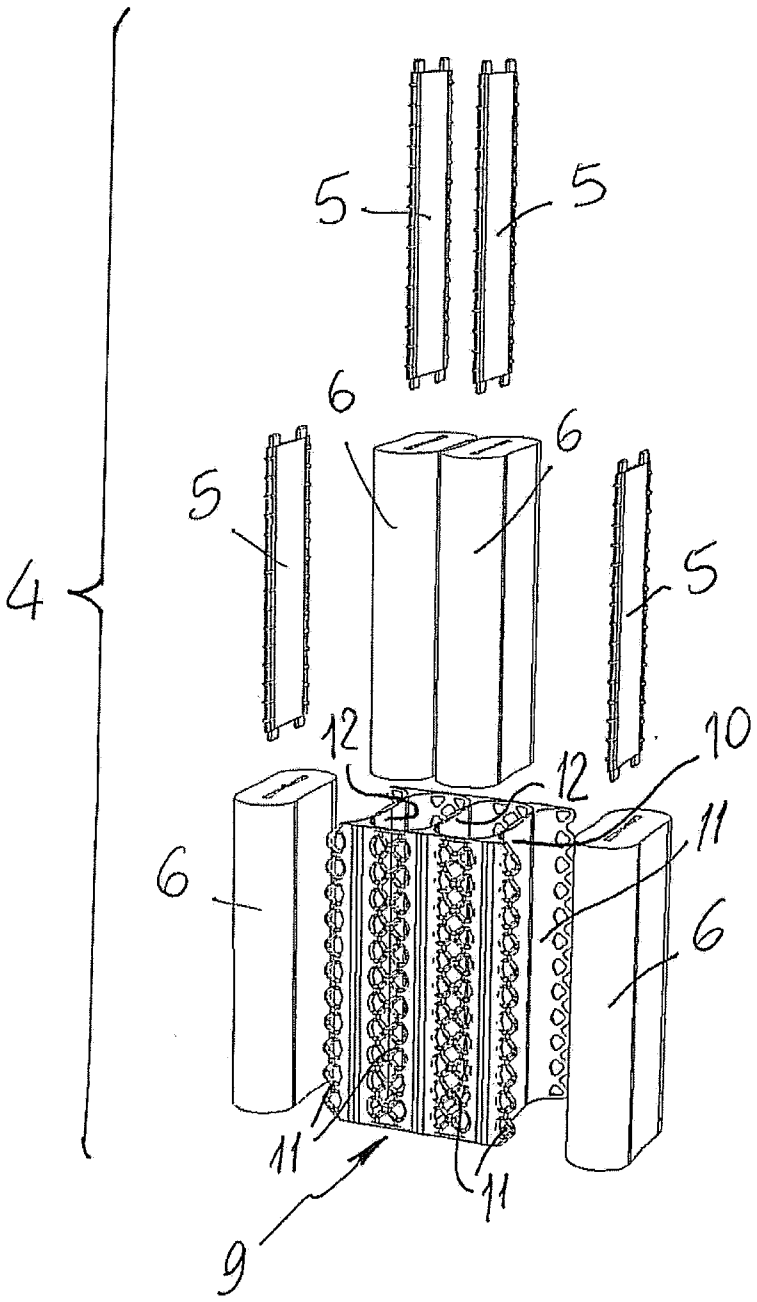

FIG. 4

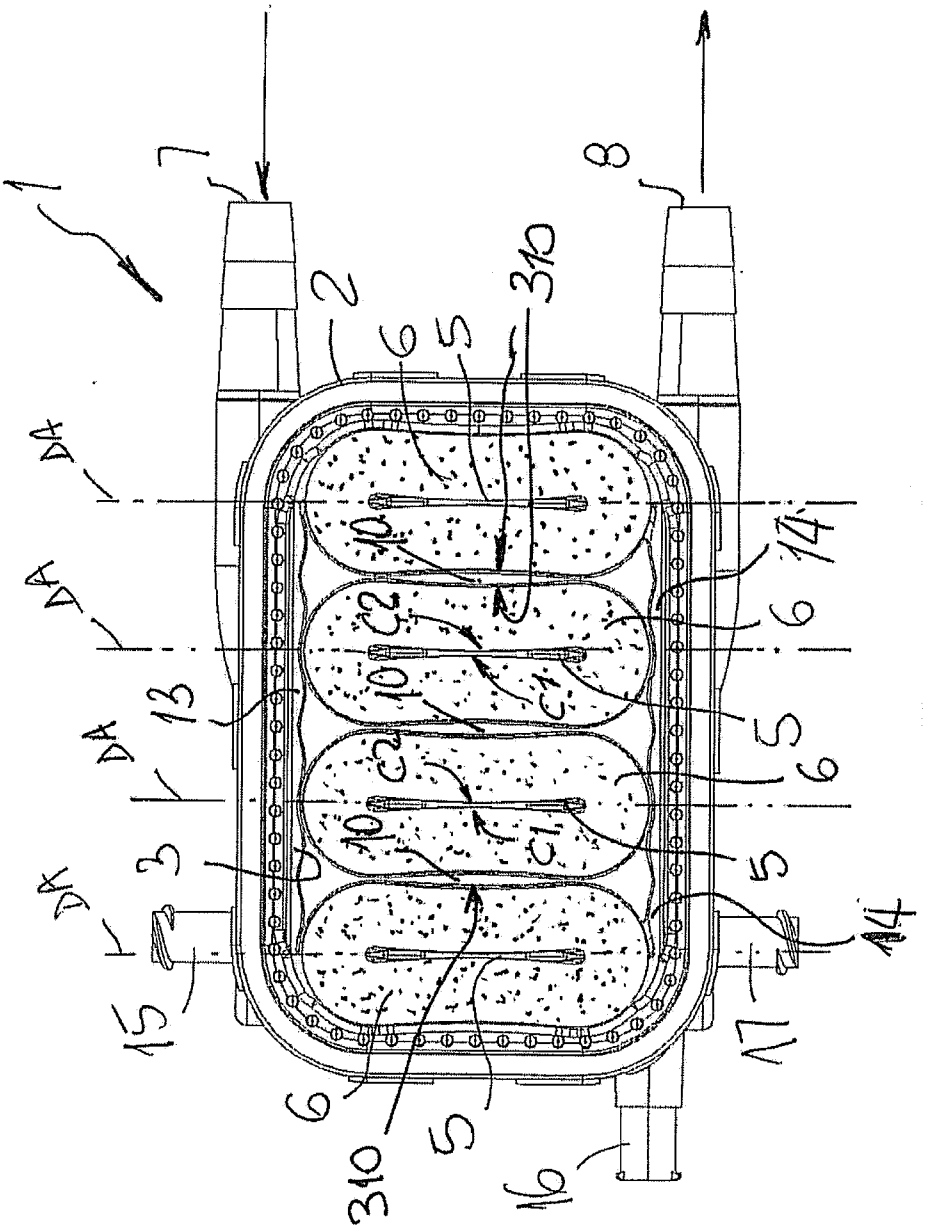

FIG. 5

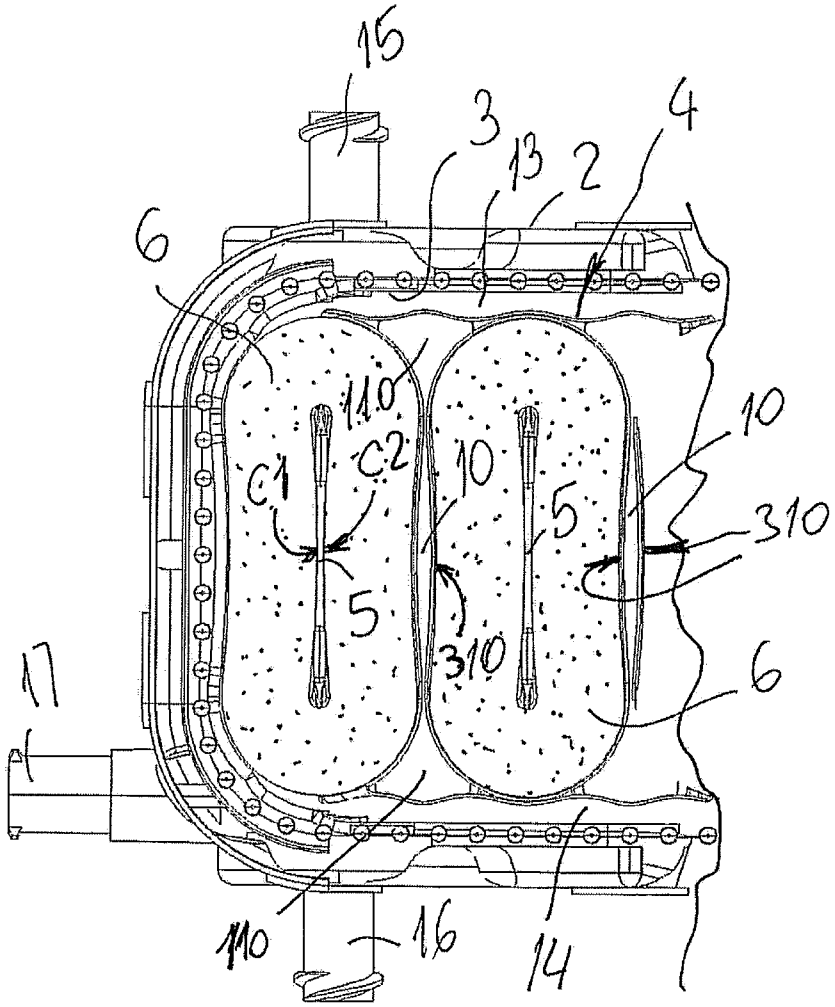

FIG. 6

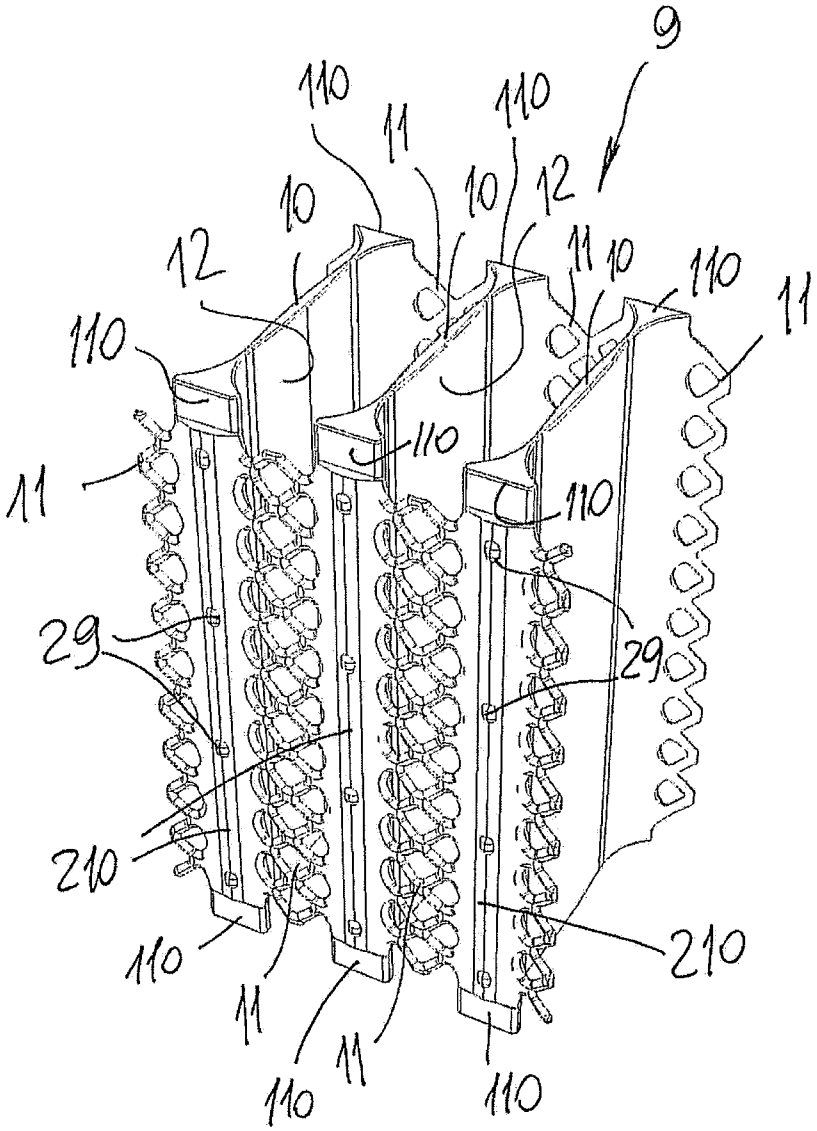
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FIG. 7

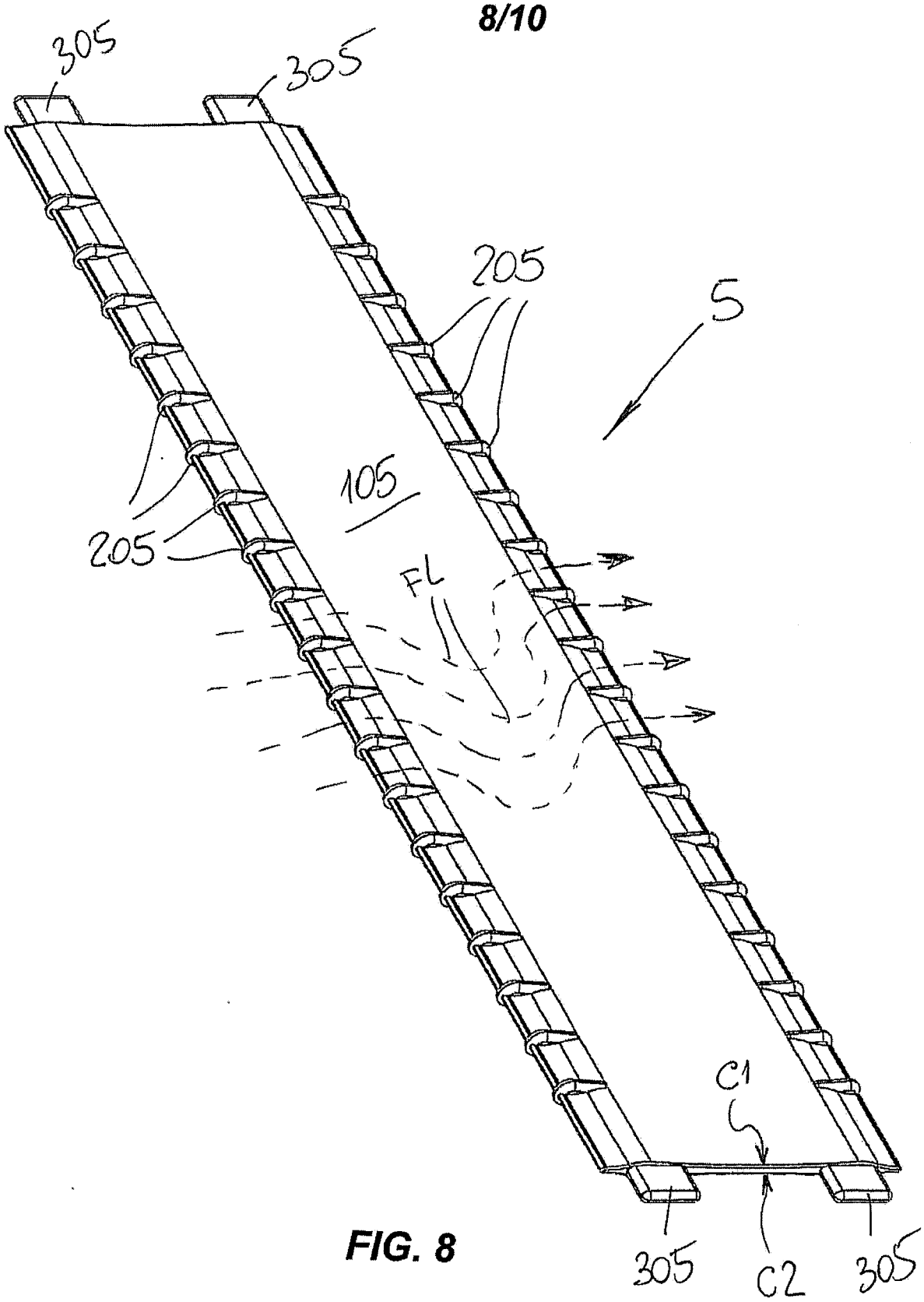
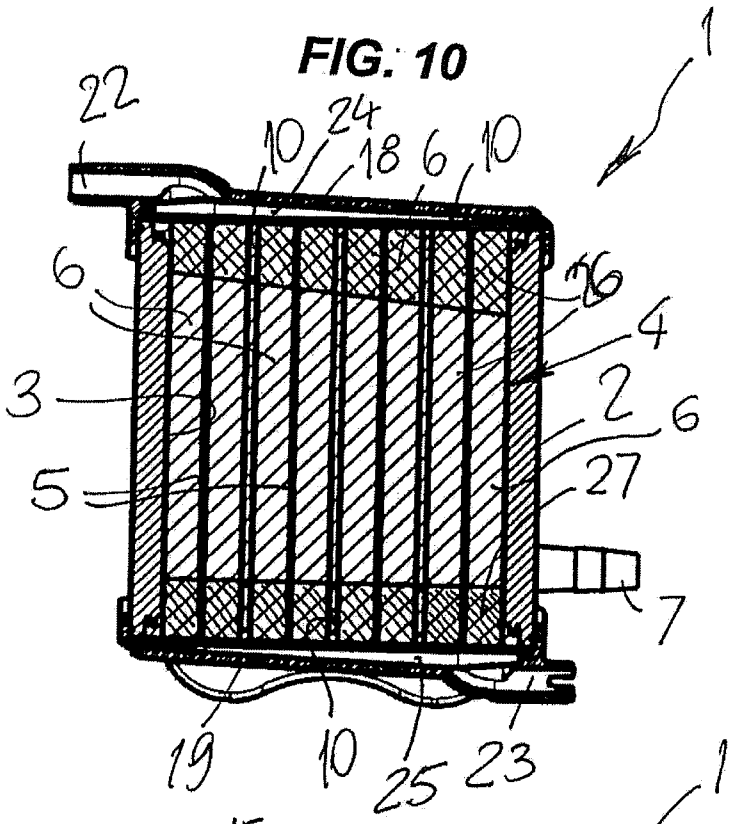


FIG. 8

FIG. 10



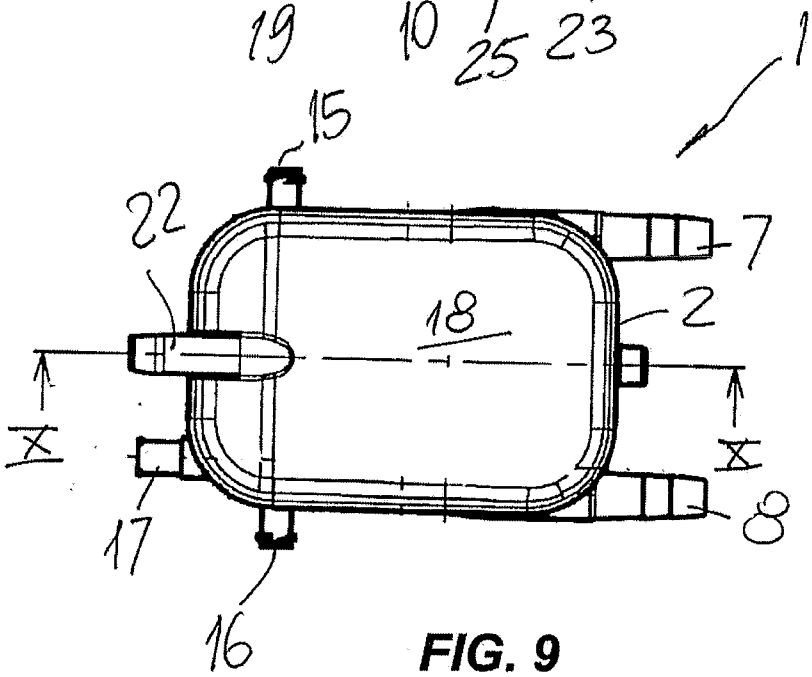
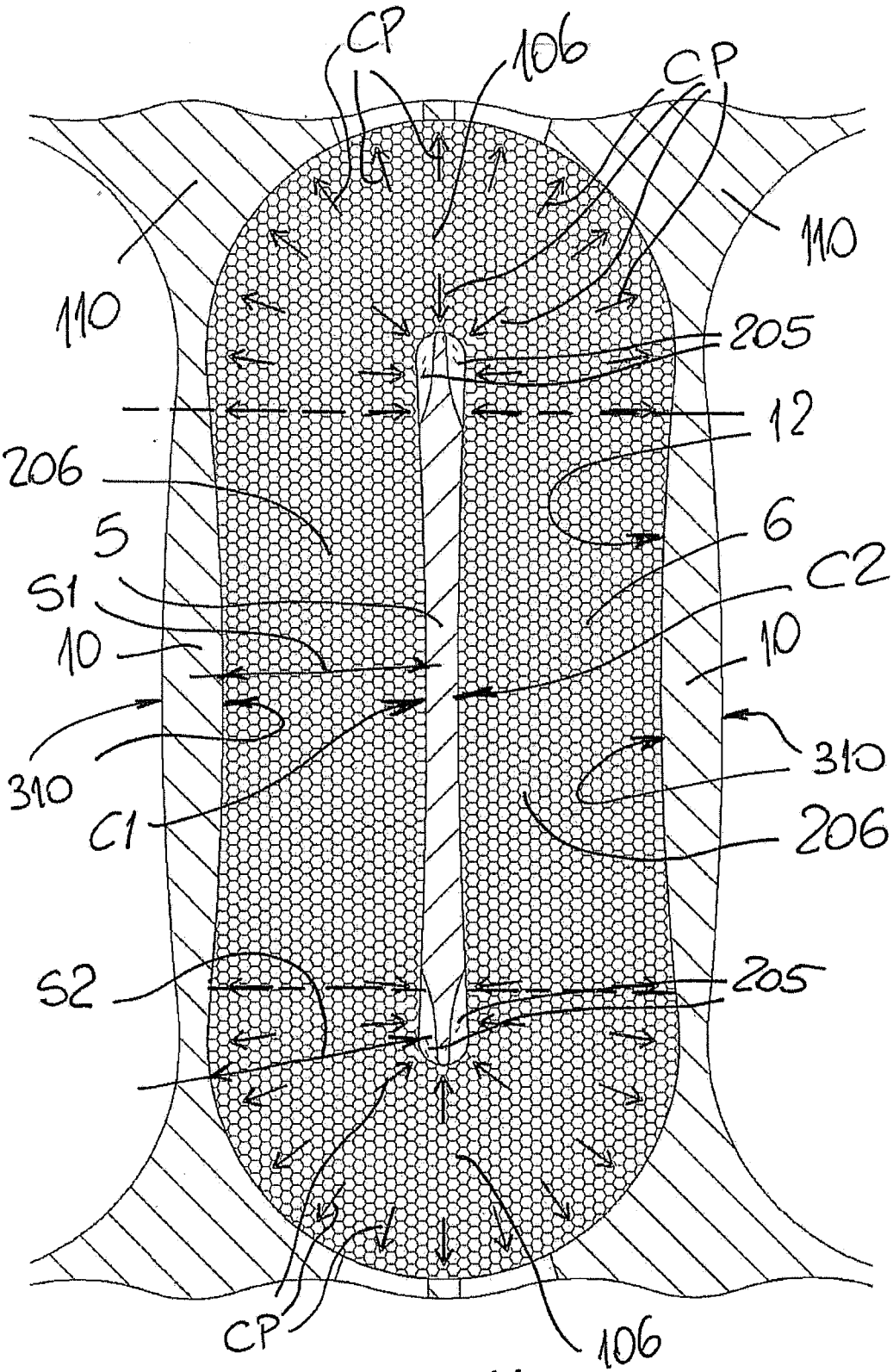


FIG. 9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S2
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CP
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FIG. 11