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(54) Title: BLOODLINE LIQUID EMPTYING DEVICE, BLOOD TREATMENT DEVICE, BLOOD TREATMENT MACHINE, METHOD FOR EMPTYING EXTRACORPOREAL BLOOD CIRCUIT, CONTROL SYSTEM AND COMPUTER READABLE PROGRAM CARRIER

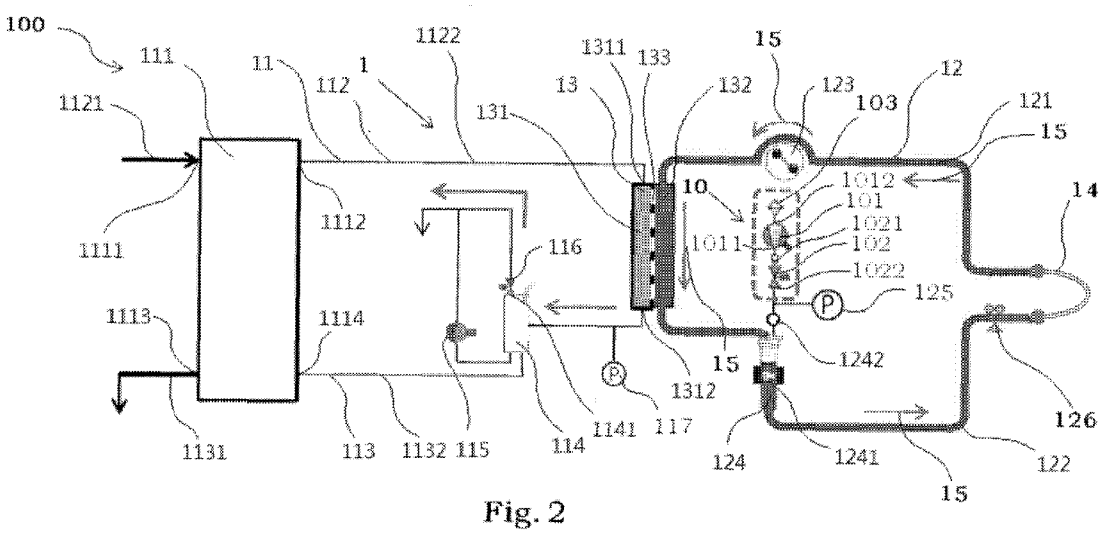

Fig. 2

(57) Abstract: A bloodline liquid emptying device (10) for a blood treatment device (1) is disclosed. The blood treatment device (1) comprises: a membrane filter (13) having a first chamber (131) and a second chamber (132) separated from the first chamber (131) by a membrane (133); a dialysate balancing hydraulic circuit (11) connected fluidly with the first chamber (131); an extracorporeal blood circuit (12) comprising an arterial blood line (121) and a venous blood line (122) each connected fluidly with the second chamber (132); and a venous bubble catcher (124) disposed at the venous blood line (122); wherein the bloodline liquid emptying device (10) is configured such that a pressurized air can be supplied to the venous blood line (122) via the venous bubble catcher (124) to displace liquid remaining in the extracorporeal blood circuit (12) from the second chamber (132) into the first chamber (131) across the membrane (133). Also disclosed are a corresponding blood treatment device (1), a corresponding blood treatment machine (100), a method for emptying an extracorporeal blood circuit of the blood treatment device (1), a corresponding control system and a corresponding computer readable program carrier. The emptying method can be carried out simply and the corresponding blood treatment machine (100) has a simple

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structure and even can be achieved by simply retrofitting the known blood treatment device.

Bloodline Liquid Emptying Device, Blood Treatment Device, Blood Treatment Machine, Method for Emptying Extracorporeal Blood Circuit, Control System and Computer Readable Program Carrier

Technical Field

The disclosure relates to a bloodline liquid emptying device, a blood treatment device, a blood treatment machine, a method for emptying an extracorporeal blood circuit of the blood treatment device, a control system and a computer readable program carrier.

Background Art

An emptying procedure usually is carried out after blood reinfusion to a patient during dialysis treatments. The used dialysate remaining in a dialyzer and a blood tubing set should be drained as much as possible to reduce the weight of used disposable items and the risk of cross-contamination, in particular with increasingly strict requirements for disposal of medical wastes.

There are some known methods to empty the dialyzer and/or the blood tubing set. However, such methods are usually complicated and may need many manual operations so that they are less automatic. Some of the manual operations may need assistance of the medical staff, such as the nurse.

Summary of the Disclosure

In view of at least one of the problems existing in the prior art, an object of the present disclosure is to provide a bloodline liquid emptying device, a blood treatment device, a blood treatment machine, a method for emptying an extracorporeal blood circuit of the blood treatment device, a control system and a computer readable program carrier.

For achieving this object, according to a first aspect, provided is a bloodline liquid emptying device for a blood treatment device, the blood treatment device comprising: a membrane filter having a first chamber and a second chamber separated from the first chamber by a membrane; a dialysate balancing hydraulic circuit connected fluidly with the first chamber; an extracorporeal blood circuit comprising an arterial blood line and a venous blood line each connected fluidly with the second chamber; and a venous bubble catcher disposed at the venous blood line; wherein the bloodline liquid emptying device is configured such that a pressurized air can be supplied to the venous blood line via the venous bubble

catcher to displace liquid remaining in the extracorporeal blood circuit from the second chamber into the first chamber across the membrane.

According to an optional embodiment of the present disclosure, the bloodline liquid emptying device comprises an air compressor and a valve, preferably a solenoid valve, wherein the valve has a first port connected with an outlet of the air compressor and a second port connected with the venous bubble catcher.

According to an optional embodiment of the present disclosure, the blood treatment device further comprises a positive pressure test unit and the bloodline liquid emptying device is configured at least partially based on at least one portion of the positive pressure test unit.

According to an optional embodiment of the present disclosure, the venous bubble catcher comprises a venous chamber and a pressure connector connected with the venous chamber, and the bloodline liquid emptying device is connected with the pressure connector.

According to an optional embodiment of the present disclosure, the bloodline liquid emptying device further comprises a hydrophobic filter connected with an inlet of the air compressor.

According to a second aspect, provided is a blood treatment device adapted to be connected with the bloodline liquid emptying device described above.

According to an optional embodiment of the present disclosure, the membrane filter is a dialyzer.

According to a third aspect, provided is a blood treatment machine comprising the bloodline liquid emptying device described above and/or the blood treatment device described above.

According to a fourth aspect, provided is a method for emptying an extracorporeal blood circuit of a blood treatment device by using the bloodline liquid emptying device described above, the method at least comprising: a first operation at least for connecting the arterial blood line and the venous blood line to one another to form a closed circuit including the membrane filter, the arterial blood line and the venous blood line; and a second operation for supplying the pressurized air to the venous blood line via the venous bubble catcher, preferably while the blood pump is in operation, to displace the liquid remaining in the extracorporeal blood circuit from the second chamber into the first chamber across the membrane.

According to an optional embodiment of the present disclosure, the method further comprises: a third operation for draining liquid collected in the first chamber, preferably executed in parallel with the second operation.

According to an optional embodiment of the present disclosure, the dialysate balancing hydraulic circuit comprises a balancing chamber system which is turned off during executing of the method.

According to an optional embodiment of the present disclosure, the first operation is executed manually after a patient is disconnected; and a first signal is generated to allow for starting second operation and the third operation in parallel.

According to an optional embodiment of the present disclosure, the first signal is displayed on a display, for example a touch screen.

According to an optional embodiment of the present disclosure, a blood pump is disposed at the arterial blood line such that during the second operation, preferably the blood pump is in operation continuously; and/or a trans-membrane pressure of the membrane filter is monitored.

According to an optional embodiment of the present disclosure, the second operation is executed automatically in parallel with the first operation.

According to an optional embodiment of the present disclosure, after completing the second operation and the third operation, a second signal is generated to indicate that all emptying operations have been finished.

According to a fifth aspect, provided is a control system configured to execute the method described above.

According to a sixth aspect, provided is a blood treatment machine comprising the control system described above.

According to a seventh aspect, provided is a computer readable program carrier storing program instructions therein, wherein the method described above is performed when the program instructions are executed by a processor.

According to the present disclosure, the emptying method can be carried out simply and the corresponding blood treatment machine has a simple structure and even can be achieved by simply retrofitting the known blood treatment device.

Brief Description of the Drawings

The disclosure and advantages thereof will be further understood by reading the

following detailed description of some preferred exemplary embodiments with reference to the drawings in which:

Fig.1 shows a schematic representation of a blood treatment machine according to an exemplary embodiment of the present disclosure.

Fig.2 schematically shows a configuration status of the blood treatment machine as shown in Fig.1 when an emptying method is executed.

Detailed Description of Preferred Embodiments

Some exemplary embodiments of the present disclosure will be described hereinafter in more details with reference to the drawings to better understand the basic concept of the present disclosure.

According to an aspect of the present disclosure, herein firstly proposed is a blood treatment machine, in particular a hemodialysis machine.

Fig.1 shows a schematic representation of the blood treatment machine 100 according to an exemplary embodiment of the present disclosure.

As shown in Fig.1, the blood treatment machine 100 may comprise a blood treatment device 1 and a bloodline liquid emptying device 10 for the blood treatment device 1.

The blood treatment device 1 may comprise: a dialysate balancing hydraulic circuit 11, an extracorporeal blood circuit 12 and a membrane filter 13 connected between the dialysate balancing hydraulic circuit 11 and the extracorporeal blood circuit 12. The membrane filter 13 may comprise a first chamber 131 and a second chamber 132 separated from the first chamber 131 by a membrane 133. The dialysate balancing hydraulic circuit 11 may be connected fluidly with the first chamber 131 and the extracorporeal blood circuit 12 may be connected fluidly with the second chamber 132.

Specifically, the dialysate balancing hydraulic circuit 11 may comprise a balancing chamber system 111, a fresh dialysate line 112 and a used dialysate line 113. The balancing chamber system 111 may be any kinds of balancing chamber systems, for example a single-chamber balancing chamber system or a dual-chamber balancing chamber system. The fresh dialysate line 112 may comprise a first fresh dialysate line 1121 connected fluidly with a fresh dialysate inlet 1111 of the balancing chamber system 111 to supply a fresh dialysate into the balancing chamber system 111 from a source (not shown), and a second fresh dialysate line 1122 connected fluidly between a fresh dialysate outlet 1112 of the

balancing chamber system 111 and a fresh dialysate inlet 1311 of the first chamber 131 of the membrane filter 13. The used dialysate line 113 may comprise a first used dialysate line 1131 connected fluidly with a used dialysate outlet 1113 of the balancing chamber system 111 to drain a used dialysate from the balancing chamber system 111 into a first drain (not shown), and a second used dialysate line 1132 connected fluidly between a used dialysate inlet 1114 of the balancing chamber system 111 and a used dialysate outlet 1312 of the first chamber 131 of the membrane filter 13.

According to an exemplary embodiment of the present disclosure, the membrane filter 13 may be a dialyzer.

As also can be seen from Fig.1, an air separation chamber 114 may be disposed at the second used dialysate line 1132 to prevent air from entering the balancing chamber system 111, and an ultrafiltration pump 115 may be connected fluidly with the air separation chamber 114 to achieve ultrafiltration of excessive patient body water from the used dialysate. In addition, a valve 116 may be connected fluidly with a port 1141 of the air separation chamber 114 to allow for draining liquid within the air separation chamber 114 to a second drain (not shown). Preferably, the valve 116 may be disposed at the port 1141 of the air separation chamber 114. More details can be found in Fig.1 and are not described herein.

It may be understood by the skilled person in the art that the first drain and the second drain may be the same drain.

Additionally, a dialysate pressure sensor 117 may be configured to measure a dialysate pressure at a side of the first chamber 131 of the membrane filter 13. In particular, the dialysate pressure sensor 117 may be disposed at the second used dialysate line 1132 adjacent to the used dialysate outlet 1312 of the first chamber 131 of the membrane filter 13.

The extracorporeal blood circuit 12 may comprise an arterial blood line 121 and a venous blood line 122 each connected fluidly with the second chamber 132, wherein during blood treatment, the arterial blood line 121 is used to transfer blood from a patient into the second chamber 132 and the venous blood line 122 is used to return the purified blood from the second chamber 132 to the patient.

According to an exemplary embodiment of the present disclosure, as shown in Fig.1, a blood pump 123, for example a peristaltic pump, may be disposed at the extracorporeal blood circuit 12, preferably at the arterial blood line 121. By means of the blood pump 123, the blood can be drawn from the patient into the

second chamber 132 through the arterial blood line 121 and then be returned to the patient through the venous blood line 122.

According to an exemplary embodiment of the present disclosure, as shown in Fig.1, a venous bubble catcher 124 may be disposed at the venous blood line 122 to catch bubbles in the purified blood before the purified blood is returned to the patient. The venous bubble catcher 124 may comprise a venous chamber 1241 and a pressure connector 1242. The pressure connector 1242 is usually disposed on a machine panel of the blood treatment device 1.

According to an exemplary embodiment of the present disclosure, a venous pressure sensor 125 may be connected fluidly with the venous bubble catcher 124 via the pressure connector 1242 to measure a blood pressure at a side of the second chamber 132 of the membrane filter 13.

It may be understood by the skilled person in the art that a trans-membrane pressure of the membrane filter 13 can be monitored by using the dialysate pressure sensor 117 and the venous pressure sensor 125.

The bloodline liquid emptying device 10 may be connected (optionally fluidly) with the venous bubble catcher 124, in particular via the pressure connector 1242. The bloodline liquid emptying device 10 may be configured to supply a pressurized air into the venous blood line 122 at the venous bubble catcher 124.

According to an exemplary embodiment of the present disclosure, the bloodline liquid emptying device 10 may comprise an air compressor 101 for generating the pressurized air, and a valve 102 for controlling flowing of the pressurized air toward the venous bubble catcher 124, wherein the valve 102 has a first port 1021 connected with an outlet 1011 of the air compressor 101 and a second port 1022 connected with the venous bubble catcher 124, in particular with the pressure connector 1242 of the venous bubble catcher 124.

The valve 102 may be an on-off valve. According to an exemplary embodiment of the present disclosure, the valve 102 may be a solenoid valve.

According to an exemplary embodiment of the present disclosure, the bloodline liquid emptying device 10 may further comprise a hydrophobic filter 103 connected with an inlet 1012 of the air compressor 101.

According to an exemplary embodiment of the present disclosure, the blood treatment device 1 may further comprise a venous clamp 126 disposed at the venous blood line 122, which may be closed or opened as desired.

According to an exemplary embodiment of the present disclosure, the blood treatment device 1 may further comprise a positive pressure test unit (not shown) configured to be connected fluidly with the second fresh dialysate line 1122. The positive pressure test unit may be used to execute positive pressure test of the blood treatment device 1 by applying a pressurized air.

In this case, the bloodline liquid emptying device 10 may be configured at least partially based on at least one portion of the positive pressure test unit, which is very simple to be implemented.

The blood treatment device 1 often comprises a controller (not shown) for controlling operations of the blood treatment device 1. Operations of the bloodline liquid emptying device 10 can be controlled advantageously by the controller or also can be controlled by a separate controller.

Thereafter, a method for emptying the extracorporeal blood circuit 12 of the blood treatment device 1 by means of the bloodline liquid emptying device 10 will be described in connection with Fig.2, which can also help to further understand the above structure features and possibly other structure features of the blood treatment device 1.

Fig.2 schematically shows a configuration status of the blood treatment machine 100 as shown in Fig.1 when the method is executed.

The method may at least comprise the following operations: 1) a first operation at least for connecting the arterial blood line 121 and the venous blood line 122 to one another to form a closed circuit including the membrane filter 13, the arterial blood line 121 and the venous blood line 122; and 2) a second operation for supplying the pressurized air to the venous blood line 122 via the venous bubble catcher 124 by the bloodline liquid emptying device 10 to displace the liquid remaining in the extracorporeal blood circuit 12 from the second chamber 132 into the first chamber 131 across the membrane 133.

For generating the pressurized air, the valve 102 is opened and the air compressor 101 is turned on.

More specifically, the arterial blood line 121 and the venous blood line 122 can be connected directly to each other by means of corresponding connectors (not shown), or can be connected to each other by means of a connection tube 14 as shown in Fig.2. The connecting operation can be done by the patient or a nurse after the patient is disconnected.

When the pressurized air is introduced into the venous blood line 122 via the

venous bubble catcher 124, the pressurized air can flow in the closed circuit along directions indicated by arrows 15 as shown in Fig.2. The pressurized air flows sequentially through a segment of the venous blood line 122, the arterial blood line 121 and then into the second chamber 132 while dislodging the residual liquid, for example blood in the segment of the venous blood line 122 and the arterial blood line 121 to the second chamber 132 and thus to be collected in the second chamber 132.

For allowing for or assisting in dislodging the residual liquid, the venous clamp 126 is opened.

The second chamber 132 of the membrane filter 13 is thus loaded at both sides with air/liquid and thus with pressure so that the residual liquid can be transported from the second chamber 132 into the first chamber 131 across the membrane 133.

According to an exemplary embodiment of the present disclosure, the method may further comprise a third operation for draining liquid collected in the first chamber 131. It may be understood that the third operation can be executed in at least partial time overlap with the second operation or after the second operation, more preferably in parallel with the second operation.

According to an exemplary embodiment of the present disclosure, during executing of the method, the balancing chamber system 111 may be turned off.

It can be seen easily that the method can be carried out simply with possibly only requiring a manual operation of connecting the arterial blood line 121 and the venous blood line 122. The subsequent emptying process after the first operation can then be started by pressing a button (not shown). As an exemplary embodiment, a first signal may be displayed on a display (not shown), for example a touch screen to allow for starting the emptying process. The emptying process may be carried out automatically after pressing the button.

According to an exemplary embodiment of the present disclosure, the pressurized air enters the venous chamber 1241 via the pressure connector 1242 to pressurize the whole closed circuit.

According to an exemplary embodiment of the present disclosure, during the second operation, the blood pump 123 can be in operation continuously or intermittently, preferably periodically for supporting the emptying process. By means of operation of the blood pump 123, the residual liquid in the venous blood line 122 and the arterial blood line 121 can be dislodged more easily into

the second chamber 132, in particular in the case of the blood pump being a peristaltic pump. It may be understood by the skilled person in the art that the blood pump may not work necessarily where the blood pump is configured in a certain type of pump.

Preferably, the trans-membrane pressure of the membrane filter 13 may be monitored at least after the first operation to for example avoid rupture of the membrane 133 when the trans-membrane pressure is too high. When the trans-membrane pressure is too high, the air compressor 101 will be turned off and/or the valve 102 is closed. If such a problem cannot be resolved with a reasonable time period, the emptying process will be ended and then a corresponding message signal will be generated and preferably displayed on a screen.

According to an exemplary embodiment of the present disclosure, the emptying process may be stopped automatically when the emptying process has been executed for a predetermined time period, for example 30-90 seconds. The predetermined time period can be predetermined experimentally.

According to an exemplary embodiment of the present disclosure, the third operation for draining liquid collected in the first chamber 131 can be executed via the opened valve 116, in particular in parallel with the second operation.

Preferably, after completing the emptying process, a second signal, for example an acoustic and/or optical signal, may be generated to indicate that all emptying operations have been finished.

As another aspect of the present disclosure, a further subject matter of the present disclosure relates to the bloodline liquid emptying device 10 for the blood treatment device 1.

According to a further aspect of the present disclosure, proposed is a control system configured to execute the above method, in particular operations of the emptying process. Some program parameters, for example the predetermined time period and/ the blood pump speed, can be stored in a memory and then are recalled as desired to execute the emptying process. It may be understood by the skilled person in the art that at least one of these program parameters may be determined based on characteristics of components of the blood treatment device, for example a type of the membrane 133, a speed of the blood pump 123, bloodline type, and so on.

Further proposed is a blood treatment machine comprising the above control

system.

According to another aspect of the present disclosure, further proposed is a computer readable program carrier storing program instructions therein, wherein the method may be achieved when the program instructions are executed by a processor.

It may be understood by the skilled person in the art that an emptying time period required to complete the emptying process depends on a plurality of factors, such as the type of the membrane 133, a bloodline type, the speed of the blood pump 123, and a pressure built in the closed circuit by the pressurized air and so on. The optimized emptying time period and the optimized speed of the blood pump may be set in a corresponding program for example by a user when other factors are known.

It can be seen from the above that the arterial blood line 121 and the venous blood line 122 on the blood treatment device 1 do not need to be changed according to the present disclosure and the corresponding operation also is simple.

While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the disclosure. The attached claims and their equivalents are intended to cover all the modifications, substitutions and changes as would fall within the scope and spirit of the disclosure.

CLAIMS

1. A bloodline liquid emptying device (10) for a blood treatment device (1), the blood treatment device (1) comprising:

a membrane filter (13) having a first chamber (131) and a second chamber (132) separated from the first chamber (131) by a membrane (133);

a dialysate balancing hydraulic circuit (11) connected fluidly with the first chamber (131);

an extracorporeal blood circuit (12) comprising an arterial blood line (121) and a venous blood line (122) each connected fluidly with the second chamber (132); and

a venous bubble catcher (124) disposed at the venous blood line (122);

wherein the bloodline liquid emptying device (10) is configured such that a pressurized air can be supplied to the venous blood line (122) via the venous bubble catcher (124) to displace liquid remaining in the extracorporeal blood circuit (12) from the second chamber (132) into the first chamber (131) across the membrane (133).

2. The bloodline liquid emptying device (10) according to claim 1, wherein

the bloodline liquid emptying device (10) comprises an air compressor (101) and a valve (102), preferably a solenoid valve, wherein the valve (102) has a first port (1021) connected with an outlet (1011) of the air compressor (101) and a second port (1022) connected with the venous bubble catcher (124).

3. The bloodline liquid emptying device (10) according to claim 1 or 2, wherein

the blood treatment device (1) further comprises a positive pressure test unit and the bloodline liquid emptying device (10) is configured at least partially based on at least one portion of the positive pressure test unit.

4. The bloodline liquid emptying device (10) according to any one of claims 1-3, wherein

the venous bubble catcher (124) comprises a venous chamber (1241) and a pressure connector (1242) connected with the venous chamber (1241), and the bloodline liquid emptying device (10) is connected with the pressure connector (1242).

5. The bloodline liquid emptying device (10) according to any one of claims 1-4, wherein

the bloodline liquid emptying device (10) further comprises a hydrophobic filter (103) connected with an inlet (1012) of the air compressor (101).

6. A blood treatment device (1) adapted to be connected with the bloodline liquid emptying device (10) according to any one of claims 1-5.

7. The blood treatment device (1) according to claim 6, wherein

the membrane filter (13) is a dialyzer.

8. A blood treatment machine (100) comprising the bloodline liquid emptying device (10) according to any one of claims 1-5 and/or the blood treatment device (1) according to claim 6 or 7.

9. A method for emptying an extracorporeal blood circuit (12) of a blood treatment device (1) by using the bloodline liquid emptying device (10) according to any one of claims 1-5, the method at least comprising:

a first operation at least for connecting the arterial blood line (121) and the venous blood line (122) to one another to form a closed circuit including the membrane filter (13), the arterial blood line (121) and the venous blood line (122); and

a second operation for supplying the pressurized air to the venous blood line (122) via the venous bubble catcher (124), preferably while the blood pump is in operation, to displace the liquid remaining in the extracorporeal blood circuit (12) from the second chamber (132) into the first chamber (131) across the membrane (133).

10. The method according to claim 9, wherein the method further comprises:

a third operation for draining liquid collected in the first chamber (131), preferably executed in parallel with the second operation.

11. The method according to claim 9 or 10, wherein

the dialysate balancing hydraulic circuit (11) comprises a balancing chamber system (111) which is turned off during executing of the method.

12. The method according to claim 10 or 11, wherein

the first operation is executed manually after a patient is disconnected; and

a first signal is generated to allow for starting second operation and the third operation in parallel.

13. The method according to claim 12, wherein

the first signal is displayed on a display, for example a touch screen.

14. The method according to any one of claims 9-13, wherein

a blood pump (123) is disposed at the arterial blood line (121) such that during the second operation, preferably the blood pump (123) is in operation continuously; and/or

a trans-membrane pressure of the membrane filter (13) is monitored.

15. The method according to any one of claims 9-14, wherein

the second operation is executed automatically in parallel with the first operation.

16. The method according to any one of claims 10-15, wherein

after completing the second and the third operation, a second signal is generated to indicate that all emptying operations have been finished.

17. A control system configured to execute the method according to any one of claims 9-16.

18. A blood treatment machine (100) comprising the control system according to claim 17.

19. A computer readable program carrier storing program instructions therein, wherein the method according to any one of claims 9-16 is performed when the program instructions are executed by a processor.

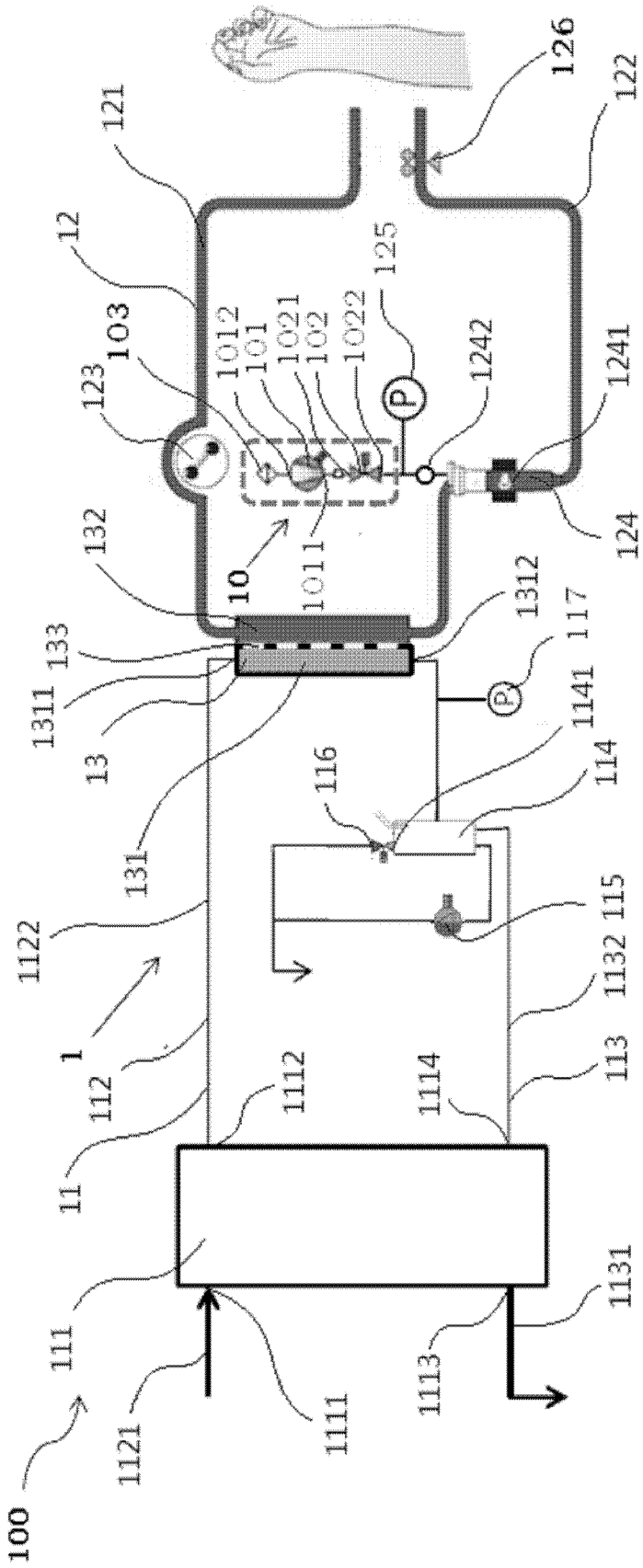
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Fig. 1

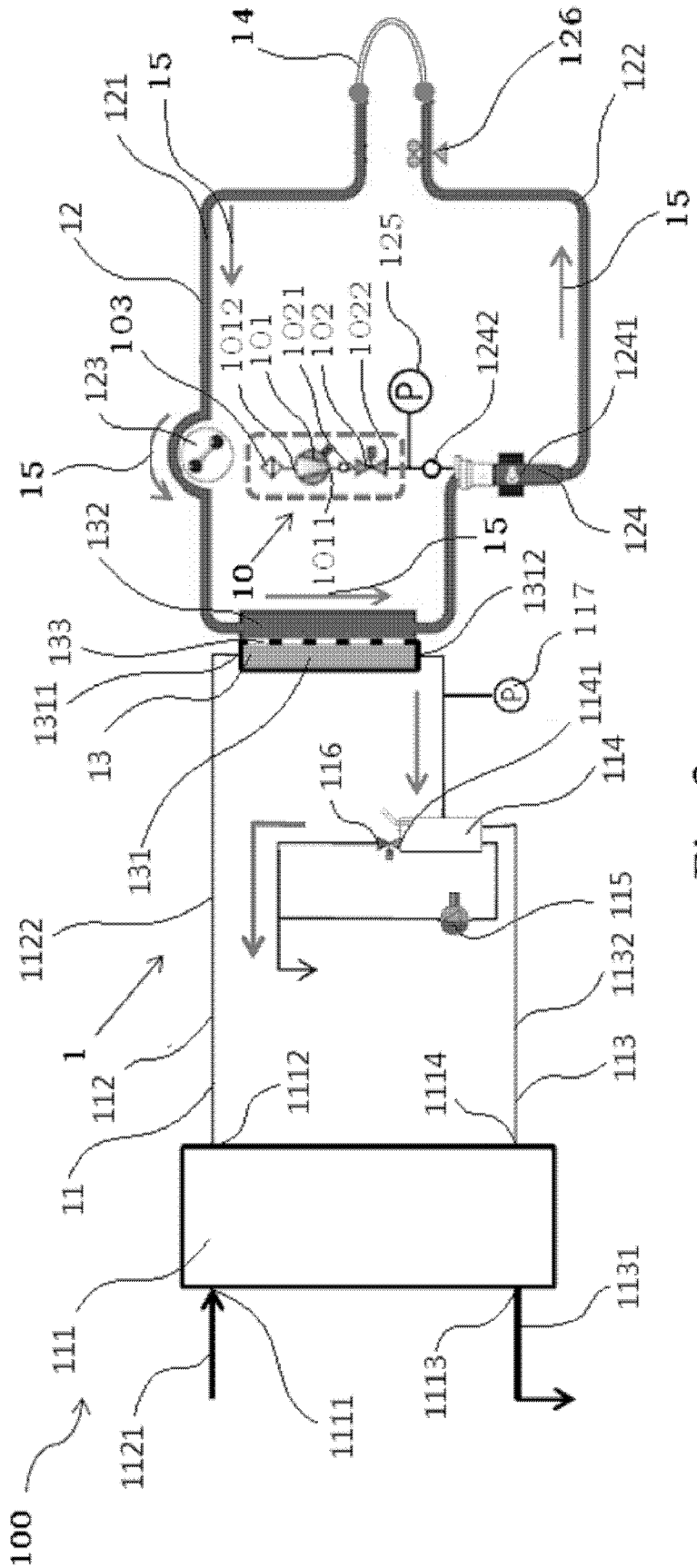
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Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2020/076234

A. CLASSIFICATION OF SUBJECT MATTER

A61M 1/36(2006.01)i; A61M 1/16(2006.01)i; A61M 1/34(2006.01)i

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)

A61M1/-

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)

WPI,EPODOC,CNKI,CNPAT:FRESENIUS,DEUTSCHLAND,dialysate,bloodline,liquid,empty,remov+,membrane,film, filter+,balanc+,air,gas,bubble,catch+,displac+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 101400387 A (FRESENIUS MEDICAL CARE DEUTSCHLAND G.M.B.H.) 01 April 2009 (2009-04-01) pages 5-8 in the description, figure 1	1-19
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☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
15 October 2020	**28 October 2020**
Name and mailing address of the ISA/CN **National Intellectual Property Administration, PRC** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China** Facsimile No. **(86-10)62019451**	Authorized officer **ZHANG,Meng** Telephone No. **86-(10)-53962402**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2020/076234

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