



Office de la Propriété

Intellectuelle
du Canada

Un organisme
d'Industrie Canada

Canadian
Intellectual Property
Office

An agency of
Industry Canada

CA 2652940 A1 2007/12/06

(21) **2 652 940**

(12) **DEMANDE DE BREVET CANADIEN**
CANADIAN PATENT APPLICATION

(13) **A1**

(86) Date de dépôt PCT/PCT Filing Date: 2007/05/29
(87) Date publication PCT/PCT Publication Date: 2007/12/06
(85) Entrée phase nationale/National Entry: 2008/11/20
(86) N° demande PCT/PCT Application No.: NL 2007/000136
(87) N° publication PCT/PCT Publication No.: 2007/139374
(30) Priorité/Priority: 2006/05/31 (NL1031926)

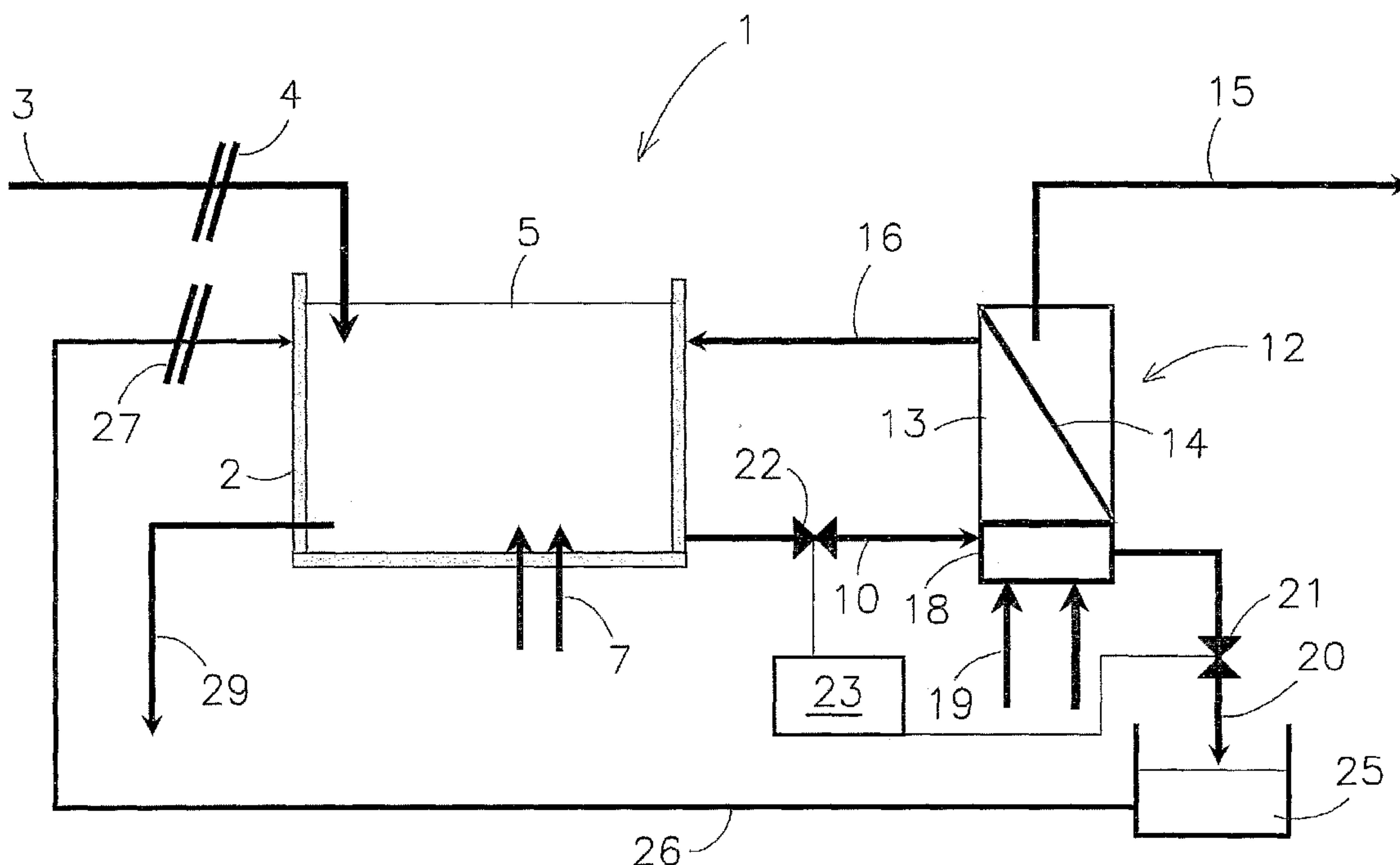
(51) Cl.Int./Int.Cl. *C02F 3/12*(2006.01),
B01D 65/02(2006.01)

(71) Demandeur/Applicant:
X-FLOW B.V., NL

(72) Inventeurs/Inventors:
FUTSELAAR, HARRY, NL;
BORGERINK, ROB, NL

(74) Agent: KIRBY EADES GALE BAKER

(54) Titre : APPAREIL DOTE D'UN BIORÉACTEUR ET D'UN MODULE DE FILTRATION SUR MEMBRANE POUR LE TRAITEMENT D'UN FLUIDE ENTRANT
(54) Title: APPARATUS HAVING A BIOREACTOR AND MEMBRANE FILTRATION MODULE FOR TREATMENT OF AN INCOMING FLUID



(57) Abrégé/Abstract:

An apparatus for treatment of an incoming fluid, comprising a bioreactor with a basin (2) with a fluid space and a membrane filtration module (12) comprising a housing (13) with one or more incorporated membranes (14), an inlet side, a permeate side and a retentate side, wherein the housing (13) delimits a connection chamber (18) on the inlet side of the membranes (14) into which a fluid inlet line (10) discharges which is connected to the fluid space of the basin (2). A closable flushing discharge line (20) is provided which is connected on one side to the connection chamber (18) and on the other side discharges outside the fluid space. A fluid mixture feed-through line from the basin to the connection chamber is closable, and a control unit (23) is provided for periodically closing the fluid mixture feed-through line and opening the flushing discharge line (20), and vice versa, for periodic flushing of at least the inlet side of the membranes (14) and the connection chamber (18) disposed underneath it.

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

(19) World Intellectual Property Organization
International Bureau(43) International Publication Date
6 December 2007 (06.12.2007)

PCT

(10) International Publication Number
WO 2007/139374 A1(51) International Patent Classification:
C02F 3/12 (2006.01) **B01D 65/02** (2006.01)

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, 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, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(21) International Application Number:
PCT/NL2007/000136

(22) International Filing Date: 29 May 2007 (29.05.2007)

(25) Filing Language: Dutch

(26) Publication Language: English

(30) Priority Data:
1031926 31 May 2006 (31.05.2006) NL(71) Applicant (for all designated States except US): **X-FLOW B.V.** [NL/NL]; Marssteden 50, NL-7547 TC Enschede (NL).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **FUTSELAAR, Harry** [NL/NL]; Kretastraat 34, NL-7559 CS Hengelo (NL). **BORGERINK, Rob** [NL/NL]; 58, Kapittelhuisstraat, 7665 BB Albergen (NL).(74) Agent: **RIEMENS, R., H.**; Exter Polak & Charlouis B.V., P.O. Box 3241, NL-2288 EC Rijswijk (NL).

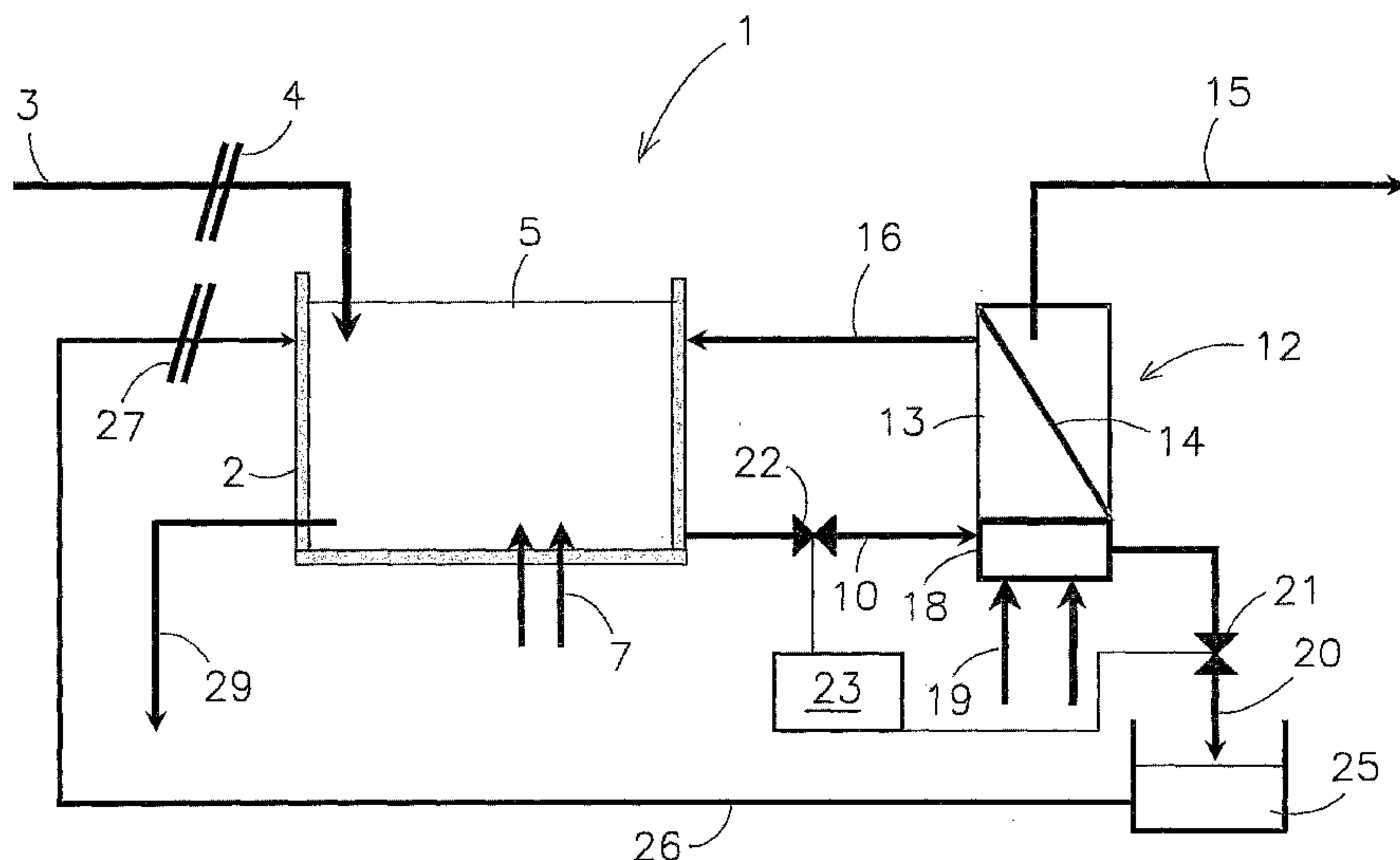
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: APPARATUS HAVING A BIOREACTOR AND MEMBRANE FILTRATION MODULE FOR TREATMENT OF AN INCOMING FLUID



(57) Abstract: An apparatus for treatment of an incoming fluid, comprising a bioreactor with a basin (2) with a fluid space and a membrane filtration module (12) comprising a housing (13) with one or more incorporated membranes (14), an inlet side, a permeate side and a retentate side, wherein the housing (13) delimits a connection chamber (18) on the inlet side of the membranes (14) into which a fluid inlet line (10) discharges which is connected to the fluid space of the basin (2). A closable flushing discharge line (20) is provided which is connected on one side to the connection chamber (18) and on the other side discharges outside the fluid space. A fluid mixture feed-through line from the basin to the connection chamber is closable, and a control unit (23) is provided for periodically closing the fluid mixture feed-through line and opening the flushing discharge line (20), and vice versa, for periodic flushing of at least the inlet side of the membranes (14) and the connection chamber (18) disposed underneath it.

WO 2007/139374 A1

APPARATUS HAVING A BIOREACTOR AND MEMBRANE FILTRATION MODULE FOR TREATMENT OF AN INCOMING FLUID

5

The invention relates to an apparatus for treatment of an incoming fluid, comprising a bioreactor and a membrane filtration module, also referred to as membrane bioreactor (MBR).

10

Such a membrane bioreactor is known, for example, for purifying waste water, and comprises a basin which is partially filled with active sludge. During operation, the waste water is fed to the basin where it mixes with the sludge. The active ingredients in the sludge take care of purifying the waste water. This process is accelerated even more by supplying a gas, usually air, from below to (part of) the basin. The mixture of sludge and waste water is then fed to the membrane filtration module where purified water is discharged as permeate, while the retained liquid, polluted particles and sludge particles as retentate are fed back to the basin. The membrane bioreactor is able to work with a high concentration of sludge particles, especially compared to a conventional system in which the bioreactor is combined with a settling tank. As a result, the discharged purified water can be of high quality, and it is even readily possible to use the membrane bioreactor for treating heavily polluted sewage water and/or streams of industrial waste water.

The known membrane bioreactors can be divided into two groups, i.e.: a dry-pit system or a submerged system. With the dry-pit system, a membrane filtration module is placed outside the basin of the bioreactor. With the submerged system, membranes are suspended inside the basin of the bioreactor. In recent years, both systems have developed in such a way that they show an increasing number of similarities. Thus, for example, the membranes of the submerged system are more and more often accommodated in a housing provided with inlet and outlet apertures, which housing is then suspended in the basin like a box. In addition, there is a development taking place where more and more facilities are being placed around these boxes which are intended to supervise the flow past these membranes in order to optimize the performance of these membranes. This has

resulted in a membrane filtration module for the purpose of the submerged system which is or will be increasingly similar to a membrane filtration module in the dry-pit system.

5 An example of a submerged system with flat membrane panels in a treatment tank is disclosed in EP 0 510 328. An example of a dry-pit system with tubular membranes which are accommodated in a membrane filtration module is disclosed in US 5,494,577.

10 For both systems, it is disadvantageous that the membrane surfaces can become soiled quickly and that the flow passages inside the membranes and/or between and/or around the membranes often become blocked with foreign particles in the liquid stream during operation. This soiling and/or these blockages are caused by all kinds of particles which are entrained with the waste water, such as hairs, threads, etc. The soiling and/or the blockages may also be caused by biologically, physically or otherwise deformed particles which result from the reactions between the sludge and the waste water. Another possibility is that soiling may precipitate or blow or otherwise end up in the basins which are usually open to the elements. The direct consequence of the soiling and/or the blockage of the flow passages is the loss of effective membrane surface. In addition, it results in the distribution of the liquid stream across the flow passages no longer being homogeneous. This non-homogeneous distribution leads to 15 large variations in the liquid velocity and the turbulence thereof along the flow passages, as a result of which a crust of particles may form along the membrane surfaces. This in turn leads to a greater risk of blockage of (a part of) the flow passages, as a result of which the liquid distribution may become disturbed even further. As a 20 result, an increasing amount of effective membrane surface is lost and an increasing amount of energy has to be supplied in order to maintain the through-flow through the flow passages which are 25 increasingly difficult to flow through.

30

35 In order to prevent the flow passages from becoming soiled and/or blocked, it is known to use a filter upstream of the membrane filtration module in order thereby to catch particles. However, it has been found that thread-like particles are still able to slip through the filter, and then still cause the abovementioned problems.

40 Furthermore, it has been found that the encrusted particles in the

membrane filtration module are very difficult to remove, and that they can damage the membrane material. If soiling is observed with the known systems, then the soiled membrane filtration module is disconnected, connected to a cleaning unit and cleaned manually or 5 semi-automatically. In this case, it is common practice for the blocked flow passages to be flushed back regularly with a cleaning liquid. This procedure usually takes up 10 to 20% of the operating time of a membrane filtration module. The possibility and the frequency thereof is dependent on the type of membrane filtration 10 module and is usually in the order of magnitude of one to 60 minutes. In addition, the membrane filtration module can also be cleaned using a chemical cleaning liquid. This entire process takes as much as half an hour to a few hours per membrane filtration module and is again carried out at a frequency of once a day to once a week, or once a 15 month to once a year, depending on the membrane filtration module and operation. If desired, the membrane filtration module can be opened, the blocked membranes can be removed therefrom and the soiling can then be removed using brushes, jets of water or any other mechanical ancillary means. This cleaning method takes even more process time 20 and is generally very labour-intensive and is only carried out in cases of extreme soiling and/or blockage. If, in addition, a filter having openings smaller than 5 mm, or more commonly smaller than 3 mm and preferably smaller than 1 mm is used upstream of the membrane filtration module, then this filter has to be cleaned very regularly.

25

It is an object of the present invention to at least partially overcome the abovementioned drawbacks and/or to provide a usable alternative. In particular, it is an object of the invention to provide an efficient membrane bioreactor which is less affected by 30 soiling and/or blockage.

This object is achieved by an apparatus according to claim 1. The apparatus in this case comprises a bioreactor having a dry-pit or submerged membrane filtration module, which module is provided on the 35 inlet side, where a connection chamber is left clear, with a discharge line which discharges outside the fluid space. The discharge line is provided with a controllable closing element. A fluid mixture feed-through line from the fluid space of the basin to the connection chamber is also provided with a controllable closing element. In addition, a control unit is provided for closing the 40

fluid mixture feed-through line and opening the discharge line at the desired moment, and vice versa. As a result thereof, it is advantageously possible to automatically flush at least the inlet side of the membrane and the connection chamber beneath it. During 5 flushing, soiled and encrusted particles are released from the inlet side and/or from the surfaces of the membranes and are discharged outside the fluid space via the open discharge line. When flushing has finished, for example after a preset period of time has lapsed, the treatment process can be resumed immediately, by again closing 10 the discharge line and opening the fluid mixture feed-through line.

It has been found in practice that the flushing step advantageously, if repeated regularly, after a certain period of normal operation of the apparatus, ensures that the pressure on the inlet side of the 15 membrane filtration module can remain stable for a long period of time. This is connected with the fact that the flushing step ensures that the soiling and/or blockages of the flow passages of the membranes is/are cleaned away in an efficient manner. Furthermore, it has been found that the flushing step leaves the membrane surface, 20 the flow passages, as well as the inlet side of the flow passages intact.

The succession of a period of fluid treatment and a period of flushing is referred to in this case as a filtration cycle. After a 25 number of such filtration cycles, it is possible to use other cleaning methods in order to further improve the membrane performance. Consideration may be given to flushing the module with supplied pressurized air, the use of chemical cleaning agents, and/or disassembling the membrane filtration module in order to be able to 30 clean the parts separately.

In accordance with a particular embodiment, the control unit is equipped with a counter for periodically initiating the flushing step. The counter may in this case be set to a value of between 0.1- 35 1000 hours, in particular between 0.2-1000 hours, or more in particular between 1-24 hours. When the counter reaches the preset value, the control unit ensures that the fluid mixture feed-through line is closed and the discharge line opened.

In another embodiment, the control unit is designed in order to start the flushing process in dependence on measurement values relating to the performance of the membrane filtration module. This may, for example, be measuring pressure at certain positions within the 5 membrane filtration module or recording the amount of energy which is required in order to pass the fluid through the flow passages of the membranes. A combination of initiating mechanisms is likewise possible.

10 The time which is required for the flushing step can be made dependent on the observed soiling and/or blockages in the flow passages, but may also be set to a fixed value.

In one particular embodiment, the closable fluid mixture feed-through 15 line is formed by the fluid inlet line which discharges into the connection chamber of the membrane filtration module. To this end, the fluid inlet line is provided with a controllable closing element. This embodiment is in particular advantageous in combination with a dry-pit membrane filtration module. In a variant thereof, the 20 membrane filtration module is submerged in the fluid space of a sub-basin. In this case, the connection chamber of the membrane filtration module is then provided with one or more inflow openings. The closable fluid mixture feed-through line can in this case be formed by a flow connection between the fluid space of the basin and 25 the fluid space of the sub-basin. This flow connection may then be provided with a controllable closing element.

In a preferred embodiment, it is possible to provide a controllable flushing liquid feed line on the permeate side and/or retentate side 30 and/or on the connection chamber of the membrane filtration module. This flushing liquid can then ensure that a more thorough flushing and discharging of the soiling and/or blockages to beyond the fluid space takes place during the flushing step. Depending on the observed soiling or blockage, the flushing liquid can be supplied at a 35 significantly higher pressure than the fluid pressure in the module during treatment. In particular, the flushing liquid pressure may be more than 1-20 times higher than the fluid pressure during operation, more particularly more than 3-10 times higher.

In a variant or in addition to supplying flushing liquid, the fluid which is already present within the membrane filtration module can advantageously also be used. For example, if the flow passages of the membranes have a length of 1-6 metres and these flow passages are 5 arranged in the vertical direction above the connection chamber, there is more than sufficient fluid pressure in these flow passages as a result of the force of gravity. This fluid pressure ensures that the flow passages and the connection chamber are automatically flushed with the fluid which is inside the flow passages as soon as 10 the fluid mixture feed-through line is closed and the discharge line is opened.

The slurry which has been discharged via the discharge line to beyond the fluid space can be collected in an external settling tank and 15 subsequently be fed back to the basin of the bioreactor, optionally after further purification by means of a filter. Thus, it is advantageously possible to maintain the concentration of treatment fluid in the bioreactor at the desired level. This may in practice also advantageously ensure a periodical cleaning of the treatment 20 fluid in such a manner that periodical cleaning or changing of the entire amount of treatment fluid in the basin is no longer required. This significantly reduces the down time of the apparatus. It is also possible to discharge (part of) the slurry to the outside. However, 25 in that case treatment fluid will have to be supplied to the basin regularly as a compensating measure.

In a preferred embodiment, gas distribution means are provided which discharge into the connection chamber of the membrane filtration module. During the fluid treatment, these gas distribution means 30 supply gas bubbles which also ensure that the fluid is conveyed through the flow passages of the module. Advantageously, it is also possible to clean the gas distribution means during the flushing step, for example by temporarily increasing the gas supply pressure. Thus, it is prevented that the gas distribution means require an 35 increasingly high pressure in order to be able to supply gas during the fluid treatment. Other possibilities of cleaning these gas distribution means are flushing with a fluid, for example permeate or a liquid to which cleaning chemicals have been added.

Further preferred embodiments of the invention are defined in the subclaims.

The invention also relates to a method for cleaning the membranes and
5 the inlet side of a membrane filtration module of an apparatus according to the invention as defined in claims 28-35, as well as to the use of such an apparatus according to claim 36.

The invention will be explained in more detail with reference to the
10 attached drawings, in which:

Fig. 1 shows a diagrammatic view of an embodiment of the apparatus according to the invention with a dry-pit membrane filtration module; Fig. 2 shows a view corresponding to that of Fig. 1 with submerged membrane filtration modules;

15 Fig. 3 shows a part view of Fig. 1 of a first variant embodiment of the membrane filtration module;

Fig. 4 shows a view corresponding to that of Fig. 3 of a second variant embodiment;

20 Fig. 5 shows a view corresponding to that of Fig. 3 of a third variant embodiment;

Fig. 6 shows a diagrammatic view in more detail of a variant embodiment of Fig. 1;

Fig. 7 shows a diagrammatic view of a membrane filtration module with plate-shaped membranes;

25 Fig. 8 shows a view corresponding to that of Fig. 7 with tubular membranes placed in a row;

Fig. 9 shows a view corresponding to that of Fig. 7 with bundled tubular membranes; and

30 Fig. 10 shows a greatly magnified bottom view of an exploded membrane filtration module with several bundled tubular membranes.

In Fig. 1, the apparatus for treatment of a fluid is denoted overall by reference numeral 1. The apparatus 1 comprises a bioreactor with a basin 2 with a fluid space which contains a biomass, in particular active sludge. A fluid feed line 3 opens into the basin 2 via which fluid feed line 3 raw waste water is passed to the basin 2. In the fluid feed line 3, there is a filter 4 by means of which a first purification of the waste water is carried out. This may be a filter with one specific mesh width or a range of different mesh widths. In
35 the basin 2, the waste water mixes with the active sludge, as a
40

result of which a fluid mixture 5 is formed. First gas distribution means 7 discharge into the bottom of the basin 2 via which gas distribution means 7 gas is added to (part of) the fluid mixture 5. In the fluid mixture 5, the waste water is cleaned further by means 5 of, inter alia, aerobic reactions with the active sludge particles. Depending on the geometry of basin 2, the location of the gas distribution means 7, and the flow patterns in basin 2, different reaction zones may result. The fluid mixture 5 is supplied to a membrane filtration module 12 via a fluid inlet line 10. It is 10 possible to incorporate another filter in this feed line as well in order to recover soiling components which have not been recovered before and/or which were formed during the reactions. The membrane filtration module 12 comprises a housing 13 in which there is a membrane surface 14. On the permeate side of the membrane 14, a permeate discharge line 15 is provided. On the retentate side of the membrane 14, a retentate discharge line 16 is provided. The retentate discharge line 16 opens into the basin 2. On the inlet side of the module 12, that is to say where the fluid inlet line 10 joins the housing 13, there is a connection chamber 18. Second gas distribution 15 means 19 discharge into the bottom of the connection chamber 18. These ensure that the membrane surface 14 is kept clean by means of treatment with gas during fluid treatment, and ensure that the fluid mixture is conveyed along and through the membrane surface 14.

20 According to the invention, the connection chamber 18 is provided with a discharge line 20. The discharge line 20 is provided with a controllable shut-off valve 21. The fluid inlet line 10 is likewise provided with a controllable shut-off valve 22. A control unit 23 is provided for controlling the shut-off valves 21 and 22. Following a 25 period of fluid treatment in which clean water is discharged via the permeate discharge line 15, and in which retained fluid is fed back to the basin 2 via the retentate discharge line 16, according to the invention a flushing step takes place in each case by means of a suitable actuation of the shut-off valves 21 and 22 via the control 30 unit 23. In this case, the shut-off valve 22 of the fluid inlet line 10 is closed and the shut-off valve 21 of the discharge line 20 is opened. The fluid which is inside the membrane filtration module 12 35 (on the retentate side) is then free to flow away in a downwards direction in one go via the connection chamber 18 towards the open 40 discharge line 20. This sudden downwards flow ensures in a very

efficient way that the soiling components inside the membrane filtration module 12, both along the membrane surface and in the connection chamber 18, are discharged outside the module 12. As soon as this flushing process has finished, the control unit 23 makes sure
5 that the shut-off valve 21 of the discharge line 20 is closed again, and the shut-off valve 22 of the fluid inlet line 10 is reopened. Then, another fluid treatment can be carried out, following which another flushing step can be carried out, etc.

10 The discharge line 20 ends above a settling container 25. The contents of this settling container 25 can be discharged to an external receptacle at set times. It is also possible to feed the contents of the settling container 25, or part thereof, back to the basin 2 via a sediment discharge line 26. The sediment discharge line
15 26 may optionally be provided with a filter 27.

The basin 2 is also provided with a drain discharge line 29 via which, usually in a discontinuous manner, sludge can be drained.

20 Fig. 2 shows a variant with two submerged membrane filtration modules. Identical components are in this case denoted by the same reference numerals as in Fig. 1. The apparatus comprises a separate sub-basin 34 with a fluid space which is in flow connection with the fluid space in the basin 2 via supply and discharge lines 35, 36. Two
25 membrane filtration modules 38 are submerged in the fluid space of the sub-basin 34. Each membrane filtration module 38 comprises a surrounding housing 40 containing the membrane surface 14. At the bottom side, the housing 40 delimits a connection chamber 42 which is in turn provided with a closable discharge line 20 which discharges
30 outside the fluid space of the sub-basin 34. The location of the fluid inlet line cannot be specified as clearly as is the case with a dry-pit embodiment, and forms part of one or more inflow openings in the connection chamber 42 in which the fluid mixture from the sub-basin 34 mixes with gas which has been introduced by the gas
35 distribution means 19, which mixture then passes along and through the membrane surface 14. The exact design of the fluid inlet line depends on the embodiment of the submerged membrane filtration module 38.

The feed line 35 is provided with a controllable shut-off valve 43. Following a period of fluid treatment, a flushing step can then be carried out by means of a suitable actuation of the shut-off valves 21 and 43 via the control unit 23. In this case, the shut-off valve 5 43 of the feed line 35 is closed and the shut-off valves 21 of the discharge lines 20 are opened. The fluid which is in the sub-basin 34 and inside the membrane filtration modules 38 is then free to flow away in a downwards direction in one go to the open discharge lines 20 via the connection chambers 42. The fluid mixture level in the 10 sub-basin 34 will in this case fall to the level of the connection chambers 42, as the discharge lines 20 start at the connection chambers 42. If desired, the discharge lines may also start at a lower level and/or be provided with inflow openings at a lower level, so that the sub-basin 34 can empty further or even completely. As 15 soon as the flushing process has finished, the control unit 23 again ensures that the shut-off valves 21 are closed, and the shut-off valve 43 is opened.

Fig. 2 furthermore shows that an additional prefilter 45 is provided 20 at the top of the connection chamber 42, in order to protect the inflow side of the membranes which are inside the membrane filtration module against blockage. This additional prefilter 45 will also be flushed clean in an efficient manner during each flushing step, after which the resulting slurry is discharged via the discharge line 20. 25 The prefilter 45 can supplement or even take over the function of any filter in the feed line 35.

For the flushing step, the embodiments of Fig. 1 and 2 use the fluid which is in the membrane filtration modules. With the variant shown 30 in Fig. 3, a controllable flushing liquid feed line 50 is provided in addition thereto and is connected to the permeate side of the module 12. During the flushing step, the shut-off valve 51 of the flushing liquid feed line 50 is temporarily opened by the control unit. As a result thereof, the space inside the module 12, including the 35 membrane surfaces 14 and the connection chamber 18 are cleaned further by flushing. Fig. 4 shows a variant in which the closable flushing liquid feed line 50 is connected to the retentate side of the module 12. Fig. 5 shows a variant in which the closable flushing liquid feed line 50 is connected to the connection chamber 18 of the 40 module 12. With these variants as well, a further improvement of the

flushing step can be achieved. It is also possible to provide a combination of the flushing liquid feed lines shown in figures 3-5, so that, depending on the soiling and/or blockage observed, one or more of these flushing liquid feed lines can be opened.

5

Fig. 6 shows a variant of Fig. 1 in which identical components are denoted by the same reference numerals. Only the differences will be briefly discussed below. The first gas distribution means are in this case formed by a distribution panel provided with a plurality of outflow openings which extends over the bottom of the basin 2 and is connected to a ventilator 60. In order to be able to pass the fluid mixture through the membrane filtration module 12 with greater force, a pump 62 is provided in the closable fluid inlet line 10. The second gas distribution means 19 in the connection chamber 18 are supplied with a gas via a ventilator 64. A controllable shut-off valve 65 is provided between the ventilator 64 and the second gas distribution means 19. The module 12 is provided with two membrane panels 14 between which a flow passage 68 is left clear which forms the retentate side. At its top, this flow passage 68 opens out into a chamber 69 which is connected to the fluid space in the basin 2 via the retentate discharge line 16. The retentate discharge line 16 is furthermore provided with a branch 70 for discharging retentate to another location, if desired.

25 On the outside of the membrane panels 14 is the permeate side 72 to which the permeate discharge line 15 is connected. The permeate discharge line 15 is provided with a controllable shut-off valve 74, via which the permeate discharge line 15 can be closed during the flushing step, if desired. Furthermore, the permeate discharge line 30 15 comprises a pump 75 for pressurized discharge of the cleaned fluid. The cleaned fluid can then be discharged to a receptacle 76 and/or to an external location (not shown in any more detail). From the receptacle 76, the treated fluid can be supplied as flushing liquid to the module 12 via the flushing liquid feed line 50 during the flushing step. In order to be able to supply the flushing liquid 35 at sufficient pressure, a pump 78 is provided.

The settling container 25 is provided with a closable sediment discharge line 80. Furthermore, the sediment discharge line 26

40 leading back to the basin is provided with a pump 81, and the

sediment discharge line 26 now discharges into the filter 4 provided in the fluid feed line 3. Thus, a highly multifunctional treatment apparatus is achieved, in which use is made of treated fluid and discharged retentate or slurry, respectively, in an efficient way.

5

Fig. 7 shows a variant of a membrane filtration module, in which identical components are again denoted by the same reference numerals as in the preceding figures. It can clearly be seen that the membranes 14 in this case are of the flat plate-shaped type. The 10 prefilter 45 which is provided at the top of the connection chamber 18 can also clearly be seen.

Fig. 8 shows a variant of Fig. 7 in which the membranes 14 comprise a plurality of hollow fibres or capillaries placed in rows next to one 15 another.

Fig. 9 shows a variant of Fig. 7 in which the membranes 14 comprise a plurality of hollow fibres or capillaries arranged in bundled form.

20 If several hollow fibres or capillaries or tubelets placed next to one another are used as membranes, in particular in a bundled form, then these can together advantageously form a prefilter. This can render the function of the prefilter 45 provided in Fig. 9 and/or the possible filter in the fluid inlet line mentioned before obsolete or 25 significantly facilitate the task thereof. Thus, for example, a larger mesh width may then be selected for the prefilter 45. Fig. 10 shows the way the plurality of hollow fibres or capillaries or tubelets work as a prefilter.

30 Many variants are possible in addition to the embodiments illustrated. Thus, the membranes and/or the membrane filtration modules can be arranged both horizontally and vertically or in other positions. With the submerged variant, it is also possible to place the membrane filtration modules directly in the basin. If desired, a 35 dividing wall can be placed in the basin between the section where the membrane filtration module is disposed and the section where the incoming fluid flows in.

Furthermore, the invention can be used with all types of membranes, 40 independent of their shape (for example, but not exclusively, flat or

of any possible diameter), filtration side (inner side or outer side) or material (for example polymer or ceramic).

In addition, the invention can be used with any membrane process of 5 which a membrane bioreactor forms part. Currently, the most common processes are those which are referred to as microfiltration or ultrafiltration, but other membrane processes, such as nanofiltration and reverse osmosis/hyperfiltration, are also possible.

10 Thus, according to the invention, a membrane bioreactor with a significantly improved action has been provided due to the feature of periodically flushing the membrane filtration modules and, if desired in combination with the former, the gas distribution means with discharge line to outside the fluid space. The flushing step is 15 advantageously combined with the integrated cleaning of the treatment fluid and the periodic draining thereof, respectively.

C L A I M S

1. Apparatus for treatment of an incoming fluid, comprising:
 - 5 - a bioreactor with a basin (2) with a fluid space that is meant to be at least partially filled with a treatment fluid;
 - a fluid feed line (3) discharging into the basin (2) for feeding, during operation, the incoming fluid to the treatment fluid and mixing and treating it with the latter so as to obtain a fluid mixture (5); and
 - 10 - a membrane filtration module (12) comprising a housing (13) with one or more incorporated membranes (14), an inlet side, a permeate side and a retentate side, wherein the housing (13) delimits a connection chamber (18) on the inlet side of the membranes (14) into which a fluid inlet line (10) discharges which is connected to the fluid space of the basin (2), and wherein the housing (13) further comprises a permeate discharge line (15) connected to the permeate side and a retentate discharge line (16) connected to the retentate side,
 - 15
 - 20
 - characterized in that
 - a closable flushing discharge line (20) is provided which is connected on one side to the connection chamber (18) and on the other side discharges outside the fluid space,
 - 25
 - a fluid mixture feed-through line from the basin (2) to the connection chamber (18) which is closable, and
 - a control unit (23) is provided for periodically closing the fluid mixture feed-through line and opening the flushing discharge line (20), and vice versa, for periodic flushing of
 - 30
 - at least the inlet side of the membranes (14) and the connection chamber (18) disposed underneath it.
2. Apparatus according to claim 1, wherein the closable fluid mixture feed-through line is formed by the fluid inlet line (10) which is provided with a closing element (22) and which discharges into the connection chamber (18).
3. Apparatus according to claim 1 or 2, wherein a flushing liquid feed line controllable by the control unit is connected to the permeate side of the membrane filtration module.

4. Apparatus according to any one of the preceding claims, wherein a flushing liquid feed line controllable by the control unit is connected to the retentate side of the membrane filtration module.
- 5.
10. Apparatus according to any one of the preceding claims, wherein an external flushing liquid feed line controllable by the control unit is connected to the closable fluid mixture feed-through line.
15. Apparatus according to any one of the preceding claims, wherein the flushing discharge line discharges into a settling container.
20. Apparatus according to claim 6, wherein the settling container is provided with a sediment discharge line leading back to the basin.
25. Apparatus according to claim 7, wherein the sediment discharge line from the settling container to the basin passes through a filter.
30. Apparatus according to claim 6, wherein the settling container is provided with a sediment discharge line to an external system other than the basin.
11. Apparatus according to any one of the preceding claims, wherein the retentate discharge line leads back to the basin.
35. 12. Apparatus according to any one of the preceding claims, wherein second gas distribution means are provided which discharge into the connection chamber of the membrane filtration module.

13. Apparatus according to claim 12, wherein a flushing liquid feed line controllable by the control unit is connected to the gas distribution means.
- 5 14. Apparatus according to claim 13, wherein a compressed air line is connected to the flushing liquid feed line.
- 10 15. Apparatus according to any one of claims 3, 4, 5, 13 or 14, wherein a line carrying an external flushing liquid is connected to the flushing liquid feed line.
- 15 16. Apparatus according to any one of the preceding claims, wherein the treatment fluid is biomass, in particular active sludge.
- 20 17. Apparatus according to any one of the preceding claims, wherein the membranes have the form of plates.
18. Apparatus according to any one of the preceding claims, wherein the membranes have the form of tubes.
- 20 19. Apparatus according to claim 18, wherein the membranes comprise tubelets.
- 25 20. Apparatus according to claim 18, the membranes comprise capillaries.
21. Apparatus according to claim 18, wherein the membranes comprise hollow fibres.
- 30 22. Apparatus according to any one of the preceding claims, wherein the membrane filtration module is submerged in the fluid mixture during operation.
- 35 23. Apparatus according to any one of the preceding claims, wherein the fluid space of the basin comprises a section separated off by a partition wall in which the membrane filtration module is provided.
- 40 24. Apparatus according to any one of the preceding claims, wherein a separate sub-basin is provided with a fluid space which, via

a feed line, is in flow connection with the fluid space of the said basin, the membrane filtration module being provided in the fluid space of the sub-basin.

- 5 25. Apparatus according to claim 24, wherein the closable fluid mixture feed-through line is formed by the feed line between the basin and the sub-basin which is provided with a closing device.
- 10 26. Apparatus according to any one of the preceding claims, wherein the membrane filtration module is disposed outside the fluid space of the basin.
27. Apparatus according to any one of the preceding claims, wherein 15 a plurality of tubular membranes is bundled together, and wherein the inlet side of the bundle of tubular membranes forms a cleaning/filtering additional facility for the fluid mixture, in particular with filter operation.
- 20 28. Apparatus according to any one of the preceding claims, wherein a cleaning/filtering additional facility for the fluid mixture, in particular a filter, is provided in the connection chamber on the inlet side of the membranes of the membrane filtration module.
- 25
29. Method for cleaning the membranes and the inlet side of a membrane filtration module of an apparatus according to any of the preceding claims, which comprises the following steps:
 - filling the basin with a treatment fluid;
 - feeding an incoming fluid to the treatment fluid present in the basin and mixing and treating it with the latter fluid so as to obtain a fluid mixture;
 - feeding the fluid mixture to the membrane filtration module;
 - discharging permeate filtered by and retentate retained by the membranes;
 - periodically closing the fluid mixture feed-through line and opening the flushing discharge line, so that at least the inlet side of the membranes and the connection chamber of the membrane filtration module disposed underneath it are flushed.

30. Method according to claim 29, wherein the periodic closing of the fluid mixture feed-through line and opening of the flushing discharge line is initiated by a counter, a time period, the local pressure and/or a calculated transmembrane pressure differential.
5
31. Method according to claim 29 or 30; wherein during the periodic closing of the fluid mixture feed-through line and opening of the flushing discharge line a flushing liquid is delivered to the permeate side of the membrane filtration module.
10
32. Method according to any one of claims 29-31, wherein during the periodic closing of the fluid mixture feed-through line and opening of the flushing discharge line a flushing liquid is delivered to gas distribution means which discharge into the connection chamber of the membrane filtration module.
15
33. Method according to any one of claims 29-32, wherein during the periodic closing of the fluid mixture feed-through line and opening of the flushing discharge line a flushing liquid is delivered to the retentate side of the membrane filtration module.
20
34. Method according to any one of claims 29-33, wherein during the periodic closing of the fluid mixture feed-through line and opening of the flushing discharge line a flushing liquid is delivered to the inlet side of the membrane filtration module.
25
35. Method according to any one of claims 29-34, wherein the step of feeding an incoming fluid to the treatment fluid present in the basin and mixing and treating it with the latter fluid to obtain a fluid mixture takes place in a continuous process.
30
36. Use of an apparatus according to any one of claims 1-28 for the purification of waste water.
35

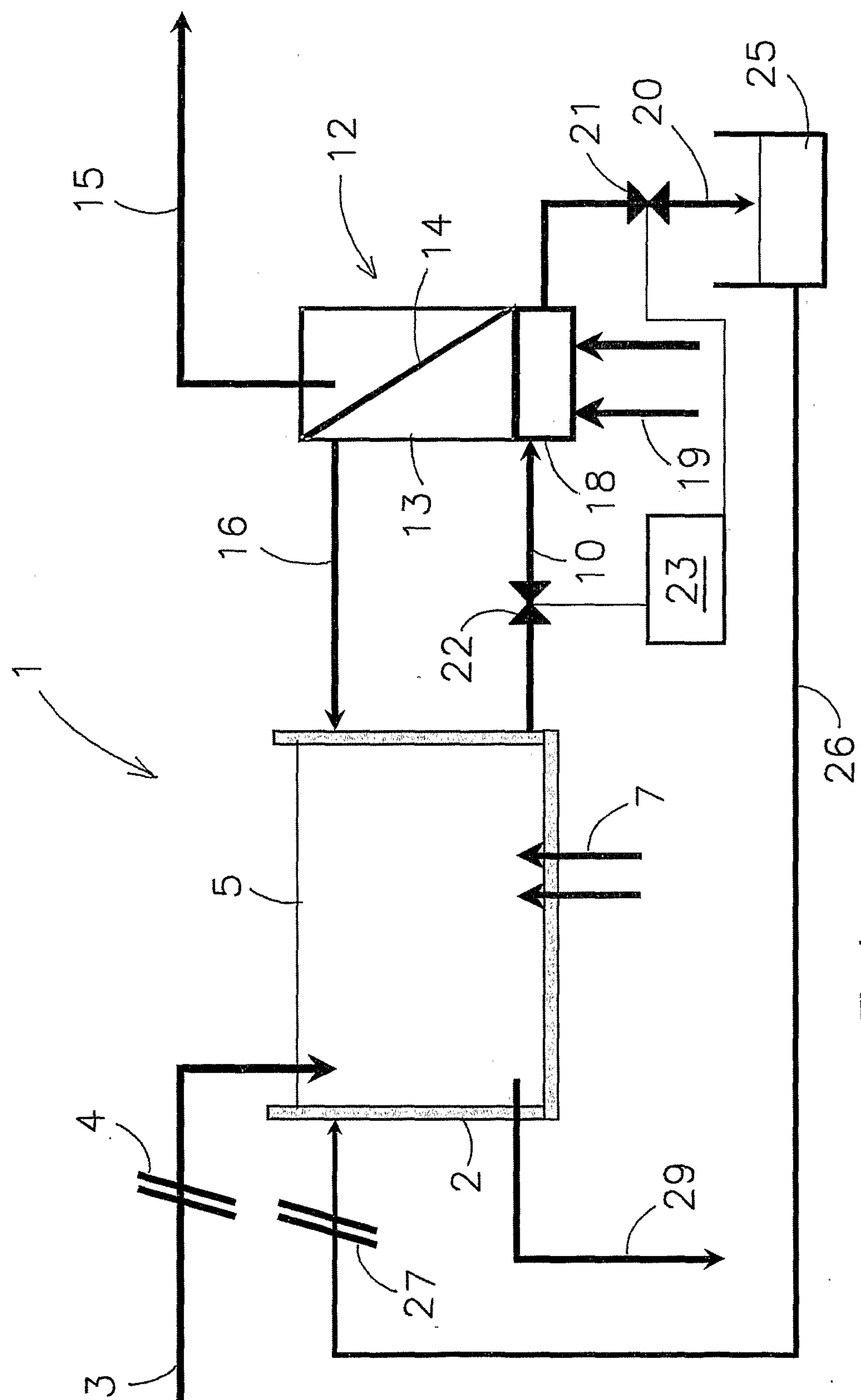


Fig.1

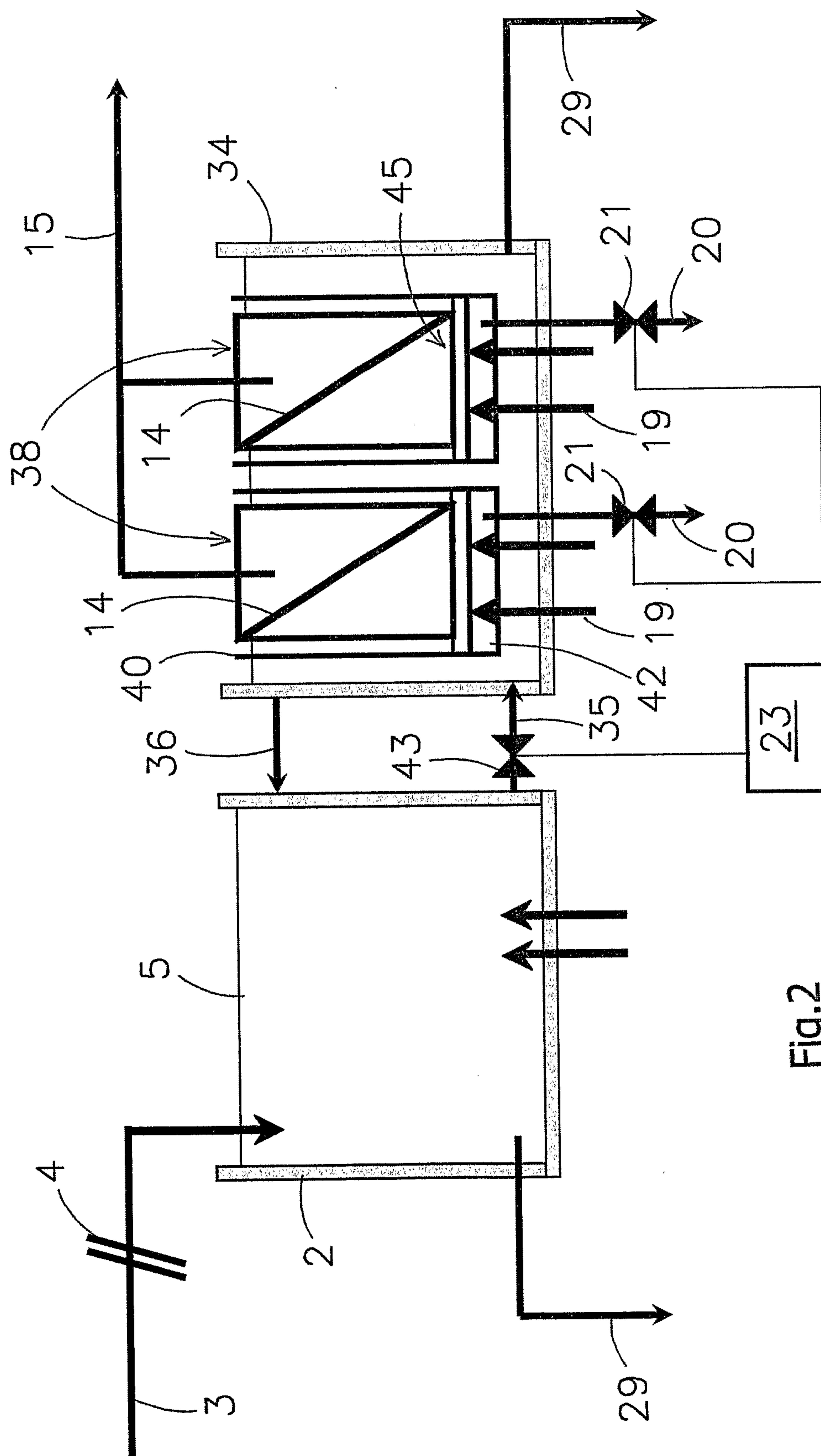


Fig.2

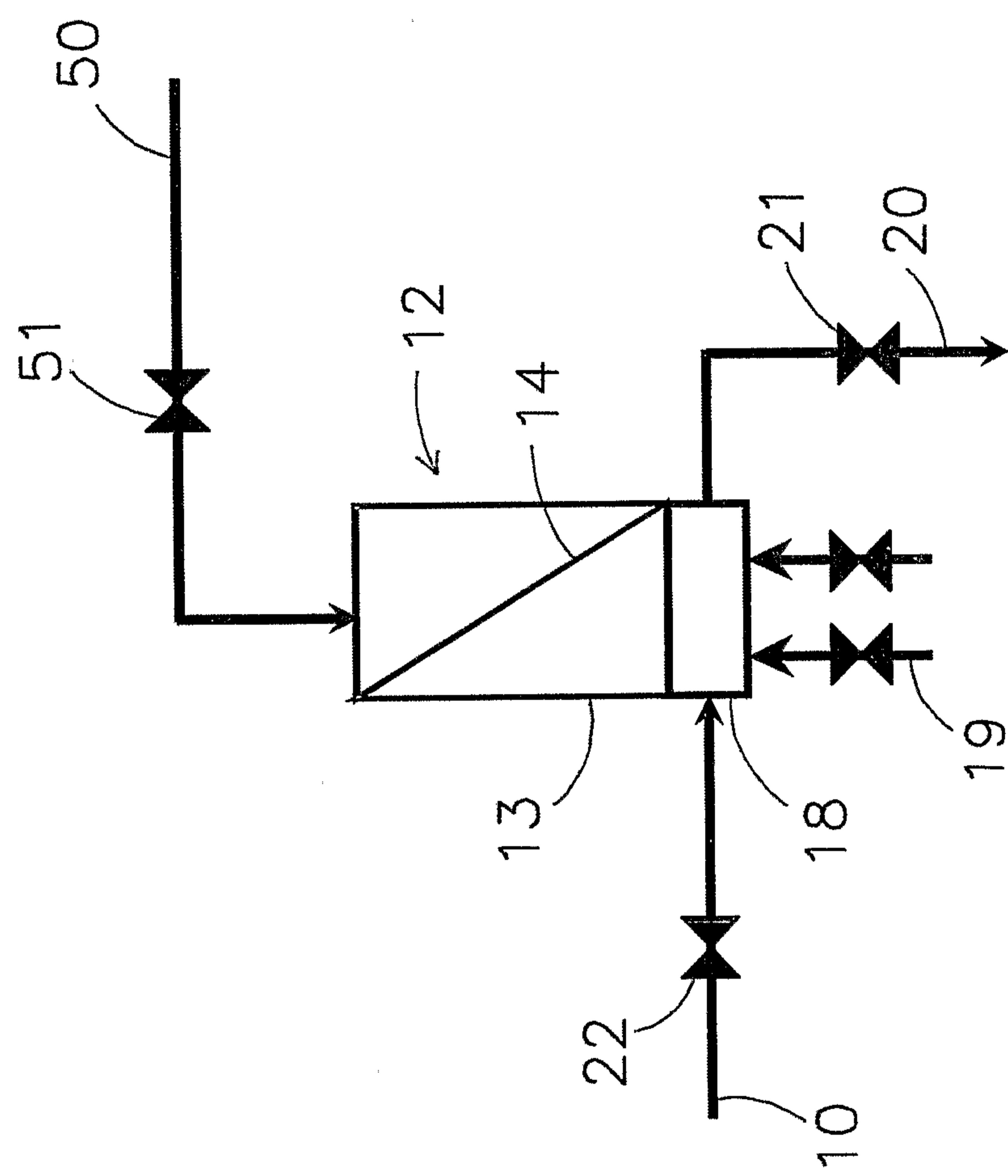
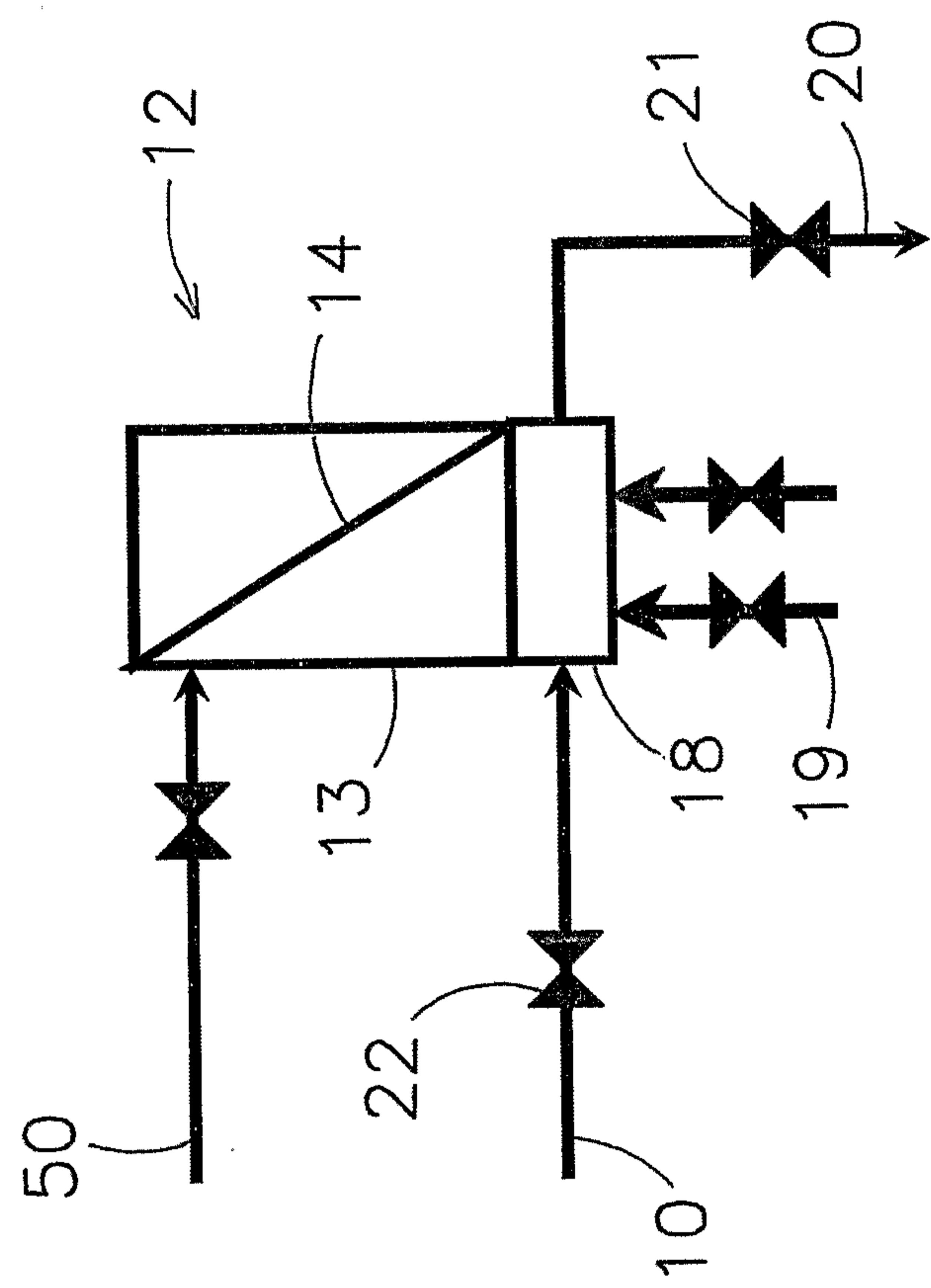
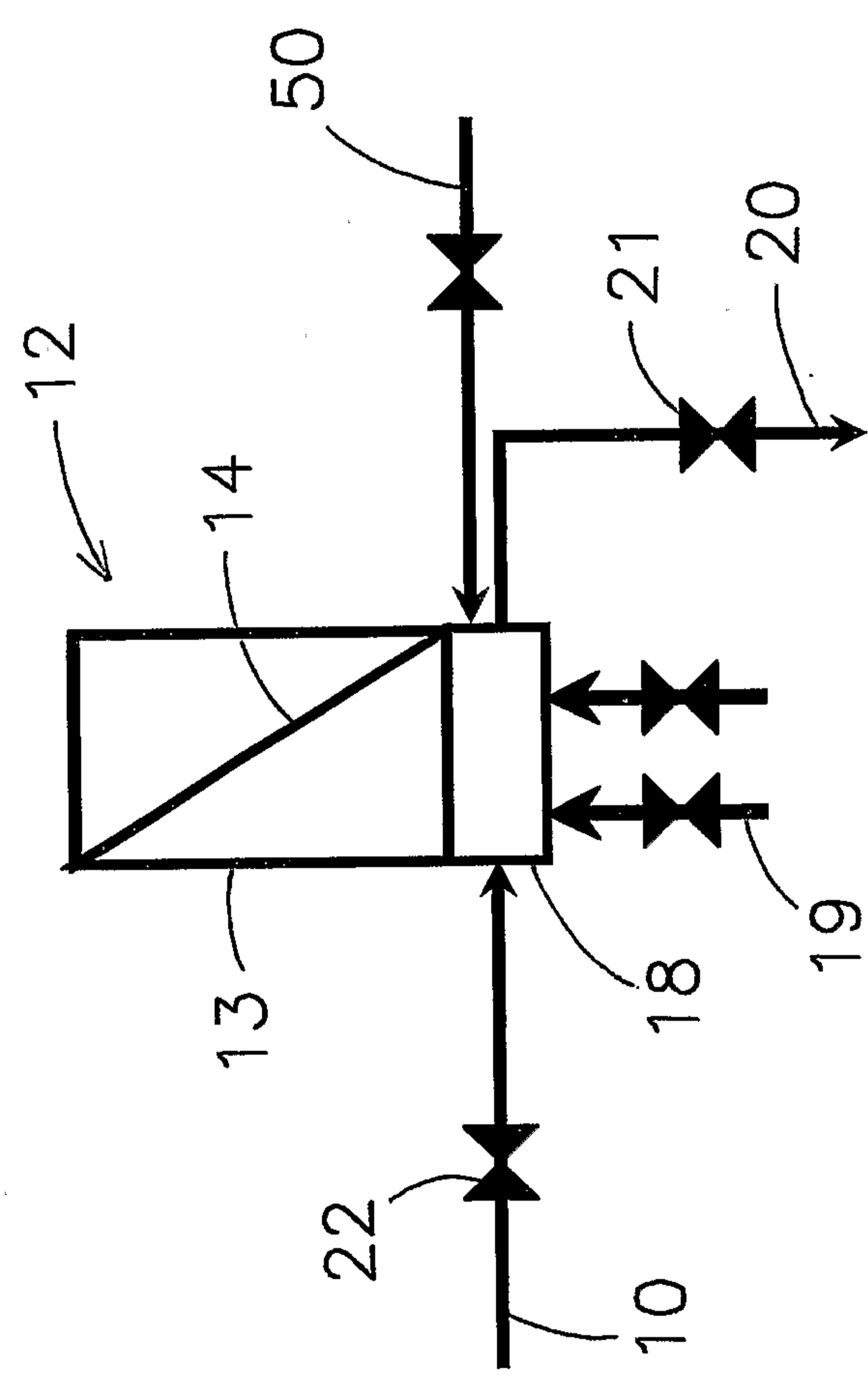


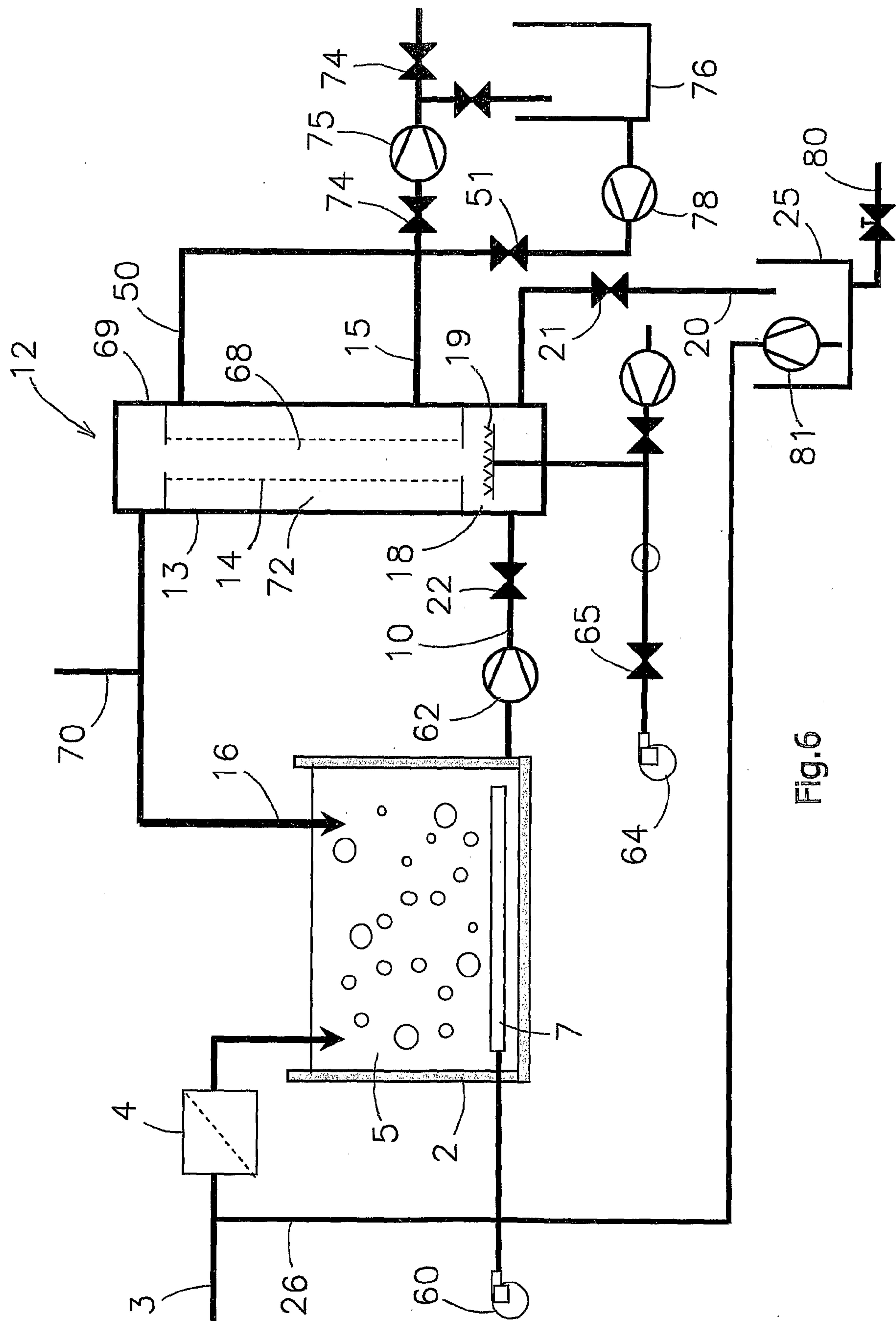
Fig.3



卷之三



卷之三



卷之三

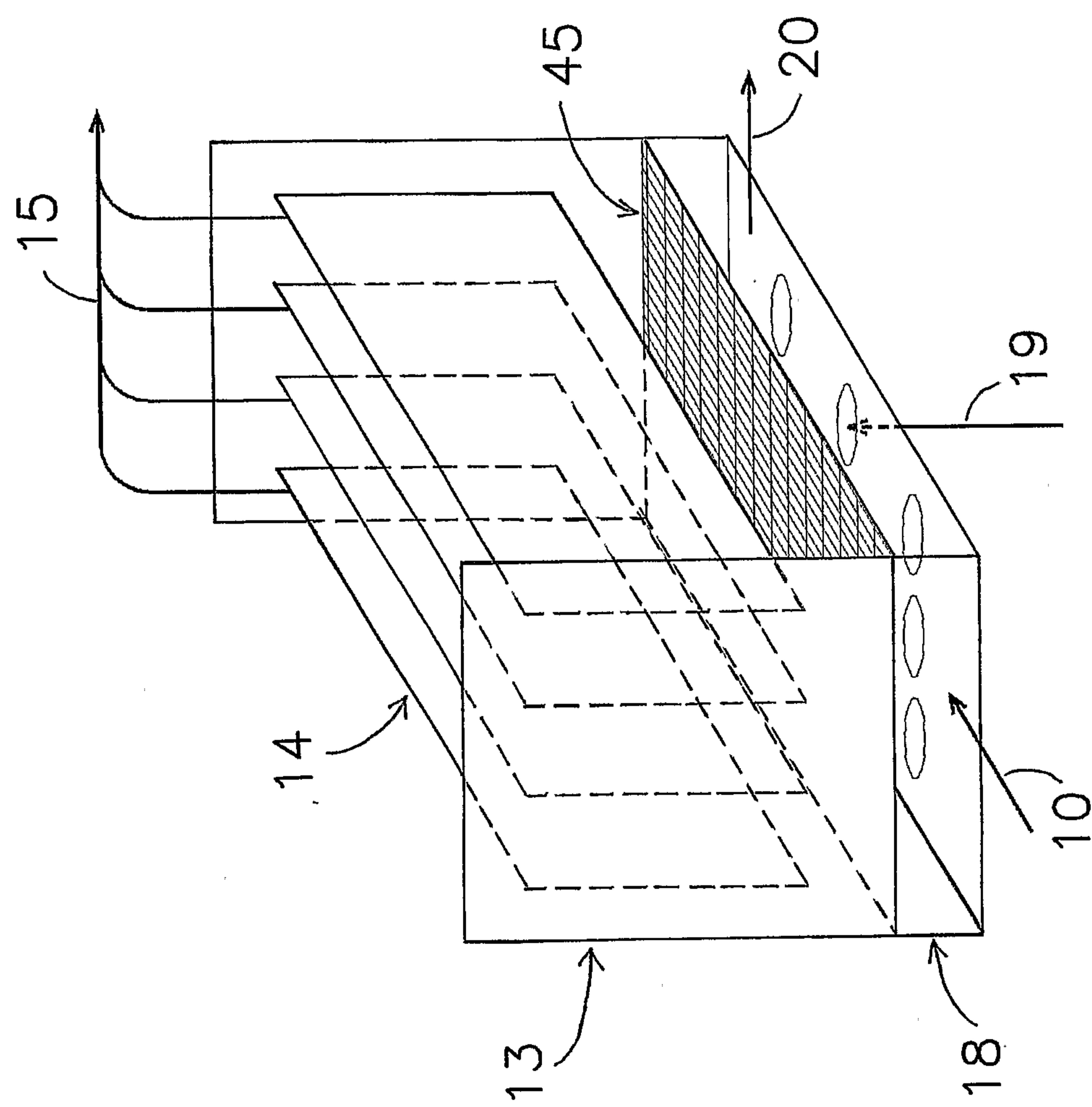


Fig.7

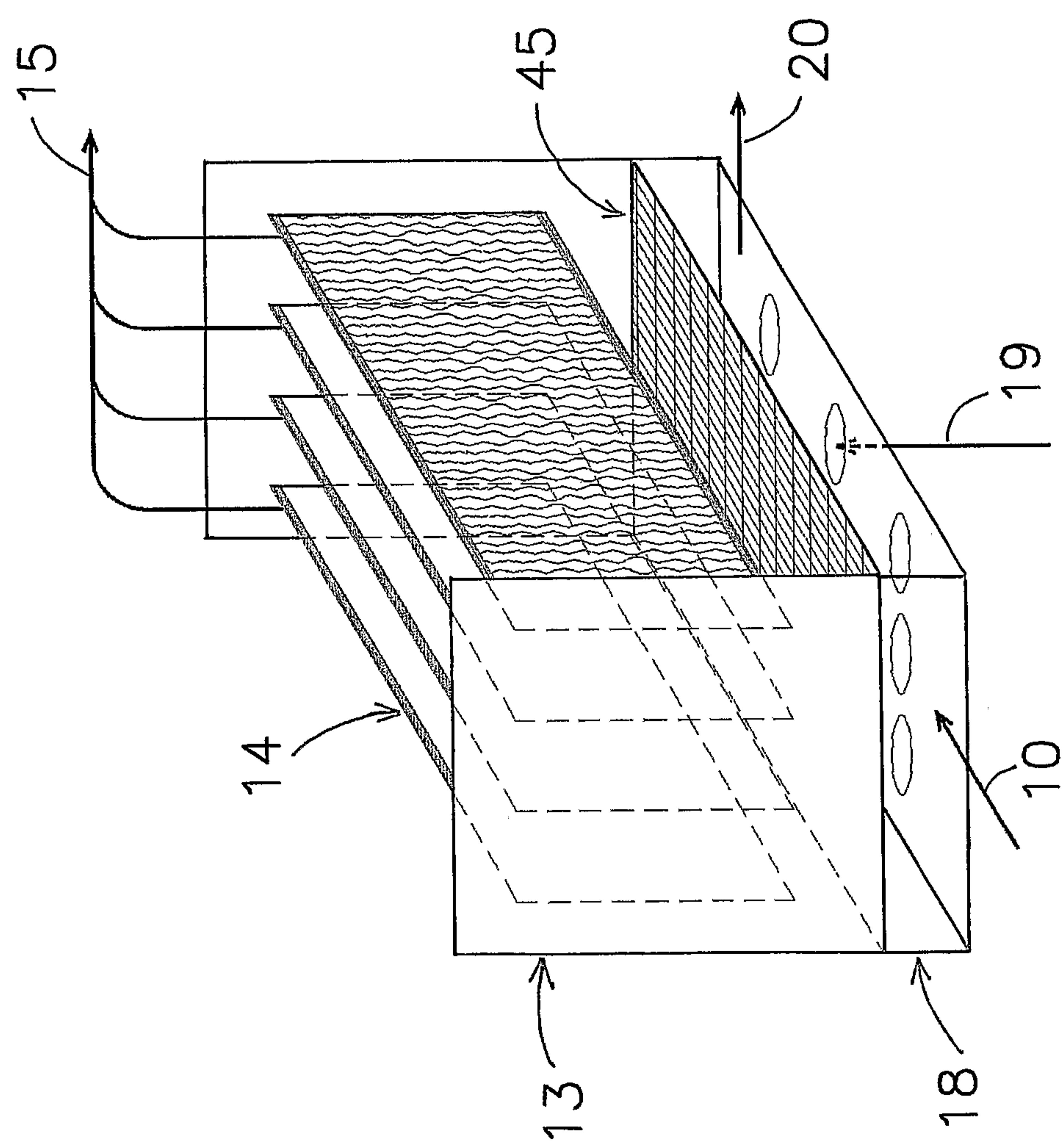


Fig.8

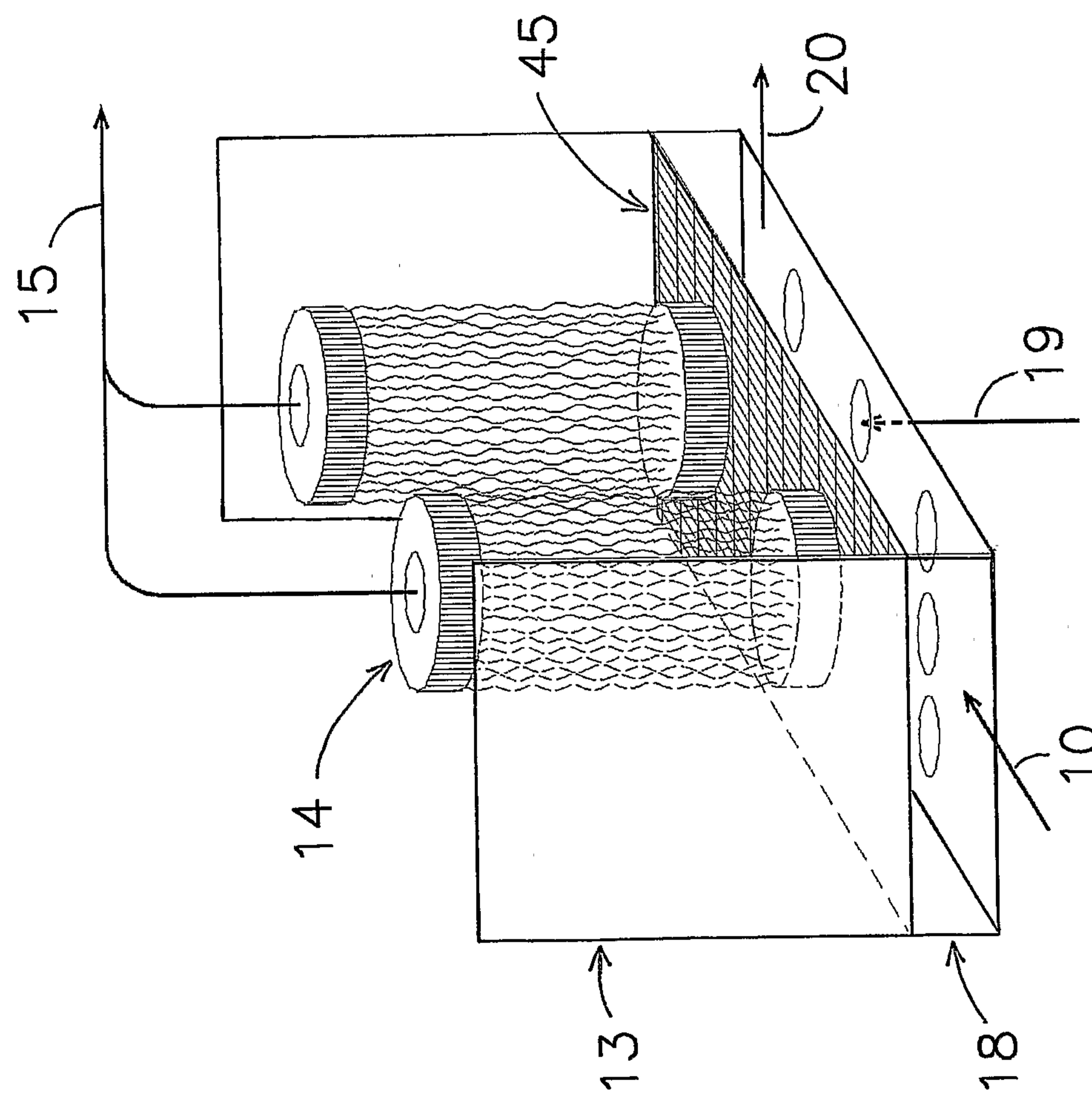


Fig.9

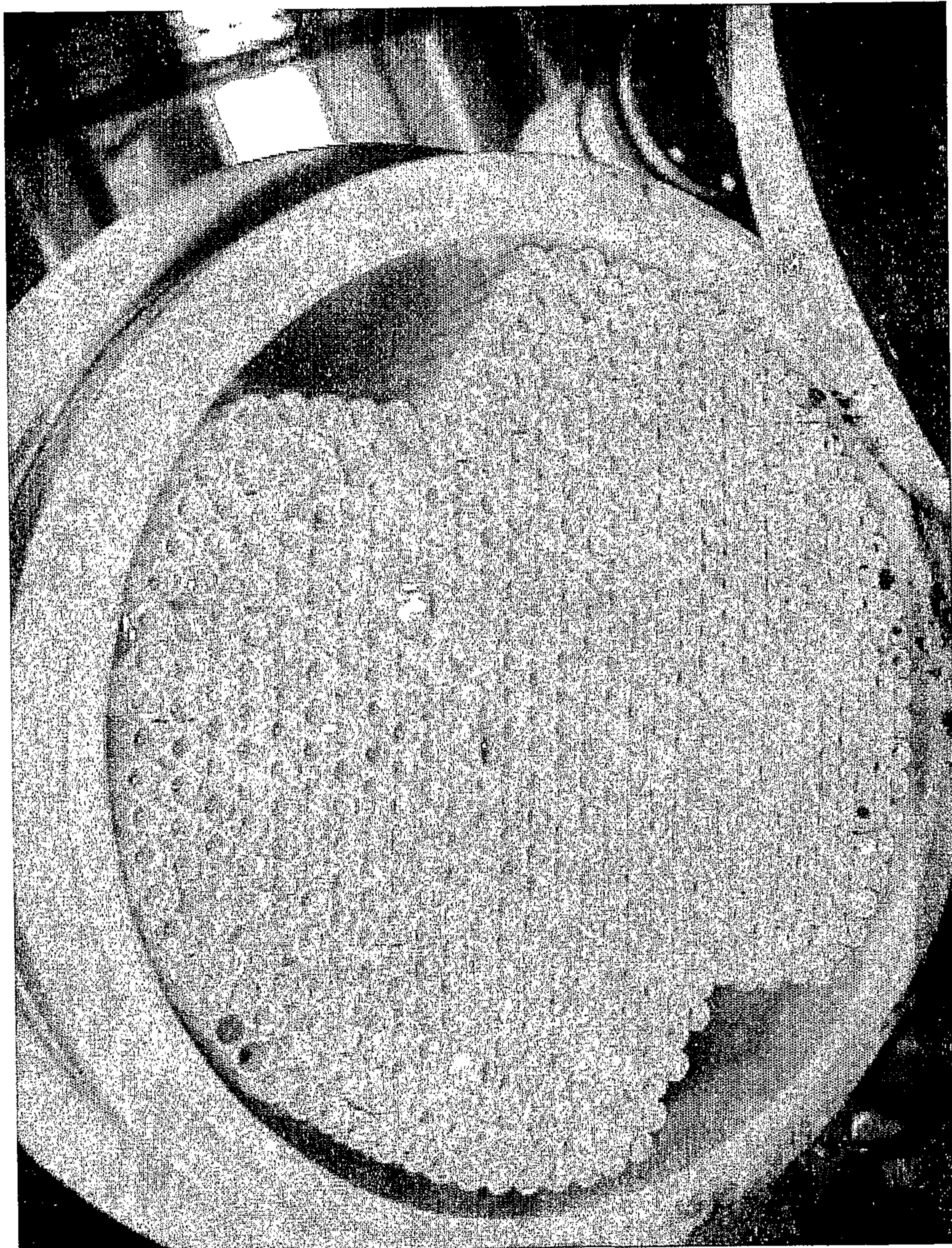


Fig.10

