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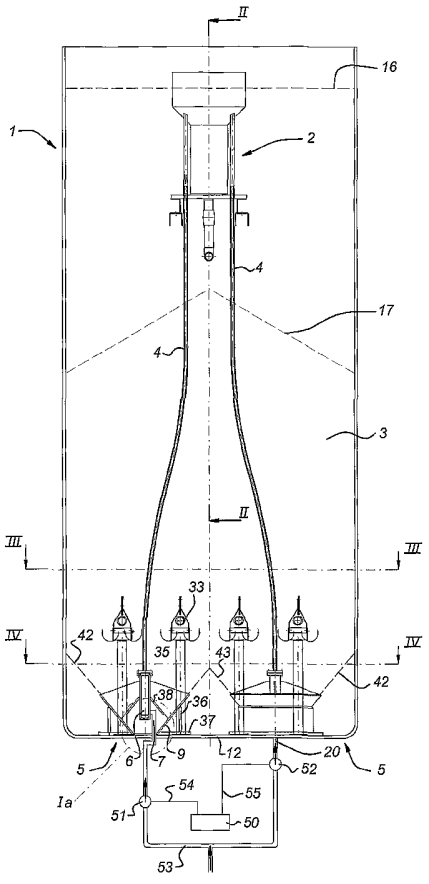
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(54) Title: LIQUID PURIFICATION INSTALLATION



(57) Abstract: The invention relates a purification installation for purifying a liquid. The purification installation comprises: a reactor vessel containing a bed of a granular medium; a medium mass; and at least one gas lift system; the at least one gas lift system comprises a riser with a suction inlet located in the bed and a blow outlet, at a higher position, opening into the medium mass, as well as gas feed means for generating a gas lift in the riser that draws in medium, liquid and gas at the suction inlet and feeds these upwards through the riser to the medium washer. The medium washer has a medium outlet for returning washed medium to the bed. The purification installation has a multiplicity of gas lift systems, the respective blow outlets of which emerge in the medium washer. The medium washer can be provided centrally with respect to the gas lift systems and/or with respect to the reactor vessel.

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LIQUID PURIFICATION INSTALLATION

The present invention relates to a purification installation for purifying a liquid, comprising:

- a reactor vessel containing a bed of a granular medium;
- a medium washer;
- at least one gas lift system;

wherein the at least one gas lift system comprises a riser with a suction inlet located in the bed and a blow outlet, at a higher position, opening into the medium washer, as well as gas feed means for generating a gas lift in the riser that draws up medium and liquid at the suction inlet and feeds these upwards through the riser to the medium washer, wherein the medium washer has a medium outlet for returning washed medium to the bed.

Such installations are known. In the known installations the reactor vessel is conical at the base. The cone is usually deep, that is to say the bottom wall has a steep slope. A gas lift system is arranged centrally in the known reactor vessel. In this known installation the gas lift system has a suction inlet that is close to the point of the conical base and a blow outlet that opens into a medium washer arranged centrally in the reactor vessel. In the case of the known installation the granular medium is usually sand. By blowing air into the riser at the bottom, dirty sand drawn up from the bottom of the sand bed is fed upwards through the riser to the medium washer. The sand is cleaned in the medium washer so as then, after cleaning, to drop back onto the top of the sand bed. The liquid to be purified is fed into the sand bed in the reactor vessel. On passing upwards through the sand bed, the liquid is cleaned, so as then to be discharged from the reactor vessel from the top. With this procedure the sand bed is in counter-current because dirty sand is always fed upwards from the bottom via the riser for cleaning and drops back onto the top of the sand bed after cleaning. The supply of liquid to be purified and the distribution thereof over the sand bed is effected by means of outflow arms that run radially.

One disadvantage of the known purification installation is that the total height of the reactor vessel is large because of the cone required. A further disadvantage is that the greater the reactor surface area the less effective is the suction of the medium for feeding upwards via the riser to the medium washer. This ineffectiveness is associated with a relatively high energy requirement for the gas lift system and a relatively large amount of wash liquid required for the medium washer.

The aim of the present invention is to provide an improved purification installation of the type mentioned in the preamble, which, in particular, overcomes one or more of the abovementioned disadvantages.

Said aim is achieved according to the invention by providing a purification installation of the type mentioned in the preamble, which is characterised in that the purification installation has a multiplicity of gas lift systems, the respective blow outlets of which emerge in the medium washer. By providing several gas lift systems it is possible to draw up the medium from various locations at the bottom of the reactor vessel. The cone of the known reactor vessel can then be made less deep because the depth of the cone is no longer needed, or at least is needed to a much lesser extent, to ensure uniform withdrawal of granular medium – for the purposes of the cleaning thereof – from the bed. Because a cone of less deep construction can suffice, the height over which the medium has to be fed upwards around the central gas lift system is also reduced.

Although it is possible according to the invention to provide a medium washer per gas lift system, an advantageous embodiment of the invention is characterised in that one medium washer is provided per two or more gas lift systems or even one medium washer is provided per reactor vessel. The number of components susceptible to fouling and wear can be reduced in this way.

According to a further advantageous embodiment, the medium washer, viewed in the horizontal direction, is provided centrally with respect to the associated gas lift systems. What can be achieved in this way is that the risers of the associated gas lift systems can as far as possible be of approximately equal length, which is advantageous in order as far as possible to be able to utilise the reactor vessel uniformly over the reactor surface area – viewed horizontally. In the case of a single medium washer for the reactor vessel it is particularly advantageous with this arrangement if the medium washer is provided centrally in the reactor vessel.

According to a further advantageous embodiment, each gas lift system is provided at the bottom with a bowl, such as a cone, that opens at the top. A cone at the bottom of each gas lift system promotes effective suction of medium by the gas lift system. It is particularly advantageous here if each bowl is integral with the respective gas lift system, such that each respective gas lift system can be fitted or removed as a unit together with the respective bowl in each case. Here, "integral with" is understood to mean that the bowl and the gas lift system, or at least the bottom section thereof, have already been fixed to one

another outside the reactor vessel. This can be effected, for example, by making the inlet end of the gas lift system and the bowl from an injection moulding made of plastic or optionally a metal. However, it is also readily conceivable that the bowl is fixed to the inlet end of the gas lift system by means of assembly means such as screws or bolt or snap-fit connections.

With a view to uniform withdrawal of the medium over the reactor surface area, it is advantageous according to the invention if the gas lift systems, at least viewed in a horizontal plane, are distributed over the reactor vessel in accordance with a pattern.

According to a further advantageous embodiment, the purification installation according to the invention has a liquid feed system for feeding the liquid to be purified into the bed. In this context, it is particularly advantageous according to the invention if the liquid feed system comprises a multiplicity of parallel distribution arms that are equipped for feeding liquid into the bed over the length of the distribution arms. Such distribution arms can consist of elongated caps that are open at the bottom and at one end are mounted on a feed line for the liquid. The liquid fed underneath the cap will enter the bed of medium via the open lower end of the cap. With this arrangement the cap ensures that there is a hollow space in the bed via which the liquid can flow into the bed, distributed over the bed. Such distribution arms are known per se from the state of the art. However, in the state of the art the distribution arms are arranged radially. This has the significant disadvantage that in the case of larger reactor vessel diameters the distribution of liquid over the reactor vessel at the radial outer side differs from that in the centre of the reactor vessel. Positioning the distribution arms parallel with one another in accordance with the present invention now makes it possible to ensure that the feed of the liquid to be purified is uniform at all points over the entire reactor surface area. Incidentally, these parallel distribution arms can also highly advantageously be used with purification installations already known from the state of the art, i.e. separately from the multiple gas lift systems. According to a second aspect the present invention therefore also relates to a purification installation for purifying a liquid, comprising:

- a reactor vessel containing a bed of a granular medium,
- a medium washer;
- a gas lift system;
- a liquid feed system with a multiplicity of distribution arms;
- wherein the gas lift system comprises a riser with a suction inlet located in the

bed and a blow outlet that is located higher and opens into the medium washer, as well as gas feed means for generating a gas lift in the riser that draws in medium, liquid and gas at the suction inlet and feeds these upwards through the riser to the medium washer;

- wherein the medium washer has a medium outlet for returning the washed medium to the bed;

characterised in that the liquid feed system comprises a multiplicity of parallel distribution arms that are equipped for feeding liquid into the bed over the length of the distribution arms. Here the distribution arms can be constructed as is known from the state of the art, for example by means of the caps open at the bottom, which have already been mentioned above. The characterising clause of Claim 1 and Claims 2 - 10 of this application can be linked as dependent claims to the purification installation according to the second aspect.

According to a further advantageous embodiment, the purification installation according to the invention has a control system equipped for mutually independent control of the gas feed to the respective gas lift systems. In this way it is possible to increase the effectiveness when rectifying process malfunctions, in that the medium transport in a specific segment of the reactor can be temporarily increased in a targeted manner.

According to a further advantageous embodiment, the reactor vessel of the purification installation according to the invention can have a base that is essentially flat. Thus, according to the invention, the distance from the distribution arms to the base can be reduced to 60 to 90 cm, whilst this is approximately 2 to 3 m in the state of the art. Furthermore, the flat base enables very easy positioning of the gas lift systems.

The present invention will be explained in more detail below with reference to an example shown diagrammatically in the drawing. In the drawing:

Fig. 1 shows, diagrammatically, a vertical longitudinal sectional view of a purification installation according to the invention;

Fig. 1A shows the detail Ia from Figure 1;

Fig. 2 shows the upper section of the purification installation, likewise in vertical longitudinal section, according to the arrows II in Fig. 1;

Fig. 3 shows, diagrammatically, a horizontal section according to the arrows III in Fig. 1; and

Fig. 4 shows, diagrammatically, a horizontal section according to arrows IV.

Figure 1 shows a reactor vessel with a bed 3 of granular medium therein. This

granular medium can be of diverse types. For example, consideration can be given to filter sand.

Medium washer 2 is provided centrally in the reactor vessel 1. Furthermore, several, three in this example drawn, gas lift systems 4, 5 are provided in the reactor vessel. Each gas lift system has a riser 4 with a suction inlet 6 located in the bed 3 and a blow outlet 7 that is at a higher position and opens into the medium washer 2, as well as gas feed means 20 for generating a gas lift in the riser 4. This gas lift sucks medium from the bed, as well as liquid contained in the bed, and feeds these upwards through the riser to the medium washer 2. The medium of the bed is then washed in the medium washer 2 so as, after having been washed, to be returned to the bed via a medium outlet 8 of the medium washer.

The liquid to be purified in the reactor vessel is fed via liquid distribution system 10 into the bed 3 in the reactor vessel.

The mode of operation of a purification installation as shown in the figures in the general sense is as follows:

- Liquid to be purified is introduced via the liquid feed system 10 into the reactor vessel 1. This feed of the liquid to be purified takes place in particular in the bed of granular medium 3. The liquid introduced into the bed 3 passes upwards through the bed 3 and is purified during this passage. A discharge 14, 15 for purified liquid is provided at the top of the reactor vessel 1. By way of example, this discharge 14, 15 here consists of an overflow trough 14 with a discharge line 15. Broken line 16 indicates the level of the liquid at the top of the reactor vessel.
- The bed of granular medium 3 is subjected to a downward flow in that the granular medium is drawn up at the bottom by the gas lift systems – this is one gas lift system in the state of the art – and fed upwards to the medium washer 2. The cleaned granular material then drops back onto the top of the bed 3 from the medium washer 2. As a consequence of this return of granular medium, the bed 3 slopes at the top, as indicated by the broken lines 17 in Figure 1.

The medium washer 2 will now be described with reference to Figure 2.

Before discussing the medium washer 2 in more detail, it is pointed out that dirt is also already dissociated from the medium in the gas lift, in particular in the risers 4. Further impurities are then removed from the medium in a medium washer. The medium washer 2 comprises a space delimited by a peripheral wall 21. The blow outlets 7 of the risers 4 open

into the top of this space. A discharge for liquid to be washed is provided centrally in the chamber 22. This discharge comprises a discharge line 23 and a central inlet pipe section 24. An inlet opening 25 has been made in the top of the inlet pipe section 24. The top end of the pipe section 24 is also provided with a slider 26, by means of which the bottom of this can be set with opening 25. In this way it is possible to set the level of the liquid in the medium washer 2 with respect to the level 16 of the liquid in the reactor vessel over the range B. A partition 27 is provided around the top end of the inlet pipe section 24. The reason for this is to form an inlet chamber for the gas lift systems that is separated from the inlet of the inlet pipe section 24. This prevents medium fed upwards with the gas lift being discharged directly from the medium washer via the inlet 24 and the discharge 23. The medium fed into the medium washer via the risers 4 drops down into the medium discharge channel 28 under the influence of gravity. Baffles 29 are provided in the medium discharge channel 28 such that a labyrinth is produced in the discharge channel 28. By setting the level of the liquid in the medium washer by means of the slider 26 to be lower than the level 16 of the liquid in the reactor vessel, an upward stream of liquid from the top section of the reactor vessel, that is to say completely or partially purified liquid, is generated through the medium discharge channel 28. This liquid stream, termed wash water, contributes to cleaning of the medium. Depending on the level difference set using the slider 26, this upward stream of wash water will be larger or smaller.

The liquid feed system according to the invention will be discussed in more detail below, in particular with reference to Figure 3 and also with reference to Figure 1.

The liquid feed system 10 comprises a distribution pipe 30 on which a number of – in this example four – connection stubs 32 for pipe sections 31 are provided. The pipe sections 31 extend through the wall of the reactor vessel. The pipe section 31 and the connection stubs 32 are connected to one another by means of flange joints and optionally can also be dismantled. The pipe sections 31 open into the longitudinal ends of each cap 33. The various caps 33 are arranged parallel to one another in the reactor vessel, preferably with a mutual spacing D. The caps 33 are closed off from above, at the longitudinal side edges – preferably also at the longitudinal ends – and are open at the undersides. In this way the caps create a space free from medium in the bed of granular medium 3, via which space the liquid to be purified can be fed, distributed over the bed 3. The caps 33 are generally referred to as so-called distribution arms. The distribution arms can also be constructed in a different way. In the state of the art it is customary to make the distribution

arms run in a radial pattern, which has the disadvantage that the spacing between the distribution arms at the radial outer ends is greater than in the centre, which, in turn, is inherently associated with a non-uniform distribution of the liquid over the reactor surface area. Uniform distribution can be achieved by constructing the distribution arms not so much as straight distribution arms but rather as rings or segments of a circle and providing adjacent rings/segments of a circle with a fixed radial spacing in the reactor vessel. However, this is a relatively complex construction which, moreover, has the disadvantage that a liquid feed system then always has to be designed depending on the diameter of the reactor vessel. By making the distribution arms straight and positioning them parallel to one another in accordance with the invention, an appreciably simplified liquid feed system is possible. Moreover, the length of the distribution arms can easily be adapted depending on the distance to be spanned in the reactor vessel. If use is made of a distribution pipe 30 with rigid connection stubs 32, then it is only the manifold 30 that has to be adapted. However, this can easily be overcome by providing flexible lines between the pipes 31 and connection stubs 32 and optionally closing off superfluous connection stubs 32.

The gas lift systems according to the invention will be discussed in more detail below with reference to, in particular, Figures 1 and 4.

The gas lift systems comprise a riser 4. This riser can be made of metal and can be rigid, but can also be a flexible line made of, for example, plastic. An air chamber 35, into which a nozzle 7 for blowing in air emerges, is at the bottom of the riser 4. The nozzle 7 for blowing in air is provided with air via the air feed line 20. The air chamber 35 is located concentrically around the bottom end 60 of the riser 4. The air chamber is essentially closed. The air passes from the air chamber 35 into the riser 60, 4 via passages, such as slits. With this arrangement the lift action sucks in liquid and medium via the open bottom end 61.

Each gas lift system is provided with a cone 9 at the bottom of the riser 4. The cone 9 is provided with a plate 37 at the bottom and, for the purposes of stable support, bears on the plate 37 via a cylindrical part 36. The cone is connected to the gas chamber 6 by means of arms 38. The gas chamber 6 as such can be connected to the riser 4. This connection can already be made before assembly in the reactor vessel. In this way it becomes possible to lower the whole into the reactor vessel and to fix it in a desired position on the base of the reactor vessel. The broken lines 42 and 43 show, diagrammatically, an interface in the bed of granular material 3 along which the granular medium sinks into the respective cones 9.

The portion of the granular medium that is below the broken lines 42 and 43 will then essentially form a sort of dead zone that remains unutilised. However, it will be clear that the construction height needed in the reactor vessel for the cones 9 of the gas lift systems according to the invention is appreciably less that the construction height in the case of a cone for a reactor vessel according to the state of the art. Per se, it is optionally possible to provide base wall sections along the interfaces indicated by broken lines 42 and 43, so that no medium has to be present in the dead spaces. The dead spaces, also termed stagnant zones, are relatively small and do not interfere with, or barely interfere with, the process. Said additional bottom wall sections are then not really necessary.

The gas used for the gas lift systems can be air or another suitable gas.

Finally, Figure 1 also shows, diagrammatically, a control system 50 that via signal leads 54, 55 can control a control valve 51, 52 in each of the feed lines 20 to a gas lift system. The control valves 51, 52 can preferably be controlled independently of one another to allow a specific quantity of gas that has been supplied via line 53 to pass through.

The present invention can be employed, inter alia, in: polishing filtration of effluent, on its own or combined with biofiltration; treatment of surface water, groundwater or cooling water, to remove the suspended particles or – after flocculation – dissolved substances.

Claims

1. Purification installation for purifying a liquid, comprising:
   - a reactor vessel (1) containing a bed (3) of a granular medium;
   - a medium washer (2);
   - at least one gas lift system (4, 5);

   wherein the at least one gas lift system (4, 5) comprises a riser (4) with a suction inlet (6) located in the bed (3) and a blow outlet (7), at a higher position, opening into the medium washer (2), as well as gas feed means (20) for generating a gas lift in the riser (4) that draws up medium and liquid at the suction inlet and feeds these upwards through the riser (4) to the medium washer (2),
   wherein the medium washer (2) has a medium outlet (8) for returning washed medium to the bed (3);
   characterised in that the purification installation has a multiplicity of gas lift systems (4, 5), the respective blow outlets (7) of which emerge in the medium washer (2).

2. Purification installation according to Claim 1, characterised in that two or more gas lift systems (4, 5) are provided per medium washer (2).

3. Purification installation according to Claim 2, characterised in that the reactor vessel (1) contains a single medium washer (2).

4. Purification installation according to Claim 2 or 3, characterised in that, viewed horizontally, the medium washer (2) is provided centrally with respect to the associated gas lift systems (4, 5).

5. Purification installation according to one of the preceding claims, characterised in that, viewed horizontally, the medium washer (2) is provided centrally in the reactor vessel (1).

6. Purification installation according to one of the preceding claims, characterised in that each gas lift system (4, 5) is provided at the bottom with a bowl (9) , such as a cone (9), that is open at the top.

7. Purification installation according to Claim 6, characterised in that each bowl (9) is integral with the respective gas lift system (4, 5), such that each respective gas lift system (4, 5) can be fitted or removed as a unit together with the respective bowl (9) in each case.

8. Purification installation according to one of the preceding claims, characterised in that, viewed horizontally, the gas lift systems (4, 5) are distributed over the reactor vessel (1) in accordance with a pattern.

9. Purification installation according to one of the preceding claims, having a control system (50) equipped for mutually independent control of the gas feed (51, 52) to the respective gas lift systems (4, 5).

10. Purification installation according to one of the preceding claims, wherein the base (12) of the reactor vessel is essentially flat.

11. Purification installation according to one of the preceding claims, having a liquid feed system (10) for feeding the liquid to be purified into the bed (3).

12. Purification installation according to Claim 11, wherein the liquid feed system (10) comprises a multiplicity of parallel distribution arms (11) that are equipped for feeding liquid into the bed over the length of the distribution arms (11).

Fig 1

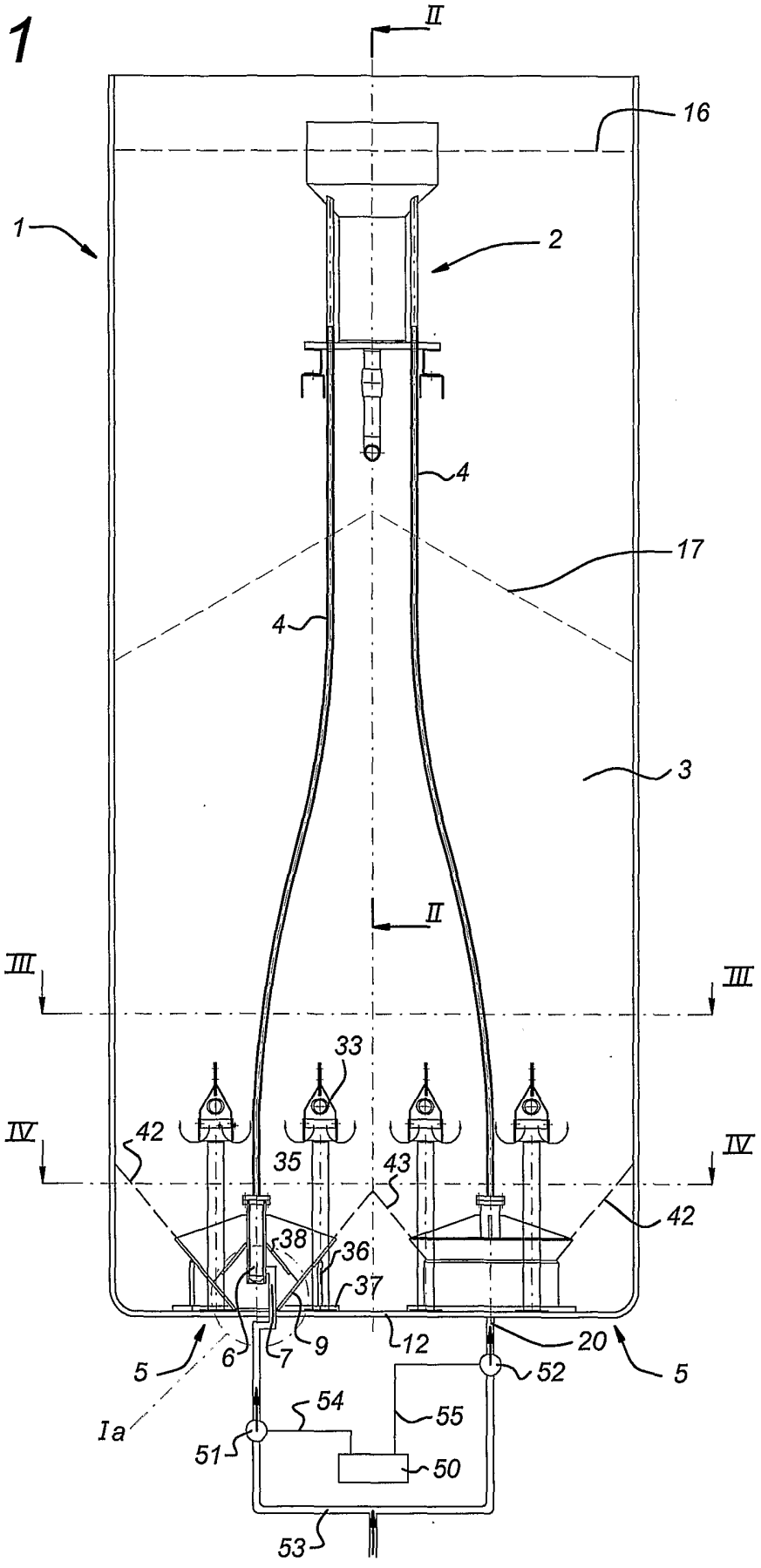

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Fig 1a

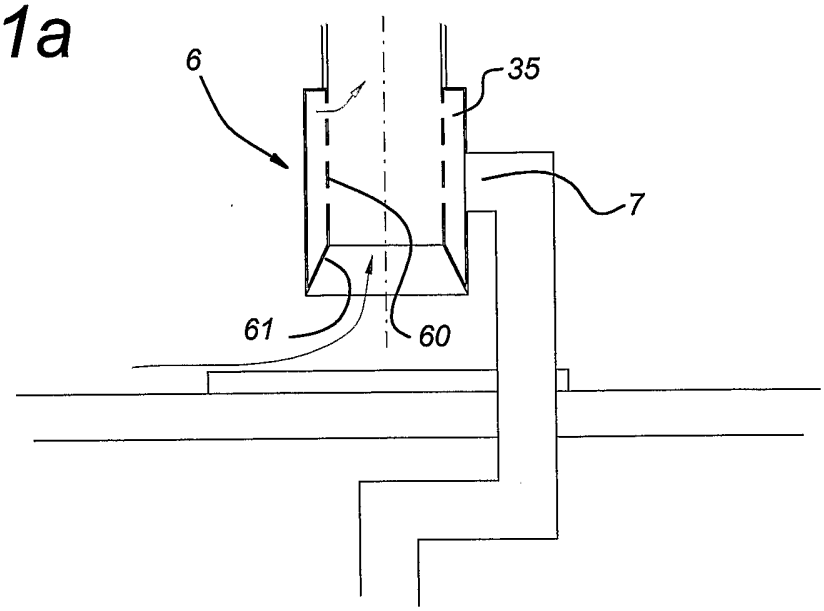


Fig 2

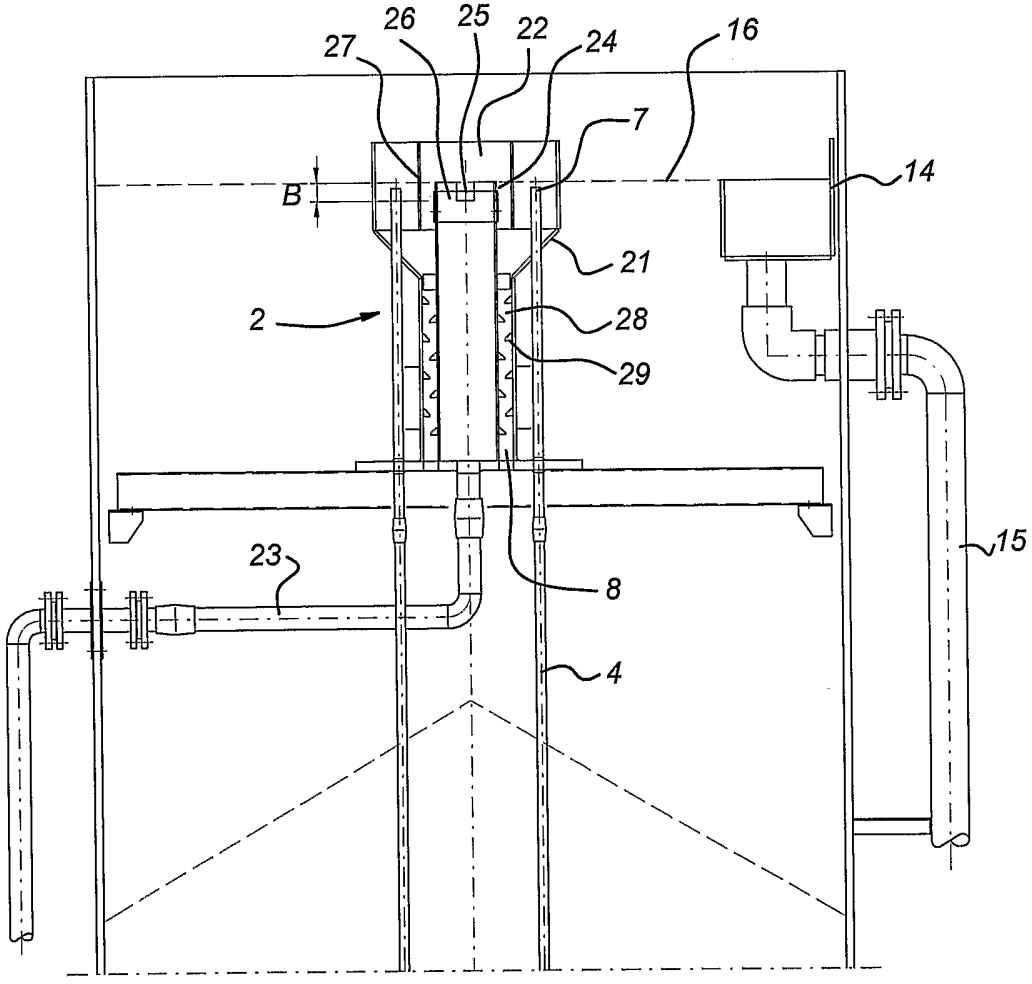


Fig 3

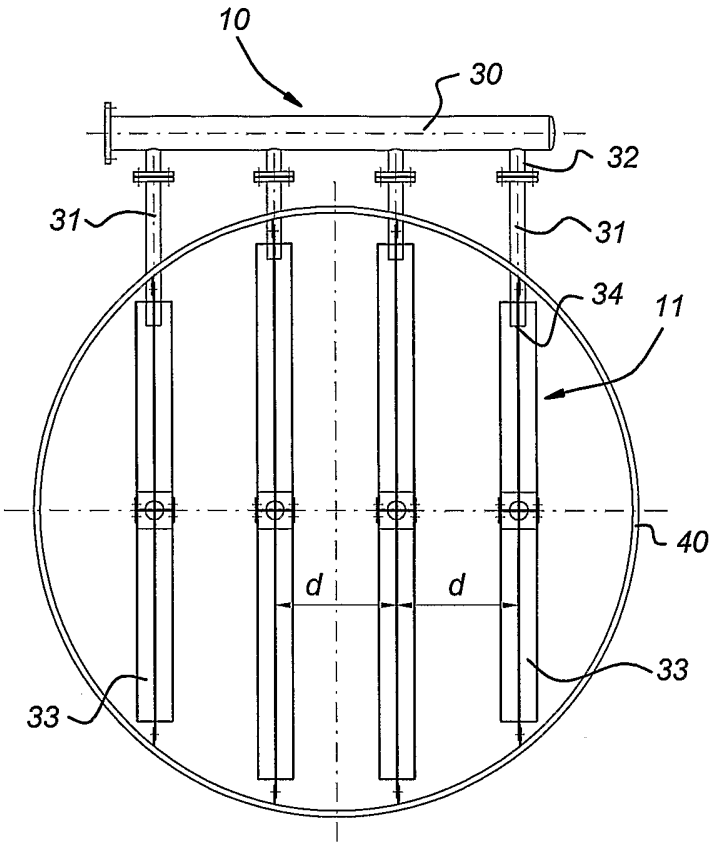
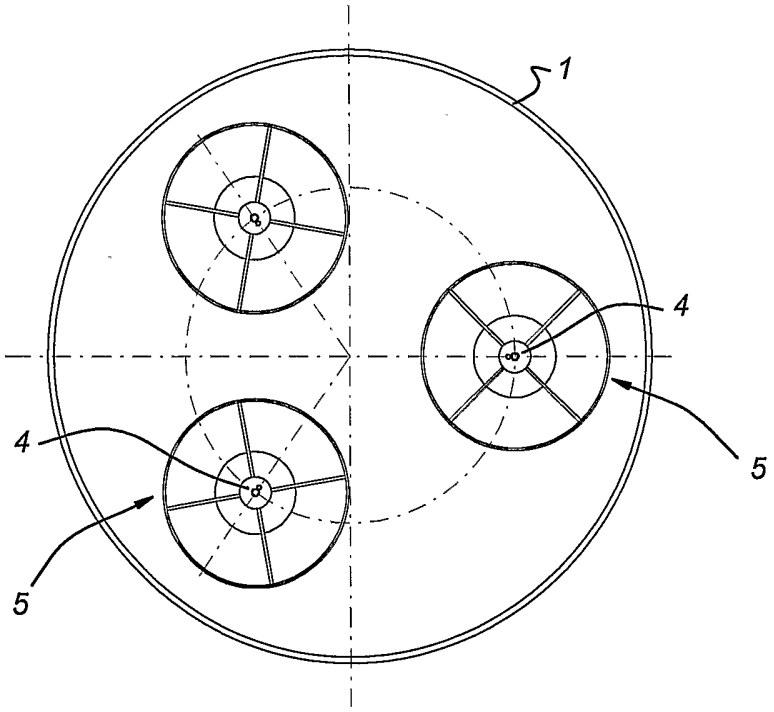


Fig 4



INTERNATIONAL SEARCH REPORT

national Application No
T/NL2004/000415

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B01D24/30 B01D24/46

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)
IPC 7 B01D F04F

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 practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 727 908 A (WARD STEPHEN DANIEL) 17 March 1998 (1998-03-17) abstract column 5, line 27 - line 47 column 6, line 26 - column 7, line 8 figure 1	1-5,8-12
X	PATENT ABSTRACTS OF JAPAN vol. 005, no. 004 (C-038), 13 January 1981 (1981-01-13) -& JP 55 132612 A (HITACHI CHEM CO LTD), 15 October 1980 (1980-10-15) abstract & DATABASE WPI Week 198048 15 October 1980 (1980-10-15), Derwent Publications Ltd., London, GB; AN 1980-85130C abstract	1,2,4,5, 8,9

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
29 September 2004	06/10/2004

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 471 857 B1 (KAIBARA KAZUTOSHI) 29 October 2002 (2002-10-29) figures 2-5	1,2,4,8, 9

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Information on patent family members

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