

VACUUM FILTER DEVICE AND WASTEWATER TREATMENT PLANT USING THE SAME

Technical Field

The present invention relates to a vacuum filter device, intended to be used, in particular, in wastewater treatment. Furthermore, it relates to a wastewater treatment plant which employs such a vacuum filter device, in which the latter is mounted in an oxidation tank in order to extract clarified water from the wastewater preferably aerated in order to increase the concentration of microorganisms inside the tank with the effect of accelerating organic matter digestion.

Background Art

US 5,300,221 A describes a filter device in the form of a continuous conveyor which is removably mounted within a tank fed from an inlet duct with a liquid to be filtered and provided with an outlet duct. The filter device, which is transversely partially immersed in the tank, has a load bearing structure having opposed walls with upper and lower rollers. A belt filter that runs between the upper and lower rollers carries upward suspended solid matter, which is discharged on a transverse discharge conveyor.

The filter device is mounted to supports at the bottom of the tank, from which the filter device can be removed to be washed. Seals are provided between the sides of the filter device and the side walls of the tank in order to prevent passage of liquid. A plurality of filter devices may be provided in the tank, each one being associated to its own discharge conveyor for removing the material separated from the liquid. Clarified liquid flows out of the tank downstream of the filter devices without the previously removed material.

The filter device according to US 5,300,221 A has a screening function which stops and extracts coarse material in suspension in the liquid, while the smallest particles are released again into the liquid when the belt filter is again immersed in the liquid when rotating between the upper and lower rollers. It is clear that the filter device does not allow a liquid with a high level of purification to be obtained downstream.

WO 2014/197468 A2 describes a continuous belt screen assembly placed partially immersed in a channel so that a liquid that skims the inner walls of the continuous

belt, passes through it. The continuous belt is moved by a pair of drive links which run parallel in the vicinity of the walls of the channel. In the inner side the continuous belt has lifters that lift debris in suspension in the liquid flow. The continuous belt is moved by a geared motor placed at the top of the belt screen assembly in which there is provided a chute that receives and removes the debris lifted by the lifters. It should be obvious that the belt screen assembly according to WO 2014/197468 A2 serves only to remove the debris and not to purify the liquid to be treated.

FR 2575397 A1 discloses a continuous belt filter movable in vertical direction and partially immersed in a tank in the direction of a liquid flow. The belt, which is wave shaped in transverse direction for collecting debris, is closed on one side and, on the other side, it communicates with the outside of the tank. The belt lifts upwards the material contained in the liquid in suspension in the tank which is removed by means of a chute. FR 2575397 A1 also gets a removal of the debris in suspension and a filtrate dependent on the porosity of the belt used. Moreover, the belt filter can be placed only at the outlet of the tank. Therefore, the number of belt filters employable in the tank is equal to one. In other words, more than one movable filter cannot be installed in the tank. The flow rate of filtered liquid is not adjustable because it flows out freely from a wall of the tank through the outlet indicated above. In addition, the filter consists of filter panels mounted to respective frames joined together in correspondence of a pair of sliding rollers on respective tracks fixed inside a guide provided at the outlet. It is understood that the filter is designed for a fine screening but not for a micro screening, also because it is not possible to provide a hydraulic seal between the tank and the compartment inside the continuous belt filter: the liquid to be filtered, together with the impurities in suspension, easily passes inside the guide between a sliding roller and the other.

US 2004/0262242 A1 describes a conveyor belt for an overflow weir for sewerage system. In addition, US 4,186,091 A and EP 0728512 A2 describe particular forms of screens.

Summary of the Invention

An object of the present invention is to create a filter device which has a simple and

economic structure of vacuum filtration.

In particular, one object of the invention is to provide a belt filter that, by means of its lateral ends, creates a hydraulic seal with the side walls of the filter device, an internal compartment being formed as delimited by the belt filter and by the side
5 walls of the device filter and adapted to contain the clarified liquid, in a manner that liquid still to be filtered is introduced in the compartment of the clarified liquid when the clarified liquid is extracted from the internal compartment.

Another object of the invention is to provide a filter device with a belt filter having a desired porosity.

10 A particular object of the invention is to provide filter devices for wastewater treatment that are installed in an oxidation tank of a wastewater treatment plant in the desired number, with the function of extracting clarified water.

Still another object of the invention is to provide self-supporting filter devices that can be installed anywhere in an oxidation tank of a wastewater treatment plant.

15 In addition, one object of the invention is to provide a wastewater purification plant which employs the filter device in order to avoid a step of secondary sedimentation and recirculation of sludge.

A further object of the invention is to provide a filter device in which the quantity of water output from the filter device can be adjusted as desired.

20 In particular, an object of the present invention is to provide a filter device, which, when placed in an oxidation tank, produces clarified water that can be delivered directly to the filtration instead of a secondary sedimentation with subsequent return to the oxidation tank.

The technical task mentioned and the objects specified are substantially achieved by
25 a vacuum filter device, partially immersed, when used, in a tank for thickening and filtering a liquid, comprising:

- a vertically extended load bearing structure having opposite walls with facing faces and opposite faces;
- at least two upper pulleys mounted to a drive shaft;
- 30 - at least two lower pulleys mounted to a driven shaft;
- a belt filter including a membrane holding flexible structure engaged to move

together with the upper pulleys and lower pulleys, membrane holding flexible frame on which at least one filter membrane is mounted;

- a geared motor mounted to a wall of the load bearing structure and connected to the drive shaft;

- 5 - an electric pump for washing filter membranes, the electric pump being mounted to a wall of the load bearing structure;

characterized in that a sealing arrangement of the membrane holding flexible structure and the pulleys with the facing faces of opposite walls of the load bearing structure is made for creating between the at least one filter membrane and the

10 opposite walls of the load bearing structure a compartment for only filtered liquid that has passed through the at least one filter membrane from the tank; and

the clarified liquid compartment communicates with the exterior of the tank by means of a clarified liquid pipe connected to an outlet opening formed in at least one of the opposite walls at a height lower than that of the free surface of the liquid in

15 the tank.

The present invention has also the task of providing a wastewater treatment plant, comprising a pre-treatment section, such as for screening, desanding, and deoiling, a primary sedimentation section, a pre-denitrification-oxidation section, a filtration section and a disinfection section, in which the pre-denitrification-oxidation section

20 comprises a tank inside which a vacuum filter device is installed according to any one of the preceding claims.

The filtering capacity of the device according to the invention allows to eliminate a secondary sedimentation section and a sludge recirculation that are normally provided in a wastewater treatment plant. In fact, thanks to the oxidation tank

25 containing the vacuum filter device according to the invention, the clarified liquid output from the tank is so depurated that it must not return to the pre-denitrification-oxidation section, but it may be delivered directly to the section of filtration and disinfection.

Brief Description of Drawings

- 30 Further features and advantages of the present invention will become more apparent from the indicative, and therefore non-limiting, description of a preferred but not

exclusive embodiments of a vacuum filter device, as illustrated in the accompanying drawings in which:

- Figure 1 is a perspective view of a first embodiment of the vacuum filter device according to the invention inserted in a tank;
- 5 - Figure 2 is an enlarged three quarter perspective view from above of the device seen from the opposite side to that in Figure 1;
- Figure 3 is a longitudinally sectioned perspective view of the device in Figure 1;
- Figure 4 is an exploded perspective view of a flexible structure and a framed membrane of the belt filter of the device in Figure 1;
- 10 - Figure 5 is a further enlarged perspective view of a bottom portion of the device in Figure 1;
- Figure 6 is a perspective view of the device in Figure 1 as seen from the opposite side;
- Figure 7 is a greatly enlarged detail of the bottom part of the device shown in Figure 6;
- 15 - Figure 8 is a perspective view similar to that in Figure 5 but devoid of pulleys and flexible structure;
- Figure 9 is a perspective view similar to that in Figure 3 but of a second embodiment of the vacuum filter device according to the invention;
- 20 - Figure 10 is an enlarged perspective view of a pulley of the device in Figure 9;
- Figure 11 is an enlarged front view of a detail in Figure 9;
- Figure 12 is a perspective view of the second embodiment of the vacuum filter device according to the invention inserted in an oxidation tank; and
- Figure 13 is a flowchart of a wastewater purification plant employing the device
- 25 according to the present invention.

Detailed Description of Invention Embodiments

Reference is made initially to Figures 1 and 2, which are a perspective view of a first embodiment of a vacuum filter device 1 inserted in a tank V and, respectively, an enlarged three quarter perspective view from above of the filter device 1 as seen

30 from the opposite side to that in figure 1.

The tank V is filled with liquid up to a free surface level indicated as PLV. The

vacuum filter device 1, simply called hereinafter device 1, is partially immersed, when used, in the tank V in order to thicken and filter the liquid. The device 1 comprises a vertically extended load bearing structure 2 having opposite walls 3, 4 which have facing faces 30, 40, and opposite faces 31, 41.

5 Reference also is made to Figure 3 that is a longitudinally cross-sectioned perspective view of the device in Figure 1. In the load bearing structure 2, where a base connected to the side walls 3 and 4 is indicated as 5, and a top member as 6, there are two upper pulleys 7 mounted to a drive shaft 16, and two lower pulleys 8 mounted to a driven shaft 24. The drive shaft 16 is mounted at an adjustable height,
10 together with its geared motor 15, in the load bearing structure 2. A belt filter 9, which is formed by a membrane holding flexible structure 10 and a plurality of filter panels 11, moves periodically on the upper pulleys 7 and lower pulleys 8. Each filter panel 11 is constituted by a membrane 12 and a perimeter frame 29, as best shown in figure 4, which is an exploded perspective view of the flexible structure 10 and a
15 filter panel 11 of the belt device in Figures 1 and 2. The flexible frame 29 of the filter panel 11 is preferably made of a composite material, and the membrane 12 is made of plastic, generally polyester, or steel. The porosity of the membrane can be chosen as desired depending on the filtrate to be obtained. For example, if they are membranes for microfiltration, the size of their pores is comprised between 0.1 and
20 10 μm .

The flexible structure 10 is formed by two end strips 13 and by a plurality of thrust spacer elements 14 fixed in parallel between the two strip ends 13. These are the end strips 13 which engage frictionally the upper pulleys 7 and lower pulleys 8, and on the end strips 13 and on the thrust spacer elements 14 the plurality of filter panels 11
25 is fixed, by their respective flexible frames 29. Both the flexible structure 10 and the flexible frames 29 are made of suitable material. Each flexible frame 29 is joined to the flexible structure 10 with suitable attaching means such as bolts, but also possibly by welding and sticking depending on the materials used and the type of filtration. As above said, the membranes 12 are selected with the desired porosity for
30 the destination of the device 1. It should be evident that other solutions may be found for manufacturing the belt filter 9 that is formed by the flexible structure 10

and the membranes 12; the belt filter 9, as will be seen below, is periodically moved by means of the upper pulleys 7 and lower pulleys 8 in order to be cleaned. The displacement of the belt filter 9 is performed by means of the geared motor 15 that is mounted to the outer face 31 of the wall 3 of the load bearing structure 2 and connected to the drive shaft 16. The geared motor 15 is positioned in adjustable manner on the wall 3 of the load bearing structure 2 by means of guides 51 on the one hand, while on the other end there is provided a tensioning assembly 38 mounted to guides 52 (Fig. 6). In addition, a splashback 28 is shown full of side walls.

On the outer face 41 of the opposite wall 4 of the load bearing structure 2 there is mounted an electric washing pump 17. The electric washing pump 17 of the membranes 12 is connected to a suction pipe 18 passing through the wall 4 of the load bearing structure 2 and sucking in the compartment 23 of the clarified liquid below its free surface PLF. As shown in Figure 3, the free surface PLF of the clarified liquid is lower than free surface PLV of the liquid in the tank V. The electric washing pump 17 has a delivery pipe 19 connected to a series of pipes 20 provided with nozzles 21 for spraying washing water on the membranes 12 that are located above the free surface PLV of the liquid in the tank V (Figure 3). The pipes 20 are made so that jets of washing water through the nozzles 21 are directed from the inside of the compartment 23 to the outside so as to clean the membranes but also tangentially to the membranes 12 externally of the compartment 23.

In order to create the above-mentioned depression between the outside of the tank V and the internal compartment 23 inside the belt filter 9, the latter is connected sealingly with the opposite walls 3 and 4 of the load bearing structure 2. According to the present invention, a sealing arrangement of the belt filter 9 is performed by creating an engagement between the flexible membrane holding structure 10 and four elongated U-shaped gaskets 22 that extend mirror-symmetrically on the facing faces 30, 40 of the opposite walls 3, 4 of the load bearing structure 2. This is shown in particular in Figure 5, which is a further enlarged perspective view of a bottom portion of the device in Figure 1. As an alternative to the elongated U-shaped gaskets 22, distinct opposite pairs of gaskets 22a, 22b may be provided as shown in

Figures 6 and 7, which are a perspective view of the device in Figure 1, as seen from the opposite side, and a very enlarged detail of a bottom part of the device shown in Figure 6.

5 Inserted in the elongated U-shaped gaskets 22 or 22a, 22b are the end strips 13 of the flexible structure 10 in parallel vertical tracts tangent to the upper pulleys 7 and lower pulleys 8. In this way, created between the plurality of filter panels 11 and the opposite walls 3, 4 of the load bearing structure 2 is a compartment 23 only for the clarified liquid which passed through the membranes 12 from the tank V, in which the device 1 is immersed. These membranes 12 are mainly shown in Figure 3 and in
10 the corresponding partial enlargement of Figure 5, which is a further enlarged perspective view of a bottom part of the device in Figure 1. Alternatively, the filter membrane may be in a single piece and not divided into filter panels 11 shown in the figures.

With reference to Figure 5, where the lower membranes are not shown, the lower
15 pulley 8 and the other facing lower pulley (not visible) are mounted to the driven shaft 24. Advantageously, the pulleys are provided with a circumferential gasket 25 in abutment with the inner face 30, 40 of the walls 3, 4. Preferably, a coil spring 26 pushes the pulleys 8 against the walls 3, 4.

In the device 1 according to the invention, a sealing arrangement is created by
20 means of:

- the elongated U-shaped gasket 22 or the pair of gaskets 22a, 22b that are mounted to the facing faces 30, 40 of the opposite walls 3, 4 tangentially to the periphery of the pulleys 7, 8, the two end strips 13 sealingly engaging said gaskets, and
- the circumferential gasket 25 in abutment between each lower pulley 8 and the
25 respective inner face 30, 40 of the walls 3, 4 of the load bearing structure 2.

As shown in Figure 7, the pairs of elongated gaskets 22a, 22b have inferiorly end profiles 22c and 22d, respectively. The end profile 22c is tapered downwardly to clean up the end strip 13, while the belt filter 9 is periodically moved for washing the membranes 12; the end profile 22d of the gasket 22b is concave to fit to the
30 convexity of the pulley 8 which rotates inferiorly.

To better see the pairs of elongated gaskets 22a, 22b and the circumferential gasket

25, also reference is made to Figure 8 which is a perspective view similar to that of Figure 5 but devoid of pulleys and flexible structure.

Thanks to the sealing of the circumferential gaskets 25 on the pulleys 8 and the elongated U-shaped gasket 22, or to the pair of gaskets 22a, 22b, in engagement
5 with the end strips 13, the compartment 23 of the clarified liquid communicates with the liquid in the tank V only through the membranes 12. The same compartment communicates with the outside of the tank V by means of a pipe 27 of the clarified liquid (figure 1) connected to an outlet opening 37 (figure 6) formed in the wall 4 at a height lower than that of the free surface PLV of the liquid in the tank V.

10 In summary, the liquid to be clarified in the tank V passes through the belt filter 9 in the direction of an arrow E, and the clarified liquid exits the compartment 23 in the device 1 through the pipe 27 in an arrow U direction for its subsequent treatment (Figure 1).

During the operation, the membranes 12, which are beneath the free surface PLV of the liquid in the tank V, get dirty during the filtration of the liquid and become
15 clogged. This would lead to an interruption of their service. According to the invention, the belt filter 9 is moved in the direction of an arrow F (Figures 1 and 3) and the membranes that have worked are subjected to washing with the jet of clarified liquid exiting the nozzles 21 delivered through the pipes 19 and 20 by the
20 electric pump 17. The direction of the jets is outlined in Figure 3. On the load bearing structure there is a splashback designed as 28.

As usually in the flexible transmissions, the tensioning assembly 38 of the membrane holding flexible structure 10 acts on the drive shaft 16 carrying the upper pulleys 7. This tensioning assembly 38 is not described in detail.

25 It should be understood that the present invention is not limited to the above description, since variations and modifications can be envisaged. In this regard, see Figure 9, which is a perspective view of a second embodiment of a vacuum filter device, and Figures 10 and 11 that show enlarged details of Figure 9. The figures contain reference numerals equal to those used in the previous figures to designate
30 same or similar parts. The differences consist in the provision of a modulating valve 32 on the pipe 27 of the clarified liquid. The modulating valve may be of a type

different from that shown. At the bottom, arranged in a position tangential to the vertical tracts of the belt filter 9 is a pair of aerators 33, preferably tubular diffusers. The aerators 33 are connected to a compressed air supply (not shown), and emit bubbles B useful to hit the material, that, standing on the membranes 12, would
5 reduce the filtering capacity thereof.

Furthermore, the end strips 13 of the flexible structure 10 holding the panels 11 are provided with holes 34, and provided in the upper pulleys 7 and lower pulleys 8 are pins 35, such as those shown in Figure 10, to engage the holes 34 formed on the end strips 13. Thanks to the presence of the holes 34 and of the pins 35 in mutual
10 engagement, a slip of the flexible structure 10 with respect to the upper pulleys 7 and the lower pulleys 8, and a lack of synchronism in the advancement of the end strips 13 are prevented. This lack of synchronism could lead to a breakage of the belt filter 9. It should be evident that pins 35 can be only in the upper pulleys 7, which are the driving ones.

15 Refer now to Figure 12, which is a perspective view of a second embodiment of a vacuum filter device inserted into an oxidation tank VO. The oxidation tank VO has disc diffusers 36 connected by pipes 39 to compressed air suppliers, not shown. The disc diffusers 36 serve to achieve optimum yields of oxygen transfer and avoid sedimentation phenomena in the oxidation tank VO.

20 The oxidation tank VO as the one shown in Figure 12 can be employed in a wastewater treatment plant as depicted in the flowchart in Figure 13. Conventionally, the wastewater treatment plant comprises a slurry incoming section AL, a pre-treatment section P, such as for screening, desanding and deoiling, a primary sedimentation section SP, a pre-denitrification-oxidation section PDO, a
25 filtration section F and a disinfection section D. According to the invention, the pre-denitrification-oxidation section PDO comprises the oxidation tank VO, installed inside which is a vacuum filter device 100 according to the invention. It can be noted that the plant does not require at the exit from the oxidation tank VO a secondary sedimentation section with recirculation of the sludge in the tank of
30 oxidation. In fact, the clarified liquid AC exiting the oxidation tank VO has the same characteristics of the one that would exit the secondary sedimentation section, and it

is sent directly to the filtration section F. The sludge remains in the oxidation tank VO and, once established their concentration to be maintained therein, the quantity in excess is removed directly from the same oxidation tank VO.

The advantage obtained is remarkable, because the secondary sedimentation tank
5 can be avoided, which, as known, has several drawbacks:

it does not allow to work with more than 5 kg of suspended solids for cubic meter of water in the oxidation tank;

the microorganisms inside the secondary sedimentation tank are under oxygen deficiency;

10 furthermore, a secondary sedimentation tank occupies a considerable part of the surface available for the purification plant.

Ultimately, the vacuum filter device according to the invention has the advantage of being installed directly in the oxidation tank and allows, in a wastewater purification plant, the elimination of the secondary sedimentation tank, with a consequent

15 increase in the concentration of microorganisms in the oxidation tank, the increase of the purification capacity, almost doubled, as compared with a modest increase in costs, optimal oxidation conditions of the mixture and the surface saving of the plant.

CLAIMS

1. A vacuum filter device, partially immersed in a tank (V; VO), when used, for thickening and filtering a liquid comprising:
- a vertically extended load bearing structure (2) having opposite walls (3, 4) with facing faces (30, 40) and opposite faces (31, 41);
 - at least two upper pulleys (7) mounted to a drive shaft (16);
 - at least two lower pulleys (8) mounted to a driven shaft (24);
 - a belt filter (9) including a membrane holding flexible structure (10) engaged to move together with the upper pulleys (7) and lower pulleys (8), membrane holding flexible structure (10) to which at least one filter membrane is mounted;
 - a geared motor (15) mounted to a wall (3) of the load bearing structure (2) and connected to the drive shaft (16);
 - an electric pump (17) for washing filter membranes, the electric pump (17) being mounted to a wall (4) of the load bearing structure (2);
- characterized in that the membrane holding flexible structure (10) and the pulleys (7, 8) are in a sealing arrangement with the facing faces (30, 40) of opposite walls (3, 4) of the load bearing structure (2), so as to create between the at least one filter membrane and the opposite walls (3, 4) of the load bearing structure (2) a compartment (23) for only clarified liquid that has passed through the at least one filter membrane; and
- the filtered liquid compartment (23) communicates with the outside of the tank (V; VO) by means of a clarified liquid pipe (27) connected to an outlet opening (37) formed in at least one of the opposite walls (3, 4) at a height lower than that of the free surface (PLV) of the liquid in the tank (V; VO).
2. The device according to claim 1, wherein the membrane holding flexible structure (10) is formed by two end strips (13) and a plurality of thrust spacer elements (14) fixed in parallel between the two end strips (13).
3. The device according to claim 2, wherein a plurality of filter panels (11), being each formed by a membrane (12) and a perimeter frame (29) is fixed on the two end strips (13) and the plurality of thrust spacer elements (14).
4. The device according to claim 3, wherein the frames (29) are made of

composite material and the membranes (12) are microfiltration membranes made of a material chosen from the group comprising plastic materials and iron, the microfiltration membranes having a pore dimension between 0.1 and 10 μm .

5 5. The device according to claim 2, wherein the sealing arrangement is made by means of four elongated U-shaped gaskets (22) fixed on the facing faces (30, 40) of opposite walls (3, 4) tangentially at the periphery of the upper pulleys (7) and lower pulleys (8), which the two end strips (13) sealingly engage and by means of a circumferential gasket (25) in the abutment between each pulley (7, 8) and the respective facing face (30, 40) of the opposite walls (3, 4) of the load bearing
10 structure (2).

6. The device according to claim 2, wherein the sealing arrangement is made by means of four pairs (22a, 22b) of elongated gaskets fixed on the facing faces (30, 40) of opposite walls (3, 4) tangentially at the periphery of the upper pulleys (7) and lower pulleys (8), the two end strips (13) sealingly engaging between the four pairs
15 (22a, 22b) of elongated gaskets, and by means of a circumferential gasket (25) in the abutment between each pulley (7, 8) and the respective facing face (30, 40) of the opposite walls (3, 4) of the load bearing structure (2).

7. The device according to claim 3, wherein a spring (26) interposed between the pairs of lower pulleys (8) coaxially with the driven shaft (24) urges the lower
20 pulleys (8) in abutment against the facing faces (30, 40) of the opposite walls (3, 4) of the load bearing structure (2).

8. The device according to claim 1, wherein a tensioning assembly for the membrane holding flexible structure (10) operates on the motor shaft (16) bearing the upper pulleys (7).

25 9. The device according to claim 1, wherein the electric pump (17) for washing the at least one filter membrane (11) is connected on one hand to a suction pipe (18) passing through the wall (4) of the load bearing structure (2) and being immersed in the clarified liquid compartment (23) below its free surface (PLF), and, on the other hand, to a delivery tube connected to pipes (20) provided with nozzles (21) for
30 spraying washing water onto the at least one filter membrane which is located above the free surface (PLV) of the liquid in the tank (V).

10. The device according to claim 1, wherein the load bearing structure (2) has a splashback (28).
11. The device according to claim 1, wherein a modulating valve (32) is located on the pipe (27) exiting the compartment (23).
- 5 12. The device according to claim 1, wherein a pair of aerators (33) is disposed inferiorly to the belt filter (9) tangentially to its vertical tracts.
13. The device according to claim 3, wherein the end strips (13) of the flexible structure (10) are provided with holes (34), and at least pivots (35) are provided in the superior pulleys (7) in order to engage the holes (34).
- 10 14. A wastewater treatment plant comprising a slurry incoming section (AL), a pre-treatment section (P), such as for screening, desanding and deoiling, a primary sedimentation section (SP), a pre-denitrification-oxidation section (PDO), a filtration section (F) and a disinfection section (D), characterized in that the pre-denitrification-oxidation section (PDO) comprises an oxidation tank (VO) inside
- 15 which a vacuum filter device according to any one of the preceding claims is installed.

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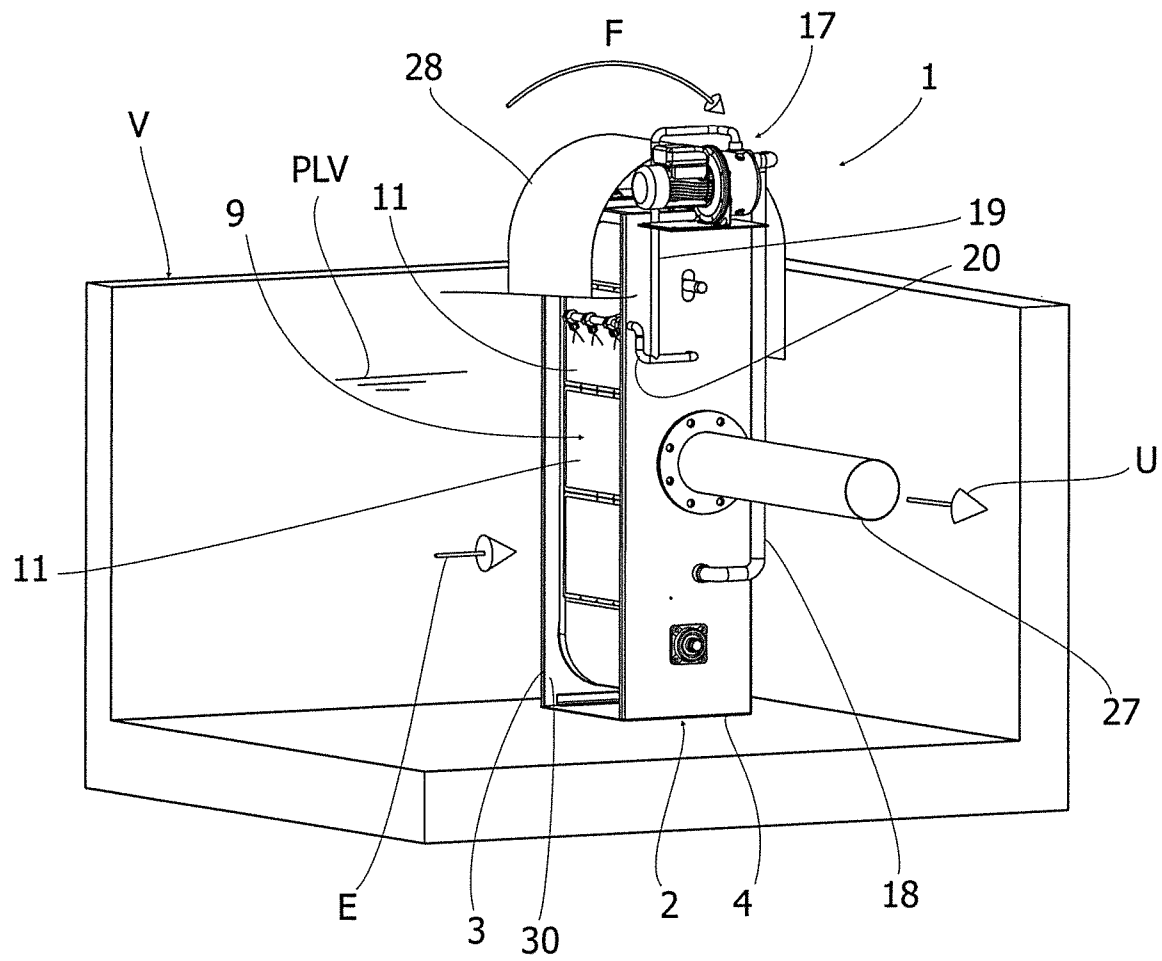


Fig. 1

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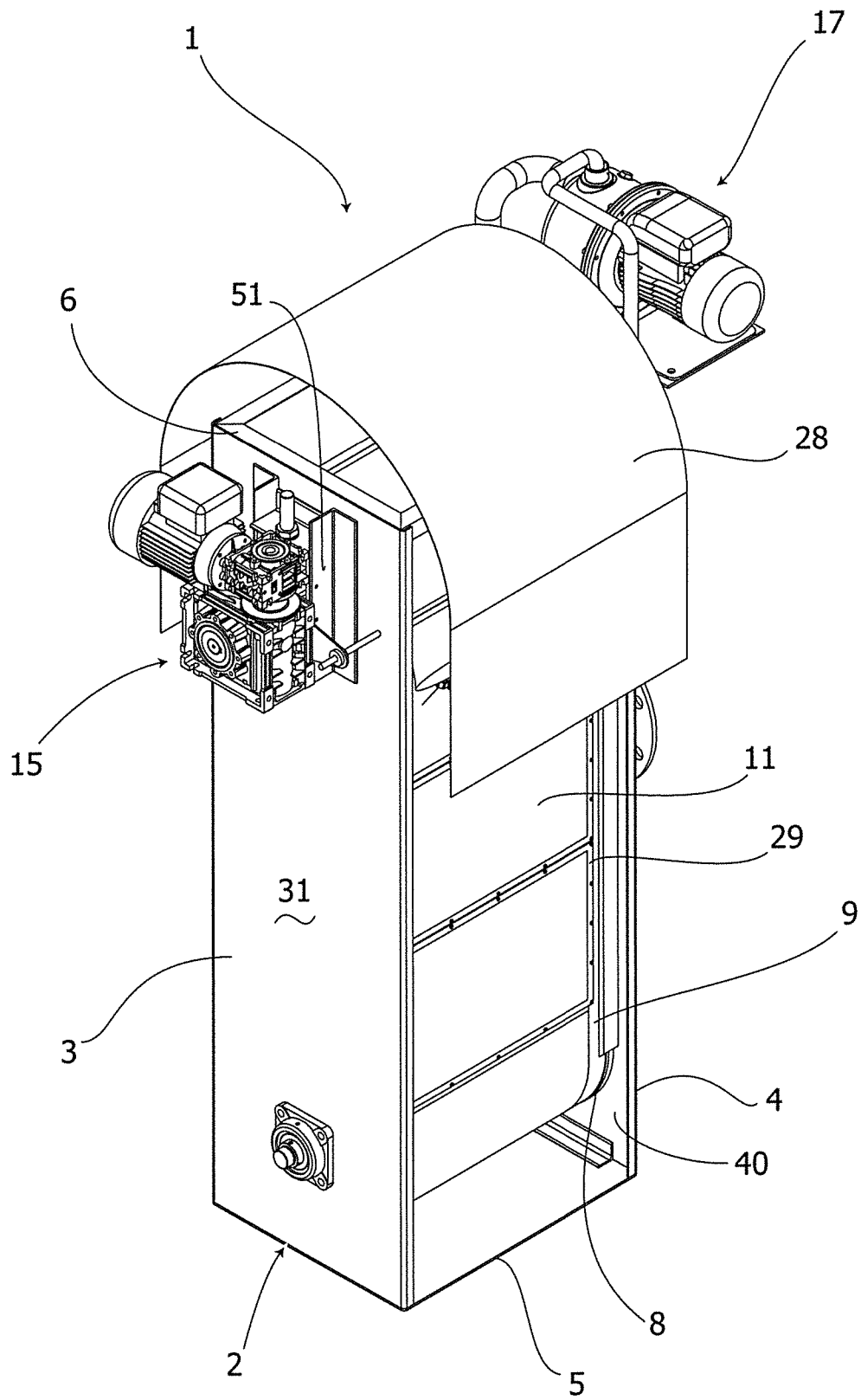


Fig. 2

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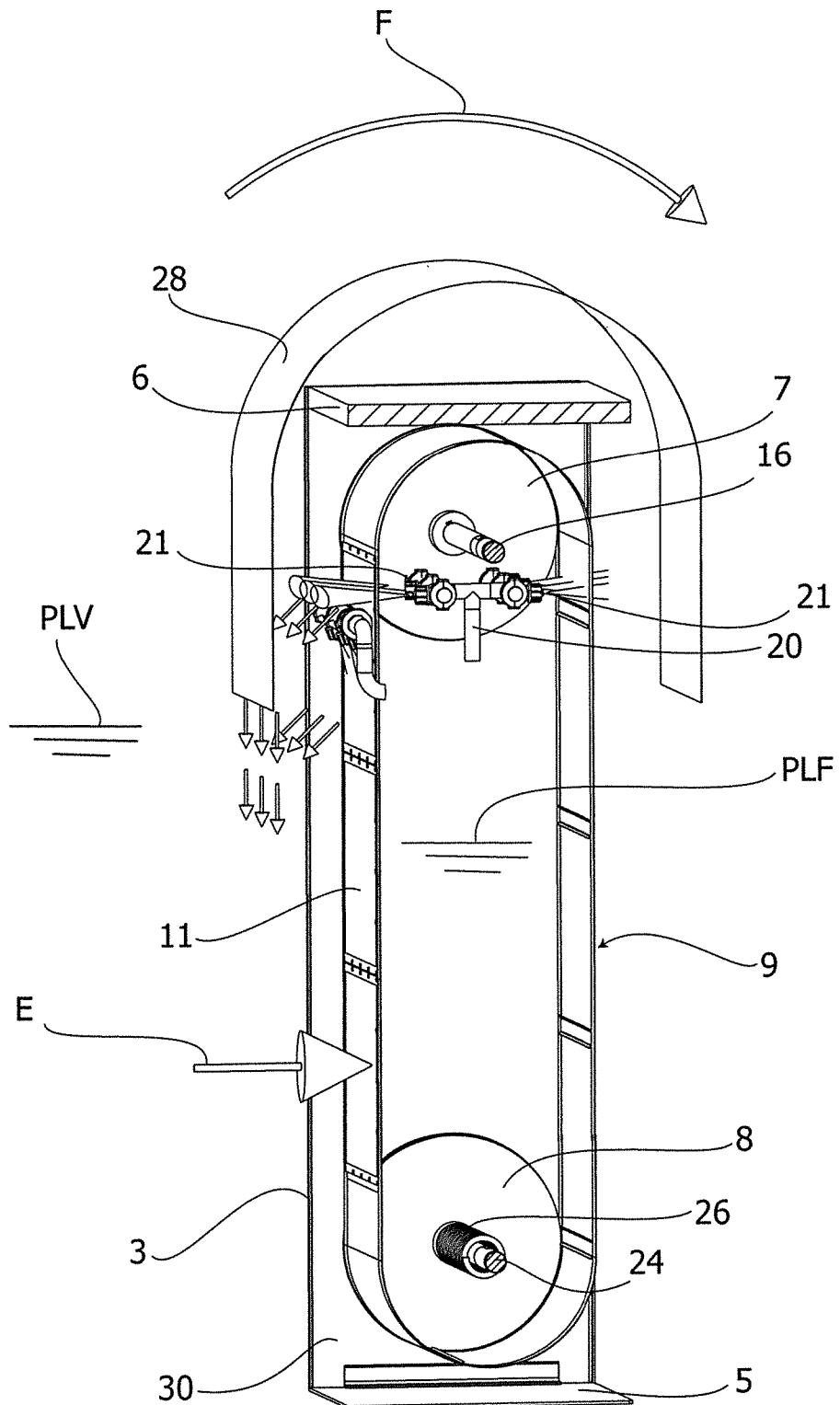


Fig. 3

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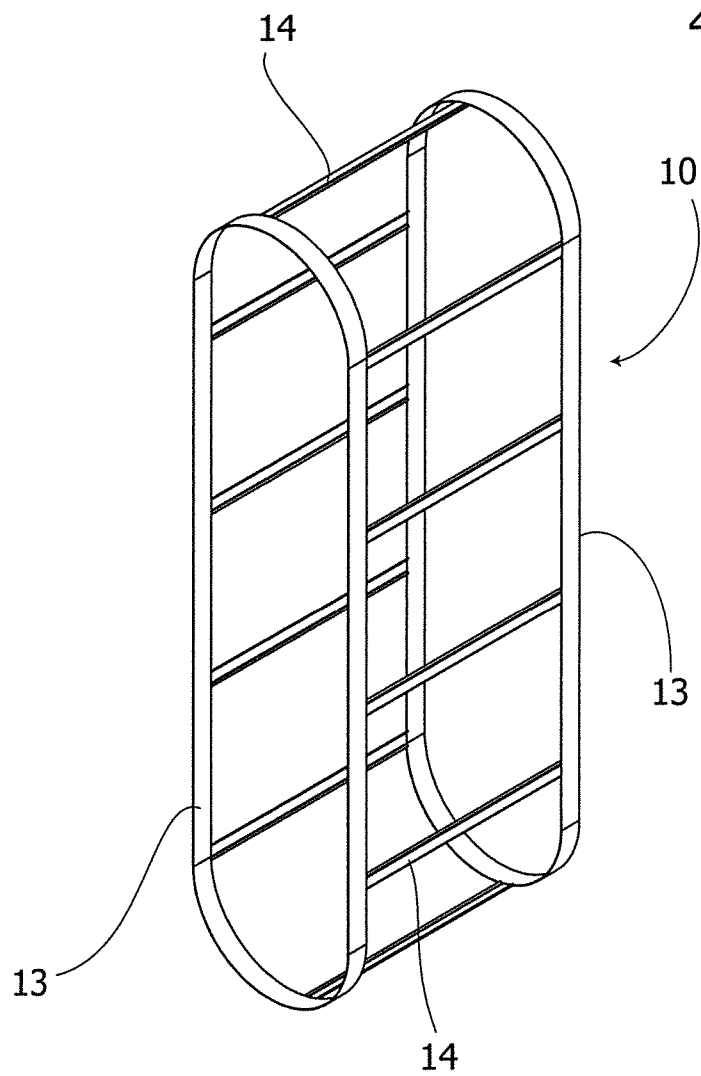


Fig. 4

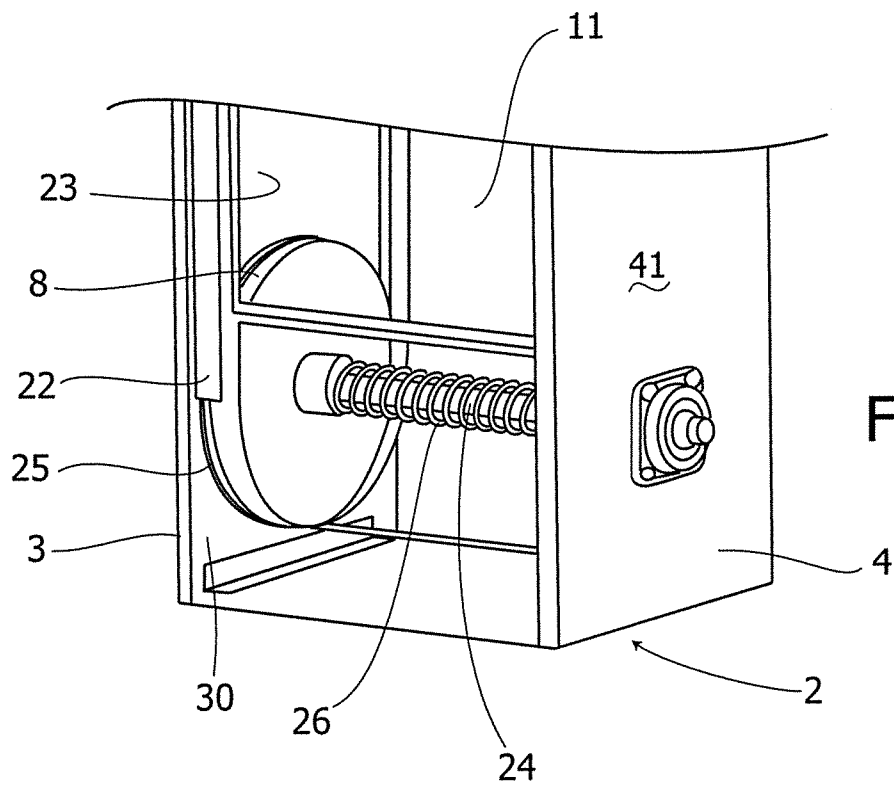
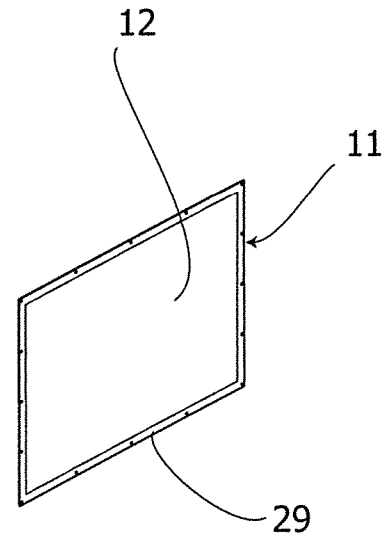


Fig. 5

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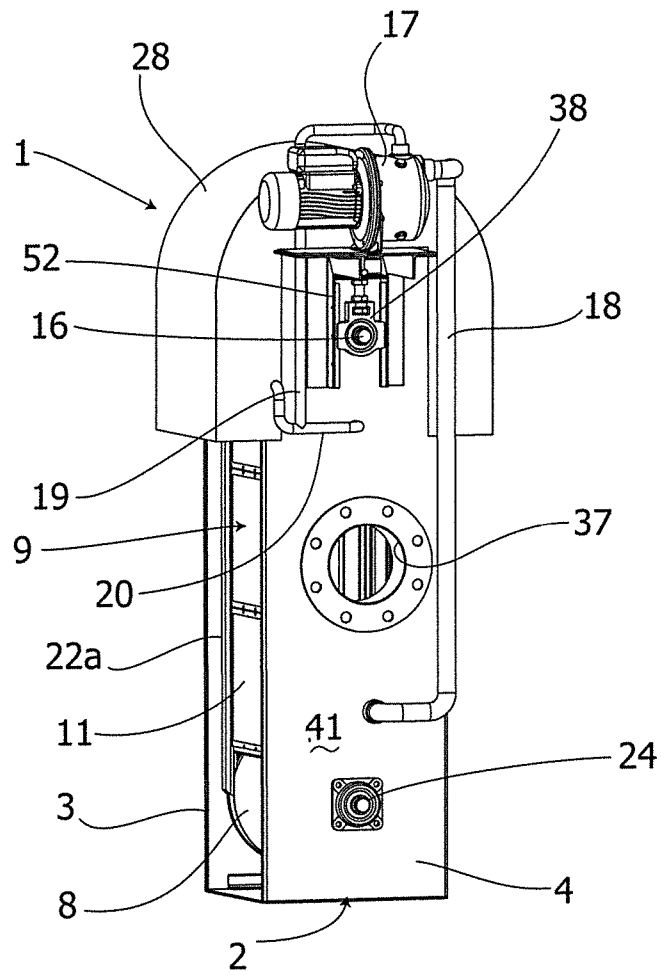


Fig. 6

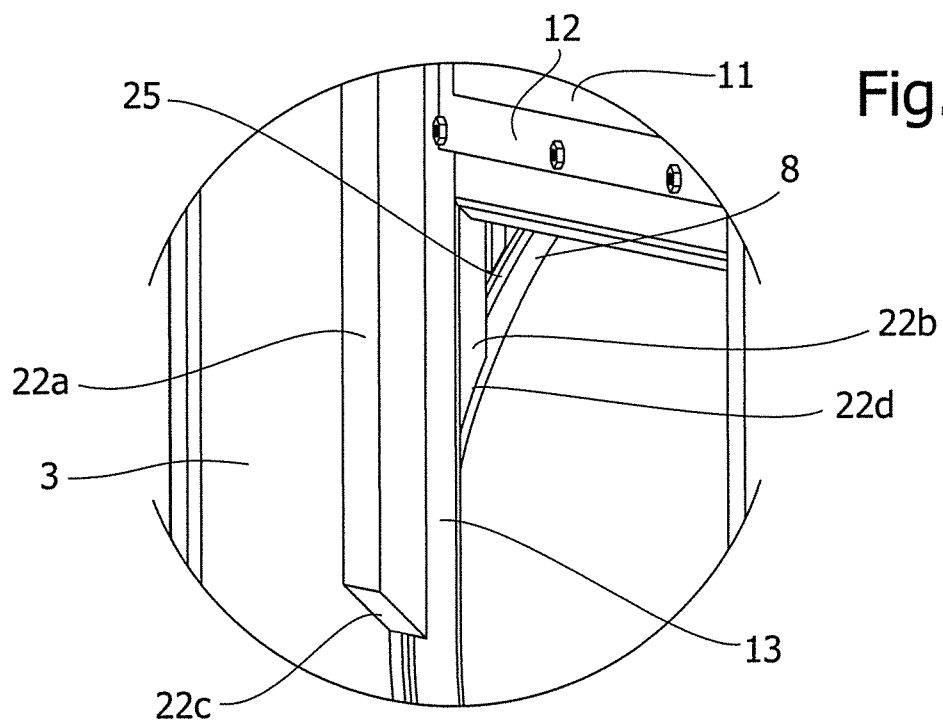


Fig. 7

Fig. 8

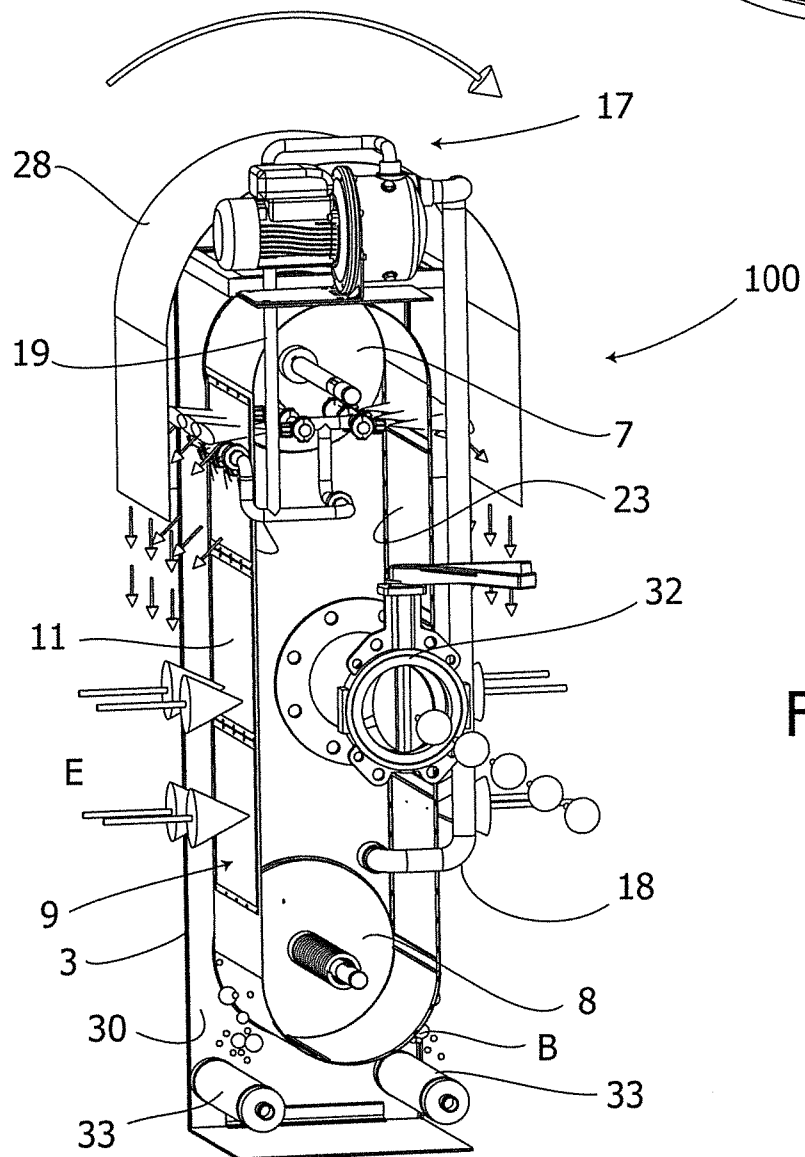
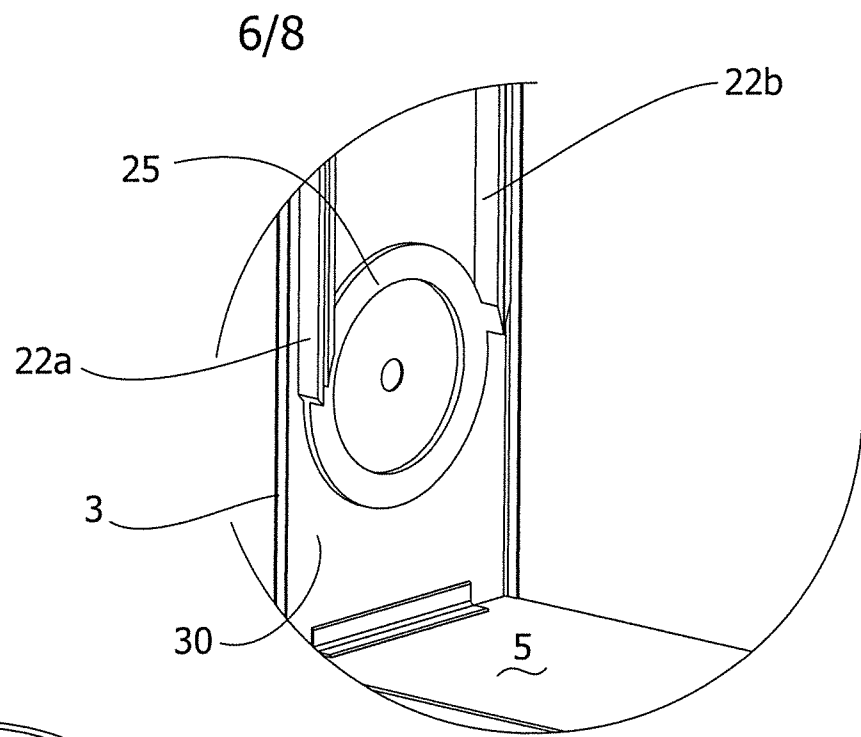


Fig. 9

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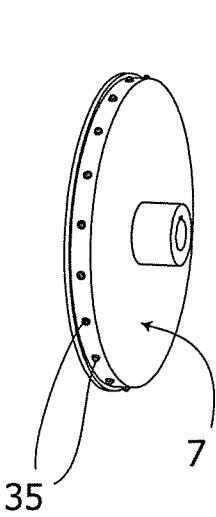


Fig. 10

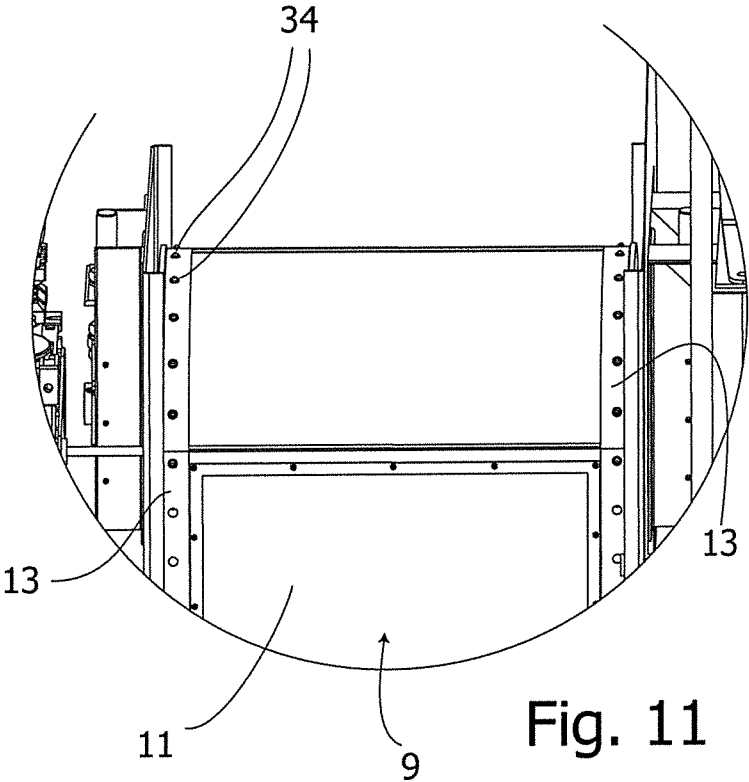


Fig. 11

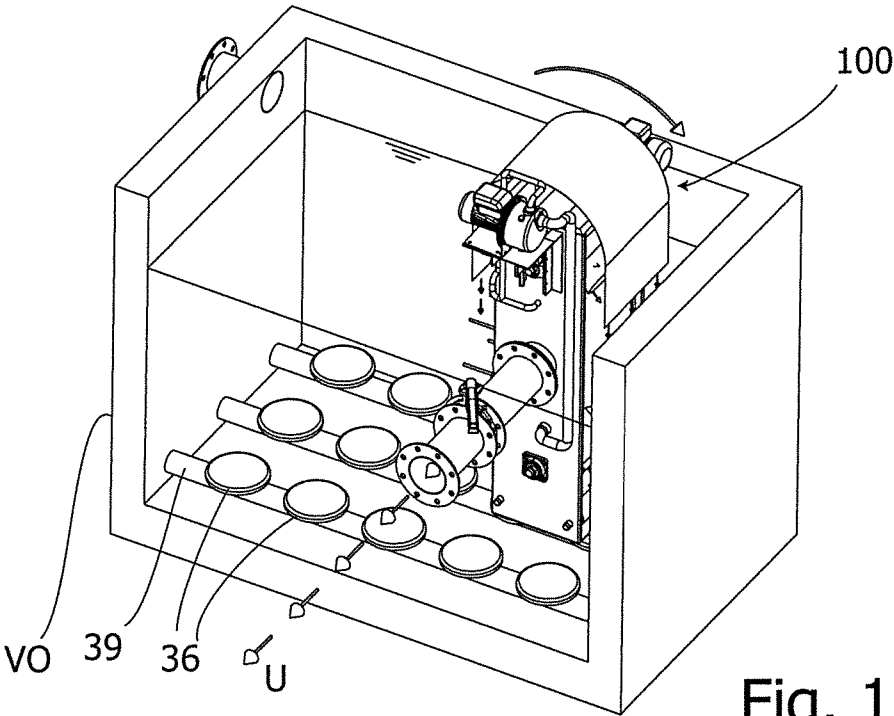


Fig. 12

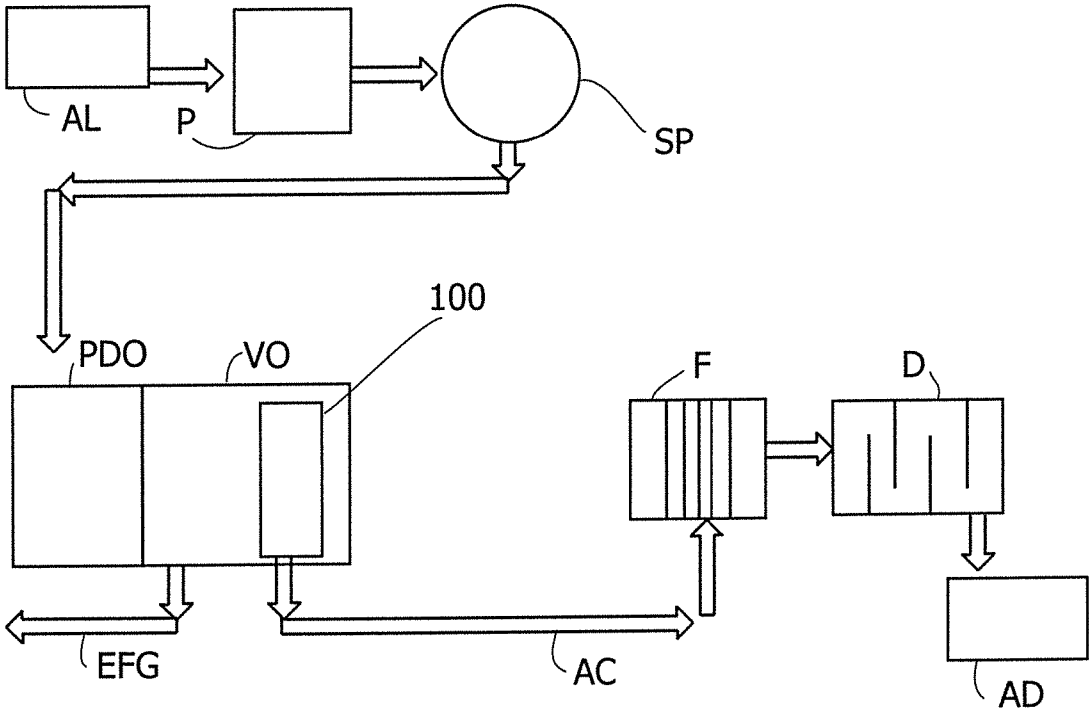


Fig. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/IT2017/000042

A. CLASSIFICATION OF SUBJECT MATTER

INV. B01D33/04 B01D33/048 B01D33/056 B01D33/333 B01D33/41
B01D33/46 B01D33/50

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B01D

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 300 221 A (AUSTEVOLL OYSTEIN [NO]) 5 April 1994 (1994-04-05)	1,2,14
Y	column 5, line 37 - line 60; figures 1-6 -----	3-13
Y	WO 2014/197468 A2 (BILFINGER WATER TECHNOLOGIES INC [US]) 11 December 2014 (2014-12-11)	3-13
A	the whole document -----	1,2
A	FR 2 575 397 A1 (JACKSON PHILIP [FR]) 4 July 1986 (1986-07-04)	1-14
	the whole document -----	
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Date of the actual completion of the international search

29 May 2017

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16/06/2017

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