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(12) (19) (CA) **Demande-Application**

(21) (A1) **2,230,601**
(86) 1996/08/13
(87) 1997/03/06

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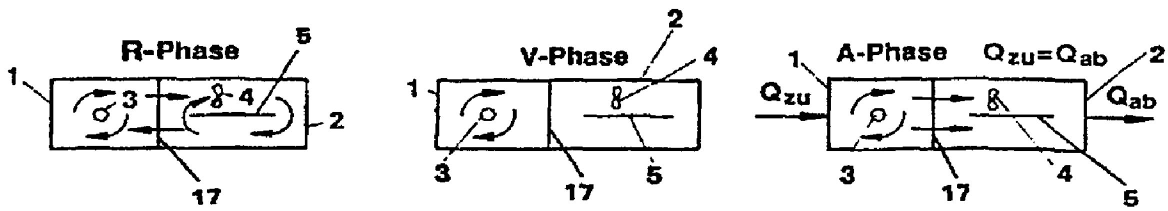
(51) Int.Cl.[6] C02F 3/12
(30) 1995/08/28 (A 1445/95) AT
(30) 1995/10/06 (A 1658/95) AT
(30) 1995/12/01 (GM 655/95) AT

(54) **PROCEDE D'EPURATION DES EAUX USEES**
(54) **PROCESS FOR PURIFYING SEWAGE**



(57) Cette invention concerne un procédé d'épuration des eaux usées au moyen de boues activées. Selon ce procédé, les eaux usées à épurer sont tout d'abord introduites dans un bassin d'aération (1) puis dans un bassin de décantation (5) où l'eau épurée est séparée des boues, puis ces boues sont renvoyées dans le bassin d'aération (1) et l'eau épurée est retirée. Un cycle opérationnel se déroule plusieurs fois par jour dans le bassin de décantation (5). Les boues sont alors à nouveau mélangées à l'eau (phase d'agitation R) et la phase de retrait (A) du cycle opérationnel est séparé de la phase d'agitation (R) par un intervalle (phase de prédécantation V).

(57) A process for purifying waste water by means of activated sludge in which the waste water to be purified is taken into an aeratable sludge basin (1) followed by a sedimentation basin (5) in which the sludge and clear water are separated, whereafter sludge is taken back to the sludge basin (1) and clear water is drawn off; an operating cycle takes place in the sedimentation basin (5) several times a day in which the sludge is again mixed with the water (agitation phase R) and the withdrawal phase (A) of the operating cycle is separated from the agitation phase (R) by an interval (presedimentation phase V).

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WELTORGANISATION FÜR GEISTIGES EIGENTUM
Internationales Büro

INTERNATIONALE ANMELDUNG VERÖFFENTLICHT NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS (PCT)

(51) Internationale Patentklassifikation 6 : C02F 3/12

A1

(11) Internationale Veröffentlichungsnummer: WO 97/08104

(43) Internationales Veröffentlichungsdatum: 6. März 1997 (06.03.97)

(21) Internationales Aktenzeichen: PCT/AT96/00144

(22) Internationales Anmeldedatum: 13. August 1996 (13.08.96)

(30) Prioritätsdaten:

A 1445/95	28. August 1995 (28.08.95)	AT
A 1658/95	6. Oktober 1995 (06.10.95)	AT
GM 655/95	1. December 1995 (01.12.95)	AT

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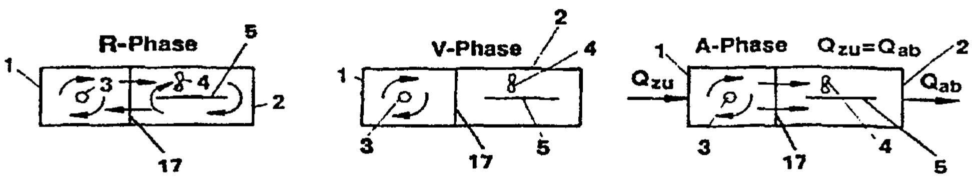
(81) Bestimmungsstaaten: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO Patent (KE, LS, MW, SD, SZ, UG), eurasisches Patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), europäisches Patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI Patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Veröffentlicht
Mit internationalem Recherchenbericht.

(54) Title: PROCESS FOR PURIFYING WASTE WATER

(54) Bezeichnung: VERFAHREN ZUR REINIGUNG VON ABWASSER



(57) Abstract

A process for purifying waste water by means of activated sludge in which the waste water to be purified is taken into an aeratable sludge basin (1) followed by a sedimentation basin (5) in which the sludge and clear water are separated, whereafter sludge is taken back to the sludge basin (1) and clear water is drawn off; an operating cycle takes place in the sedimentation basin (5) several times a day in which the sludge is again mixed with the water (agitation phase R) and the withdrawal phase (A) of the operating cycle is separated from the agitation phase (R) by an interval (presedimentation phase V).

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WO 97/08104 PCT/AT96/00144

Process for purifying sewage

The invention relates to a process for purifying sewage by means of activated sludge, in which the sewage to be purified is introduced firstly into an aeratable activation vessel and then into a sedimentation vessel in which separation of sludge and clear water occurs, whereupon sludge is returned into the activation vessel and clear water is drawn off.

In processes of that kind (see AT-B-395 413) organic carbon compounds are broken down by bacteria in a biological reactor - in the activation vessel - with a supply of oxygen, and converted into activated sludge. Nitrification, denitrification and the removal of phosphorus additionally take place. In the subsequent post-settlement vessel the activated sludge undergoes sedimentation and the clear water can be drawn off. To maintain the procedure the sedimented activated sludge must be pumped back into the activation vessel again. Between 5 and 10% of the sludge is removed from the system per day as excess sludge.

A disadvantage with the known process is that the post-settlement vessel only serves for the separation of sludge and clear water whereas the biochemical procedures which at best take place therein are without practical significance. On the other hand a process is certainly known in which further and in general all biochemical and physical events which are necessary for sewage purification also take place in a single vessel, in addition to sedimentation. For that purpose the sludge is firstly stirred up in the vessel. Operation can be implemented with or without the introduction of oxygen in that stirring phase. Depending on the presence of free or bound oxygen nitrification (aerobic medium) or denitrification (anoxic medium) is effected. The sludge is then allowed to undergo sedimentation, and it is only after a certain time has expired that the operation of drawing off clear water is begun. In that period which is referred to as the pre-settlement phase on the one hand the sludge undergoes settlement, while on the other hand denitrification occurs. The sludge which settles forms a filter body which also filters small activated sludge flakes or flocks out of the clear water. The sludge also sinks further to the bottom during the subsequent draw-off phase which serves to draw off clear water, and it is capable of involving denitrification. In the total absence of oxygen (anaerobic medium), phosphorus can also be biologically eliminated. Substantial phosphorus elimination however requires a suitable precipitation agent which moreover also has positive effects on the settlement properties of the sludge.

The invention is based on the consideration that the post-settlement vessel which in the activation process only serves for the separation of sludge and clear water can take over a part or all of the functions which in the single-vessel process take place in the single treatment vessel.

It is therefore provided in accordance with the invention that an operating cycle takes place in the sedimentation vessel several times during the day, in which cycle the sludge is mixed again with the water (stirring phase), and that the draw-off phase of the operating cycle is separated from the stirring phase by an interval (pre-settlement phase).

If the content of the sedimentation vessel is aerated during the stirring phase, the single-vessel process which takes place in the sedimentation vessel thus promotes the primary functions of the activation vessel, namely breaking down organic carbon compounds and denitrification. In that situation the devices which serve for introduction of nitrogen advantageously simultaneously produce stirring in accordance with the invention of the sludge in the sedimentation vessel.

Further details of the invention are described hereinafter with reference to the drawing in which Figure 1 is a diagrammatic plan view of an apparatus according to the invention, indicating three different functional phases, Figure 2 is a cross-sectional view on an enlarged scale through an apparatus as shown in Figure 1, Figure 3 is a cross-sectional view through a detail on an enlarged scale from Figure 2, Figure 5 is a cross-sectional view through a second embodiment, and Figure 4 is a plan view of a further embodiment.

The spatially adjacent arrangement of an activation vessel 1 and a sedimentation vessel 2 is common to all illustrated embodiments. The separating wall 17 between those two vessels is respectively provided with a lower opening 6 which is continuous over the entire width of the vessels so that the vessels 1, 2 behave as communicating vessels. Disposed in the activation vessel 1 is a respective fan or aerator 3 for the introduction of oxygen; the operation of swirling up the sludge in the sedimentation container 2 can be effected by a propeller 4 which at the same time generates a flow which homogenises the content of the vessels 1 and 2 so that the two vessels have approximately identical dry substance contents and approximately equal sludge ages.

In the apparatus shown in Figure 1 the propeller 4 generates a circulatory flow around a guide wall 5 which stands up from the bottom in the center of the vessel, that flow being maintained only in a stirring phase which involves homogenisation of the container contents and recycling of sludge back into the activation vessel 1. The duration of the stirring phase can be greatly varied depending on weather conditions, in which respect rainy weather indicates a reduction (for example to ten minutes) and dry weather indicates an extension (for example to seventy minutes).

As can be seen from Figure 1 the stirring phase, the R-phase, is followed by an interval (pre-settlement phase or V-phase) in which the sludge sinks in the sedimentation container 2 without clear water already being drawn off. In order in particular in this phase to prevent sludge settlement from being disturbed by the aerator 3 in the activation vessel 1, a baffle wall 7 is desirably disposed in front of the opening 6. The baffle wall 7 provides that air bubbles escape upwardly in the intermediate space between the baffle wall 7 and the separating wall 17 between the two vessels so that - apart at most from the stirring phase - only bubble-free sludge can pass into the sedimentation vessel 2. In the V-phase the level of sludge falls to such an extent (> 50cm) that clear water can be drawn off in the subsequent draw-off phase (A-phase). A typical value for the duration of the V-phase, with a total cycle duration of 200 minutes, is about 40 minutes.

The discharge flow from an installation consisting of the vessels 1 and 2 occurs only in the A-phase. The feed flow can be implemented continuously in all three phases or also only in one or two phases. The flow through an installation occurs in a free fall mode if the feed and discharge flows occur only in the A-phase and are equal ($Q_{in} = Q_{out}$). A plurality of installations can be operated in phase-displaced relationship in such a way that there is always at least one A-phase available. The settling installation discharge then corresponds to the settling installation feed.

Figure 3 shows a possible clear water draw-off situation. In the A-phase, when the level 8 of sludge is already more than 50 cm below the water level 9, clear water is drawn off by way of round discharge flow openings 10 of a diameter of about 8 cm, which are arranged at a spacing of 1.0 m and which are disposed about 30 cm below the water level and which are closed off with flaps. The clear water then passes into a pressure passage 11 which can be closed off with an electrical slider 12. The discharge flow from the sedimentation vessel 2 is regulated by the slider 12 (open and closed position), downstream of which is arranged a fixed overflow or spillway 13 for maintaining a desired water level in the vessels. By introducing small amounts 14 of clear water into the pressure passage, it is possible to avoid sludge from penetrating into the draw-off system when the slider is closed.

To calculate the admissible draw-off amount from the sedimentation vessel 2 (Q_{out}), it is to be assumed that, throughout the entire A-phase, the level of sludge is always to be at least 50 cm below the water level. As an approximation and to be on the safe side, it can be assumed that the amount of clear water formed in the A-phase can also be drawn off. The V-phase then serves to produce the clear water body of at least 50 cm in thickness, that is required for the draw-off operation. The creation of clear water is then governed by the speed of downward movement of the level of sludge v_s which can be assumed approximately constant. That gives as an admissible draw-off amount $Q_{out}\,[m^3/h] = F[m^2] \times v_s[m/h]$ with $v_s^{[m/h]} \times ISV^{[ml/g]} \times TS^{[kg/m3]} = 725$ (see also Kayser, gwf, No 12, 1995).

With a continuous feed flow the water level in the vessels rises during the R-phase and the V-phase. In such a case it is possible to operate with a pre-settlement phase which is divided into two, in which case firstly the level of liquid in the vessels rises and then it is kept constant by means of a fixed overflow. That procedure provides that the draw-off amount is reduced in the subsequent A-phase and the draw-off time can be reduced.

With a mixed water feed flow to an installation according to the invention, it is possible to operate with a dry weather mode (DW) and a rainy weather mode (RW), in which case the A-phase is prolonged in the case of rainy weather, at the expense of the R-phase, as a percentage. The sedimentation vessel is then used more for the biochemical procedures in the case of dry weather and more for the hydraulic procedures in the case of rainy weather.

Several tasks have to be managed in the R-phase. The sludge which is transported from the activation vessel 1 into the sedimentation vessel in the V-phase and the A-phase has to be returned to the vessel 1 again. Sludge which has settled and thickened at the bottom of the vessel 2 has to be swirled up again so that there is approximately equal dry substance in the vessel. In addition any floating sludge or scum which has possibly been formed must be incorporated into the sludge body again. Finally it is advantageous if oxygen can also be introduced into the sedimentation vessel. The four tasks referred to above are to be solved in different ways depending on the respective size of the settlement installations. In the case of large installations for example it is possible to operate with the circulatory principle, that is to say all vessels are operated as circulatory vessels and the stirring mechanisms are so situated that the flows shown in Figure 4 are produced. In that case guide walls 5 provide for a uniform flow at a speed of about 0.5 m/sec.

In the case of small settlement vessels aeration in the activation vessel 1 and the mixing effect in the sedimentation vessel can be effected with a single piece of equipment, as shown in Figure 5. A jet aerator 3 which is located in the activation vessel 1 and which is rotatable about a vertical axis permits aeration and circulation in both vessels. In the R-phase the water jet which is enriched with small air bubbles is directed on to the opening 16, which is provided with a non-return flap, between the two vessels, so that turbulence and circulation acts primarily in the sedimentation vessel 2. Any floating sludge or scum which may be formed is passed from the sedimentation vessel 2 into the activation vessel 1 through a return flow 15 at the height of the water level, and in the activation vessel 1 is incorporated into the sludge body again. In the other two phases the water jet is directed away from the opening 16. The jet aeration effect then only acts in the activation vessel 1. Instead of turning the jet aeration effect away, the opening 16 can also be closed with a slider.

A particular advantage of the invention is that homogenisation of the content of the vessels 1 and 2 makes it possible to measure the dry substance content in that vessel - the sedimentation vessel - from which the excess sludge is drawn off. At the end of the V-phase, before the beginning of the A-phase, the level of sludge must already have moved down to such a depth (for example about 75 cm) that solids-free clear water can be drawn off in the A-phase. In that time, a floating excess sludge pump is briefly brought into operation (for example automatic excess sludge draw-off for about between 1 and 2 minutes). If the level of sludge is still too high, excess sludge is concentratedly drawn off, while it is already too low, the draw-off of clear water predominates. The drawn-off sludge-clear water mixture passes into a sludge reservoir where the sludge settles. The solids-free cloudy water is passed into the activation vessel again by way of a return. The sludge which thickens in the sludge reservoir is to be drawn off from time to time and removed.

Another possible way of automatically drawing off excess sludge involves measuring the level of sludge at the end of the V-phase with a sludge level measuring apparatus and effecting the operation of drawing off excess sludge, in dependence on the position of the level of sludge. That method can be effected for example by means of a floating density measuring apparatus and a sludge conduit which is arranged at the bottom of the vessel and which is provided with an electrical slider. If for example at the end of the V-phase the level of sludge is below 75 cm below the water level, no sludge is drawn off, while if it is thereabove, then sludge is drawn off. That method - primarily suitable for larger sewage treatment installations - has the advantage that only sludge which has already thickened is drawn off and there is no need for a sludge reservoir for the separation of sludge and clear water.

It is possible to connect upstream of an installation according to the invention a sewage or process water reservoir or storage means, a screening or sieving installation, a sand and grease or fat separator, a preliminary sedimentation means, an anaerobic vessel or only individual ones of those parts of an installation. A filter for more extensive purification can be connected downstream of the installation.

In order to increase biological phosphorus elimination, it is possible to provide a sufficiently long anaerobic medium in the activation vessel during the A-phase. The content of the activation vessel is only stirred, and no oxygen is introduced, in that period.

A particular situation provides that the activation vessel is neither stirred nor aerated during the A-phase or during the V-phase and the A-phase. The activation vessel then acts as a sewage reservoir or storage unit. It is only when the level of sludge has reached the communicating opening, arranged at the vessel bottom, between the two vessels, that raw sewage can pass into the sedimentation vessel. That prevents raw sewage from penetrating through into the discharge.

The advantage of the process according to the invention lies in the high level of purification efficiency, the very small volume required for vessels and the machine equipment, which is reduced to a minimum, thus affording a high level of economy. The aeration devices are only required in the activation vessel and are practically always in operation, under oxygen control. The operation of swirling up the sedimented sludge and circulating the sludge which has been transferred into the sedimentation vessel is effected by simple stirring mechanisms. It is also possible to operate with very high dry substance (between 5.0 and 8.0 g/l) in the system. Finally the sedimentation vessel is used in the optimum fashion as the biochemical procedures can be preferred with a low level of hydraulic loading (dry weather DW) and the hydraulic processes can be preferred with a high level of hydraulic loading (rainy weather RW).

CLAIMS

1. A process for purifying sewage by means of activated sludge, in which the sewage to be purified is introduced firstly into an aeratable activation vessel and then into a sedimentation vessel in which separation of sludge and clear water occurs, whereupon sludge is returned into the activation vessel and clear water is drawn off, characterised in that an operating cycle takes place in the sedimentation vessel several times during the day, in which cycle the sludge is mixed again with the water (stirring phase R), and that the draw-off phase (A) of the operating cycle is separated from the stirring phase (R) by an interval (pre-settlement phase V).

2. A process as set forth in claim 1 characterised in that the content of the sedimentation vessel (2) is aerated during the stirring phase (R).

3. A process as set forth in claim 2 characterised in that the sludge is mixed with the rest of the vessel content by the aeration effect.

4. A process as set forth in one of claims 1 through 3 characterised in that the content of the sedimentation vessel (2) is homogenised in the stirring phase (R).

5. A process as set forth in one of claims 1 through 4 characterised in that in the stirring phase (R) so much sludge is returned into the activation vessel (1) that therein there is approximately the same density in respect of dry substance (DS) as in the sedimentation vessel (2).

6. A process as set forth in claim 5 characterised in that during the stirring phase (R) the content of the activation vessel (1) is mixed with that of the sedimentation vessel (2) until substantial homogenisation occurs.

7. A process as set forth in claim 1 characterised in that the pre-settlement phase (V) is extended until the level of sludge has fallen at least 50 cm so that as far as possible no sludge flakes pass into the discharge.

8. A process as set forth in one of claims 1 through 7 characterised in that the draw-off of excess sludge is effected in each case for example for two minutes at the end of the pre-settlement phase (V), a pump conveying the clear water/sludge mixture into a sludge reservoir and excess cloudy water being passed back into the purification installation.

9. A process as set forth in one of claims 1 through 8 characterised in that the draw-off of excess sludge is effected in dependence on the dry substance content in the sedimentation vessel (2), the dry substance content being detected by a density measuring means.

10. Apparatus for carrying out the process as set forth in one of claims 1 through 9 comprising an activation vessel (1) and a sedimentation vessel (2) which is connected downstream thereof and a means for returning sludge from the sedimentation vessel (2) into the activation vessel (1) characterised in that the two vessels adjoin each other and are communicated by an opening (6) in the bottom region.

11. Apparatus as set forth in claim 10 characterised in that a baffle wall (7) which projects from the bottom into the activation vessel (1) is provided in the activation vessel at a spacing from the opening (6).

12. Apparatus as set forth in claim 10 or claim 11 characterised in that a vertical guide wall (5) is provided in the central region of the sedimentation vessel (2) so that a flow which circulates along the container walls can be produced.

13. Apparatus as set forth in claim 12 characterised in that the activation vessel (1) also has a vertical guide wall (5) for a circulatory flow.

14. Apparatus as set forth in one of claims 10 through 13 characterised in that there is provided a propeller (4) in the sedimentation vessel (2).

15. Apparatus as set forth in one of claims 10 through 14 characterised in that the aeration means (3) arranged in the activation vessel can be directed towards an opening (16) to produce a flow in the sedimentation vessel (2).

16. Apparatus for carrying out the process as set forth in one of claims 1 through 9, in particular as set forth in one of claims 9 through 15, characterised in that the sedimentation vessel (2) has a discharge (10) which is between about 20 and 30 cm below the surface of the water and which is adjoined by a pressure passage (11) with shut-off slider (12) and fixed overflow (13).

17. Apparatus as set forth in claim 16 characterised in that a clear water conduit (14) opens into the pressure passage.

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Fig. 1

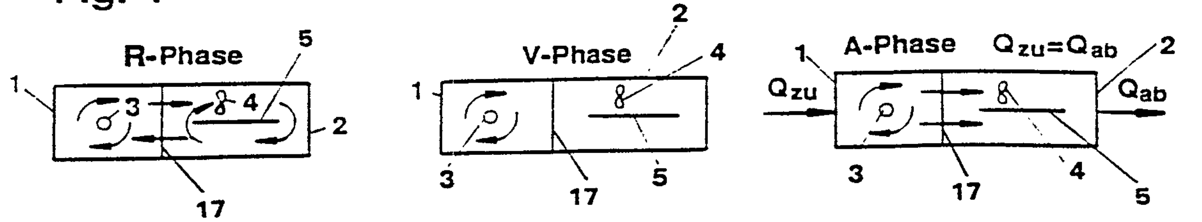


Fig. 2

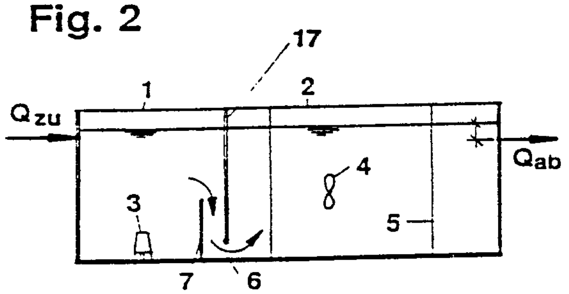
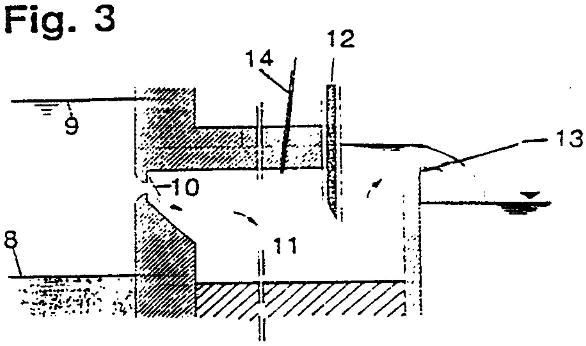


Fig. 3



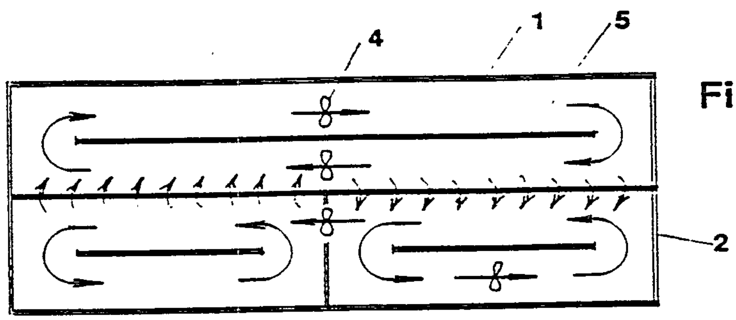


Fig. 4

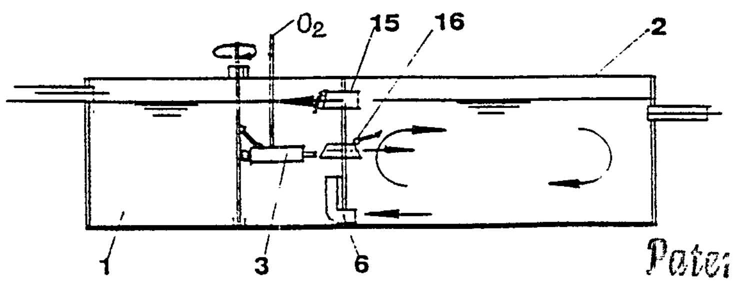
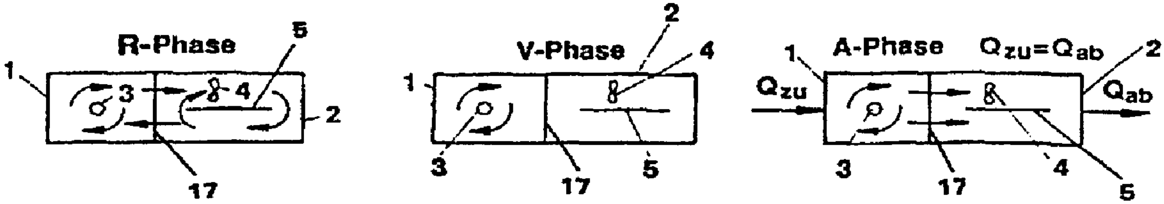


Fig. 5


R-Phase
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