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(71) Applicants and

(72) Inventors: MACKRLE, Svatopluk [CZ/CZ]; Pavlíkova 5, 602 00 Brno (CZ). MACKRLE, Vladimír [CZ/SK]; Medvedovej 2700/21, 850 00 Bratislava (CZ).

(72) Inventor; and

(75) Inventor/Applicant (for US only): DRACKA, Oldrich [CZ/CZ]; Lipová 25, 602 00 Brno (CZ).

(74) Agents: SEDLÁK, Zdenek et al.; Mendlovo nám. 1a, 603 00 Brno (CZ).

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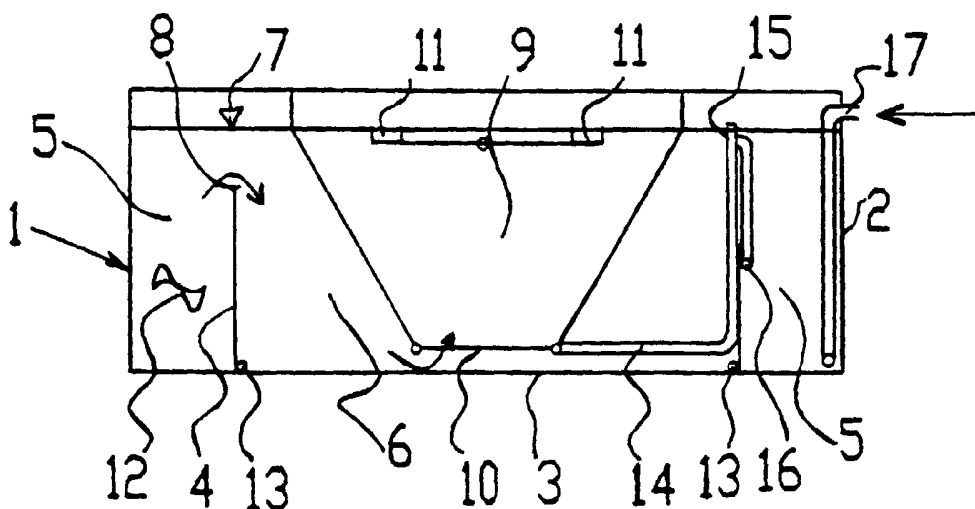
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(54) Title: REACTOR FOR TREATMENT OF SEWAGE WATER BY ACTIVATED SLUDGE



(57) Abstract: Reactor for activation treatment of sewage water by unified suspended activated sludge created by a tank (1) of circular ground plan with circumferential casing (2) containing at least one anoxic space (5) with a drive source of the activation mixture, at least one oxic space (6) connected with the anoxic space (5) and provided with an aeration device (13) and at least one, at least partially upwards widening separation space (9) provided with an inlet opening (10) for the activation mixture from the oxic space (6), an overflow device (11) of purified water and an outlet tube (14) of separated activated sludge connected with a discharge tube (16), the discharge tube (16) and the inlet tube (17) of sewage water to the reactor being introduced into the anoxic space (5), mentioned reactor comprises a circular anoxic space (5) arranged at least along the whole internal surface of the circumferential casing (2) of tank (1) and completely encasing the oxic space (6), the drive source of the activation mixture being directed so as to create a circular flow of activation mixture.



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REACTOR FOR TREATMENT OF SEWAGE WATER BY ACTIVATED SLUDGE

Field of the invention

The invention relates to a reactor for activation treatment of sewage
5 water by unified suspended activated sludge created by at least one tank of
circular ground plan with circumferential casing containing at least one
anoxic space with a drive source of the activation mixture, at least one oxic
space connected with the anoxic space and provided with an aerating device
and at least one at least partially upwards widening separation space
10 provided with an inlet opening for the activation mixture from the oxic
space, an overflow device of purified water and an outlet tube of separated
activated sludge connected with the discharge tube, the discharge tube and
the inlet tube of sewage water to the reactor being introduced into the anoxic
space.

Description of the prior art

The activation treatment by unified suspended activated sludge with
nitrification and de-nitrification is frequently used up to date technology of
sewage treatment. Impurities in wastewater are preferentially used as carbon
source for de-nitrification. In such case the water to be treated flows into the
20 denitrification zone, i.e. the anoxic zone, where it gets mixed with returning
activated sludge and re-circulated water. Then the activation mixture flows
from the anoxic space to the nitrification space, i.e. the oxic space, and
therefrom into the separation space where the treated water gets separated
from the activated sludge. The separated activated sludge is returned to the
25 anoxic space whereto also water from the oxic space returns which contains
nitrates produced in the oxic space by oxidation of matter containing
nitrogen. These nitrates in the anoxic space get biologically reduced to
gaseous nitrogen, while the bacteria in the activated sludge use the

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biologically oxidable carbonaceous material from the onflowing sewage water for this purpose.

The apparatus for treating water by the above technology, as a rule, contains separate functional spaces for the separate described processes. The de-nitrification is carried on in the absence of oxygen and, accordingly, the corresponding functional activation space is of the anoxic type that is provided by agitation means for maintaining the activated sludge in suspended state. A sufficient concentration of dissolved oxygen being indispensable for the nitrification, the corresponding functional activation space is an oxic zone that is provided with an apparatus for introducing air or, possibly, of oxygen, such apparatus serving usually also for retaining the activated sludge in suspension. As a rule, the separation of activated sludge from purified water is achieved by gravity, that is why the separation space is usually provided by discharge of purified water in its upper part. An older current separation method is sedimentation wherein the activated mixture from the oxic space is introduced into the upper part of the separation space, the activated sludge gravitating down. A more up-to-date separation method is the fluid filtration in a floating layer of a sludge blanket wherein the activated mixture from the oxic space is introduced to the bottom part of the separation space and the activated sludge gets caught in the fluidised layer of the sludge blanket from the upward stream of activation mixture. For establishing and maintaining the fluidised layer of the sludge blanket often at least a partially upwards widening separation space is used; The fluidised layer of the sludge blanket tends to establish in the widening part of the separation space, being held in place by the widening walls of the separation space. In some instances yet another area is included before the anoxic space, the so-called anaerobic space wherein, by various arrangements of re-circulation, the activated sludge, in the presence of introduced sewage water,

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is exposed to conditions characterised by both lack of dissolved oxygen and of nitrate oxygen, which results in increased biological removal of phosphorus in the overall process of water treatment (see e.g. Maccalf & Eddy, Wastewater engineering, 3rd ed., McGraw-Hill, New York 1991, p. 733). The anoxic space, and possibly also the anaerobic space, can, in addition to that, under suitable arrangement of flow conditions, achieve also the effect of a selector improving the characteristics of activated sludge by suppressing the growth of micro-organisms that would result in sludge bulking. The function of selector requires, after sewage water has been mixed with activated sludge, a high ratio between biodegradable matter, i.e. nutrients, and to the micro-organisms to be maintained under lack of oxygen (e.g. the previous reference, p. 538.)

The particular spaces for various functions in the apparatus for sewage treatment are implemented in different ways. In some instances, e.g., they are designed as separate tanks that are interconnected. This solution is often used, if the separation is achieved by sedimentation. In case of applying a upflow sludge blanket filtration the functional spaces can be preferably unified in one integrated reactor, accommodating them in one single vessel by way of suitably inserted partition walls. Irrespective of the arrangement of the functional spaces, however, a number of problems must be tackled, to name just the most substantial ones: integration and separation of the individual functional spaces, their interlinking with respect to the flow and the re-circulation of activated sludge and water, the suspension of activated sludge in the activation space and such flow arrangement in the individual functional spaces as necessary for achieving optimum parameters of the purification process. Maintaining the activated sludge in suspension presents an additional problem at the present day, namely some aeration systems have already achieved such efficiency of oxygen transfer that an aeration system

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that is sufficient for supplying oxygen to the oxic space may not suffice, in some instances of operation, to maintain the activated sludge in suspension.

For ensuring the ever more demanding objectives concerning the quality of purified water, the new technological procedures require ever
5 larger volumes of anoxic space that is only one part of the total activation space. In the progressive water treatment systems, possibly including also the anaerobic zone in the anoxic space, the anoxic space may need up to 40 – 50 per cent of the total activation space. The types of integrated reactors with upflow sludge blanket filtration known down to the present day have had
10 considerable difficulties with including such large anaerobic and anoxic spaces into the design of such apparatus. Known solutions arrange the anoxic space in the central part of the integrated reactors, surrounded by oxic space serving as the second part of the total activation space, while the separation space is either within the anoxic space (CZ patent No. 275476 in analogical
15 US patent No. 5,032,276), or outside the anoxic space (CZ patent No. 280284). Another known alternative solution according to the CZ patent No. 281907 includes the anoxic space into the integrated reactor by adding a separate tank to the monobloc of the integrated reactor, associating the oxic space with the separation spaces having fluid filtration. Such solution,
20 preferred for treatment plants using concrete tanks, is suitable for large treatment capacities. In such case the anoxic space has usually the form of a rectangular vessel laterally adjacent to one or more tanks with oxic space, the suspension of activated sludge being ensured by streaming induced by a mechanical agitating equipment, e.g. of propeller type, and channelled by
25 inserted partitions. Another known solution is the inclusion of a central anoxic space in the form of a cone widening upwards to the oxic space. The suspension of activated sludge in the anoxic zone in such case is ensured by

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fluidisation of the suspension in the rising stream (CZ patent application No. PV 1479-97, PCT/CZ98/00023).

Other solutions are known wherein the anoxic space is designed as a fully separate tank with mixing means requiring a connection tube to the
5 remaining part of the treatment plant (CZ patent No. 275746).

All these known and used solutions are burdened with many drawbacks. If a fully separate anoxic space is used, or if an individual separate vessel is added to the treatment block, the advantage of a compact apparatus in form of an integrated reactor gets lost. Another disadvantage of
10 such solutions are the geometrically inconvenient forms of such anoxic spaces for maintaining the activated sludge in suspension by mechanical means. Namely, the shapes of those known anoxic spaces are to blame for high investment and running cost of mechanical mixing. The disadvantage of the anoxic space with a fluidised bed, on the other hand, resides in its limited
15 capacity, being suitable only for the smallest types of plants, and prone to fluidisation failures.

Increasing requirements concerning the dimensions of the anoxic space due to the inclusion of the anaerobic zone are seen to potentiate the mentioned disadvantages.

20 All known solutions of integrated reactors show also further deficiencies relating to the oxic zone. Namely, the aeration systems get ever more efficient, achieving such oxygen transfer rates that an aeration system supplying sufficient oxygen to the oxic space may not succeed to maintain the activated sludge in suspension under certain operating conditions.

25 This is yet another aspect of the deficiencies of the existing integrated reactors that is manifested in the soaring of investment costs and especially running costs.

Substance of the invention

It is an object of the present invention to do away with the above disadvantages and deficiencies of the known solutions and to create a reactor meeting the most recent requirements.

5 Such task is fulfilled by a reactor for activation treatment of sewage by unified suspended activated sludge created by at least one tank of circular ground plan with a circumferential coat containing at least one anoxic space with a drive source of the activation mixture, at least one oxic space connected with the anoxic space and provided with a aerating device and at
10 least one at least partially upwards widening separation space provided with an inlet opening for the activation mixture from the oxic space, an overflow device of purified water and an outlet tube of separated activated sludge connected with the discharge tube, the discharge tube and the inlet tube of sewage water to the reactor being introduced into the anoxic space,
15 according to the invention residing in that it contains a circular anoxic space arranged at least around the whole internal surface of the circumferential casing of the tank and fully enclosing the oxic space, the drive source of the activation mixture in the circular anoxic space being directed so as to create circular streaming of the activation mixture.

20 According to the invention a drive source of the activation mixture in the circular anoxic space can be a mechanical agitating device.

A drive source of the activation mixture in the circular anoxic space can be the mouth of the inlet tube of sewage into the reactor introduced to the bottom part of the circular anoxic space and the outlet of the discharge
25 tube connected to the outlet tube of separated activated sludge from the separation space into the circular anoxic space, both outlets being oriented to the direction of the desirable circular stream of the activation mixture.

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The mouthing of the discharge tube of the separated activated sludge from the separation space can be preferably introduced to the central height of the circular anoxic space.

According to the invention the circular anoxic space can be separated
5 from the internally arranged oxic space with the separation space by way of circular ground plan partition wall seated at the bottom of the tank and terminating under the water level as an overflow edge for the connection of the circular anoxic space with the oxic space.

The separation space with the intake opening for the activation
10 mixture from the oxic space can be preferentially arranged in the central zone of the tank.

It is yet another advantage according to the invention, if the circular anoxic space is divided from the oxic space by a separation space in form of a prism wining to form a ring, or possibly a ring shaped polygon, the
15 removal of activation mixture from the circular anoxic space mouthing through a connecting tube to the central area of the bottom of tank.

The circular anoxic space can be enlarged by the addition of a central anoxic space arranged inside the oxic space and divided from said oxic space by a circular ground plan partition wall seated on the bottom and terminating
20 under the water level as an overflow edge for connecting the central anoxic space with the oxic space, the circular anoxic space being connected with the central anoxic space with a connecting tube and provided with a separate drive source of the activation mixture flow created by a mechanical agitating device.

25 The connecting tube may mouths into the central anoxic space in the central area of the bottom of tank and be connected to the upper part of the circular anoxic space to the inlet neck directed against the sense of circular stream of the activation mixture in the circular anoxic space.

The reactor according to the present invention has a number of advantages. The annular shape of the anoxic space, and possibly the circular shape of the central anoxic space are an ideal form for establishing and maintaining a circular flow retaining the activating sludge in suspended state.

5 This flow within the above shapes can be easily induced and maintained with minimum energy requirements. Moreover, in some reactors this flow is transferred over the overflow edge of the partition wall into the oxic space where it can further contribute to sustainable suspension of the activated sludge in case of a highly efficient aeration system. The annular shape of the

10 anoxic space allows further easy ways for creating conditions for its simultaneous selector function and de-phosphorising function in various zones. Also the circular or annular shape of the oxic space offers advantages for establishing and retaining of circular flow contributing to the suspension of activated sludge. The connection between various functional spaces is

15 simple and the shape of the reactor enables its simple and cost saving design. The geometric arrangement of the anoxic space enclosing the oxic space with optional inclusion of the separation space creates a flexible geometric configuration of a compact reactor enabling the adaptation of size of the three mentioned main functional spaces to the needs of varying hydraulic

20 capacity in a broad range, from the smallest plants up to the largest, as well as to the changing quality of water. All that makes a reactor according to our invention an almost universal reactor design for covering the needs of biological sewage treatment in a very large application range, while enabling a high degree of standardisation and typisation of reactors, which simplifies

25 their design and construction very substantially. Another advantage that is not negligible is due to the concentric shape of the tank allowing to use very up-to-date construction of both the tank and, if case be, also of the internal partition wall of the technological inner structure, using e.g. pre-assembled

units of reinforced concrete, cast shell design or bolted enamel steel sheets, or possibly stainless steel, fibre glass parts, and plastic material. Many types of this design allow these components to be mass produced and their shapes, especially those for smaller plants, allow cost saving mass transport.

5 **Brief description of the drawings**

Exemplifying embodiments of the invention are illustrated in the drawings where Fig. 1 shows a schematic view of the first example of the embodiment of the reactor in ground plan, Fig. 2 is a schematic vertical axial section of the reactor according to Fig. 1, Fig. 3 is a schematic view of the
10 second example of embodiment of the reactor in ground plan, Fig. 4 is a schematic vertical section of the reactor in section IV – IV of Fig. 3, Fig. 5 is a schematic view of the third example of the embodiment of the reactor in ground plan and Fig. 6 is a schematic vertical axial section of the reactor according to Fig. 5.

15 **Exemplifying embodiments of the invention**

The reactor according to the first example of the embodiment of the invention (Figs. 1 and 2) consists of tank 1 of circular ground plan with circumferential casing 2 and provided with bottom 3. The tank 1 accommodates an inserted partition wall 4 of circular ground plan creating
20 between itself and the internal surface of the circumferential casing 2 a circular anoxic space 5 of annular shape. In direction to the centre of tank 1 the partition wall 4 delimits the oxic space 6 that is connected with the circular anoxic space 5. The partition wall 4 starting at bottom 3 of tank 1 ends under water level 7 in tank 1 by overflow edge 8 ensuring the
25 interconnection of the circular anoxic space 5 with the oxic space 6. Within the oxic space 6 in the central zone of tank 1 the separation space 9 is accommodated having the shape of an upwards widening truncated cone

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having in its bottom part the inlet opening 10 for the inflow of the activation mixture from the oxic space 6 to the separation space 9 and in the upper part the overflow device 11 for the discharge of purified water. This overflow device 11 can be created either as a superficial trough provided with comb
5 overflow and a discharge, or as a discharge under the water level created by not illustrated perforated tubes under water level 7 and provided by not illustrated independent overflow at the discharge. The circular anoxic space 5 is provided by drive means of circular flow of the activation mixture in this circular anoxic space 5, such as a mechanical agitating device 12, preferably
10 of propeller type, whereas the oxic space 6 accommodates at the bottom 3 of tank 1 the aeration device 13. In this case it is created by plastic hoses with fine perforation laid along the partition wall 4 so as to create concentric circles in ground plan view. The separation space 9 is provided with an outlet tube 14 of separated activated sludge with included re-circulation
15 pump 15 and discharge tube 16, preferably introduced to middle height of the circular anoxic space 5 where its mouthing is orientated in the direction of the circular flow of activation mixture. The bottom part of the circular anoxic space 5 in direction to bottom 3 of tank 1 receives the inlet tube 17 of sewage water from a not illustrated apparatus for its mechanical pre-
20 treatment. The mouthing of this inlet tube 17 of sewage water is also orientated in the sense of the circular flow of activation mixture in said circular anoxic space 5.

The described reactor operates in following way: The mechanically pre-treated sewage water enters the bottom part of circular anoxic space 5
25 through the inlet tube 17. The re-circulated separated sludge from the separation space 9 together with re-circulated activation mixture from the oxic space 6 flow together through the discharge tube 16 under the effect of the re-circulation pump 15 to middle height of the circular anoxic space 5.

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The mixture in the circular anoxic space 5 is imparted circular motion by the drive source of circular flow, such as a mechanical agitating device 12. The directing of the mouthing of both inflows, i.e. the re-circulated separated sludge and the re-circled activation mixture, in the sense of circular flow of the activation mixture supports this circular stream, while limiting turbulence and cross-flow, thus reducing vertical mixing in the circular anoxic space 5. All mentioned inflows, together with the described circular flow, create a helical stream within the circular anoxic space 5, rising in a spiral from the bottom 3 of tank 1 to the water level 7. The re-circulated activation mixture from the oxic space 6 contains nitrates and oxygen dissolved in water. The nitrates and oxygen brought through the discharge tube (16) to the middle height of the circular anoxic space 5, are carried by helical flow, mixed by cross whirls and consumed by biological reactions. The mixing by crosswise whirls can be described, in using formal mathematics, as turbulent diffusion.

The onflow, turbulent diffusion and biological consumption in their combination create a specific vertical concentration profile of oxygen and nitrates within the circular anoxic space 5, the concentration of both matter decreasing from the level of the discharge tube 16 both in the upward and in the downward direction. Due to the vertical component of helical flow, assisting the transport of dissolved matter in the upward direction, this decrease in the upward direction is slower than the downward one. The activated sludge that is brought to middle height of the circular anoxic space 5 through the discharge tube 16 is also dissipated by turbulent diffusion and carried away upwards by the vertical component of the helical flow.

However, it is also under the effect of gravity forcing it downwards against the liquid. In the result of counter movements and turbulent dissipation the concentration of activated sludge in the circular anoxic space 5 gets equalised. Thus a part of activated sludge gets to the bottom part of said

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space where the presence of oxygen and nitrates is practically eliminated by the above described mechanism, and under these conditions it gets mixed with sewage water being brought to that place at bottom 3 of tank 1 through the inlet tube 17. Accordingly, the bottom part of the circular anoxic space 5 behaves as a preliminary anaerobic zone, which results in improving the biological removal of phosphorus in the process of water treatment. In the zone where sewage gets mixed with activated sludge a high ratio of nutrients/micro-organisms is achieved and, accordingly, this zone behaves at the same time as a selector preventing the activated sludge from bulking.

10 The activation mixture moving helically upwards in the circular anoxic space 5, flows over the overflow edge 8 of the partition wall 4 at the upper part of tank 1 from the circular anoxic space 5 into the oxic space 6. Due to the law of preserving the moment of movement the circular liquid flow is transferred from the circular anoxic space 5 to the oxic space 6. The
15 aeration of this oxic space 6 creates rising streams above the aeration device 13 that are compensated by downward streams in other places of the oxic space 6. The aeration device 13 that is accommodated next to partition wall 4 of the oxic space 6 creates a whirl in the oxic space 6, the horizontal axis of said whirl having the form of a circle with centre at the central part of tank 1.
20 This whirl transfers the circular flow of liquid coming from the circular anoxic space 5 into the whole oxic space 6. By combining the above streams a flow model in form of a circularly wound solenoid is established in the oxic space 6 retaining the activated sludge in suspended condition.

 A part of the organic impurities that are bio-oxidable are oxidated in
25 the circular anoxic space 5, the re-circulated nitrates serving as oxygen source, said nitrates being reduced to gaseous nitrogen, and thus removed from the treated water. The remaining organic impurities are then biologically oxidated in the oxic space 6. Also various nitrogen compounds

are oxidated there as to form nitrates which, as above mentioned, are re-circulated into the circular anoxic space 5. Oxygen for this oxidation is supplied to the oxic space 6 by the aeration device 13. The described procedures relieve sewage water brought to the reactor from impurities.

5 The activation mixture flows through the inlet opening 10 from the oxic space 6 to the separation space 9. In the upward widening separation space 9 a layer of a sludge blanket is formed, and during the passage of the activation mixture through this sludge blanket layer the activated sludge gets trapped in it, thus being separated from the treated water. Then purified
10 water relieved from activated sludge leaves the upper part of separation space 9 over the overflow device 11. Water level 7 in tank 1 is maintained as specified, e.g. by way of a comb overflow with which the overflow device 11 is provided and, accordingly, the volume of discharged treated water corresponds with the volume of onflowing waste water.

15 The separated activated sludge is withdrawn from the separation space 9 by the outlet tube 14. Together with it also a part of the activation mixture is withdrawn that has entered the separation space 9 through the inlet opening 10 from the oxic space 6. The mentioned withdrawal can be achieved, e.g., by re-circulation pump 15, ensuring the re-circulation of the
20 separated activated sludge and of the activation mixture from the separation space 9 into the circular anoxic space 5, as described above.

A reactor according to the second example of embodiment of the invention (Fig. 3 and 4) is a modification of the reactor according to the first example, differing in that the inside of the oxic space 6 accommodates a set
25 of separation spaces 9, of which each has a form of an upward widening truncated cone, whereas the bottom part has an inlet opening 10 for the entry of activation mixture from the oxic space 6 into the separation space 9. The upper part of each separation space 9 is provided with an overflow device 11

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for the discharge of purified water. Each separation space 9 has its own outlet tube 14 of separated activated sludge that is connected, e.g., over a re-circulation pump 15, to the discharge tube 16 mouthing to middle height of the anoxic space 5, this mouthing being directed to the sense of circular flow
5 of the activation mixture in this circular anoxic space 5.

The reactor according this second embodiment operates identically as the reactor according to the first example of embodiment.

A reactor according to the third example of embodiment of the invention (Figs. 5 and 6) has a tank 1, also of circular ground plan with
10 circumferential casing 2 and bottom 3, an inserted upwards widening separation space 9 in form of a prism wound to form a ring. Thus between the separation space 9 and the circumferential casing 2 a circular anoxic space 5 is created, again of annular form. A central anoxic space 5' is created in the central part of tank 1 by partition wall 4 of circular ground plan.
15 Between partition wall 4 and separation space 9 an oxic space 6 is created, also of annular form. The partition wall 4 starts at bottom 3 of tank 1 and ends under the water level 7 in tank 1, Accordingly, the connection between the central anoxic space 5' with the oxic space 6 is established under the water level 7 in tank 1 by the overflow edge 8 of partition wall 4. The
20 upwards widening separation space 9 has again an inlet opening 10 in its bottom part, in this case in shape of an annulus, for the entry of the activation mixture from the oxic space 6 to the separation space 9, and in the upper part an overflow device 11 for drainage of purified water. The mentioned overflow device 11 can be again created as a surface though provided with
25 comb overflow and discharge, or as a discharge under the water level, created by perforated tubes under the water level 7 and provided with a separate overflow at the drainage. The circular anoxic space and/or the central anoxic space 5' are provided with drive sources for achieving circular

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flow of the activation mixture created, e.g., by mechanical agitating devices 12 and 12', preferably of the propeller type, for establishing an annular stream in this anoxic spaces 5 and 5'. The oxic space 6 accommodates an aeration device 13 at bottom 3 of tank 1. In this particular embodiment of the reactor the aeration device 13 consists of plastic tubes with fine perforation that are laid along the partition wall 4 and, accordingly, they create concentric circles in ground plan view. To the separation space 9 the outlet tube 14 is connected for discharging the separated activated sludge with an included re-circulation pump 15 and discharge tube 16 mouthed to middle height of circular anoxic space 5, this mouthed being directed to the sense of circular flow of activation mixture. The bottom part of circular anoxic space 5 in direction to bottom 3 of tank 1 receives the inlet tube 17 of sewage water from a not illustrated apparatus for mechanical pre-treatment of sewage. This inlet tube 17 is also directed with its mouthed to the sense of circular flow of activation mixture in the circular anoxic space 5. The upper part of circular anoxic space 5 receives the input neck 18 for activation mixture directed with its inlet against the sense of circular flow of the activation mixture and a connecting tube 19 is connected to it that mouths with its opposite end in the central anoxic space 5' in the central zone of bottom 3 of tank 1.

A reactor according to this third example of embodiment works in following way: The mechanically pre-treated sewage flows through the inlet tube 17 into the bottom part of the circular anoxic space 5 wherein the circular flow is imparted to the activation mixture by a mechanical agitating device 12. The re-circulated separated sludge from the separation space 9 together with the re-circulated activation mixture from the oxic space 6 flow through the discharge tube 16 to the middle height of the central anoxic space 5. The directing of the mouthed of both inlets in the sense of circular

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stream of the activation mixture supports the circular flow induced by the mechanical agitating device 12, while reducing turbulence and cross-flow, and thus also decreasing vertical mixing in this circular anoxic space 5. All mentioned inlets together with the described circular flow create helical
5 stream in the circular anoxic space 5, rising in a spiral from bottom 3 of tank 1 to water level 7. The re-circulated activation mixture from the oxic space 6 contains nitrates and oxygen dissolved in water. The nitrates and oxygen are introduced through the discharge tube 16 to middle height of the circular anoxic space 5, and carried away by the helical stream, mixed by cross
10 whirls and consumed by biological reaction. The mixing by the effect of cross whirls can be described as turbulent diffusion in terms of formal mathematics. Through the combination of the inlet, the turbulent diffusion and the biological consumption a special vertical concentration profile of oxygen and nitrates in the circular anoxic space 5 is created, the
15 concentration of both matter decreasing in the downward direction as well as in the upward direction from the level of the discharge tube 16. Through the effect of the vertical component of helical flow contributing to the rising transport of dissolved matter, this drop in the upwards direction is slower than that in the downwards direction. The activated sludge that is introduced
20 to middle height of the circular anoxic space 5 through discharge tube 16 is also dissipated by turbulent diffusion and carried away by the vertical component of the helical upward stream. In addition to that, however, it is also under the effect of gravity forcing it downwards against the liquid. In the result of counter-movements and turbulent dissipation the concentration
25 of activated sludge in the circular anoxic space 5 gets uniform. A part of activated sludge thus sinks to the bottom part where the presence of oxygen and of nitrates is practically ruled out by the described mechanism, and under these conditions it gets mixed with sewage water brought to the

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bottom 3 of tank 1 through the inlet tube 17. The bottom part of this circular anoxic space 5, accordingly, behaves as a preceding anaerobic zone, thus improving the biological removal of phosphorus in the process of water treatment. In the zone where sewage gets mixed with activated sludge a high
5 level of the ratio nutrients/micro-organisms is achieved and, accordingly, this zone behaves at the same time as a selector preventing the activated sludge from bulking. Since the separation space 9 widens in direction upwards, the circular anoxic space 5 narrows down in the upward direction. Due to that the vertical component of the helical flow grows in the upward direction,
10 which slows down the vertical decrease of the concentration of nitrates. For the completion of de-nitrification, accordingly, the activation mixture from the upper part of the circular anoxic space 5 is transferred through the input neck 18 and the connecting tube 19 to the central anoxic space 5'. The orientation of the input neck 18 against the direction of the circular flow of
15 the activation mixture makes use of the kinetic energy of this stream for compensating pressure losses during this transfer. Another mechanical agitating device 12' arranged in the central anoxic space 5' returns the activation mixture to circular flow maintaining the activated sludge in suspended state. The de-nitrification in the central anoxic space 5' gets
20 completed and the activation mixture then flows in the upper part of tank 1 from the central anoxic space 5' over the overflow edge 8 of partition wall 4 to the oxic space 6. Due to the law on maintaining the moment of motion the circular flow of liquid is transferred from the central anoxic space 5' to the oxic space 6.

25 A part of organic impurities capable of biological oxidation get oxidated in the anoxic spaces 5, 5', the source of oxygen being re-circulated nitrates that are reduced to gaseous nitrogen and thus removed from the treated water. Then the remaining of organic pollutants are biologically

oxidated in the oxic space 6. Also nitrogen compounds are oxidated there to form nitrates that are, as has already been noted, re-circulated to the circular anoxic space 5. Oxygen required for this oxidation is supplied by aeration device 13 to the oxic space 6. The aeration in oxic space 6 creates another
5 stream ensuring sufficient mixing within this oxic space 6, sustaining the activated sludge in suspended condition together with the above mentioned circular flow. The flow induced by aeration transfers the motion of circular flow also radially within the oxic space 6 which, similarly as in the foregoing examples, results in flow uniformity.

10 The activation mixture streams through the inlet opening 10 from the oxic space 6 to the separation space 9. In the upward widening separation space 9 a layer of sludge blanket is created, and during the transition of the activation mixture through this sludge blanket layer the activated sludge gets trapped, thus being separated from treated water. The purified water relieved
15 from activated sludge is then discharged from the upper part of separation space 9 by overflow device 11. The water level 7 in tank 1 is maintained at a specified height by way of the overflow component with which the overflow device 11 is provided, so that the amount of purified water corresponds with the volume of incoming sewage.

20 The separated activated sludge is drawn away from the separation space 9 by outlet tube 14. Together with it also a part of the activation mixture that has flown into the separation space 9 through inlet opening 10 from the oxic space 6 gets drawn away. This suction effect is implemented, e.g., by the re-circulation pump 15 serving for the re-circulation of separated
25 activated sludge and activation mixture from the separation space 9 into the circular anoxic space 5, as has already been described.

The invention is not limited solely to the described examples of embodiments, but relates to all equipments featuring the basic principles of

the described solutions. Some of the respective details may differ from the above described ones. For instance the re-circulating pump 15 can be left out and its function can be replaced by sucking induced within the discharge tube 16 by circular flow in the circular anoxic space 5, or vice-versa the re-

5 -circulating pump 15 can serve as the source of drive for the circular flow of activation mixture in the circular anoxic space 5 by suitable orientation and arrangement of the discharge tube 16, instead of another separate source of drive for the circular stream. A prism wound to form an annular structure according to the third example of embodiment, creating the separation space

10 9 dividing the circular anoxic space 5 from the oxic space 6, can be replaced, e.g., by a closed polygon composed of a set of straight prism. In the third example of embodiment, e.g., the central anoxic space 5' can be left out and, accordingly, the connecting tube 19 then mouths into the central zone of the oxic space 6. The oxic space 6 can be also provided with another separate

15 source of drive of the circular flow of activation mixture. In the second example of embodiment of the invention, instead of each separation space 9 having its own re-circulation pump 15 with its own discharge tube 16 mouthing to the circular anoxic space 5, e.g., a plurality of separation spaces 9 can be connected to one re-circulation pump 15, or possibly more re-

20 -circulation pumps 15 can have one single discharge tube 16 mouthing to the circular anoxic space 5. On the other hand, the separation space 9 of the third example of embodiment of the invention, can be provided with a larger number of re-circulation pumps 15.

Industrial applicability

25 A reactor according to the present invention can be used in particular for treating sewage water by unified suspended sludge with nitrification and de-nitrification, and namely both for municipal sewerage, and for industrial waste water treatment.

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CLAIMS

1. Reactor for activation treatment of sewage water by unified suspended
activated sludge created by at least one tank of circular ground plan with
5 circumferential casing containing at least one anoxic space with a drive
source of the activation mixture, at least one oxic space connected with
the anoxic space and provided with an aerating device and at least one at
least partially upwards widening separation space provided with an inlet
opening for the activation mixture from the oxic space, an overflow
10 device of purified water and an outlet tube of separated activated sludge
connected with the discharge tube, the discharge tube and the inlet tube
of sewage water to the reactor being introduced into the anoxic space,
characterised in that it contains a circular anoxic space
(5) arranged at least around the whole internal surface of the
15 circumferential casing (2) of the tank (1) and fully enclosing the oxic
space (6), the drive source of the activation mixture in the circular anoxic
space (5) being directed so as to create circular streaming of the
activation mixture.
2. Reactor according to Claim 1, **characterised in that** a
20 drive source of the activation mixture in the circular anoxic space (5) is a
mechanical agitating device (12).
3. Reactor according to Claim 1, **characterised in that** the
drive source of the activation mixture in the circular anoxic space (5) is
the mouthing of the inlet tube (17) of sewage into the reactor introduced
25 to the bottom part of the circular anoxic space (5) and the outlet of the
discharge tube (16) connected to the outlet tube (14) of separated
activated sludge from the separation space (9) into the circular anoxic

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space (5), both outlets being oriented to the direction of the desirable circular stream of the activation mixture.

4. Reactor according to Claim 1 and 3, **characterised in that** the mouthing of the discharge tube (16) of the separated activated sludge from the separation space (9) is introduced to the central height of the circular anoxic space (5).
5. Reactor according to Claim 1, **characterised in that** the circular anoxic space (5) is separated from the internally arranged oxic space (6) with the separation space (9) by way of circular ground plan partition wall (4) seated at the bottom (3) of the tank (1) and terminating under the water level (7) as a overflow edge (8) for the connection of the circular anoxic space (5) with the oxic space (6).
6. Reactor according to Claim 5, **characterised in that** the separation space (9) with the inlet opening (10) for the activation mixture from the oxic space (6) is arranged in the central zone of the tank (1).
7. Reactor according to Claim 1, **characterised in that** the circular anoxic space (5) is divided from the oxic space (6) by a separation space (9) in form of a prism wound to form a ring, or possibly a ring shaped polygon, the removal of activation mixture from the circular anoxic space (5) mouthing through a connecting tube (19) to the central area of the bottom (3) of tank (1).
8. Reactor according to Claim 1 and 7, **characterised in that** the circular anoxic space (5) is enlarged by the addition of a central anoxic space (5') arranged inside the oxic space (6) and divided from said oxic space by a circular ground plan partition wall (4) seated on the

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bottom (3) and terminating under the water level (7) as an overflow edge (8) for connecting the central anoxic space (5') with the oxic space (6), the circular anoxic space (5) being connected with the central anoxic space (5') with a connecting tube (19) and provided with a separate drive
5 source of the activation mixture flow created by a mechanical agitating device (12').

9. Reactor according to Claim 8, **characterised in that** the connecting tube (19) mouths into the central anoxic space (5') in the central area of the bottom (3) of tank (1) and connected to the upper part
10 of the circular anoxic space (5) to the input neck (18) directed against the sense of circular stream of the activation mixture in the circular anoxic space (5).

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Fig. 1

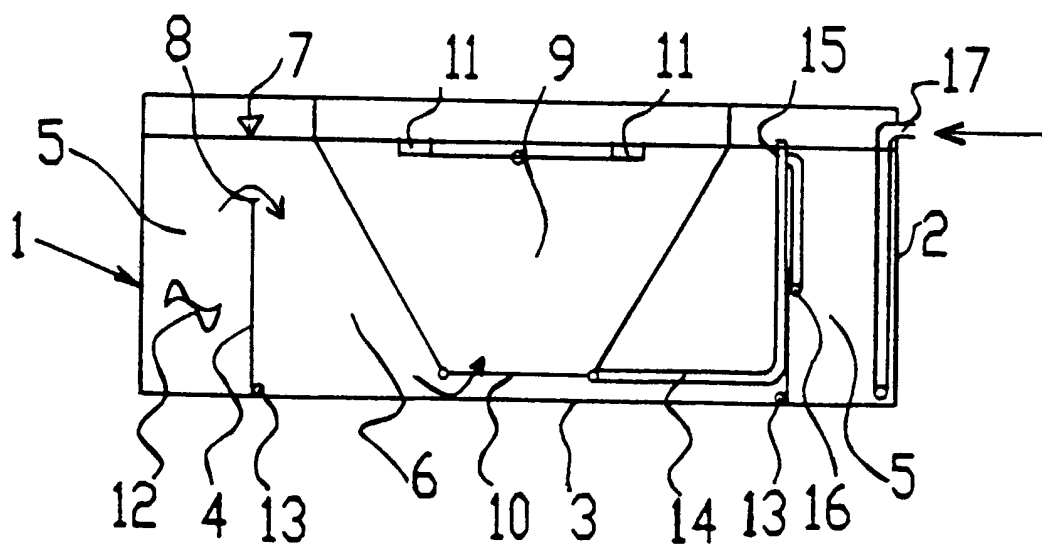
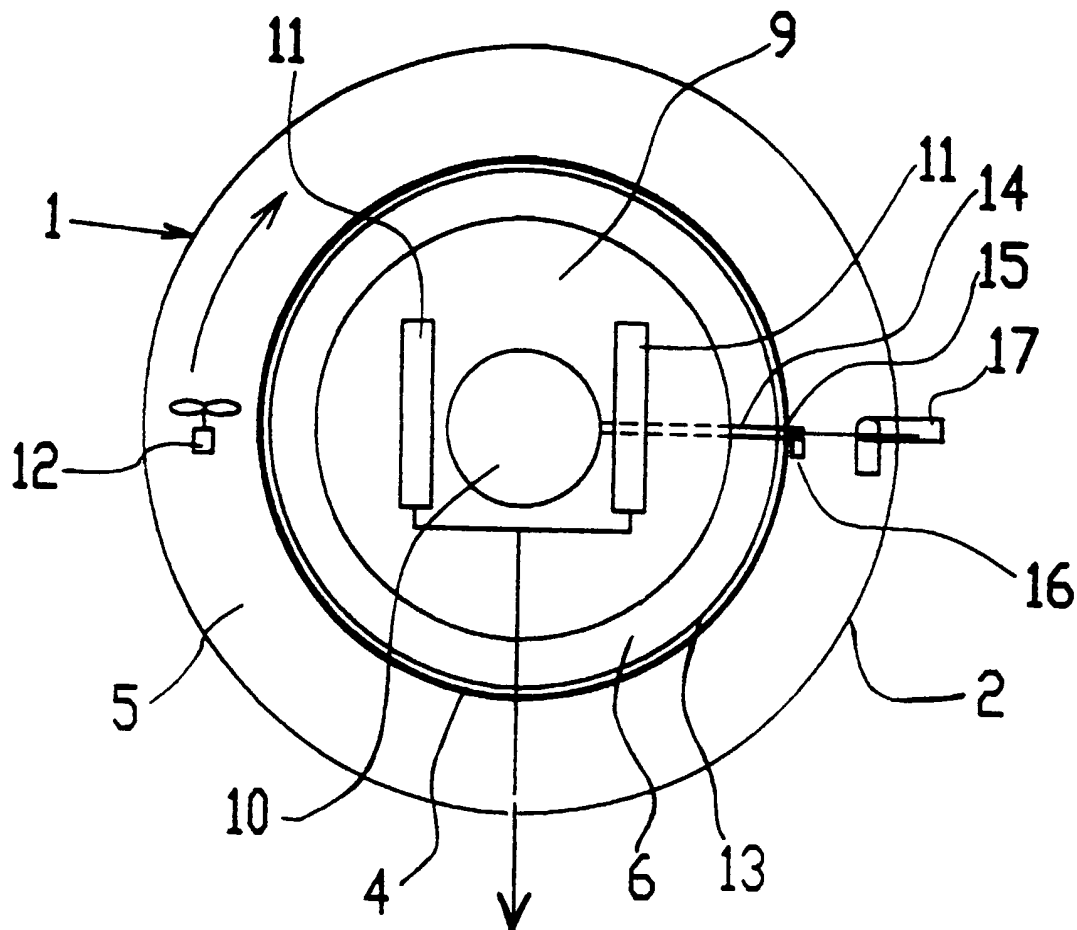


Fig. 2

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Fig. 3

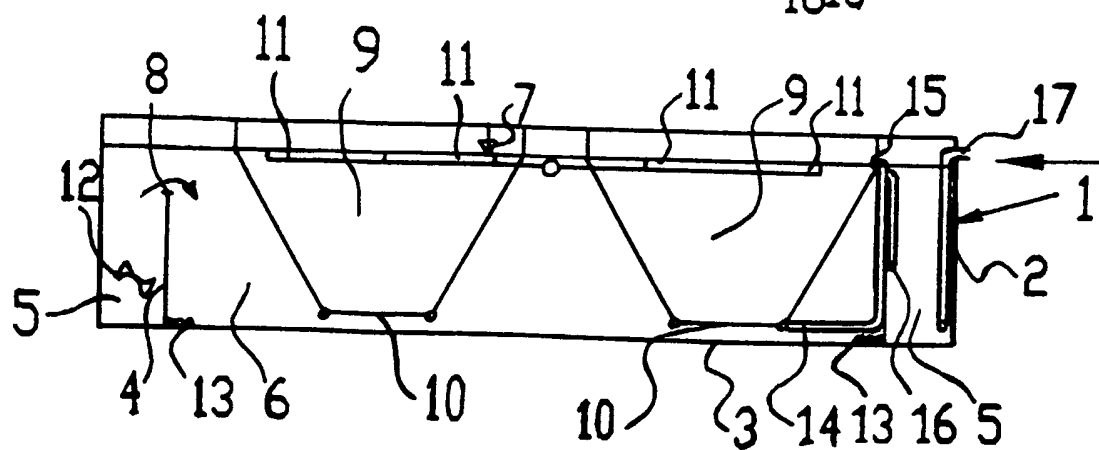
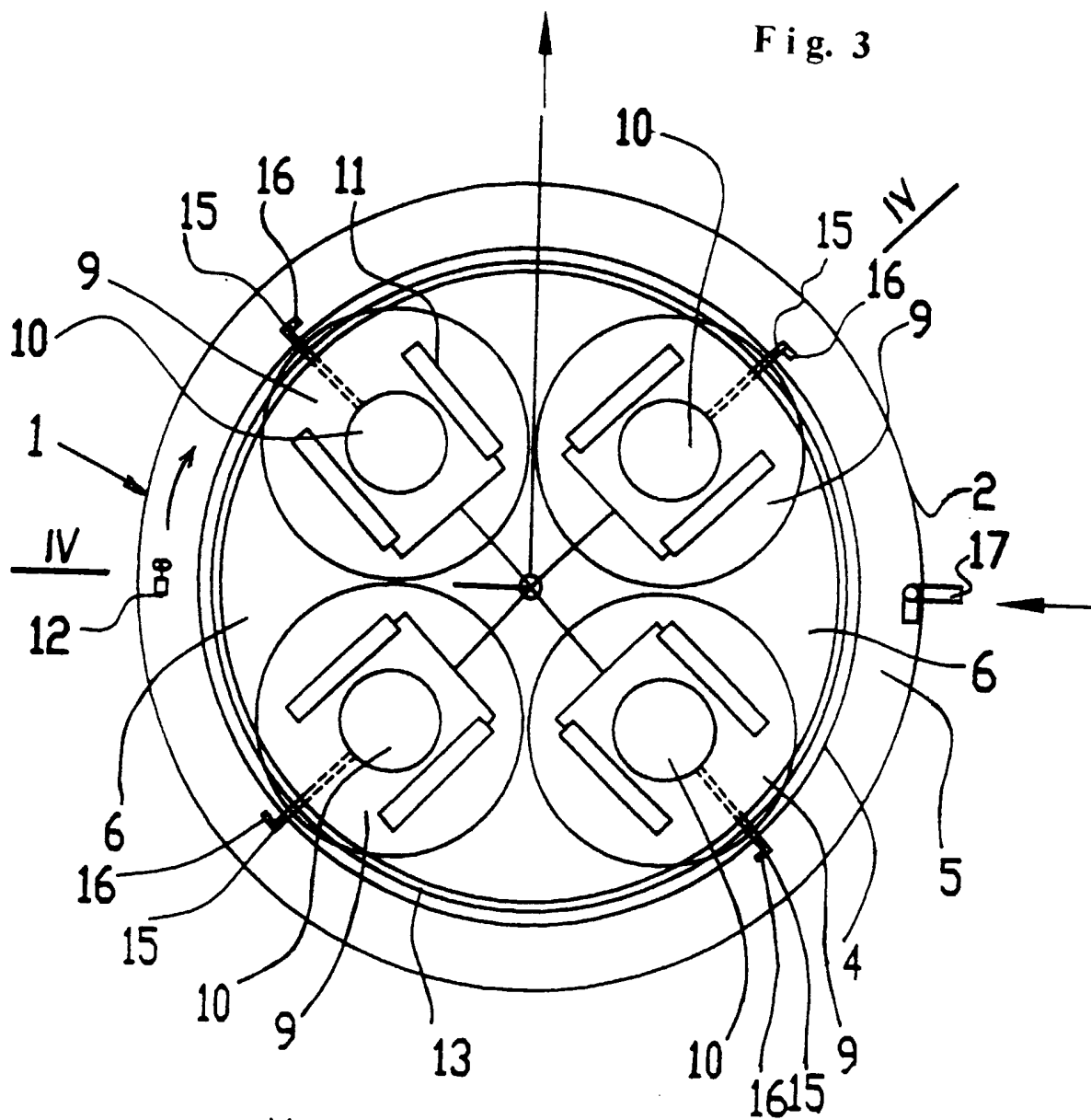


Fig. 4

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Fig. 5

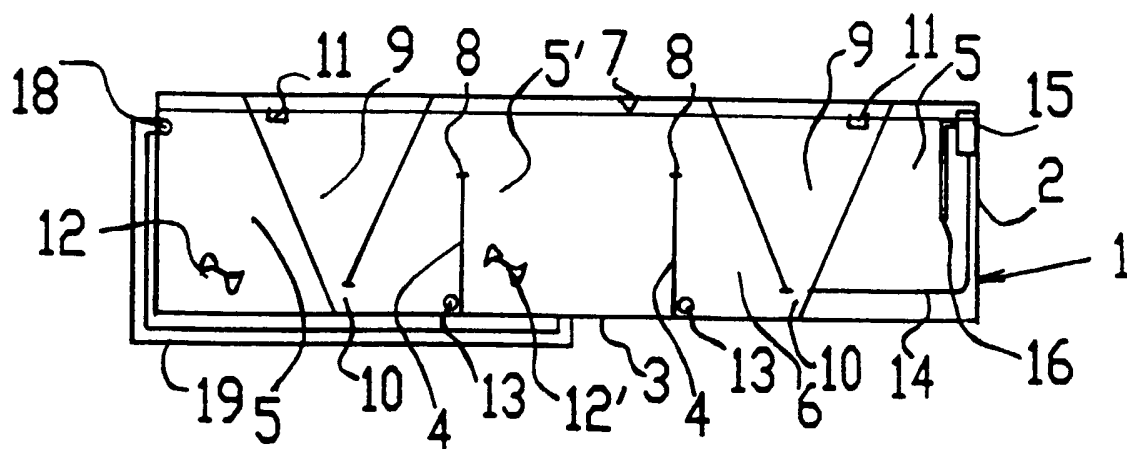
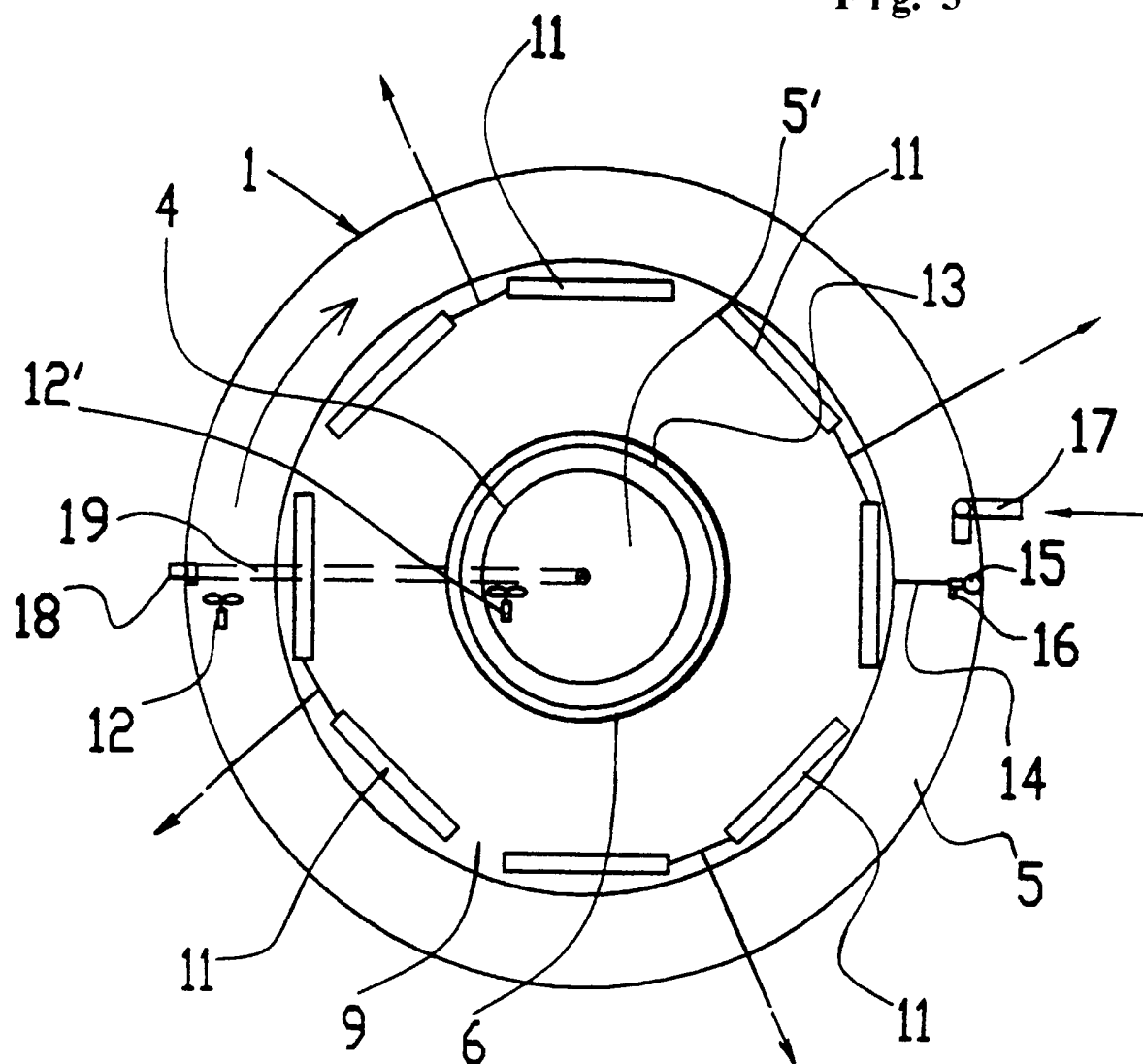


Fig. 6

INTERNATIONAL SEARCH REPORT

Intern al Application No

PCT/CZ 02/00023

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 C02F3/30 C02F3/12

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 C02F

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, WPI Data, PAJ

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X	US 5 783 071 A (GUY MONROE WAYNE) 21 July 1998 (1998-07-21) column 6, line 18 - line 27 ---	1,6
Y	US 5 032 276 A (MACKRLE SVATOPLUK ET AL) 16 July 1991 (1991-07-16) column 7, line 48 - line 61; figure 1 column 6, line 18 - line 27 ---	1-3,5,6
Y	NL 1 009 590 C (SIRIUS B V ;WATERSCHAP GROOT SALLAND (NL)) 11 January 2000 (2000-01-11) page 11, line 23 -page 12, line 7; figure 2 --- -/--	1-3,5,6



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

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- * & * document member of the same patent family

Date of the actual completion of the international search

24 September 2002

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Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
 Fax: (+31-70) 340-3016

Authorized officer

Gonzalez Arias, M

INTERNATIONAL SEARCH REPORT

Intern Application No
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