

TITLE

Improvements in flotation/fractionation systems for treating liquids and in separation of liquids to be treated thereby

FIELD OF THE INVENTION

- 5 This invention relates to an improved control arrangement for flotation/fractionation systems incorporating a reactor vessel and a particle separator therefor. The invention has particular, but not exclusive, utility as a protein skimmer to supplement the treatment of liquid containing biomass and waste from aquatic species within a holding tank.
- 10 Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

BACKGROUND ART

- 15 The use of flotation/fractionation systems incorporating a reactor vessel to function as what is commonly termed "a protein skimmer" is known in the art of treating water for sustaining aquatic species in holding tanks. An example of one form of protein skimmer used in the art is described in US patent 4,834,872. This type of protein skimmer provides for the after treatment of liquid circulated
- 20 therethrough by charging it with oxygen and removing residual biomass and nitrite to the extent that it can be fed back into an aquarium or the like from which the liquid was taken for treatment. Whilst this form of protein skimmer is effective for use with smaller types of aquaria, due to the complexity of its design, it is not suitable for treating comparatively large volumes of liquid, such as are involved
- 25 with the operating of large holding tanks for aquatic species.



In larger tank systems, a simpler form of protein skimmer design is utilized for cost effectiveness. Two examples of prior art systems used in larger tank systems are schematically shown in Figures 1A and 1B of the drawings.

Figure 1A shows a protein skimmer design involving the use of a single pump 11, which pumps liquid via an inlet 13 from a holding tank 15. The outlet 17 of the pump 11 directs liquid via a convolved pipe arrangement 19 into a main fractionation column 21 of a reactor vessel 23, at an intermediate position therealong. The pipe arrangement 19 incorporates a venturi 25 in series therewith for injecting an ozone/oxygen mix via an inlet line 27 from a concentrated source (not shown) into the pipe arrangement and consequently into the fractionation column 21. The reactor vessel 23 includes an aggregation chamber 29 surmounting the fractionation column 21 for collecting foam generated by the injection of the liquid entrained with the ozone/oxygen gas mix into the fractionation column 21 and the permeation of liquid within the column with rising bubbles of this gaseous mixture. An outlet pipe 31 is connected to the base of the fractionation column 21 to remove the lower treated fraction of liquid from the reactor vessel 23 and return it to the holding tank 15.

As described in US patent 4,834,872, nitrites are reduced and nitrates neutralized by the oxidizing effect of the ozone/oxygen gas mix bubbling through the fractionation column 21 and any residual biomass is adsorbed to the resultant foam floated and ultimately collected within the aggregation chamber 29.

The throughput of liquid through the reactor vessel 23 is determined by the control of the pump 11. The throughput effects the residency time level of liquid within the reactor vessel and is important to control to ensure that sufficient time is allowed for liquid to be eradicated of nitrites, nitrates and biomass whilst it is resident within the reactor vessel. The pump 11 also affects the flow rate of liquid through the venturi 25 and hence the amount of ozone and oxygen gas drawn into the liquid flow. Essentially, the faster the flow through the venturi, the greater is the volume of ozone and oxygen gas that is drawn into the flow. Furthermore, the faster the resultant fluid flow into the fractionation column 21 is, the greater is the turbidity caused within the fractionation column. The amount of gas within the



reactor vessel 23 determines the head pressure of the column and hence the resultant level of liquid within the fractionation column 21. Accordingly, it is desirable to maximize the flow rate of liquid through the venturi 25 as the venturi intrinsically restricts flow in any event. It is also desirable to fix the level of liquid within the reactor vessel 23 so that its surface is just below the junction between the fractionation column 21 and the aggregation chamber 29. This facilitates the aggregation of foam within the aggregation chamber 29 and keeps it dry so as not to lose liquid unnecessarily during the treatment fractionation/flootation process.

A problem that arises with this system is that it is not possible to control the operation of the pump 11 in a manner so that all of the parameters influenced by it are optimally set, especially when it is necessary to adjust one parameter and not another in order to achieve optimum operating efficiency of the system.

For example, when it is desirable to maximize the flow rate of the liquid through the venturi 25 to maximize the volume of gas being introduced into the fractionation column 21 for aeration and flotation purposes, this may result in throughput being too fast and the level of liquid within the fractionation column reducing. This is due to an increase in the head pressure of the reactor vessel provided by a direct increase in the ratio of gas to liquid within the vessel. This reduction in liquid level will cause the surface of the liquid to fall well below the junction between the fractionation column 21 and the aggregation chamber 29, resulting in a reduced volume of liquid being treated by the gas mix and not all of the foam being able to be collected in the aggregation chamber. To optimally treat the liquid, the height of liquid in the reactor vessel needs to be at a maximum.

Conversely, maximising the level of liquid within the reactor vessel 23 requires the flow rate of liquid entering the fractionation column 21 to be reduced to an extent that the ratio of gas to liquid in the column reduces the head pressure of liquid therein and allows the level to rise. This, however, results in reduced turbidity and aeration of the liquid with ozone and oxygen gas to properly treat the liquid therein, although residency time increases, due to the resultant decrease in throughput.



Although a reasonable compromise may be able to be achieved, the problem is exacerbated further by the fact that the degree of foaming that occurs to allow adsorption of biomass to foam and thus lifting of the same out from solution, is dependent upon the amount of protein containing the nitrites and nitrates in the liquid. The more protein there is in the incoming liquid from the tank that needs to be fractioned and floated out of the liquid, the more foam there is generated. As the amount of protein in the liquid is dependent on the aquatic species residing in the holding tank 15, and totally independent of the operation of the pump 11, there is a need to dissociate the control of the pump effecting throughput and hence residency time of liquid within the reactor vessel 23, from control of the flow rate of liquid through the venturi 25, which effects turbidity and the level of liquid within the column.

This problem is addressed in the protein skimmer design shown in Figure 1B by taking the convolved pipe arrangement 19, including the venturi 25, out of the inlet side of the pipe circuit and creating a discrete recirculation pipe circuit 33 incorporating the same, which has its own pump 35. This second pump 35 operates quite independently of the main inlet pump 11 that controls throughput, so that control of the second pump determines the flow rate of liquid through the venturi 25 and hence the level of liquid within the reactor vessel 23, quite independently of the throughput.

As shown in the drawing, the outlet 17 of the first pump 11 is connected to the fractionation column 21 at an intermediate location 36 along the column to directly inject liquid to be treated therein. Thus the rate of flow of this pump 11 determines the throughput and hence residency time of liquid within the reactor vessel 23. The recirculation pipe circuit 33 has an inlet 37 connected proximate to the base of the fractionation column 21 to extract liquid therefrom and supply the second pump 35. The outlet 39 of the second pump 35 is connected to the convolved pipe arrangement 19 incorporating the venturi 25. The outlet of the venturi 25 injects liquid into the fractionation column 21 at an intermediate, albeit lower, location 41 than location 36, where the outlet 17 from the first pump 11 injects liquid into the column. This allows the untreated liquid delivered via the first pump 11 to be permeated by the rising gas mix injected from the outlet of the venturi 25 at



location 41, increases the turbidity within the column to enhance contact between the liquid and gas mix. The recirculation circuit has the added benefit that it increases the residency time of liquid within the reactor vessel, separately of the speed of the pump 11. The outlet pipe 31 is connected to the base of the
5 fractionation column 21 to remove treated liquid from the reactor vessel 23 and return it to the holding tank 15.

Flow rate valves 43 and 45 are provided on the main inlet 13 and outlet 31 pipes, respectively, to allow for adjustment of throughput.

Whilst this dual pump protein skimmer design is superior to the previous single
10 pump design, in allowing independent control of parameters to achieve maximum operating efficiency, it is not as cost effective as it does require a second pump, which is not inexpensive. In addition, it does require balancing by continual adjustment of the flow rate valves to set the optimum level of liquid within the column, given that the amount of foam produced that is necessary to adsorb
15 biomass thereto, is dependent on the amount of protein in the liquid. Adjustment via the flow rate valves, however, directly affects throughput, which is preferred to be maximised.

In both of these protein skimmer designs, the inlet 13 from the holding tank 15 normally consists of a suction pipe. The pipe simply has an open end disposed
20 directly within the holding tank or within a skimmer chamber into which liquid from the holding tank flows to be drawn from the tank for treatment. The protein skimmer is normally intended to supplement a primary filtering or treatment process for liquid within the holding tank, such as a biofilter and simply draws liquid from the same source as the primary filtering or treatment process, without
25 any preliminary filtering or separation stage. Consequently, the protein skimmer can receive large biomass particles, which can be difficult for it to adsorb and float out of the system. This places an extra burden on the efficacy of the protein skimmer and in balancing the system to work efficiently to reduce or remove nitrites and nitrates manifesting themselves as protein at the molecular level, as
30 well as removing suspended solids and solids from the liquid by flotation.

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DISCLOSURE OF THE INVENTION

It is an object of one aspect of the present invention to provide for improving the control of a flotation/fractionation system in a more cost effective and efficient manner than prior art systems of the type as hereinbefore described.

- 5 It is an object of another aspect of the present invention to provide for the preliminary separation of particles from a liquid to facilitate its further treatment by a flotation/fractionation system or other means.

In accordance with one aspect of the present invention, there is provided an improvement in a fractionation/flotation system for removing waste such as
10 biosolids, nitrates or nitrites from a liquid containing same comprising: a fractionation column; a foam aggregation chamber surmounting the fractionation column; a liquid inlet means for inletting liquid containing the waste into the fractionation column; pump means for pumping the liquid through the liquid inlet means; gas injecting means for injecting a waste reducing gas such as air,
15 oxygen or ozone into the liquid immediately prior to inletting the same into the fractionation column; foam extracting means to extract foam collected within the foam aggregation chamber; and liquid outlet means for outletting treated liquid from the base of the fractionation column; the improvement residing in:-

the liquid inlet means being divided into:

- 20 (a) a first liquid inlet for inletting liquid containing waste at an intermediate location along the axial extent of said fractionation column, said first liquid inlet having a flow regulator to control the flow rate of liquid being inlet into the column thereby; and
- 25 (b) a second liquid inlet for simultaneously inletting the liquid containing waste at an intermediate, albeit lower, location along the axial extent of said fractionation column than said first liquid inlet, said second liquid inlet having said gas injecting means disposed in series therein for injecting

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said waste reducing gas into the liquid of the second liquid inlet immediately prior to inletting same within said fractionation column;

wherein the division occurs after the outlet of said pump means;

- and wherein liquid within said fractionation column is able to be maintained at an optimum level to enable foam having waste adsorbed thereto to aggregate in said aggregation chamber by controlling said regulator.

Preferably, the gas injecting means comprises a venturi whereby said waste reducing gas is drawn into the throat of the venturi to permeate and aerate the liquid containing waste passing through the venturi.

- 10 Preferably, the waste reducing gas is a mix of oxygen and ozone.

- In accordance with another aspect of the present invention, there is provided an improved method for controlling the removal of waste such as biosolids, nitrates or nitrites from a liquid containing same using a fractionation/flotation system comprising: a fractionation column; a foam aggregation chamber surmounting the fractionation column; foam extracting means to extract foam collected within the foam aggregation chamber; and liquid outlet means for outletting treated liquid from the base of the fractionation column; the method comprising:

- 20 inletting liquid containing waste under pressure into the fractionation column at first and second intermediate locations from a common source, the second location being lower than the first location;

injecting a waste reducing gas such as air, oxygen or ozone into the liquid immediately prior to inletting the same into the fractionation column at the second intermediate location; and

- 25 regulating the flow of liquid being inlet at the first intermediate location to maintain the liquid within the fractionation column at an optimum level for

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enabling foam having waste adsorbed thereto to aggregate in the aggregation chamber.

Preferably, the waste reducing gas is a mix of oxygen and ozone.

In accordance with a further aspect of the present invention, there is provided an
5 apparatus for separating liquid containing particles of varying mass or specific gravity comprising:

10 an elongated passageway having: (a) a leading wall with a primary lip for liquid containing said particles to flow over into said passageway; (b) a trailing wall with secondary lip disposed lower than said primary for liquid to flow over and out of said passageway; and (c) a base closing the bottom of said passageway to enable the liquid flowing into the passageway over said primary lip to fill the same and flow out over the secondary lip;

15 flow diverting means disposed in said passageway for diverting the liquid flow therein to create a convolving recirculating portion of laminar flow and a discharging portion of laminar flow of liquid within the passageway; and

liquid extraction means to extract liquid containing particles of lower mass or specific gravity entrained within said recirculating portion therefrom, leaving liquid containing particles of waste to flow out of said passageway and over the secondary lip.

20 Preferably, said flow diverting means comprises a circular pipe disposed in parallel and spaced relationship to the longitudinal extent of the walls and base.

Preferably, said liquid extracting means comprises a plurality of rectilinearly aligned holes disposed axially along the suction pipe at spaced apart locations and suction means to apply a negative pressure to the inside of the circular pipe
25 to draw liquid from said recirculating portion.

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Preferably, the prefilter includes a solids extracting means having an inlet confronting the cascading flow to extract solids retained therein.

Preferably, said liquid extraction means is connected to the inlet of a fractionation/flotation system for removing waste including said particles entrained
5 within the extracted liquid therefrom.

Preferably, said fractionation/flotation system is as defined in any one of the preceding aspects of the present invention.

In accordance with a further aspect of the present invention there is provided a method for separating liquid containing particles of varying mass or specific
10 gravity comprising:

cascading liquid containing said particles over a primary lip into a passageway;

diverting the flow of the liquid within the passageway to create a convolving recirculating portion of laminar flow and a discharging portion of laminar flow;

extracting liquid containing particles of lower mass or specific gravity entrained
15 within said recirculating portion therefrom; and

discharging liquid containing particles of higher mass or specific gravity entrained within said discharging portion out of said passageway over a secondary lip.

BRIEF DESCRIPTION OF THE DRAWINGS

20 Figure 1A is a schematic drawing of a known design for a protein skimmer which is characterised by a single pump and inlet;

Figure 1B is a schematic drawing of another known design for a protein skimmer which is characterised by a dual pump arrangement and recirculation circuit;

Figure 2 is a perspective view of a tank system for aquatic species;

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Figure 3 is a plan view of Figure 2;

Figure 4 is an end elevation of the tank system shown in Figures 2 and 3, taken from the services end of the tank and showing the plumbing arrangement of the piping for the protein skimmer and tank system generally in schematic form;

- 5 Figure 5 is a cross-sectional view of the tank system taken along section B-B of Figure 3;

Figure 6 is a cross-sectional view of the particle separator;

Figure 7 is a schematic diagram showing the principle of operation of the improved protein skimmer design utilising the invention; and

- 10 Figure 8 is an exploded view of the actual protein skimmer design in accordance with the embodiment.

BEST MODE(S) FOR CARRYING OUT THE INVENTION

- The best mode for carrying out the invention is described with reference to Figures 2 to 8, wherein the invention is embodied in a tank system for aquatic
15 species that is sufficiently large to efficiently handle volumes of fish on a relatively large scale for commercial purposes. The tank system is substantially described in the applicant's corresponding International Patent Application PCT/AU00/00800, which is incorporated herein by reference.

- As shown in Figures 2 to 5, the tank system 101 comprises a large main tank 111
20 that is divided into a holding tank 115 and a filtering means area 117 by an inner partition 113. A pair of longitudinally extending buffer tanks 119a and 119b is provided so that one buffer tank is disposed on either longitudinal side of the main tank 111.

- The tank system 101 includes a main services area 103 at one end thereof, which
25 accommodates the main operating components of the tank. These include:

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- a pair of main pumps 121a and 121b connected by a network of pipes on the inlet side to the respective buffer tanks 119a and 119b and the filtering means area 117, and by corresponding pipes on the outlet side to the main tank 111 for recirculating fluid throughout the main tank 111 via the buffer tanks and
5 filtering means;
- a supplementary filtering means in the form of a protein skimmer 125, which comprises a foam flotation/fractionation system to treat liquid containing waste such as biosolids, nitrites and nitrates is connected via an auxiliary pump 105 to a suction pipe 141 of a liquid and particle separator 127;
- 10 • a discharge chamber 155, which is supplied with fluid outlet from the protein skimmer 125 via an outlet pipe 173, for discharging ozone and other gases entrained into the water by the protein skimmer during flotation//fractionation process;
- a fluid cooler means in the form of refrigeration system including a cooler or
15 evaporative coil 175 disposed in the discharge chamber 155, a condenser (not shown) and a compressor (not shown); and
- an air compressor 156 which is connected to an outlet pipe 159 disposed along the bottom of the filtering means area 117.

The main pumps 121, protein skimmer 125 and fluid cooler means are all
20 disposed at one end of the system 101, adjacent to the end wall 111a of the main tank, in a separate services compartment.

The inner partition 113 maintains separation of the contents of the holding tank 115 and the filtering means area 117 and has a tank discharge means surmounted thereon. The tank discharge means incorporates the liquid and
25 particle separator 127, which includes a primary lip 129a and a secondary lip 129b over which liquid flows. The liquid and particle separator 127 separates liquid containing waste particles dependent upon the mass or specific gravity of the particles. By virtue of this arrangement liquid containing relatively low mass or



specific gravity may be treated by the protein skimmer 125 and liquid containing particles with a higher mass or specific gravity may be passed through the tank discharge means and over to the main filtering means 117. The separator 127 will be described in more detail later.

- 5 Thus the tank discharge means effectively provides a knife edge by virtue of the primary lip 129a over which water may cascade and a sequential flow path through the separator 127 to direct fluid to either the protein skimmer 125 or the middle of the filtering means area 117, over the secondary lip 129b and a 'v' shaped upper drip tray 149.
- 10 Filtering means in the form of a biofilter 131 is disposed in the area 117. The biofilter 131 is of known design, consisting of a biomass comprising a multitude of bioballs within which active bacteria may grow.

- The bacteria feeds on and thus cleans water and fluid flowing through the biofilter of ammonia and nitrite, which is excreted by the shellfish or other aquatic animals
- 15 contained within the holding tank. Thus, the biofilter 131 performs an important filtering and cleansing function for the water 123 contained within the holding tank portion 115 when live shellfish is disposed therein.

- In the present embodiment the continuous flow of water from the holding tank 115 to the filtering means area 117 is provided by filling the holding tank with sufficient
- 20 water 123 to allow it to continuously cascade over the primary lip 129a. Thus, the discharge means relies upon discharging water 123 from the holding tank 115 in a continuous flow from the top of the holding tank 115, immediately adjacent to the primary lip 129a of the tank discharge means.

- Now describing the liquid and particle separator 127 in more detail, as shown in
- 25 Figure 6 of the drawings, the separator comprises an elongated passageway 133 defined by a leading wall 135 having the primary lip 129a disposed at the top thereof, a trailing wall 137 having the secondary lip 129b disposed at the top thereof and a base 139 closing the bottom of the passageway to enable the liquid



flowing into the passageway over said primary lip 129a to fill the same and flow out over the secondary lip 129b.

The suction pipe 141 is disposed within the passageway 133 in parallel and spaced relationship to the longitudinal extent of the walls 135, 137 and the base 139, closer to the base and the trailing wall 137 than the to the leading wall 135 and the lips 129. The pipe 141 is circular in cross-section and functions as a flow diverting means and a liquid and particle extraction means. The flow diversion is provided by the shape and positioning of the pipe within the passageway 133. The liquid and particle extraction, on the other hand, is provided by a series of rectilinearly aligned holes 143 disposed axially along the pipe 141 at spaced apart locations and suction means provided by the auxiliary pump 105 to apply a negative pressure to the inside of the circular pipe to draw in liquid from the passageway. The holes 143 are disposed in the half of the pipe 141 confronting the leading wall 135 and further in the upper quartile of this half at an angle of approximately 45° from the vertical.

The positioning of the suction pipe 141 relative to the walls and base of the passageway 133 is important in diverting flow into a convolving recirculating portion 145 of laminar flow and a discharging portion 147 of laminar flow within the passageway. This separation of flow essentially allows liquid entrained with biosolids of relatively high mass or specific gravity to be diverted around the rear of the suction pipe 141 and into the discharging portion 147 of the laminar flow. Once in this portion of the flow, these higher mass biosolids will flow out of the passageway 133 and over the secondary lip 129b into the drip tray 149. On the other hand, liquid entrained with biosolids of a lower mass or specific gravity will tend to be diverted into the recirculating portion 145 of flow, where the positioning of the holes 143 in the recirculating portion of the flow, extracts this liquid with its entrained biosolids and waste from the passageway 133 and directs it to the protein skimmer 125.

The spacing of the holes 143 is relatively close, for example, at 50 millimetre intervals at the end of the pipe 141 farthest from the services end 103 of the tank system, and gradually increasing in spacing to, for example 200 millimetres apart



at the proximal end of the pipe to the services end 103. The inlet holes are typically of a diameter of 8 millimetres, however all of these dimensions may vary, depending upon the particular flow rate of the water through the separator 127 desired to be achieved and the particular type of aquatic species that is
5 accommodated within the main tank 111.

The separator 127 is disposed immediately adjacent to the 'v-shaped' upper drip tray 149, which accommodates a replaceable water permeable mat (not shown) therein. The upper drip tray 149 is positioned so that the anterior side of the 'v' is contiguous with the posterior side of the secondary lip 129b, whereby the
10 extracting portion of the laminar flow of water cascades over the secondary lip and onto the mat. As shown in Figure 5 of the drawings, the posterior of the secondary lip 129b forms a flap which surmounts the mat and the anterior side 149a of the tray.

The passageway 133 and the tray 149 are supported in position by a plurality of
15 cross-braces 108 which transversely span the top of the filtering means area 117. Each cross-brace 108 is fixed at one end to the partition 113 and at the other end to the outer side wall 111a of the main tank 111. The top of each cross-brace 108 is particularly configured so as to define a rectangular recess adjacent to the partition 113 to seat the passageway 133 therein and a 'v-shape' recess
20 intermediate the remaining portion of the brace, closer to the side wall 111a to seat the upper tray 149 therein.

The protein skimmer 125 is part of a separate treatment circuit for the liquid to supplement the filtering function of the biofilter 131. Moreover, the protein skimmer 125 functions to remove waste material such as suspended biosolids,
25 nitrates and nitrites from the holding tank. This waste is created by shellfish excrement, parts or the like, and is in solution such as protein as well as in suspension. The protein skimmer thus performs a supplementary filtering and cleansing action to the biofilter.

The protein skimmer 125 operates by sucking liquid and waste particles from the
30 passageway 133 via the suction pipe 141 and an inlet line 151 connected thereto,



to the auxiliary pump 105, as previously described. This liquid containing waste is then pumped via a liquid inlet means to a reactor vessel 153 comprising a fractionation column 153a surmounted by an aggregation chamber 153b. The liquid is injected with an ozone and oxygen gas mix and waste to reduce and
5 neutralize the nitrite and nitrate components and biomass is adsorbed to foam formed at the gas - liquid interface to be floated off and collected within the aggregation chamber 153b. In this manner, the liquid is fractionated so that the treated liquid gravitates to the bottom of the fractionation column 153a from where it is returned to the holding tank via suitable return means.

- 10 The foam containing entrained protein and solids that is collected in the aggregation chamber 153b is outlet via a foam outlet pipe 157 periodically for subsequent disposal.

The injection of ozone through the water not only promotes the foam flotation/fractionation process but also provides a filtering of nitrates and nitrites
15 from the water, which can be harmful to the aquatic species.

An important aspect of the present embodiment is the particular arrangement of the liquid inlet means between the pump 105 and the fractionation column 153a. The liquid inlet means essentially comprises a branching circuit connected to an outlet line 159 from the pump 105. This outlet line includes a flow regulator valve
20 161 and is connected to a first liquid inlet line 163 and a second liquid inlet line 165 via a coupling 167. The outlet lines 163 and 165 inlet liquid containing waste at intermediate locations along the axial extent of the fractionation column 153a. The intermediate location 163a for the first liquid inlet line 163 is at a higher position than the intermediate location 165a for the second liquid inlet line 165.

- 25 Flow control valves 191 are connected to each of the branches of the branching circuit so that a flow regulator valve 191a is provided along the inlet line 163, and a flow regulator valve 191b is provided along the inlet line 165, in addition to the flow regulator valve 161 of the outlet 159 of the auxiliary pump 105.

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A gas injecting means in the form of a venturi 169 is incorporated into the inlet line 165 for introducing a waste reducing gas, which in the present embodiment is an ozone and oxygen gas mix, into the liquid containing waste, immediately prior to entering the fractionation column 153a at the lower intermediate location 165a.

- 5 The outlet side of the protein skimmer comprises an outlet pipe 173 which is connected to the outlet of the fractionation column 153, proximate to the bottom thereof, and directs treated liquid to the discharge chamber 155. The outlet pipe 173 is also provided with a control valve 193 and a vent 195 to control the outlet flow of fluid from the fractionation column 153a and to vent gases such as ozone
10 and oxygen introduced into the water during the flotation/fractionation process, on its way to the discharge chamber 155. The distal end 173a of the outlet pipe discharges fluid from the reactor vessel into the top of the discharge chamber 155. As shown, the discharge chamber 155 is disposed at the end of the holding tank 111 adjacent to the services area end 103 and returns liquid back to the
15 holding tank.

- An important feature of this arrangement of the liquid inlet means is that the level of the liquid within the reactor vessel can virtually be set by adjustment of the flow regulator 191a alone, without effecting throughput, the latter being determined by the pump speed and the regulator valve 161 and control valve 193. This enables
20 the pressure head within the reactor vessel 153 to be varied so as to determine the level that liquid reposes within the column, which is preferably just below the junction between the fractionation column 153a and the aggregation chamber 153b, without having to alter the throughput.

- It should be appreciated that the scope of the present invention is not limited to
25 the specific embodiment described herein. For example the invention may have utility in alternative liquid treatment arrangements, where it is desirable to provide a separation of liquid depending on the relative mass or specific gravity of particles contained therein, or where a flotation/fractionation process is used to treat liquid containing solids and waste.





THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS

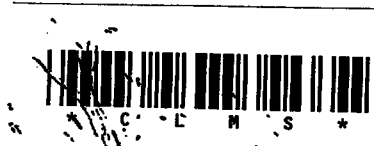
1. An improvement in a fractionation/flotation system for removing waste such as biosolids, nitrates or nitrites from a liquid containing same comprising: a fractionation column; a foam aggregation chamber surmounting the
5 fractionation column; a liquid inlet means for inletting liquid containing the waste into the fractionation column; pump means for pumping the liquid through the liquid inlet means; gas injecting means for injecting a waste reducing gas such as air, oxygen or ozone into the liquid immediately prior to inletting the same into the fractionation column; foam extracting means to
10 extract foam collected within the foam aggregation chamber; and liquid outlet means for outletting treated liquid from the base of the fractionation column; the improvement residing in:-

the liquid inlet means being divided into:

- (c) a first liquid inlet for inletting liquid containing waste at an intermediate
15 location along the axial extent of said fractionation column, said first liquid inlet having a flow regulator to control the flow rate of liquid being inlet into the column thereby; and
- (d) a second liquid inlet for simultaneously inletting the liquid containing waste at an intermediate, albeit lower, location along the axial extent of said
20 fractionation column than said first liquid inlet, said second liquid inlet having said gas injecting means disposed in series therein for injecting said waste reducing gas into the liquid of the second liquid inlet immediately prior to inletting same within said fractionation column;

wherein the division occurs after the outlet of said pump means;

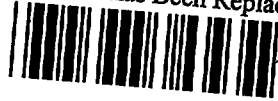
- 25 and wherein liquid within said fractionation column is able to be maintained at an optimum level to enable foam having waste adsorbed thereto to aggregate in said aggregation chamber by controlling said regulator.





2. An improvement as claimed in claim 1, wherein said gas injecting means comprises a venturi whereby said waste reducing gas is drawn into the throat of the venturi to permeate and aerate the liquid containing waste passing through the venturi.
- 5 3. An improvement as claimed in claim 1 or 2, wherein said waste reducing gas is a mix of oxygen and ozone.
4. An improved method for controlling the removal of waste such as biosolids, nitrates or nitrites from a liquid containing same using a fractionation/flotation system comprising: a fractionation column; a foam aggregation chamber
10 surmounting the fractionation column; foam extracting means to extract foam collected within the foam aggregation chamber; and liquid outlet means for outletting treated liquid from the base of the fractionation column; the method comprising:
- 15 inletting liquid containing waste under pressure into the fractionation column at first and second intermediate locations from a common source, the second location being lower than the first location;
- injecting a waste reducing gas such as air, oxygen or ozone into the liquid immediately prior to inletting the same into the fractionation column at the second intermediate location; and
- 20 regulating the flow of liquid being inlet at the first intermediate location to maintain the liquid within the fractionation column at an optimum level for enabling foam having waste adsorbed thereto to aggregate in the aggregation chamber.
5. An improved method as claimed in claim 4, wherein said waste reducing gas is
25 a mix of oxygen and ozone.
6. An apparatus for separating liquid containing particles of varying mass or specific gravity comprising:





an elongated passageway having: (a) a leading wall with a primary lip for liquid containing said particles to flow over into said passageway; (b) a trailing wall with secondary lip disposed lower than said primary for liquid to flow over and out of said passageway; and (c) a base closing the bottom of said passageway to enable the liquid flowing into the passageway over said primary lip to fill the same and flow out over the secondary lip;

flow diverting means disposed in said passageway for diverting the liquid flow therein to create a convolving recirculating portion of laminar flow and a discharging portion of laminar flow of liquid within the passageway; and

liquid extraction means to extract liquid containing particles of lower mass or specific gravity entrained within said recirculating portion therefrom, leaving liquid containing particles of waste to flow out of said passageway and over the secondary lip.

7. An apparatus as claimed in claim 6, wherein said flow diverting means comprises a circular pipe disposed in parallel and spaced relationship to the longitudinal extent of the walls and base.

8. An apparatus as claimed in claim 7, wherein said circular pipe is disposed closer to the base and the trailing wall than to the leading wall and the lips.

9. An apparatus as claimed in claim 7 or 8, wherein said liquid extracting means comprises a plurality of rectilinearly aligned holes disposed axially along the suction pipe at spaced apart locations and suction means to apply a negative pressure to the inside of the circular pipe to draw liquid from said recirculating portion.

10. An apparatus as claimed in claim 9, wherein said holes are disposed in the half of the pipe confronting the leading wall to repose in the recirculating portion of the liquid within the passageway.





11. An apparatus as claimed in claim 10, wherein said holes are disposed in the upper quartile of said half of the pipe.
12. An apparatus as claimed in claim 11, wherein said holes are disposed at approximately 45° from the vertical.
- 5 13. An apparatus as claimed in any of claims 6 to 12, wherein said liquid extraction means is connected to the inlet of a fractionation/flotation system for removing waste including said particles entrained within the extracted liquid therefrom.
14. An apparatus as claimed in claim 13, wherein said fractionation/flotation
10 system is as claimed in any one of claims 1 to 3.
15. An apparatus as claimed in any one of claims 6 to 14, wherein said secondary lip directs discharged liquid to a filtering means.
16. An apparatus as claimed in claim 15, wherein said filtering means is a biofilter.
17. A method for separating liquid containing particles of varying mass or specific
15 gravity comprising:
- cascading liquid containing said particles over a primary lip into a passageway;
- diverting the flow of the liquid within the passageway to create a convolving recirculating portion of laminar flow and a discharging portion of laminar flow;
- extracting liquid containing particles of lower mass or specific gravity entrained
20 within said recirculating portion therefrom; and
- discharging liquid containing particles of higher mass or specific gravity entrained within said discharging portion out of said passageway over a secondary lip.



18. An improvement in a fractionation/flotation system for removing waste such as biosolids, nitrates or nitrites from a liquid containing same substantially as herein described with respect to the drawings as appropriate.
19. An improved method for controlling the removal of waste such as biosolids, nitrates or nitrites from a liquid containing same using a fractionation/flotation system substantially as herein described with reference to the accompanying drawings as appropriate.
20. An apparatus for separating liquid containing particles of varying mass or specific gravity substantially as herein described with reference to the accompanying drawings as appropriate.
21. A method for separating liquid containing particles of varying mass or specific gravity substantially as herein described with reference to the accompanying drawings as appropriate.

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