

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
4 March 2004 (04.03.2004)

PCT

(10) International Publication Number
WO 2004/017726 A1

(51) International Patent Classification⁷: **A01K 63/04**,
61/00

(21) International Application Number:
PCT/IB2003/003471

(22) International Filing Date: 22 August 2003 (22.08.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2002/6718 22 August 2002 (22.08.2002) ZA

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(81) Designated States (national): AE, AG, AL, AM, AT, AU,
AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU,
CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH,
GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC,
LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW,
MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC,
SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA,
UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

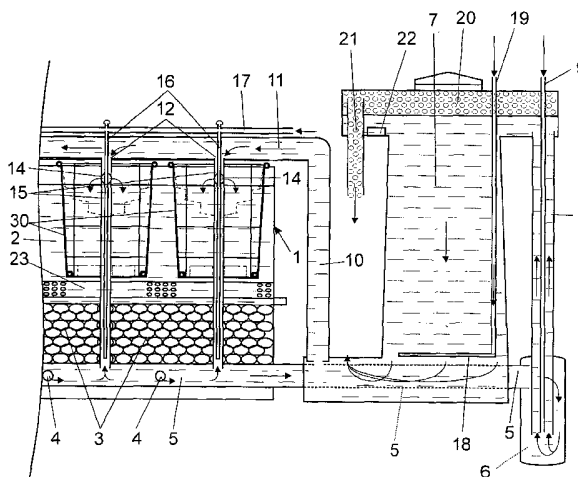
(84) Designated States (regional): ARIPO patent (GH, GM,
KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),
Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),
European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE,
ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO,
SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM,
GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— as to applicant's entitlement to apply for and be granted
a patent (Rule 4.17(ii)) for the following designations AE,
AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA,
CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES,
FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE,
KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD,
MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH,

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(54) Title: WATER RECYCLING AQUACULTURAL EQUIPMENT AND ITS APPLICATION



(57) Abstract: An aquaculture tank assembly is provided comprising an open topped tank (1) having formed in a lower region thereof a biofilter (3), a water outlet assembly (4,5) located at or towards a bottom of the biofilter, a protein skimmer (7), and a water return arrangement (11,14) for returning water from the protein skimmer to the aquaculture tank. At least one, and typically a series of upwardly extending airlift pipes (15) is provided for lifting a portion of the water that has operatively passed through the biofilter to an elevated position within the tank by an airlift process so as to return said portion of the water directly to an upper region of the aquaculture tank and simultaneously aerate it. The balance of water that has operatively passed through the biofilter is passed through the protein skimmer prior to return to the aquaculture tank. Preferably about 25 to 50% of the recycled water is passed through the protein skimmer with the balance being recycled directly from the bottom of the biofilter by way of the upwardly extending airlift pipes. In a preferred form a solids collection facility (23) is provided above the biofilter for collecting and enabling periodic discharge of solids including faeces.



PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)

— of inventorship (Rule 4.17(iv)) for US only

Published:

— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WATER RECYCLING AQUACULTURAL EQUIPMENT AND ITS APPLICATION

5 FIELD OF THE INVENTION

This invention relates to water recycling aquacultural equipment suitable for use in the culturing of aquatic species including fish and marine organisms that may be of a type that grow and develop on submerged surfaces, but are
10 not necessarily so. The invention also relates to the application of such equipment to the production of aquatic species and.

More particularly, but not exclusively, the invention relates to aquacultural equipment that is especially suitable in application to the culturing of abalone
15 but that may find application in the culturing of numerous other types of aquatic organisms as well as fish, depending on the configuration of the tank used and the nature of the particular aquatic species.

It is to be noted that, because of its particular economic significance, the
20 culturing of abalone will be discussed in particular in the specification. It will, however, be apparent to those skilled in the art that the equipment and application thereof discussed in this specification can be used for the culturing of numerous other aquatic species including fish and the scope of this invention is not intended to be limited in any way by the reference to
25 abalone.

BACKGROUND TO THE INVENTION

The culture of aquatic species, and in particular abalone, has long been
30 practised to some extent and, more recently, to an appreciably increasing extent. Many such culture facilities, from the point of view of the supply of clean aerated water (seawater in the case of marine species) simply draw

water on a continuous basis and discharge used water to waste, generally back into the body of water from which it was originally drawn, after it has passed through the culture facility.

- 5 This practice has come to be regarded by many as unacceptable not only from a pollution point of view, but also from an economic point of view in that a substantial amount of water needs to be supplied to a facility operating on this basis and the cost of pumping it is generally significant.
- 10 The tendency has therefore been towards facilities in which the water is recirculated with possibly a small bleed stream being discarded and a small make-up stream of fresh water or seawater being provided. In many, if not all cases, in particular in the instance of marine species such as abalone, the recycled water needs to be treated for the removal of nitrogen, typically
- 15 released in the form of ammonia, and the removal of protein.

The nitrogen is commonly removed using a biofilter that is generally contained in a separate container although, in one prior art arrangement, it has been located in the bottom of the aquaculture tank. In either

20 arrangement, water is drawn through the biofilter and passed through a separate protein skimmer in order to remove the protein. The water is thereafter returned to the tank. Typical of such an arrangement is that described in US patent 5,961,831 to Lee et al.

- 25 With further reference to the equipment used, aquaculture is, in appropriate instances, often conducted in tanks in which a series of removable aquaculture containers, often referred to as baskets, are positioned. Each aquaculture container has an assembly of a series of generally vertical, spaced, parallel plates located in the container and on the surface of which
- 30 abalone or other organisms are cultivated. In the arrangement referred to above in which a biofilter is positioned in the bottom of the tank, these containers have perforated bottom walls; are open at the top; and have

impervious sidewalls. The recycled water flows in at the top; over the plates; through the perforated bottom wall of the container; through the biofilter; through the protein skimmer and back to the tank. In instances in which the biofilter is separate from the tank, it is sometimes positioned downstream of the protein skimmer, as in the case of the arrangement of Lee et al referred to above.

Whatever the aquatic species being grown, the requirements for enabling water to be effectively recycled are very much the same in that both the function of a biofilter and the function of the protein skimmer are required.

OBJECT OF THE INVENTION

It is an object of this invention to provide equipment having an enhanced water circulation and purification system that renders the recycling of water in an aquacultural tank installation both effective and efficient.

It is another object of the invention to provide aquacultural equipment that is particularly suitable for the culture of abalone or other organisms in tanks, particularly, but not exclusively, organisms that grow and develop on submerged surfaces of the general type outlined above.

SUMMARY OF THE INVENTION

In accordance with this invention there is provided an aquaculture tank assembly comprising an open topped tank having formed in a lower region thereof a biofilter, a water outlet assembly located at or towards a bottom of the biofilter, the water outlet assembly being arranged to feed water from the biofilter to a protein skimmer, and a water return arrangement for returning water from the protein skimmer to the aquaculture tank, the aquaculture tank assembly being characterized in that at least one upwardly extending airlift pipe is provided for lifting a portion of the water that has operatively passed

through the biofilter to an elevated position within the tank by an airlift process so as to aerate said portion of the water and return it directly to an upper region of the aquaculture tank and the said water outlet assembly communicates with the biofilter to provide a path for the balance of water that
5 has operatively passed through the biofilter to pass it to the protein skimmer preparatory to its return to the aquaculture tank.

Further features of the invention provide for there to be a series of upwardly extending airlift pipes positioned to collectively return said portion of water
10 directly to the upper region of the aquaculture tank; for the airlift pipes to communicate at their upper ends with transverse distribution pipes typically located at or above the operative water level of the aquaculture tank; for the transverse distribution pipes and the airlift pipes to communicate also with a main return pipe from the protein skimmer such that water elevated directly
15 from the biofilter and water passed through the protein skimmer are delivered together to the upper region of the aquaculture tank; for the water outlet assembly to include a transfer pipe with which communicates an arrangement of collector pipes in the lower region of the biofilter for drawing water downwardly through the biofilter; for the lower ends of the airlift pipes
20 to communicate with the interior of the transfer pipe at spaced positions along its length; and for approximately 25 to 50%, and preferably about 33% of the recycled water to be passed through the protein skimmer with the balance being recycled directly from the bottom of the biofilter by way of the upwardly extending airlift pipes.

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Still further features of the invention provide for the aquaculture tank to be of elongate shape in plan view in which case the transfer pipe and main return pipe extend centrally along the length of the tank in plan view; for the tank to operatively receive a series of aquaculture containers above the biofilter in
30 which case the water distribution pipes preferably extend over the aquaculture containers and are adapted to distribute return water over substantially the entire length of each aquaculture container; for the protein

skimmer to be located externally of the tank; for the protein skimmer to operate on the basis of an airlift combined with a froth flotation process; and for froth generated in the protein skimmer to be discarded.

- 5 It will, of course, be understood that in each case in which an airlift is used, simultaneous transport and re-aeration of the water that has passed through the biofilter takes place. This water is inherently depleted of oxygen in consequence of the action of the biofilter.
- 10 It is a particular feature of the invention that a solids collection facility be positioned above the biofilter and, in the case that aquaculture containers are present, between the bottom of the aquaculture containers and the biofilter. Such solids collection facility may comprise a plurality of juxtaposed elongate channels having downwardly convergent walls that terminate in a gutter at
- 15 the bottom of the channel with the entrance to the gutter being restricted so that an elongate closure can be supported by the entrance to the gutter. The entrance to the gutter is generally open with the elongate closure raised so that solids collect in the gutter itself.
- 20 From time to time the elongate closure may be lowered to close the entrance to the gutter and the solids that have accumulated may be withdrawn, typically by suction, for disposal. Provision is made for the flow of water through, or past the layer of channels, and in the case that aquaculture containers are present, the sides of the channels can be perforated in
- 25 between adjacent aquaculture containers. Alternatively, adjacent edges of sides of the channels could overlap, in plan view, with a transverse gap between the edges of adjacent channels in which case flow of water takes place between such edges.
- 30 In the event that the aquaculture tank assembly of this invention is employed with aquaculture containers, those containers are preferably as set forth in my co-pending patent application of even date and entitled "AQUACULTURE

CONTAINER AND COMPONENTS THEREOF". Briefly, that application discloses an aquaculture container element in the form of a panel having a surface suitable for the growth of abalone or other organisms thereon wherein the panel has extending along two opposite side edges an integral
5 sidewall section with the two sidewall sections each having a free edge lying in a plane that is parallel to the panel but spaced therefrom. The panel and sidewall sections are such that the free edges of the sidewall sections can be engaged with another similar container element in a series thereof to form a series of parallel panels held in spaced relationship by means of said
10 sidewall sections that together define composite aquaculture container sidewalls. Various additional features of those panels are described in my said co-pending patent application, and the disclosure of that patent application is included herein by reference.

15 In order that the above and other features of the invention may be more fully understood one embodiment thereof, and its application in an aquaculture tank assembly used together with aquaculture containers that are particularly suitable for growing abalone, will now be described with reference to the accompanying drawings.

20

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:-

25 Figure 1 is a schematic perspective illustration of an aquaculture tank assembly employing, in this particular case, aquaculture containers in a system particularly adapted for the growth of abalone, and being partly empty for illustrative purposes;

30 Figure 2 is a plan view thereof;

Figure 3 is a perspective illustration showing an assembly of container elements forming a composite aquaculture container suitable for use in the aquaculture tank assembly according to the invention; with

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Figure 4 is a schematic cross-section taken through the tank illustrated in Figures 1 and 2;

Figure 5 is a detailed cross-section of two juxtaposed channels of a solids collection facility showing the gutter in its normally open condition;

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Figure 6 is the same as Figure 5 but illustrating the gutter in its closed, solids removal condition;

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Figure 7 is a side view of a part of the length of a solids collection channel;

Figure 8 illustrates in cross-section an alternative to the provision of the holes illustrated in Figure 7; and,

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Figure 9 is a longitudinal section taken through the end of the aquaculture tank to which is connected the protein skimmer.

25 DETAILED DESCRIPTION WITH REFERENCE TO THE DRAWINGS

In this embodiment of the invention an elongate, open topped, generally squat aquaculture tank (1) has an upper region (2) for the conduct of the culturing of aquatic species and a lower region that is formed into a bed (3) of biofilter material that is adapted to act on the excess nitrogen formed in the water, in the normal way. At the bottom of the biofilter is a series of laterally extending collector pipes (4) communicating with a single longitudinally

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extending transfer pipe (5) of relatively substantial diameter. The collector pipes and transfer pipe together formed the outlet assembly referred to above.

- 5 The transfer pipe (5), as shown in Figure 9, communicates with an external sump (6) that is located adjacent an external upright protein skimmer (7) at one end of the tank, the sump extending somewhat below the bottom of both the tank and the skimmer. The arrangement is such that an advantageous height is achieved for an airlift pipe (8) that operates to lift the water drawn in
10 through the transfer pipe to the top of the protein skimmer. Air for the airlift is supplied through an air pipe (9) that is positioned within the airlift pipe (8).

The bottom of the protein skimmer is connected by way of a vertical connecting pipe (10) with a longitudinally extending return pipe (11) that is
15 located centrally above the longitudinal axis of the tank. The return pipe has a series of downwardly directed outlets (12) each of which communicates with a four way connector (13) to which is connected a pair of oppositely directed horizontal distribution pipes (14) and the upper end of a vertical airlift pipe (15). The lower end of each of the vertical airlift pipes opens into the
20 transfer pipe (5), typically between collector pipes (4).

The air supply for the vertical airlift pipes (15) is by way of a small diameter air pipe (16) positioned within the relevant airlift pipe. Each of these air pipes (16) passes, in its upper region, through the return pipe and thence through
25 an air supply pipe (17) located above the return pipe and extending along the length thereof. The small diameter air pipe (16) has, in each case, lateral perforations whereby air can pass from the air supply pipe into the small diameter air pipe. The upper end of each small diameter air pipe that is located above the air supply pipe is fitted with a plug in order to close it. This
30 arrangement is highly advantageous in that the air pipe can be withdrawn at any time in order to unblock its lower end, for example, or easily replace it for whatever reason.

The water recirculation circuit is thus from the upper region (2) of the tank; through the biofilter (3); into the lateral collector pipes (4) and thence into the longitudinally extending transfer pipe (5) at the bottom of the tank.

5 Part of the water in the transfer pipe is extracted by the airlift pipes (15) that each extracts a portion of the water and lifts it, whilst aerating it, to the four way connector (13) from whence it is split to flow two ways into the two laterally extending horizontal distribution pipes (14). In practice, as at the present time, and as applied to be culturing of abalone, it appears that
10 approximately two-thirds of the total water collected by the collector pipes may be returned to the tank via the airlift pipes directly to the upper region of the tank whilst approximately one third proceeds along the transfer pipe and through the protein skimmer. Different proportions may well apply to different aquatic species being cultured.

15 At the protein skimmer, the water from the transfer pipe enters the sump; is elevated by the airlift pipe (8) to an upper region of the skimmer and thence flows downwards through the skimmer in counter-current fashion to air introduced towards the bottom of the skimmer through an air ring (18)
20 supplied by a downwardly extending air pipe (19). This is a substantially conventional operation of the protein skimmer that operates on a froth flotation principle. Water that has passed through the skimmer proceeds up the vertical connecting pipe (10) and into the return pipe (11) from whence it becomes distributed to the various outlets (12) and thence to the four way
25 connectors (13) and laterally extending distribution pipes (14).

It will be quite clear that the distributed return water from the protein skimmer becomes mixed, in this way, with the water that has been conveyed directly up the airlift pipes (15). This is considered to be advantageous in order to
30 ensure that the water delivered to each part of the tank is of the same overall composition and contains the same amount of oxygen. It is to be noted that the oxygen content of the water leaving the protein skimmer is generally

higher than that of the water that is directly airlifted by way of the airlift pipes (15).

It is to be noted that, in order to ensure an equal distribution of the two
5 separately recycled portions of water, the transfer pipe and return pipe each
have a substantial diameter relative to the individual collector pipes, airlift
pipes and distribution pipes so that a substantially even distribution of water
drawn through the collector pipes and delivered through the distribution pipes
is achieved as a result of the fact that there is substantially no relevant
10 pressure drop along the length of the transfer pipe and return pipe.

Froth (20) that develops in the top of the protein skimmer, exits to waste via a
discharge pipe (21) communicating with the top of the skimmer.

15 It is also to be mentioned that tablets or chemicals in any other form, that are
known in the art for the purpose of stabilising the pH and correcting alkalinity
can conveniently be located within the body of water in the top of the
skimmer, typically at a position such as that indicated by numeral (22).

20 Still further, whilst not being illustrated, it will be clear to those skilled in the
art that make-up water will be added either continuously, or from time to time,
and an overflow or bleed stream of the water in the tank could be discharged
to waste in the normal manner to avoid any undesirable buildup of dissolved
materials, in particular nitrates.

25

In one practical implementation of the invention it has been found that with a
water content of a tank being about 10 cubic metres (about 2600 US
gallons), water recirculation is carried out at a rate that results in the water in
each container being changed every five to ten minutes, typically about every
30 8 minutes. In this case, make-up and overflow (bleed) streams of about 0.1 -
0.2 cubic metres/hour (about 26 - 52 gallons/hour) operates effectively to
maintain water chemistry at satisfactory levels.

In a preferred application of the invention, a solids collection facility is provided for solids such as faeces and this facility may, for example, assume the form of a series of generally horizontal juxtaposed channels (23) that substantially cover the top of the biofilter. These channels each have, in
5 cross-section, a downwardly convergent configuration in the basic form of a Vee, with the bottom opening, by way of a restricted entrance (24), into a generally circular cross-sectioned gutter (25). The angle at which the sides of the channels converge is chosen such that solids falling on the surfaces will slide down them into the gutter.

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In order to enable the removal of accumulated solids to take place, each of the restricted entrances has associated with it a longitudinally extending, elongate closure (26) that is adapted to be held, either by virtue of buoyancy, or mechanically, in an elevated position such as is illustrated in Figure 5
15 during normal operation of the tank. Each of the elongate closures can be lowered into a position in which it closes the associated entrance (24), periodically, in order to remove the solids within the gutter, typically by flow out through a manifold (27) that interconnects all of the gutters. Flow of water into the gutters takes place from the end opposite the manifold so that
20 there is a constant flow along the entire length of the gutter. This arrangement ensures removal of the solids along the entire length of the gutter. The elongate closures could be heavier than water and held off the entrances by any mechanical means or, they may be hollow so that, when filled with the air, they are buoyant, and if filled with water they sink in order
25 to close the entrances to the gutters. Many different possibilities are envisaged.

In order to enable the flow of water to take place past the channels, the sides of the channels can be provided, as shown in Figure 7 with holes (28)
30 through them in regions in which solids are unlikely to fall upon them. Alternatively, as shown in Figure 8, the sides of the channels could be configured to overlap whilst leaving a vertical gap (29) between them for the

flow of water yet providing an uninterrupted catchment surface for solids, in plan view.

It will be understood that, in this way, solids, and in particular faeces, are
5 collected in the gutters and withdrawn for disposal from time to time, as may be required.

It is to be mentioned that, in this particular embodiment of the invention the aquaculture tank is designed to receive a series of composite containers or
10 so-called baskets (30) in which marine species are to be cultivated and, in this particular application of the invention, abalone. In this particular case the containers are arranged in two rows of ten containers each with the length of the containers being transverse to the length of the tank.

15 The containers are conveniently those made according to my co-pending patent application referred to above and are as illustrated in Figure 3. Each thus has a circular hole (31) in the one end wall (32); an imperforate end wall (33) at the other end; and a pair of frame members (34) extending outwards from the latter end and serving to interconnect the individual plastics
20 elements (35). Engagement of a hole (31) with the cross piece (13) supports the one end of each container, in each case, and the pair of frame members (34) resting on the edge of the tank support the other end of each container. The associated distribution pipe (14) therefore extends through the hole (31), as well.

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In this instance therefore, there is one horizontal distribution pipe (14) that extends centrally over each of the containers and, clearly, one airlift pipe for each pair of distribution pipes. There are thus ten airlift pipes equally spaced apart along the length of the transfer pipe and return pipe and twenty laterally
30 extending distribution pipes. With this arrangement, the sides of the gutters are perforated in between the containers as shown most clearly in Figure 9. For more detail on the construction of the containers and the effective use

thereof, reference can be had to my said co-pending patent application. For the purposes of this patent application, that is primarily concerned with the purification and recycling of the water, the foregoing will enable any person skilled in the art to implement the invention without any difficulty.

It will be understood that numerous variations may be made to the embodiment of the invention described above without departing from the scope hereof. In particular, the tank could be used without any containers to cultivate fish, crustaceans or other species not needing a submerged surface on which to live, such as abalone, and the configuration of the containers could be varied to suit any other type of aquatic species.

Also, the exact nature of the solids collection facility could be varied widely, and could indeed be omitted although such an omission would give rise to existing problems, in particular, temporary removal of the species being cultivated.

Numerous other variations may be made to the embodiment of the invention described above which is only intended to be illustrative of the invention.

CLAIMS:

1. An aquaculture tank assembly comprising an open topped tank (1) having in a lower region thereof a biofilter (3), a water outlet assembly (4,5) located at or towards a bottom of the biofilter, the water outlet assembly being arranged to feed water from the biofilter to a protein skimmer (7), and a water return arrangement (11,14) for returning water from the protein skimmer to the aquaculture tank, the aquaculture tank assembly being characterized in that at least one upwardly extending airlift pipe (15) is provided for lifting a portion of the water that has operatively passed through the biofilter to an elevated position within the tank by an airlift process so as to aerate said portion of the water and return it directly to an upper region of the aquaculture tank and the said water outlet assembly communicates with the biofilter to provide a path for the balance of water that has operatively passed through the biofilter to pass it to the protein skimmer preparatory to its return to the aquaculture tank.
2. An aquaculture tank assembly as claimed in claim 1 in which there are a series of upwardly extending airlift pipes positioned to collectively return said portion of water directly to the upper region of the aquaculture tank.
3. An aquaculture tank assembly as claimed in either one of claims 1 or 2 in which the airlift pipes communicate at their upper ends with transverse distribution pipes (14) located at or above the operative water level of the aquaculture tank.
4. An aquaculture tank assembly as claimed in claim 3 in which the transverse distribution pipes and the airlift pipes communicate also with a main return pipe (11) from the protein skimmer such that water elevated directly from the biofilter and water passed through the protein

skimmer are together delivered to the upper region of the aquaculture tank.

- 5 5. An aquaculture tank assembly as claimed in any one of the preceding claims in which the water outlet assembly includes a transfer pipe (5) with which communicates an arrangement of collector pipes (4) in the lower region of the biofilter for drawing water downwardly through the biofilter.
- 10 6. An aquaculture tank assembly as claimed in claim 5 in which the lower ends of the airlift pipes communicate with the interior of the transfer pipe at spaced positions.
- 15 7. An aquaculture tank assembly as claimed in any one of the preceding claims in which approximately 25 to 50% of the recycled water is to be passed through the protein skimmer with the balance being recycled directly from the bottom of the biofilter by way of the upwardly extending airlift pipes.
- 20 8. An aquaculture tank assembly as claimed in any one of the preceding claims in which the aquaculture tank is of elongate shape in plan view in which case the transfer pipe and main return pipe extend centrally along the length of the tank in plan view.
- 25 9. An aquaculture tank assembly as claimed in any one of the preceding claims in which the tank operatively receive a series of aquaculture containers (30) above the biofilter in which case the water distribution pipes extend over the aquaculture containers and are adapted to distribute return water over substantially the entire length of an
30 aquaculture container.

10. An aquaculture tank assembly as claimed in any one of the preceding claims in which the protein skimmer is located externally of the tank and operates on the basis of an airlift (8) combined with a froth flotation process.
- 5
11. An aquaculture tank assembly as claimed in any one of the preceding claims in which a solids collection facility (23) is positioned above the biofilter.
- 10
- 12.. An aquaculture tank assembly as claimed in claim 11 in which the solids collection facility comprises a plurality of juxtaposed elongate channels (23) each having downwardly convergent walls that terminate in a gutter (25) at the bottom of the channel with the entrance (24) to the gutter being restricted, and an elongate closure (26) adapted to be supported
- 15
- by the entrance to the gutter to close it selectively from time to time and wherein means are provided for holding the closure in a raised position relative to the entrance and allowing it to move into contact with the entrance selectively.
- 20
13. An aquaculture tank assembly as claimed in either one of claims 11 or 12 in which provision is made for flow of water through, or past the channels, such provision being selected from perforations (28) through the sides of the channel and an overlap of adjacent sides of the channels with a vertical gap (29) between the overlapped sides.

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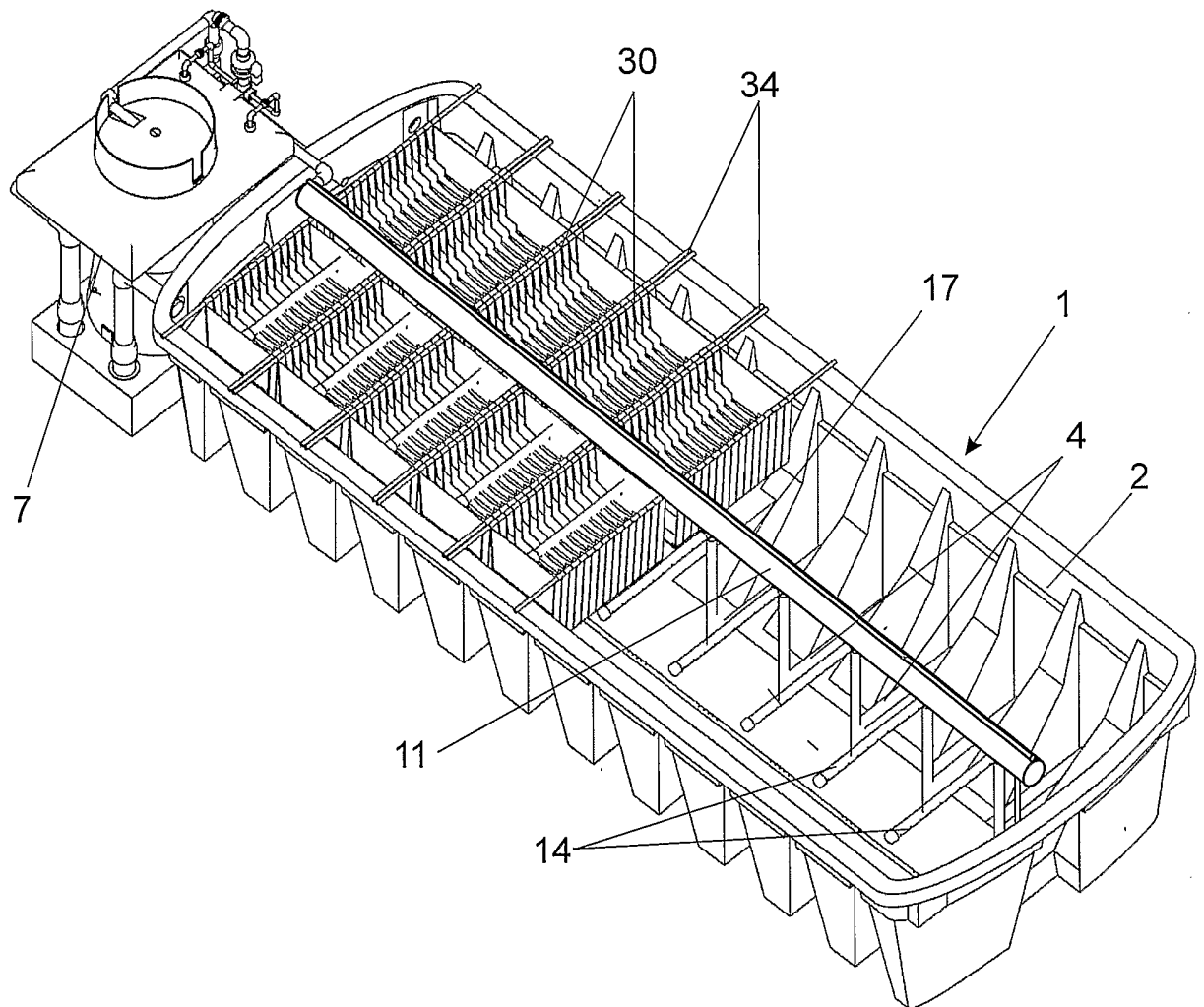


Figure 1

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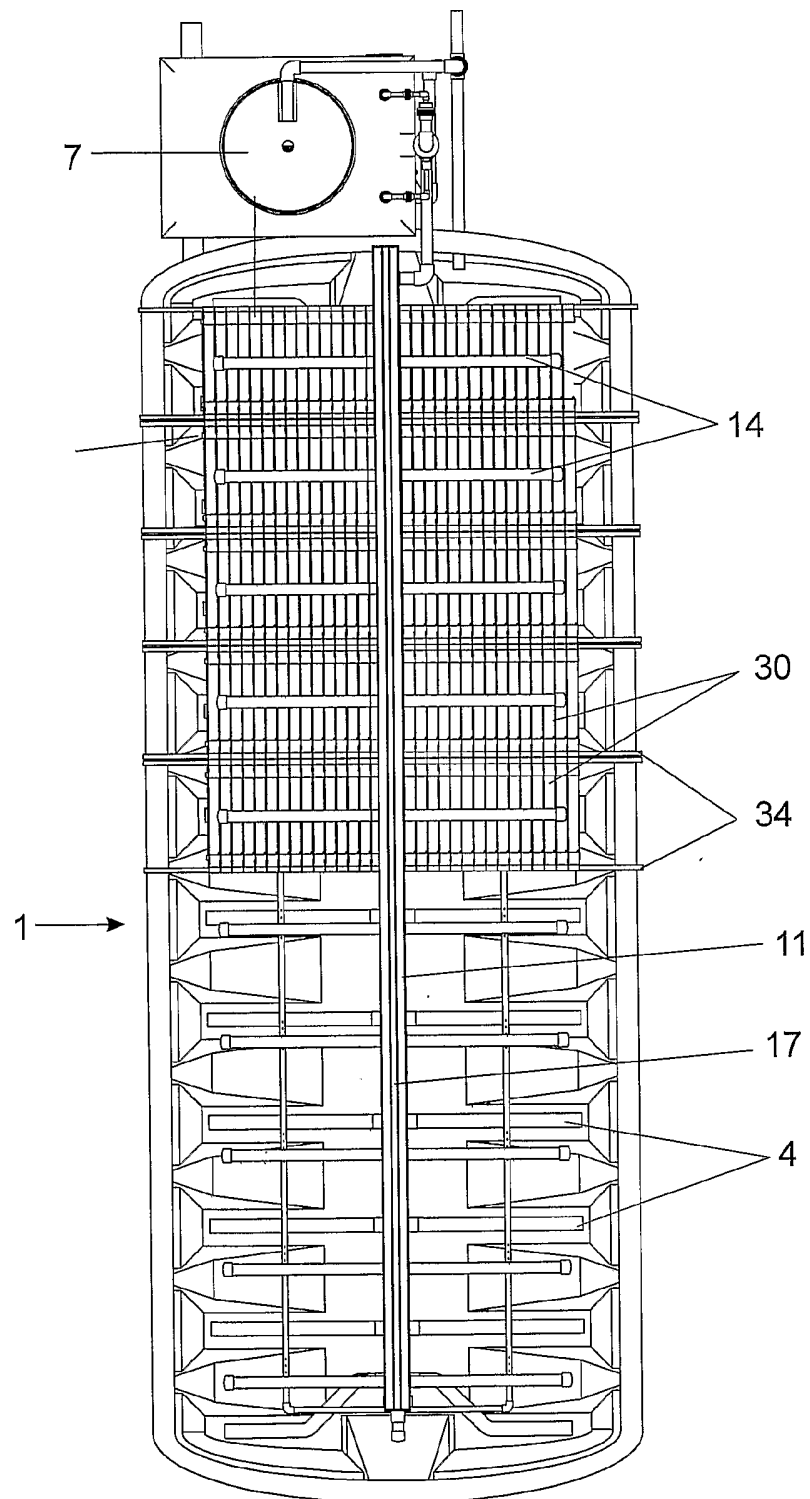


Figure 2

3 / 4

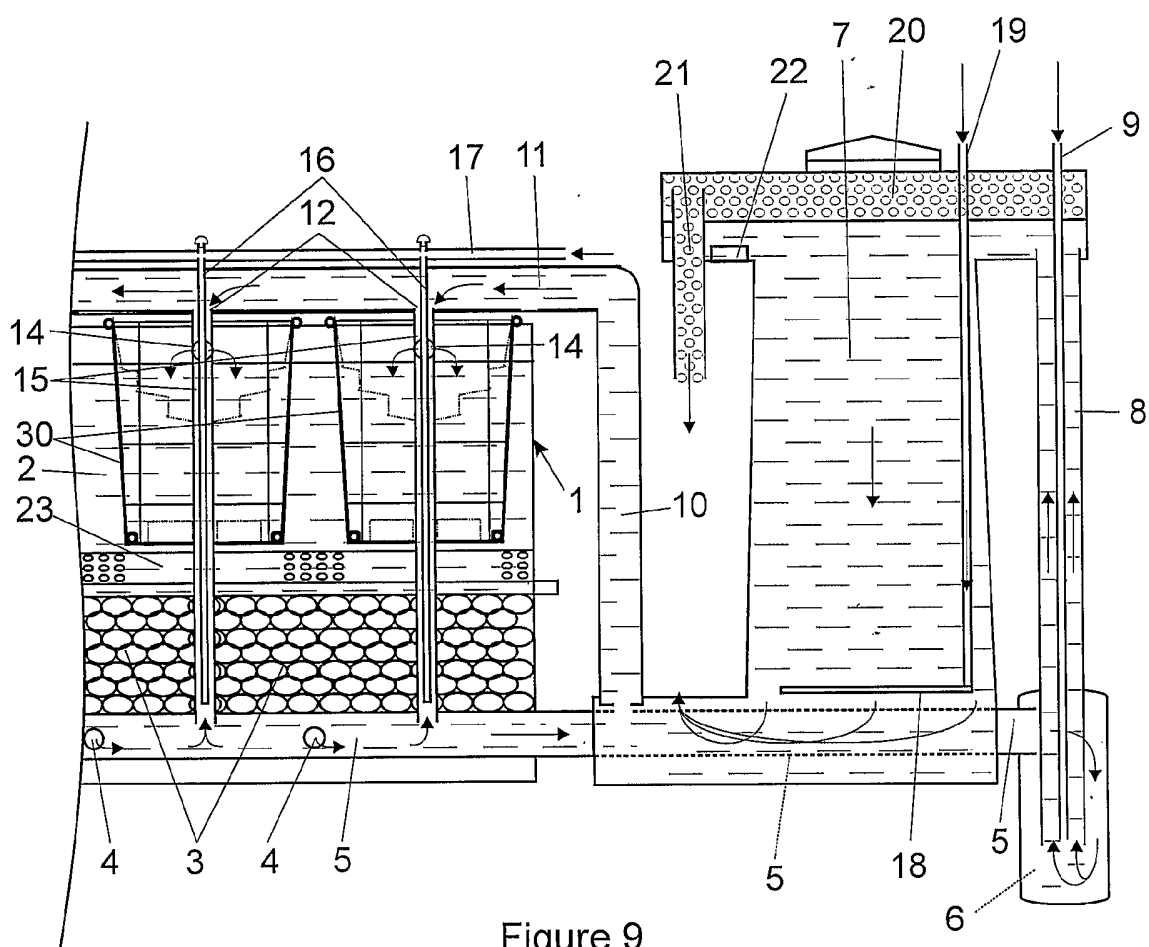


Figure 9

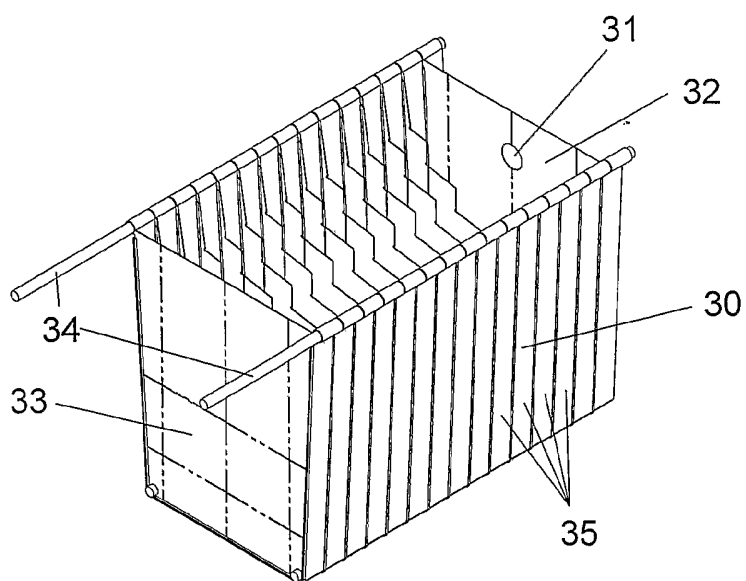


Figure 3

4 / 4

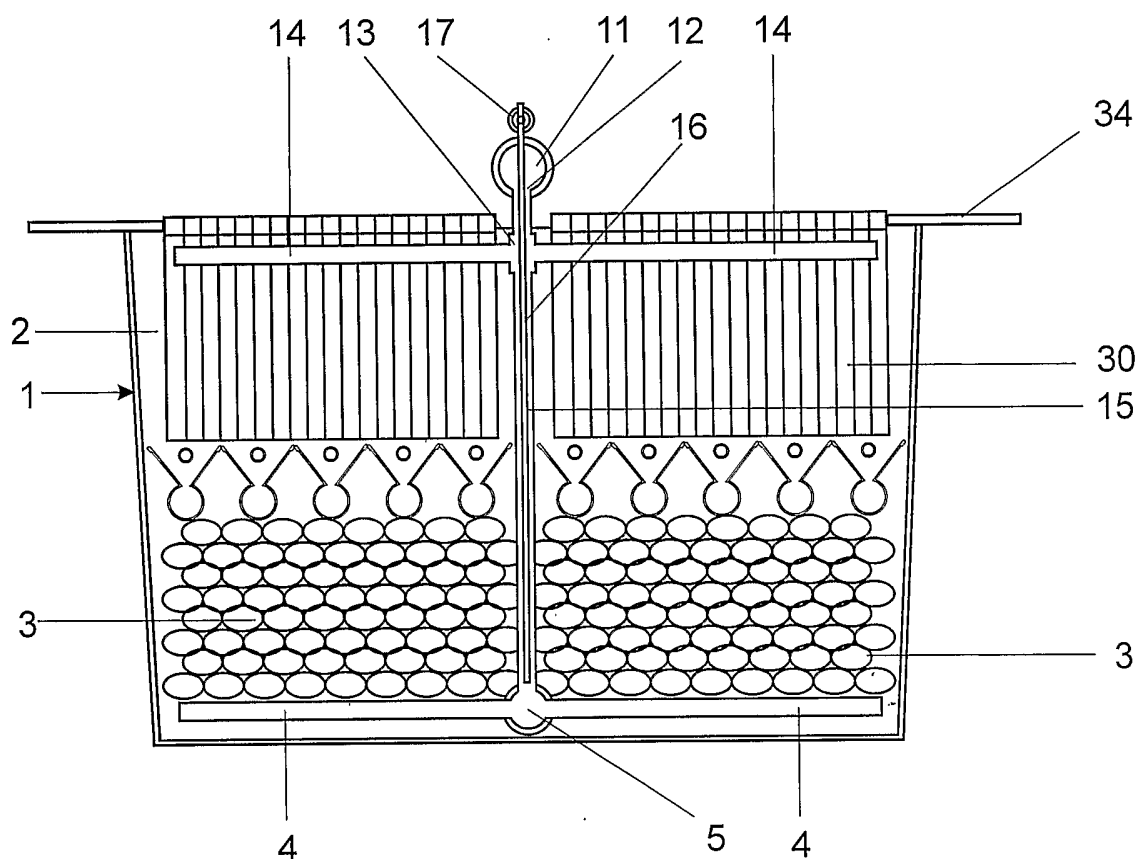


Figure 4

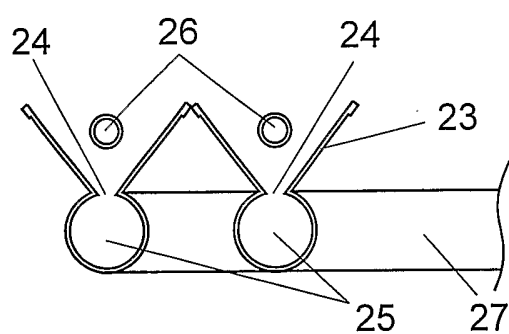


Figure 5

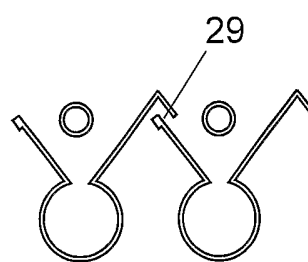


Figure 8

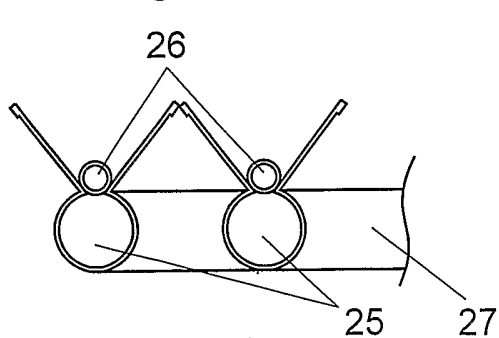


Figure 6

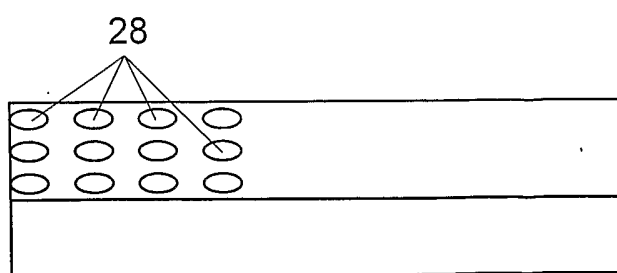


Figure 7

INTERNATIONAL SEARCH REPORT

PCT/IB 03/03471

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 A01K63/04 A01K61/00

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 A01K

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DATABASE WPI Section PQ, Week 199950 Derwent Publications Ltd., London, GB; Class P14, AN 1999-583005 XP002258301 & ES 2 135 323 A (INSUINA SL), 16 October 1999 (1999-10-16)	1,2,5,8, 10,13
A	abstract; figures	3,4,6,7, 9,11-13
X	US 4 556 485 A (OGAWA YONEKICHI) 3 December 1985 (1985-12-03)	1
A	column 2, line 41 -column 9, line 68; figures	2-13
	--- -/--	



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

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Date of the actual completion of the international search

17 October 2003

Date of mailing of the international search report

29/10/2003

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 97 49279 A (LEE PHILLIP G ;TURK PHILIP E (US); UNIV TEXAS (US); WHITSELL ANDRE) 31 December 1997 (1997-12-31) cited in the application column 5, line 35 -column 7, line 52; figures -----	1-13

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			US	5961831 A	05-10-1999