US 20120125940A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2012/0125940 A1

(43) Pub. Date: May 24, 2012

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(54) TRIPLE DRAIN APPARATUS FOR AN AQUACULTURE RECIRCULATION SYSTEM

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(21) Appl. No.: **13/322,736**

(22) PCT Filed: **Jun. 17, 2009**

(86) PCT No.: **PCT/CA2009/000844**

§ 371 (c)(1), (2), (4) Date: **Nov. 28, 2011**

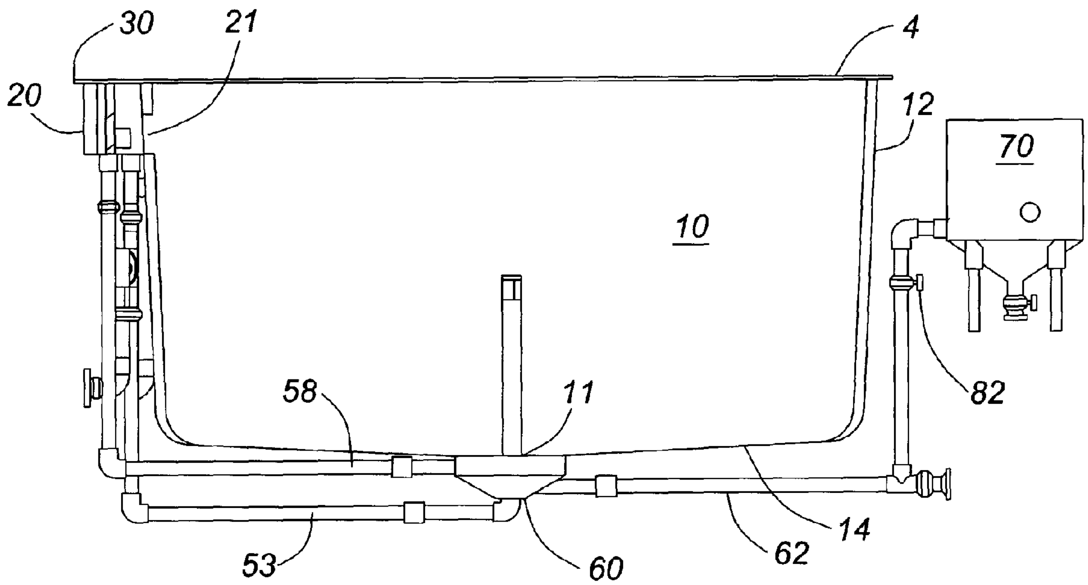
Publication Classification

(51) **Int. Cl.**
B65D 6/40 (2006.01)

(52) **U.S. Cl.** **220/601**

(57) **ABSTRACT**

Triple drain apparatus for an aquaculture system tank for reducing water input requirements and minimizing breakdown of solids whereby the solids are larger and more concentrated when removed from a solids settling device. Water flow is split by the apparatus into a side box fluid stream which flows into a side box coupled to the tank, and both a clean fluid stream and a high solids fluid stream which flow into a center drain. The center drain comprises a central stand pipe coupled to a clean water outlet, a sump coupled to a high solids fluid outlet and a collection plate separating the tank and the sump. The center drain may include a mortality trap coupled to a mortality outlet and the sump, whereby the collection plate separates the mortality trap from the sump, to provide means for easily removing dead fishes and large debris from the tank.



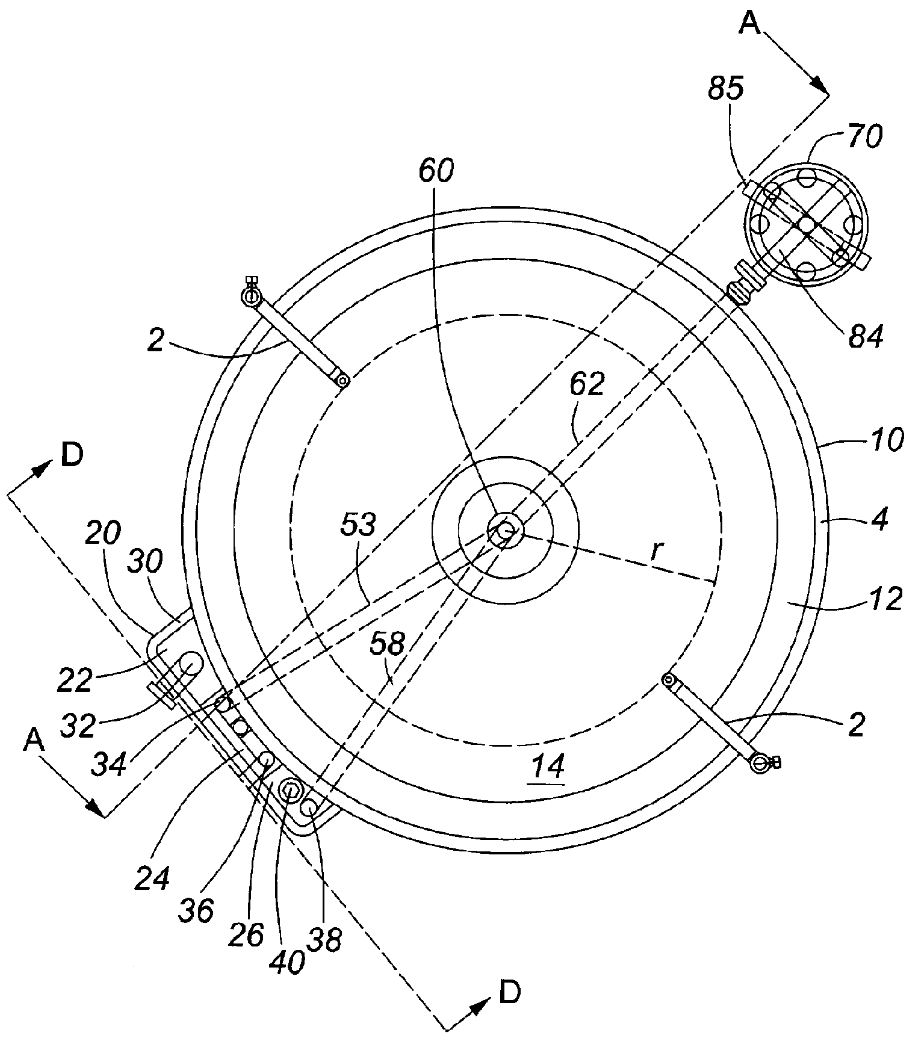


FIG. 1

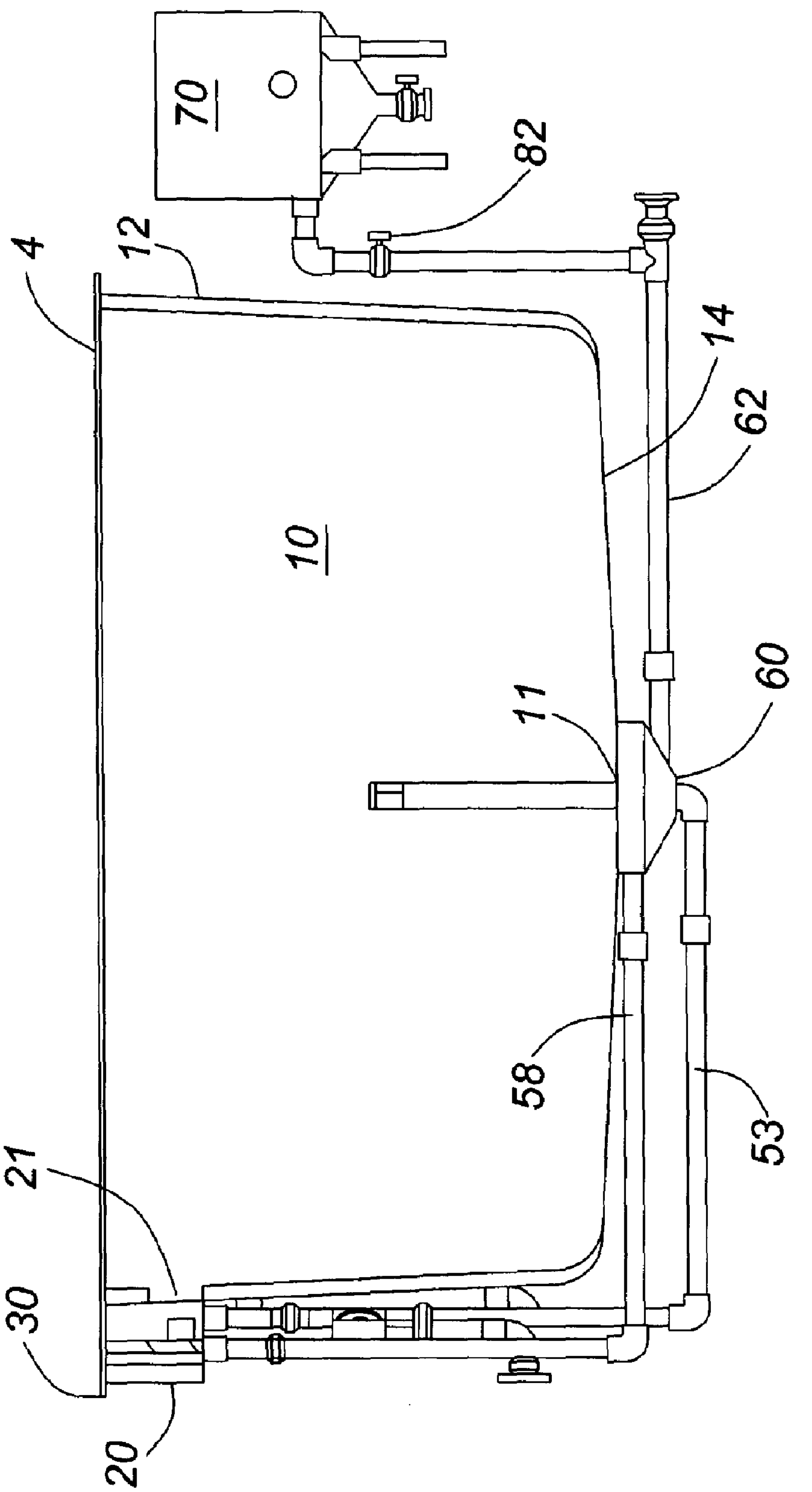


FIG. 2a

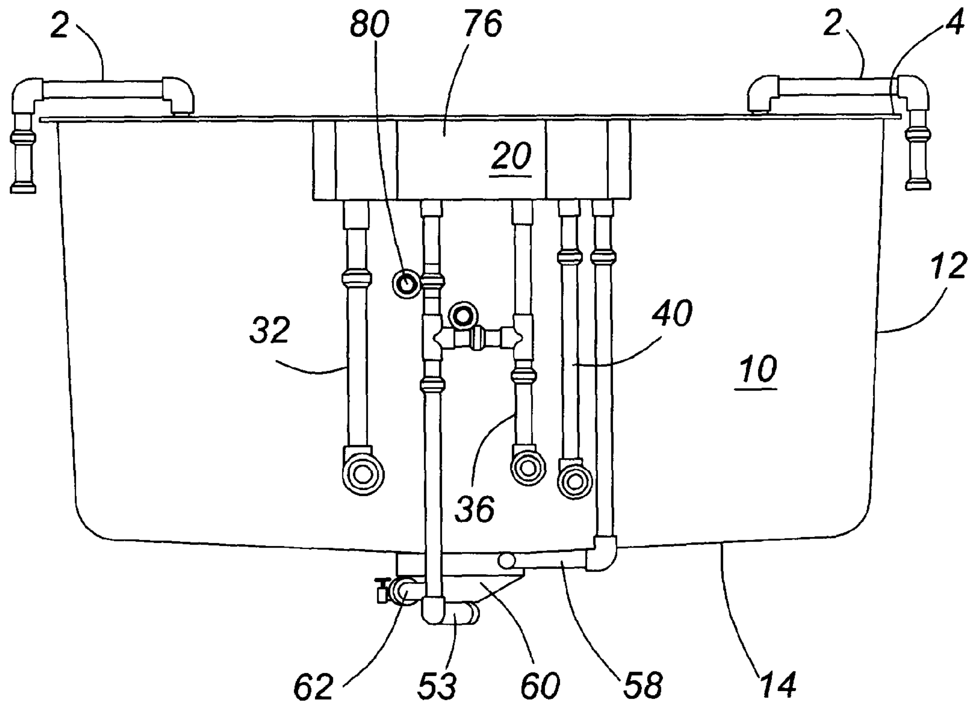


FIG. 2b

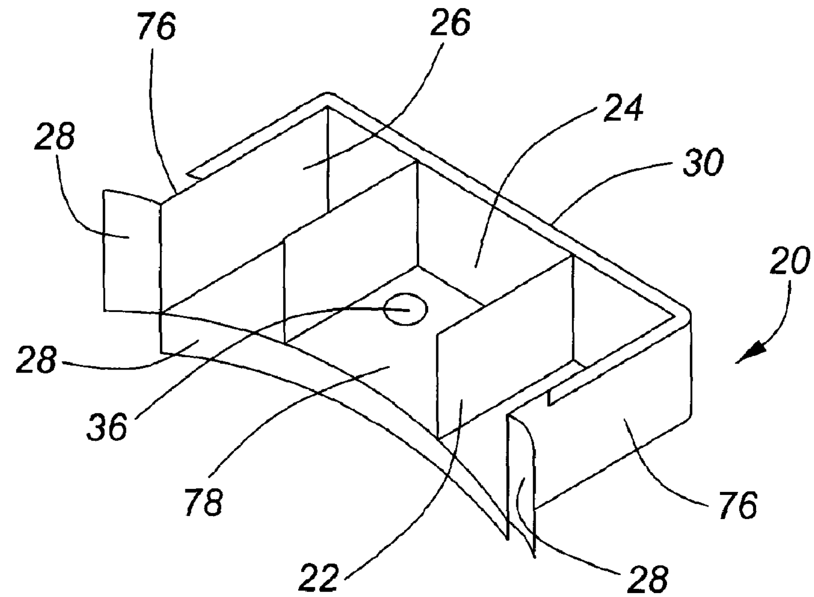

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FIG. 3a

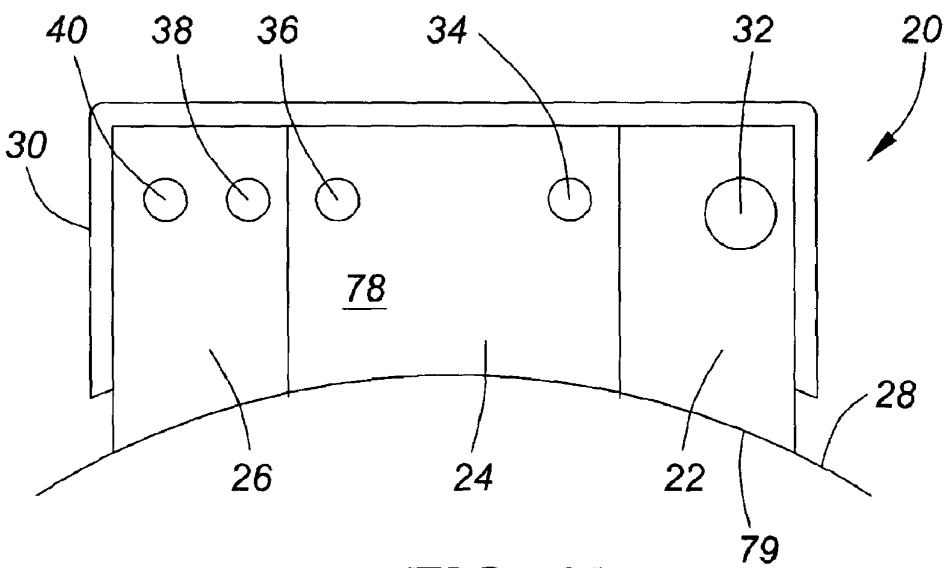
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FIG. 3b

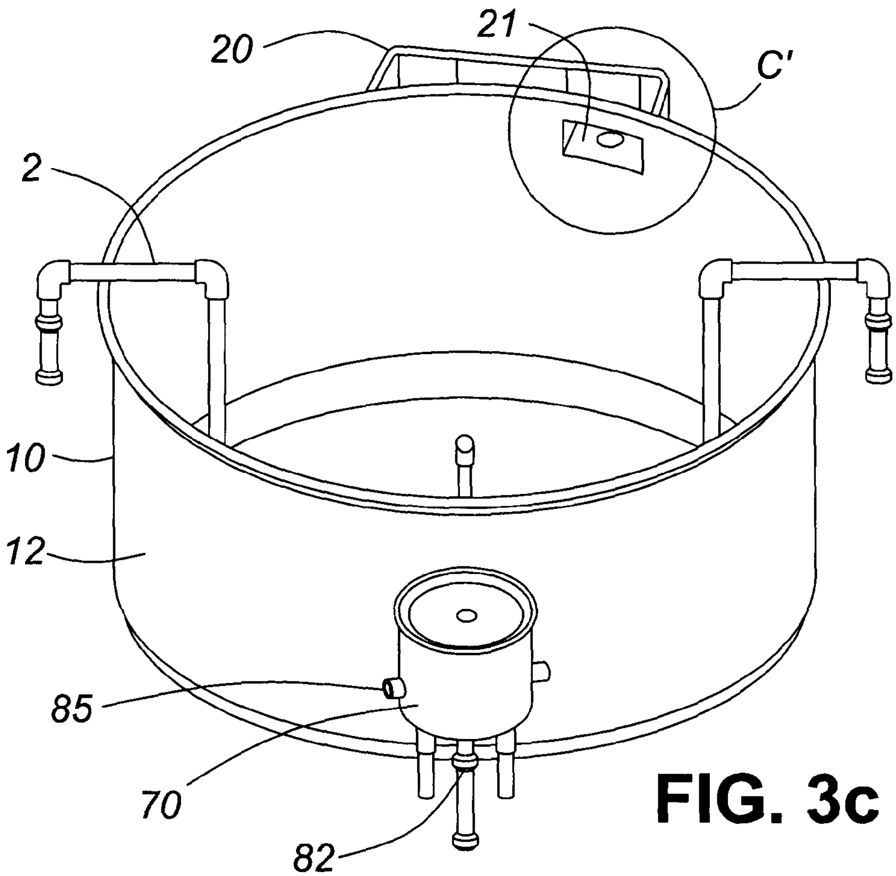

FIG. 3c

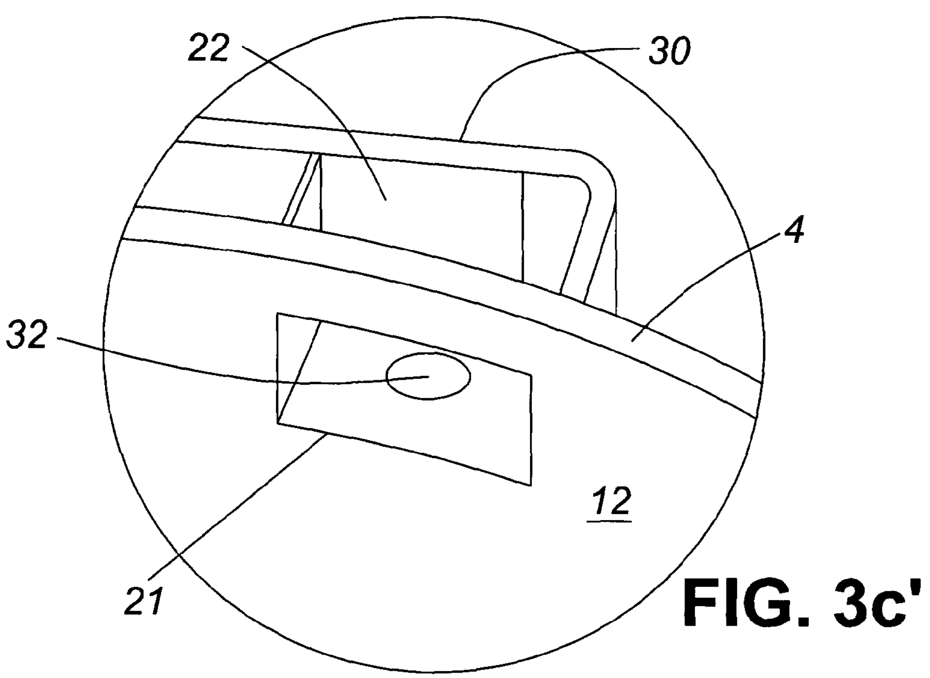

FIG. 3c'

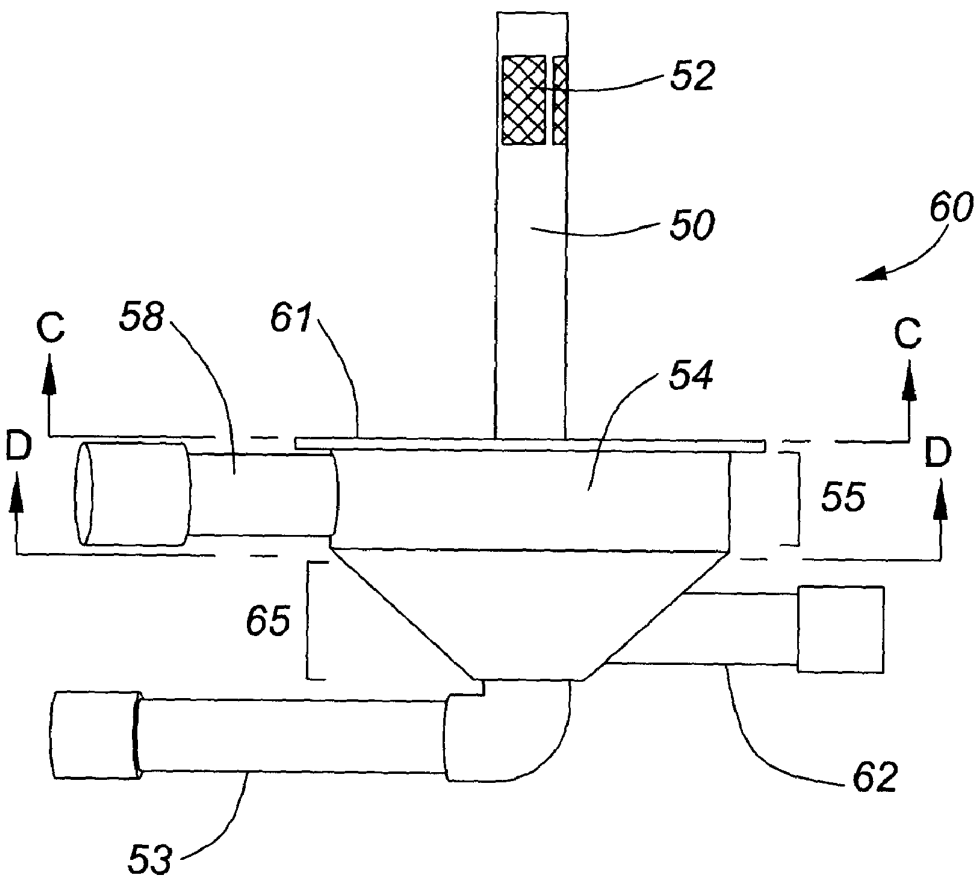

FIG. 4a

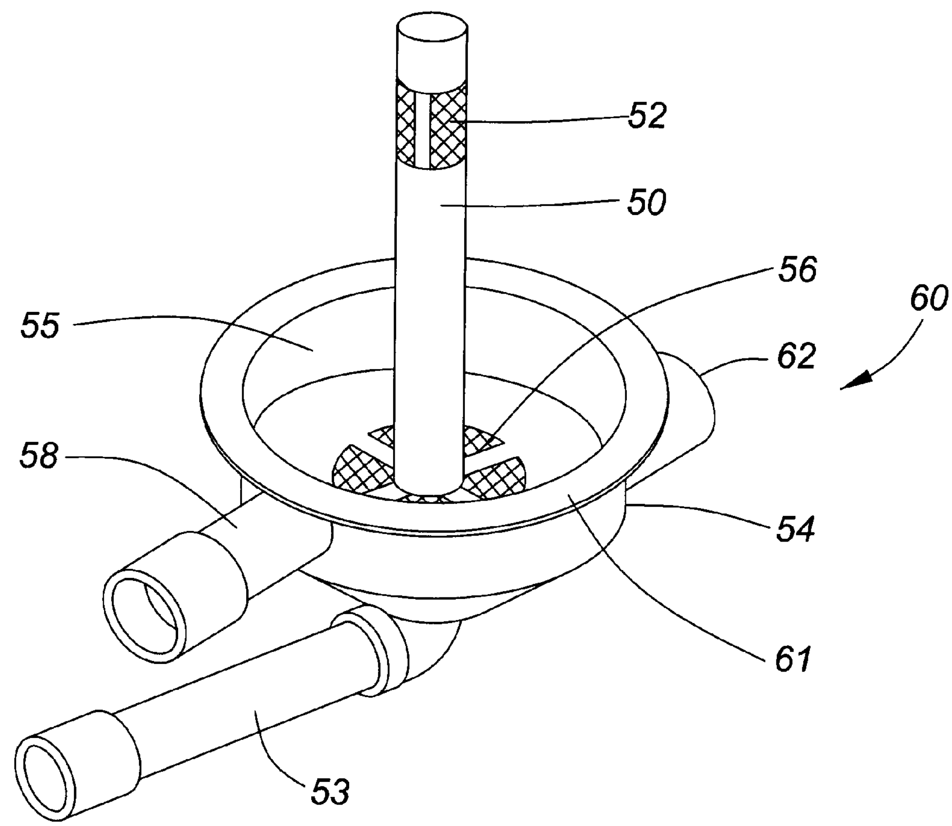

FIG. 4b

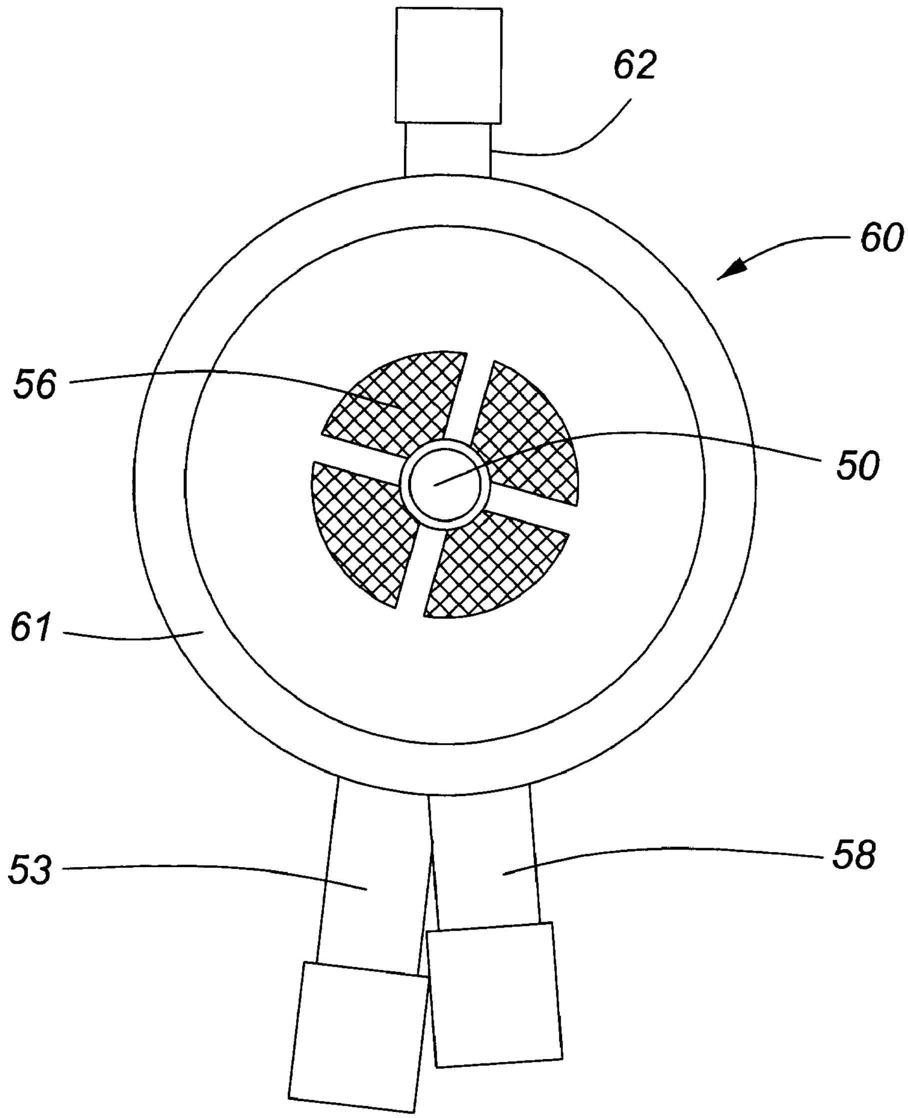

FIG. 4c

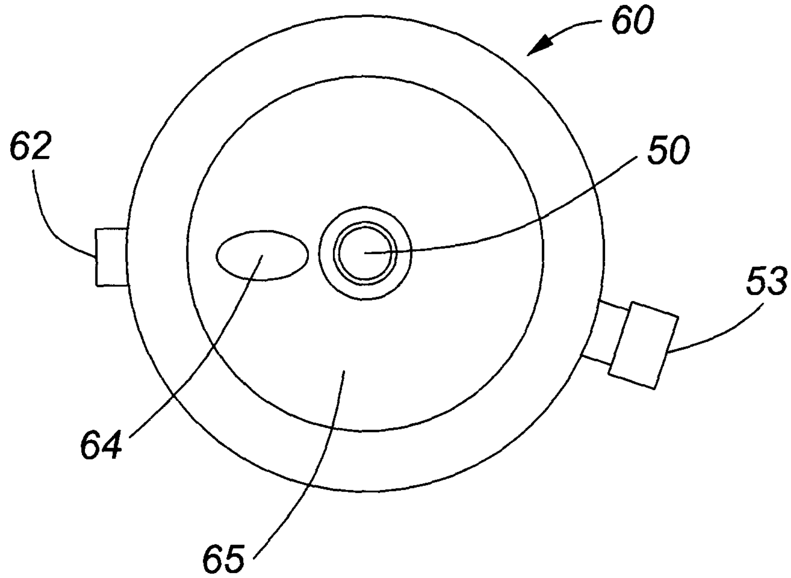

FIG. 4d

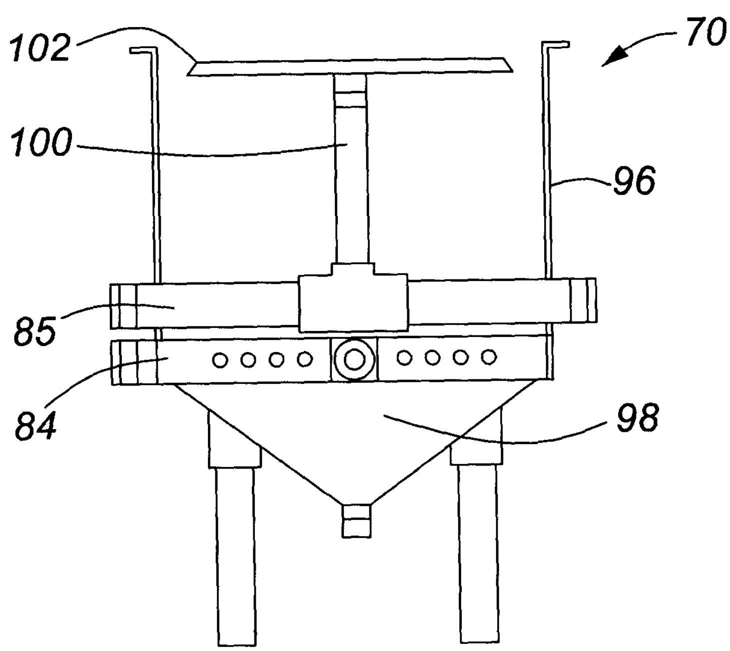

FIG. 5a

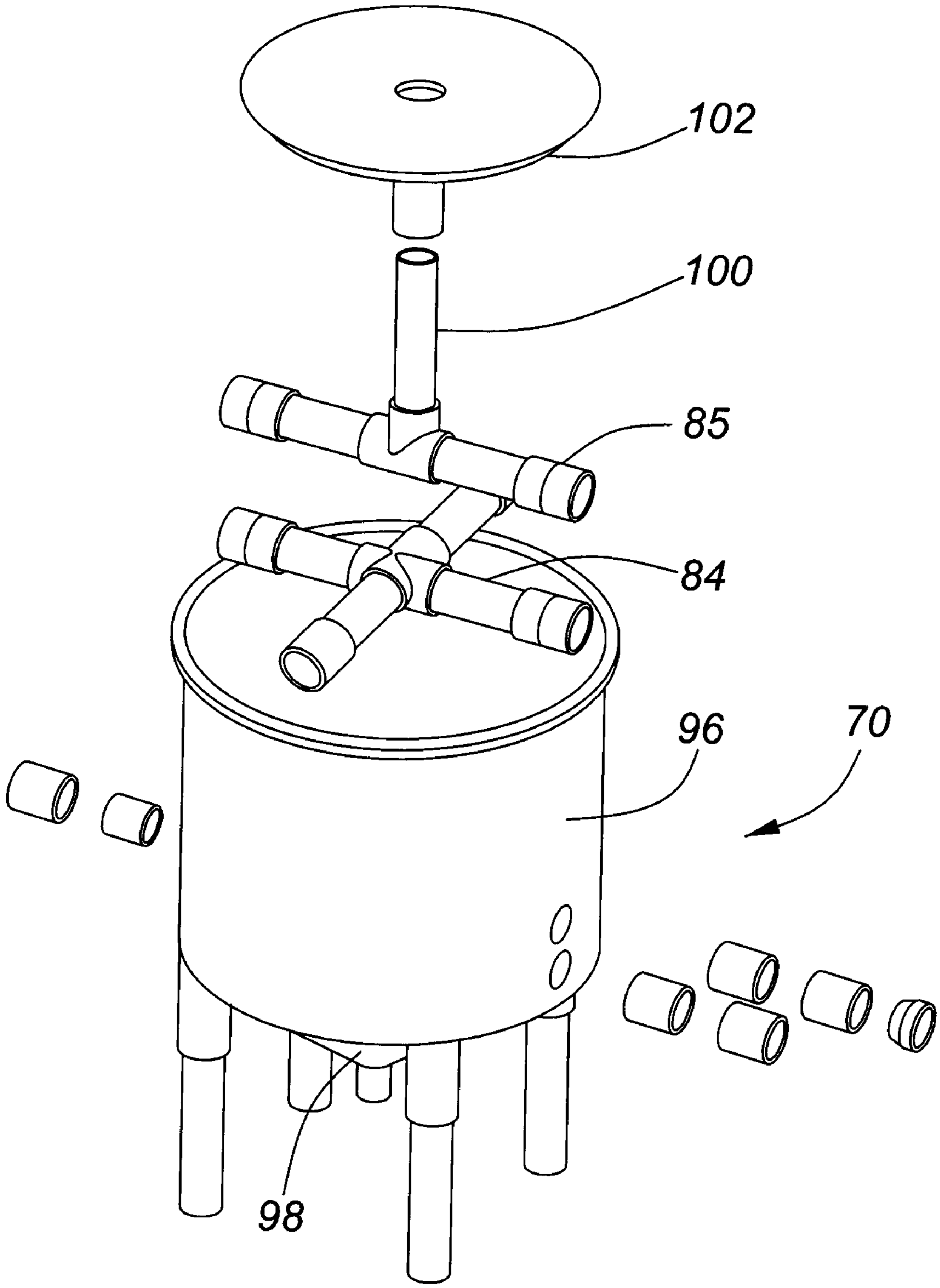

FIG. 5b

TRIPLE DRAIN APPARATUS FOR AN AQUACULTURE RECIRCULATION SYSTEM

FIELD OF THE INVENTION

[0001] Apparatus for an aquaculture recirculation system, in particular triple drain apparatus designed to remove solid wastes, such as fecal matter, uneaten food, and dead fishes, from within rearing tanks produced from typical aquaculture activity.

BACKGROUND

[0002] In aquaculture recirculation systems, 95% of all solids are produced within a rearing tank. Solids in the tank may include fish waste, uneaten food, and dead fishes, for example. Left in the tank, these solids can result in poor water quality and decreased fish health. A key to good water quality in intensive recirculation systems is to capture these solids and remove them from the tank before they break down.

[0003] Correct tank hydraulics is important to produce a self-cleaning tank. Proper tank hydraulics requires establishment of what is known as a "tea cup effect", which produces a strong water flow along the tank bottom to carry solid waste to the tank center. The radial velocity created within the tank in part as a consequence of the direction, speed, and volume of water flow entering the tank, produces the tea cup effect. The tea cup effect is well understood and documented in the field.

[0004] There have been many aquaculture systems designed to produce and utilize the tea cup effect, (see e.g. U.S. Pat. No. 5,178,093; U.S. Pat. No. 6,443,100; U.S. Pat. No. 5,636,595). These systems generally have a double drain concentric to the tank bottom, which consists of a top drain to carry away relatively clean water (clean fluid stream) and a bottom drain to carry away water laden with solids and other debris (high solids stream). With this style of drain, all water entering the tank leaves at the tank center through the double drain. As a result, very high rotational velocities are created at tank center. These velocities can be so high that fish will avoid the area resulting in poor utilization of tank volume for fully effective fish rearing.

[0005] To attempt to compensate for the deficiency of the center double drain, a recirculation system known as the Cornell-style system was developed by Cornell University. Generally, this system also employs two drains, splitting the water streams between a drain located on the side of the tank, near the upper surface of the water in the tank, called a side box (clean water stream) and a single drain concentric to the tank at tank bottom (high solids stream). Split in this way, the system does reduce the problem of high water velocity at tank center; however, because less water is exiting the tank at its bottom center, the system loses its ability to maintain the tea cup effect in larger diameter tanks to effectively remove solids and debris. To compensate, the Cornell-style system must divert larger flows to the tank center as tank diameter increases thereby greatly increasing the volume of the high solids streams, which in turn results in increased effluent treatment costs.

[0006] Fish mortality presents its own tank cleaning problems, whether the aquaculture system employed is of the double drain style or the Cornell-style. Fish casualties occur for a variety of reasons, and dead fishes, as with other solids, can settle in the tank, where they can block drains and lower overall tank water quality and fish health through disease, increased bacteria, and cannibalization by other fishes.

[0007] There are several common methods currently used for removing dead fishes from aquaculture tanks. One common simple method is manual removal using a net on a long pole, for instance. However, this is not practical in larger applications. A second common approach is to include a 15-20 cm diameter pipe positioned with a first end placed roughly concentric to the bottom of the tank. The pipe runs directly through the tank water column to a second end emptying into a containment means outside the tank. The pipe typically operates through a differential pressure to pull water, dead fishes and even live fishes from the tank bottom to the containment means via suction. The water in the containment means may be treated and recirculated, while dead fishes may be removed from the containment means manually and live fishes returned to the tank. The drawback of this technique is that the relatively large pipe creates considerable resistance in the water column and impairs rotational velocity which in turn impairs the self-cleaning characteristics of the system.

[0008] The subject apparatus, disclosed herein, addresses the above key deficiencies, namely solids breakdown, high effluent and water treatment costs, poor tank water circulation and inefficient large solids removal, in aquaculture recirculation systems.

SUMMARY OF INVENTION

[0009] In accordance with the invention there is provided a triple drain apparatus for installation in a tank of an aquaculture system, the tank having a substantially cylindrical tank side wall and a tank bottom wall, and configured to receive incoming water entering the tank with a momentum substantially tangent to the tank side wall and a velocity of about 100-120 cm/sec. The triple drain apparatus includes a side box configured for attachment to an outside side wall of the tank distally from a bottom wall of the tank, the side box having at least a first compartment configured to receive a side box fluid stream from the tank and to expel the side box fluid stream for treatment. A stand pipe has a first end and a second end, and is configured for installation concentrically within the tank whereby the first end of the stand pipe is positioned below a surface of water in the tank and the second end of the stand pipe extends through the bottom wall of the tank to an outlet. The stand pipe has openings (e.g. slots) which are proximal to the bottom wall of the tank when installed in the tank, for passing a clean fluid stream from the tank into the stand pipe, the openings being sized to prevent fish from passing into the stand pipe and to produce a clean fluid stream velocity of less than 10-20 cm/sec when the clean fluid stream passes into the stand pipe. A conical sump is configured for installation concentrically with the stand pipe and extending below the bottom wall of the tank whereby the conical sump is coupled to the bottom wall of the tank to permit a high solids fluid stream to pass from the tank into the conical sump. A collection plate, having perforations (e.g. slots) sized to prevent the passage of fish, is configured for separating the tank and the conical sump when the conical sump is installed whereby the conical sump temporarily contains solids passing through the collection plate in a high solids fluid stream. A solids outlet is proximal to a vertex of the conical sump and is configured for directing the high solids fluid stream to a solids settling device. The triple drain apparatus may be constructed as an assembly and preferably the tank has a conical bottom wall.

[0010] A side box fluid stream valve means is preferably included for controlling the volume of the side box fluid stream. The second end of the stand pipe may couple to a clean fluid outlet with the clean fluid outlet coupling to a second compartment of the side box, wherein the second compartment of the side box is configured for receiving the clean fluid stream and for expelling the clean fluid stream from the second compartment for treatment and preferably a clean fluid stream valve means is included for controlling the volume of the clean fluid stream entering the openings in the stand pipe.

[0011] In one embodiment, the solids settling device is a solids concentrator comprising a generally cylindrical shaped portion vertically coupled to a generally conical shaped portion; diffuser piping concentric to the solids concentrator between the cylindrical shaped portion and the conical shaped portion, the diffuser piping configured for coupling to the solids outlet and comprising a plurality of spaced openings to produce an upward laminar flow of fluid in the solids concentrator of less than 2 cm/sec (or, preferably, less than 1 cm/sec) when the high solids fluid stream passes through the diffuser piping into the solids concentrator; and, a vertical pipe outlet having a first end positioned to receive fluid from the upward laminar flow of fluids and the second end coupled to a concentrator fluids outlet; wherein solids in the high solids fluid stream concentrate in the generally conical shaped portion of the solids concentrator to be removed. A generally disc-shaped diffuser plate may be positioned proximal the first end of the vertical pipe outlet and oriented in a direction perpendicular to the laminar flow. Preferably, the volume of the high solids fluid stream is controlled by a high solids fluid stream valve means.

[0012] In a further embodiment, the triple drain apparatus includes a mortality trap configured for installation concentric with the stand pipe and conical sump in the bottom wall of the tank whereby the mortality trap sits within a substantially circular recess in the bottom wall of the tank above the conical sump. The mortality trap has a substantially cylindrical trap side wall which couples with the conical sump. In this embodiment, the collection plate separates the mortality trap and the conical sump whereby the high solids fluid stream passes through the mortality trap into the conical sump and dead fish and solids collected by the collection plate are temporarily contained in the mortality trap. A mortality outlet may be configured for removing a mortality fluid stream containing dead fish and solids from the mortality trap, a first end of the mortality outlet configured for coupling to the trap side wall proximal to the collection plate and a second end of the mortality outlet configured for coupling to a third compartment of the side box upon installation of the apparatus in the tank whereby the third compartment receives the mortality fluid stream. The third compartment is configured to expel the mortality fluid stream from the third compartment for treatment through a screened third compartment outlet having openings sized to prevent passage of fish. Preferably, the volume of the mortality fluid stream is controlled by a mortality fluid stream control means coupled to the mortality outlet.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The invention is described below with reference to the following drawings in which like reference numerals refer to like elements throughout.

[0014] FIG. **1** is a top view of an aquaculture system embodying a preferred triple drain apparatus in accordance with the subject invention.

[0015] FIG. **2**(*a*) is a cross-sectional view of the system of FIG. **1** along line "A-A".

[0016] FIG. **2**(*b*) is a side view of the system of FIG. **1** along line "D-D".

[0017] FIG. **3**(*a*) is a perspective view of the side box of the triple drain apparatus of FIG. **1**.

[0018] FIG. **3**(*b*) is a top view of the side box of the triple drain apparatus of FIG. **1**.

[0019] FIG. **3**(*c*) is a perspective view of the system of FIG. **1** highlighted, as "C", a cut-out in the tank leading to the side box and FIG. **3**(*c*) is a detailed view of that highlighted section "C".

[0020] FIG. **4**(*a*) is a side view of a center drain of the triple drain apparatus of FIG. **1**.

[0021] FIG. **4**(*b*) is a perspective view of the center drain of FIG. **4**(*a*).

[0022] FIG. **4**(*c*) is a cross-sectional view of the center drain of FIG. **4**(*a*) along line "C-C".

[0023] FIG. **4**(*d*) is a cross-sectional view of the center drain of FIG. **4**(*b*) along line "D-D".

[0024] FIG. **5**(*a*) is a cross-sectional view of a preferred solids concentrator of the triple drain apparatus of FIG. **1**.

[0025] FIG. **5**(*b*) is an exploded view of the solids concentrator of FIG. **5**(*a*).

DETAILED DESCRIPTION

[0026] In an aquaculture recirculation system, a cultivation tank (**10**) is used to hold water in which aquatic organisms, typically fishes, are to be reared. For optimum water circulation, the tank (**10**) has a generally circular cross-section, as depicted in FIG. **1** which depicts a top view of an aquaculture system incorporating a preferred embodiment of the subject triple drain apparatus. For optimum use of floor space, other cross-sectional shapes for the tank (**10**) are possible, such as hexagonal-shape, or even substantially square-shape provided the corners are rounded and not so acute to disrupt the water circulation. For the purpose of this disclosure, a circular configuration is depicted and described.

[0027] The tank (**10**) has a generally cylindrical tank side wall (**12**) and a tank bottom wall (**14**). Preferably the tank bottom wall (**14**) is slightly conical, forming a vertex (**11**) near tank center, as shown in FIGS. **2**(*a*) and **2**(*b*). The tank (**10**) may be mounted on a foundation or other support structure (not shown in the drawings).

[0028] The tank (**10**) is configured to meet user preferences within accepted norms in the field. Generally the diameter of the tank (**10**) ranges in size from 2 m-40 m, and the tank side wall (**12**) has a height range of 1-10 m. The tank (**10**) may be constructed of fiberglass/steel composite, a fiberglass/gel coat composite or a high density polyethylene, as desired. Where the tank (**10**) is fiberglass, the tank foundation may be constructed of either concrete or fiberglass. For other tank materials, the tank foundation is most often composed of concrete.

[0029] Depending on the diameter of the tank, the tank (**10**) may be outfitted with one or more inlet diffusers (**2**). Two inlet diffusers (**2**) are shown for the embodiment of FIG. **1**. Incoming water enters the tank (**10**) via the inlet diffusers (**2**) with momentum substantially tangential to the tank side wall (**12**). Incoming water may be pumped or gravity fed from a head tank (not shown in the drawings) into the inlet diffusers (**2**).

The inlet diffusers (**2**) are designed to optimally create an inlet water velocity of 100-120 cm/sec from the tank water surface to the tank bottom wall (**14**). The inlet water velocity is ideally consistent across the entire vertical height of the tank (**10**) and is important to create sufficient tangential velocity. The tangential velocity creates a radial current towards the tank center, moving solids to the tank center along the tank bottom wall (**14**). The radial current has a velocity of 20-40 cm/sec along the tank bottom wall (**14**) to move the solids to tank center.

[0030] Ideally, the inlet diffusers (**2**) are positioned inside the tank (**10**) at a radius r from the center of the tank (**10**) such that the tank volumes within the radius of the diffuser (**2**) location (i.e. the tank volume from r to the center of the tank) and outside that radius (i.e. the tank volume from r to the tank side wall (**12**)) are about equal. This equality minimizes friction losses in the radial current along the tank side wall (**14**).

[0031] Attached to the outer surface of the tank side wall (**12**) is a side box (**20**), as shown in FIG. **1** and in greater detail in FIGS. **3**(*a-c*). The side box (**20**) allows water flow to be diverted away from the tank center and also acts to maintain a desired tank water level. Of the total tank fluid flow, approximately 40-60% is diverted to the side box (**20**). It is to be understood that the term water, herein, with reference to the tank means the fluid content of the tank, largely comprised of water; accordingly, in the following description, the terms water and fluid, and the terms water stream and fluid stream, are used interchangeably in relation to the tank to refer to the fluid content of the tank.

[0032] In the illustrated embodiment, the side box (**20**) is box-shaped, defined by three sides (**76**), a bottom (**78**) and an attaching side (**79**). The attaching side (**79**) of the side box (**20**) is coupled to an outer surface of the tank side wall (**12**). The attaching side (**79**) of the side box (**20**) may be open and contoured to form a tight seal with the tank side wall (**12**) as shown in FIGS. **3**(*a*) and **3**(*b*). The side box (**20**) is secured to the tank by side flanges (**28**) on the attaching side (**79**) of the side box (**20**) to prevent leaks. Other means of coupling the side box (**20**) may be alternatively used. It is to be understood herein that the term coupling means any type of effective attachment or means of coupling elements together, including attachment, fastening and/or integral construction, as appropriate. The side box (**20**) is located near the top of the tank (**10**) and, in the illustrated embodiment, a top flange (**30**) of the side box is flush with a top flange of the tank (**4**).

[0033] As shown, the illustrated embodiment of the side box (**20**) is divided into multiple leak-proof compartments (**22**, **24**, **26**); in the illustrated embodiment, the side box (**20**) contains three compartments (**22**, **24**, **26**). A side box fluid stream flows into a first compartment (**22**) of the side box from the tank (**10**) through a matching cut out (**21**) in the tank side wall (**12**) as illustrated in FIG. **3**(*c*). A screen (not shown in the drawings), with perforations sized to prevent fish from entering the first compartment (**22**), may be placed over the cut out (**21**). Optionally, to enable the side box to be used at a wider range of tank water levels, the cut out (**21**) may, instead, be situated on the tank side wall (**12**) in a position more proximal to the tank bottom wall. In this way, the level of tank water need not be at capacity in order for the side box to function. The side box fluid stream exits the first compartment (**22**) through a first compartment outlet (**32**) for treatment by a water treatment system (not shown in the drawings) or directly through a biofilter (not shown in the drawings) and recirculated back into the tank (**10**) via the inlet diffusers (**2**). Optionally, the volume of the side box fluid flow may be controlled through a control means located outside the tank, such as a valve (not shown in the drawings) located on the first compartment outlet (**32**).

[0034] While 40-60% of the total tank fluid flow is directed to the side box (**20**), the remaining flow is directed to a center drain (**60**), shown in FIGS. **1** and **2**(*a*) and in greater detail in FIGS. **4**(*a-c*). As shown, in the illustrated embodiment, the center drain (**60**) is concentric with the tank and proximal (i.e. relatively near) to the tank bottom wall (**14**). Fluid entering the center drain (**60**) is split into two separate fluid streams referred to herein as the clean fluid stream, comprising relatively clean water, and the high solids fluid stream comprising a relatively higher amount of solids and other debris in water.

[0035] In a first fluid stream entering the center drain, the clean fluid stream, relatively clean water leaves the tank (**10**) via a first end of a vertical stand pipe (**50**) located concentric to the tank (**10**) and below the surface of the water in the tank (**10**). This stand pipe (**50**) contains openings (**52**), proximal to, yet not directly adjacent to the tank bottom wall (**14**). The openings (**52**) in the stand pipe (**50**) are designed with sufficient open area to produce minimum velocity (less than 10-20 cm/sec) when the clean fluid stream enters the stand pipe (**52**), but are also small enough to avoid fish impingement and particle entrainment. The openings (**52**) of the illustrated embodiment, for example, are slot-shaped.

[0036] A second end of the stand pipe (**50**) is coupled to a clean fluid outlet (**53**). In one example, which uses a side box (**20**) as illustrated by FIGS. **3**(*a*) and **3**(*b*), the clean fluid outlet (**53**) is coupled to a second compartment inlet (**34**) of a second compartment (**24**) of the side box (**20**). The clean fluid stream is carried by the clean fluid outlet (**53**) via differential pressure through the second compartment inlet (**34**) to the second compartment (**24**). The clean fluid stream exits the second compartment (**24**) through a second compartment outlet (**36**), which may direct the clean fluid stream to a water treatment system such as a mechanical drum filter (20-90 um) (not shown in the drawings) and/or biofilter (not shown in the drawings) before being recirculated back into the tank (**10**) in the manner described above.

[0037] Means for controlling how much water is permitted to leave the tank (**10**) via the clean fluid stream may be located outside the tank (**10**). In the illustrated embodiment (FIG. **2**(*b*)), the volume of the clean fluid stream is controlled by a clean fluid valve (**80**) located on the clean fluid outlet (**53**). The clean water valve (**80**) can be adjusted (i.e. opened or closed) to increase or reduce the clean water stream, as required.

[0038] The second fluid stream entering the center drain (**60**), the high solids fluid stream of water carrying solids and debris, flows towards a collection plate (**56**) which is provided in the illustrated embodiment in the form of a perforated disk incorporated into the tank bottom wall (**14**) concentric to the tank (**10**) and over a sump (**65**). The collection plate (**56**) is situated at the deepened vertex (**11**) of the tank (**10**), as shown by FIG. **2**(*a*). The high solids fluid stream is caused to flow towards the collection plate (**56**) by the radial current, then passes through perforations in the collection plate (**56**) into the sump (**65**), as shown in FIG. **4**(*d*), via a combination of gravity and suction. The perforations in the collection plate (**56**) may be slotted or generally circular-shaped, for example, and sized to prevent fish or large debris from entering the sump. Solids sized too large to pass through the collection plate (**56**) collect atop the collection plate (**56**).

[0039] As shown by FIG. **4**(*a*), the sump (**65**) of the illustrated embodiment is conical in shape. Once in the sump (**65**), the high solids fluid stream is carried out of the tank (**10**) via a solids outlet (**62**). The solids outlet (**62**) is coupled to the sump (**65**) through an opening (**64**) in the sump wall near the vertex of the sump and is designed to produce sufficient velocity to remove the solids, reduce chances of solids settling in the pipe and reduce the chances of solids being torn apart by shear forces, wherein a velocity of 40-60 cm/sec has been found to be appropriate for the illustrated embodiment. Means for controlling how much water is permitted to leave the tank (**10**) via the high solids fluid stream may be located outside the tank (**10**). In the illustrated embodiment, the volume of the high solids fluid stream is controlled by a high solids valve (**82**) located on the solids outlet (**62**), as shown by FIG. **2**(*a*).

[0040] The solids outlet (**62**) directs the high solids fluid stream to a solids settling device located outside the tank (**10**) yet in relatively close proximity to the tank (**10**), and configured for collecting concentrated solids from the high solids fluid stream. In the illustrated embodiment the solids settling device is provided by a solids concentrator (**70**), as shown in FIGS. **5**(*a*) and **5**(*b*). The solids concentrator (**70**) is designed to remove about 95% of solids in the high solids fluid stream by capturing the solids within the solids concentrator (**70**). The solids concentrator (**70**) includes a generally cylindrical top portion (**96**) and a generally conical bottom portion (**98**), functioning as a settling cone. The high solids fluid stream enters the solids concentrator (**70**) near the intersection of the cylindrical top portion (**96**) and the conical bottom portion (**98**) through diffuser piping (**84**) which is coupled to the solids outlet (**62**). The diffuser piping (**84**) includes a plurality of space openings designed to produce laminar flow (upwards) through the solids concentrator (**70**) with minimized flow velocity and turbulence. In the illustrated embodiment the diffuser piping (**84**) design is a cross-shaped configuration, as shown by FIG. **5**(*b*). Alternatively, the design could be a more circular configuration around the inside perimeter of the solids concentrator, and other configurations may also be suitable depending upon the particular application. The upward laminar flow velocity in the illustrated embodiment of the concentrator (**70**) is maintained below 2 cm/sec an, preferably, below 1 cm/sec, and will not overcome the average settling velocity of solids in typical aquaculture operation of about 2 cm/sec. Relatively clean water flows from the solids concentrator (**70**) into a vertical pipe outlet (**100**) proximal the top of the solids concentrator (**70**), and then flows out a concentrator fluid outlet (**85**) to a water treatment system (not shown in the drawings) and/or biofilter (not shown in the drawings) before being recirculated back into the tank (**10**) in the manner described above. Solids in the high solids fluid stream settle in the conical portion (**98**) of the solids concentrator (**70**) and are removed to a central effluent treatment and/or disposal system (not shown in the drawings) either manually or automatically, for example, using solenoid valves.

[0041] A diffuser plate (**102**) may be installed near the top of the solids concentrator (**70**) in an orientation perpendicular to the laminar flow but configured to allow fluid to flow into the vertical pipe outlet (**100**). This forces upward moving fluids to flow around the diffuser plate (**102**) to further slow the rate of upward movement and promote settling of the solids. In the illustrated embodiment, the diffuser plate (**102**) is coupled to the vertical pipe outlet (**100**) with an opening in the diffuser plate (**102**) corresponding to the opening in the vertical pipe outlet (**100**), as shown in FIGS. **5**(*a*) and **5**(*b*).

[0042] In the illustrated embodiment, the center drain (**60**) is configured to also include a mortality trap (**55**) located between the tank bottom wall (**14**) and the collection plate (**56**) whereby the high solids fluid stream passes through the mortality trap (**55**) before passing through the collection plate (**56**) and the sump (**65**). The mortality trap (**55**), as illustrated in FIGS. **4**(*a*) and **4**(*b*), is concentric with the tank (**10**) and has a substantially cylindrical trap side wall (**54**), forming a substantially circular recess in the tank bottom wall (**14**). The mortality trap (**55**) is coupled to the sump (**65**) and separated from the sump (**65**) by the collection plate (**56**). Dead fishes and large debris are directed by the radial current in the tank (**10**) to the center of the tank (**10**) and enter the mortality trap (**55**), settling atop the collection plate (**56**). Those dead fishes and large debris, collected in the mortality trap (**55**), are removed from the tank (**10**) in a mortality fluid stream through a mortality outlet (**58**) coupled to the mortality trap (**55**).

[0043] In the illustrated embodiment, the mortality outlet (**58**) is coupled at a first end to the trap side wall (**54**) and in close proximity to the collection plate (**56**). The second end of the mortality outlet (**58**) is coupled to a third compartment inlet (**38**) of the side box (**20**). The third compartment inlet (**38**) is further coupled to a third compartment (**26**) of the side box (**20**). The mortality fluid stream is carried by pressure differential through the mortality outlet (**58**) and third compartment inlet (**38**) and enters the third compartment (**26**). Dead fishes and large debris carried in the mortality fluid stream to the third compartment (**26**) are manually removed from the third compartment (**26**). Any live fishes carried by the mortality fluid stream into the third compartment (**26**) are manually returned to the tank (**10**). The fluid portion of the mortality fluid stream exits the third compartment (**26**) through a screened third compartment outlet (**40**) where it is directed to a water treatment system (not shown in the drawings) and/or biofilter (not shown in the drawings) before being recirculated back into the tank (**10**) in the manner described above. The volume and timing of the mortality fluid stream into the mortality outlet (**58**) may be controlled by a mortality valve (not shown in the drawings), activated manually or at set intervals by a control means. For an application which does not include the mortality trap (**55**) and mortality outlet (**58**), the dead fishes and large debris collected by the collector plate (**56**) may be removed manually or by other conventional means.

[0044] In the illustrated embodiment, the vertical stand pipe (**50**) passes centrally through the mortality trap (**55**), the collection plate (**56**) and the sump (**65**), and is coupled to the clean fluid outlet (**53**) below the sump, as depicted in FIGS. **4**(*a*), (*b*), (*c*) and (*d*). The center drain (**60**) is an assembly of the stand pipe (**50**), central to the center drain (**60**) and coupled to the clean water outlet (**53**), the mortality trap (**55**) coupled to both the mortality outlet (**58**) and the sump (**65**), a collection plate (**56**) separating the mortality trap (**55**) and the sump (**65**), and the sump (**65**) coupled to the high solids fluid outlet (**62**). The center drain (**60**) is secured flush to the tank bottom wall (**14**) by a lip (**61**).

[0045] For a commercial system application, several tanks (**10**) may be configured to share a common filtration system, as described herein, with solids settling devices such as the solids concentrator (**70**) described herein.

[0046] The triple drain apparatus of the present application splits the flow of water in a tank (**10**) between a side box (**20**) attached to the tank (**10**) and a center drain (**60**), whereby a side box fluid stream flows into the side box (**20**) and both a clean fluid stream and a high solids fluid stream flow into the center drain (**60**). This design produces improved center tank water velocities for maintaining a fish culture. As tank diameter increases and more flow must be diverted to the center to maintain the tea cup effect, the volume of water flow that is comprised of the clean fluid stream can be increased, thereby maintaining a low flow high solids fluid stream which reduces the capital requirements of the downstream effluent treatment system. Effluent treatment costs and water quality are further improved when the triple drain apparatus is combined with a solids concentrator (**70**) situated near the tank (**10**). Advantageously, the apparatus described herein reduces water input requirements and minimizes a breakdown of solids into smaller components so that the solids which are ultimately removed from the solids concentrator are larger and more concentrated than in traditional systems. In addition, the collection plate (**56**) above the sump (**65**), which optionally includes a mortality trap (**55**), advantageously provides means for easily removing dead fishes and large debris from the tank (**10**).

[0047] The foregoing examples of embodiments of the invention are provided only for the purposes of describing the invention and are not intended to limit the scope of the invention claimed herein. Rather, the invention in which an exclusive property or privilege is claimed is defined as set forth in the following pages.

What is claimed is:

1. Triple drain apparatus for installation in a tank of an aquaculture system, the tank having a substantially cylindrical tank side wall and a tank bottom wall and configured to receive incoming water entering the tank with a momentum substantially tangent to the tank side wall and a velocity of about 100-120 cm/sec, the triple drain apparatus comprising:

a side box configured for attachment to an outside side wall of the tank distally from a bottom wall of the tank, the side box having at least a first compartment configured to receive a side box fluid stream from the tank and to expel the side box fluid stream for treatment;

a stand pipe having a first end and a second end, and configured for installation concentrically within the tank whereby the first end of the stand pipe is positioned below a surface of water in the tank and the second end of the stand pipe extends through the bottom wall of the tank to an outlet, the stand pipe having openings which are proximal to the bottom wall of the tank, when installed in the tank, for passing a clean fluid stream from the tank into the stand pipe, the openings being sized to prevent fish from passing into the stand pipe and to produce a clean fluid stream velocity of less than 10-20 cm/sec when the clean fluid stream passes into the stand pipe;

a conical sump configured for installation concentrically with the stand pipe and extending below the bottom wall of the tank whereby the conical sump is coupled to the bottom wall of the tank to permit a high solids fluid stream to pass from the tank into the conical sump, and including a collection plate having perforations sized to prevent the passage of fish and configured for separating the tank and the conical sump when the conical sump is installed whereby the conical sump temporarily contains solids passing through the collection plate in a high solids fluid stream; and,

a solids outlet proximal to a vertex of the conical sump and configured for directing the high solids fluid stream to a solids settling device.

2. A triple drain apparatus according to claim **1** and configured as an assembly.

3. A triple drain apparatus according to claim **1** and for installation in a tank having a conical bottom wall.

4. A triple drain apparatus according to claim **1** including a side box fluid stream valve means for controlling the volume of the side box fluid stream.

5. A triple drain apparatus according to claim **1** wherein the second end of the stand pipe couples to a clean fluid outlet, and the clean fluid outlet couples to a second compartment of the side box, wherein the second compartment of the side box is configured for receiving the clean fluid stream and for expelling the clean fluid stream from the second compartment for treatment.

6. A triple drain apparatus according to claim **1** wherein the openings in the stand pipe are slots.

7. A triple drain apparatus according to claim **5** including a clean fluid stream valve means for controlling the volume of the clean fluid stream entering the openings in the stand pipe.

8. A triple drain apparatus according to claim **1** wherein the perforations in the collection plate are slots.

9. A triple drain apparatus according to claim **1** wherein the solids settling device is a solids concentrator comprising:

a generally cylindrical shaped portion vertically coupled to a generally conical shaped portion;

diffuser piping concentric to the solids concentrator between the cylindrical shaped portion and the conical shaped portion, the diffuser piping configured for coupling to the solids outlet and comprising a plurality of spaced openings to produce an upward laminar flow of fluid in the solids concentrator of less than 2 cm/sec when the high solids fluid stream passes through the diffuser piping into the solids concentrator; and,

a vertical pipe outlet having a first end positioned to receive fluid from the upward laminar flow of fluids and the second end coupled to a concentrator fluids outlet;

wherein solids in the high solids fluid stream concentrate in the generally conical shaped portion of the solids concentrator to be removed.

10. A triple drain apparatus according to claim **9** wherein the upward laminar flow velocity produced by the diffuser piping is less than 1 cm/sec.

11. A triple drain apparatus according to claim **9** wherein the solids concentrator further comprises a generally disc-shaped diffuser plate positioned proximal the first end of the vertical pipe outlet and oriented in a direction perpendicular to the laminar flow.

12. A triple drain apparatus according to claim **9** wherein the volume of the high solids fluid stream is controlled by a high solids fluid stream valve means.

13. A triple drain apparatus according to claim **1** and further comprising a mortality trap configured for installation concentric with the stand pipe and conical sump in the bottom wall of the tank whereby the mortality trap sits within a substantially circular recess in the bottom wall of the tank above the conical sump, the mortality trap having a substantially cylindrical trap side wall which couples with the conical sump, wherein the collection plate separates the mortality trap and the conical sump whereby the high solids fluid stream passes through the mortality trap into the conical sump and dead fish and solids collected by the collection plate are temporarily contained in the mortality trap.

14. A triple drain apparatus according to claim **13** and further comprising a mortality outlet configured for removing a mortality fluid stream containing dead fish and solids from the mortality trap, a first end of the mortality outlet configured for coupling to the trap side wall proximal to the collection plate and a second end of the mortality outlet configured for coupling to a third compartment of the side box upon installation of the apparatus in the tank whereby the third compartment receives the mortality fluid stream, the third compartment being configured to expel the mortality fluid stream from the third compartment for treatment through a screened third compartment outlet having openings sized to prevent passage of fish.

15. A triple drain apparatus according to claim **14** wherein the volume of the mortality fluid stream is controlled by a mortality fluid stream control means coupled to the mortality outlet.

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