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United States Patent [19]

Rice

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[54] **OIL-WATER SEPARATOR**

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[73] Assignee: **McTighe Industries, Inc.**, Mitchell, S. Dak.

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[51] **Int. Cl.**^{6} **C02F 1/40**

[52] **U.S. Cl.** **210/802**; 210/519; 210/521; 210/540; 210/DIG. 5

[58] **Field of Search** .... 210/801, 802, 210/803, 519, 521, 532.1, 538, 540, DIG. 5

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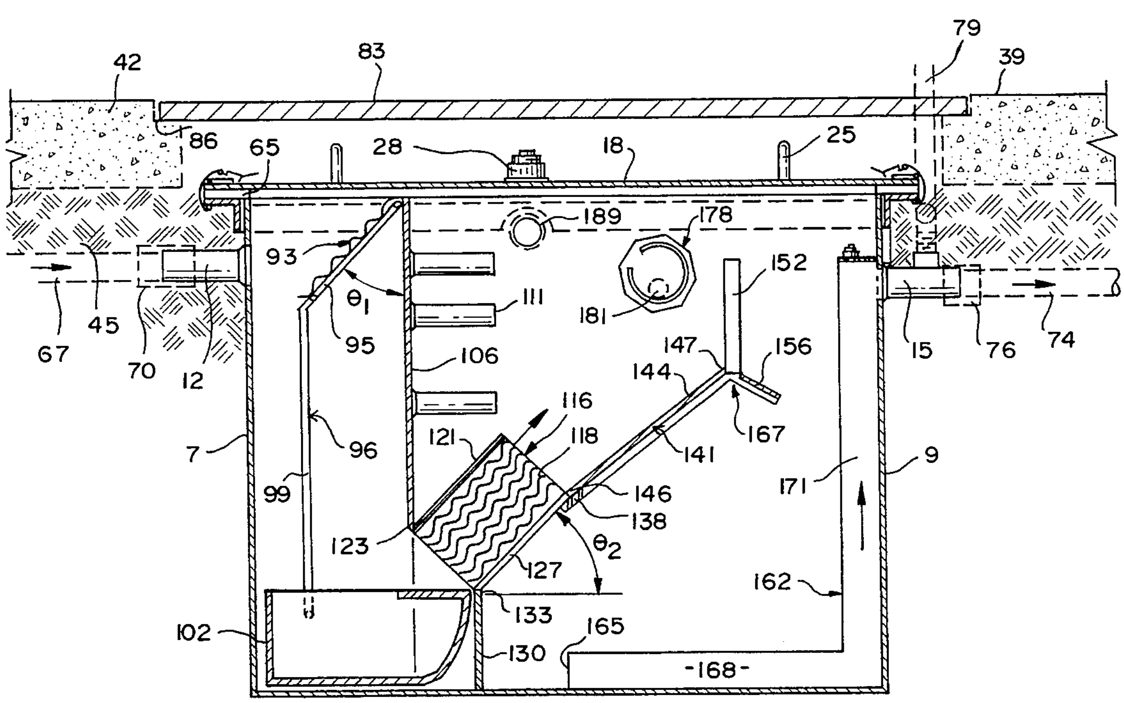
[57] **ABSTRACT**

A compact gravitational oil-water separator particularly adapted for use in small drainage systems in order to avoid pollution to the environment is provided with a plurality of separating components housed within a tank. More specifically, these components include a baffle member which provides initial separation of an incoming oil-water flow stream and distributes the flow substantially across the entire width of the tank. After the flow impinges the baffle member, the flow is directed downward towards a sediment bucket which captures any large particles separated from the flow and then the flow is directed upwardly at an angle through a coalescer unit. After exiting the coalescer unit, the flow is guided over a separation plate and then is re-directed, in a reverse direction, to an inlet opening of an outlet flow passage. By reversing the fluid flow, substantially the entire tank is utilized in the separation process. All of the separating components are removably mounted within the tank to ease maintenance thereof. Finally, a skimmer unit and an oil-water interface sensing/indicating unit can also be provided.

20 Claims, 4 Drawing Sheets



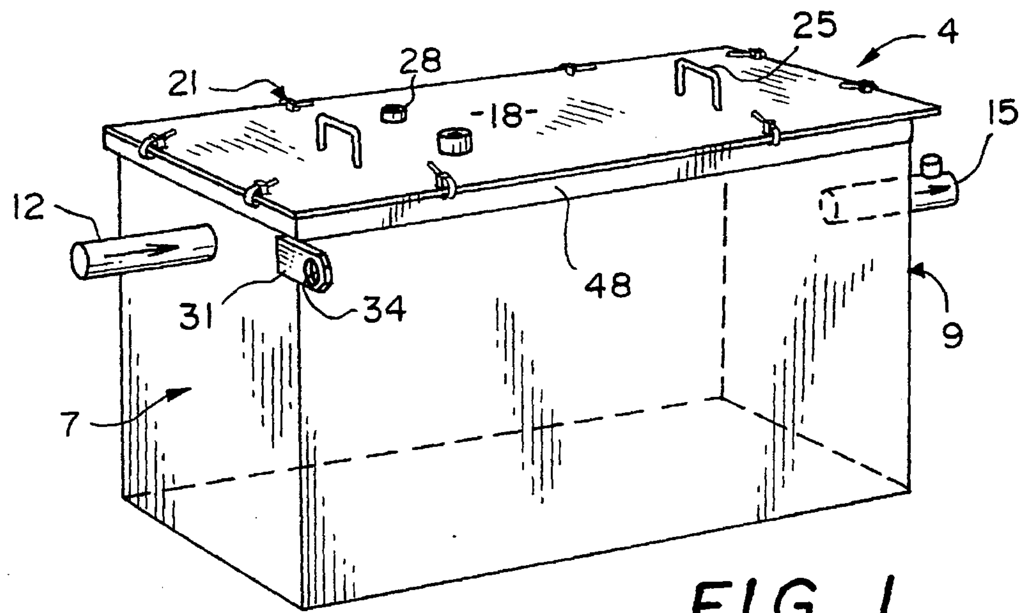

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FIG. 1

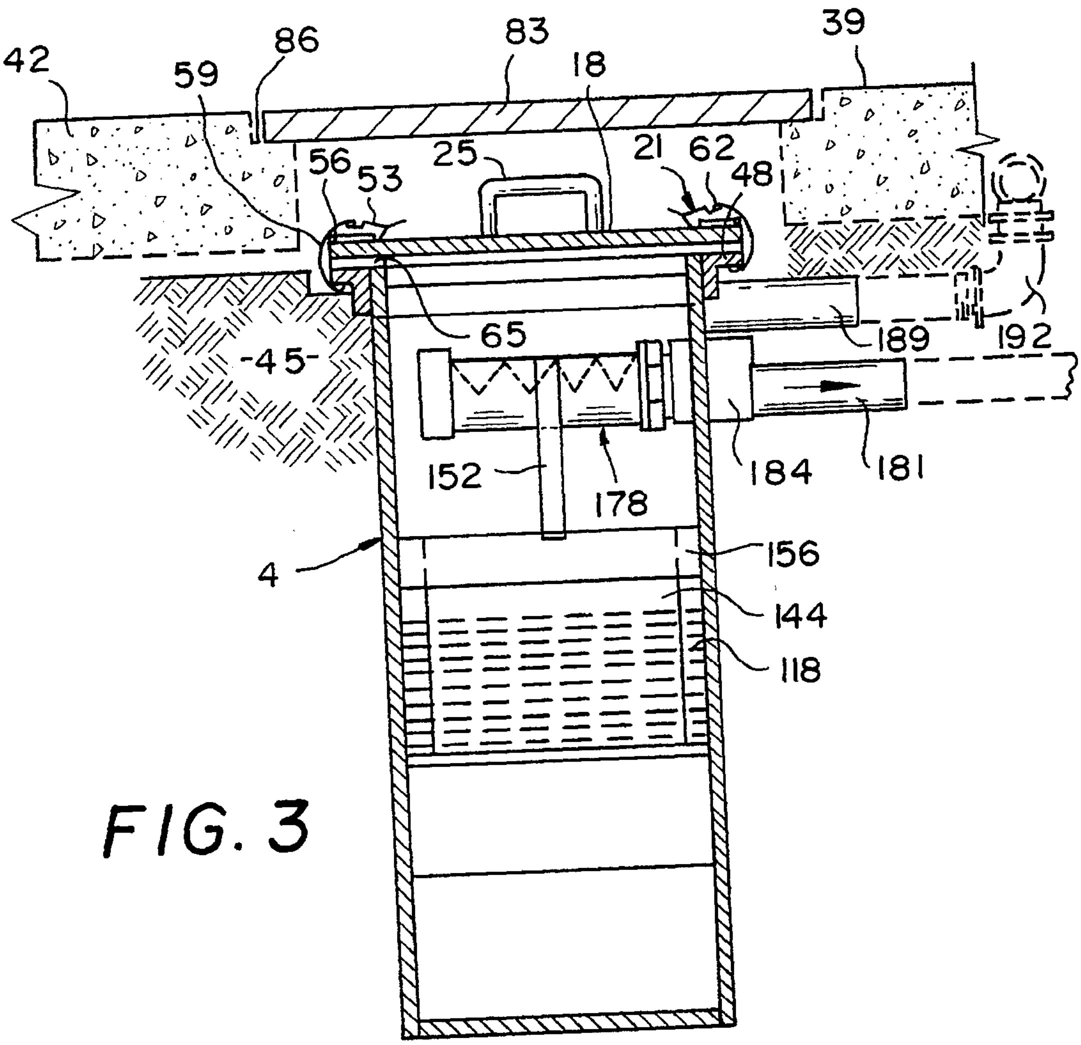
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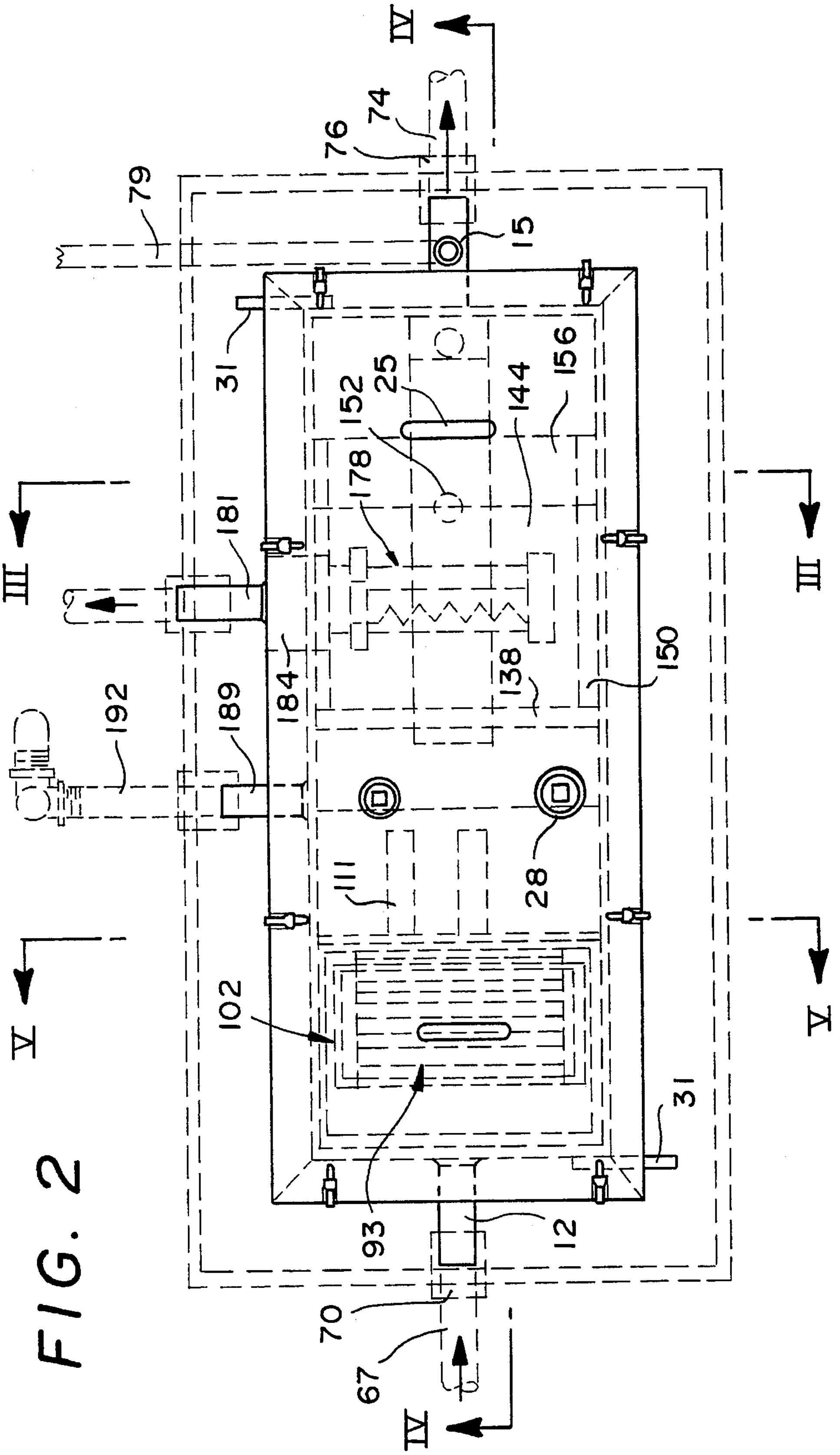
FIG. 3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74
76
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156
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152
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III
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138
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192
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V
93
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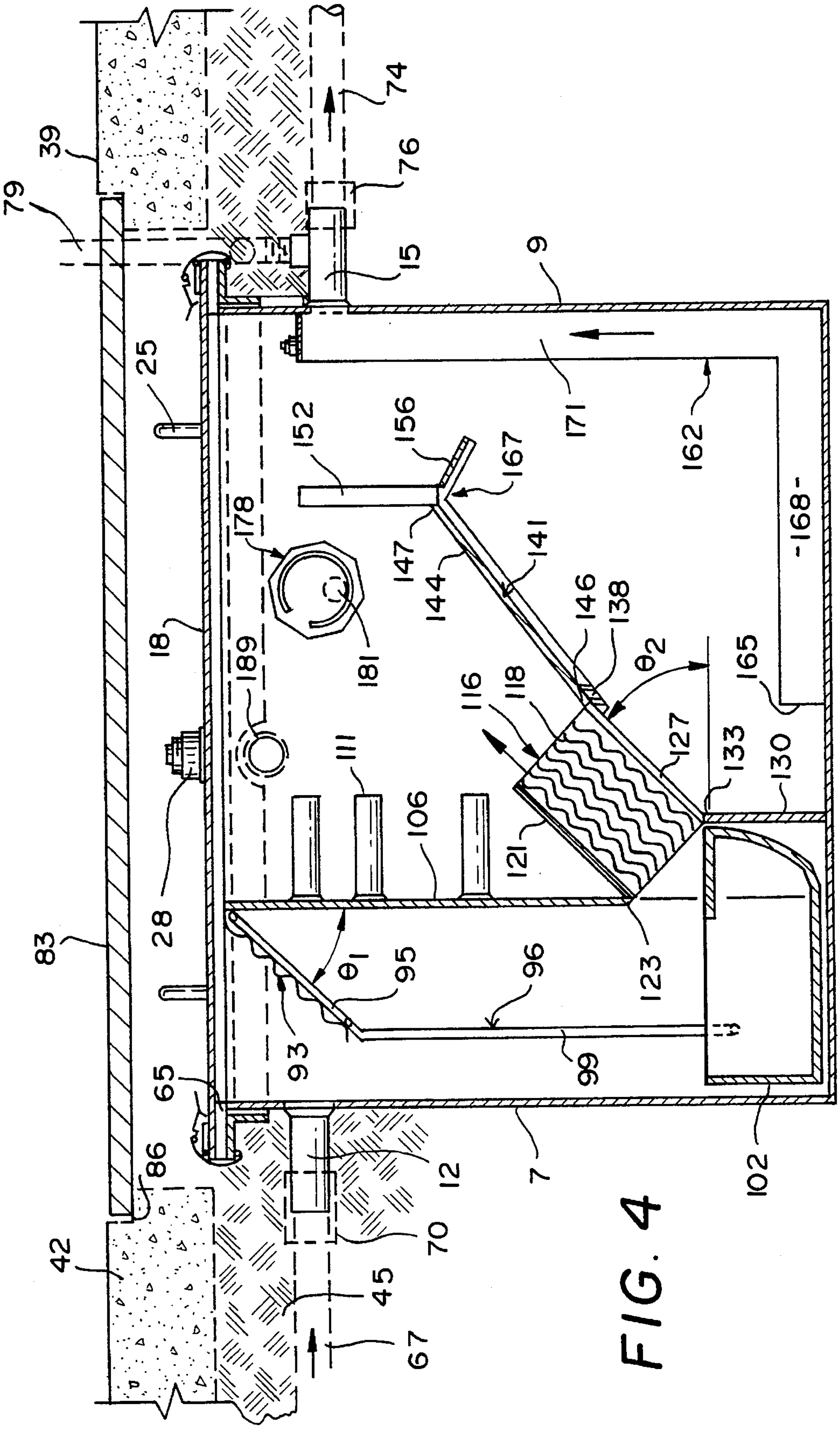
FIG. 2


39
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74
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152
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189
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111
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121
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123
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95
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θ1
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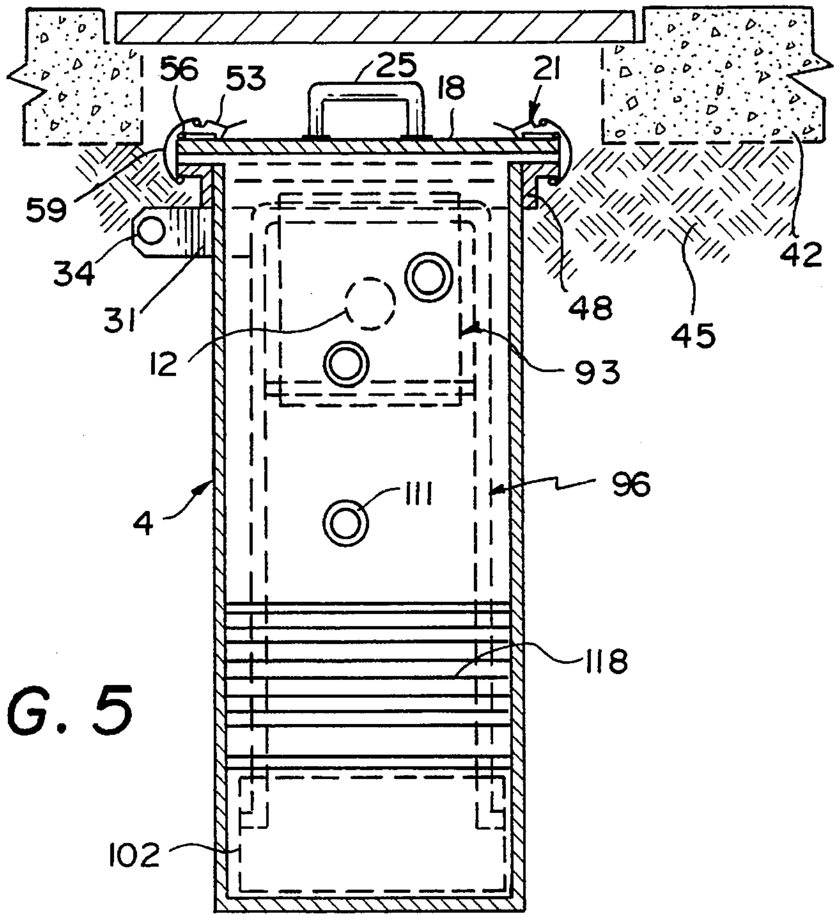
FIG. 4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93
111
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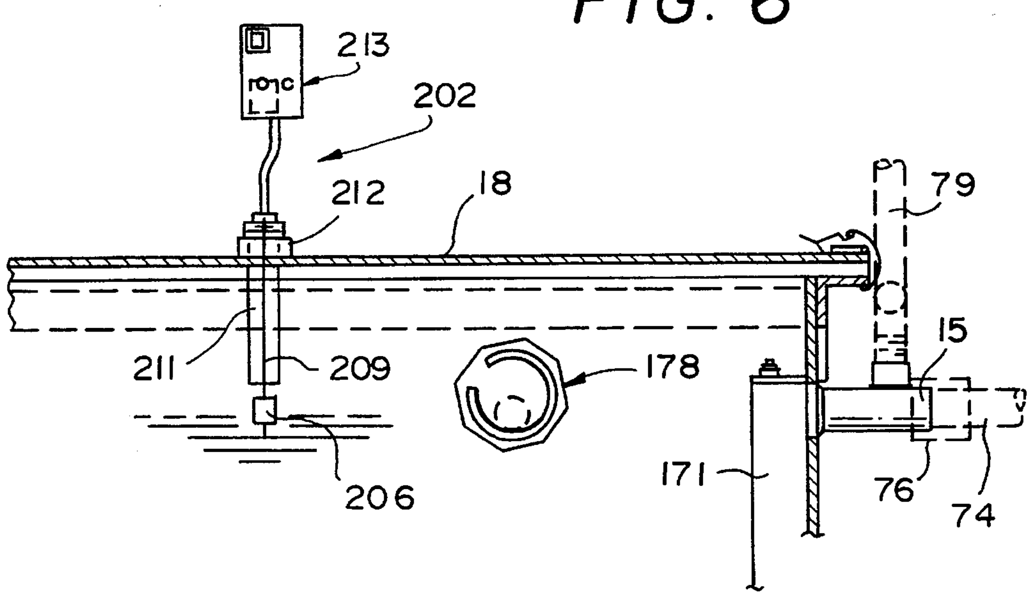
118
102

FIG. 5

FIG. 6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202
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211
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178
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206
171
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74

OIL-WATER SEPARATOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention pertains to an apparatus and method for gravitationally separating oil and water. The invention has particular use in clarifying run-off or drainage water so as to avoid pollution in streams, lakes or the like. The term "oil-water" as used herein is intended to cover a wide range of immiscible liquids and possibly light weight solids. In general, the invention is applicable to the separation of immiscible liquids of different specific gravities and which are therefore susceptible to gravity separation.

2. Discussion of the Prior Art

Many devices have been proposed for gravitationally separating oil and other lightweight materials from run-off or drainage water to avoid pollution of streams lakes or the like. Such apparatuses are often installed underground and are adapted for handling oil-water run-off from rain or hose downs at gasoline service stations, truck stops, parking lots, shopping mall areas, roadways, bus garages, petroleum plants and the like. Such known apparatuses have not been completely satisfactory, mainly due to the difficulties associated with maintenance of the apparatus and/or the ability of the apparatus to adequately separate the immiscible liquids while still maintaining a relatively compact size. Actually, such known apparatuses often perform an adequate separation function when working on a batch basis, however, the same apparatuses have not been satisfactory for continuous flow processing at a rate commensurate with the amount of run-off flow generally developed for separation.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a compact gravitational oil-water separator for use in a small drainage system that is subject to a continuous flow or intermittent flow basis.

It is another object of the present invention to provide an oil-water separator that requires a minimum of maintenance, but which also is designed with removable components to aid in servicing the apparatus when necessary.

These and other objects of the present invention are achieved by providing an oil-water separator that includes a tank within which various separator devices are designed and mounted such that a continuous or intermittent gravity flow of immiscible liquids will be subjected to both horizontal and vertical flow and which can effectively separate the immiscible liquids with full use of fluid gravitational differentials, laminar flow, coalescence, undulation, fluid impingement, flow reversing and tertiary separation within a single containment tank. By utilizing these separation methods and the complete volume of the containment tank, an efficient separation system can be provided in a compact tank that can handle a reasonable rate of continuous flow.

When the flow of oil-water enters the separator tank, the flow is directed to impinge upon a baffle member that is mounted at an angle to the vertical within an upper portion of the tank. Instantly, large oil particle separation and solid separation occurs while the flow is distributed and directed across the entire width of the tank. The fluid then continues vertically downward which causes separated solids to accelerate and to be collected in a sediment bucket positioned below the baffle member. The direction of the fluid flow is then changed to an upward direction and the flow is caused to pass through a coalescer unit composed of a plurality of vertically spaced and upwardly sloping corrugated plates.

The laminar flow leaving the parallel plates will contain coalesced oil particles and will be guided, at an angle, upwardly by a tertiary separation plate to a point where, in gentle return to downward vertical flow, the coalesced particles are wiped free of the flow by contact with an air/water or oil/water interface of the separator. The flow is then forced to reverse in direction toward an opening of an outlet flow passage. Remaining free oil particles in the flow will rise, impinge each other and be captured in a small alcove defined by the separation plates. A vertical pipe conducts the oil particles from the above towards the oil interface at the top of the separator. The flow again reverses direction before entering the outlet flow passage and is directed to a discharge outlet.

The oil-water separator according to the invention is capable of effectively separating immiscible liquids on a continuous basis with essentially no supervision and minimum maintenance. When maintenance is required, the separating components can be readily removed from the tank.

Additional objects, features and advantages of the invention will become more evident from the following detailed description of a preferred embodiment thereof, when taken in conjunction with the following drawings wherein like reference numerals refer to corresponding parts in the several views.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic, perspective view of the oil-water separator of the present invention;

FIG. **2** is a top view of the oil-water separator of the invention shown mounted underground and with its internal separating components shown in phantom;

FIG. **3** is a cross-sectional view taken along line III—III of FIG. **2**;

FIG. **4** is a cross-sectional view generally taken along line IV—IV of FIG. **2**;

FIG. **5** is a cross-sectional view generally taken along line V—V of FIG. **2**; and

FIG. **6** depicts an enlarged sectional view of a portion of the separator shown in FIG. **4** with the inclusion of a supplemental indicating assembly.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With initial reference to FIG. **1**, the oil-water separator of the present invention includes a tank generally indicated at **4**. Tank **4** includes a first end **7** and a second end **9**. Although tank **4** is generally indicated to be rectangular in shape, it should be readily recognized that tank **4** can take the form of various shapes including cylindrical. Tank **4** is adapted to receive a supply of oil-water to be separated through an inlet **12** that projects through an upper portion (not labeled) of tank **4** at first end **7**. This oil-water flow is adapted to be separated within tank **4** such that clarified water is delivered out of tank **4** through a discharge outlet **15** extending from the upper portion of tank **4** at second end **9**.

A cover member **18** is removably secured upon tank **4** by means of a plurality of clamps **21** in the manner which will be more fully discussed below. Cover member **18** is provided with a pair of spaced handles **25**. In addition, various holes can be provided within cover member **18** which are adapted to receive plugs **28**. Once plugs **28** are removed, tank **4** can be visually inspected without the need to entirely remove cover member **18**. Tank **4** is also provided with at least one lug **31** that is fixedly secured thereto and which includes a throughhole **34**. Lug **31** provides a connection member that enables tank **4** to be positioned by means of heavy machinery. As best shown in FIG. **2**, two such lugs **31** are preferably provided at opposing corners of tank **4**. In the preferred embodiment, tank **4** and cover member **18** are formed from steel, however, it should be readily understood that various materials, including polymeric materials, could be utilized without departing from the spirit of the invention.

Reference will now be made to FIGS. **3** and **4** in describing the manner in which tank **4** is mounted underground. In these figures, reference numeral **39** indicates ground level that is defined by an upper surface of a concrete slab **42**. Below concrete slab **42** the earth **45** has been dug out to accommodate tank **4**. At an uppermost portion of tank **4**, just below cover member **18**, an L-shaped plate **48** is permanently secured to tank **4** and extends about its upper perimeter. L-shaped plate **48** cooperates with clamps **21** to secure cover member **18** in place. More specifically, each clamp **21** includes a lever **53** that is pivotally mounted to cover member **18** by means of a pin **56**. A spring clip **59** is pivotally secured at an upper end thereof (not labeled) to lever **53** by means of a pin **62** and includes a lower end (not labeled) that is adapted to extend beneath and engage L-shaped plate **48** such that when lever **53** is in the position shown in these figures, cover member **18** is secured in place. However, if lever **53** is pivoted about pin **56**, spring clips **59** will be readily disengaged from L-shaped bracket **48** such that cover member **18** can be removed from upon tank **4** by means of handles **25**. In the preferred embodiment shown, a sealing member **65** is secured about the bottom perimeter of cover member **18** and is adapted to engage L-shaped plate **48** to seal tank **4** when cover member **18** is secured in the manner outlined above.

Inlet **12** is adapted to receive the oil-water flow from a supply line **67** that is connected to inlet **12** by means of a coupling **70**. In a similar manner, discharge outlet **15** is adapted to be attached to a discharge line **74** by means of a coupling **76**. Discharge outlet **15** is also further provided with a vent line **79** as best shown in FIGS. **2** and **4**.

Although not clearly shown in the Figures, tank **4** preferably rests upon earth **45** so as to be supported from below. After tank **4** is set in place, additional earth **45** can be placed about tank **4** for stabilization purposes. Finally, a cover plate **83** can be set within recesses **86** formed in concrete slab **42** so as to completely cover tank **4** and to provide a surface level with ground surface **39**.

Reference will now be made to FIGS. **2–5** in describing the internal separation components provided within tank **4** and the manner in which the separator of the present invention operates. Mounted in the upper portion of tank **4**, adjacent first end **7** and juxtaposed to inlet **12**, is a baffle member **93**. Baffle member **93** comprises a transversely corrugated plate that slopes upwardly at an angle of Θ_1 with respect to the vertical. Preferably, the angle Θ_1 is within the range of 30°–60°. In this position, the oil-water flow through inlet **12** will be directed upon baffle member **93**. Instantly, larger oil particles and solids will be separated from the flow upon impingement with baffle member **93** while the remainder of the flow will change in direction such that the flow is distributed across substantially the entire width of tank **4**. Baffle member **93** is actually mounted upon a sloped portion **95** of a handle unit **96**. Handle unit **96** also includes a vertical portion **99** that is secured to a sediment bucket **102** positioned within tank **4** below baffle member **93**. After the oil-water flow is distributed by baffle member **93**, the flow will continue vertically downward causing the separated solids to accelerate. These solids will be captured within sediment bucket **102** which can be emptied as required in the manner which will be more fully discussed below. At this point, it should simply be recognized that baffle member **93** and sediment tank **102** are both secured to handle unit **96**. Baffle member **93** and sediment tank **102** are positioned in a portion of tank **4** generally referred to as a sludge chamber which is separated from a remainder of tank **4** by means of a dividing wall **106**. Dividing wall **106** is generally vertically arranged and includes a plurality of vertically spaced flow tubes **111** which permit oil particles that tend to float relative to the majority of the oil-water flow to pass out of this sludge chamber.

Positioned at a lower portion of tank **4**, above sediment tank **102**, is a coalescer unit **116**. Coalescer unit **116** includes a plurality of vertically spaced, corrugated plates **118**. In general, coalescer unit **116** slopes upwardly from adjacent sediment bucket **102** towards second end **9** of tank **4**. Coalescer unit **116** includes an upper plate **121** that is fixedly secured to a lower end **123** of dividing wall **106** and a lower plate **127**. A dividing wall extension **130** is vertically disposed within tank **4** adjacent sediment tank **102** and includes an upper end **133** that is fixedly secured to lower plate **127** of coalescer unit **116**. The other end of lower plate **127** rests upon a support member **138** that extends across tank **4**.

Coalescer unit **116** functions in a manner known in the art whereby the vertically spaced plates **118** direct a generally laminar flow upwardly within tank **4** to induce coalescence. Coalescer unit **116** is mounted within tank **4** at an angle of Θ_2 with respect to the horizontal. This angle of inclination is preferably within the range of 20°–60°. Within coalescer unit **116**, oil globules will rise the short distance between adjacent plates **118** to coalesce on the undersides of plates **118** and creep up plates **118** toward the outlet region of coalescer unit **116**. Coalescence occurs when large oil droplets rising at a high rate of speed collide with smaller, slower droplets, as well as impinging upon the corrugated plate surface. The larger droplets which are formed combine again with small droplets to form even larger droplets which have an even higher associated rise rate.

The flow leaving coalescer unit **116** will be guided upwardly by means of a tertiary separation plate **141** including a first portion **144** that slopes upwardly towards second end **9** and the oil-water interface associated with tank **4**. It has been found that contact with the layer of already separated oil according to this invention functions to wipe free some additional particles of free oil from the flow which might not otherwise have been separated. First portion **144** includes a lower end **146** that rests upon support member **138** and an uppermost end **147**. Support member **138** actually constitutes a transversely extending member of an overall support arrangement provided within tank **4**. The overall support arrangement is best shown in phantom in FIG. **2** and includes support member **138** and longitudinally extending members **150**. Separation plate **141** is therefore actually supported upon support member **138** and longitudinally extending; members **150**.

Extending through separation plate **141**, at uppermost section **147** thereof, is a collection tube **152** which functions in a manner which will be more fully discussed below. Separation plate **141** further includes a second portion **156** which slopes downwardly for a predetermined distance from uppermost section **147** towards second end **9** of tank **4**. As the flow exits coalescer unit **116** and is guided upwardly by means of separation plate **141**, the coalesced oil droplets will rise while the remainder of the flow will be redirected along second portion **156** of separation plate **141**. The flow is then directed to an outlet flow passage **162** including an inlet opening **165**. As best shown in FIG. **4**, inlet opening **165** is located rearward of uppermost section **147** of separation plate **141** and is actually located closer to first end **7** than second end **9** of tank **4**. Due to this arrangement, the flow is caused to reverse in direction after separation plate **141** in order to enter inlet opening **165**. This reverse flow will cause any remaining free oil particles in the flow stream to rise toward a bottom portion (not labeled) of separation plate **141** and be directed along separation plate **141** to an alcove **167** defined between first portion **144** and second portion **156** of separation plate **141**. Collection tube **152** opens at alcove **167** and functions to guide these remaining free oil particles toward the oil-water interface at the upper section of tank **4**.

By the time the flow enters inlet opening **165** of outlet flow passage **162**, an effective oil-water separation process has been completed. The flow will be directed initially along a bottom portion of tank **4** within a first section **168** of outlet flow passage **162** and then along a second portion **171** of outlet flow passage **162** which extends along second end **9** of tank **4**. Finally, second portion **171** of outlet flow passage **162** converges and directs the flow out of tank **4** through discharge outlet **15**.

By this arrangement, an oil-water separator is provided which is capable of effectively separating immiscible liquids on a continuous basis for a generally small source drainage over reasonable extended time periods with minimum maintenance and little or no supervision. If maintenance is required, cover member **18** can be removed by unlatching clamps **21** such that spring clips **59** are disengaged from L-shaped plate **48**. Following removal of cover member **18**, separation plate **141** and collection tube **152** can be removed as a unit from tank **4**. In addition, due to the interconnection between divider wail **106**, divider wall extension **130**, and plates **121** and **127**, coalescer unit **116** can also be readily removed from tank **4** as a unit. Finally, since baffle member **93** is interconnected with sediment bucket **102** through handle unit **96**, these components can be removed from tank **4** as a unit. This removability feature of the separation components incorporated in the separator of the present invention not only aids in effectively cleaning these components and removing particles collected within sediment bucket **102**, but also provides for relatively unrestricted access to the interior of tank **4** if necessary.

Tank **4** can also be provided with a skimmer unit **178** that includes an associated skimmer outlet pipe **181** and coupling **184**. In general, the structure and function of skimmer unit **178** is known in the art and therefore will not be described in detail herein. In addition, a vent pipe **189** that is joined to an extension pipe **192** (see FIG. **3**) can be used to vent tank **4**. Vent pipe **189** opens at or above the oil-water interface associated with tank **4**.

Reference will now be made to FIG. **6** in describing an auxiliary feature of the oil-water separator of the present invention. FIG. **6** is actually an enlarged view of a portion of the arrangement shown in FIG. **4** and indicates the presence of an oil-water interface sensing/indicating unit generally indicated at **202**. Unit **202** incorporates a float member **206** that hangs from a suspension member **209** positioned within a sleeve **211**. Unit **202** is used to sense and indicate the level of the oil-water interface within tank **4** by determining the height of float member **206**. The height of float member **206** is actually determined by sensing the

position of suspension member **209** within sleeve **211** by a position sensor **212**. The specific structure of position sensor **212** is not disclosed in this application since it is considered well known in the art and not an inventive aspect in this application. The output of position sensor **212** is supplied to an indicating panel **213** which can provide either an audible or visual indication/alarm regarding the height of the sensed oil-water interface.

Although described with respect to a preferred embodiment of the invention, it should be readily understood that various changes and/or modifications can be made to the invention without departing from the spirit thereof. In general, the invention is only intended to be limited by the scope of the following claims.

I claim:

1. An oil-water separator comprising:

a tank having first and second longitudinally spaced ends, a upper portion and a lower portion;

a baffle member positioned within said tank adjacent the first end thereof;

an oil-water flow inlet opening into the upper portion of said tank at a position juxtaposed to said baffle member so as to direct an oil-water flow against said baffle member;

a sediment bucket positioned in the lower portion of said tank below said baffle member;

a coalescer unit positioned downstream of said sediment bucket, said coalescer unit including a plurality of vertically spaced, substantially parallel corrugated baffle plates sloping upwardly from a coalescer inlet, adjacent the lower portion of said tank, to a coalescer outlet;

a separation plate including a section that slopes upwardly from said coalescer outlet toward the second end of said tank, said separation plate including an uppermost section; and

an outlet flow passage terminating in a discharge outlet for said separator, said outlet flow passage having a passage opening located in the lower portion of said tank, closer to the first end of said tank than the uppermost section of said separation plate.

2. An oil-water separator as claimed in claim **1**, further comprising a cover member removably attached to the upper portion of said tank, said baffle member sloping upwardly away from the first end of said tank toward said cover member.

3. An oil-water separator as claimed in claim **2**, wherein said baffle member includes a surface portion, opposite said inlet, defining transversely extending corrugations.

4. An oil-water separator as claimed in claim **1**, further comprising handle means fixed to said sediment bucket for use in removing said sediment bucket from said tank.

5. An oil-water separator as claimed in claim **4**, wherein said baffle member is supported by said handle means within said tank.

6. An oil-water separator as claimed in claim **1**, further comprising a dividing wall extending substantially vertically between said baffle member and said coalescer unit, said coalescer unit being mounted to, supported by and readily removable from said tank with said dividing wall.

7. An oil-water separator as claimed in claim **6**, wherein said dividing wail has extending therethrough, above said coalescer unit, a plurality of vertically spaced pipes providing for oil transfer through said dividing wail and impingement coalescence of oil droplets.

8. An oil-water separator as claimed in claim **1**, further including a collection tube extending through and upwardly from the uppermost section of said separation plate for guiding particles upward, away from said separation plate, toward an oil-water interface.

9. An oil-water separator as claimed in claim **1**, wherein said separation plate further includes a section that slopes downwardly from the uppermost section of said separation plate toward the second end of said tank.

10. An oil-water separator as claimed in claim **1**, wherein said outlet flow passage extends along the lower portion of said tank a predetermined distance and then upwardly at the second end of said tank to said water discharge outlet.

11. An oil-water separator as claimed in claim **10**, wherein said passage opening is located closer to the first end of said tank than the second end thereof.

12. An oil-water separator as claimed in claim **1**, further comprising skimmer means mounted in said tank above said separation plate.

13. An oil-water separator as claimed in claim **1**, further comprising means for sensing and indicating the location of an oil-water interface within said tank.

14. An oil-water separator comprising:

a tank having first and second longitudinally spaced ends, an upper portion and a lower portion;

an inlet opening into the upper portion of said tank at the first end thereof for introducing an oil-water flow into said tank;

first separator means positioned within said tank, adjacent the first end thereof, juxtaposed to said inlet, said first separator means directing the oil-water flow generally downwardly within said tank;

second separator means positioned adjacent the lower portion of said tank and downstream of said first separator means, said second separator means directing the oil-water flow from the lower portion of said tank upwardly and toward the second end of said tank at a predetermined angle;

third separator means positioned downstream of said second separator means, said third separator means initially directing the oil-water flow from said second separator means upwardly toward the second end of said tank and then re-directing the flow in a reverse direction, generally downwardly and toward the first end of said tank; and

an outlet flow passage terminating in a discharge outlet for said separator, said outlet flow passage having a passage opening located in the lower portion of said tank, closer to the first end of said tank than at least a portion of said third separator means.

15. An oil-water separator as claimed in claim **14**, wherein said first separator means comprises a corrugated baffle member that slopes upwardly away from the first end of said tank and a sediment bucket positioned in the lower portion of said tank below said baffle member.

16. An oil-water separator as claimed in claim **15**, further including means for interconnecting said baffle member and said sediment bucket whereby said baffle member and said sediment bucket can be readily removed from said tank as a unit.

17. An oil-water separator as claimed in claim **14**, wherein said second separator means comprises a coalescer unit including a plurality of vertically spaced, substantially parallel corrugated baffle plates and said third separator means comprises a separation plate including a portion that slopes upwardly from said coalescer unit toward the second end of said tank.

18. An oil-water separator as claimed in claim **17**, further including a divider member extending substantially vertically between said first separator means and said second separator means, said divider member being attached to said coalescer unit such that said divider member and said coalescer unit can be removed from said tank as a unit.

19. An oil-water separator as claimed in claim **17**, further including a collection tube extending through and upwardly from an uppermost section of said separation plate.

20. A method of separating an oil-water mixture comprising:

introducing a flow of fluid initially containing oil and water into an upper portion of a first end of a tank;

directing the flow toward a sloped, corrugated surface of a baffle member positioned in the upper portion of the tank such that at least a substantial portion of the flow is directed over said corrugated surface to cause partial separation thereof by causing large oil globules to be separated from the flow;

directing the flow downward within the tank while enabling any heavy solids in the flow to drop and be contained within a sediment bucket positioned in a lower portion of the tank;

directing the flow upwardly and towards a second end of the tank between a plurality of vertically spaced, corrugated plates of a coalescer unit;

guiding the flow along an upward path toward the second end of the tank by means of a sloping separation plate mounted within the tank;

re-directing the flow in a downward and reverse direction toward an inlet opening of an outlet flow passage;

guiding the flow within the outlet flow passage such that the flow moves upwardly along the second end of the tank; and

ejecting the flow from the tank through a discharge outlet.

* * * * *

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(12) **United States Patent**
Burwell

(10) **Patent No.: US 6,517,719 B1**
(45) **Date of Patent: Feb. 11, 2003**

(54) **OIL AND WATER SEPARATOR**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 38 days.

(21) Appl. No.: **09/722,559**

(22) Filed: **Nov. 28, 2000**

(51) **Int. Cl.**[7] **C02F 1/28**

(52) **U.S. Cl.** **210/257.1**; 210/305; 210/314; 210/320; 210/336; 210/323.2; 210/DIG. 5

(58) **Field of Search** .... 210/799, 284, 210/305, 314, 320, 336, 257.1, 323.2, DIG. 5

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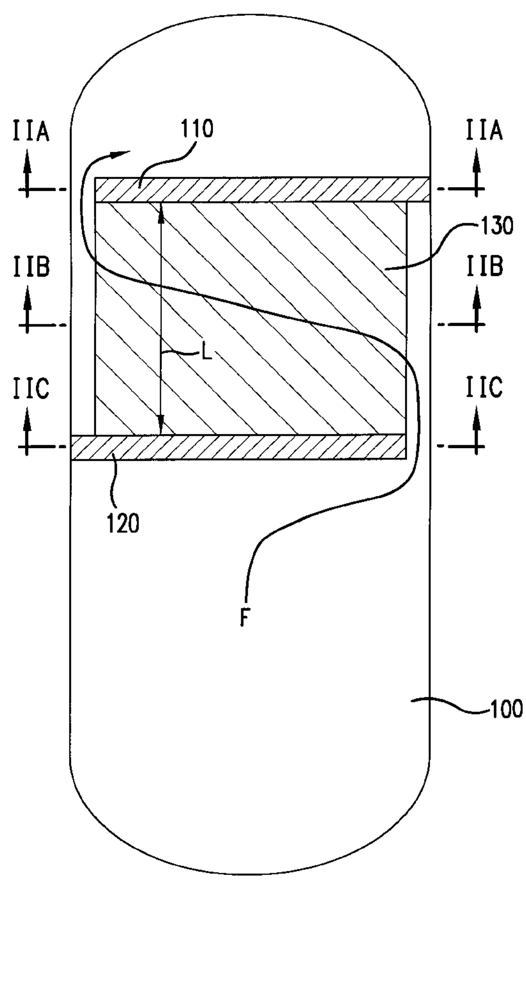
Primary Examiner—Peter A. Hruskoci
(74) *Attorney, Agent, or Firm*—Piper Rudnick LLP; Steven B. Kelber

(57) **ABSTRACT**

A storage tank includes an oil and water separator in which the frontal area of the coalescers is increased relative to known arrangements of coalescers in oil and water separators. By arranging the coalescers such that the surface area of the coalescers is increased, the efficiency of the coalescers is increased. In some preferred embodiments, the coalescers are arranged in a bank with free flow fluid paths between the coalescers in the bank, each of the paths being closed by a baffle on one end and open on an opposite end, and the baffles are arranged such that the open and closed ends of paths alternate. In other preferred embodiments, the coalescers are arranged in a tubular fashion and fluid flows from the outside surface of the tube through the coalescers and out a central path.

11 Claims, 10 Drawing Sheets



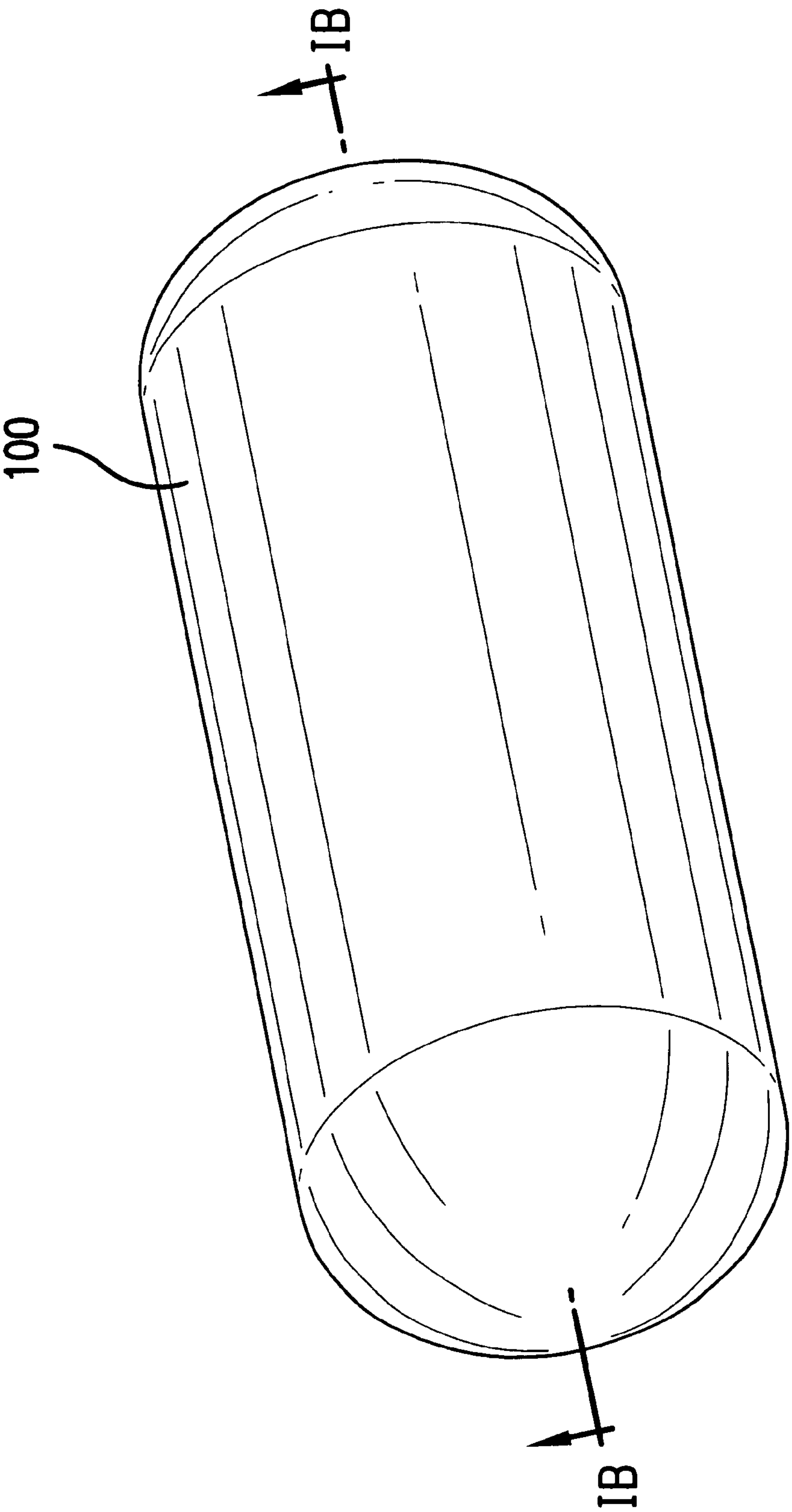


FIG.1(a)

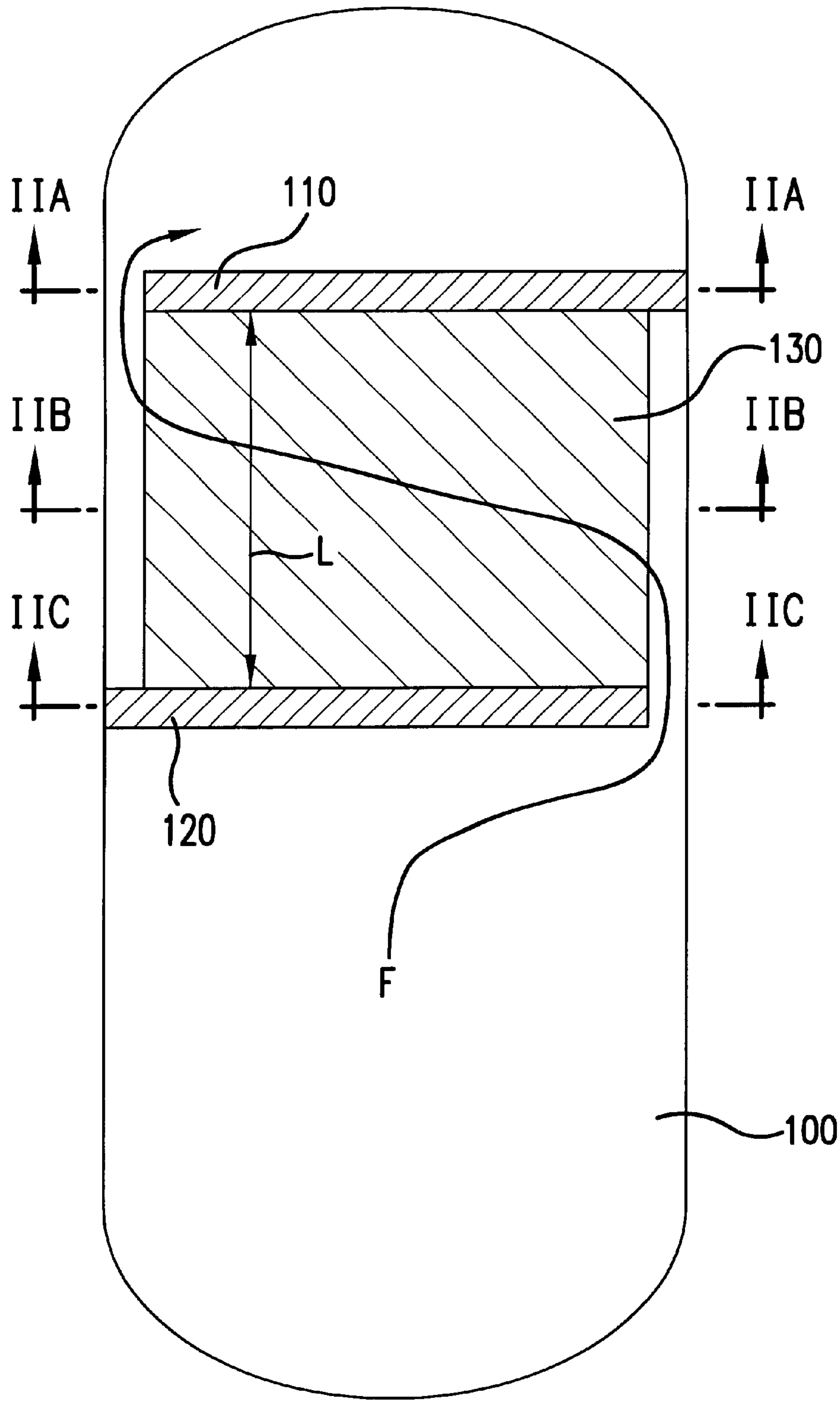


FIG.1(b)

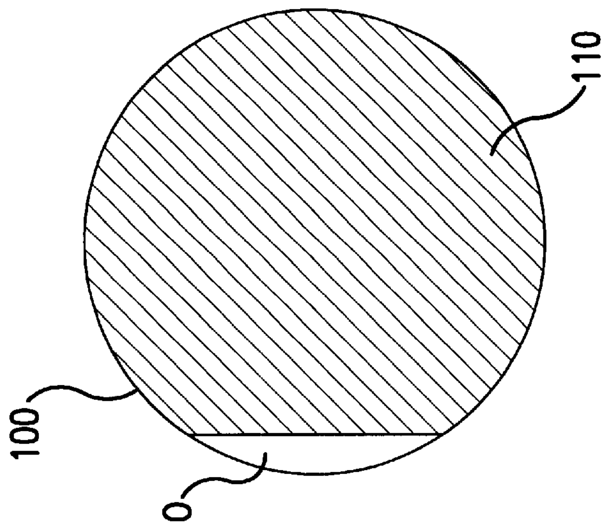


FIG.2(c)

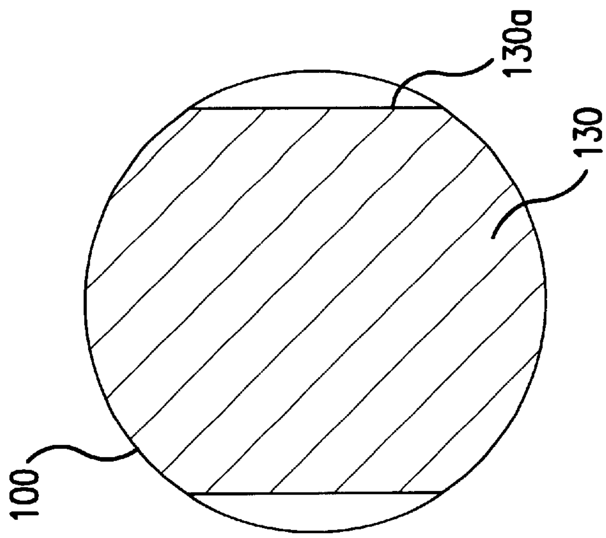


FIG.2(b)

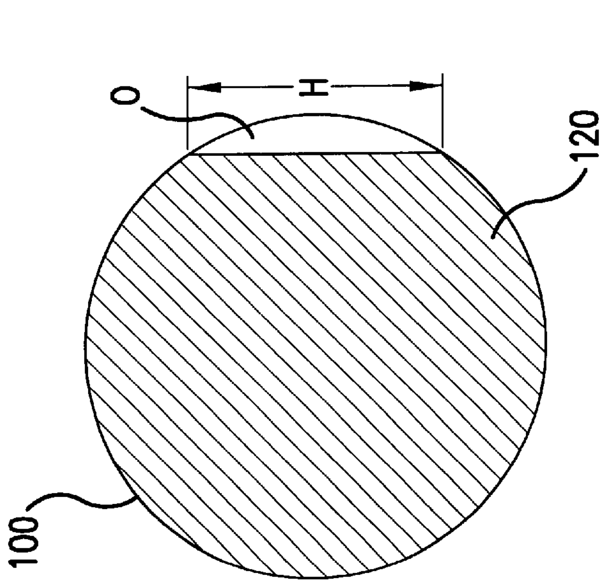


FIG.2(a)

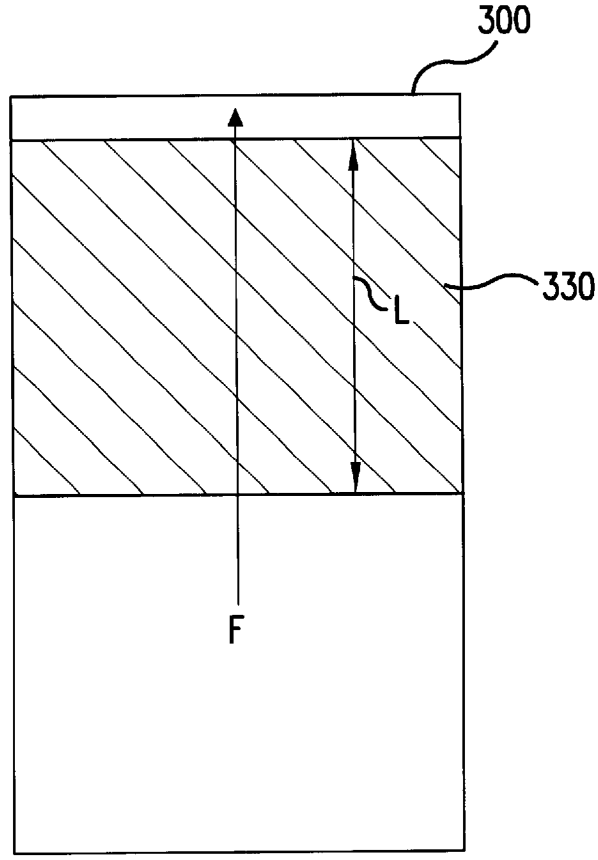


FIG.3(a)

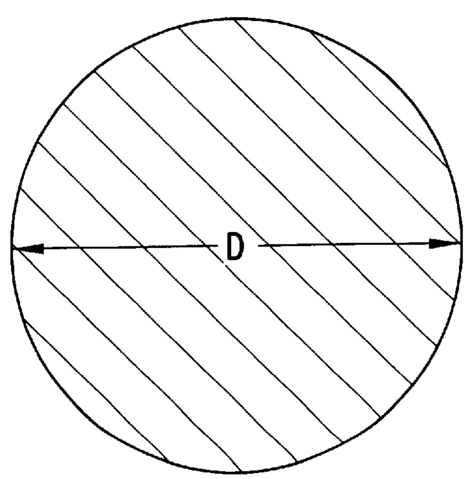


FIG.3(b)

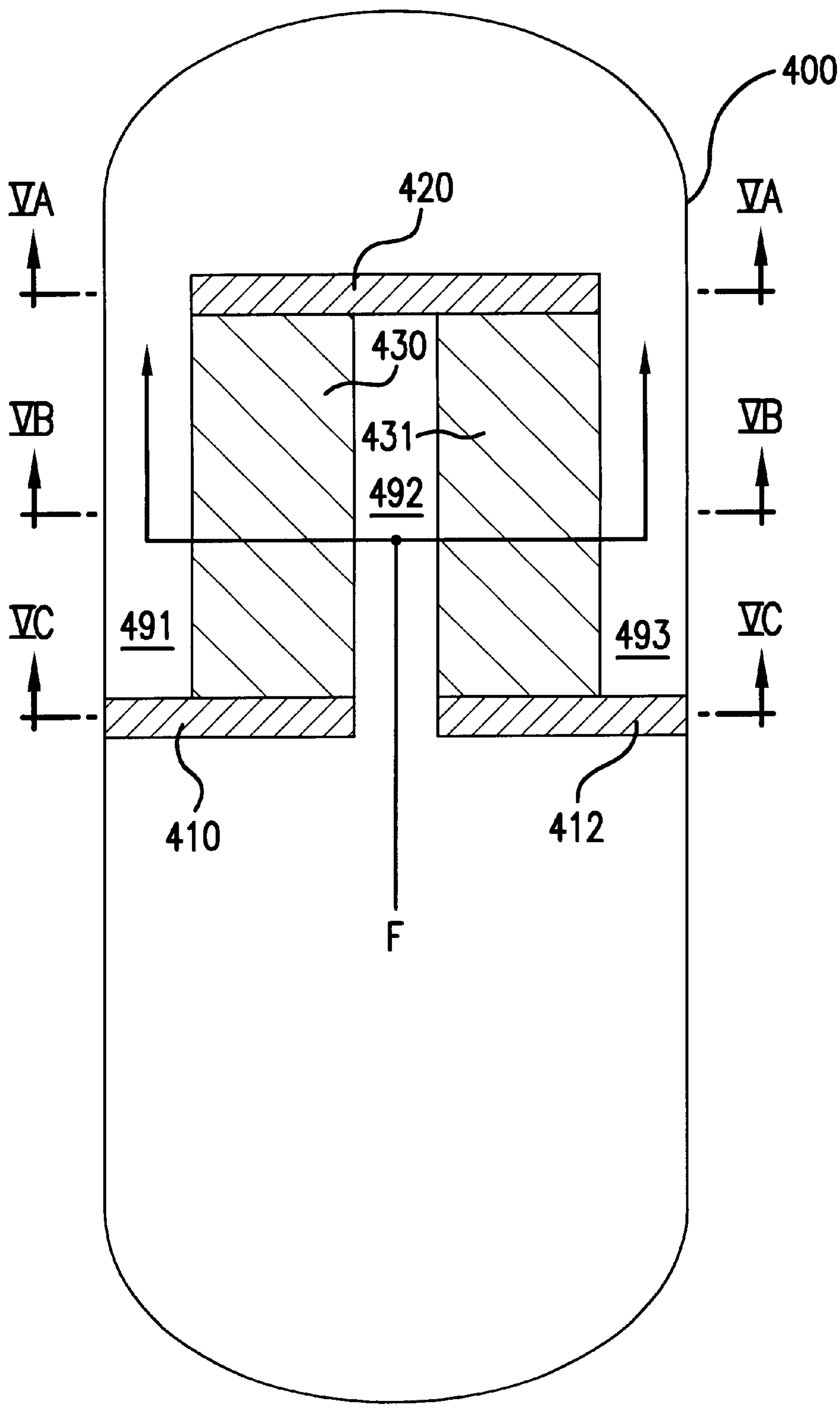


FIG.4

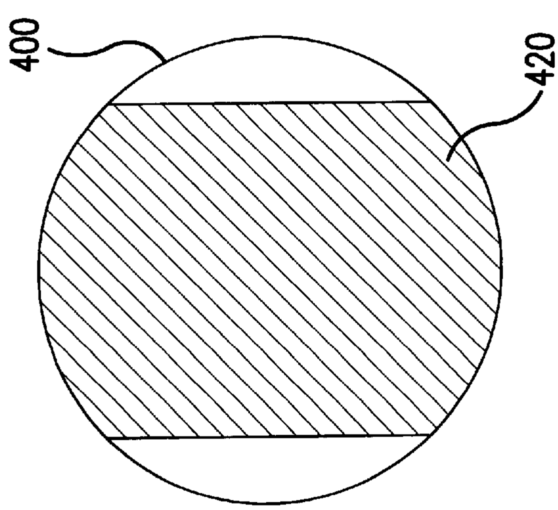


FIG.5(a)

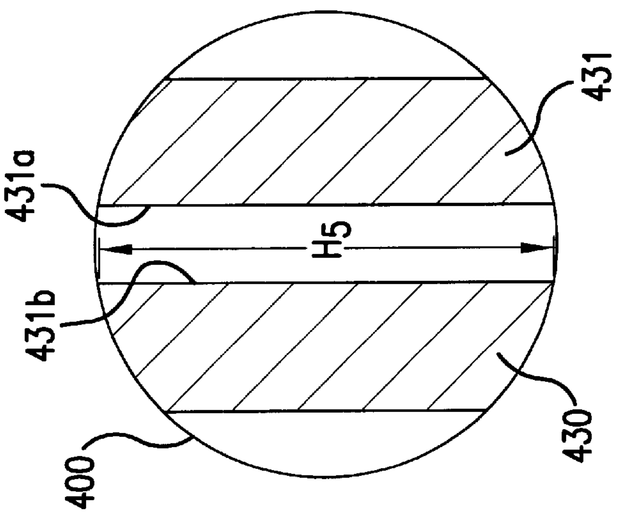


FIG.5(b)

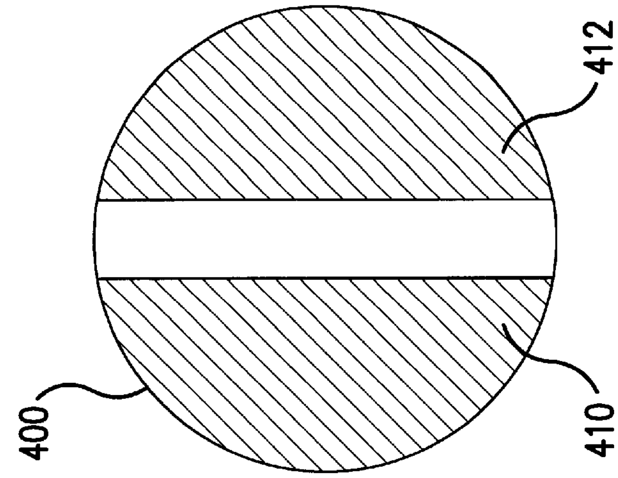


FIG.5(c)

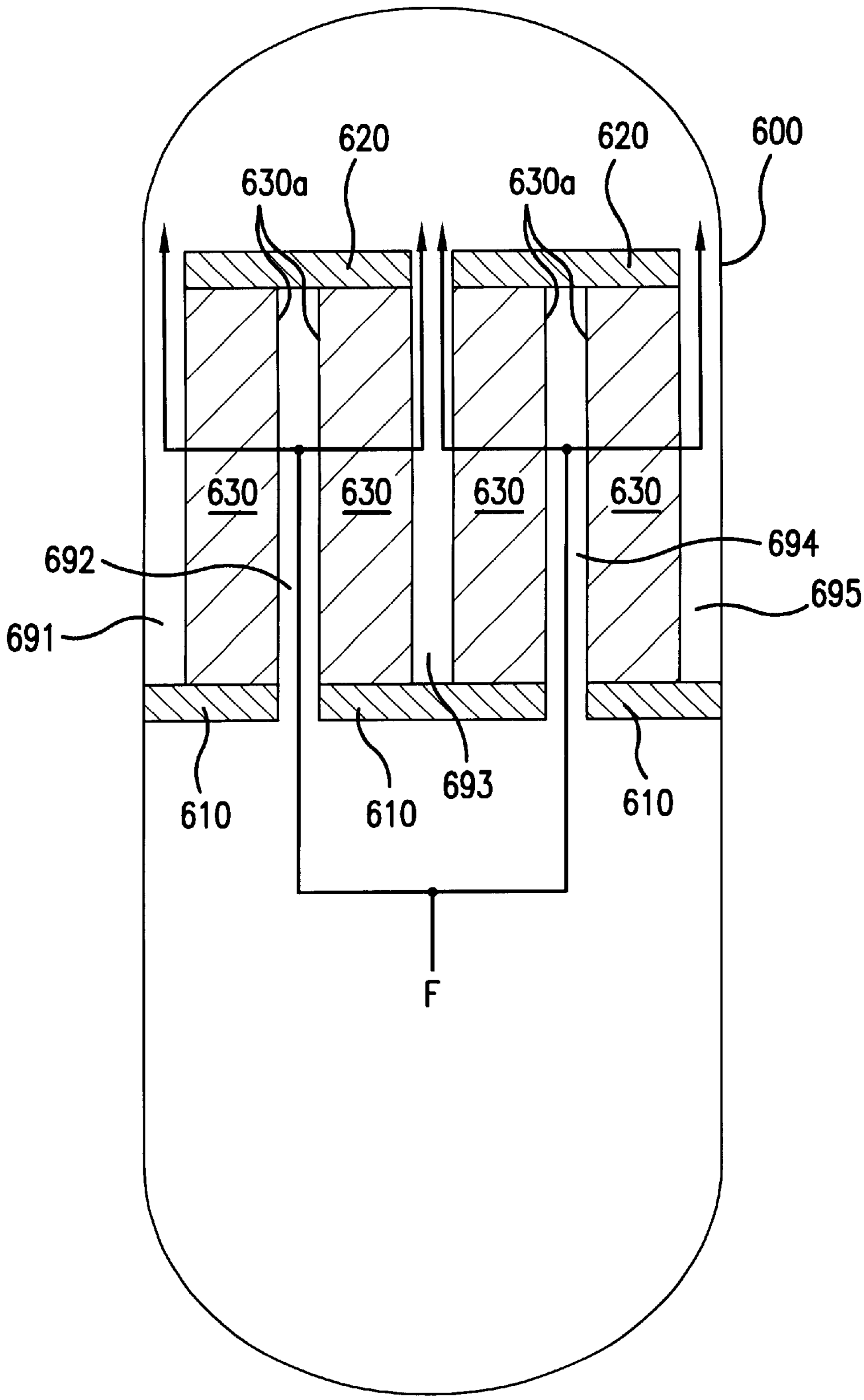

620
620
600
630a
630a
630
630
630
630
692
694
691
695
610
610
693
610
F

FIG.6

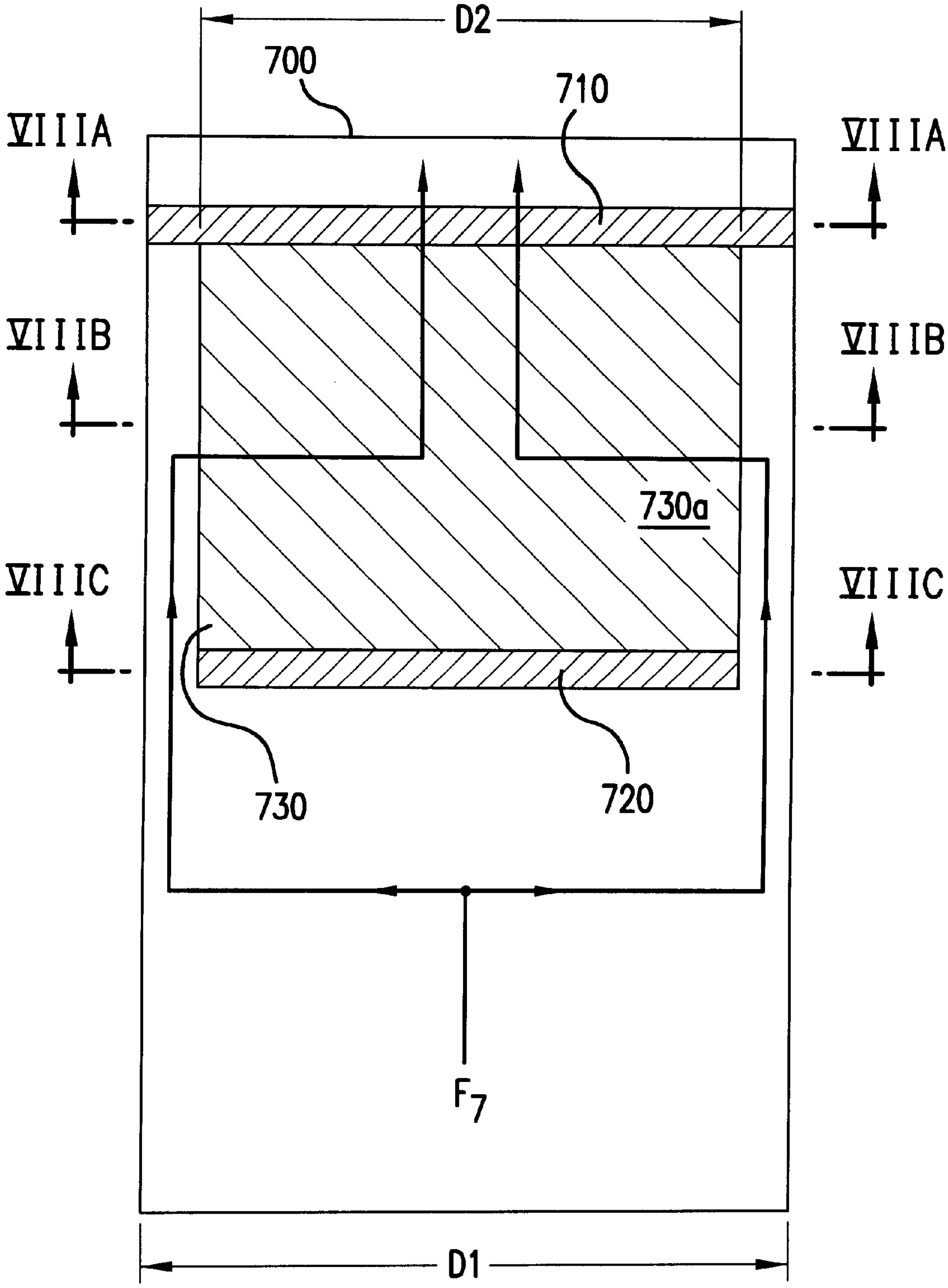

D2
700
710
VIIIA
VIIIA
VIIIB
VIIIB
730a
VIIIC
VIIIC
730
720
F7
D1

FIG.7

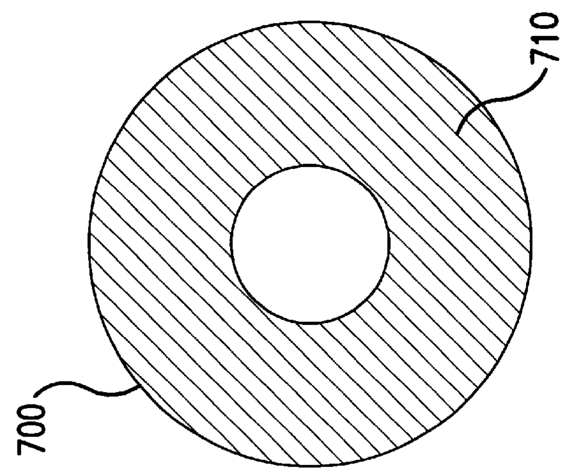


FIG.8(c)

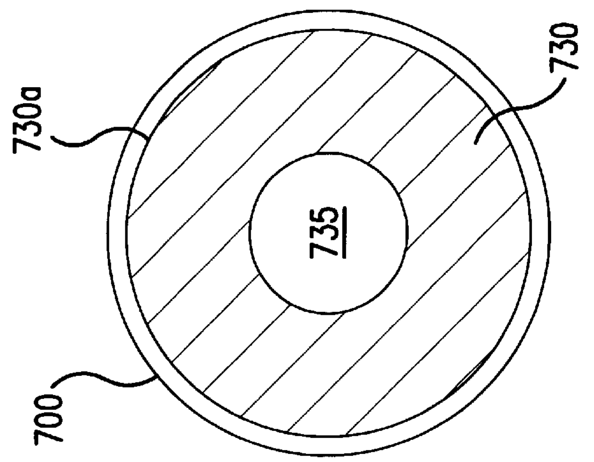


FIG.8(b)

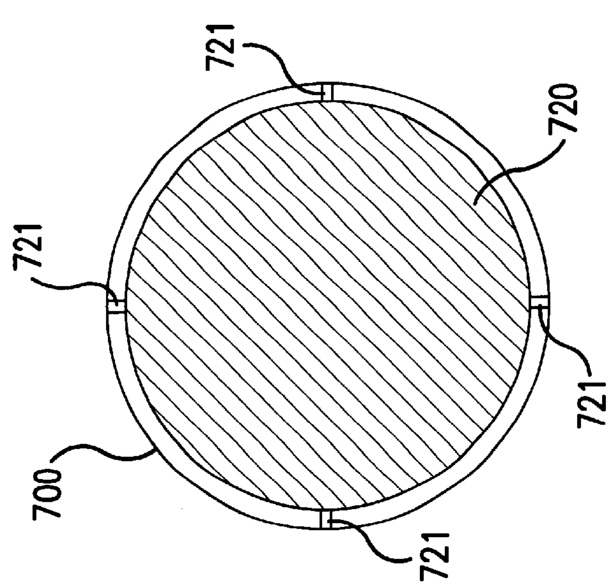


FIG.8(a)

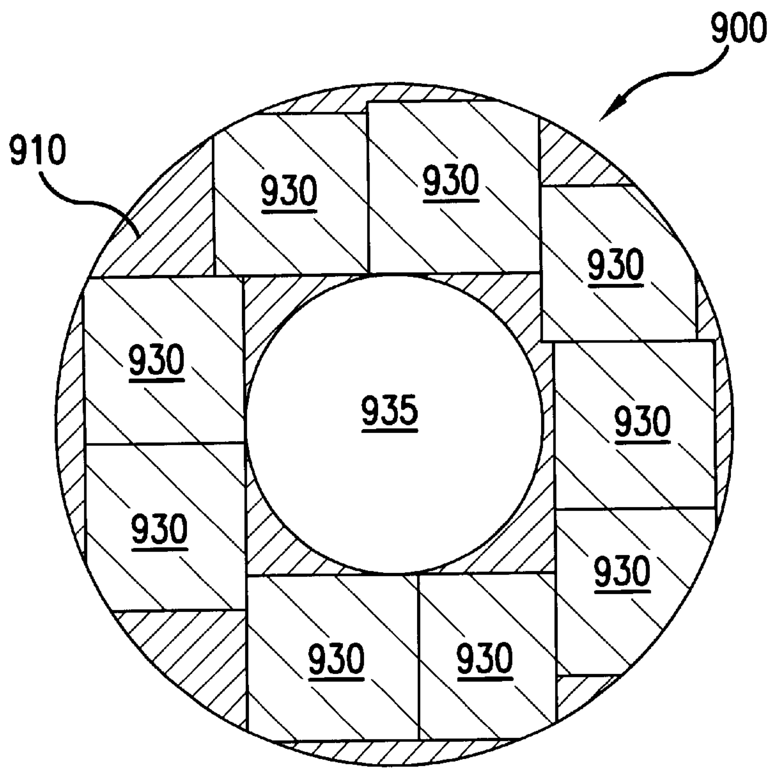

900
910
930
930
930
930
930
930
930
930
930
930
935

FIG.9

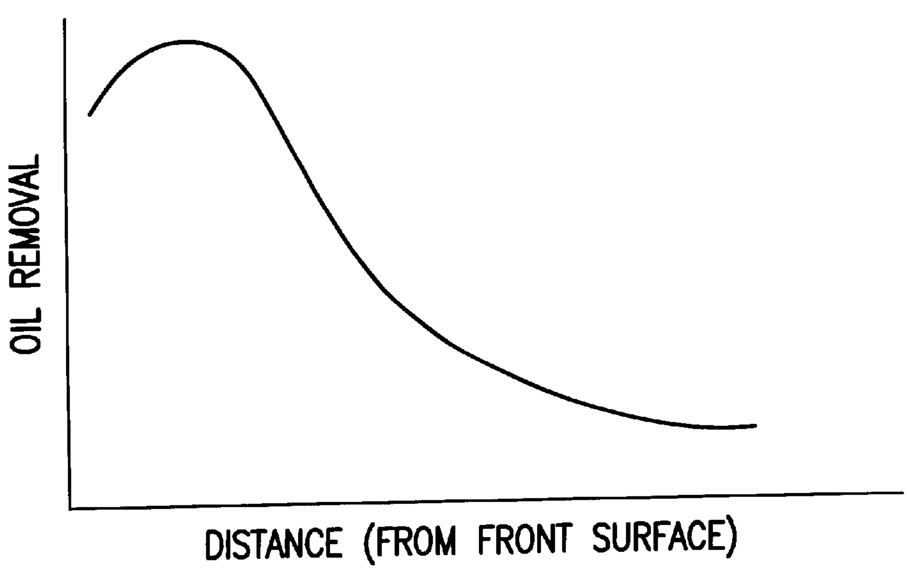

OIL REMOVAL
DISTANCE (FROM FRONT SURFACE)

FIG.10

OIL AND WATER SEPARATOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to oil and water separators generally and more particularly to oil and water separators employing coalescers.

2. Discussion of the Background

Concerns over possible contamination of the water supply through the presence of oil and other contaminants in wastewater has risen dramatically in recent years. Many governmental authorities require such contaminants to be removed before the wastewater may be discharged into the environment. The level of contamination permitted by government regulation varies. Typically, oil in such wastewater should be less than 25 parts per million, and preferably 5–10 parts per million or less.

Oil/water separating systems are the preferred method of treating oil-contaminated wastewater. An example of such a gravity oil/water separator is described in U.S. Pat. No. 5,204,000 to Steadman, et al. One known type of oil/water separator is the gravity oil/water separator. The gravity separators function by allowing gravity to separate the oil from the water. A serious problem associated with gravity separators is that they require a large volume and/or long processing times to accomplish the separation. This makes such separators costly and impractical for many applications.

The aforementioned problems associated with gravity separators has led many to incorporate coalescers into oil and water separators. One well-known type coalescer is formed from oleophilic and/or hydrophobic materials for attracting oil and/or repelling water as oil-contaminated water passes through the coalescer. An example of coalescers of this type are the vertical tube coalescers available from AFL Industries, Inc. These coalescers are described in U.S. Pat. No. 4,333,835 to Lynch. Such coalescers have been used by Xerxes Corp., the assignee of the present invention, in underground wastewater storage tanks. Tanks such as these have generally been designed under the assumption that the oil separation gradient is linear; that is, that the amount of oil in wastewater decreases linearly as the wastewater passes through the coalescers. Thus, the coalescers have generally been arranged in a single continuous block. While tanks with such arrangements of coalescers have proven effective in removing oil from wastewater in smaller areas and/or more quickly than gravity separators, these tanks are expensive.

What is needed is a more economical oil and water separator.

SUMMARY OF THE INVENTION

The present invention meets the above-identified need to a great extent by providing a storage tank with an oil and water separator in which the frontal area of the coalescers is increased relative to known arrangements of coalescers in oil and water separators. It has been discovered through experimentation that the oil separation gradient is not linear, but rather exponential. That is, the vast majority of the oil/water separation occurs at the first portion of the coalescer that is exposed to wastewater, and oil removal decreases in efficiency as wastewater moves through the coalescer. Therefore, by arranging the coalescers such that the frontal surface area of the coalescers is increased, the

efficiency of the coalescers is increased. In some preferred embodiments, the coalescers are arranged in a bank with free flow fluid paths between the coalescers in the bank, each of the paths being closed by a baffle on one end and open on an opposite end, and the baffles are arranged such that the open and closed ends of paths alternate. In other preferred embodiments, the coalescers are arranged in a tubular fashion and fluid flows from the outside surface of the tube through the coalescers and out a central path.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. **1***a* is a perspective view of a known underground wastewater storage tank.

FIG. **1***b* is a cross sectional plan view of the tank of FIG. **1** taken along the line IB—IB of FIG. **1***a*.

FIGS. **2***a–c* are cross sectional views of the tank of FIG. **1** taken along the lines IIA—IIA, IIB—IIB and IIC—IIC of FIG. **1***b*.

FIGS. **3***a–b* are a cross-sectional views of a second known underground wastewater storage tank.

FIG. **4** is a cross-sectional plan view of a storage tank according to a first embodiment of the present invention.

FIGS. **5***a–c* are cross sectional views taken along the lines VA—VA, VB—VB and VC—VC, respectively, of the tank of FIG. **4**.

FIG. **6** is a cross sectional plan view of a storage tank according to a second embodiment of the present invention.

FIG. **7** is a cross sectional plan view of a storage tank according to a third embodiment of the present invention.

FIGS. **8***a–c* are cross sectional views taken along the lines VIIIA—VIIIA, VIIIB—VIIIB and VIIIC—VIIIC, respectively, of the tank of FIG. **7**.

FIG. **9** is a cross sectional view of a tank according to a fourth embodiment of the present invention.

FIG. **10** is a graph of oil removal as a function of distance from the front surface in a typical coalescer.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will be discussed with reference to preferred embodiments of storage tanks including coalescers. Specific details, such as the arrangements and numbers of coalescers, are set forth in order to provide a thorough understanding of the present invention. The preferred embodiments discussed herein should not be understood to limit the invention.

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views, FIG. **1***a* illustrates a perspective view of a known arrangement of coalescers in an underground wastewater storage tank **100** as discussed above. The tank **100** may be comprised of any material, including but not limited to steel or plastic (preferably fiber reinforced plastic, referred to herein as fiberglass).

A top cross sectional view of the tank **100** is shown in FIG. **1***b*. The tank **100** includes a coalescer **130**. The coalescer **130** may comprise a single coalescer or may comprise several coalescers placed side to side (coalescers are sometimes manufactured in 1 foot by 1 foot sections of varying length and can be trimmed to size as necessary). Baffles **110** and **120** direct the flow of wastewater through the coalescer **130**. As seen more clearly in FIGS. **2***a–c*, the baffles **110, 120** block the entire tank save for an opening O, which is formed on opposite sides of the baffles **110, 120**. This arrangement causes wastewater to flow in an "S" like fashion as indicated by the flow path F shown in FIG. **1***b*. This configuration is currently used in 8 foot and 10 foot diameter fiberglass storage tanks manufactured by the Xerxes Corporation.

The frontal surface area (the area of the coalescer surface exposed to wastewater flow) of the coalescer **130** is found by multiplying the length L (FIG. **1**(*b*)) of the coalescer **130** by the height H (FIG. **2**(*a*)) of the opening O of the baffle **120**. This arrangement results in a relatively small frontal area.

FIG. **3** represents a second known arrangement of coalescers in an underground storage tank **300**. The coalescer **330** in cylindrical in shape and has a diameter D equal to the inside diameter of the tank **300**. No baffles are used in the tank **300**. Wastewater simply flows through the coalescer **330** from one end of the tank **300** to the other. This arrangement is used in 4 foot and 6 foot diameter tanks manufactured by Xerxes Corp.

The frontal area of the coalescer **330** is equal to $\pi^*(D/2)^2$. While this arrangement results in a relatively larger frontal area as compared to the tank **100**, it is still less than optimal.

As discussed above, it has been discovered that oil/water separation decreases exponentially as a function of distance from the surface to which the wastewater is first exposed. FIG. **10** is a graph of the amount of oil/water separation that occurs in a typical coalescer as a function of distance from the front surface (the surface that is first exposed to the wastewater). It is clear from FIG. **10** that the vast majority of the oil/water separation occurs in the first portion of the coalescer where the wastewater first comes into contact with the coalescers. Accordingly, if the frontal area of the coalescer can be increased, the efficiency of the coalescer will likewise be increased.

A tank **400** with an improved arrangement of coalescers **430, 431** resulting in an increased frontal area is shown in FIGS. **4** and **5***a–c*. Referring now to FIG. **4**, it can be seen that, rather than providing a single coalescer, two coalescers **430, 431** have been provided. Free flow paths **491–493** are provided on either side of the coalescers **430, 431**. Baffles **410, 412** (FIG. **5**(*c*)) direct the wastewater flow F through the central path **492**. Baffle **420** (FIG. **5**(*a*)) then forces the flow through the coalescers **430, 431** and side paths **491, 493**. It will be readily apparent that the locations of the baffles **410, 412** and **420** could also be reversed such that wastewater would flow from paths **491** and **493**, through coalescers **430, 431** and out the central path **492**.

The arrangement illustrated in FIGS. **4** and **5** results in a frontal area that is more than doubled with respect to the frontal area achieved with the arrangement of FIGS. **1**(*b*) and **2**. This is readily apparent as the arrangement of FIGS. **4** and **5** results in two coalescer frontal surfaces **431***a,b* as opposed to the single frontal surface **130***a* of FIG. **2**, while the height H_5 of the coalescer frontal surfaces **431***a,b* a is larger than the height H of the frontal surface **130***a* of FIG. **2**. The relative improvement with respect to the arrangement shown in FIG. **3** depends upon the length of the coalescers and the diameter of the tank. For example, a 4 foot diameter tank with a 3 foot long coalescer arranged as shown in FIG. **3** has a frontal area approximately equal to $\pi^*(4/2)^2$=12.6 square feet. In contrast, the frontal area of the arrangement shown in FIGS. **4** and **5** is approximately equal to 2*3*(3.5)=21 square feet (assuming that the height H_5 (FIG. **5**(*b*))of the coalescers **430, 431** is approximately equal to 3.5 feet). The improvement in frontal area is approximately 67% for this example.

The increase in efficiency resulting from the above-discussed arrangement can be utilized in different ways. For example, the flow through the coalescer is given by equation (1):

$$Q=A^*V \tag{1}$$

where Q is the flow, A is the frontal area of the coalescer bank, and V is the velocity of the wastewater. Thus, by increasing the frontal area A, the total flow Q is increased. Alternatively, because the majority of the oil/water separation occurs at the frontal area **431***a,b* of the coalescers **430, 431**, and the frontal area of the coalescers **430, 431** is increased in the tank **400**, the total volume of the coalescers may be reduced while maintaining the same oil/water separation performance (i.e., the wastewater will just as clean with a smaller volume of coalescers). This allows the cost of the tank system to be reduced significantly.

Other embodiments of tanks with increased coalescer frontal area are also possible. For example, the tank **600** of FIGS. **6** and **7** is a variation on the same theme shown in FIGS. **4** and **5**. In the tank **600**, there are 4 coalescers **630** instead of two. Baffles **610** and **620** are arranged such that flow paths **691–695** are closed on one end and open on another and the orientation of the open and closed ends alternates from path to path. Thus, the baffles **610** provide two entry paths **692, 694** for wastewater to reach one of the four front surfaces **630***a*, flow through coalescers **630**, and out one of three exit paths **691, 693, 695** provided by baffles **620**. It will be apparent to those of skill in the art that arrangements comprising greater numbers of coalescers arranged in the same manner are also possible. As discussed above, the vast majority of oil/water separation occurs at the surface where the wastewater first contacts the coalescers. In such embodiments, the thickness of the coalescers, measured in a direction normal to the first surfaces, is preferably between approximately one foot and approximately two feet. Even numbers of coalescers are preferable in such embodiments.

Another arrangement of a coalescer **730** in a tank **700** is illustrated in FIGS. **7** and **8**. This embodiment is directed primarily toward tanks that are oriented vertically rather than horizontally. In this embodiment, the coalescer **730** is tubular and has a diameter D2 smaller than the diameter D1 of the tank **700**. The baffle **720**, which has a diameter sufficient to close the central path **735** of the coalescer **730**, directs wastewater to the outside surface **730***a* of the coalescer **730**, through the coalescer **730**, and out the central path **735** past baffle **710**. In the tank **700**, it is preferable that the flow F_7 be directed from the outside surface **730***a* to the central path **735** (rather that a flow in the opposite direction from the central path **735** to the outside surface **730***a*) as the flow F_7 results in an increased coalescer surface area relative to a flow in the opposite direction.

As discussed above, coalescers are sometimes provided in one foot by one foot bundles of varying lengths (each of the sections is comprised of approximately **100** vertical tubes arranged in a 10 tube by 10 tube matrix). The arrangement shown in FIGS. **7** and **8** can be approximated using such coalescers as shown in the tank **900** of FIG. **9**. In the tank **900**, the coalescers **930** are arranged about a central pathway **935** in a somewhat circular fashion.

The actual construction of any of the above embodiments is straightforward. The tanks themselves may be constructed using fiberglass, steel, or any other suitable material. The tanks may be single or multi-walled. The coalescers may be any suitable type, but are preferably of the vertical tube type available from AFL Industries, Inc. The coalescers may be held in place in the tank by attaching them to each other and the baffles. Alternatively, simple frames may be constructed to keep the coalescers in place. The baffles likewise may be comprised of fiberglass, steel, or any other suitable material that will substantially block the passage of wastewater and may be attached to the inside surface of the tank using conventional methods.

Although the preferred embodiments of the invention have been discussed in the context of underground storage tanks, it is readily apparent that the invention is equally useful in above ground storage tanks as well as in other vessels in which wastewater is stored or transported, including pipes and reservoirs of all many different types. In tank embodiments, the tanks may be single or multiwalled, and in multiwalled variants may include sensors for monitoring an annular space between walls. The tanks may have flat or domed shaped ends (embodiments showing both flat and dome shaped ends have been depicted herein). The cross sectional shape of the wall of the vessel, while circular in the preferred embodiments, can be of any shape (e.g., oval, square, elliptical, etc.), regular or not, that forms an enclosure. It is also possible to employ the invention in mobile wastewater treatment units such as that discussed in U.S. Pat. No. 5,296,150.

Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

What is claimed is:

1. A wastewater storage tank comprising:

a cylindrical wall having a first closed end and a second closed end;

two coalescers positioned inside the cylindrical wall, each of the coalescers having a proximal end and a distal end, the coalescers being spaced apart to define a central path between the coalescers, each of the coalescers being spaced apart from at least a portion of the wall to form a side path between each coalescer and the wall;

a first baffle positioned adjacent to the proximal end of each coalescer and extending between the coalescers to close the central path; and

a second baffle comprising a first baffle portion and a second baffle portion, each of the baffle portions being positioned adjacent to the distal end of a coalescer and extending from the coalescer to the wall such that the corresponding side path is blocked;

wherein the tank is configured such that the first baffle and the second baffle cause wastewater to flow past one of the baffles, through the coalescers, and past the second baffle as the wastewater flows between the first closed end and the second closed end of the tank.

2. The tank of claim **1**, wherein the coalescers are vertical tube coalescers.

3. The tank of claim **2**, further comprising a second wall surrounding the first wall and forming an annular space between the first and second walls.

4. The tank of claim **3**, wherein the walls are comprised of plastic.

5. The tank of claim **4**, wherein the plastic is fiber reinforced.

6. The wastewater storage tank of claim **1**, wherein the coalescers are adapted to remove oil from the wastewater.

7. The wastewater storage tank of claim **1**, wherein the coalescers comprise an oleophilic material.

8. A vessel comprising:

a cylindrical wall having a first diameter;

a cylindrical coalescer having a second diameter and a proximal end and a distal end, the second diameter being smaller than the first diameter, the coalescer being positioned inside the cylindrical wall such that an exterior path between the wall and the coalescer is formed, the coalescer having an interior path formed therethrough, the interior path being approximately parallel to a longitudinal axis of the coalescer;

a first baffle, the first baffle being positioned adjacent to the proximal end of the coalescer and sized to close the interior path; and

a second baffle having a third diameter approximately equal to the first diameter and having a hole formed therein corresponding in size and shape to the interior path, the second baffle being positioned adjacent to the distal end of the coalescer;

wherein the vessel is configured such that wastewater is forced to flow past the first baffle, along the exterior path, through the coalescer, along the interior path and past the second baffle.

9. The vessel of claim **8**, further comprising a first end wall attached to a first end of the cylindrical wall and a second end wall attached to a second end of the cylindrical wall, the cylindrical wall, first end wall and second end wall forming an enclosed storage area for the storage of wastewater.

10. The vessel of claim **9**, wherein the cylindrical wall, the first end wall and the second end wall are comprised of plastic.

11. The vessel of claim **8**, wherein the coalescers are vertical tube coalescers.

* * * * *

US006824696B1

(12) **United States Patent**
Tolmie et al.

(10) **Patent No.: US 6,824,696 B1**
(45) **Date of Patent: Nov. 30, 2004**

(54) **OIL FROM WATER SEPARATOR**

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(73) Assignee: **Unisearch Limited**, Kensington (AU)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/403,800**

(22) PCT Filed: **Apr. 24, 1998**

(86) PCT No.: **PCT/AU98/00298**

§ 371 (c)(1),
(2), (4) Date: **Feb. 22, 2000**

(87) PCT Pub. No.: **WO98/49101**

PCT Pub. Date: **Nov. 5, 1998**

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Apr. 1, 1998 (AU) PP2742

(51) **Int. Cl.**[7] **C02F 1/40**

(52) **U.S. Cl.** **210/801**; 210/532.1; 210/538; 137/132; 137/140; 137/152

(58) **Field of Search** 210/800, 801, 210/104, 513, 532.1, 532.2, 538; 137/123, 130, 132, 134, 140, 152; 37/123, 130, 132, 134, 140, 152

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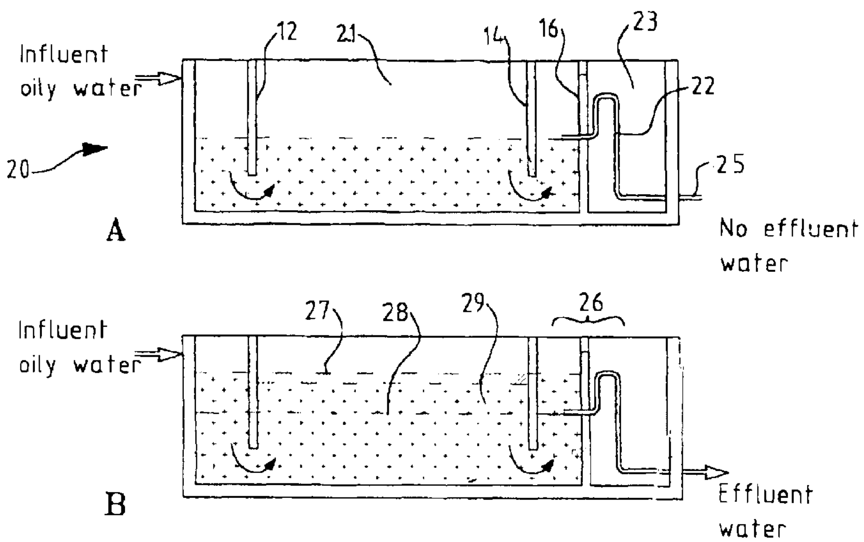
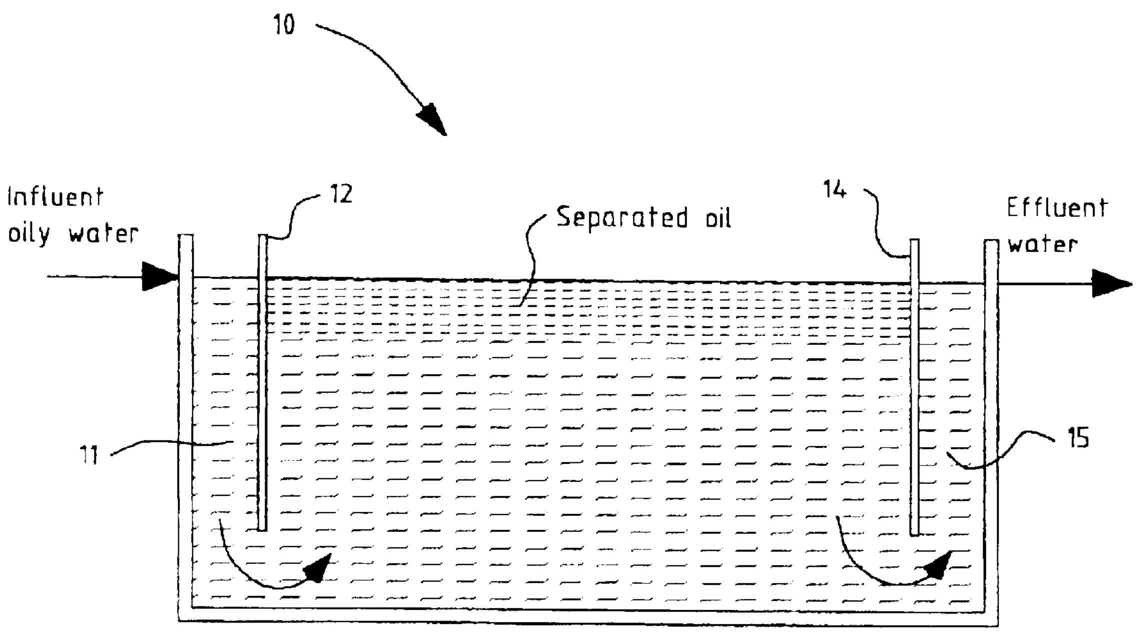
Primary Examiner—Robert James Popovics
(74) *Attorney, Agent, or Firm*—Knobbe, Martens, Olson & Bear, LLP

(57) **ABSTRACT**

An oil from water separator has an oil disengagement chamber adapted to receive an oil and water mixture and retain it for a sufficient time in a relatively undisturbed state so that oil in the mixture floats to the top of the mixture. This results in a substantially oil free volume of water having a layer of oil derived from said oil and water mixture floating on the surface of the mixture. The oil disengagement chamber is partially separated from an effluent water chamber by an under flow baffle which ducts said substantially oil free volume of water to the effluent water chamber. The oil disengagement chamber has a low liquid level which is higher than the under flow baffle. The outflow of the substantially oil free volume of water from the effluent water chamber is limited to a rate of outflow which is a function of the head of the liquid in the effluent water chamber. The outflow is limited by a siphon which primes at a chamber high liquid level and loses prime at said chamber low liquid level, or by holes in a weir wall.

24 Claims, 8 Drawing Sheets





Prior Art

Fig. 1

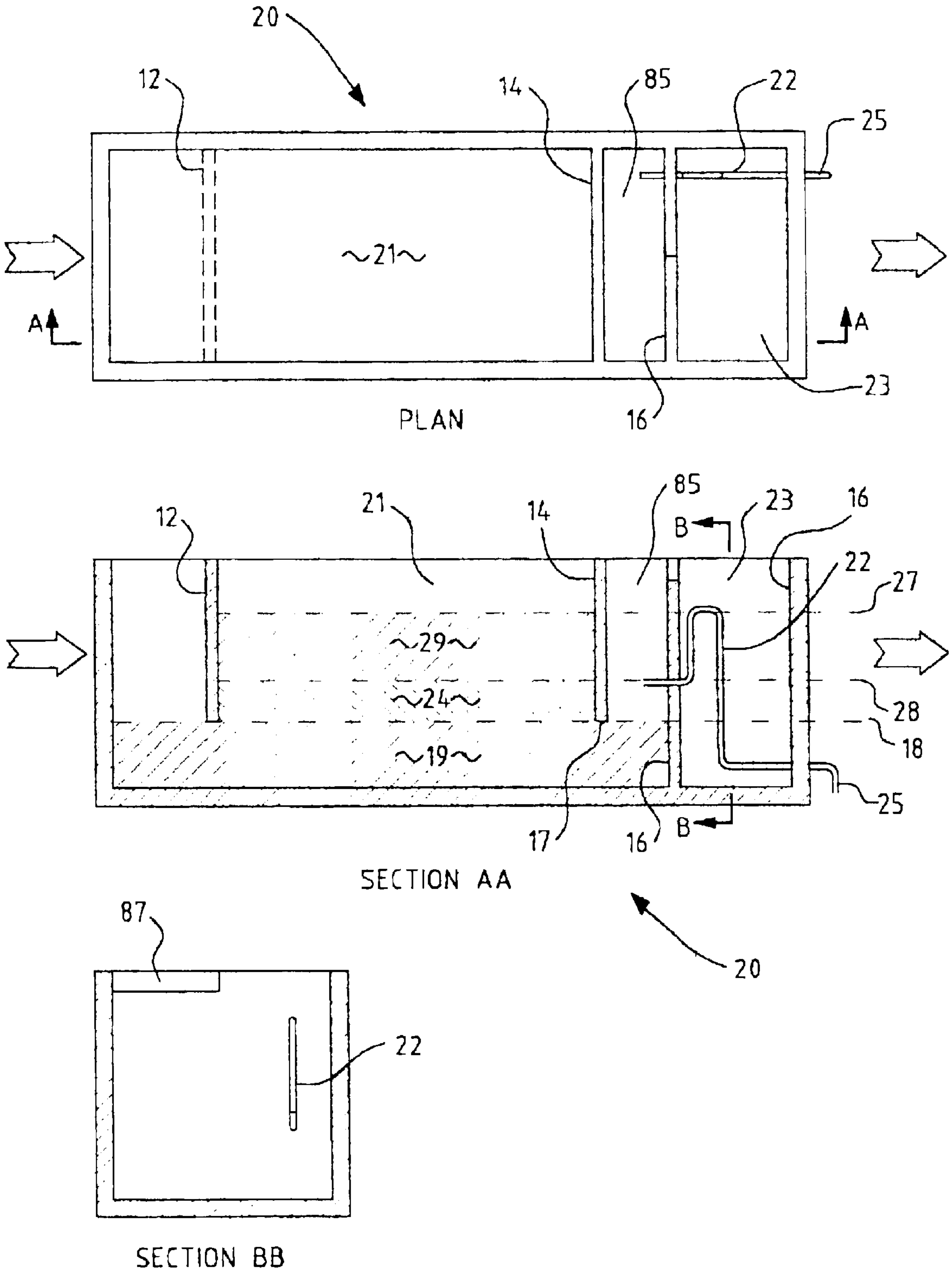

20
12
14
85
22
25
21
A
A
23
PLAN
16
85
23
16
21
12
14
B
22
27
29
24
28
19
18
25
17
16
B
SECTION AA
20
87
22
SECTION BB

Fig. 2

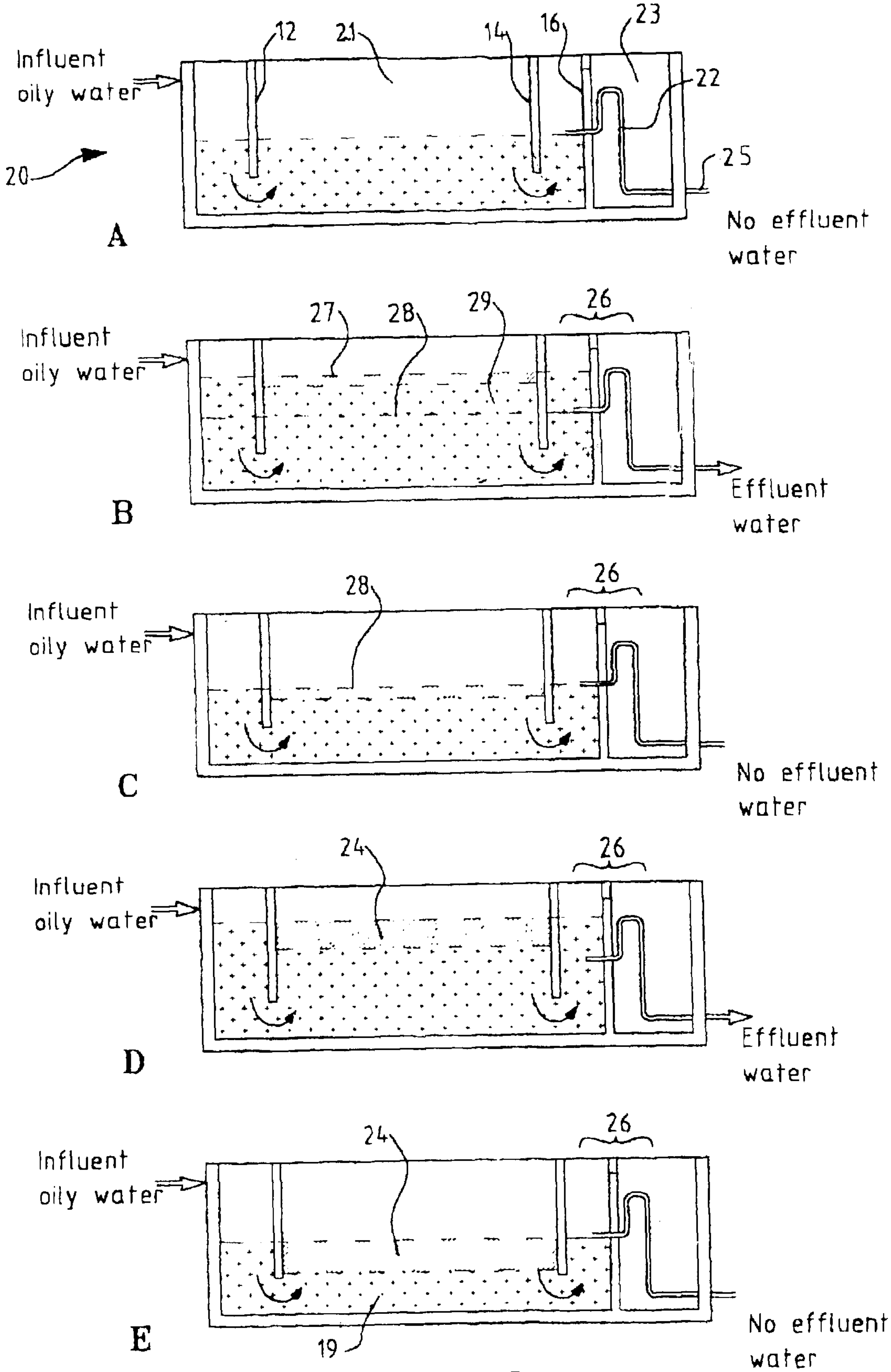

Influent oily water
12
21
14
16
23
22
25
20
A
No effluent water
27
28
29
26
B
Effluent water
C
24
D
E
19

Fig. 3

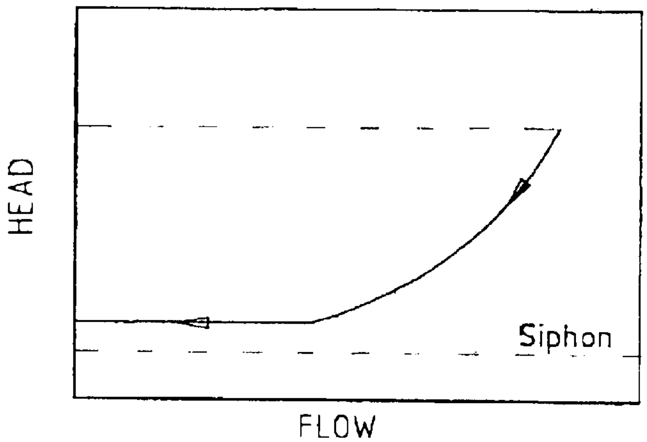


Fig. 4A

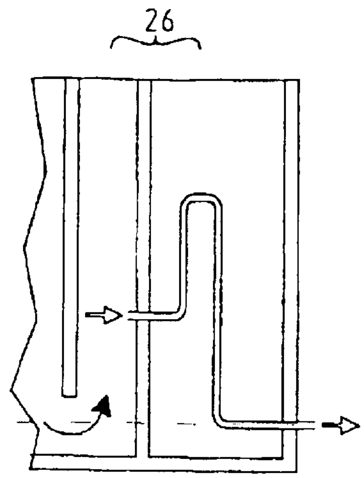


Fig. 4B

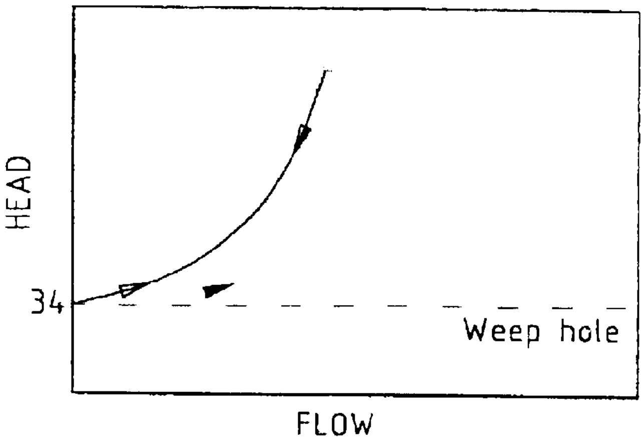


Fig. 5A

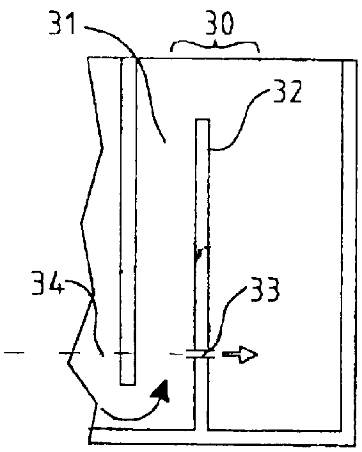


Fig. 5B

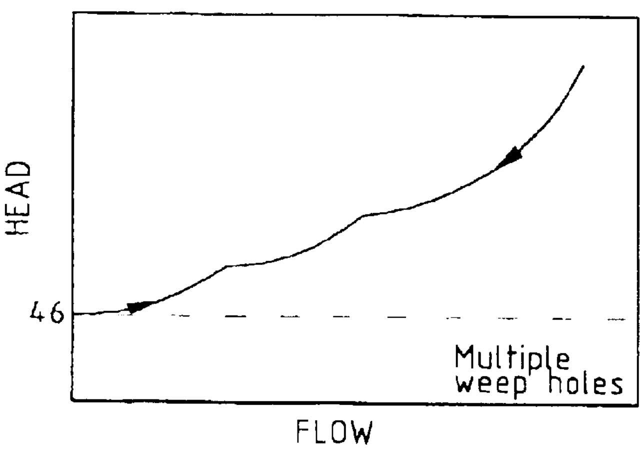


Fig. 6A

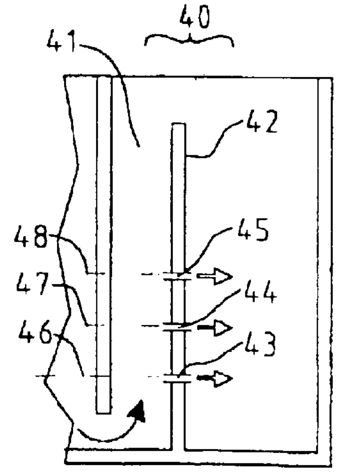


Fig. 6B

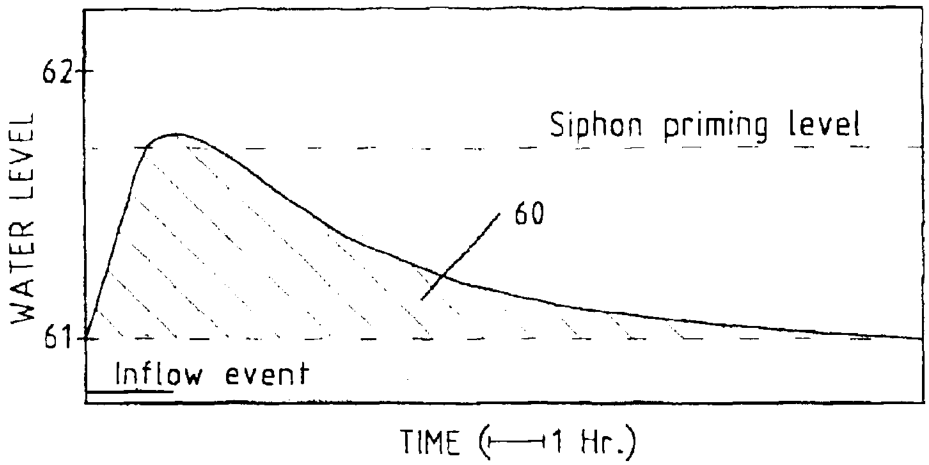


Fig. 7

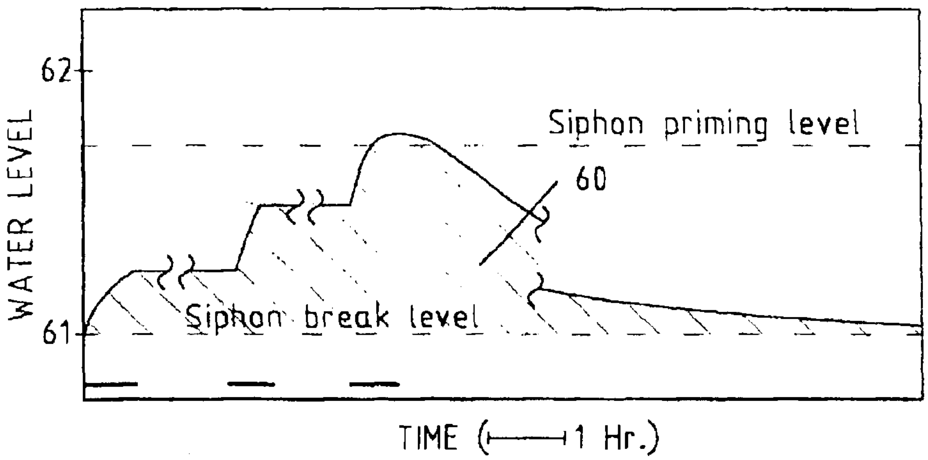


Fig. 8

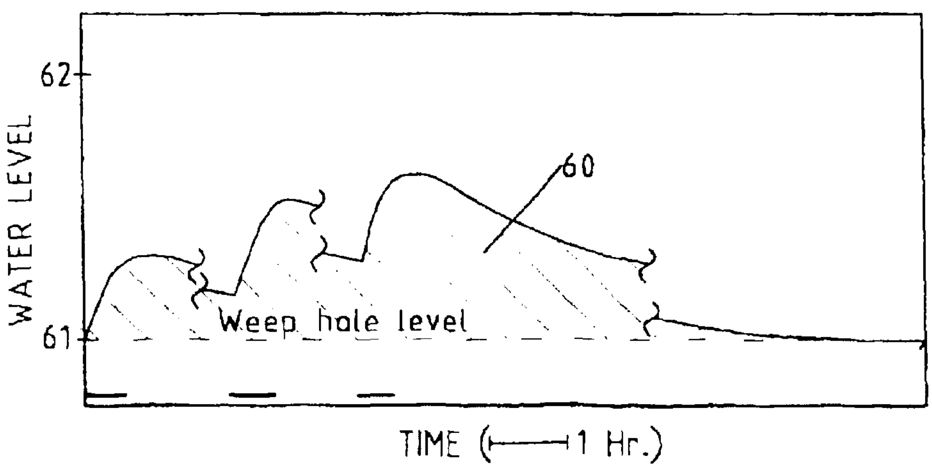


Fig. 9

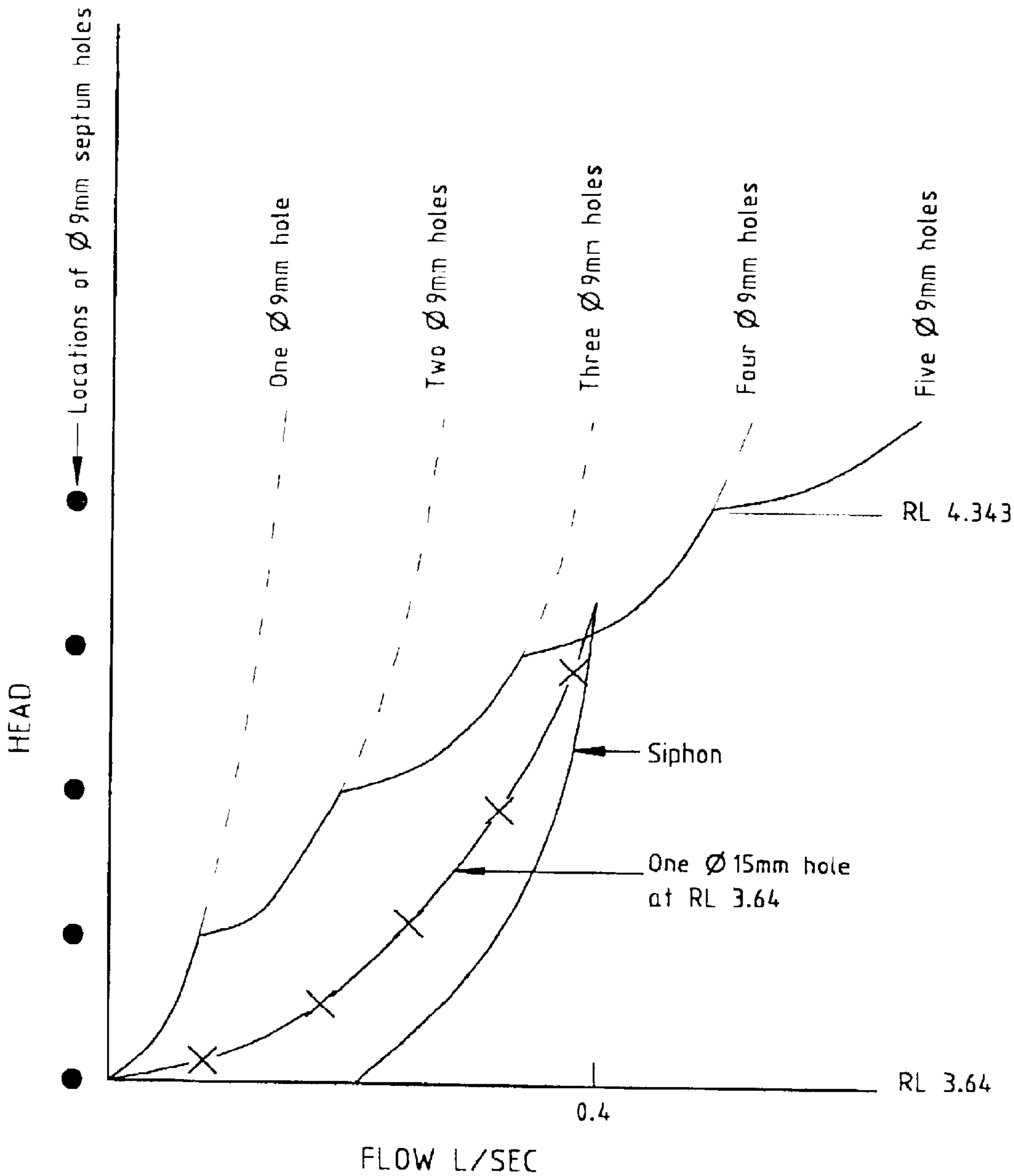

Locations of Ø 9mm septum holes
One Ø 9mm hole
Two Ø 9mm holes
Three Ø 9mm holes
Four Ø 9mm holes
Five Ø 9mm holes
RL 4.343
HEAD
Siphon
One Ø 15mm hole
at RL 3.64
RL 3.64
0.4
FLOW L/SEC

Fig. 10

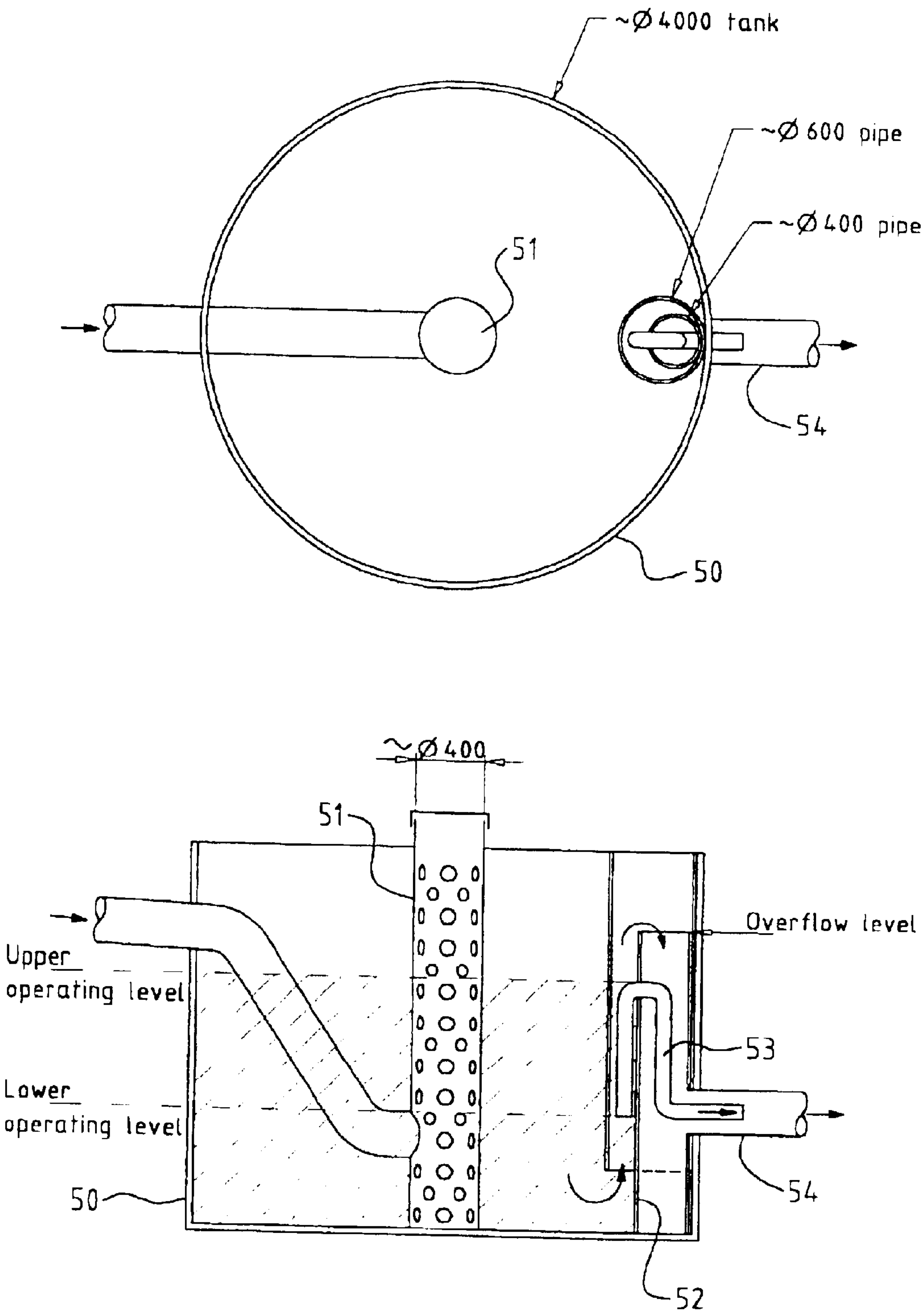

~Ø4000 tank
~Ø600 pipe
~Ø400 pipe
51
54
50
~Ø400
51
Overflow level
Upper
operating level
53
Lower
operating level
54
50
52

Fig. 11

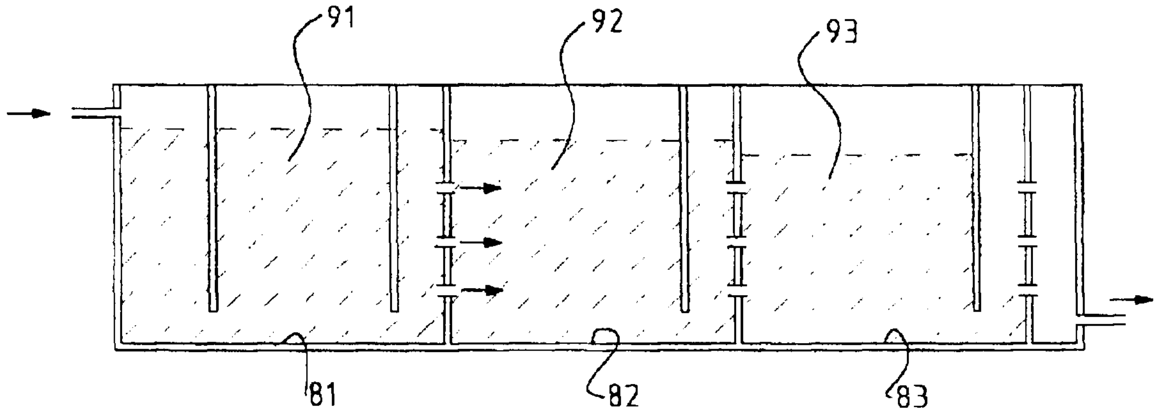


Fig. 12

OIL FROM WATER SEPARATOR

FIELD OF THE INVENTION

The present application relates to oil from water separators and, more particularly, such separators suitable for use in inground or aboveground installations where it is desired to prevent oil in water concentrations above a predetermined limit from being distributed to the environment in an uncontrolled fashion.

BACKGROUND

Mechanical oil from water separator systems are known. Devices/systems are also known that provide settling in chambers separated by baffles—refer the arrangement of FIG. **1** which shows a Prior Art American Petroleum Institute (API) oil from water separator design. It consists of a rectangular tank with two or more vertical partitions or baffles to separate entry chamber, oil disengagement chamber and effluent water chamber, and which is designed to run full of water.

The API oil from water separator is sized to provide low turbulence conditions and sufficient residence time for oil globules with a minimum diameter of 0.015 cm (150 microns) to separate from the oil/water mixture flowing though the separator.

This prior art system can be characterised as a decant-type system where for every input of liquid there is an output of a similar amount at the same time, thereby affecting separation efficiency.

Attempts have been made in the prior art to control the level of the oil/water interface, for example see U.S. Pat. No. 5,147,534 (Rymal) and U.S. Pat. No. 4,031,007 (Sierra) and, more generally, see U.S. Pat. No. 4,960,513 (Young), U.S. Pat. No. 4,436,630 (Anderson) and U.S. Pat. No. 5,378,353 (Koch).

In all of these systems, whilst there has been a move away from a simple decant-type approach, there is usually added a specific oil from water separation process beyond mere gravitational separation. Koch requires a specific separate coalescer unit whilst U.S. Pat. No. 4,554,074 (Broughton) utilises separation plates.

In many applications it would be desirable to employ a separator system having the intrinsic simplicity of the API-type systems whilst achieving consistent predetermined levels of separation of oil from water.

It is an object of the present invention to provide an inherently simple oil from water separator system which provides consistent levels of separation of oil from water over a predetermined range of inflow conditions.

SUMMARY OF INVENTION

Accordingly, in one broad form of the invention there is provided an oil from water separator including an oil disengagement chamber adapted to receive an oil and water mixture and retain it for a sufficient time in a relatively undisturbed state whereby oil in the mixture floats to the top of the mixture resulting in a substantially oil free volume of water having a layer of oil derived from said oil and water mixture floating on the surface thereof; said oil disengagement chamber partially separated from an effluent water chamber by an under flow baffle which ducts said substantially oil free volume of water to said effluent water chamber; said oil from water separator characterised in that outflow of said substantially oil free volume of water from

said effluent water chamber is limited by flow retarding means to a rate of outflow which is a function of the head of the liquid in said effluent water chamber.

In a further broad form of the invention there is provided an oil from water separator including an oil disengagement chamber adapted to receive an oil and water mixture and retain it for an extended time in a relatively undisturbed state whereby oil in the mixture floats to the top of the mixture resulting in a substantially oil free volume of water having a layer of oil derived from said oil and water mixture floating on the surface thereof; characterised in that outflow from said chamber is controlled in a predetermined way by flow retarding means.

In a further broad form of the invention there is provided an oil from water separation system including an oil disengagement chamber having a flush storage volume defined between a chamber high liquid level and a chamber low liquid level; a liquid volume equivalent to said flush storage volume caused to exit from said chamber on attainment of said chamber high liquid level.

Preferably said flush storage volume is caused to exit by means of a siphon mechanism.

In a further broad form of the invention there is provided an oil from water separator including an oil disengagement chamber adapted to receive an oil/water mixture and retain it for a sufficient time in a relatively undisturbed state whereby oil in the mixture floats to the top of the mixture resulting in a substantially oil free volume of water having a layer of oil derived from said oil and water mixture floating on the surface thereof; characterised in that outflow from said chamber is prevented until said mixture reaches a predetermined chamber high liquid level whereupon said volume of water is caused to exit said chamber.

In a further broad form of the invention there is provided an oil from water separator including an oil disengagement chamber adapted to receive an oil/water mixture and retain it for a sufficient time in a relatively undisturbed state whereby oil in the mixture floats to the top of the mixture resulting in a substantially oil free volume of water having a layer of oil derived from said oil and water mixture floating on the surface thereof; characterised in that outflow from said chamber is limited by flow retarding means to a predetermined function of the level of said oil and water mixture in said chamber.

Preferably said flow retarding means is operable only between a chamber low liquid level and a chamber high liquid level.

In one particular preferred form said flow retarding means comprises at least one siphon which primes at said chamber high liquid level and loses prime at said chamber low liquid level.

In an alternative preferred form said flow retarding means comprises at least one bleed aperture or weep hole.

Preferably said at least one bleed aperture or weep hole is located at the level of said chamber low liquid level.

More preferably said at least one bleed aperture or weep hole is sized with reference to expected inflow of said oil and water mixture into said oil disengagement chamber such that, during operation, the level of said oil and water mixture will rise from said chamber low liquid level up to a higher liquid level and then return to said chamber low liquid level, thereby defining for each situation an oil and water mixture active lag capacity or accumulation capacity between said chamber low liquid level and said higher liquid level.

More preferably said active lag capacity or accumulation capacity has a characteristic which is a function of

(a) inflow rate

(b) desired residence time of said oil and water mixture in said oil disengagement chamber.

BRIEF DESCRIPTIONS OF THE DRAWINGS

Embodiments of the invention will now be described with reference to the accompanying drawings wherein:

FIG. **1** illustrates a Prior Art (API) separator and

FIG. **2** illustrates a separator system according to a first embodiment of the system.

FIG. **3** illustrates the sequence of filling and emptying of the separator system of FIG. **2**.

FIG. **4**A is a graph of head versus flow for the separator system of FIG. **2**,

FIG. **4**B illustrates in cross section the first embodiment system of FIG. **2** to which FIG. **4**A is applicable.

FIG. **5**A is a graph of head versus flow for the system, of FIG. **5**B,

FIG. **5**B illustrates in cross section a separator system according to a second embodiment of the invention,

FIG. **6**A is a graph of head versus flow for the system of FIG. **6**B,

FIG. **6**B illustrates, in cross section, a separator system according to a third embodiment of the invention involving multiple weep holes,

FIG. **7** is a graph of the behaviour of water level in the system of FIG. **2** in the form of a graph of water level versus time,

FIG. **8** illustrates the behaviour of the system of FIG. **2** under alternative operating conditions in the form of a graph of water level versus time,

FIG. **9** illustrates the behaviour of the system of FIG. **5** in the form of a graph of water level versus time,

FIG. **10** illustrates particular flow characteristics of particular implementations of the invention (example 2) and

FIG. **11** is a top view and side section view of a separator system according to a further embodiment of the invention.

FIG. **12** is a side section view of multiple separator systems connected in a flow-through, series configuration.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The Prior Art separator **10** of FIG. **1** comprises an entry chamber **11** separated by a baffle **12** from an oil disengagement chamber **13** which, in turn, is separated from an effluent water chamber **(15)** by a baffle **(14)**.

Various embodiments of the invention as to be described below are characterised in their most broad form by the addition of a flow retarding device to an outlet portion of a separator. The separator can be in the box form of the prior art API separator of FIG. **1** or can take an alternative form (for example refer the cylinder form of example 3 of FIG. **11** to be described later in this specification).

The flow retarding device acts to ensure that for the majority of operating conditions likely to be encountered, water in the storage volume will have a sufficient residence time and flow in a sufficiently undisturbed manner to ensure oil from water separation substantially to a predetermined value.

In the embodiments described below the flow retarding device operates continuously to retard flow. Embodiments differ in how the outflow is permitted.

In all cases, accumulation occurs in the oil disengagement chamber as a result of control of outflow.

Furthermore, it imposes an outflow rate from the separator which is a function of the liquid head over the outflow level in the separator.

First Embodiment

With reference to FIG. **2** an oil from water separator system **20** according to a first embodiment of the invention is illustrated.

FIG. **3** shows a series of operating conditions A–E for the separator of FIG. **2**.

The system **20** directs an influent of oily water through or under a baffle **12** to an oil disengagement chamber **21** the water from which passes beneath a skimmer wall or second baffle **14** to a siphon pipe **22** in an end wall **16**. This siphon pipe discharges effluent water into exit pipe **25** through draw off chamber **23**.

The siphon pipe **22**, in operation, causes the level of liquid in oil disengagement chamber **21** to move between high level **27** and low level **28**.

The volume of liquid defined between these two levels forms an accumulation capacity which is designated the flush storage volume or oil and water accumulation volume **29**.

In use water laden with oil enters oil disengagement chamber **21** as in FIG. **3** with the level in the chamber **21** rising until the maximum accumulation volume **29** is achieved at which time siphon pipe **22** operates to cause the flush storage volume or accumulation volume **29** to exit via exit pipe **25** until the siphon breaks at low level **28**. Low level **28** is selected to be, for design conditions, such that accumulated, separated oil cannot pass under the baffle **14** and escape from the separator oil disengagement chamber.

As more oil laden water enters oil disengagement chamber **21** the process repeats itself in accordance with FIG. **3** C, D, E.

In this manner a relatively large volume of oil/water mixture is retained for a relatively long period of time to allow oil separation to occur prior to siphoned exit.

Restated in other terms: A feature of this embodiment is the incorporation of one or more automatic siphons which release water only periodically from an oil disengagement chamber and which chamber creates a potential storage for a selected volume of first flush oil/water mixture or a major oil spillage of a volume equal to the flush storage volume or accumulation volume **29**.

This volume **29** is sized to contain a major oil spillage or to be filled progressively with oil/water mixture from successive rainfall events. Until this volume **29** is accumulated, oil globules can coalesce and separate from the water over a period greater than the residence time available in the standard flow through decant separator of FIG. **1** for a given separator tank volume. The oil disengagement chamber **21** is quiescent with virtually zero turbulence except at the end of each cycle when the siphon is operating.

When the water surface reaches a selected chamber high liquid level **27** a siphon which discharges into draw off chamber **23** is primed whereby substantially oil-free water is released until the water surface falls to a selected chamber low liquid level **28** at which the siphon breaks. This releases a volume of effluent water equal to the accumulation volume **29** leaving capacity for the next cycle of oil/water inflows.

One can more specifically differentiate the volumes of liquid in the separator and, more specifically in the oil disengagement chamber as follows:

A. The flush storage volume or oil and water accumulation volume **29** as previously defined comprising that volume of liquid which can be accumulated in the disengagement chamber **21** between low level **28** and high level **27**.

B. A separated oil volume **24** defined as the volume of liquid which can be stored in the chamber **21** between low level **28** and the lower edge **17** of baffle **14** defined at under pass level **18** in FIG. **2**.

C. A quiescent volume **19** defined between under pass level **18** and the bottom of the disengagement chamber **21**.

As will be appreciated the quiescent volume **19** will, in use, always contain a liquid. In a correctly sized and designed separator this liquid will be substantially effluent water.

As will be further appreciated periodic flushing of the separator by operation of the flow retarding device **26** will result in a volume of liquid equal to the oil and water accumulation volume **29** being moved from the oil disengagement chamber **21** through the effluent water chamber **85** and, via the flow retarding device **26** to the draw off chamber **23** and exit pipe **25**. The liquid actually moved will include liquid found in all of the defined volumes **19, 24, 29,** but not all of it in any one instance.

It is the oil and water accumulation volume **29** with its dynamic nature in that separation can take place within this volume whilst the liquid actually contained within the volume changes in quantity over time which provides the substantive separation characteristic and permits effective residence times of the order of hours (thereby achieving effective oil/water separation) for a treatment capacity in a given separator size greater than can be achieved with an equivalent sized API-type separator.

It will be further observed that when outflow does occur the rate of outflow is a function of the head of the liquid in the effluent water chamber **85**.

FIG. **4**A illustrates a head versus flow characteristic for the siphon arrangement of the first embodiment of FIG. **2**.

FIG. **4**B is a side section view of the siphon-based retarding device **26** of FIG. **2**.

Second Embodiment

FIG. **5**A illustrates a second embodiment of the invention (in cross section) comprising a flow retarding device **30** in the end wall of a storage volume **31**. In this instance the flow retarding device **30** comprises a retention wall **32** having a bleed aperture **33** (also termed a weep hole) therewithin which will permit the gradual release of liquid in storage volume **31** above a predetermined low level **34**. The head versus flow characteristics for this arrangement are shown in FIG. **5**B.

Third Embodiment

An alternative arrangement of the system of the invention according to a third embodiment is illustrated in cross section in FIG. **6**A and comprises, in this instance, a retention wall **42** in an end wall of storage volume **41** having within it a first bleed aperture **43**, a second bleed aperture **44** and a third bleed aperture **45** located at respective predetermined levels **46, 47, 48**.

FIG. **6**A shows a graph of head versus flow for this multiple weep hole embodiment of the flow retarding device **40**.

Broadly it will be observed that the first embodiment of FIG. **2** utilises a siphon to achieve controlled flow retardation whilst the second and third embodiments utilise weep holes.

Whereas water will not start to flow through a siphon until a priming level is reached and will continue to flow until the water surface reaches some lower level, water will flow through a hole whenever the hole is submerged on and only on the upstream side.

The objective of controlling the release of water from an oil from water separator is to provide residence time in the separator during which the desired separation of oil droplets from the water can occur.

The siphon achieves this residence time by storing incoming water until the provided capacity is full, when the relatively oil-free water is released and the cycle starts again.

In some applications of a disengagement chamber for oil from water separation, the load may be regular as in daily washdowns and in these applications a slow drawdown overnight may be more desirable than the siphon characteristic.

Such an alternative characteristic can be achieved by replacing the siphon with weep holes, varying their number, sizes and locations to achieve any desired outflow/level relationship. This allows the water surface in the separator to return slowly to the bottom operating level without first reaching some top operating level but after a sufficient time for oil from water separation.

The relationship between separator water level and outflow for a siphon and one or more weep holes is illustrated in FIGS. **4**A, **5**A and **6**A as earlier described.

Relative Inflow—Outflow Behaviour

The movement in separator water level during an inflow event, however, will be broadly similar for the siphon and the weep holes, at least as far as achieved residence time is concerned. With some generality it can be asserted that:

An effective separator design will not require a cycle time (from rising above the bottom operating level to returning to it) of more than 12–24 hours

For rainfall runoff typical of a 1 in 1 year event, the separator can fill to the top operating level in less than an hour

The initial rise of the separator water level will be steep compared with the exponential fall after the outflow through the weep holes or the siphon (see FIGS. **7**, **8** and **9**)

The earlier release of water through a weep hole than will occur with a siphon not yet at its priming level will have negligible effect on the initial rise in water level

During water level fall from the top operating level, the flow through both the weep hole and the siphon will decline exponentially as a function of head above the outlet

If the inflow event is not large enough to prime the siphon, the water will remain in the separator until there is sufficient water; with a weep hole, the water outflow will continue to decline exponentially until the weep hole level is reached, still providing (by design) the desired residence time.

Fourth Embodiment

FIG. **11** illustrates an alternative storage volume arrangement which, as seen in plan view, takes the form of a doughnut-shaped tank **50** with inflow to a central distributor in the form of a stand pipe **51**.

Outflow is from a circular retention wall **52**. Controlled outflow is achieved either via a siphon pipe **53** to clarified water outlet **54** or via bleed apertures (not shown) in retention wall **52** or other flow retarding means.

For this embodiment dimensions of the siphon pipe and/or the bleed apertures can be as for either example 1 or example 2 below.

Active Lag Capacity

With reference to FIGS. **7**, **8** and **9** the previously described embodiments can be seen to incorporate an active lag capacity or accumulation volume **60** which operates above a predefined liquid low level **61** and can extend as high as a predefined liquid high level **62** set by an overflow weir (such as weir **87** in FIG. **2**).

The active lag capacity **60** comes into operation when inflow to the oil disengagement chamber is such that the liquid level rises above liquid low level **61**.

Liquid low level **61** has associated with it, in these examples, either the lower end of a siphon or the lowest of at least one weep hole sized in the manner previously described and which, in combination with the end wall **16** or retention walls **32**, **42**, **52**, forms a flow retarding means which is the dominant factor which controls the shape and characteristic of the active lag capacity **60** for a given inflow characteristic and storage volume characteristic.

The active lag capacity **60** by virtue of its coming into existence whilst there is mismatched relative inflow and outflow from the oil disengagement chamber has a dynamic or active characteristic which assists in efficient oil from water separation such that, for a predefined range of inflows, outflow will contain a proportion of oil in water substantially below a predefined limit.

Interconnected Separator Units

With reference to FIG. **12** three separator units are connected in series whereby a first separator **81** having a lag capacity in the form of a first active lag volume **91** feeds its output, as illustrated, directly into second separator unit **82** having a second active lag volume **92**, which separator unit in turn feeds its outflow into third separator unit **83** having a third active volume **93**. In this instance the active lag capacity of the total system is determined by the composite characteristic of the active lag volumes **91**, **92**, **93**.

This arrangement has particular advantage where site shape and/or size dictates that one large tank is inappropriate. The arrangement also provides additional flexibility in terms of total residence time.

It has one particular distinguishing characteristic as compared with the single tank implementations in that overflow from first separator **81** in the event of unforseen catastrophic inflow merely results in overflow of untreated or insufficiently treated oil/water mix into second volume **92** of second separator **82** rather than the immediate discharge of untreated or insufficiently treated oil/water mixture from the entire treatment system. This multiple tank arrangement, therefore, provides a "soft-fail" mode as well as providing additional design flexibility.

Examples of the various embodiments will now be given:

EXAMPLE 1

An API type rectangular tank with siphon installed in the exit wall. Typical dimensions are 7 m long, 1.5 m wide and siphon operating levels 1.6 m and 0.8 m above the floor. Volume=approx 17KL, about half of which is the range between siphon operating levels. The siphon is made of 18 mm OD hard drawn copper pipe and takes about 10 hours to draw the water level down.

EXAMPLE 2

FIG. **10** illustrates a particular example of head versus flow behaviour for the siphon embodiment of FIG. **2**, the single weep hole embodiment of FIG. **5** and the multiple weep hole embodiment of FIG. **6** for various hole diameters as indicated.

The above describes only some embodiments of the present invention and modifications obvious to those skilled in the art can be made thereto without departing from the scope and spirit of the present invention.

It is expected that, in many embodiments, operation of the oil from water separator system would be unattended and/or automatic.

INDUSTRIAL APPLICABILITY

The oil from water separator device can be applied in situations such as transformer substations and other industrial sites where retention and controlled discharge of an oil and water mix to a specified level of separation is required.

What is claimed is:

1. An oil from water separator comprising:

an oil disengagement chamber adapted to receive an oil and water mixture and retain it for a sufficient time in a relatively undisturbed state whereby oil in the mixture floats to the top of the mixture resulting in a substantially oil free volume of water having a layer of oil derived from said oil and water mixture floating on the surface thereof;

an effluent water chamber partially separated from said oil disengagement chamber by an under flow baffle which ducts said substantially oil free volume of water to said effluent water chamber, the oil disengagement chamber having a chamber low liquid level which is higher than the underside of the under flow baffle, the outflow of said substantially oil free volume of water from said effluent water chamber being limited at a rate as a function of the head of the liquid in said effluent water chamber; and

a flow retarding means comprising at least one siphon coupled to said effluent water chamber to limit the rate of outflow of said substantially oil free volume of water from said effluent water chamber wherein said flow retarding means primes at a chamber high liquid level and loses prime at said chamber low liquid level such that during operation, the level of said oil and water mixture will rise from said chamber low liquid level up to a higher liquid level and then return to said chamber low liquid level, thereby defining an oil and water mixture active lag capacity within an oil and water mixture accumulation volume in said oil disengagement chamber and wherein said flow retarding means operates to accumulate said oil and water mixture in said oil disengagement chamber in said oil and water mixture accumulation volume above said chamber low liquid level and wherein said accumulation volume is sized with reference to inflow rate and

desired residence time of said oil and water mixture in said oil disengagement chamber such that, for a predefined range of inflows into said oil disengagement chamber, outflow from said effluent water chamber will contain a proportion of oil in water substantially below a predefined limit.

2. The separator of claim **1** operable whereby said desired residence time is such that said oil and water mixture is retained in said oil and water mixture accumulation volume in said oil disengagement chamber for an effective residence time comprising a period of time long relative to conventional liquid full separators thereby to allow oil separation to occur prior to periodic siphoned exit.

3. The separator of claim **2** wherein said effective residence time is of the order of hours.

4. The separator of claim **1** operable such that periodic flushing of said separator by operation of said flow retarding means will result in a volume of liquid equal to said oil and water accumulation volume being moved periodically from said oil disengagement chamber through said effluent water chamber so as to exit via said flow retarding means.

5. The separator of claim **1** whereby said flow-retarding means operates to provide an outflow characteristic of outflow from said oil and water mixture accumulation volume which has a different characteristic from an inflow characteristic of inflow into said oil and water mixture accumulation volume.

6. The separator of claim **5** wherein said outflow characteristic is a discontinuous function of the liquid level in said effluent water chamber.

7. The separator of claim **5** wherein there exists a mismatch whereby said inflow characteristic is mismatched relative to said outflow characteristic.

8. The separator of any one of claim **1** or claims **2** to **7** wherein separation can take place within said oil and water accumulation volume whilst liquid contained in said volume changes in quantity and level over time.

9. A method of converting a separator which has an oil disengagement chamber and an effluent water chamber partially separated from said oil disengagement chamber by an under flow baffle such that the separator normally operates liquid full, to a separator which operates in a manner whereby liquid level in said separator will vary with time and rate of inflow into said separator, said method comprising:

installing a flow retarding device in the form of at least one siphon in or in association with a weir wall of the separator so that a rate of outflow of a substantially oil free volume of water from the effluent water chamber is controlled as a function of a head of liquid in the effluent water chamber, such that during operation, the oil disengagement chamber receives an oil and water mixture and retains it for a sufficient time in a relatively undisturbed state to allow oil in the mixture to float to the top of the mixture resulting in a substantially oil free volume of water with a layer of separated oil floating thereon wherein the substantially oil free volume of water flows to the effluent water chamber under the under flow baffle to define the head of liquid in the effluent water chamber, the oil disengagement chamber having a chamber low liquid level which is higher than the underside of the under flow baffle, and wherein the flow retarding device operates to accumulate the oil and water mixture in the oil disengagement chamber such that the level of the oil and water mixture rises from said chamber low liquid level up to a higher liquid level and then returns to said chamber low liquid level by the action of the flow retarding device thereby defining an oil and water mixture active lag capacity within an oil and water mixture accumulation volume in the oil disengagement chamber, wherein the flow retarding device primes at a chamber high liquid level and loses prime at the chamber low liquid level and wherein said accumulation volume is sized with reference to an inflow rate and desired residence time of said oil and water mixture in said oil disengagement chamber such that, for a predefined range of inflows into said oil disengagement chamber, outflow from said effluent water chamber will contain a proportion of oil in water substantially below a predefined limit.

10. The method of claim **9** wherein said separator after conversion according to said method is operable whereby said desired residence time is such that said oil and water mixture is retained in said oil and water mixture accumulation volume in said oil disengagement chamber for an effective residence time comprising a period of time long relative to conventional liquid full separators thereby to allow oil separation to occur prior to periodic siphoned exit.

11. The method of claim **10** wherein said effective residence time is of the order of hours.

12. The method of claim **9** wherein said separator is operable such that periodic flushing of said separator by operation of said flow retarding means will result in a volume of liquid equal to said oil and water accumulation volume being moved periodically from said oil disengagement chamber through said effluent water chamber so as to exit via said flow retarding means.

13. The method of claim **9** wherein said flow-retarding means operates to provide an outflow characteristic of outflow from said oil and water mixture accumulation volume which has a different characteristic from an inflow characteristic of inflow into said oil and water mixture accumulation volume.

14. The method of claim **13** wherein said outflow characteristic is a discontinuous function of the liquid level in said effluent water chamber.

15. The method of claim **13** wherein there exists a mismatch whereby said inflow characteristic is mismatched relative to said outflow characteristic.

16. The method of any one of claim **9** or claims **10** to **15** wherein separation can take place within said oil and water accumulation volume whilst liquid contained in said volume changes in quantity and level over time.

17. An oil from water separation system comprising:

a plurality of oil from water separators wherein each oil from water separator comprises:

an oil disengagement chamber adapted to receive an oil and water mixture and retain it for a sufficient time in a relatively undisturbed state whereby oil in the mixture floats to the top of the mixture resulting in a substantially oil free volume of water having a layer of oil derived from said oil and water mixture floating on the surface thereof;

an effluent water chamber partially separated from said oil disengagement chamber by an under flow baffle which ducts said substantially oil free volume of water to said effluent water chamber, the oil disengagement chamber having a chamber low liquid level which is higher than the under flow baffle, the outflow of said substantially oil free volume of water from said effluent water chamber being limited at a rate as a function of the head of the liquid in said effluent water chamber;

a flow retarding means comprising at least one siphon coupled to said effluent water chamber to limit the rate of outflow of said substantially oil free volume of water from said effluent water chamber wherein said flow retarding means primes at a chamber high liquid level and loses prime at said chamber low liquid level such that during operation, the level of said oil and water mixture will rise from said chamber low liquid level up to a higher liquid level and then return to said chamber low liquid level, thereby defining an oil and water mixture active lag capacity within an accumulation volume in said oil disengagement chamber and wherein said flow retarding means operates to accumulate said oil and water mixture in said oil disengagement chamber in said accumulation volume above said chamber low liquid level and wherein said accumulation volume is sized with reference to inflow rate and desired residence time of said oil and water mixture in said oil disengagement chamber such that, for a predefined range of inflows into said oil disengagement chamber, outflow from said effluent water chamber will contain a proportion of oil in water substantially below a predefined limit; and

wherein said plurality of separators are connected in series whereby outflow from each preceding separator passes to an inlet of the next succeeding separator.

18. The separation system of claim **17** wherein each said separator is operable whereby said desired residence time is such that said oil and water mixture is retained in said oil and water mixture accumulation volume in said oil disengagement chamber for an effective residence time comprising a period of time long relative to conventional liquid full separators thereby to allow oil separation to occur prior to periodic siphoned exit.

19. The separation system of claim **18** wherein said effective residence time is of the order of hours.

20. The separation system of claim **17** wherein each said separator is operable such that periodic flushing of said separator by operation of said flow retarding means will result in a volume of liquid equal to said oil and water accumulation volume being moved periodically from said oil disengagement chamber through said effluent water chamber so as to exit via said flow retarding means.

21. The separation system of claim **17** wherein said flow-retarding means operates to provide an outflow characteristic of outflow from said oil and water mixture accumulation volume which has a different characteristic from an inflow characteristic of inflow into said oil and water mixture accumulation volume.

22. The separation system of claim **21** wherein said outflow characteristic is a discontinuous function of the liquid level in said effluent water chamber.

23. The separation system of claim **21** wherein there exists a mismatch whereby said inflow characteristic is mismatched relative to said outflow characteristic.

24. The separation system of any one of claim **17** or claims **18** to **23** wherein separation can take place within said oil and water accumulation volume whilst liquid contained in said volume changes in quantity and level over time.

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