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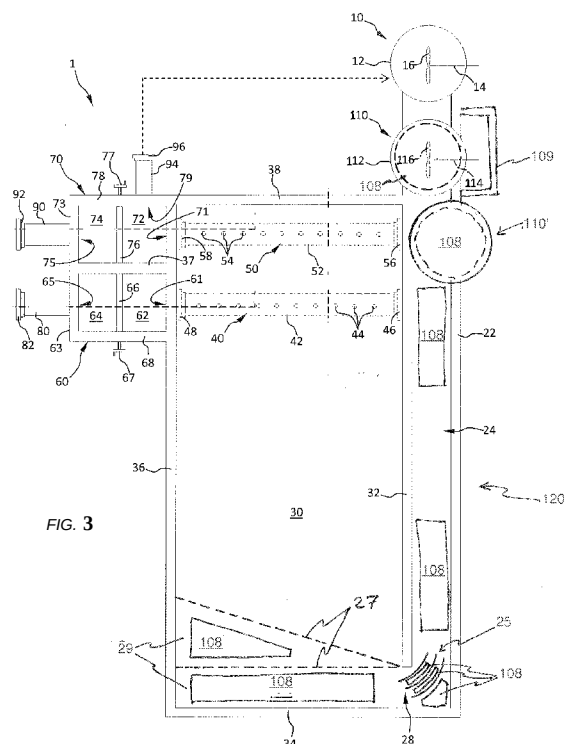
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(54) Title: SOLVENT EXTRACTION MIXER SETTLER COALESCING MEDIA PLACEMENT



(57) Abstract: In a mixer settler apparatus, coalescing media are disposed within a structure, which structure forms a mixed-liquid transmission flow path that extends between an outlet of a mixing tank and settling tank and which structure and path may include at least one auxiliary tank. The coalescing media may include particulates, woven wire mesh, knitted wire mesh, interwoven layers of metal and plastic strands, and/or various other structured media such as layers of hydrophobic plastic media alternating with layers of hydrophobic plastic media coated with a thin layer of hydrophilic material.

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SOLVENT EXTRACTION MIXER SETTLER COALESCING MEDIA PLACEMENT

BACKGROUND OF THE INVENTION

This invention relates to separation processes and equipment, and more particularly to liquid-liquid extractors or mixer settlers, such as those used in liquid-liquid extraction or solvent-extraction processes during chemicals or minerals processing.

Mixer settlers generally comprise of two stages. The first stage comprises mixing two immiscible fluids (e.g., an organic phase and an aqueous phase) in one or more mixers to create a dispersion that facilitates mass transfer of target mineral(s) from one of the phases to the other. During the mixing process, additional phase(s) may be formed, due to physical and/or chemical changes occurring. The second quiescent settling stage allows the phases to separate from their suspended state according to their densities.

Typically, the second stage utilizes a settling tank largely resembling a pool. A fixed overflow weir generally extends across the entire width of the settling tank and serves to "skim" the very top of the lighter phase. An adjustable underflow weir, typically also extending across the entire width of the settling tank, allows collection of the heavier phase for recycle. The adjustable underflow weir also enables control of depth and flow rate during the process.

FIGS. 1 and 2 illustrate respective side and top views of one example of a conventional mixer settler, shown in this case for a lighter organic phase and heavier aqueous phase. A primary mixer and one or more auxiliary mixers are provided - the primary mixer serves to mix an organic feed with an aqueous feed, typically both phases entering the primary mixer from underneath a false bottom. One or more auxiliary

mixers may be utilized to increase the residence time of mixing and improve mass transfer between the two phases. The suspension then moves to a settling area where the lighter organic layer separates from the heavier aqueous layer. A fixed organic (overflow) weir, which extends across the entire settler, collects and advances the organic fraction to the next stage in the process. The aqueous fraction flows around (e.g., below) the organic weir, and then into an up comer before pouring over an adjustable aqueous (underflow) weir. Fluid flowing over the adjustable aqueous weir is collected and typically returned to the primary mixer to supplement the aqueous feed. A second fixed aqueous weir may be provided downstream of the adjustable aqueous weir, wherein fluid passing over the fixed aqueous weir is collected and advanced to another stage in the process.

Mixing units of mixer-settler trains typically utilize pumper mixer and auxiliary mixers to produce droplets for efficient mass transfer between phases. The production of finer droplets in the mixer causes increased disengagement times requiring longer settlers and results in increased entrainment. Some settler designs use coalescing media placed in the settlers to minimize the shortcomings. Structured packings, mainly chevron type media, normally used in distillation columns as mist eliminators, have been used in solvent extraction, but may result in only marginal improvement in coalescing duty. At higher flow rates, entrainment remains high due to not as effective coalescing as desired.

OBJECTS OF THE INVENTION

It is, therefore, an object of the invention to provide an improved mixer settler apparatus.

It is also an object of the invention to provide a mixer settler apparatus which reduces disengagement times, thereby reducing the requirement for longer settlers.

It is a further object of the invention to provide mixer settler apparatus that reduces or eliminates cross contamination or entrainment/carry-over of one phase into the other, e.g., organic with aqueous and aqueous with organic.

Another object of the invention is to provide a mixer settler apparatus that localizes, reduces, or eliminates air entrainment in fluids, thereby reducing the formation of crud and buildup.

Another object of the invention is to provide a mixer settler apparatus that is easy and inexpensive to implement in retrofit.

These and many other objects of the invention will be apparent from the drawings and description herein. Although every object of the invention is believed to be attained by at least one embodiment of the invention, there is not necessarily any one embodiment of the invention that achieves all of the objects of the invention.

SUMMARY OF THE INVENTION

A mixer settler apparatus typically comprises at least one mixing tank, a settling tank, an organic launder provided within the settling tank, and an aqueous launder provided within the settling tank and positioned lower than the organic launder so as to allow submersion during operation. The organic launder is operably connected to an organic advance effluent pipe. Pursuant to the present invention, the mixer settler apparatus includes a structure defining a mixed-liquid transmission flow path extending between the mixing tank and the settling tank and coalescing media are variously

disposed or located within the structure and the defined mixed-liquid transmission flow path. Said structure and defined flow path may further include one or more auxiliary tanks.

Where the transmission-conveyance-flow path structure includes a channel or
5 conduit connected at a downstream end to the settling tank, the auxiliary tank(s) is/are connected to and communicate(s) with an upstream end of the channel, opposite the settling tank at the downstream end of the channel. In reverse-flow type mixer settlers, the channel or conduit generally extends alongside a wall of the settling tank.

The media-containing auxiliary tank(s) may constitute one or more dedicated
10 coalescing media tanks. Alternatively, the auxiliary tanks may also constitute one or more auxiliary mixing tanks disposed in the liquid conveyance path between the one mixing tank and the settling tank. Any type of said auxiliary tank may also variously include a single stream, two stream, or multiple flow stream output; and/or an internal or external bypass component, such as a channel or pipe, allowing for continuous operation
15 of the overall apparatus while said auxiliary tank, or at least said media, are bypassed by the flow path and cleaned, such as through backwashing, or otherwise maintained or replaced.

Pursuant to another feature of the present invention, the coalescing media may include woven wire mesh, knitted wire mesh, interwoven strands of metal and plastic,
20 and/or various other structured media having different surface properties. More particularly, the coalescing media may include structured packings made up of alternating layers of dissimilar material, one being hydrophobic and another hydrophilic. Even more particularly, the coalescing media may include layers of hydrophobic plastic media

alternating with layers of hydrophobic plastic media coated with a thin layer of hydrophilic material.

The present invention lends itself well to retrofit installations. Accordingly, the invention is directed in part to a method for constructing or retrofitting a mixer settler apparatus which comprises at least one mixing tank, a settling tank, and structure that defines a mixed-liquid transmission flow path extending between the at least one mixing tank and the settling tank. The method includes providing coalescing media and variously placing, disposing or installing the coalescing media anywhere within the structure, said structure possibly including one or more auxiliary tanks.

In a retrofit, the auxiliary tank(s) may be pre-existing, in the form an auxiliary mixing tank. Alternatively, the auxiliary tank(s) may be added as part of the retrofit process. In that case, the auxiliary tank(s) is/are installed so as to form part of the structure defining the liquid transmission flow path. Where the liquid-transmission or conveyance structure includes a channel or conduit connected at a downstream end to the settling tank, the auxiliary tank may be installed anywhere along said structure or flow path, but is generally preferably installed upstream of the channel or conduit so as to communicate with an upstream end thereof.

The placing of the coalescing media may include disposing, within the structure and/or inside the auxiliary tank(s), various coalescing media, including woven wire mesh, knitted wire mesh, interwoven strands of metal and plastic, and/or various other structured media having different surface properties. Exemplary media include structured packings made up of alternating layers of dissimilar material, one being

hydrophobic and another hydrophilic. The hydrophilic material may be provided as coatings on hydrophobic plastic media.

The present invention provides an improved mixer settler apparatus wherein disengagement times are reduced, thereby enabling the use of shorter settlers.

5 A mixer settler apparatus in accordance with the present invention reduces the
entrainment of aqueous in organic and organic in aqueous streams.

A mixer settler apparatus in accordance with the present invention localizes, reduces, or eliminates air entrainment in fluids, thereby reducing the formation of crud and buildup.

10 Retrofitting an existing mixer settler apparatus in accordance with the present
invention is easy and inexpensive.

The use of commercially available woven wire mesh, knitted wire mesh, interwoven metal and plastic strand media, and/or plastic media (hydrophobic) coated with a thin layer of hydrophilic material, pursuant to the present invention, provides a lightweight coalescing medium that is easy to handle for maintenance purposes.

The invention improves the design of mixer settlers for more efficient use of the settler, resulting in a smaller overall settler area, lower entrainment, and convenient maintenance.

20 BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1 and 2 are side and top views, respectively, of a conventional mixer settler.

FIG. 3 is a schematic top plan view of a mixer settler according to the present invention.

FIG. 4 is a schematic top plan view of another mixer settler according to the present invention.

5 FIG. 5 is a schematic cross-sectional view of an embodiment of coalescing media that may be used in the mixer settlers of FIGS. 3 and 4 in accordance with the present invention.

FIG. 6 is a schematic cross-sectional view of an embodiment of another type of coalescing media that may be used in the mixer settlers of FIGS. 3 and 4 in accordance
10 with the present invention.

FIG. 7 is a schematic cross-sectional view of an embodiment of yet a further type of coalescing media that may be used in the mixer settlers of FIGS. 3 and 4 in accordance with the present invention.

FIG. 8 is a schematic side view of a mixer according to some embodiments of the
15 present invention.

FIG. 9 is a cross-sectional view of FIG. 8 in accordance with the present invention.

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DETAILED DESCRIPTION

FIG. 3 shows a reverse flow type mixer-settler 1 capable of mixing, and then separating, two immiscible fluids, e.g., an organic phase and an aqueous phase. The mixer settler 1 comprises at least one mixer 10 having a tank 12, an agitator 16, and a

drive 14. The mixer settler 1 further comprises a settling tank 30 and a mixed-liquid channel or conduit 24 extending from the one or more mixers 10 to the settling tank 30. The settling tank has a first tank wall 32, a second tank wall 34, a third tank wall 36, and a fourth tank wall 38; an organic launder 40 provided in an upper portion of the settling tank 30 and leading to an external organic weir box 60; and an aqueous launder 50 provided to a lower portion of the settling tank 30 and leading to an external aqueous weir box 70.

The channel or conduit 24 may be defined by an inlet sidewall 22 and the first tank wall 32. A threshold 28 existing between channel 24 and settling tank 30 may help reverse flow direction as well as diffuse energy of flows from channel 24, and may include turning vanes 25. The settling tank 30 may also include a variously located distribution and/or picket fence or fences 27 which would then form a pre-chamber 29 upstream of the main settling tank 30. In fact, multiple such pre-chambers 29 may be formed, as shown in FIG. 3.

In some instances, one or both of the organic launder 40 and aqueous launder 50 comprise a pipe 42, 52 having one or more perforations, apertures, or slits 44, 54 therein. A first end of each pipe 42, 52, adjacent the first tank wall 32, may be closed off and attached to the first tank wall 32 via a closed side mount 46, 56. A second end of each pipe 42, 52 may comprise an open side mount 48, 58 attached to the third tank wall 36, the open side mounts 48, 58 being open and communicating with said external organic weir box 60 and external aqueous weir box 70 via inlet ports 61, 71, respectively. In some instances, a valve mechanism for adjusting flow may be provided in or adjacent to inlet ports 61, 71.

External organic weir box 60 and external aqueous weir box 70 may be separated by a divider 37, such as a shared wall as shown. Divider 37 may alternatively comprise two individual walls (not shown) separated by a space, rather than a shared wall. External organic weir box 60 comprises a collection chamber 62 and an advance chamber 64 separated by an adjustable weir 66, which is configured to be moved up and down by means of an adjustment actuator or control 67. The adjustment actuator or control 67 may comprise, for instance, a complimentary rack and pinion or other arrangement such as a worm gear, mechanical linkage, hydraulic jack, or cam-and-follower arrangement. The external organic weir box 60 may be formed by a first wall 63, a second wall 68, and the divider 37, which extends from the third wall 36 of the settling tank 30 as shown. However, the external organic weir box 60 may comprise any round, cylindrical, or polyhedral-shaped tank, including prismatic shapes. An outlet port 65 in the advance chamber 64 leads to an organic advance effluent pipe 80 having a flange 82 for connecting to other system components. Fluid exiting the organic advance effluent pipe 80 enters a downstream process.

External aqueous weir box 70 comprises a recycle chamber 72 and an advance chamber 74 separated by an adjustable weir 76, which is configured to be moved up and down by means of an adjustment actuator or control 77. The adjustment actuator or control 77 may comprise, for instance, a complimentary rack and pinion or other arrangement such as a worm gear mechanism, mechanical linkage, hydraulic jack, or cam-and-follower arrangement. The external aqueous weir box 70 may be formed by a first wall 73, a second wall 78, and the divider 37. However, the external aqueous weir box 70 may alternatively comprise any round, cylindrical, or polyhedral-shaped tank, including prismatic shapes. An

outlet port 75 in the advance chamber 74 leads to an aqueous advance effluent pipe 90 having a flange 92 for connecting to other system components. Fluid exiting the aqueous advance effluent pipe 90 enters a downstream process. An outlet port 79 in the recycle chamber 72 leads to an aqueous recycle effluent pipe 94 having a flange 96 for connecting to other system components. Fluid exiting the aqueous recycle effluent pipe 94 re-enters an upstream process, for instance, supplementing an aqueous feed to mixer 10. In some instances, a valve mechanism for adjusting flow may be provided in or adjacent to outlet ports 65, 75, 79, for example along effluent pipes 80, 90, 94.

Mixer settler 1 further includes a coalescing-media container 110 comprising an auxiliary tank 112 that forms, together with channel 24 and pre-chamber 29, a structure defining a mixed-liquid transmission flow path between mixing tank 10 and settling tank 30. Auxiliary tank 112 contains coalescing media 108 designed to enhance or accelerate the agglomeration of organic media particles or droplets with each other and the agglomeration of aqueous particles or droplets with each other. Auxiliary tank 112 may define a dedicated chamber essentially containing only coalescing media 108 and the organic-aqueous liquid mixture. Alternatively, auxiliary tank 112 may be an auxiliary mixing tank provided with an agitator 116 and a drive 114 in addition to coalescing media 108. Any number, and certainly more than one, auxiliary tank(s) of varying sizes, shapes, and locations, e.g., tank 110', containing media 108, may be provided as shown.

Said structure 120 and auxiliary tank 112 may further include an internal and/or external bypass component 109 to or around auxiliary tank 112 for said flow path, thereby allowing for continuous operation of the overall mixer settler apparatus while said auxiliary tank 112 and/or said media 108 are backwashed, using any generally

known backwashing system in the art, and/or otherwise cleaned, serviced or replaced.

Furthermore, and as shown in FIG. 3, coalescing media 108 may also be variously placed, located or disposed anywhere within said structure along said path, such as proximate the turning vanes 25 and/or within the pre-chamber 29.

5 FIG. 4 shows a mixer-settler 400 of the non-reverse flow type, which is capable of mixing, and then separating, two immiscible fluids, e.g., an organic phase and an aqueous phase. The mixer settler 400 comprises at least one mixer 410 having a tank 412, an agitator 416, and a drive 414. The mixer settler 400 further comprises structure 420 defining a mixed-liquid transmission or conveyance path (not separately designated)
10 between the mixing tank 412 and a settling tank 430. Settling tank 430 has a first tank wall 432, a second tank wall 434, a third tank wall 436, and a fourth tank wall 438; an organic launder 440 provided to an upper portion of the settling tank 430 and leading to an external organic weir box 460; and an aqueous launder 450 provided to a lower portion of the settling tank 430 and leading to an external aqueous weir box 470. In some
15 instances, one or both of the organic launder 440 and the aqueous launder 450 comprise a pipe 442, 452 having one or more perforations, apertures, or slits 444, 454 therein. A first end of each pipe 442, 452, adjacent the first tank wall 432, may be closed off and attached to the first tank wall 432 via a closed side mount 446, 456. A second end of each pipe 442, 452 may comprise an open side mount 448, 458 attached to the third tank
20 wall 436—the open side mounts 448, 458 being open and communicating with said external organic weir box 460 and external aqueous weir box 470 via inlet ports 461, 471, respectively. In some instances, a valve mechanism for adjusting flow may be provided in or adjacent to inlet ports 461, 471.

External organic weir box 460 and external aqueous weir box 470 may be separated by a divider 437, such as a shared wall as shown. Divider 437 may alternatively comprise two individual walls, which are separated by a space, rather than the shared wall depicted in FIG. 4. External organic weir box 460 comprises a collection
5 chamber 462 and an advance chamber 464 separated by an adjustable weir 466, which is configured to be moved up and down via an adjustment actuator or control 467.

Actuator or control 467 may comprise, for instance, a complimentary rack and pinion or other arrangement such as a worm gear, mechanical linkage, hydraulic jack, or cam-and-follower arrangement. The external organic weir box 460 may be formed by a first wall

10 463, a second wall 468, and a divider 437 extending from the third wall 436 of the settling tank 430 as shown. Alternatively, the external organic weir box 460 may comprise any round, cylindrical, or polyhedral-shaped tank, including prismatic shapes.

An outlet port 465 in the advance chamber 464 leads to an organic advance effluent pipe 480 having a flange 482 for connecting to other system components. Organic fluid

15 exiting the advance effluent pipe 480 enters a downstream process. External aqueous weir box 470 comprises a recycle chamber 472 and an advance chamber 474 separated by an adjustable weir 476 which is configured to be moved up and down via an adjustment actuator or control 477. Actuator or control 477 may comprise, for instance, a

complimentary rack and pinion or other arrangement such as a worm gear mechanism,

20 mechanical linkage, hydraulic jack, or cam-and-follower arrangement. The external aqueous weir box 470 may be formed by a first wall 473, a second wall 478, and a divider 437 extending from the third wall 436 of the settling tank 430 as shown as shown.

Alternatively, the external aqueous weir box 470 may comprise any round, cylindrical, or

polyhedral-shaped tank, including prismatic shapes. An outlet port 475 in the advance chamber 474 leads to an aqueous advance effluent pipe 490 having a flange 492 for connecting to other system components. Aqueous fluid exiting the advance effluent pipe 490 enters a downstream process. An outlet port 479 in the recycle chamber 472 leads to
5 an aqueous recycle effluent pipe 494 having a flange 496 for connecting to other system components. Aqueous fluid exiting the effluent pipe 494 re-enters an upstream process, for instance, supplementing an aqueous feed to mixer 410. Various placed distribution and/or picket fence or fences 427 may be provided within the settling tank 430, thereby forming a pre-chamber 429, in order to improve efficiency of the mixer settler 400. In
10 fact, one or more such pre-chambers 429 may be formed, as shown in FIG. 4. In some instances, a valve mechanism for adjusting flow may be provided in or adjacent to outlet ports 465, 475, 479, for example along effluent pipes 480, 490, 494.

Mixer settler 400 further includes a coalescing-media container 310 comprising an auxiliary tank 312 that is part of structure 420 defining a mixed-liquid transmission
15 flow path between mixing tank 410 and settling tank 430. Auxiliary tank 312 contains coalescing media 308 designed to enhance or accelerate the agglomeration of organic media particles or droplets with each other and the agglomeration of aqueous particles or droplets with each other. Auxiliary tank 312 may define a dedicated chamber essentially containing only coalescing media 308 and the organic-aqueous liquid mixture.

20 Alternatively, auxiliary tank 312 may also be an auxiliary mixing tank provided with an agitator 416 and a drive 414 in addition to coalescing media 308.

Said structure 420 and auxiliary tank 312 may further include an internal or external bypass component 309 to or around said auxiliary tank 310, and for said mixed-

liquid transmission flow path, allowing for the continuous operation of the overall mixer-settler system apparatus while said auxiliary tank 312 and/or said media 308 are backwashed, or otherwise cleaned using any method as is known in the art, and/or serviced, maintained or replaced.

5 Coalescing media 108 and 308 may take any suitable form, including but not limited to particulates, mesh, pickets, latticework, and combinations thereof. Coalescing media 108 and 308 may be made of any suitable material including, but not limited to, any particulates, such as sand, gravel and/or rock; steel, woven wire mesh, knitted wire mesh, interwoven strands of metal, e.g., stainless steel, and plastic, and/or any other
10 metals and alloys, polymeric compositions and combinations thereof. Furthermore, and as shown in FIG. 4, said media may also be variously placed, located or disposed anywhere within said structure, generally along said path, such as within said pre-chamber 429, for further efficiency gains.

As an exemplary embodiment, FIG. 5 shows the coalescing media 108 and 308 in
15 the form of multiple alternating or interleaved layers 120 and 122 of different microstructures and different materials. Layer 120 may take the form of one kind of coalescing media, for instance, an undulating or corrugated lattice of hydrophobic polymeric media, while layer 122 may take the form of another kind of coalescing media, for instance, an undulating or corrugated lattice of hydrophobic polymeric media coated
20 with a thin layer of hydrophilic material. Either lattice layer 120 or 122 may incorporate another kind of coalescing material, for instance, polymeric granules or particulates 124 with outer surfaces that are hydrophilic (or hydrophobic). Layers 120 and 122 are adapted for respectively collecting the organic component and the aqueous component of

a mixed liquid. Coalescing media 108 and 308 may take other forms including stainless steel or plastic coalescers and/or picket fences placed in settlers to provide enhanced coalescence. Structured media such as that of layers 120 and 122 (FIG. 5), one being hydrophobic and other hydrophilic, improve the coalescing performance and form a lightweight coalescing medium that is easy to handle for maintenance purposes.

As yet other exemplary embodiments, FIG. 6 shows a coalescing media made up of woven wire mesh 210 while FIG. 7 shows a coalescing media made up of interwoven strands of metal 220 and plastic 222. One such preferred media includes the Sulzer DC Coalescer™ composite media which is marketed and sold by Sulzer Chemtech USA, Inc.

Turning now to FIG. 8, a mixer 500 for use in solvent extraction systems is shown. Features of the mixer 500 may be advantageously utilized within any of the previously described mixers 10, 112, 312, 410. Mixer 500 may comprise a central mixing chamber 512 defined within an optional top panel 507, a bottom panel 509, and an annular sidewall 508 which may take various configurations and cross-sectional shapes (e.g., rectangular, polygonal, or circular as shown). The mixer 500 may further comprise one or more agitators, for example, provided in the form of a motor 502 coupled to a drive shaft 504 mounted with one or more impellers 506. One or more inlets 514, 516 may be provided for receiving influent organic and aqueous solutions, and for delivering said influent organic and aqueous solutions to the central mixing chamber 512. In some embodiments, one or more inner sidewalls 511 having apertures 513 therein may be provided adjacent the mixing chamber 512, thereby forming an outer dispersed phase zone 510 which surrounds at least a portion of the central mixing chamber 512. One or more flexible members 515 may be provided within the dispersed phase zone 510 to

facilitate early coalescence and reduce turbulence within the dispersed phase zone 510.

Flexible members 515 may, without limitation, comprise streamers, netting, webs, fabrics, braided rope, thin baffles, or flexible extrusions of various cross-sectional shapes.

In some embodiments, flexible members 515 may comprise apertures, pores, interstices,

5 or other openings (e.g., tubular). In some embodiments, the flexible members 515 may comprise materials with different coalescing properties. For example, some or all surfaces of the flexible members 515 may contain materials which are hydrophobic and/or hydrophilic. Flexible members 515 may comprise homogeneous composites, or may be formed using layers of different materials.

10 One or more coalescing pads 522D, 524, 525, 526 may be provided on either side of the inner sidewall 511. In the embodiment shown in FIGS. 8 and 9, three nested cylindrical coalescing pads 524, 525, 526 are provided within the central mixing chamber adjacent to the inner sidewall 511, and one or more cylindrical coalescing pads 522D are arranged in the dispersed phase zone 510, adjacent the annular sidewall 508. Other

15 configurations of coalescing pads 522D, 524, 525, 526 are envisaged. Each of the coalescing pads 522D, 524, 525, 526 may comprise different properties, for example, material composition and/or porosity may differ between the coalescing pads 522D, 524, 525, 526. In this manner, the coalescing pads 522D, 524, 525, 526 may synergistically work together to facilitate "graded" coalescing functionality within the mixer 500. For

20 example, one or more inner coalescing pads 524 may have greater porosities than one or more outer coalescing pads 526 to collectively form coalescing media having a porosity gradient.

In some embodiments, coalescing media such as one or more pads 522A, 522B, 522C may also be provided at upper portions of the mixer 500, within either the mixing chamber 512 or dispersed zone 510. As shown in the figures, coalescing media 522C may be provided within or adjacent to an outlet 518.

5 The present invention results in a better design of a mixer settler promoting more efficient use of the settler and resulting in lower entrainment and convenient maintenance. In addition, the more efficient, faster separating behavior of the fluid will result in mixer settler designs which require less settler area and thus a smaller dedicated footprint or amount of floor space.

10 A contractor or other entity may provide a mixer settler apparatus, or operate a mixer settler apparatus in whole, or in part, as shown and described. For instance, the contractor may receive a bid request for a project related to designing or operating a mixer settler apparatus, or the contractor may offer to design such a system or a process for a client. The contractor may then provide, for example, any one or more of the
15 devices or features thereof shown and/or described in the embodiments discussed above. The contractor may provide such devices by selling those devices or by offering to sell those devices. The contractor may provide various embodiments that are sized, shaped, and/or otherwise configured to meet the design criteria of a particular client or customer. The contractor may subcontract the fabrication, delivery, sale, or installation of a
20 component of the devices disclosed, or of other devices used to provide said devices. The contractor may also survey a site and design or designate one or more storage areas for stacking the material used to manufacture the devices, or for storing the devices and/or components thereof. The contractor may also maintain, modify, or upgrade the

provided devices. The contractor may provide such maintenance or modifications by subcontracting such services or by directly providing those services or components needed for said maintenance or modifications, and in some cases, the contractor may modify a preexisting mixer settler apparatus, or parts thereof with a "retrofit kit" to arrive
5 at a modified mixer settler apparatus comprising one or more method steps, devices, components, or features of the systems and processes discussed herein.

Although the invention has been described in terms of particular embodiments and applications, one of ordinary skill in the art, in light of this teaching, can generate additional embodiments and modifications without departing from the spirit of or
10 exceeding the scope of the claims.

Additionally, while explicitly shown for reverse-flow and non-reverse-flow mixer settlers, features and components of the invention may be equally adapted for use in various types of mixer settlers including, but not limited to: segmented circular mixer settlers, Kermac mixer-settlers, Israeli Mining Industries (IMI) mixer settlers, Lurgi
15 mixer settlers, combined mixer settlers, vertical smooth flow (VSF) mixer settlers, Krebs mixer settlers, and conventional mixer settlers.

Accordingly, it is to be understood that the drawings and descriptions herein are proffered by way of example to facilitate comprehension of the invention and should not be construed to limit the scope thereof.

WHAT IS CLAIMED IS:

1. A mixer settler apparatus comprising:
 - at least one mixing tank;
 - a settling tank;
 - structure defining a mixed-liquid transmission flow path extending between said at least one mixing tank and said settling tank; and
 - coalescing media disposed within said structure.
2. The mixer settler apparatus according to claim 1, wherein said structure includes at least one auxiliary tank.
3. The mixer settler apparatus according to claim 2, wherein said structure includes a bypass component for said defined mixed-liquid transmission flow path to or around said auxiliary tank.
4. The mixer settler apparatus according to claim 2, wherein said auxiliary tank is a dedicated coalescing media tank.
5. The mixer settler apparatus according to claim 2, wherein said auxiliary tank is also an auxiliary mixing tank.

6. The mixer settler apparatus according to claim 2, wherein said auxiliary tank is located upstream of a liquid-conveyance channel or conduit connected at a downstream end to said settling tank.

7. The mixer settler apparatus according to claim 1, wherein said structure includes a distribution fence forming a pre-chamber upstream of said settling tank.

8. The mixer settler apparatus according to claim 7, wherein said coalescing media is located within said pre-chamber.

9. The mixer settler apparatus according to claim 1, wherein said structure includes turning vanes.

10. The mixer settler apparatus according to claim 9, wherein said coalescing media is located proximate said turning vanes.

11. The mixer settler apparatus according to claim 9, wherein said coalescing media is located downstream of said turning vanes and upstream of said settling tank.

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12. The mixer settler apparatus according to claim 1, wherein said coalescing media comprises media selected from the group consisting of particulates, woven wire mesh, and knitted wire mesh.

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13. The mixer settler apparatus according to claim 1, wherein said coalescing media comprises interwoven strands of metal and plastic.

14. The mixer settler apparatus according to claim 1, wherein said coalescing media comprises structured media having different surface properties.

15. The mixer settler apparatus according to claim 14, wherein said structured media comprises structured packings made up of alternating layers of dissimilar material, one being hydrophobic and another hydrophilic.

16. The mixer settler apparatus according to claim 14, wherein said structured media comprises layers of hydrophobic plastic media alternating with layers of hydrophobic plastic media coated with a thin layer of hydrophilic material.

17. A method for constructing or retrofitting a mixer settler apparatus, said method comprising:

providing a mixer settler apparatus including at least one mixing tank and a settling tank;

providing a structure defining a mixed-liquid transmission flow path extending between said at least one mixing tank and said settling tank;

providing coalescing media; and

placing said coalescing media within said structure.

18. The method according to claim 17, wherein said step of providing a structure includes the providing at least one auxiliary tank as part of said structure.

19. The method according to claim 18, wherein placing said coalescing media within said structure includes placing said media within said auxiliary tank.

20. The method according to claim 18, said method further including the step of providing a bypass component to said auxiliary tank.

21. The method according to claim 18, wherein the providing of said auxiliary tank includes installing said auxiliary tank so that said auxiliary tank communicates with said at least one mixing tank on an upstream side and said settling tank on a downstream side.

22. The method according to claim 18, wherein the installing of said auxiliary tank includes connecting said auxiliary tank to an upstream end of a channel or conduit extending alongside a sidewall of said settling tank, said auxiliary tank communicating with said settling tank via said channel or conduit.

23. The method according to claim 17, wherein the placing of said coalescing media includes disposing, within said structure, coalescing media comprised of media selected from the group consisting of particulates, woven wire mesh, and knitted wire mesh.

24. The method according to claim 17, wherein the placing of said coalescing media includes disposing, within said structure, media comprised of interwoven strands of metal and plastic.

25. The method according to claim 17, wherein the placing of said coalescing media includes disposing, within said structure, structured media having different surface properties.

26. The method according to claim 25, wherein the placing of said coalescing media includes disposing, within said structure, structured media packings made up of alternating layers of dissimilar material, one being hydrophobic and another hydrophilic.

27. The method according to claim 25, wherein the placing of said coalescing media includes disposing, within said structure, layers of hydrophobic plastic media alternating with layers of hydrophobic plastic media coated with a thin layer of hydrophilic material.

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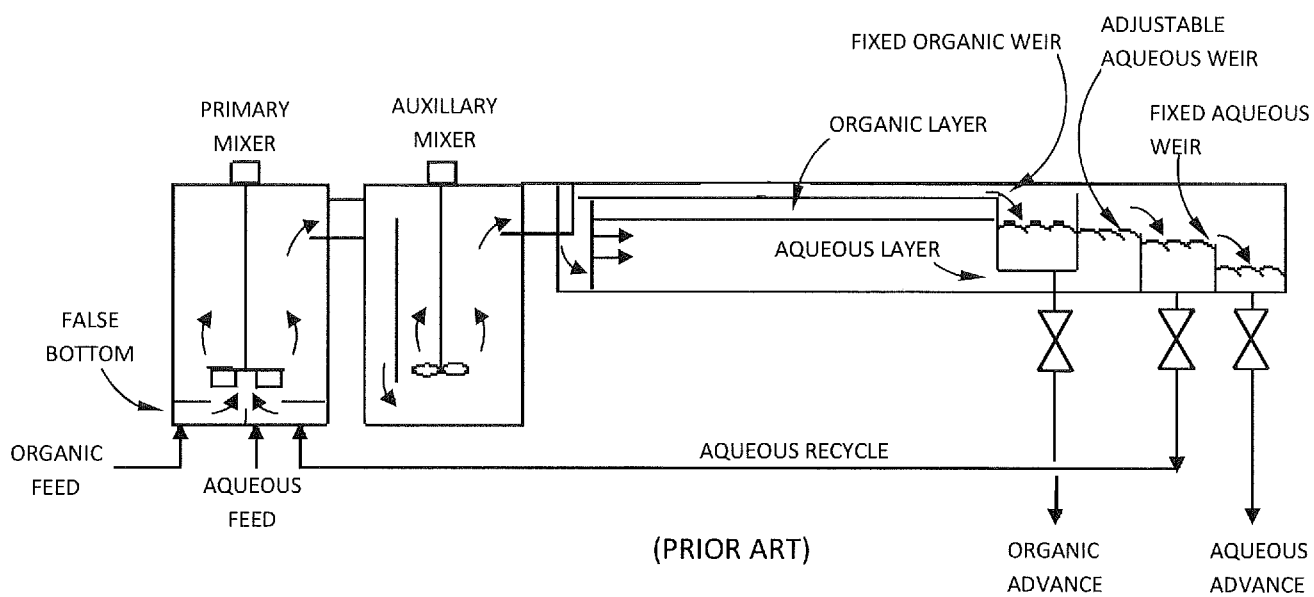


FIG. 1

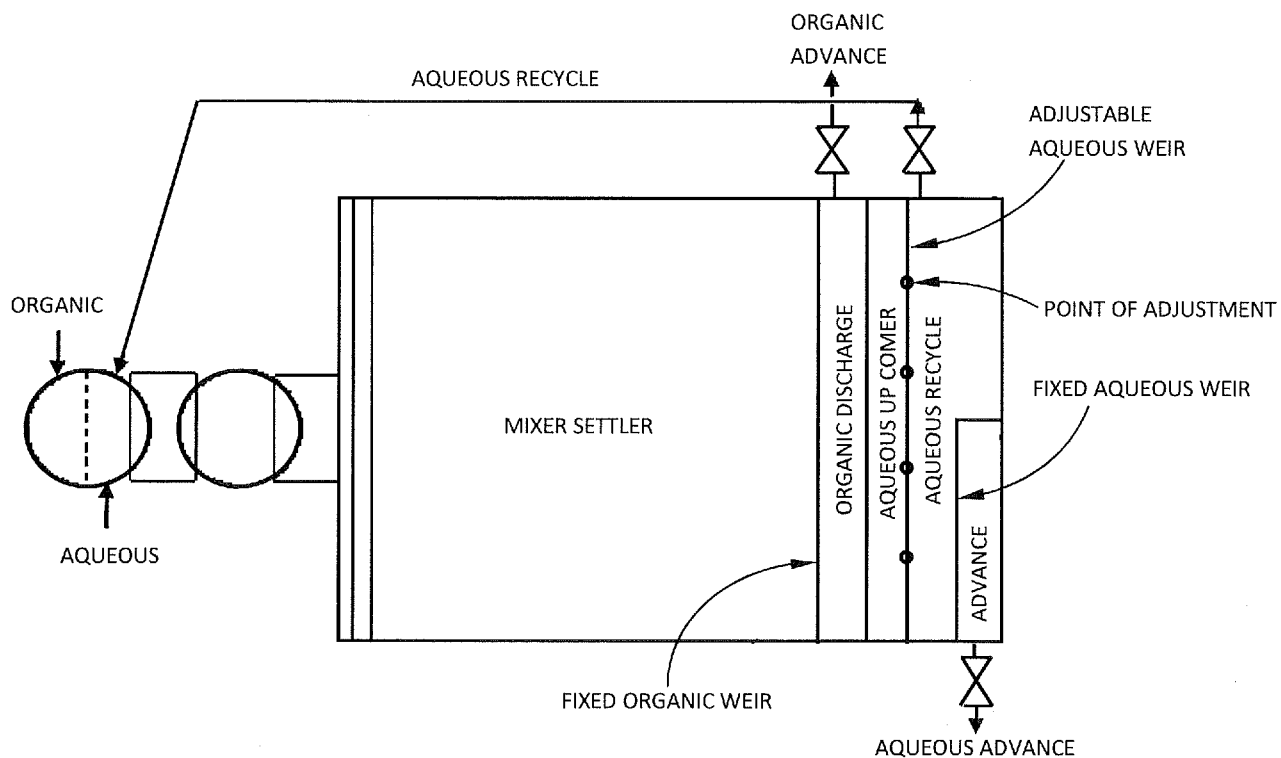
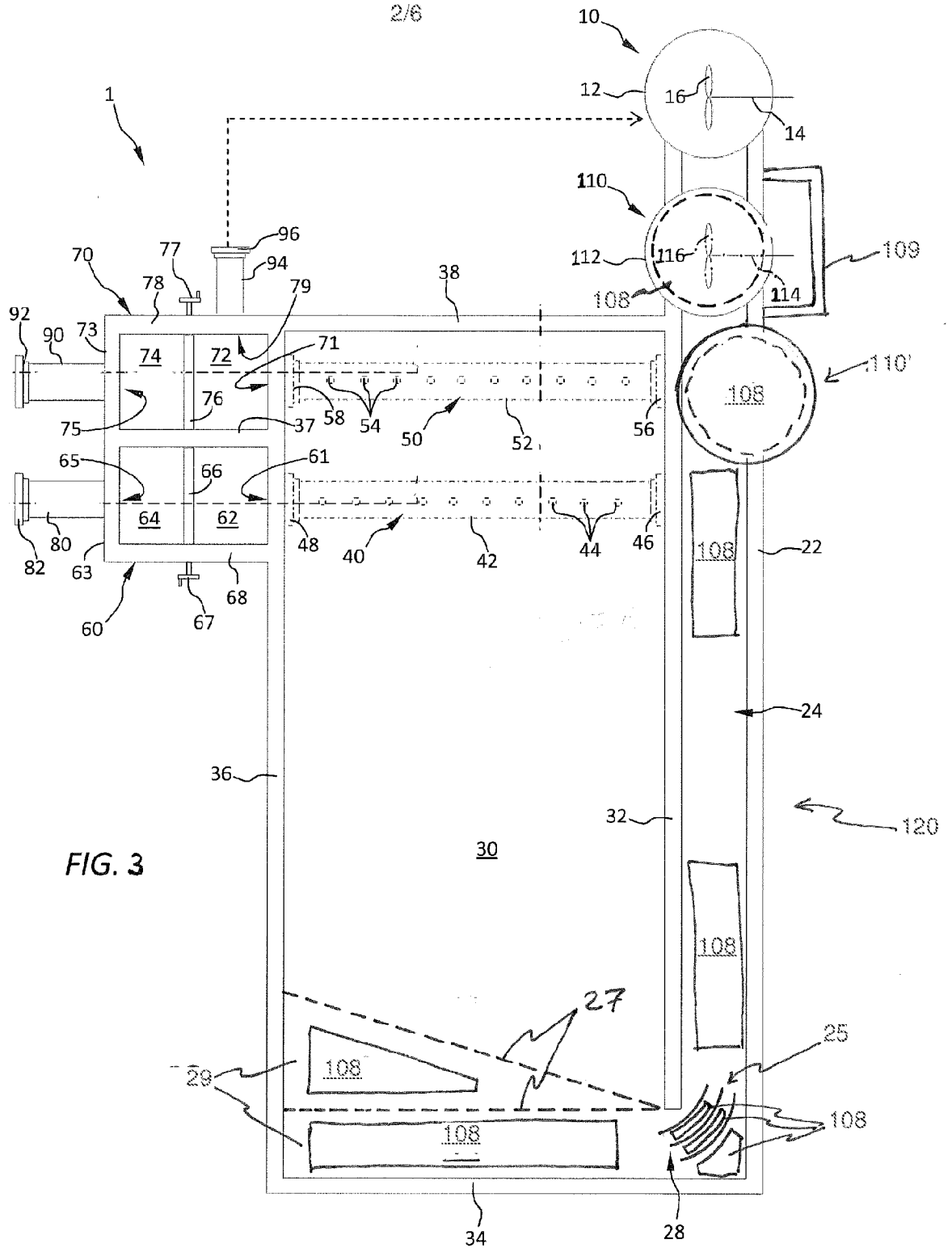
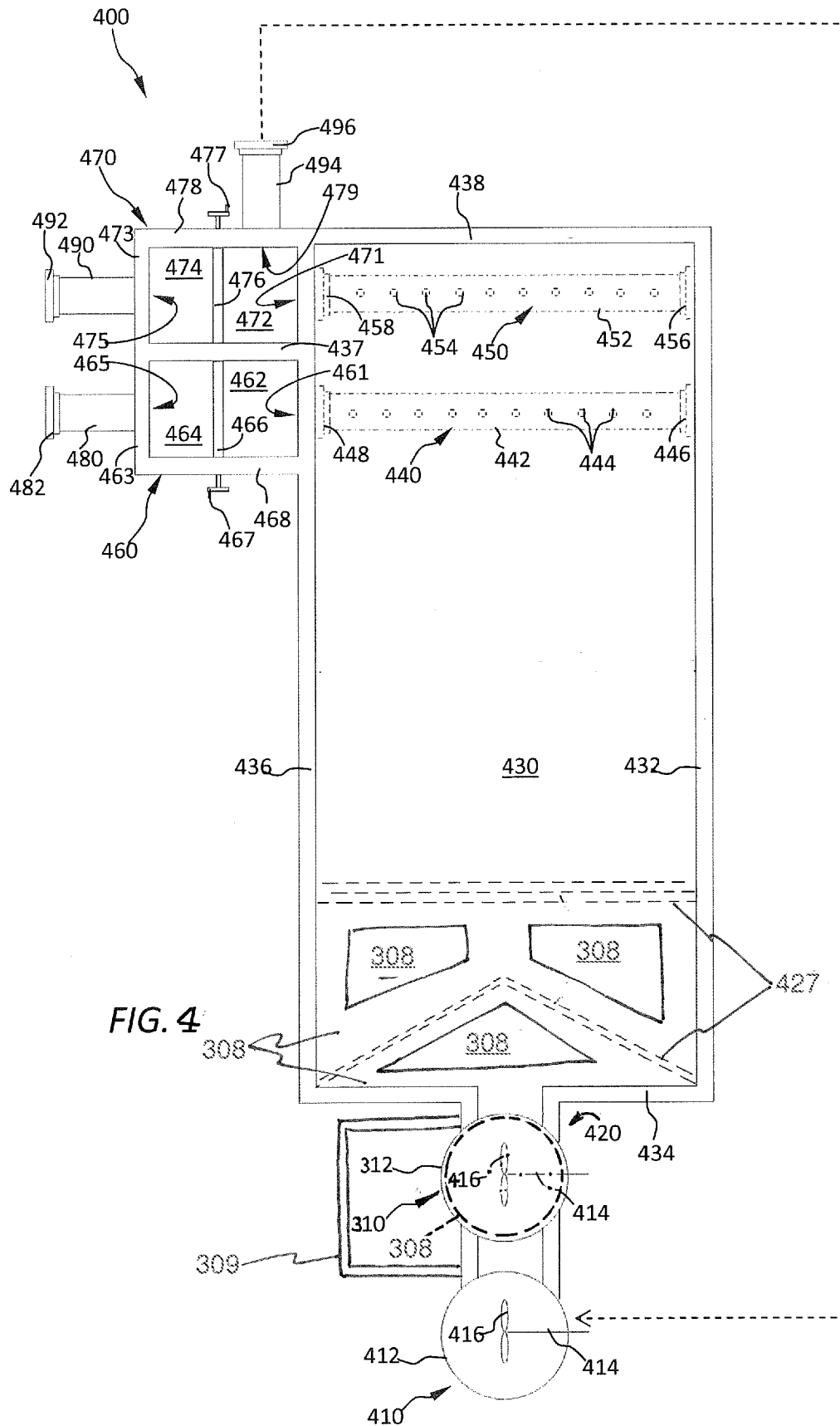


FIG. 2

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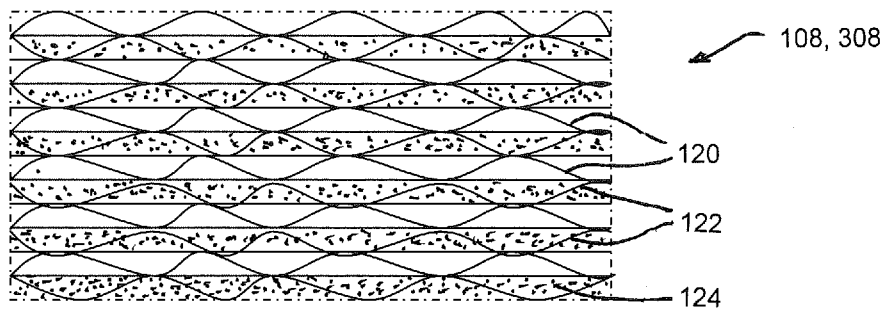


FIG. 5

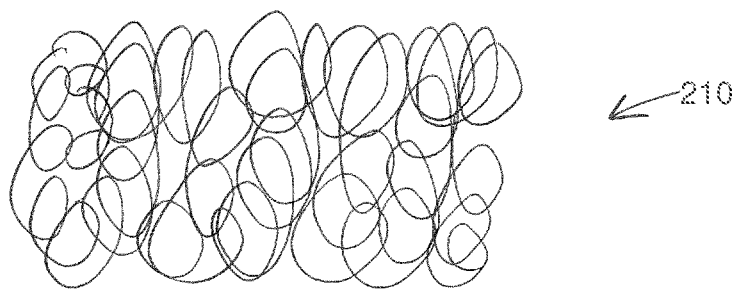


FIG. 6

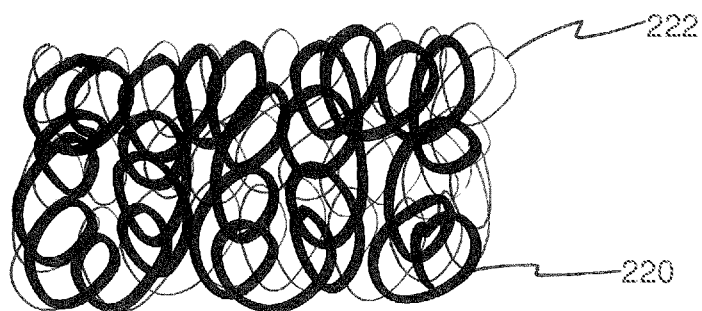


FIG. 7

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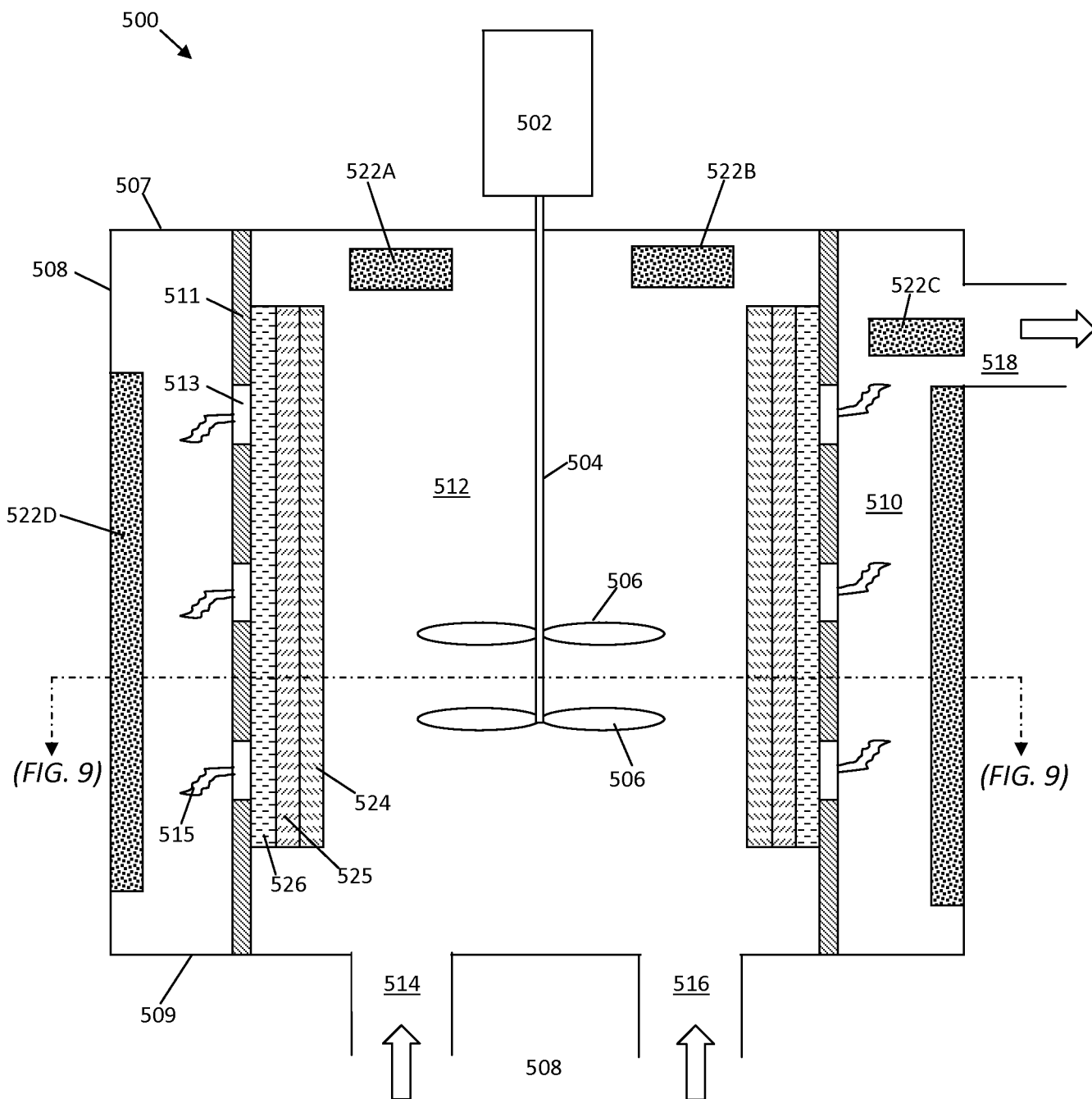


FIG. 8

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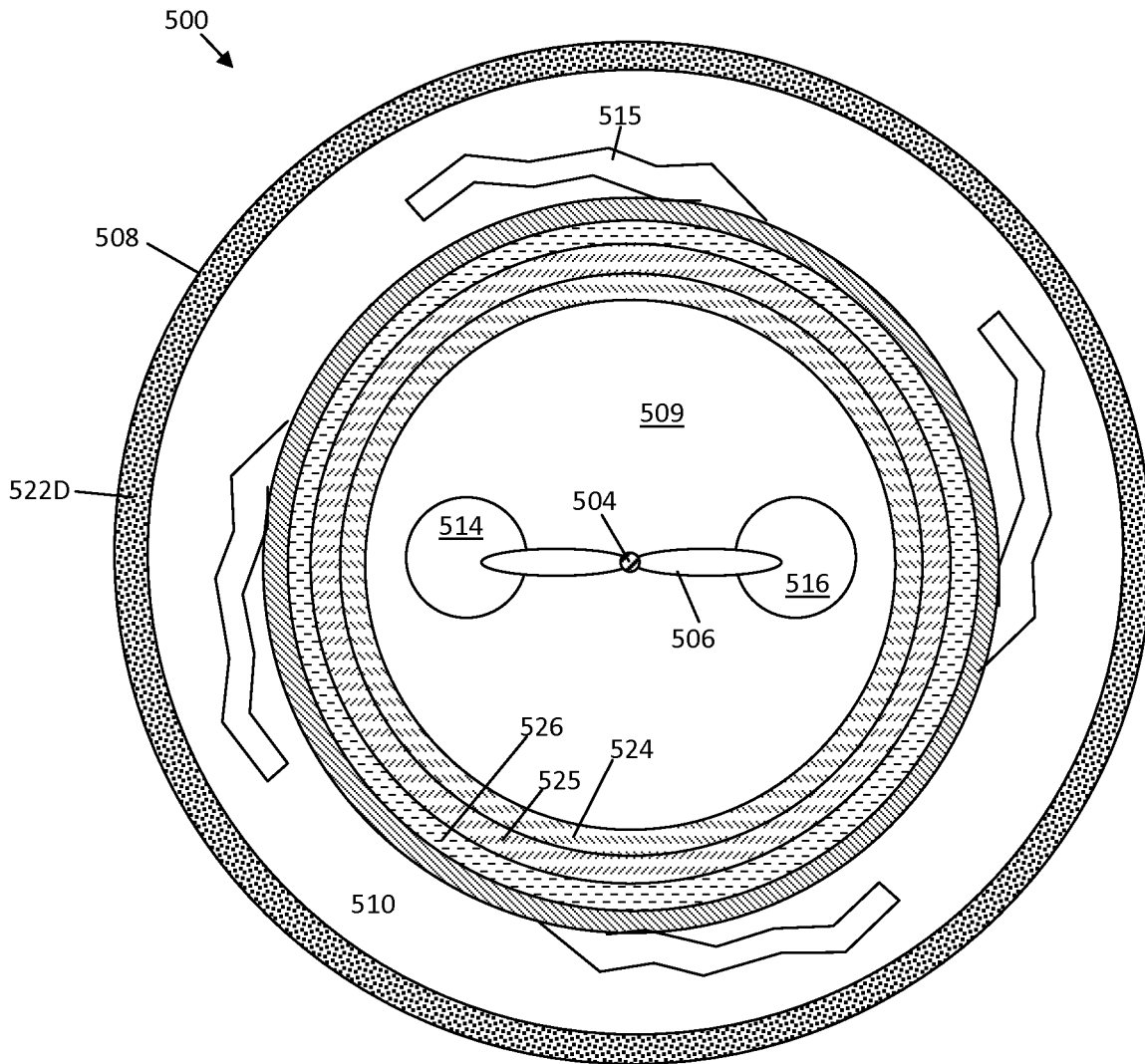


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 12/71944

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B01 D 17/028 (2013.01)**USPC - 210/521, 210/540**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8)- B01D 17/028 (2013.01);

USPC- 210/521, 210/540

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

IPC(8)- B01D 17/028; B01D 11/04 (2013.01);

USPC- 210/521, 210/522, 210/532.1, 210/538, 210/540 Patents and NPL (classification, keyword; search terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PubWest (USPTO, EPO, JPO, WIPO), GoogleScholar (PL, NPL), FreePatentsOnline (USPTO, EPO, JPO, WIPO, NPL);

Search terms used: mixer, settler, coalescer, weir, baffle, vane, coalesce, coalescing, media, filter, pad, fabric, woven, nonwoven, mesh, screen, knit, extract, solvent

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 2006/0131233 A1 (GIRALICO et al.) 27 July 2006 (27.07.2006), Fig. 4; para [0007], [0026], [0027], [0031], [0034]	1, 2, 5, 14,15,17,18,25,26 ----- 3, 4, 6-13, 16, 19-24, 27
Y	US 2010/0130800 A1 (LUO et al.) 27 May 2010 (27.05.2010), Fig. 1; para [0008], [0058], [0059], [0070]	3, 4, 6-8, 19-22
Y	US 4,218,31 1 A (NEWRICK) 19 August 1980 (19.08.1980), Fig. 1; col 1, ln 4-1 1; col 1, ln 27-49; col 2, ln 22-60	9-13, 16, 23, 24, 27
Y	US 7,328,809 B2 (GIGAS et al.) 12 February 2008 (12.02.2008), Fig. 2; col 3, ln 25-32; col 4, ln 25-54	1-27
Y	US 4,221,658 A (HARDWICK) 09 September 1980 (09.09.1980), Fig. 4; col 11, ln 29 to col 12, ln 56	1-27

☐ Further documents are listed in the continuation of Box C.
 ☐

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search

18 February 2013 (18.02.2013)

Date of mailing of the international search report

12 MAR 2013

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
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