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(54) Title: SYSTEMS AND METHODS FOR SCREENING

(57) Abstract: A screening system for solid removal includes a housing and a screen positioned within the housing. A flow inlet is operatively connected to an interior chamber defined by the screen. A sump is downstream from the flow inlet for capturing solids that do not pass through the screen. A flow outlet is downstream from the screen in fluid communication with the flow inlet. A moveable cleaning assembly may be positioned either within a perimeter of the screen, around the perimeter of the screen or both. The moveable cleaning assembly is moveable with respect to the screen.

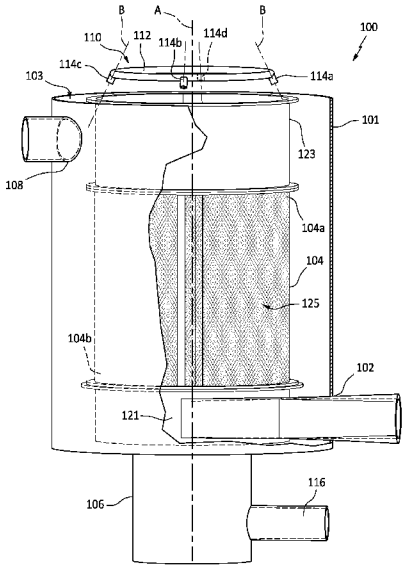

FIG. 1

[Continued on next page]

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SYSTEMS AND METHODS FOR SCREENING

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority to U.S. Provisional Patent Application No. 63/063,201 filed August 7, 2020, which is incorporated by reference herein in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The subject disclosure relates to screening systems, and more particularly to screening systems that separate floating and suspended solids from a flowing liquid, such as those in storm water drain systems, mixed sewage and storm water drain systems, and/or industrial waste systems.

2. Background of the Related Art

[0003] In general, screening systems for use in storm water drain systems, mixed sewage and storm water drain systems, and/or industrial waste systems act to remove solids, e.g. floating and suspended solids, from a fluid mixture. Continuous deflection screen systems channel a flow mixture into an interior portion of a screen where the mixture forms a circulating flow that sweeps the screen clean of solids captured from the fluid flow that concentrate inside of the screen. The settleable (e.g. heavier) solids settle into a lower chamber, often called a sump, while floatable solids are retained at the surface of an upper separation chamber. Filtrate (e.g. the liquid from the mixture) passes out of the screen and to an outlet that can then be discharged to a receiving body of water, or other disposal location. Solids that are accrued in the sump can be removed with an underflow pump. When the build-up of solids begins to interfere with the hydraulic operation and screen cleaning, it becomes necessary to clean them out. Typically, this cleaning done with mechanical cleaning (vactor trucks, clamshells, etc.) or with a sump pump.

[0004] Screening systems in storm water drain systems can assist in removing pollutants from storm water before the storm water drains to the receiving body of water. Screening systems in mixed sewage and storm water drain systems allow some of the excess fluid volume to be shed from the sewer prior to reaching a sewage plant, which in turn can make the sewage plant more efficient. This is particularly helpful during excess wet-weather events. Screening systems in industrial waste systems act to separate solid pollution from a liquid flow to reduce the overall volume of polluted liquid being discharged into sewers. Continuous deflection screen systems are described in more detail in U.S. Patent No. 7,465,391, which is hereby incorporated by reference in its entirety.

[0005] Traditional screening systems have been considered satisfactory for their intended purpose. However, there is an ongoing need for screening systems that are more efficient and easier to use.

SUMMARY OF THE INVENTION

[0006] As will be discussed in greater detail below in the Detailed Description section of this disclosure, the present disclosure is directed to a screening system for solid removal. The screening system for solid removal includes a housing and a screen positioned within the housing. A flow inlet is operatively connected to an interior chamber defined by the screen. A sump is downstream from the flow inlet for capturing solids that do not pass through the screen. A flow outlet is downstream from the screen in fluid communication with the flow inlet. A moveable cleaning assembly may be positioned either within a perimeter of the screen, around the perimeter of the screen or both. The moveable cleaning assembly is moveable with respect to the screen.

[0007] In accordance with some embodiments, the moveable cleaning assembly includes a ring and a series of nozzles circumferentially disposed around the ring.

[0008] The screen extends from a top to a bottom. The nozzles can be angled in a direction toward the bottom of the screen.

[0009] In certain embodiments, the moveable cleaning assembly includes a downwardly extending member, which can include at least one nozzle. The downwardly extending member can be a center member positioned within the perimeter of the screen along a central longitudinal axis defined by the screen. The center member can be mounted for movement along the longitudinal axis. It is also contemplated that the downwardly extending member can be positioned around the outer perimeter of the screen. The downwardly extending member can be mounted for circumferential movement about the outer perimeter of the screen. In some embodiments, the at least one nozzle includes a nozzle positioned at a distal end of the downwardly extending member. In certain embodiments, the at least one nozzle includes a series of nozzles spaced apart along the length of the downwardly extending member. It is contemplated that the downwardly extending member can be one of a plurality

of downwardly extending members spaced apart within the perimeter of the screen, around the perimeter of the screen or both.

[0010] In some embodiments, the inlet is operatively connected to a base portion positioned below a bottom of the screen to channel a fluid mixture into the interior chamber. The outlet can be operatively connected to a top of the housing to channel a screened fluid from an annulus between the screen and the housing out of the housing.

[0011] In accordance with another aspect, a screening system for solid removal includes a flow inlet, a frame having a screen body removably positioned therein, a sump downstream from the flow inlet for capturing solids that do not pass through the screen, and a flow outlet downstream from the screen in fluid communication with the flow inlet.

[0012] In accordance with yet another aspect, a screen body for use in a screening system includes a metal sheet and angled holes defined in the metal sheet. When viewing a given hole from a first side of the hole in a direction perpendicular to a surface of the metal sheet a view through the metal sheet is obstructed by a backside surface of the given hole.

[0013] In accordance with yet another aspect, a screen body for use in a screening system includes a metal sheet and angled holes defined in the metal sheet. The angle (α) of each hole with respect to a surface of the metal sheet is a function of the sheet thickness (t) at the hole and the hole diameter (d), wherein $\alpha \leq 90 - \sin^{-1}\frac{d}{t}$.

[0014] In accordance with another aspect, a method of manufacturing a screen body for use in a screening system includes providing a metal sheet and cutting holes in the metal sheet at an angle with respect to a surface defined by the metal sheet and at an angle with respect to a direction perpendicular to the surface of the metal sheet to form a screen body. The holes can be cut such that when viewing a given hole from a first side of the hole in the direction perpendicular to the surface of the metal sheet a view through the metal sheet is obstructed by a backside surface of the given hole.

[0015] In accordance with another aspect, a method of manufacturing a screen body for use in a screening system includes providing a metal sheet and cutting holes in the metal sheet at an angle (α) with respect to a surface defined by the metal sheet. The angle (α) with respect to the surface of the metal sheet can be a function of the sheet thickness (t) at the hole and the hole diameter (d), wherein $\alpha \leq 90 - \sin^{-1}\frac{d}{t}$.

[0016] The method can include electro-polishing the screen. Cutting holes can include using a water-jet and/or laser cutter.

[0017] In accordance with another aspect, a screening system for solids removal includes a variable volume flow inlet assembly and a screen positioned downstream from the variable volume flow inlet assembly. A sump is downstream from the variable flow inlet assembly for capturing solids that do not pass through the screen. A flow outlet is downstream from the screen in fluid communication with the variable volume flow inlet assembly.

[0018] In accordance with some embodiments, the variable volume flow inlet assembly includes an inlet conduit and a series of moveable steel shims having a triangular cross-section. The steel shims can be varying sizes.

[0019] In accordance with another aspect, a screening system for solid removal includes a housing and a screen positioned within the housing. A flow inlet is operatively connected to an interior chamber defined by the screen. A sump is positioned downstream from the flow inlet for capturing solids that do not pass through the screen. A flow outlet is positioned downstream from the screen. A weir positioned between the screen and the flow outlet.

[0020] In some embodiments, the system includes a housing outlet between the screen and the flow outlet. The weir can be movably mounted to the housing and configured to move with respect to the housing outlet. In some embodiments, the system includes a threshold section of the housing between the flow outlet and the housing outlet. The weir can be movably mounted to the threshold section of the housing and configured to move with

respect to the threshold section of the housing. The flow outlet can be defined in the threshold section of the housing. It is contemplated that the flow outlet can be a floating debris outlet, and/or a filtrate outlet.

[0021] In accordance with another aspect, a screening system for solid removal includes a housing and a screen positioned within the housing. A flow inlet operatively connected to an interior chamber defined by the screen. A sump is positioned downstream from the flow inlet for capturing solids that do not pass through the screen. A sump drain is downstream from the sump. A sump valve and/or a sump pump is operatively connected to the sump drain to control the flow rate therethrough based on at least one characteristic of the waste in the system. A plurality of sensors are operatively connected to the at least one of the sump valve or the sump pump to sense the at least one characteristic of the waste.

[0022] These and other features of the systems and methods of the subject disclosure will become more readily apparent to those skilled in the art from the following detailed description of the preferred embodiments taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] So that those having ordinary skill in the art to which the present disclosure pertains will more readily understand how to employ the systems and methods of the present disclosure, embodiments thereof will be described in detail below with reference to the drawings, wherein:

[0024] FIG. 1 is a schematic depiction of a cut-away partial cross-section of an embodiment of a screening system constructed in accordance with the present disclosure, showing an internal moveable wash-down ring in a raised position;

[0025] FIG. 2 is a schematic depiction of a portion of the screening system of FIG. 1, showing the housing removed and the moveable internal wash-down ring in a lowered position within the interior of the screen;

[0026] FIG. 3 is a schematic depiction of a portion of an embodiment of a screening system constructed in accordance with the present disclosure, showing the system with the housing removed and with an external moveable wash-down ring in a lowered position around the screen;

[0027] FIG. 4A is a schematic depiction of a cut-away partial cross-section of an embodiment of a screening system constructed in accordance with the present disclosure, showing the system having a filtrate outlet and a floatable debris outlet each including an associated weir structure;

[0028] FIG. 4B is a schematic depiction of the screening system of Fig. 4A, showing the outside of the system housing;

[0029] FIG. 5A is a schematic depiction of a cut-away of a portion of an embodiment of a screening system constructed in accordance with the present disclosure, showing a floatable debris outlet of the system having its weir raised;

[0030] FIG. 5B is a schematic depiction of the system of FIG. 5A, showing the floatable debris outlet of the system having its weir partially lowered;

[0031] FIG. 5C is a schematic depiction of the system of FIG. 5A, showing the floatable debris outlet of the system having its weir fully lowered;

[0032] FIG. 6 is a schematic depiction of a partial cross-section of a portion of an embodiment of a screening system constructed in accordance with the present disclosure, showing a filtrate outlet of the system and its associated overflow and underflow weir structure;

[0033] FIG. 7 is a schematic depiction of a partial cross-section of the embodiment of FIG. 6 with the fluid removed for clarity;

[0034] FIG. 8 is a schematic depiction of a portion of an embodiment of a screening system constructed in accordance with the present disclosure, showing a filtrate outlet of the system and a floatable debris outlet of the system, where the weir associated with the floatable debris outlet is partially lowered;

[0035] FIG. 9 is a schematic depiction of a cut-away partial cross-section of an embodiment of a screening system constructed in accordance with the present disclosure, showing a system without a floatable debris outlet; and

[0036] FIG. 10 is a schematic depiction of an embodiment of a cross-section of a portion of a screen body constructed in accordance with the present disclosure, showing the angled holes of the screen body;

[0037] FIG. 11 is a schematic top-view depiction of an embodiment of a variable volume flow inlet assembly constructed in accordance with the present disclosure for use in the systems of Figs. 1, 3 and/or 4A;

[0038] FIG. 12 is a schematic top-view depiction of another embodiment of a variable volume flow inlet assembly constructed in accordance with the present disclosure for use in the systems of Figs. 1, 3 and/or 4A; and

[0039] FIG. 13 is a schematic top-view depiction of another embodiment of a variable volume inlet assembly constructed in accordance with the present disclosure for use in the systems of Figs. 1, 3 and/or 4A.

[0040] These and other aspects of the subject disclosure will become more readily apparent to those having ordinary skill in the art from the following detailed description of the invention taken in conjunction with the drawings.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0042] Disclosed herein are detailed descriptions of specific embodiments of the screening systems and methods of the present disclosure. It will be understood that the disclosed embodiments are merely examples of the way in which certain aspects of the invention can be implemented and do not represent an exhaustive list of all of the ways the invention may be embodied. Indeed, it will be understood that the systems, devices and methods described herein may be embodied in various and alternative forms. Moreover, the figures are not necessarily to scale and some features may be exaggerated or minimized to show details of particular components. Well-known components, materials or methods are not necessarily described in great detail in order to avoid obscuring the present disclosure. Any specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a basis for the claims and as a representative basis for teaching one skilled in the art to variously employ the invention.

[0043] As shown in FIGS. 1-2, a screening system 100 for solid removal includes a housing 101 (shown translucently so that the inner components can be appreciated) and a flow inlet 102. Flow inlet 102 includes a conduit 117 that feeds into an interior chamber 125 defined, in part, by a screen 104. A fluid with entrained solids and/or particulates, e.g. a fluid mixture or a fluid flow, is channeled into the interior of screen 104 and circulates around the inner surface of screen 104. Flow inlet 102 is offset from a longitudinal axis A of screen 104 and directs flow in a substantially tangential direction with respect to screen 104 and a base portion 121. The substantially tangential direction of flow inlet 102 with respect to base portion 121 (described in more detail below) and screen 104 acts to establish a circular flow direction for the fluid mixture. This circular flow causes solids or particulate matter of a predetermined size entrained in the fluid mixture to be trapped and to circulate within the confines of interior chamber 125 of screen 104. The circular motion of the flowing liquid or

gas within interior chamber 125 of screen 104 also results in the entrained solids or particulate matter generally not adhering to screen 104, but being entrained in the circular motion of the fluid. There is effectively a hydraulic head between inlet 102 and flow outlet 108. In this way, the establishment of a circular flow motion of the fluid with screen 104 enables screen 104 to act as a generally self-cleaning filter. Fluid from the flow is able to pass freely through openings in screen 104 and is thereby able to be discharged to an outlet means. Captured solids from the flow concentrate inside of screen 104 and/or fall down into a sump 106, described below.

[0044] With continued reference to FIGS. 1-2, fluid that flows through screen 104 travels upward through an annulus 103 between screen 104 and the housing 101 toward flow outlet 108. Flow outlet 108 is downstream from the screen 104 in fluid communication with flow inlet 102. Flow outlet 108 receives the screened filtrate fluid (e.g. liquid and some very small particulates) that is permitted to pass through screen 104. Housing 101 is depicted transparently so that the inner portion of the system 100 is visible. Screen 104 is positioned within housing 101 operatively connected to flow inlet/conduit 102/117. Screen 104 extends from a top 104a to a bottom 104b along a longitudinal axis A. Top 104a of screen is operatively connected to a header portion 123 and bottom 104b of screen 104 is operatively connected to base portion 121. Header portion 123 and base portion 121 define upper and lower portions of interior chamber 125, respectively. Header and base portions 123 and 121, respectively, are made from solid (non-permeable) material instead of a screen or other filter material. Header and base portions 123 and 121, respectively, can include, however, defined inlets/outlets formed by removing material. For example, base portion 121 includes an opening for inlet conduit 117 to connect to and channel fluid into interior 125. Similar inlets/outlets are contemplated for header portion 123.

[0045] With continued reference to FIGS. 1-2, sump 106 is downstream from flow inlet 102 below screen 104 for capturing solid debris or waste that do not pass from interior chamber 125 of screen 104 to the exterior of screen 104. A sump valve and/or a sump pump is operatively connected to sump drain 116 (e.g. an outlet 116) to control the flow rate therethrough based on at least one characteristic of the waste in system 100. The sump pump can be downstream from sump drain 116. A plurality of sensors (not shown) are operatively connected to the at least one of the sump valve or the sump pump to sense the at least one characteristic of the waste, such as the waste level in the screening chamber, the measured flow rate(s), solids level measured inside the sump, solids percentage or parts per million in the incoming filtrate flow, solids percentage in the previous sump drain cycle (used to determine how if sump 106 was emptied in time or too early), a comparison of one or more sensor inputs (such as solids level inside the sump 106 vs. solids percentage in the incoming filtrate flow).

[0046] With continued reference to FIGS. 1-2, a moveable cleaning assembly, shown as a movable wash-down ring 110, is positioned within a perimeter of the screen 104. The wash-down ring 110 is a separate component that is inserted into screen 104 (or outside of it, as described with external wash-down ring 210) for cleaning the screen by maintenance personnel or the like, but is removed from screen 104 during active filtration operation. Wash-down ring 110 is moveable with respect to screen 104. For example, as shown in FIG. 1, wash-down ring 110 is in a raised position. It is contemplated that ring 110 can pause at the raised position of FIG. 1, or toward the top of screen 104 generally, and use downward-pointing spray nozzles 114a-114d, described in more detail below, to wash screen 104. Or, ring 110 can drop all the way to the bottom of screen 104, or a position in between, like that shown in FIG. 2. In FIG. 2, wash-down ring 110 is in a lowered position, which, in some cases, may be able to better clean the screen 104.

[0047] As shown in FIG. 1, moveable wash-down ring 110 is an assembly that includes a ring 112 and a series of nozzles 114a-114d circumferentially spaced apart around ring 112. Each nozzle 114a-114d is angled along a respective nozzle axis B in a direction toward bottom 104b of screen 104. Nozzle axes B are shown for nozzles 114a and 114c, however it is contemplated that nozzles 114b and 114d would have similar respective nozzle axes that run along the longitudinal axis of the nozzle in the direction that the nozzle is pointing. Each nozzle 114a-114d can be in fluid communication with a fluid source, e.g. water, to supply a pressurized stream of cleaning fluid to the screen.

[0048] With reference now to FIG. 3, a screening system 200 includes a moveable cleaning assembly that is an external movable wash-down ring 210. System 200 is the same as screening system 100 except that instead of internal wash-down ring 110, external wash-down ring 210 is used. System 200 includes a housing similar to housing 101. Housing of system 200 is not shown in Fig. 3, in order to better show wash-down ring 210. System 200 includes a flow inlet 202 and a screen 204 operatively connected to the flow inlet 202 to receive a filtrate mixture therefrom into an interior chamber 225 of the screen 204. Flow inlet 202 is positioned toward a bottom 204b of screen 204 and includes a conduit 217. A sump (not shown) is downstream from the flow inlet 202 for capturing solids that do not pass through the screen 204, similar to sump 106. A flow outlet (not shown) is downstream from the screen 204 in fluid communication with the flow inlet 202 and would be similar to outlet 108. A top 204a of the screen 204 is operatively connected to a header portion 223 and a bottom 204b of screen 104 is operatively connected to a base portion 221, header and base portions 223 and 221, respectively, are similar to header and base portions 123 and 121, respectively, described above.

[0049] As shown in FIG. 3, external wash-down ring 210 in a lowered position. Those skilled in the art will readily appreciate that in a raised position, external wash-down ring 210

can be in a similar axial position as wash-down ring 110 is in a raised position (e.g. as shown in FIG. 1). External wash-down ring 210 is, in certain aspects, similar to wash-down ring 110 in that it includes a ring 212 and a series of nozzles 214a-214d circumferentially disposed around the ring 212. Each nozzle 214a-214d is angled along a respective nozzle axis in a direction toward bottom 204b of the screen 204.

[0050] In certain embodiments, the moveable cleaning assembly for system 100 and/or 200 can include a downwardly extending member instead of, or in addition to, an internal/external ring. The downwardly extending member can include at least one nozzle, similar to nozzles 114a-114d and 214a-214 described above, except that instead of being circumferentially arranged about a ring, the nozzles are linearly arranged. The downwardly extending member can be a drop down stalk within the perimeter of the screen that is movable along a central longitudinal axis, e.g. longitudinal axis A, defined by the screen. The stalk can rotate about longitudinal axis A (and/or its own longitudinal axis) or it can remain fixed with respect to rotation. There can be multiple stalks movable in a direction along longitudinal axis A that can be lowered and raised within the interior chamber of the screen. For example, they can be circumferentially spaced apart about the inner diameter of the screen. The multiple stalks can be fixed with respect to rotation, can rotate about longitudinal axis A, and/or can rotate about their own respective longitudinal axes.

[0051] It is also contemplated that the downwardly extending member can be positioned around the outer perimeter of the screen. For example, downwardly extending member can be a drop down stalk (e.g. a vertical bar) that goes around the outer perimeter of the screen, in the space between an outer perimeter of the screen, e.g. screen 104, and an inner perimeter of the housing, e.g. housing 101. This can rotate around longitudinal axis A, can rotate about its own respective longitudinal axis, and/or can be fixed with respect to rotation about either axis. This system can include multiple vertical bars circumferentially spaced apart around the

outer perimeter of the screen, or spaced apart around the inner diameter of the screen. The vertical bars can rotate about longitudinal axis A, can rotate about their own respective longitudinal axes, and/or can be fixed with respect to rotation about either axis. A configuration with multiple drop down stalks/vertical bars, whether internal or external, may increase wash-down speed, but will likely require more fluid flow connected to the nozzles.

[0052] It is contemplated that the downwardly extending member (whether internal or external, single or multiple), can include a nozzle positioned at a distal end of the downwardly extending member, e.g. the end closest to the inlet 102 or 202. In some embodiments, the downwardly extending member can include a plurality of nozzles spaced apart along the length of the downwardly extending member, e.g. spaced apart in a direction parallel to longitudinal axis A.

[0053] As shown in FIG. 4A, a screening system 300 for solid removal includes a housing 301 (shown translucently so that the inner components can be appreciated) and a flow inlet 302 defined in a bottom portion of the housing 301. For sake of completeness, FIG. 4B shows the outer surface of housing 301. Flow inlet 302 includes a conduit 317. System 300 is similar to system 100 except that system 300 includes separate filtrate and floatable debris outlets, 318 and 320 respectively, that are included in its overall flow outlet. Housing 301 is depicted transparently so that the inner portion of the system 300 is visible. A screen 304 is positioned within housing 301 and is operatively connected to flow inlet 302 to receive a filtrate mixture for screening. Screen 304 forms a hollow cylinder that extends from a top 304a to a bottom 304b along a longitudinal axis A and defines an interior chamber 325 within its perimeter. Top 304a is proximate to filtrate and floatable debris outlets, 318 and 320, respectively, and the top of housing 301. Top 304a of screen is operatively connected to a header portion 323 and bottom 304b of screen 304 is operatively connected to base portion 321. Header and base portions 323 and 321, respectively, are similar to header and base

portions 123 and 121, respectively, except that header portion 323 includes a header outlet 327, described in more detail below. Bottom 304b is proximate to inlet 302 and the bottom of the housing 301. Screen 304 includes a frame 305 that has a screen body 307 removably positioned therein. Specifically, screen body 307 can be slid in and out of frame 305. This allows for 'quick swap' screen changes by sliding screen body 307 into frame 305. Frame 305 includes bolts configured to close around the screen body 307 and hold it in place.

[0054] With continued reference to FIG. 4A, a sump 306 is downstream from the flow inlet 302, below screen 304 for capturing solids that do not pass through the screen 304. Sump 306 is operatively connected to a sump drain 316. System 300 is shown with a moveable cleaning assembly that is an internal wash-down ring 310, similar to the movable wash-down ring 110. However, it is also contemplated that an external movable wash-down ring, e.g. wash-down ring 210, can also be used in system 300, in conjunction with or in place of wash-down ring 310. It is also contemplated that a downwardly extending member (described above) can be used in conjunction with, or in place of, wash-down rings 110 or 210.

[0055] With continued reference to FIG. 4A, the flow outlet includes header outlet 327, housing outlets 326a and 326b. Housing outlet 326b is associated with a filtrate outlet 318. Header outlet 327 and housing outlet 326a are associated with a floatable debris outlet 320. Filtrate outlet 318 and floatable debris outlet 320 are shown as conduits extending from respective threshold sections. System 300 includes first and second threshold sections 328a and 328b, respectively, of the housing 301. First threshold section 328a is between the housing outlet 326a and the floatable debris outlet 320 and is in fluid communication with interior chamber 325 via header outlet 327. Second threshold section 328b is between the filtrate outlet 318 and housing outlets 326b. Movable weir 322a and 322b are positioned at their respective housing outlets 326a and 326b.

[0056] With reference now to FIGS. 4A, 5A-5B and 8, movable weir 322a is positioned between screen 304 and floatable debris outlet 320. Weir 322a-322b are movably mounted to housing 301 and configured to move with respect housing 301 to occlude or unocclude their respective outlets 326a-326b. For example, FIGS. 5A-5C are schematic depictions of system 300 from the other side of system 301, as compared with FIG. 4A. FIGS. 5A-5B do not show housing 328b and filtrate outlet 318. FIG. 5A shows weir 322a in a raised position with respect to housing and outlet 326a. FIG. 5B shows weir 322a in a partially lowered position with respect to housing 301 and outlet 326a. FIG. 5C shows weir 322a in a lowered position with respect to housing 301 and outlet 326a. FIG. 8 depicts system 300 with fluid slightly over the top of weir 322a with weir 322a partially lowered. This allows floating debris to drain off the top and through floating debris outlet 320.

[0057] As shown in FIGS. 4A, 6 and 7, movable weir 322b is positioned between the screen 304 and the filtrate outlet 318. A weir 324 may be fixed or movably mounted to second threshold section 328b of the housing 301 and configured to move with respect to second threshold section 328b of housing 301. Weir 324 is positioned between the moveable weir 322b of the housing outlet 326b and the filtrate outlet 318. Filtrate outlet 318 is operatively connected to second threshold section 328b of the housing 301. Weir 324 is considered an overflow weir and weir 322b is considered an underflow weir. Underflow weir 322b and overflow weir 324 act to prevent loss of lighter than water solids, as well as loss of similar density or heavier than water solids. The water level W inside housing 301 must be higher than the level of the underflow weir 322b for the underflow weir to be opened and used, e.g. similar to the water level W as shown in FIG. 6.

[0058] One or more of weirs 322a-322b and 324 may be adjustable, either manually or via automated systems. It is contemplated that weirs 322a-322b and 324 may be raised or lowered to maintain continuous evacuation of floatable debris from the top of the water level

inside the filter system, either inside the screen, outside the screen, or some combination thereof. The weirs may be periodically raised or lowered and then returned to a closed position, e.g. where the housing outlets 326a and 326b are blocked, to periodically evacuate trapped floatables from the filter system. The weirs 322a, 322b and 324 can be raised or lowered, opening a hole for the trapped solids in either or both chambers to be released into a separate path from the main flow. Movable weirs 322a-322b and 324 may lower periodically to operator-chosen set point, completely lower periodically, or partially lower via either operator-chosen set point or using sensors to determine water level and appropriate partially lowered position. This creates a mechanism to ensure floating waste is trapped in the top of the screening chamber, and heavier-than-water waste has one last chance to be trapped in the screening system before being drained to an external body of water. Debris that is either heavier or lighter than water can therefore be trapped in the system and removed instead of being drained to an external body of water.

[0059] With continued reference to FIGS. 4A-4B and 10, a screen body 307 can be used in screens 104, 204, or 304. For example, it can be curved to form the hollow cylinder described above, where fluid would flow from an interior chamber, e.g. interior chamber 325, to an annular portion, e.g. annulus 103, between screen 304 and housing 301. Screen body 307 includes a metal sheet 311 and angled holes 313 defined in metal sheet 311. The holes 313 are angled in a direction away from the flow direction within the interior chamber, shown schematically with an arrow, such that, when viewing a given hole from a first side of the hole in a direction perpendicular to the plane of the metal sheet, a view through metal sheet 311 is obstructed by a backside surface 315 of the given hole. For a hole with a constant diameter (d), this means that the angle (α) of a given hole with respect to a surface 309 of metal sheet 311 is a function of the sheet thickness (t) at the hole and the hole diameter (d). This is represented as:

$$\alpha \leq 90 - \sin^{-1}\frac{d}{t}$$

Generally, angled holes 313 prevent material from passing directly through, which reduces the likelihood of debris from getting to the outlet. The oblique angle also reduces the likelihood of debris that may be stringy or similar in size to the hole from being caught and occluding the hole. Electro-polishing the screen, as described below, may enhance these characteristics.

[0060] A method of manufacturing a screen body, e.g. screen body 307, for use in a screening system includes providing a metal sheet, e.g. metal sheet 311, and cutting holes, e.g. holes 313, in the metal sheet at an angle (α) with respect to a surface, e.g. surface 309, of the metal sheet and at an angle with respect to a direction perpendicular to the metal sheet to form the screen body. The holes are cut such that when viewing a given hole from a first side of the hole in the direction perpendicular to the plane of the metal sheet a view through the metal sheet is obstructed by a backside surface, e.g. surface 315, of the given hole, such that light is prevented from passing through when viewed perpendicular to the screen. For a hole with a constant diameter (d), this means that angle (α) can be calculated as shown by the equation above. It is contemplated that the holes can be cut using a water-jet and/or laser cutter. Water-jet or laser-cut holes punched through a metal sheet or thin plate at an angle, as described above, can create 0.2-1.5mm holes. The screen body can be bent into a cylindrical shape to fit into a frame, e.g. frame 305, to form a screen, e.g. screen 304.

[0061] The method can include electro-polishing the screen. Laser-cut holes and electro polishing result in a rippled surface effect on a micrometer scale. The angle of the holes, as described above, combined with the surface erosion that takes place during electro polishing, result in a screen that, when viewed from an angle perpendicular to the screen, will show what appears to be a solid, although rippled surface.

[0062] As shown in FIG. 9, a screening system 400 is shown. System 400 is the same as system 300 except that instead of having a floatable debris outlet and a filtrate outlet, e.g. 320 and 318, respectively, there is only a single filtrate outlet 418 downstream from a housing outlet 426. System 400 includes an underflow weir 422 combination similar to underflow weir 322b and overflow weir 424 similar to overflow weir 324 to prevent loss of solids through the filtrate outlet. In system 400, it is contemplated that a secondary drain or flush system may assist cleanout of solids caught between the two weirs, either back into the main filter system to exit via the sump drain 416, or to immediately exit the system separately from the filtrate.

[0063] As shown in FIGS. 11-13, a screening system for solid removal, similar to systems 100, 200 and 300, includes a variable volume flow inlet assembly. This assembly can include a conduit 117/217/317 such as those provided for inlets 102, 202 and 302, and a series of moveable steel shims that when used in conjunction with the inlet housing form generally v-shape or wedge shape. The shims can be positioned within the conduits of inlets 102, 202 or 302 and can be varying sizes.

[0064] As shown in FIG. 11, a shim 530 can be made from a relatively thin steel sheet of steel or other metal and can be welded, hinged, bolted, or otherwise affixed at one end 533 to the inside of an inlet conduit 117/217/317. In FIG. 11, shim 530 can be rotated about end 533 and/or flexed by moving adjustment screws 532 (as indicated schematically by the double headed arrows) such that, as adjustment screws are moved back and forth, a tip 531 of shim 530 is moved inward/outward (as shown schematically by the double headed arrow proximate to the tip 531) increasing or decreasing the inlet size and also narrowing or widening the flow path through the inlet conduit 117/217/317. A narrower inlet conduit will create a higher velocity for the same flow rate, potentially improving the self-cleaning aspect of the screen. A wider inlet will lower the velocity but allow more flow through the system,

potentially increasing system capacity and reducing head pressure loss. Flow through the inlet will keep the shim/plate in contact with the adjustment screws 532. The flow path through inlet conduit 117/217/317 can be adjusted to determine a required minimum velocity for the system to function for a given wastewater stream.

[0065] Shims can be flexed and/or rotated inwards via adjustment screws, as described above, or other methods of increasing the 'choke.' Decreasing the inlet size will allow various flow velocities on a single system 100/200/300. On a permanent installation, as shown in FIG. 12, a shim 534 can be thicker, e.g. too thick to flex, and can be positioned to achieve a set velocity at a given flow rate. In this case, screws 536 are used to secure the shim 534.

[0066] As shown in FIG. 13, stacked shims 538a-538d of various sizes can all be removeably affixed to the inside of inlet conduit 117/217/317 at one end 537 to allow flow velocities to be modified in permanent installations by unscrewing screws 535 and removing/adding one or more of stacked shims 538a-538d as needed. Those skilled in the art would readily appreciate that instead of shims 534 and 538a-538d, described above for Figs. 12 and 13, a block(s) of material, box(ex), or the like can be used.

[0067] While the screening systems and methods of the subject invention have been shown and described with reference to preferred embodiments, those skilled in the art will readily appreciate that various changes and/or modifications may be made thereto without departing from the spirit and scope of the subject invention as defined by the appended claims. For example, portions of systems 100, 200 and 300 can be used interchangeably across systems 100, 200 and 300. It is believed that the present disclosure includes many other embodiments that may not be herein described in detail, but would nonetheless be appreciated by those skilled in the art from the disclosures made. Accordingly, this disclosure should not be read as being limited only to the foregoing examples or only to the designated embodiments.

CLAIMS

What is claimed is:

1. A screening system for solid removal comprising:

a housing;

a screen positioned within the housing;

a flow inlet operatively connected to an interior chamber defined by the screen;

a sump downstream from the flow inlet for capturing solids that do not pass through the screen;

a flow outlet downstream from the screen in fluid communication with the flow inlet; and

a moveable cleaning assembly positioned either within a perimeter of the screen, around the perimeter of the screen or both, wherein the moveable cleaning assembly is moveable with respect to the screen.

2. The screening system as recited in Claim 1, wherein the moveable cleaning assembly includes a ring and a series of nozzles circumferentially disposed around the ring.

3. The screening system as recited in Claim 1, wherein the screen extends from a top to a bottom, wherein the nozzles are angled in a direction toward the bottom of the screen.

4. The screening system as recited in Claim 1, wherein the moveable cleaning assembly includes a downwardly extending member, wherein the downwardly extending member includes at least one nozzle.

5. The screening system as recited in Claim 4, wherein the downwardly extending member is a center member positioned within the perimeter of the screen along a central longitudinal axis defined by the screen.

6. The screening system as recited in Claim 5, wherein the center member is mounted for movement along the longitudinal axis.

7. The screening system as recited in Claim 4, wherein the downwardly extending member is positioned around the outer perimeter of the screen.

8. The screening system as recited in Claim 7, wherein the downwardly extending member is mounted for circumferential movement about the outer perimeter of the screen.

9. The screening system as recited in Claim 4, wherein the at least one nozzle includes a nozzle positioned at a distal end of the downwardly extending member.

10. The screening system as recited in Claim 4, wherein the at least one nozzle includes a series of nozzles spaced apart along the length of the downwardly extending member.

11. The screening system as recited in Claim 4, wherein the downwardly extending member is one of a plurality of downwardly extending members spaced apart within the perimeter of the screen, around the perimeter of the screen or both.

12. The screening system as recited in Claim 1, wherein the inlet is operatively connected to a base portion positioned below a bottom of the screen to channel a fluid mixture into the interior of the screen.

13. The screening system as recited in Claim 1, wherein the outlet is operatively connected to a top of the housing to channel a screened fluid from an annulus between the screen and the housing out of the housing.

14. A screening system for solid removal comprising:

a flow inlet;

a frame having a screen body removably positioned therein operatively connected to the flow inlet;

a sump downstream from the flow inlet for capturing solids that do not pass through the screen; and

a flow outlet downstream from the screen in fluid communication with the flow inlet.

15. A screen body for use in a screening system, the screen body comprises:

a metal sheet; and

angled holes defined in the metal sheet, wherein when viewing a given hole from a first side of the hole in a direction perpendicular to a surface of the metal sheet a view through the metal sheet is obstructed by a backside surface of the given hole.

16. A screen body for use in a screening system, the screen body comprises:

a metal sheet; and

angled holes defined in the metal sheet, wherein the angle (α) of each hole with respect to a surface of the metal sheet is a function of the sheet thickness (t) at the hole and the hole diameter (d), wherein $\alpha \leq 90 - \sin^{-1}\frac{d}{t}$.

17. A method of manufacturing a screen body for use in a screening system, the method comprising:

providing a metal sheet; and

cutting holes in the metal sheet at an angle with respect to a surface defined by the metal sheet and at an angle with respect to a direction perpendicular to the surface of the metal sheet to form a screen body, wherein when viewing a given hole from a first side of the hole in the direction perpendicular to the surface of the metal sheet a view through the metal sheet is obstructed by a backside surface of the given hole.

18. A method of manufacturing a screen body for use in a screening system, the method comprising:

providing a metal sheet; and

cutting holes in the metal sheet at an angle (α) with respect to a surface defined by the metal sheet, wherein the angle (α) with respect to the surface of the metal sheet is a function of the sheet thickness (t) at the hole and the hole diameter (d), wherein $\alpha \leq 90 - \sin^{-1}\frac{d}{t}$.

19. A screening system for solid removal comprising:

a variable volume flow inlet assembly;

a screen positioned downstream from the variable volume flow inlet assembly;

a sump downstream from the flow inlet assembly for capturing solids that do not pass through the screen; and

a flow outlet downstream from the screen in fluid communication with the variable volume flow inlet assembly.

20. The screening system as recited in Claim 19, wherein the variable volume flow inlet assembly includes an inlet conduit and a series of moveable steel shims having a triangular cross-section.

21. The screening system as recited in Claim 20, wherein the steel shims are varying sizes.

22. A screening system for solid removal comprising:

a housing;

a screen positioned within the housing;

a flow inlet operatively connected to an interior chamber defined by the screen;

a sump downstream from the flow inlet for capturing solids that do not pass through the screen;

a flow outlet downstream from the screen; and

a weir positioned between the screen and the flow outlet.

23. The screening system as recited in Claim 22, further comprising a housing outlet between the screen and the flow outlet.

24. The screening system as recited in Claim 23, wherein the weir is movably mounted to the housing and configured to move with respect to the housing outlet.

25. The screening system as recited in Claim 24, further comprising a threshold section of the housing between the flow outlet and the housing outlet, wherein the weir is movably mounted to the threshold section of the housing and configured to move with respect to the threshold section of the housing.

26. The screening system as recited in Claim 25, wherein the flow outlet is defined in the threshold section of the housing.

27. The screening system as recited in Claim 22, wherein the flow outlet is a floating debris outlet.

28. The screening system as recited in Claim 22, wherein the flow outlet is a filtrate outlet.

29. A screening system for solids removal comprising:

a housing;

a screen positioned within the housing;

a flow inlet operatively connected to an interior chamber defined by the screen;

a sump downstream from the flow inlet for capturing solids that do not pass through the screen;

a sump drain downstream from the sump;

at least one of a sump valve or a sump pump operatively connected to the sump drain to control the flow rate therethrough based on at least one characteristic of the waste in the system; and

a plurality of sensors operatively connected to the at least one of the sump valve or the sump pump to sense the at least one characteristic of the waste.

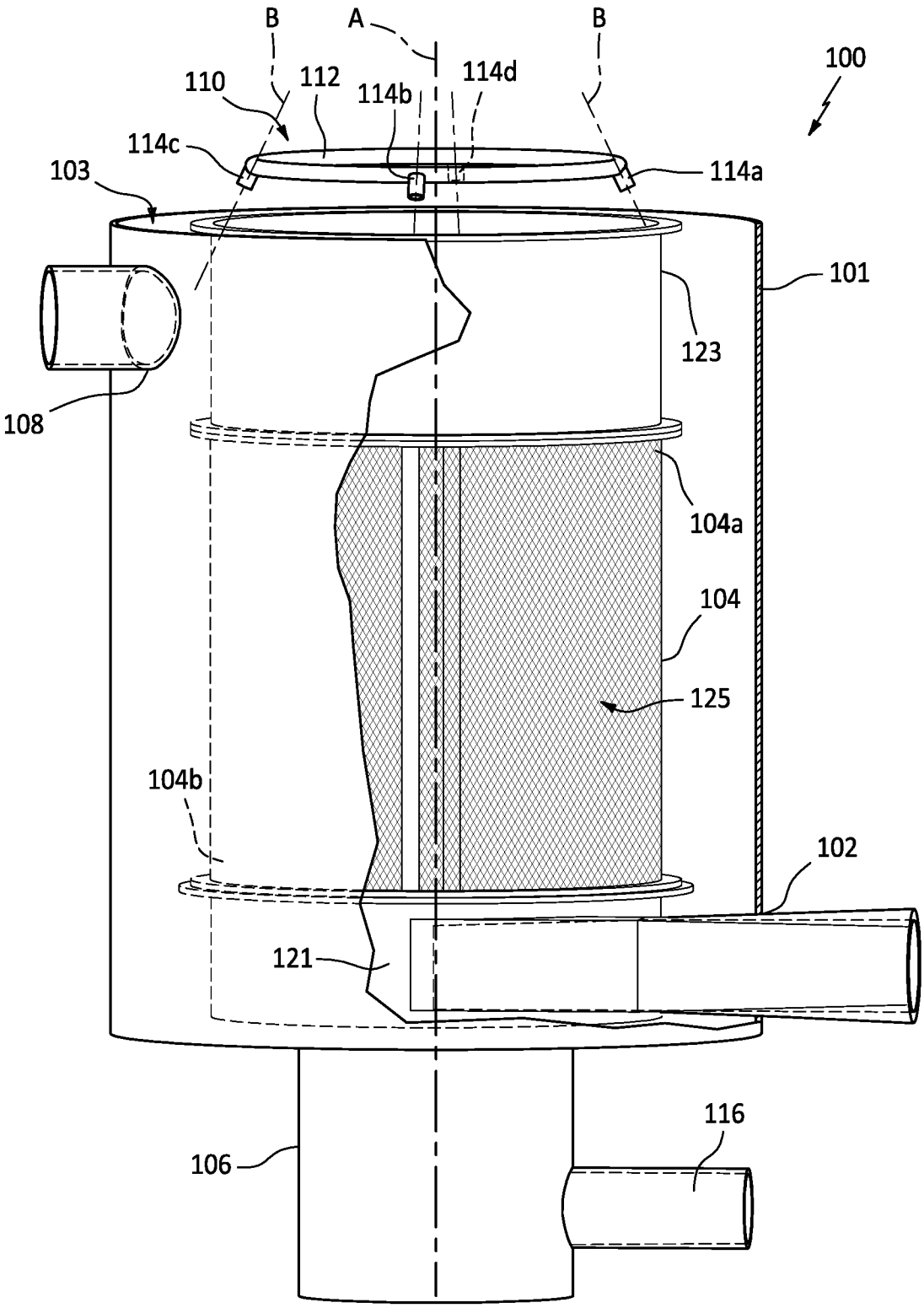

B
A
B
100
110
112
114b
114d
114c
103
114a
101
123
108
104a
104
125
104b
102
121
116
106

FIG. 1

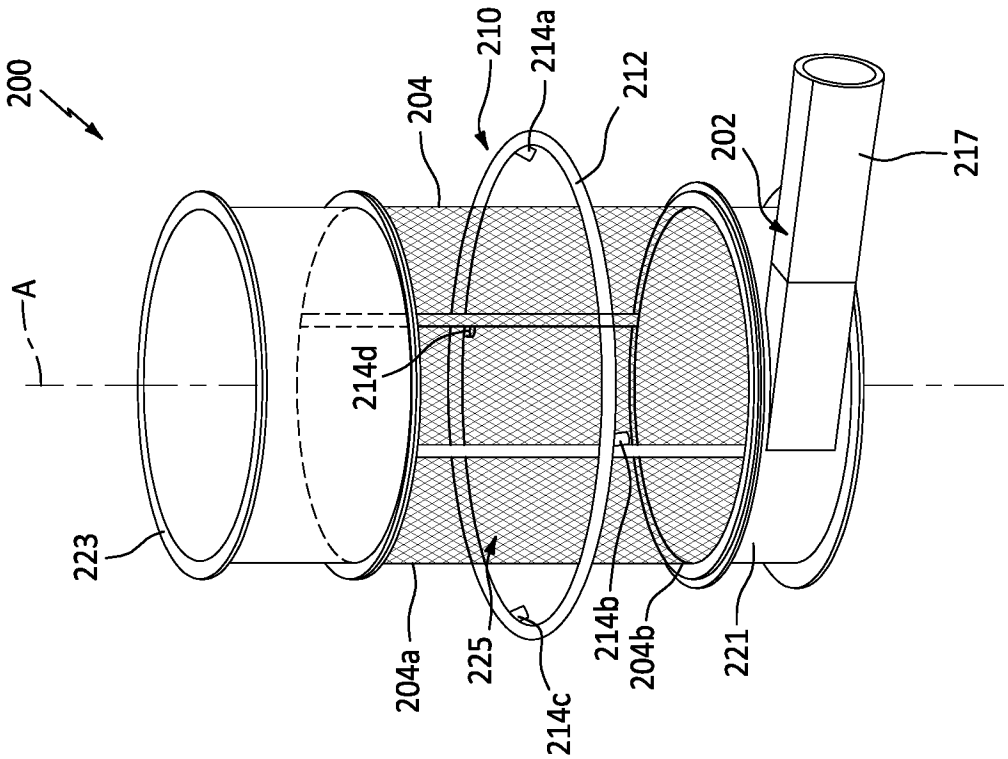
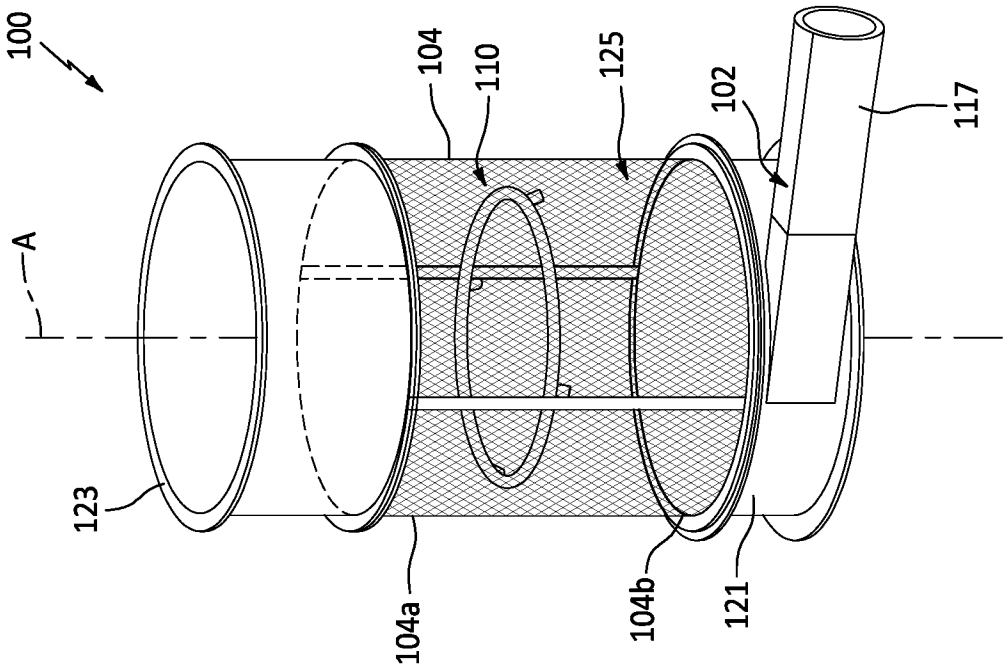

200
210
214a
204
212
202
217
A
214d
223
204a
225
214c
214b
204b
221

FIG. 3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104
110
125
102
117
A
123
104a
104b
121

FIG. 2

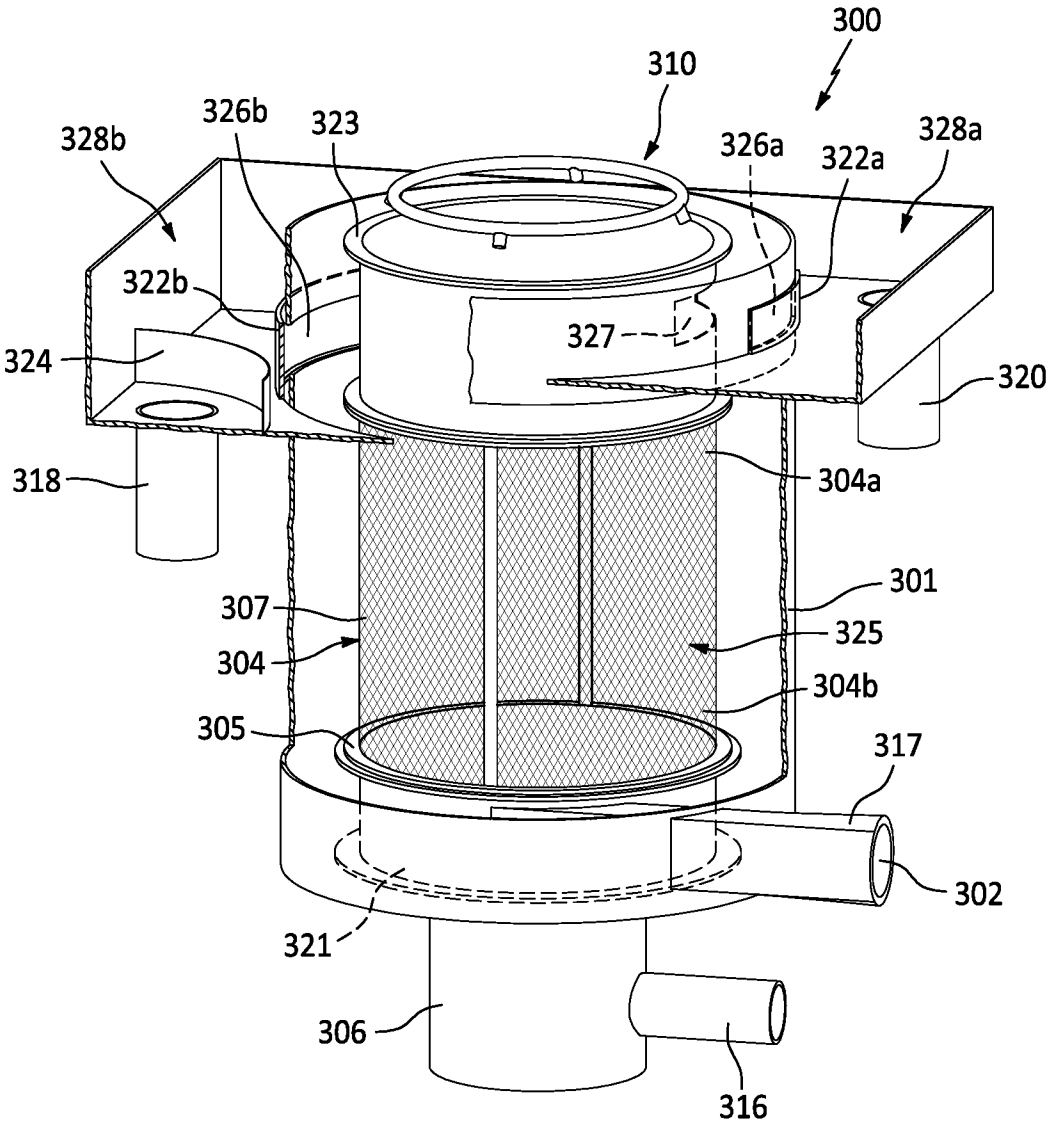
300
310
326b
323
328b
326a
322a
328a
322b
327
324
320
318
304a
301
307
325
304
304b
305
317
302
321
306
316

FIG. 4A

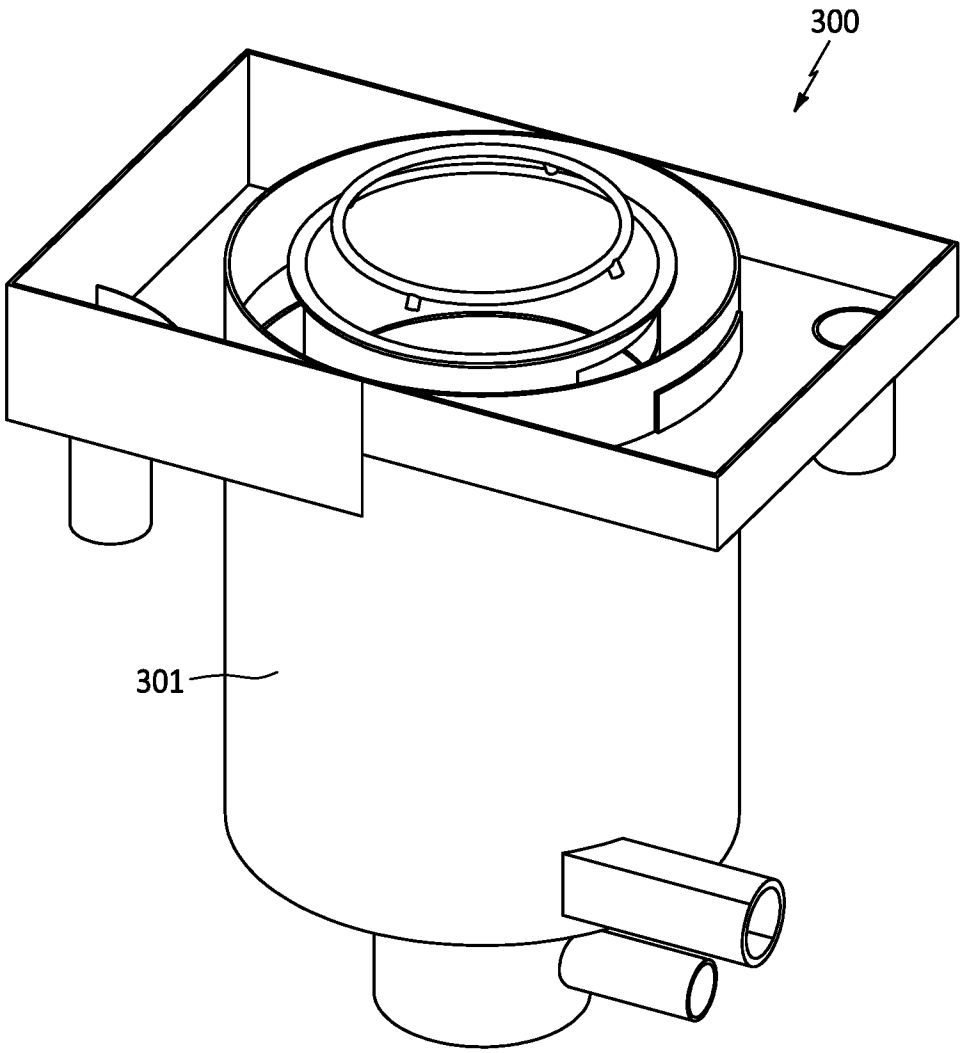

FIG. 4B

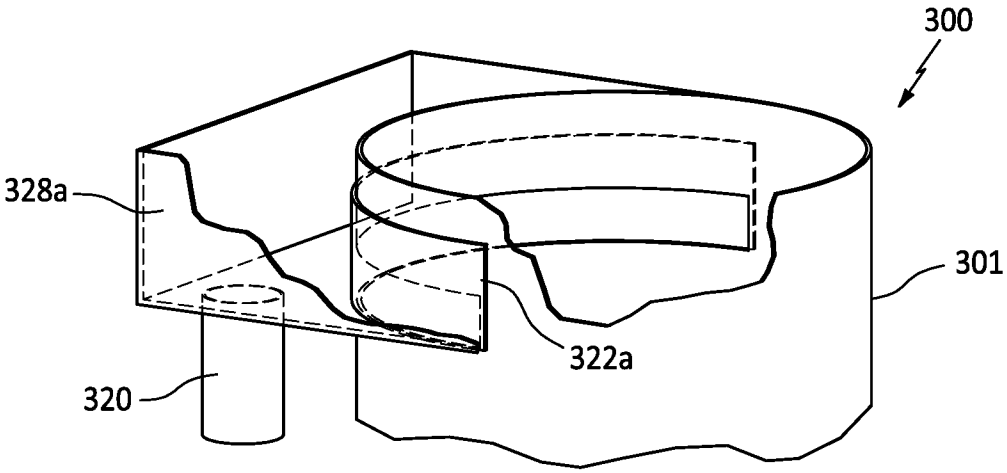

FIG. 5A

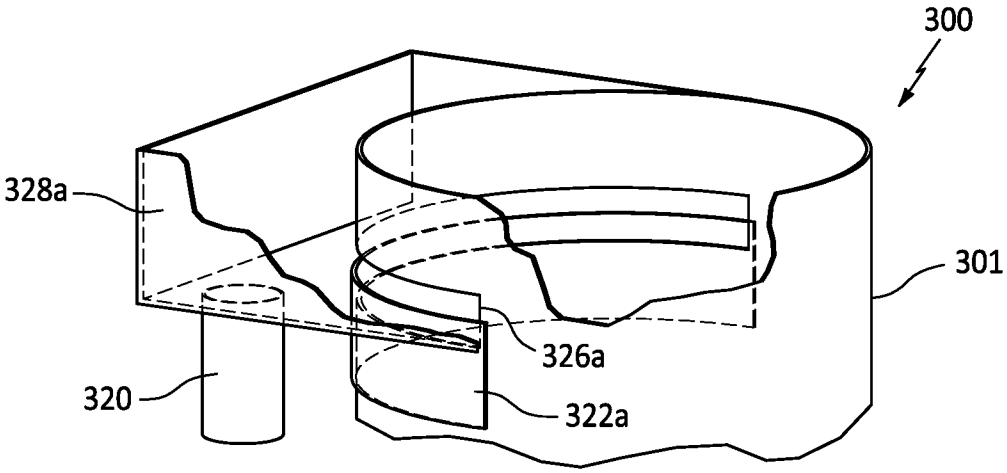

FIG. 5B

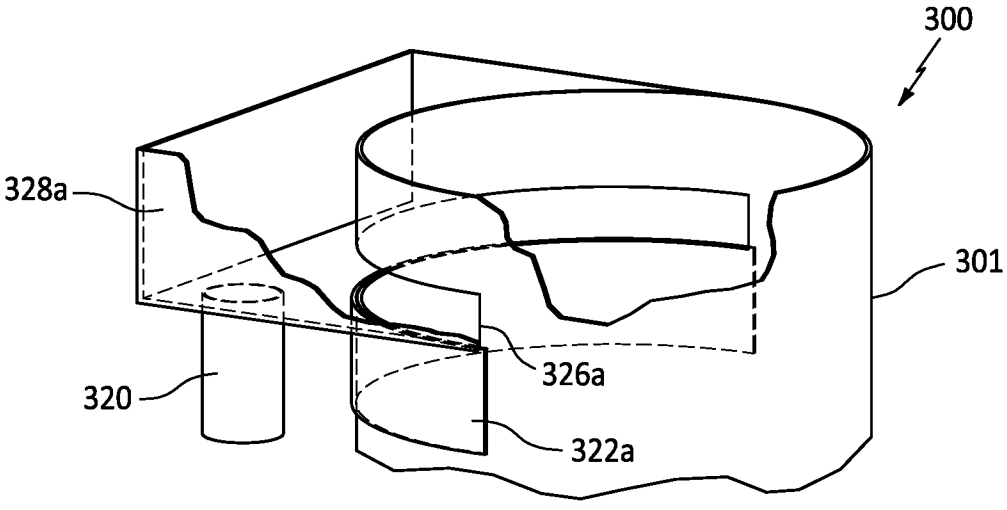

FIG. 5C

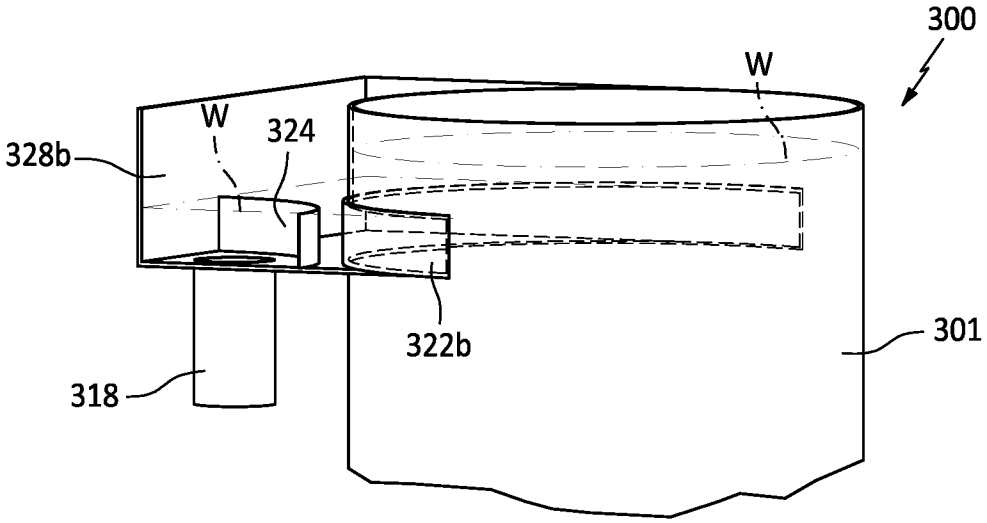

FIG. 6

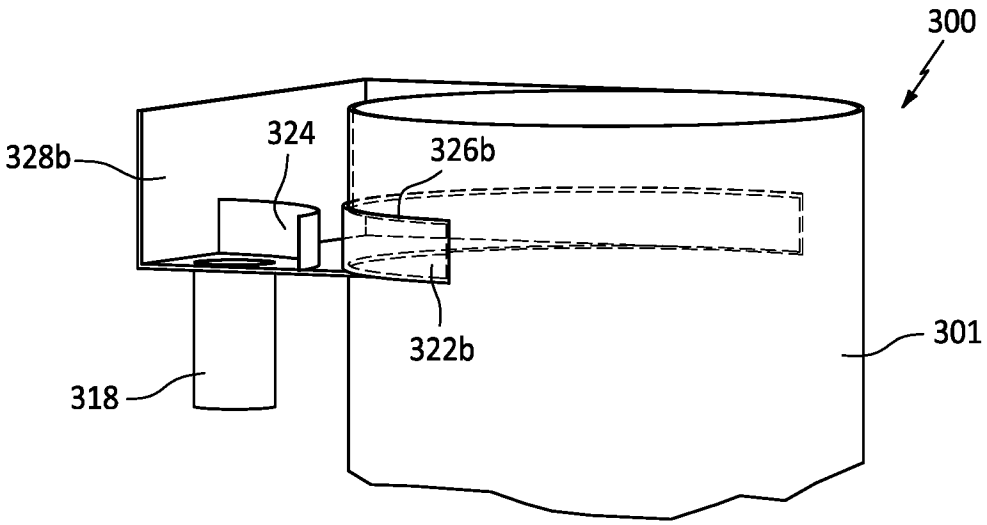

FIG. 7

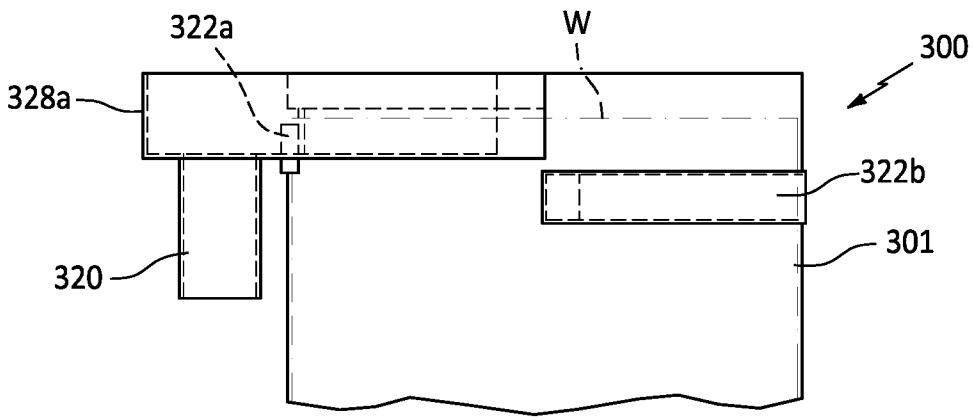

FIG. 8

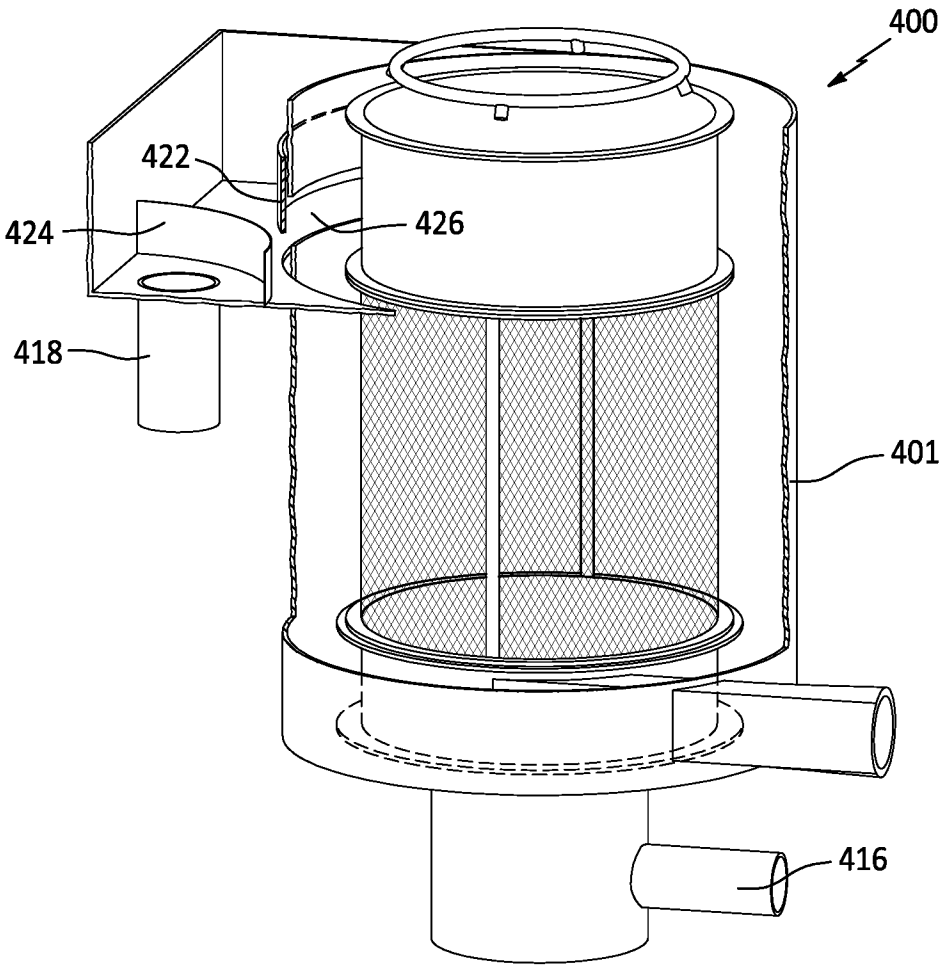
400
422
424
426
418
401
416

FIG. 9

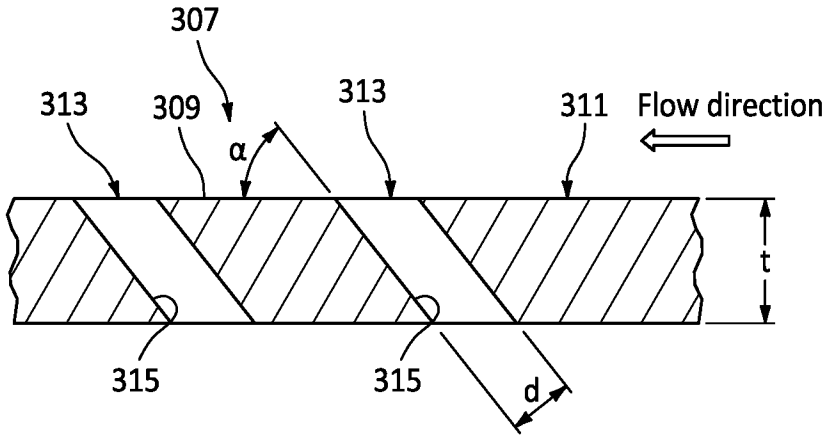
307
313
309
α
313
311
Flow direction
t
315
315
d

FIG. 10

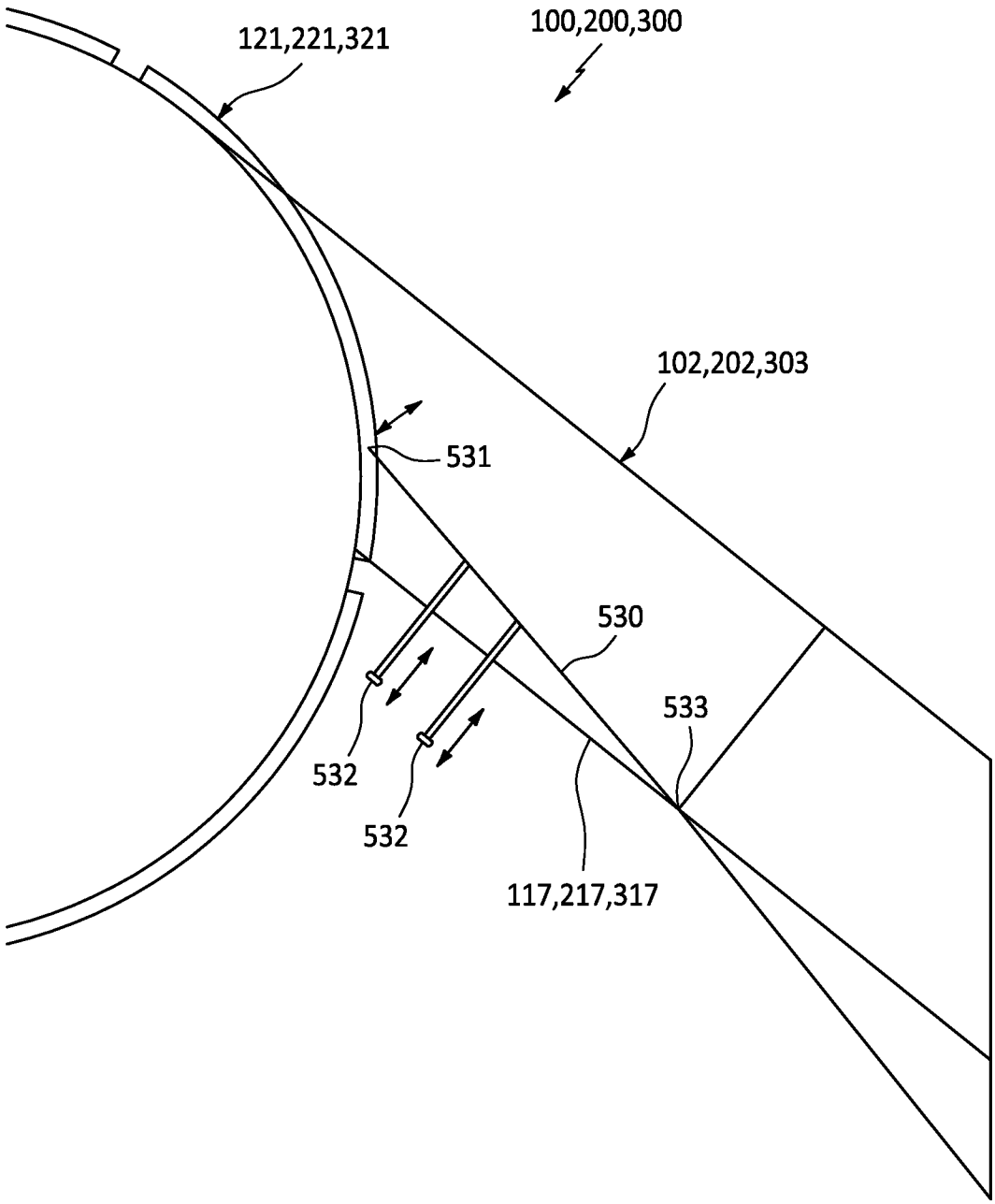
121,221,321
100,200,300
102,202,303
531
530
533
532
532
117,217,317

FIG. 11

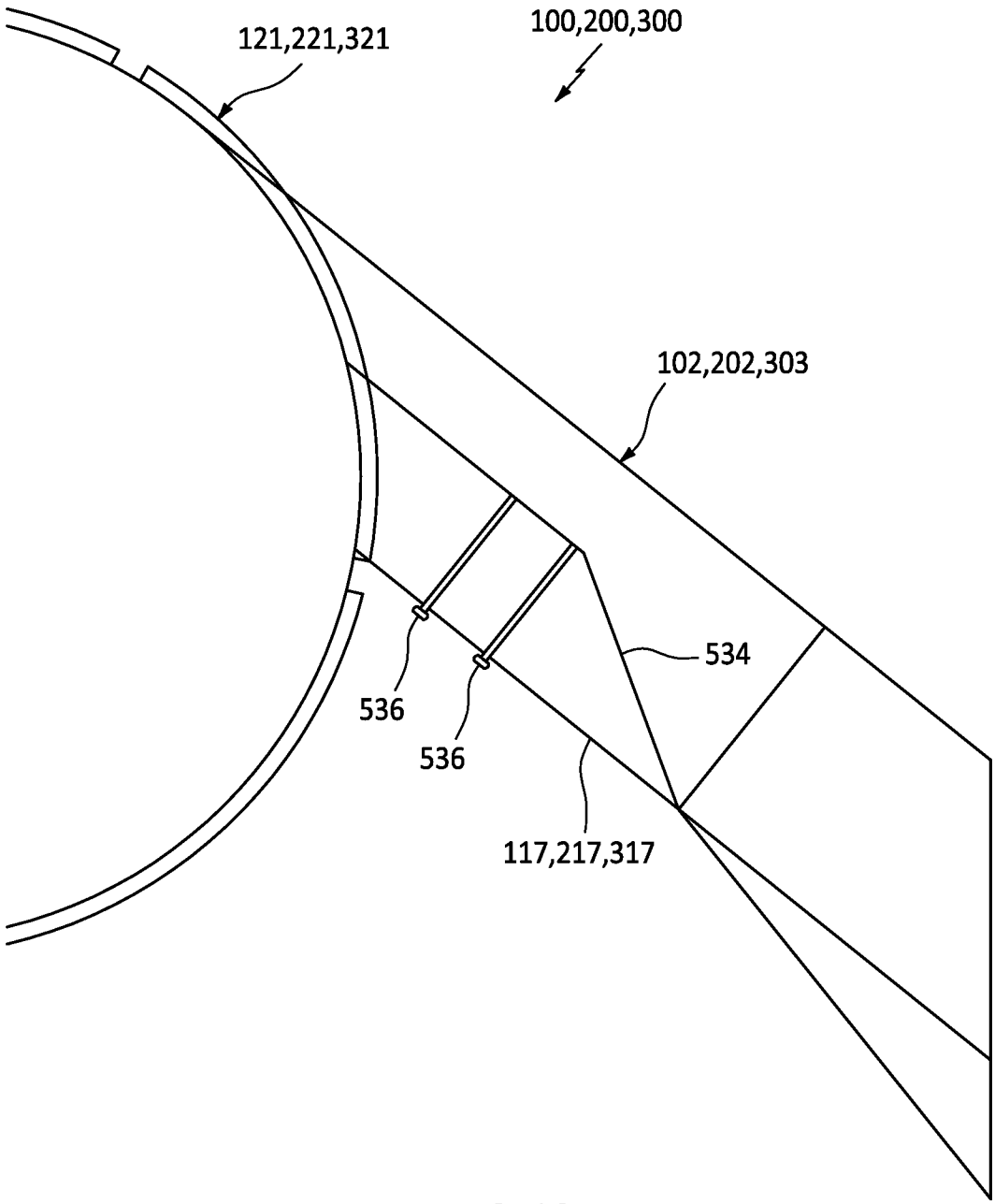

FIG. 12

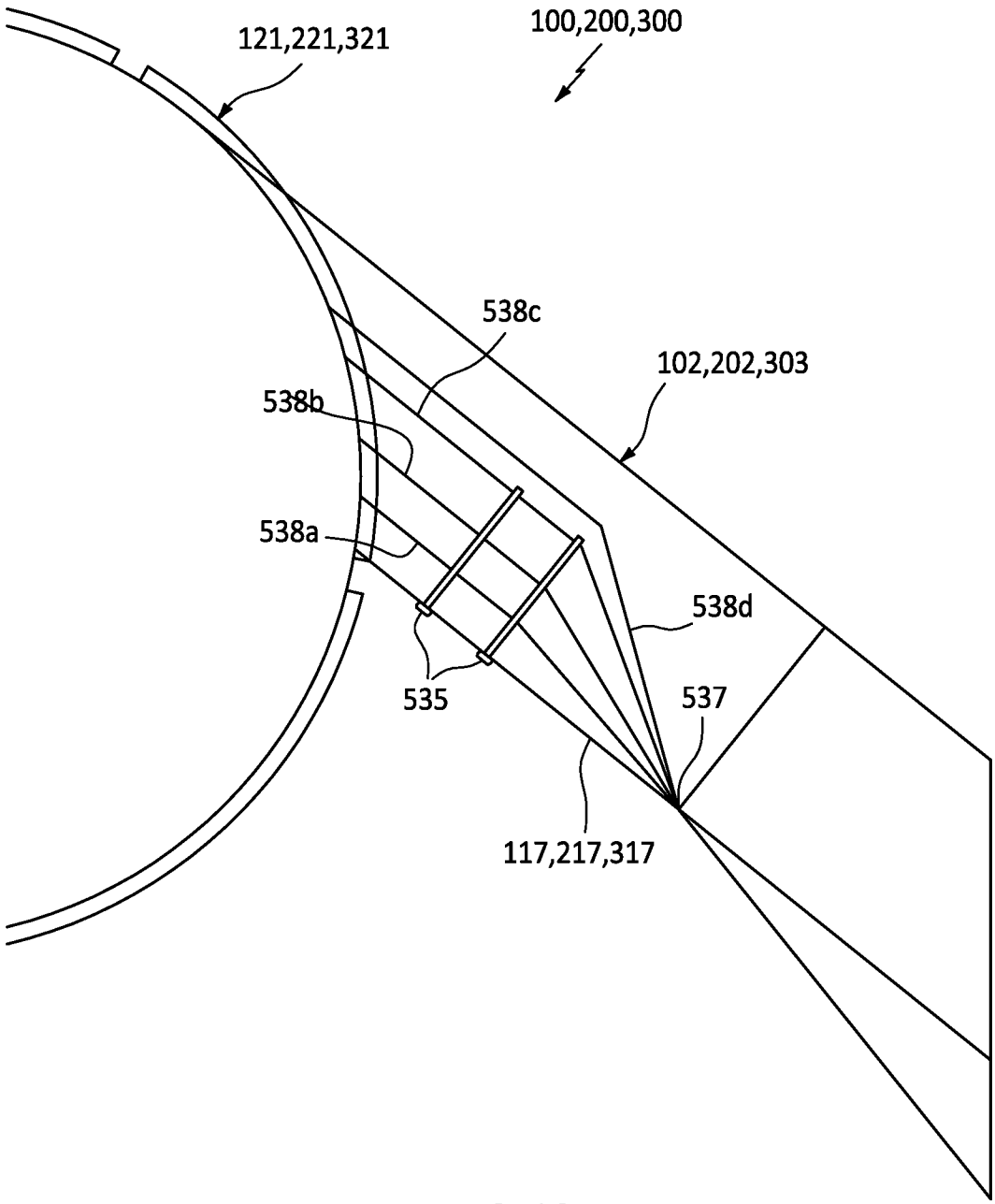
121,221,321
100,200,300
538c
102,202,303
538b
538a
538d
535
537
117,217,317

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 21/45167

A. CLASSIFICATION OF SUBJECT MATTER

IPC - B01D 29/35, C02F 1/38, B01D 36/00, B01D 35/22, B01D 36/04, B01D 35/00

CPC - E03F 5/14, C02F 1/38, B01D 29/35, B01D 35/22, B01D 36/00, B01D 36/04, B01D 21/0012, B01D 35/00, C02F 1/00

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/0263448 A1 (Heist et al.) 01 December 2005 (01.12.2005), entire document, especially Fig. 1A, 1B, 2A, 2B, 2C, 2D, 2E, 2G, 5A, 5B, 5C; para[0018]; para[0019]; para[0024]; para[0026]; para[0025]; para[0028]; para[0032]; para[0033];	1-6, 9-10, 12-13
X	US 4,130,478 A (Swallow) 19 December 1978 (19.12.1978), entire document, especially Fig. 1; col 2, ln 39-48; col 3, ln 17-34; col 4, ln 13-24; col 4, ln 38-50;	1, 4, 7-8, 11
A	US 3,221,886 A (Lamort) 07 December 1965 (07.12.1965), entire document	1-13
A	US 4,379,058 A (Bolton) 05 April 1983 (05.04.1983), entire document	1-13
A	US 4,923,600 A (Krofta) 08 May 1990 (08.05.1990), entire document	1-13
A	CN 102580387 A (QING HUANG) 18 July 2012 (18.07.2012), entire document	1-13
A	EP 1,064,977 A1 (CELLIER GROUPE SA) 03 January 2001 (03.01.2001), entire document	1-13

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"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
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 October 2021	JAN 18 2022
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Kari Rodriquez Telephone No. PCT Helpdesk: 571-272-4300

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 21/45167

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I: Claims 1-13 directed to a moveable cleaning assembly.
Group II: Claims 14 directed to a frame having a screen body removably positioned therein.
Group III: Claims 15-18 directed to a screen body comprising a metal sheet and angled holes.
Group IV: Claims 19-21 directed to a variable volume flow inlet assembly.
Group VI: Claims 29 directed to a sump drain, at least one of a sump valve or a sump pump, and a plurality of sensors.

The inventions listed as Groups I-VI do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

--- Continued in Supplemental Box ---

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-13

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 21/45167

--- Continuation of Box No. III Observations where unity of invention is lacking ---

SPECIAL TECHNICAL FEATURES

The invention of Group I includes the special technical feature of a screening system comprising a moveable cleaning assembly positioned either within a perimeter of the screen, around the perimeter of the screen or both, wherein the moveable cleaning assembly is moveable with respect to the screen, not required by the claims of Groups II-VI.

The invention of Group II includes the special technical feature of a screening system comprising a frame having a screen body removably positioned therein operatively connected to the flow inlet, not required by the claims of Groups I and III-VI.

The invention of Group III includes the special technical feature of a screen body for use in a screening system, the screen body comprises: a metal sheet; and angled holes defined in the metal sheet, wherein when viewing a given hole from a first side of the hole in a direction perpendicular to a surface of the metal sheet a view through the metal sheet is obstructed by a backside surface of the given hole, not required by the claims of Groups I-II and IV-VI.

The invention of Group IV includes the special technical feature of a screening system comprising a variable volume flow inlet assembly, not required by the claims of Groups I-III and V-VI.

The invention of Group V includes the special technical feature of a screening system comprising a weir positioned between the screen and the flow outlet, not required by the claims of Groups I-IV and VI.

The invention of Group VI includes the special technical feature of a screening system comprising a sump drain downstream from the sump; at least one of a sump valve or a sump pump operatively connected to the sump drain to control the flow rate therethrough based on at least one characteristic of the waste in the system; and a plurality of sensors operatively connected to the at least one of the sump valve or the sump pump to sense the at least one characteristic of the waste, not required by the claims of Groups I-V.

COMMON TECHNICAL FEATURES

Groups I-II and IV-VI share the common technical features of a screening system for solid removal comprising: a flow inlet; a screen; a sump downstream from the flow inlet for capturing solids that do not pass through the screen; and a flow outlet downstream from the screen in fluid communication with the flow inlet.

However, this shared technical feature does not represent a contribution over prior art as being anticipated by US 2005/0263448 A1 to Heist et al. (hereinafter 'Heist'), which discloses a screening system for solid removal (180, Fig. 1A, 5A, 5B, 5C; para[0018], 'a continuous deflection separation device, which is useful in separating solids from a flowing fluid such as water. The continuous deflection separation device 180') comprising: a flow inlet (220, Fig. 1A, 1B, 5A, 5B, 5C - see flow inlet 220 operatively connected to an interior chamber defined by the screen 205; para[0019], 'Fluid enters continuous deflection separation device 180 via an inlet 220, in the direction of arrow 190, wherein the inlet curves into chamber 210. Water and entrained particles are presented through inlet 220 into separation chamber 210, which is defined by separation panel 205'); a screen (205, Fig. 1A, 1B - see cylindrical screen 205 positioned within the housing; para[0018], 'The continuous deflection separation device 180, includes a separation panel 205, which is preferably circular in shape in cross-section and having first and second open-ends'; para[0019]); a sump downstream from the flow inlet for capturing solids that do not pass through the screen (187, Fig. 1A, 1B, 2E, 5A, 5B, 5C - see sump 187 located downstream from the inlet 220 for capturing solids that do no pass through the screen 205; para[0024], 'FIG. 2E depicts an embodiment where device 180 may also include sump 187 for the containment (and removal, if desired) of settleable particles'); and a flow outlet downstream from the screen in fluid communication with the flow inlet (230, Fig. 1A, 5A, 5B, 5C - see flow outlet 230 downstream from the screen 205 and in fluid communication with the fluid inlet 220; para[0019], 'the fluid carrying the particles 101 can flow in direction 103 through separation panel 205 into chamber 209 and out outlet 230 along the path indicated by arrow 200').

Groups I and IV-VI share the common technical features of a screening system for solid removal comprising: a housing; a screen positioned in the housing; a flow inlet; a sump downstream from the flow inlet for capturing solids that do not pass through the screen; and a flow outlet downstream from the screen in fluid communication with the flow inlet.

However, this shared technical feature does not represent a contribution over prior art as being anticipated by Heist, which discloses a screening system for solid removal (180, Fig. 1A, 5A, 5B, 5C; para[0018], 'a continuous deflection separation device, which is useful in separating solids from a flowing fluid such as water. The continuous deflection separation device 180') comprising: a housing (207, Fig. 1A, 5A, 5B, 5C - see housing comprising outer chamber wall 207; para[0018], 'Separation device 180 is located within chamber 209 defined by outer chamber wall 207'); a screen positioned within the housing (205, Fig. 1A, 1B - see cylindrical screen 205 positioned within the housing; para[0018], 'The continuous deflection separation device 180, includes a separation panel 205, which is preferably circular in shape in cross-section and having first and second open-ends'; para[0019]); a flow inlet operatively connected to an interior chamber defined by the screen (220, Fig. 1A, 1B, 5A, 5B, 5C - see flow inlet 220 operatively connected to an interior chamber defined by the screen 205; para[0019], 'Fluid enters continuous deflection separation device 180 via an inlet 220, in the direction of arrow 190, wherein the inlet curves into chamber 210. Water and entrained particles are presented through inlet 220 into separation chamber 210, which is defined by separation panel 205'); a sump downstream from the flow inlet for capturing solids that do not pass through the screen (187, Fig. 1A, 1B, 2E, 5A, 5B, 5C - see sump 187 located downstream from the inlet 220 for capturing solids that do no pass through the screen 205; para[0024], 'FIG. 2E depicts an embodiment where device 180 may also include sump 187 for the containment (and removal, if desired) of settleable particles'); a flow outlet downstream from the screen in fluid communication with the flow inlet (230, Fig. 1A, 5A, 5B, 5C - see flow outlet 230 downstream from the screen 205 and in fluid communication with the fluid inlet 220; para[0019], 'the fluid carrying the particles 101 can flow in direction 103 through separation panel 205 into chamber 209 and out outlet 230 along the path indicated by arrow 200').

Groups I-VI share the common technical features of a screening system comprising a screen.

However, this shared technical feature does not represent a contribution over prior art as being anticipated by Heist, which discloses a screening system comprising a screen (205, Fig. 1A, 1B - see cylindrical screen 205 positioned within the housing; para[0018], 'The continuous deflection separation device 180, includes a separation panel 205, which is preferably circular in shape in cross-section and having first and second open-ends'; para[0019]).

As the common technical features were known in the art at the time of the invention, these cannot be considered special technical feature that would otherwise unify the groups.

Therefore, Groups I-VI lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.