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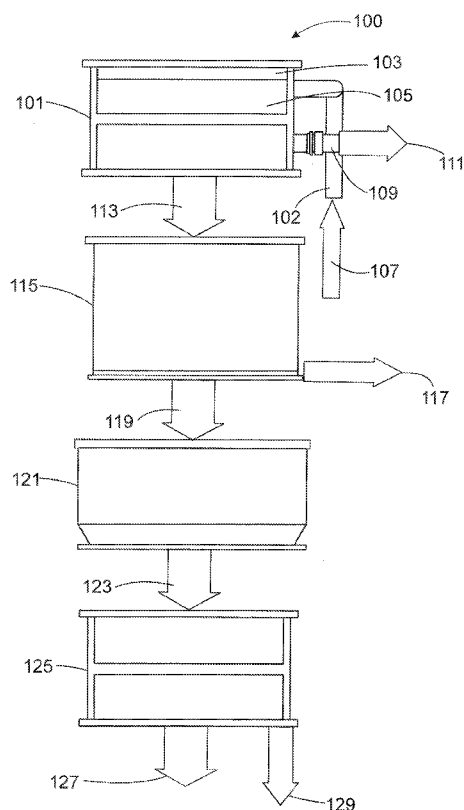


FIG. 1

(57) Abstract: A modular, compact, mobile, dewatering and liquid-liquid separation and filtration system. The system processes incoming influents of slurries, solids and liquids at a high speed of operation and in large volumes. System is capable of being modularly scaled, allowing for a continuous steady state operation accommodating any slurry flow rate in a synchronous dynamic equilibrium process. Components and modules integrated into the system include a dynamic filtration clarifier 101 (DFC), a nested-filter dewatering cell 115 (NDC) and/or a compression filter press 125 (CFP). The DFC performs the primary dewatering phase of separating the primary water from the solids creating sludge. The NDC further breaks apart the solids of the sludge, removing interstitial water in a secondary dewatering phase, further lowering the moisture content of the sludge, while the CFP removes the tertiary water from the remaining solid particles by pressing the particles into a solid cake.



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DYNAMIC SEPARATION AND FILTRATION

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority and benefit of U.S. Patent Application No. 62/305,025 filed March 8, 2016, entitled “DYNAMIC SEPARATION AND FILTRATION”, the content of which is hereby incorporated by reference.

FIELD OF TECHNOLOGY

[0002] The following disclosure relates generally to apparatuses, systems and methods for separating and filtering solid and/or liquid mixtures of material and more specifically to mobile apparatuses, systems and methods of solid-liquid separation and liquid-liquid separation of mixtures.

BACKGROUND

[0003] Access to clean water is essential to the ability of mankind and the environment to survive and thrive. The initial step to cleaning contaminated and non-contaminated water is the separation and removal of suspended solids from water, a method referred to as dewatering.

[0004] Currently, there is a need to separate solids from liquids and separate liquids from other liquids more efficiently, effectively and economically, in large volumes, at higher speeds, and with a more compact environmental footprint. At the same time it is desired for separation techniques to have less equipment, reduced energy requirements and reduced pollution; reduced manpower as well as a reduced disruption to commerce and the community.

[0005] There are numerous examples during recent history where current separation methods were incapable of responding or preventing emergency situations and disasters. The emergencies and disasters resulted in a severe impact on waterways, the environment and the local economies surrounding the events. Examples of such devastating events include oil spills, such as the 2010 BP Gulf oil spill; pipeline breaches, and the 2010 Kalamazoo River oil spill; tailing ponds and sludge lagoon breaches, such as 2014 Duke Energy fly ash spill and the 2008 TVA Kingston coal ash spill; Flooding, such as the 2015 Mississippi River flooding and 2015 Oregon flooding; and unintended releases, such as the 2015 EPA Colorado River Gold King.

[0006] Currently, operations requiring slurry dewatering or liquid-liquid separation employ a series of mechanical systems, technologies, pumps and conveying mechanisms for primary dewatering and liquid-liquid separation followed by the conveyance of any resulting sludge to downstream mechanisms in order to sufficiently perform secondary or tertiary dewatering and dehydration of the resulting sludge. Such secondary and tertiary methods in the current state of the art are needed to provide economical transport, disposal, asset recovery or beneficial reuse. Examples of these operations include: dredging operations, mining operations, paper mills, gas and oil operations, including fracking and oil sands, oil spill cleanups, tailing ponds and sludge lagoons, sewage, septage and wastewater treatment, confined animal feeding operations (CAFO), food processing, soil and cake washing, nutrient removal and reduction and

desalination.

[0007] The most widely employed technologies and methodologies for primary dewatering are settling clarifiers and detention settling ponds or lagoons. Secondary and tertiary dewatering and sludge dehydration typically employ belt filter presses, plate and frame filter presses, centrifuges, rotary presses, dewatering cells or boxes, or geo-textile bags. All of these technologies and methodologies are bulky and heavy, requiring a significant energy footprint to support operations, including time and energy. Moreover, widely employed technologies are manpower intensive. Due to the weight and footprint requirements, it is impractical to combine or stack multiple technologies onto a single compact vertical footprint.

[0008] The previously employed systems, technologies, processes and equipment, which usually operate and function separately and independently, are not easily transportable due to being large and heavy. Conveying slurry and sludge between available systems typically requires pumps, piping, fittings, spill containment, fuel or other energy resources, manpower and operator attention. In order to be transported, setup and teardown the equipment, a substantial operational footprint and related support structures are also required, as well as significant time, manpower, heavy equipment, and extensive resources to prepare and remediate the operating site.

[0009] For centuries, the settling of suspended solids, and then decanting the supernatant in confined vessels or basins, has been employed to separate solids and water, commonly referred to as settling clarification. Settling basins are sized according to slurry flow rates and the suspended solids settling or hydraulic retention time (HRT) required on a direct correlation basis. As an example, for each 500 gallons of water requiring 15 minutes of settling or HRT, a vessel capable of containing 7,500 gallons (500 gallons times 15 minutes) and sturdy enough to hold at least 62,550 pounds (7,500 gallons of water weighing 8.34 pounds per gallon) in addition to the volume and weight of the sedimented solids would be required. At some point, either the buildup of sediment must be removed or additional vessels employed.

[00010] Dewatering is accomplished in nature through the gravity settling of suspended solids in a water column. Then, as water flows through and around natural filter medias, such as gravel, sand and vegetation, additional suspended solids are separated and removed. This process, though often quite effective, takes considerable time, often months, years, decades or longer. As the world's population grows, the need to effectively shorten this natural process has become increasingly important. Man's pollution of water due to farming and industrial operations, has greatly impacted and complicated clean water issues.

[00011] The advent of slurry conditioning substances, such as alum, ferric and polymeric reagents, which encourage suspended solids to agglomerate into larger and heavier masses, commonly referred to as "flocs" in order to enhance settling, provided a solution to shorten settling time. However, slurry conditioning often created additional volume of settled solids, and did not adequately address floating, indefinitely suspended solids or re-suspended solids in a water column. As the basins filled with sediment, they were either abandoned and new basins were employed, or the sediment was removed. Both of these options resulted in significant amounts of saturated, high moisture content and low viscosity

sediment, which was not easily transportable.

[00012] Several types of clarifiers have been employed. The principal is simple. Influent slurry is pumped into a vessel or confined area, allowing the suspended solids to gravitationally settle or fall out of the water column and then sediment over time. Lamella clarifiers employ inclined plates, often in a parallel fashion. Slurries are normally conditioned, pumped or forced up the plates. The settling sludge comprised of flocs and suspended solids, may sediment onto the inclined plates. When sufficient aggregation of sludge on the plates occurs, a laminar flow forms, allowing the settling sludge mass to more easily gravitationally flow down the plates.

[00013] The rate of settling is directly dependent and correlated to the weight and mass of the suspended solids, as expressed by Stoke's Law and the Ferguson and Church Equation.

[00014] However, both Stoke's Law and the Ferguson and Church Equation are based on uniform spherical shaped material, which is rarely, if ever, the case. Even with the introduction of conditioning reagents, many ultra-fine solids or substances that are difficult to settle may remain in a water column and require extended HRT and therefore may require additional clarifiers to handle slurry flow rate requirements. There are several substances or particles with a low specific gravity, but with a significant mass, that may take many seconds, minutes, hours, days or longer to settle. Many substances even when conditioned, such as ultra-fine solids and colloids, may remain indefinitely suspended, may float or may become suspended again with minimal turbulence. Under conventional methods, if a slurry requires a prolonged HRT, either the throughput rate of the system may be lowered or the employment of additional clarifiers are required.

[00015] Once the suspended solids have sufficiently settled, the top layer of the water column, or supernatant, is then available to be decanted over a weir and discharged as effluent. The discharged effluent is often referred to as "free water" or "primary water" separation, or primary dewatering. Suspended solids or flocs that do not settle, such as those that remain indefinitely suspended, re-suspended or float, will typically remain in the supernatant and be discharged along with the decanted effluent.

[00016] Due to sedimentation and HRT, the suspended solids which do sediment at the bottom of the clarifier may benefit somewhat from compaction, but are typically a saturated or water laden mass having low viscosity. This is typically due to the formation of "sludge blankets" where layers of settling suspended solids loosely bond, then settle as a blanket. Water then becomes trapped between blanket layers creating additional interstitial or capillary water in the sedimented sludge, rendering the sedimented sludge difficult to handle, due to lower viscosity, and typically must be pumped from the bottom of the settling clarifier. The sedimented sludge is then conveyed, typically by pumps, to downstream mechanisms for additional dewatering or dehydration. Due to HRT requirements for processing, settling clarifiers typically require a large footprint and are very heavy, as they must be rigidly constructed out of strong materials to not only support the volume of slurry, but also the accumulation of settled or sedimented solids. Consequently, due to size and weight, settling clarifiers capable of processing slurry flow rates exceeding 400 GPM are not easily transportable, as they usually exceed the road height and

width restrictions. Clarifiers capable of handling slurry flow rates exceeding 400 GPM typically take extended time, manpower and heavy equipment, such as cranes, and other resources to disassemble, transport and then reassemble. These clarifiers typically require setup and placement on a reinforced and supported footprint.

Table 1

Technology Required to Process Slurry with 10% TSS by Volume and 1.5 Specific Gravity	Quantity		Width	Height	Length	Footprint Square Feet	Footprint Cubic Feet	Empty Weight	Operational Weight
Rotary Press Channels	10	Feet/Pounds	15.6	6.3	24.5	382.2	2,388.8	29,162	41,662
		Meters/Kilograms	4.8	1.9	7.5	35.5	67.6	13,228	18,898
Belt Filter Press 3 Meter Belt	2	Feet/Pounds	13.0	7.0	22.4	291.2	2,038.4	22,046	27,756
		Meters/Kilograms	4.0	2.1	6.8	27.1	57.7	10,000	12,590
Plate & Frame Filter Press 2000 mm Plates	349	Feet/Pounds	8.5	6.0	119.5	1,015.8	6,094.5	313,518	362,906
		Meters/Kilograms	2.6	1.8	36.4	94.4	172.6	142,209	164,611
Dewatering Cells 30 Cubic Yard @ 24 Hour HRT	12		51.0	6.3	40.0	2,040.0	12,750.0	81,120	909,727
			15.5	1.9	12.2	189.5	361.0	24,725	412,645
Geo-Textile Bags HRT	1		22.5	6.0	95.0	2,137.5	12,825.0	6,413	900,251
			6.9	1.8	29.0	198.6	363.2	2,909	408,347
Lamella Settling Clarifier 15 Minutes HRT	1	Feet/Pounds	11.9	12.3	19.2	228.5	2,810.3	37,000	102,678
		Meters/Kilograms	3.6	3.7	5.9	21.2	79.6	16,783	46,574
Dynamic Filtration Clarifier (DFC) & Nested-filter Dewatering Cell (NDC)	1	Feet/Pounds	4.0	6.0	6.0	24.0	144.0	1,331	2,874
		Meters/Kilograms	1.2	1.8	1.8	2.2	4.1	604	1,304
Compaction Filter Press (CFP)	1	Feet/Pounds	4.0	6.0	6.0	24.0	144.0	1,880	2,565
		Meters/Kilograms	1.2	1.8	1.8	2.2	4.1	853	1,163
DFC-NDC-CFP System Combined	1	Feet/Pounds	4.0	12.0	6.0	24.0	288.0	3,211	5,439
		Meters/Kilograms	1.2	3.6	1.8	2.2	8.2	1,456	2,467

[00017] Sludge dewatering and dehydration technologies, such as plate and frame filter presses and belt filter presses apply continuous and increasing pressure to dewater and dehydrate sludge. Belt filter presses position sludge, which has typically thickened, between two filter belts that compress the sludge. Care must be taken not to place an excess amount of sludge between belts or excess pressure on the sludge, as the sludge will be squeezed out the sides of the belts, which cannot be sufficiently enclosed, and therefore reduced or minimal dewatering results will be realized. The belts pass through a path of several sets of paired rollers, with each consecutive set having a reduced spacing between the rollers, thereby each set of rollers exert increased pressure on the sludge between the filter belts. Plate and frame filter presses receive a slurry, (typically conditioned), that is pumped into multiple filter media covered cavities enclosed between opposing plates. Pumping pressure is increased in order to force the suspended solids or “flocs” to the filter and the water to filtrate through filter media.

[00018] Plate and frame presses operate in a batch fashion, with each batch cycle requiring multiple hours. Due to the static confinement between two belts or within an enclosed cavity, sludge dehydrates

from the exterior to the interior of the sludge mass, trapping or confining interstitial water within the core of the sludge mass. As pressure is increased, interstitial water attempting to escape through capillaries in the sludge mass pushes finer particles, in turn causing a buildup of particles either within the capillaries or into the pores of the filter media. This buildup results in the clogging or collapsing of capillaries or blinding of the filter media.

[00019] Applying additional pressure on the sludge mass in an effort to extract additional interstitial water may lead to results with diminishing returns as additional or prolonged pressure eventually clogs or collapses capillaries, or blinds filter media, either inhibiting or blocking the interstitial water's discharge or filtrate path.

[00020] Dewatering cells are comprised of a vessel having walls and floors covered with filter media placed over sub-walls and sub-floors that facilitate the discharge of filtrated water. Geo-textile bags are tube shaped vessels enclosed with geo-textile filter media and having fill portals. Partitions or interior walls covered with filter media have also been employed in cells and bags to enhance dewatering by shortening the distance that interstitial water must travel for filtration. A slurry, typically conditioned, is pumped into the cells or bags through fill portals. Natural attenuation, compaction and consolidation of the sludge eventually breach the pore water pressure or tension, forcing interstitial water through capillaries in the sludge and towards filter media for filtration. In cells and bags, aside from contraction of the sludge mass due to water release and discharge, the sludge remains in a static position and is constrained within the boundaries of the cells, partitions or bags, thus restricting sludge movement, repositioning or reconsolidation. This lack of movement and repositioning may lead to capillary collapse as well as clogging and blinding of the filter media. Due to the somewhat static state, cells and bags tend to dewater from the exterior to the interior of the sludge mass, creating a crust or shell of dehydrated sludge on the perimeter of the sludge mass. Crusting impedes interstitial water release through capillaries in the sludge, leaving a saturated, higher moisture content area in the core of the sludge mass, and therefore the sludge is not uniformly dewatered or dehydrated.

[00021] Vacuum is sometimes employed to enhance sludge dehydration. However, cracks or cavities formed in the sludge resulting from dewatering and the expression of vacuum eventually creates voids.

[00022] As water evacuates sludge, the mass contracts away from the filter media and sources of vacuum, causing cracks and voids to form. Cracking leads to loss of vacuum as the voids fill with air. Sufficient dewatering time is typically many hours or days in the case of cells, or many days, weeks or months in the case of geo-textile bags. Once the sludge has sufficiently dewatered, the resulting cake is evacuated from the cells by opening one of the end or side walls and tipping the cell to evacuate the cake, or by using a mechanism, such as an excavator to extract the cake. Since cells typically employ sub-floors for filtrate plumbing, gravity evacuation of sludge or cake through the floor or bottom of the cell is not practical or possible. Should multi-sided or other irregularly shaped partitions be positioned in the cell, the partitions must be removed from the cell prior to tipping or excavation of the cake. In the case of geo-textile bags, the bags are cut open, the cake is excavated, and the bags are then discarded, as they are not normally reusable.

SUMMARY

[00023] A first aspect of the following disclosure relates generally to a separation and filtration system comprising: a dynamic filtration clarifier (DFC) comprising a uniform laminar flow (ULF) component positioned adjacent to a multi-layer self-cleaning filter (MSF); the ULF comprises a rotatable axle having a blade extending from the axle, an outlet slot and a discharge plate attached to a lower edge of the outlet slot; the MSF comprises a frame housing a layer of filter media, a drain pan attached to the frame and an outlet configured to discharge contents of the drain pan from the MSF; a nested-filter dewatering cell (NDC) connected to the MSF of the DFC, the NDC confined by exterior walls and a partitioning wall separating each cell of the NDC within the exterior walls, wherein each cell of the NDC comprises a nested filter and a directional plate; and a compression filter press (CFP) having a moveable wall and a moving mechanism configured to compress the moveable wall.

[00024] A second aspect of the following disclosure relates generally to a separation and filtration system comprising: a multi-layer self-cleaning filter (MSF) comprising a frame housing a layer of filter media, a drain pan attached to the frame and an outlet configured to discharge contents of the drain pan from the MSF; and a nested-filter dewatering cell (NDC) connected to the MSF of the DFC, the NDC confined by exterior walls and a partitioning wall separating each cell of the NDC within the exterior walls, wherein each cell of the NDC comprises a nested filter and a directional plate.

[00025] A third aspect of the following disclosure relates generally to a separation and filtration system comprising: a nested-filter dewatering cell (NDC) the NDC confined by exterior walls and a partitioning wall separating each cell of the NDC within the exterior walls, wherein each cell of the NDC comprises a nested filter and a directional plate; and a compression filter press (CFP) adjacent to the NDC, the CFP having a moveable wall and a moving mechanism configured to compress the moveable wall.

[00026] A fourth aspect is to provide a method of dewatering comprising: providing a dewatering system of a size and weight to which may be transported by an SUV or a pick-up truck; transporting the dewatering system to a dewatering site; and separating and/or filtering a solid- liquid mass at the dewatering site at a rate exceeding 400 gallons per minute with the dewatering system.

[00027] A dewatering device comprising: dewatering apparatus of a size and weight which may be transported by an SUV or a pick-up truck; and wherein the dewatering apparatus having apparatus for separating and/or filtering a solid-liquid mass at a rate exceeding 400 gallons per minute.

BRIEF DESCRIPTION OF THE DRAWINGS

[00028] FIG 1 depicts a flow diagram of an embodiment of a solid-liquid and liquid-liquid separation and filtration system (hereinafter "separation system");

[00029] FIG. 2 depicts an isometric view of an embodiment of a dynamic filtration clarifier connected to a nested filter dewatering cell of a separation system;

[00030] FIG. 3a depicts an embodiment of a uniform laminar flow device of the dynamic filtration clarifier of FIG. 2;

[00031] FIG. 3b depicts an exploded view of the uniform laminar flow device embodiment of FIG. 3a;

- [00032] FIG. 4a depicts an isometric view of an embodiment of a multi-layer self-cleaning filter;
- [00033] FIG. 4b depicts a partially exploded view of the multi-layer self-cleaning filter of FIG. 4a;
- [00034] FIG. 5a depicts an isometric view of an embodiment of a nested-filter dewatering cell;
- [00035] FIG. 5b depicts a partial cut away view of the embodiment of the nested-filter dewatering cell of FIG. 5a;
- [00036] FIG. 5c depicts an embodiment of a gutter drain of a nested-filter dewatering cell;
- [00037] FIG. 6 depicts a partial cut-away view of an embodiment of a metered volume controller of a separation system;
- [00038] FIG. 7a depicts an isometric view of an embodiment of a compression filter press of a separation system;
- [00039] FIG. 7b depicts an exploded view of the embodiment of the compression filter press of FIG. 7a;
- [00040] FIG. 7c depicts a partial cutaway view of one or more components of the compression filter press of FIG. 7a;
- [00041] FIG. 7d depicts an alternative partial cutaway view of one or more components of the compression filter press of FIG. 7a;
- [00042] FIG. 7e depicts an alternative embodiment of a compression filter press with an unfilled dynamic fluidized press plate;
- [00043] FIG. 7f depicts the alternative embodiment of FIG. 7e having a fluid or air filled dynamic fluidized press plate;
- [00044] FIG. 8a – FIG. 8c depict a visual representation of an embodiment of a compression method of a compression filter press;
- [00045] FIG. 9 depicts an isometric view of an embodiment of a spill remediation system; and
- [00046] FIG. 10 depicts an embodiment of a mobile emergency separation and filtration system.

DETAILED DESCRIPTION

[00047] A detailed description of the hereinafter described embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures. Although certain embodiments are shown and described in detail, it should be understood that various changes and modifications may be made without departing from the scope of the appended claims. The scope of the present disclosure will in no way be limited to the number of constituting components, the materials thereof, the shapes thereof, the relative arrangement thereof, etc., and are disclosed simply as an example of embodiments of the present disclosure.

[00048] As a preface to the detailed description, it should be noted that, as used in this specification and the appended claims, the singular forms “a”, “an” and “the” include plural referents, unless the context clearly dictates otherwise.

DEFINITIONS

[00049] Certain embodiments are described in detail below. Terms used herein may be defined as follows:

[00050] “Air” may refer to a gaseous substance comprising oxygen and nitrogen or it may be inclusive of any other gas that may be substituted for air.

[00051] A “cake” may refer to sludge which has been dehydrated, dewatered or has had the moisture content of the sludge reduced and/or removed.

[00052] A “conditioned slurry” may refer to a slurry influent that has been treated with coagulants, polymers or other substances. A conditioned slurry may be used or prepared for solid-liquid separation (dewatering).

[00053] “Dewatering” may refer to solid-liquid separation of a mixture of solid particles in a liquid.

[00054] “Effluent” may refer to the flow, stream of movement of a substance exiting a piece of equipment, component or module of a solid-solid or solid-liquid separation and filtration system.

[00055] “Flocs” may refer to a plurality or mass of suspended solids agglomerated together by coagulants, polymers or other substances.

[00056] “Hydraulic Retention Time” (HRT) may refer to the residence time or the average length of time that a compound may remain in a storage unit or piece of equipment receiving the compound. HRT may be measured by the following equation:

$$HRT = \frac{\text{Volume of aeration tank}}{\text{influent flowrate}}$$

[00057] “Influent” may refer to flow or stream of movement of a substance into a piece of equipment, component or module of a solid-solid or solid-liquid separation and filtration system.

[00058] “Lift” may refer to an accumulated mass of sludge, flocs or other solids.

[00059] “Liquid” may refer to an amorphous (non-crystalline) form of matter between a gaseous and solid state. A liquid may have a definite volume, but may not have a definite shape. An example of a liquid may include water, where mentioned in this disclosure, unless otherwise noted.

[00060] “Sludge” may refer to a resulting or remaining product after the occurrence of at least some amount of liquid separation from solids (i.e. removal of water), resulting in an increasing viscosity.

[00061] “Slurry” may refer to a fluid stream of contaminated or non-contaminated liquid, such as water, containing suspended solids or other substances such as oil.

[00062] “Specific Gravity” (SG) may refer to a ratio of the density of a substance to the density of water. For example, the specific gravity of water at 4°C is 1.

[00063] A “suspended solid” may refer to one or more solid particles which may remain in a suspension of water or other liquids. A suspended solid may include fine suspended solids, ultra-fine suspended solids such as silts, clays, organics, colloids, indefinitely suspended solids, solids re-suspended due to turbulence, floating suspended solids and sedimented suspended solids.

SEPARATION SYSTEM OVERVIEW

[00064] Referring to the drawings, FIG. 1 illustrates a compact, mobile, solid-liquid separation (dewatering) and/or liquid-liquid separation and filtration system 100. The system 100, as shown by the separated depiction in FIG. 1, may be modular and customizable based on the needs of the user. The system 100 may be comprised of modules and/or components that achieve solid-liquid separation (i.e. suspended solids from water) and/or liquid-liquid separation (i.e. oil and water). Embodiments of system 100 may achieve primary dewatering, secondary dewatering, and then compress the resulting sludge after dewatering into a thin low moisture content cake for tertiary dewatering in a dynamic equilibrium, while maintaining a singular compact footprint. The system 100 depicted in FIG. 1 may be suitable for eliminating and/reducing hydraulic retention time (HRT), which may result in the enablement of mobility, reduced fabrication and operational expenses of solid-liquid or liquid-liquid separation by reducing the empty weight, operating weight and footprint size requirements compared with existing systems described above.

[00065] The system 100 may process incoming influents of slurries, solids and liquids at a high speed of operation and in large volumes. System 100 may be capable of being modularly scaled, allowing for a continuous steady state operation accommodating any slurry flow rate in a synchronous dynamic equilibrium process. Embodiments of the system 100 may employ separation and filtration of solid or liquids, rather than using methods that allow for solid settling to occur for initial solids-water separation (primary dewatering), resulting in more effective suspended solids separation. Using separation and filtration rather than settling techniques may eliminate or reduce HRT, resulting in a significant reduction in operational footprint and weight of system 100 as opposed to currently available technologies described above. Embodiments of system 100 may confine sludge in an enclosed compartment to cyclically compress and compact sludge into cake with low moisture content, which significantly reduces secondary and tertiary dewatering HRT.

[00066] Embodiments of the system 100 may employ a “componentized modular scaling” rather than dimensional scaling. Modular scaling of system 100 may allow system 100 to economically scale to any contaminated or non-contaminated slurry flow rate. Embodiments of the components and modules that may be present in system 100 may include a dynamic filtration clarifier 101 (DFC), a nested-filter dewatering cell 115 (NDC), a metered volume controller 121 (MVC) and/or a compression filter press 125 (CFP). Embodiments of the componentized modular system 100 may have multiple possible configurations that address various site specific and material specific requirements. Any of the system 100's individual modules, components, sub-systems, or any combination of modules, components or sub-systems, can efficiently and effectively operate separately or collectively. Higher efficiency and effectiveness may be achieved when leveraging combinations of the modules, components and sub-systems describe below. Any combination of modules, components and subsystems described herein may be combined in conjunction with other technologies or methodologies, including, but not limited to, settling clarifiers, belt filter presses, plate and frame filter presses, dewatering cells, geo-textile bags,

increasing the efficiencies and effectiveness of these older technologies and methodologies.

[00067] Embodiments of each component and/or module described herein may be capable of functioning as a standalone unit, operating individually and independent of other components and modules, and therefore may have independent value and be integrated into other systems known in the art. The modular systems illustrated in the figures are merely examples of modular systems that may be configured by a user. The configurations of the modular systems described herein should not be limited to the specific configuration and location of components or modules depicted. Modules described herein may be connected to one another and integrated into separation systems in any particular order or formation as understood by a person skilled in the art. Embodiments of the modules and/or component of system 100 may be oriented in a vertically stacked position, one on top of another, reducing overall footprint and employing gravity as a conveyor between modules and components, thus increasing efficiency and reducing expenses, manpower and energy requirements.

[00068] Embodiments of system 100 may receive contaminated or non-contaminated slurries entering the system as an influent 107. The slurry entering the system 100 as an influent 107 through piping 207, may be a conditioned slurry or the slurry may be unconditioned (hereinafter, referred to interchangeably as simply a “slurry”). As the slurry flows through the system 100, each module 101, 115, 121, 125 may incrementally separate and release a plurality of suspended solids, water or other liquids present in the slurry (such as oil or other petroleum distillates). Each module 101, 115, 121, 125 or components of the modules 101, 115, 121, 125 of system 100 may sequentially and incrementally reduce the liquid or water present in slurry. As water, liquid or moisture is incrementally reduced a sludge may result having an increasing viscosity and a decreasing moisture content that may be less than the slurry entering the system 100 as the influent 107.

[00069] The greater the amount of water, liquid or reduction of the moisture content of the slurry and sludge that is achieved by each upstream module, the less processing may be performed by each downstream module. This reduction may reduce the overall stress on each downstream module, and increase the efficiency of each downstream component or module 101, 115, 121, 125 described herein. For example, for each incremental increased amount of free water that can be released by the DFC 101 module (upstream module), the less water that the NDC 115 (downstream module) may need to further separate from the slurry. Similarly, the more interstitial or capillary water the NDC 115 (upstream module) may separate from the slurry or sludge that passes into the NDC 115, the less interstitial water the CFP 125 (downstream module) may need to separate as well. Incrementally sequencing the separation of water or liquid from the slurry or sludge provides for a faster, more effective and more efficient overall system processing.

[00070] Embodiments of the system 100 may include a DFC 101 comprising ULF 103 and MSF 105 components, as well as a NDC 115 module, as shown in FIG. 2, operating as one system or module on a singular footprint, without pumps or other conveying mechanisms. The ULF 103 component may distribute the conditioned slurry evenly and uniformly onto the MSF

105. Embodiments of the MSF 105 component may be a multiple layered self-cleaning filter media,

enabling more efficient primary dewatering by separating flocs or suspended solids in slurry from the primary or free water in slurry. With or without the NDC 115, the dewatered sludge 113 exiting from the MSF 105 may have a higher viscosity than sludge pumped from a settling clarifier. However, after the sludge received from MSF 105 passes through the NDC 115, the viscosity of the sludge may be further increased as additional water or liquid is removed and filtered. In the exemplary embodiments discussed herein, the separated flocs (which may now be considered sludge due to the release of free water), may gravitationally flow down through the system 100 from the MSF 105 to the NDC 115. In alternative embodiments, instead of flowing downward gravitationally between the MSF 105 and the NDC 115, the separated flocs and/or sludge may be vibrated across the MSF 105 or other filter media, subsequently allowing the primary dewatered sludge 113, including the flocs to fall off the end of MSF 113 and into the NDC 115.

[00071] Embodiments of the entire system 100 may be entirely enclosed in some instances, allowing for operation in adverse, inclement or extreme conditions and an enclosed filtering system 100 may eliminate a need for additional spill containment equipment. The enclosed embodiment of system 100 may be fitted with an appropriate venting and filtration systems to capture any noxious vapors, odors or other undesirable airborne materials that may be produced while the system 100 is in use.

[00072] Embodiments of system 100 may be compact and mobile. In some embodiments, multiple separation and filtrations systems 100 may be transported by a single light duty vehicle, such as a pickup truck, Cross-over or sport utility vehicle (SUV) as shown in embodiment 1000 of FIG 10, described below. The bed of a pick-up truck has dimensions ranging from 54 ½ inches for the inside box width to 56 ¾ for the inside box length for a Chevrolet S10 from 2001- 2004 to 100 inches by 80 inches for the inside box length by the inside box width for a Ford Super-Duty Truck from 2008-2010. SUVs can have a carrying capacity from 63.3 for a Mitsubishi Outlander to 130.8 cubic feet for a 2016 Ford Expedition EL. Trucks and SUVs are also classified by their weight carrying capacity. Class 1 includes SUVs and Pickup trucks with a weight carry capacity of 6000 pounds or less. Class 2 includes Full size pickups for a weight carry capacity of 6,001 pounds to 10,000 pounds. Class 3 includes Heavy Duty pickup trucks with a weight carry capacity of 10,001 pounds to 14,000 pounds. Trailers hauled by SUVs, Crossovers and trucks have various weights ranging from around 3500 pounds to around 23,000 pounds for a super heavy duty truck.

[00073] In other embodiments, the system 100 may be mounted on a barge, a boat or air lifted to remote locations. In some embodiments of system 100, a programmable logic controller (PLC) may be used as a centralized control mechanism of the system 100, to control each of the modules and components of the system 100. Embodiments of system 100 may further comprise one or more cameras, sensors or video recording equipment positioned at various strategic points of system 100 which may allow for remote monitoring by a user of system 100. Cellular or satellite services may further be connected to a LAN, Wi-Fi communication network or computer network to allow for remote communication between one or more users and system

100. The combination of cameras, cellular or satellite service, LAN or Wi-Fi in conjunction with the

PLC may allow for remote management and control of the system 100, as well as enabling an operator to manage multiple filtration systems 100 simultaneously.

DYNAMIC FILTRATION CLARIFIER MODULE

[00074] Embodiments of DFC 101, such as the DFC 101 portrayed in FIGs 1-2 may achieve primary dewatering of solid-liquid slurries and initial separation of liquids present in a liquid-liquid slurry.

Embodiments of the DFC 101 may be more efficient, more effective, faster, smaller, lighter, mobile and a less expensive alternative to the settling clarifiers. The DFC 101 may dewater slurries entering the DFC 101 as an influent 107 and gravitationally evacuate the separated slurry as a sludge having a reduced moisture content. Embodiments of the DFC 101 may effectively perform primary dewatering without using mechanically moving parts. Moreover, the DFC 101 may modularly scale in size to accept any slurry flow processing rate, while further delivering clearer and cleaner effluent 111 from the outlet 109 having less suspended solids than the influent 107 entering the DFC 101. The sludge obtained from the DFC 101 may comprise a lower moisture content resulting in a sludge that is easier to manage by downstream modules, making downstream dewatering less intensive than typical settling clarifiers.

[00075] Referring to the drawings of FIGs 1-2, a slurry may be pumped from a slurry source or a conditioning system (similar to the conditioning system depicted in system 1000 of FIG 10), such as a polymer injection system, into inlet conduit 207 of the DFC 101 as influent

[00076] 107. Entering through inlet conduit 207, the influent 107 may be received by a uniform laminar flow (ULF) component 103 of the DFC 101 module connected to inlet conduit 207. Embodiments of the ULF 103 may operate in a manner that manages the flow of the slurry entering the DFC 101 allowing for the slurry to be evenly and uniformly distributed over a multi-layer self-cleaning filter (MSF) 105 during the primary dewatering phase.

[00077] Due to the nature of a slurry or conditioned slurry, typically not having a laminar flow, it may be beneficial to create a laminar-like flow for more even distribution and placement of the slurry over filter media 407 to encourage a maximum amount of free water to be released from flocs within the slurry. The integration of a ULF 103 into the DFC 101 may produce a more even and uniform laminar flow by continuously sectioning, compartmentalizing and distributing the slurry influent 107 entering the DFC 101. The ULF 103 may transform a turbulent slurry flow into a smoother, streamlined uniform laminar flow, allowing for a more efficient, effective and consistent dewatering. Due to the random and unpredictable nature of an influent 107 slurry flow entering the ULF 103, the even and uniform placement of the slurry achieved by the ULF 103, may not efficiently or effectively be accomplished by other mechanisms such as weirs or other similar technologies, especially for placement of the slurry onto an inclined or horizontal filter media 407 of a MSF 105.

[00078] Embodiments of ULF 103 may be in the form of a cylinder or tube-like shape and may be enclosed on both ends as shown in FIG 2-3b. The ULF 103 may be any appropriate diameter and length and the ULF 103 may be situated at any angle between vertical and horizontal (for example, 0° to 180°). In the exemplary embodiment depicted in the figures, a horizontally angled ULF 103 is shown.

Embodiments of the ULF 103 may have a slotted inlet opening 315 connected to conduit 207 receiving an influent 107 from the source of the slurry.

[00079] The slotted inlet 315 may traverse the ULF 103 lengthwise, horizontally on an upper portion of the cylindrical housing of the ULF 103 and a slotted outlet opening 303, which may traverse lengthwise horizontally on a lower portion of the cylinder of the ULF 103. The slotted inlet opening 315 and the slotted outlet opening 303 may be less than 180 degrees opposed from each other in some embodiments whereas in alternative embodiments, the opening 315 and the outlet may be more than 180 degrees opposite of one another. In some embodiments of the ULF 103 a discharge flow plate 305 may be attached to the lower edge of the outlet slot 303. In the exemplary embodiments, the discharge flow plate 305 may extend the length of the outlet slot 303. The outlet discharge plate 305 may remain positioned at an appropriate or desired angle between 0 degrees and 90 degrees to the outlet slot 303 and direct the flow of influent onto the filter media 407 of the MSF 105.

[00080] In some embodiments of the system 100, the ULF 103 may comprise an axle 311 having a diameter and extending length relative to the size and shape of the ULF's 103 cylindrical body. The axle 311 may be centrally positioned and horizontally extending through one or more holes positioned at the distal ends of the ULF 103 receiving the axle 311 there through. Embodiments of ULF 103 may further include one or more pillow blocks 313 or other desired mechanisms which may be attached to one or both ends of the axle 311. In some embodiments, a device capable of rotating the axle 311, either mechanically such as a motor or by the hands of a user, may be attached to one or both ends of the axle 311.

[00081] Embodiments of ULF 103 may comprise one or more blades 309 or finlike projections protruding radially from the axle 311. In some embodiments, the blades 309 may be an even number of opposing positioned blades attached to the axle 311. The length of the blades 309 may be equal to an interior length of the ULF's cylindrical housing and approximately a requisite dimension to enable rotational clearance of the blades 309 within the cylinder of the ULF 103. The radial distance the blades 309 may protrude from the axle 311 may be any desired measurement but in the exemplary embodiment the blades 309 may protrude at approximately the radius of the cylinder, but the blades may extend slightly less in length in order to be an appropriate dimension to enable rotational clearance within the cylinder. The blades 309 may be positioned along the axle in a straight, helical or other appropriate pattern.

[00082] Embodiments of the ULF 103 may comprise a cylinder or tube which may be enclosed on both ends. The cylinder or tube may house the rotating axle 311 having one or more blades 309 protruding from the axle 311. The blades 309 may in some embodiments, extend the length of the cylinder. The cylinder may comprise an upper horizontal inlet having an opening 315, a lower horizontal outlet slot 303 and a discharge plate 305 positioned on the lower edge of the outlet slot 303. The opposing locations of the inlet 315 and outlet slots 303 may be less than 180 degrees apart in some embodiments. Moreover, the position of the inlet 315 and outlet slot 303 coupled with the weight and velocity of slurry, may enable gravity to sufficiently and continuously rotate the bladed axle 311 without additional force needing to be applied. In an alternative embodiment of ULF 103, a mechanism may be employed, such as a motor or

hand crank to rotate the axle 311.

[00083] The slurry may enter the cylinder of ULF 103 through the inlet slot 315 and the slurry may be positioned onto a rotating blade 309. A space created between the rotating blades 309 may form a compartment to section the slurry. As the blades 309 rotate downward, a centrifugal force operating through the force of gravity may push the compartment formed by the blades 309 containing the slurry towards the outer edge of the following blade 309 thereby consolidating and compressing flocs against the inner wall of the cylinder, forcing the flocs to extend more evenly and uniformly over the length of the following rotating blade 309. The confinement of the flocs in the space formed between the rotating blades 309 coupled with the compression force against the wall of the cylinder, may provide a conducive environment for smaller flocs and colloids to agglomerate with larger flocs, resulting in more effective and efficient initial primary dewatering.

[00084] As the floc laden blade 309 rotates toward the outlet slot 303, the flocs may be evacuated onto the discharge plate 305 in an even, sweeping, motion. Subsequently, the sweeping motion of the blades 309 discharging the flocs of the slurry onto the discharge plate 305 followed by flowing the slurry on to the MSF 105 receiving the slurry on the filter media 407 as the slurry flows off the discharge plate 305 in a uniform and consistent elongated mass of flocs uniformly flowing in a consistent laminar like flow down or across the filter media 407 of MSF 105. The uniform laminar flow encourages more effective primary water release from flocs by mitigating channeling or clumping on filter media 407, preventing the buildup of flocs or other solid objects that may cause clogging which can be disruptive to the slurry's flow down or across filter media 407. The laminar flow may reduce the occurrence of filter blinding, shortening filter media maintenance and/or reducing the number of replacement cycles.

[00085] The blinding or clogging of any portion of filter media 407 for any period of time may render filter media 407 less effective and efficient. The filtering of uniformly shaped spherical objects present in the slurry or sludge may require a filter media 407 with porosity openings smaller than the spheres being filtered. However, it may be rare for slurry or sludge to contain only uniformly shaped spherical objects. Slurries and sludge entering separation system 100 may normally include irregularly shaped objects, especially solids with sharp edges or protrusions which can penetrate pores in filter media, resulting in clogging and blinding. This is especially the case with wedge wire screens or similar slotted types of filter media 407. In an effort to clear the filter media 407 of solid objects that may be caught or jammed in the filter media 407 water or compressed air may be sprayed over the filter media 407 of MSF 105 in an effort to dislodge jammed solids.

[00086] Embodiments of MSF 105 may include one or more layers of filter media 403, 407. Embodiments of the one or more of the filter mediums present in MSF 105 may be flexible in structure. Embodiments of MSF 105 may further comprise a frame 405 to house the filter media 407. The frame 405 may be geometric shape such as parabolic, round or rectangular. Embodiments of the frame 405 may include one or more layers of filter media 403, 407 affixed to interior edges of the frame 405. Embodiments of the frame 405 may further comprise one or more orifices or holes throughout the frame to facilitate the introduction of compressed air or forced blown air from a source of compressed

air, such as a compressed air tank. In some embodiments, the frame 405 may include one or more channels or grooves within the edges of the frame. The channel or channels within the frame 405 may allow for the introduction of compressed or forced air to enable the channeled frame to operate as an “air knife” for breaking up solid flocs of the slurry and removing jams within the filter media 407.

[00087] In some embodiments of the MSF 105, a filtrate drain pan 401 may be attached to the frame 405. A slurry or conditioned slurry exiting the ULF 103 may flow onto a horizontal or inclined filter media 407 attached to frame 405. Embodiments of the filter media 407 depending on the size of the porosity of filter media 407 needed. For example, the filter media 407 attached to the drain pan 401 may be exchanged with filter media 407 of differing porosity sizes assuring that the porosity or aperture size of filter media 407 is smaller than the smallest flocs of the slurry, in order to enhance filtering and permit the efficient filtering of various sized flocs, and other solids, resulting in clearer effluent 111 exiting the MSF 105. As noted above, single or multiple layers of filter media 407, 403 may be employed to filter difficult to settle, suspended solids or flocs, such as those that remain indefinitely suspended, float or become re-suspended.

[00088] Embodiments of the MSF 105 may achieve primary dewatering by separating flocs or suspended solids in the slurry from primary or free water present in the slurry. As the slurry or conditioned slurry flows over filter media 407, gravity causes free water to immediately release and separate from the flocs, filtrating the water through filter media 407, trapping flocs on filter media 407. Free water filtrated through filter media 407 may be captured in the drain pan 401 attached to the back of the frame assembly 405 and then discharged as effluent 111 from the outlet 109. The effluent 111 of the released free water may exit the MSF 105 from outlet 109 and may be discharged from the MSF 105 back to a waterway source. Moreover, if it is desired by the user of the system 100, the MSF effluent 111 may be sent to one or more additional downstream processing technologies or additional modules for further remediation and dewatering. The remaining flocs filtered by the filter media 407, may now be considered sludge and exit the MSF 105 as the sludge falls off the edge of the filtered media 407 as primary dewatered sludge 113.

[00089] Embodiments of MSF 105 may continuously clear the filter media 407 of flocs or other objects, which may become lodged, wedged or stuck in the pores of filter media 407. In some embodiments, the removal of solid flocs may be accomplished by attaching the filter media 407 to a frame 405 in such a manner as to permit a desired amount of “slack” or flex, thereby allowing the filter media 407 to have movement or to oscillate and then recoil. The slack in the filter media 407 in conjunction with the weight of the sludge, or other solids on the filter media 407, may cause the filter media 407 to oscillate, bend or sag, then recoil. The oscillating and recoiling movement may dislodge and then eject flocs, sludge or other solids in a trampoline like effect, resulting in the elimination or reduction of clogging or blinding of the filter media 407.

[00090] In some embodiments of the system, the MSF 105 may include a combination of one or more channeled frames 405 and/or one or more layers of filter media 403, 407. One or more frame assemblies may be connected lengthwise or widthwise to form a larger frame assembly. The frame assembly 405

may be adjustable to reflect any desired angle. For instance, the frame assembly may position the filter media 403, 407 vertically, horizontal or any angle in between. The angle may be changed or adjusted in order to match slurry flow rate and particles in slurry seeking be dewatered. Channels and holes may be placed along the frame 405 to provide the ability for the frame 405 to receive an air flow from an air compressor, blower or other mechanism. The air flow can be blown over filter media 403, 407, resulting in the frame formation of an “air knife”. The air knife may be situated in such a way as to enable air to be blown from multiple directions towards the inward portion of filter media 403, 407 screen assembly. Embodiments of the air knife may be directed over or under both sides of filter media 403, 407, over one or more layers of filter media 403, 407, or between one or more layers of filter media 403, 407. The air movement may enhance filter media oscillation and further encourage the flow of sludge to exit toward the outlet of the MSF 105.

[00091] In addition to clearing filter media 403, 407 of embedded objects, oscillation and air flow, collectively or individually may break the surface tension of water adhering to the sludge, flocs or other solids, further enabling additional surface water to release from flocs and solids, enhancing the amount of filtrate passing through all layers of filter media 403, 407. As the filtrate of water or other liquid passes through the outlet 109 of the MSF 105 as effluent 111, the filtrate may further pass through an additional outlet filtration media 409 providing an additional filter for any smaller solids that may have inadvertently passed through the plurality of filter media 403, 407 layers. The small solids captured may be prevented from being released with the rest of the filtrated water or liquid passing there through.

[00092] The filtered flocs (now sludge), may gravitationally flow down the inclined filter media 407 in a tumbling or rolling motion and/or be vibrated across horizontal filter media. The sludge may be gravitationally evacuated by falling off the end of the filter media 407 frame 405. In some embodiments, the sludge exiting the MSF 105 may then enter into the NDC 115, or be evacuated or conveyed to alternative downstream technologies, methodologies or mechanisms for further dewatering.

[00093] In an alternative embodiment of MSF 105, the frame assembly 405 may be round, or another appropriate shape, permitting the placement of the MSF 105 within piping or tubing. One or more layers of filter media 403, 407 may be positioned at an angle to the flow where the top of the assembly is angled away from the bottom of the assembly in the direction of the flow. As particles are filtered by the filter media 407, they may be forced up the filter media by the flow. The velocity and pulsation of the flow of the slurry may oscillate the filter media to free solid particles from the water or other liquids present in the slurry. Air may be introduced on the filter media 407 to enhance release of lodged particles and provide further ancillary benefit of aerating the flow of slurry. The frame assembly 405 may be detachable or removable, enabling filtered particles to be discarded without disrupting the flow. The flow of the slurry may be diverted or switched to an alternate inline filter assembly to facilitate a “hot swap” of one or more filter mediums.

NESTED-FILTER DEWATERING CELL MODULE

[00094] The NDC 115 may perform a secondary dewatering function by enabling the removal of

interstitial water from the primary dewatered sludge 113 received from the MSF 105. The interstitial water being removed may also be referred to by some people skilled in the art, as capillary water. Embodiments of the NDC 115 may be constructed from any suitable or desired material that is appropriate for providing structural support to and allow for the NDC 115 system module to properly function as described herein. The NDC 115 may release the interstitial water from the sludge 113, filter out the interstitial water and then discharge the interstitial water as an NDC effluent 117 via the NDC outlet 517. Embodiments of NDC 115 may accomplish the removal of interstitial water by the confinement and compaction of sludge inside one or more nested filters 507 separated by partition walls 505. The NDC 115 may use the weight and accumulated lift of the sludge's mass entering the NDC 115 to perform the separation and release of the interstitial water. Embodiments of the NDC 115 may be a more efficient, more effective, faster, smaller, lighter, mobile and less expensive alternative to other dewatering cells and geo-textile bags.

[00095] Embodiments of the NDC may be comprised of one or more cells 501. A cell 501 of NDC 115 may be any shape desired. In the exemplary embodiment of the drawings, a rectangular or square shape is depicted, however, the shape of the cells 501 could round, triangular, pentagonal, hexagonal, rhomboid or any other multi-sided polygon shape.

[00096] Embodiments of the cell 501 may include one or more exterior walls attached to each other and one or more partitioning wall separating each cell 501 of the NDC 115. As shown in the exemplary embodiment depicted in FIG. 5a, four exterior walls may be used to form a perimeter confining the NDC 115. However, in some alternative shapes may be constructed with more than four exterior walls or less than four exterior walls as desired. Alternative geometric shapes of cell 501 may be round, oval, square or multi-sided polygons. Embodiments of each cell 501 may be positioned horizontally, vertically or any position between vertical and horizontal.

[00097] Embodiments of cell 501 may include one or more evacuation outlets 510, portals or other desired evacuation mechanisms positioned at the bottom of the cell 501. As an alternative, one or more evacuation outlets, portals or other desired evacuation mechanisms may be positioned at the lower end of one or more side walls.

[00098] Embodiments of each cell 501 may include a frame having a plurality of vertical and horizontal connected bars or slats to assist with forming the shape of the cell. Embodiments of the frame may be attached to one or more interior surfaces of the cell's interior wall 503.

Embodiments of the interior cell wall 503 may be covered with filter media and attached to the frame on interior facing sides of the frame. Embodiments of each cell's 501 frame may also be connected to the partition walls 505 constructed of or covered by filter media as well.

[00099] Embodiments of partition walls 505 may be covered with filter media on one or both sides of the partition walls 505. The partition walls 505 may be constructed in such a way as to create a space or void between the interior surface of the cell's walls and the filter media. In some embodiments, one or more partition walls 505 may be positioned at desired points within the cell 501. In some embodiments of NDC 115, one or more additional cells 501 with filter media covering both sides of the frame may be

appropriately sized to fit within the space created by the partitions in a nesting fashion as shown in FIG. 5b.

[000100] Embodiments of cell 501 having solid side walls with a frame within the cell 501 attached to the interior walls 503 of the cell 501 may be covered with filter media. In particular, the filter media covering the interior walls of the cell 501 may be the same filter media as the MSF 105 filter media 407. Embodiments of the cell 501 frame may create an unobstructed space or void between the filter media and side walls 503 allowing for the discharge of filtrated water or other liquids from the sludge entering the NDC 115. In some embodiments of NDC 115, one or more filter media covered framed partition walls 505 may be positioned within the cell 501 to create one or more smaller partitioned cells. One or more smaller cells having sides covered with filter media, and a geometric shape being similar to the partitioned cells, may be positioned within one or more partitioned cells in a nesting fashion to create nested cells. The height of the partitioned cells and the nested cells may be less than the height of the outside cell to allow for sludge entering the cell to cascade from one cell to another cell in order to fill all cells, thus creating an even lift of sludge in all cells.

[000101] As depicted in FIG 5b-5c, embodiments of the NDC 115 may further comprise a gutter drain 511 attached or positioned on the posterior surface of the cells of the NDC 115. The gutter drain 511 may be constructed of enclosed, open or channeled interconnected conduits or tubes. In some embodiments the gutter's conduits or tubes may have a center square or rectangular shaped tube as shown in FIG. 5c of this application. Embodiments of the gutter drain 511 may be connected to the bottom of the space created by the filter media of the cell walls 503 of the NDC 115 as well as the interior space of partitions 505 and nested filters 507. If, the embodiment of the drain 511 is an enclosed square or rectangular shaped tube having an open center tube, the drain 511 may have one or more orifices on the top or side of the cell 501 facing the space between filter media 503 and the exterior cell wall. One or more effluent discharge drain outlets 510 may be connected to the gutter 511 and positioned at one or more appropriate points along the base of each cell 501. Embodiments of the interconnected gutter 511 and drain outlets 510 may feed the separated liquid or water along the gutter assembly 511 and feed the filtrated water or liquid away from the remaining sludge and out through NDC outlet 517. The gutter assembly may be attached at the lower end of cell 501 as well as the partition walls 505 and the enclosed the space created between filter media 503 and the cell walls between the partitions and nested filters 507.

[000102] In some embodiments, the NDC 115 may include one or more directional plates 509 having a sizing dimension less than the opening created by the filter media covered walls 503. Embodiments of the directional plate or plates 509 may be positioned within each cell 501 either horizontally or vertically between one or more opposing filter media covered walls 503 or partition walls 505. The directional plate 509 may have an appropriate slope in the direction heading towards the filter media covered walls 503. In some embodiments of the NDC 115, one or more sections of the cell 501 may include open wire mesh constructed out of a firm material having dimensions less than the opening created by opposing filter media covered walls 503. The wire mesh may be positioned within the cell 501 in a horizontal position between one or more opposing filter media covered walls 503. In some

embodiments of NDC 115, one or more orifices or portals may be present within cell 501 and positioned throughout each cell, allowing for the introduction of a vacuum and/or compressed air.

[000103] The one or more directional plates 509 situated between one or more filter media covered walls 503 may have the directional plate 509 sloping towards filter media covered walls 503. The directional plate 509 may be stationary or static, or alternatively situated on an axle to enable mechanical rotation. One or more layers of wire mesh may be inserted between one or more opposing filter media covered walls 503. The open space at the bottom of all filter media covered cell walls 503, partitioned walls 505 and nested filters 507 may be attached to the gutter drain assembly 511. Evacuation portals, doors, or other desired methods of sludge evacuation, such as an MVC, screw conveyor or auger, may be attached to the bottom of the cell, or the lower portions of the side walls of cell 501.

[000104] At the onset of operation, embodiments of the NDC's 115 evacuation portals or other mechanisms for removal of sludge from the NDC 115 may be in a closed position. The slurry or primary dewatered sludge 113, such as from the DFC's 101 MSF 105, may be fed or placed into the NDC 115 through the top of the cell 501. The differing height between the cell 501, the partitioned cells and the nested cells permits the slurry or sludge to evenly fill all cells 501 by cascading from one section to the other as each cell 501 or nested filters of the cell receives with sludge or slurry.

[000105] In some embodiments the secondary dewatering may be achieved using compression, consolidation and compaction techniques which may be performed on the sludge 113 by the confinement of the sludge 113 into a plurality of nested filters 507 using the weight and/or the accumulated lift of sludge's 113 mass to perform the compaction. The sludge 113 entering the NDC 115 may be allowed to build up in order to consolidate and compact between all filter media covered walls 503. The closer the proximity of filter media covered walls 503, the shorter the distance interstitial or free water has to travel to be filtrated and discharged. As the lift of the sludge accumulates, compression created by the weight of the accumulating sludge and compaction created by the proximity of the filter media covered walls 503, may break the capillary pore water pressure or tension, thus releasing interstitial water inside of and adhering to capillary walls of the sludge or slurry. In some embodiments, a vacuum and/or compressed air may be introduced into the cells 501 of the NDC 115 from to further improve the removal of interstitial water.

[000106] Filtrated water from the sludge or slurry may filtrate through the filter media positioned along the filter media covered walls 503, partitioned walls 505 and nested filter 507, subsequently collecting in the gutter assembly 511, and thus discharged from the gutter assembly outlet as effluent 117. The introduction of a vacuum and/or compressed air to the NDC 115 may be beneficial and may be expressed on the NDC 115 to further enhance dewatering. However, when applying a vacuum, special care may be taken to ensure that the amount of vacuum applied does not collapse the capillaries of the filter media. Prolonged compression or vacuum on a lift or mass of sludge in a static position without movement or reconsolidation, may collapse capillaries, contract the mass and create a void between filter media or vacuum source. Such a prolonged compression by the vacuum or compressed air may encourage

the formation of an outer crust to form on the sludge mass. Crusting and capillary collapse may block, cease or impede the release of interstitial water, and therefore, may render the core of the mass disproportionately saturated and unevenly dewatered. Examples of crusting may be a common problem in static dewatering technologies such as geo-textile bags and static positioned dewatering cells.

[000107] Once a desired amount of lift of the sludge 113 has accumulated, evacuation mechanisms of the NDC 115 may be opened to a point which permits the amount of sludge being evacuated from the cell 501 as secondary dewatered sludge 119, to equal the amount of sludge entering the cells 501 of NDC 115, thereby achieving a state of dynamic equilibrium operation. The ability to gravitationally evacuate sludge from the NDC 115 may eliminate the need for tipping or excavating mechanisms for evacuation of the sludge required by other dewatering cells. The opening of evacuation portals permits and encourages sludge movement, and thus sludge repositioning and reconsolidation, thereby encouraging additional capillary formation and ultimately resulting in additional interstitial water release.

[000108] As the sludge moves down the cell 501, directional plates 509 encourages the sludge mass, and importantly the center or core of the sludge mass, to flow towards walls and partitions having filter media 503, 505, 507 thereby repositioning and reconsolidating the sludge mass and further shortening the distance interstitial water must travel to be filtrated. The presence of a wire mesh assembly may "slice" the sludge mass into smaller portions, exposing and/or creating new capillaries for interstitial water movement and release. The continuous movement of the sludge down the cell 501, facilitated by the partially opened evacuation portals, in conjunction with the plates 509 and wire mesh assemblies, continuously repositions and reconsolidates sludge.

[000109] In some embodiments, the movement of the sludge, especially when under pressure, may enhance interstitial water release, capillarity, and filtration and reduce capillary collapsing or blocking, while encouraging the formation of new capillaries as the sludge continuously repositions and reconsolidates. The introduction of air, especially compressed air, may dilate capillaries, having a drying or dehydrating effect on the sludge mass while also assisting in keeping the filter media of the NDC 115 from clogging or blinding. The continuous introduction of additional sludge into the cell 501 fills voids and cracks created by water release and/or vacuum that contracts the sludge, lifting and pulling the sludge away from filter media and vacuum sources, ultimately inhibiting or diminishing the effectiveness of expressing vacuum on sludge. The embodiments of the NDC 115 as described, separately, collectively and/or incrementally mitigates sludge contraction and crusting, as well as capillary collapse, thereby encouraging more uniform, effective and efficient sludge dewatering. In alternative embodiments, the NDC 115 may be operated in a manner that provides for the total evacuation of the cell 501 at any desired time.

[000110] In some alternative embodiments of the NDC 115, the NDC 115 may be equipped with a dynamic fluidized press plate 750 which is discussed in greater below. The fluidized press plate 750 may be constructed to include a sealed bladder and a port 751 allowing for the fluidized press plate 750 to be filled. As the sludge 113 fills the cells 501 of the NDC 115, the bladder of the fluidized press plate may be filled, causing the bladder to expand, increasing the pressure inside the cells 501 of the NDC 115. As

the bladder expands, the fluidized press plate 750 may increase the pressure inside each cell 501 of the NDC 115, compact the sludge 113 delivered to the NDC 115 and push the released water 113 through the filter media 503 lining the walls of the NDC 115, resulting in the release of interstitial fluid from the sludge which may be collected by the gutter 511 and evacuated from the NDC 115 via the NDC outlet 517.

METERED VOLUME CONTROLLER MODULE

[000111] As the evacuated secondary dewatered sludge 119 exits the NDC 115, for example via exit or outlet 219, the sludge may be deposited into a metered volume controller (MVC) 121 or discarded, depending on the configuration of the system 100. For example, at this point of separation and filtration using system 100, the sludge may have sufficiently reduced moisture content and may be considered a cake. The cake may be gravitationally evacuated for disposal, concluding dewatering or separation operations. If sufficient dewatering of sludge is not yet achieved, sludge may be gravitationally fed to the MVC 121.

[000112] Embodiments of the MVC 121 may be employed by system 100 as the sludge or solids evacuation and discharge mechanism. The MVC 121 may measure the precise amounts of sludge or solids for gravitational placement into the compression filter press (CFP) 125 or any other alternative dewatering technology. The MVC 121 may be fabricated from any suitable or desired material that is appropriate and capable of structurally supporting the features of the MVC 121 and its functions as described in the current application. Embodiments of an MVC 121 may include an MVC cell 611 which may have two opposing side walls and two opposing end walls. The end walls of the MVC 611 may be equipped with one or more appropriate sized orifices or holes to receive an MVC axle 605. The MVC axle 605 may be any appropriate length and diameter and may be positioned within the holes present of each of the end walls of MVC 121. In the exemplary embodiment, the MVC axle 605 may be centrally positioned horizontally extending through the holes in the end walls. One or more pillow blocks or other appropriate mechanisms may be attached to one or both ends of the MVC axle 605.

[000113] In some embodiments of the MVC 121, a mechanism to rotate the axle, such as a motor 603 or hand crank, may be attached to one or both ends of the MVC axle 605. The motor 603 may be a high torque-low RPM type motor or any other motor that may be sufficient for rotating the MVC axle 605. In some embodiments, a variable frequency drive or other appropriate mechanism may be employed to control the rotational speed of the MVC axle 605. Embodiments of the MVC 121 may further comprise one or more opposing blades 607 protruding from and attached to the MVC axle 605. The length of the blades 607 may be equal to the interior length of the MVC cell 611, minus a desired dimension to allow for rotational clearance of the blades 607 within the MVC cell 611 as the MVC blades 607 and MVC axle 605 rotate. Embodiments of the MVC blades 607 may have an overall width dimension between the side walls of the cell 611 less an appropriate dimension to enable rotational clearance within the MVC cell 611. The blades 607 may be positioned on the MVC axle 605 in a straight, helical or other appropriate or desired pattern.

[000114] The MVC 121 may measure a desired amount of sludge, or other volume of solids, which may be periodically or continuously evacuated from, or be delivered to, a vessel at any desired volume and evacuation rate. The space or cavity created between the blades 607 provides a measurable volume, which can be discharged at a measurable rate determined by the number of revolutions of the rotating axle 611. The ability to measure a precise volume of sludge and the rate the sludge is delivered may be important to downstream and upstream modules of the system, such as the NDC 115 and CFP 125, as well as to the overall processing rate of system 100 and the synchronous dynamic equilibrium operation thereof. For example, the volume of sludge delivered to the CFP 125 by MVC 121 may directly impact the cake thickness that the CFP 125 processes and discharges. This may be particularly true when comparing the same volume of differing types of sludge having varying compositions and moisture content.

[000115] Sludge with higher moisture content may require a greater volume delivered to the CFP 125 than a corresponding volume of sludge with a lesser moisture content.

[000116] Embodiments of the MVC 121 may operate in cycles. At the beginning and end of a cycle, the bladed axle 605 may be positioned in such a manner that each of the opposing blades 607 may rest at a horizontal position, thereby forming a barrier blocking or impeding the release of sludge or other solid materials from the MVC outlet 609 of MVC 121. Sludge or other solid material may be gravitationally placed into the inlet 601 at the top of the MVC cell 611.

[000117] Gravity may force sludge into one or more cavities formed by the space between the blades 607, thereby capturing and confining a measurable amount of sludge within in the cavity of the MVC cell 611. As the bladed axle 605 is rotated, the measured amount of sludge or other material falls away from the bladed axle 605 and is gravitationally evacuated from the cell 605 as a secondary dewatered sludge 123. If the MVC 121 is used in conjunction with the CFP 125, the measured amount of sludge may accumulate at the bottom of the MVC until a moveable inlet portal 701 of the CFP 125 is opened.

COMPRESSION FILTER PRESS MODULE

[000118] The CFP 125 may achieve secondary and tertiary dewatering of the sludge entering the CFP 125, reducing the moisture/liquid content of the sludge to form a cake by compressing and compacting sludge into cake having an appropriate or desired thickness. The resulting cake may be evacuated from the CFP 125 and made suitable for transport, stockpiling, beneficial reuse or disposal. The CFP 125 compresses sludge into cake within an enclosed dynamic cell. In some embodiments, a vacuum and compressed air also may be introduced into the CFP 125 cell when appropriate or desired. Using the embodiments of the CFP 125 as described, dewatering and filtration of the sludge may be more efficient, more effective, faster, smaller, lighter, mobile, less expensive, and less energy dependent and a less manpower intensive alternative to belt filter presses, plate and frame filter presses, rotary presses, centrifuges, dewatering cells and geo-textile bags. The CFP 125 may also modularly scale to meet any sludge processing rate.

[000119] Embodiments of CFP 125 may include a cell having two opposing fixed side walls 705 and one or both opposing end walls 717 being movable by pressure. Embodiments of the cell may be positioned at any angle between vertical and horizontal. In the exemplary embodiment of FIGs. 7a-7d, the CFP 125 is depicted as having a vertical cell. Embodiments of the moveable end walls 717 may be compressed through the use of pressure and may also be referred to as a movable press wall 717. Embodiments of the CFP 125 may further comprise a frame 723 supporting the fixed side walls 705. A track, rail or other appropriate guide 703 may be attached to the frame 723 to support one or both movable press walls 717. Embodiments of the CFP 125 may include a moveable inlet portal 701 situated at the top of the cell and a moveable outlet portal 719 situated at the bottom of the cell. Embodiments of the frame may act as a spacing device positioned between one or both movable press walls 717 and one or both side walls 705. As the frame encloses there may be unification between the movable press wall 717. In some embodiments of the CFP 125, filter media 727 may be placed over the movable press walls 717 creating a void or space between walls and the filter media 727. One or both filter media covered walls 717 may have rigid rim-like or ridge-like protrusions in a desired pattern and positioning, such as a waffle iron shape for example. In some embodiments, the CFP 125 may further include one or more filtrate drain portals 715 or orifices which may be situated at the bottom of the spacing between the walls and the filter media covered walls. In some embodiments, one or more vacuum portals 707 may be situated in either one or both walls, or within the space created between the walls and the filter media covered walls.

[000120] Moreover, the CFP 125 may also comprise one or more compressed air portals 709 which may be situated in either one or both side walls 707, or within the space created between the walls 705, 717, 701, 719 and the filter media 727. In some embodiments of the CFP 125, the CFP may include one or more injection nozzles 716 configured to deliver compressed air, a rinsing/washing solution and/or a cake remediation substance. An injection manifold 713 comprising an injection port 711, piping or tubing may be used to connect a plurality of nozzles 716 with substances injected into the manifold 713 being delivered to the cake within the cell of the CFP 125 via the end wall formed by the manifold 713.

[000121] In some embodiments of the CFP 125, a moving mechanism 721 may be attached to one or both moveable walls 717. Embodiments of the moving mechanism may be a hydraulic or pneumatic piston, worm drive or screw drive system. The CFP 125 may operate in a sequential cycled process. FIG. 8a-8c describes the sequential process of pressing the sludge 750 into an intermediate cake 751a and a final cake 751b which may be ejected from the CFP 125 through moving outlet portal 719. A cycle may begin with both the inlet 701 and outlet 719 portals being in a closed position. The opposing movable press wall 717 may be positioned apart by an appropriate and desired distance. When the inlet portal 701 is opened and a desired measured amount of sludge 750, (such as sludge delivered by the MVC 121), gravitationally falls into the cellular space formed between the separated walls 705, 717. The inlet portal 701 may be closed, thereby creating an enclosed cell. One or both opposing moveable walls 705, 717 having a filter media 727 covering said walls may then be pressed or contracted towards each other. The compression may be performed hydraulically, pneumatically, using a screw or worm drive or by any

other appropriate mechanical mechanism 721. The contracting walls compact, consolidate and compresses the sludge 750 within the enclosed cell of the CFP 125, forcing the sludge 750 to fill the entire cavity of the enclosed cell, as shown incrementally via FIGs 8b and 8c. An intermediate cake 751a is formed upon the initial compression shown in FIG 8b. As additional pressure is expressed and increased on the contracting wall 705, 717, the sludge 750 may be further compressed and compacted into a final cake 751b. The resulting pressure may break the capillary pore water pressure or tension, thus releasing interstitial water and forcing the interstitial water to move in the direction noted by arrow 752, towards filter media 727. The interstitial water released from the cake may then be filtrated and discharged through the filtrate drain portals 715 or orifices positioned within the walls or at the bottom of the space created between filter media 727 and the walls 705, 717.

[000122] In some embodiments, expressing a vacuum on the sludge may enhance capillarity, capillary wicking, allowing for additional interstitial water release and filtrate extraction. Expressing compressed air or blown air may dilate the capillaries of the sludge 750 and further dehydrate the sludge 750, providing blowback to clear residual sludge or cake particle residue that might adhere to filter media 727. As shown in FIG. 8c, the movable press walls 705, 717 may then be retracted, encouraging the compressed sludge 750, now in the form of a cake 751b, to fall away from filter media 727 as a sheet of cake and release to the bottom of the cell towards the outlet 719. The sheet of cake may fracture into pieces as it falls away from filter media 727 and further break apart into smaller chunked pieces as the sheet of cake 751b impacts the floor of the cell formed by the interior surface of outlet portal 719. The broken open fractured chunked pieces of cake 751b may expose the core of cake, which is where the most difficult area to extract interstitial water may reside. As shown in FIG. 8b and FIG. 8C, one or more cycles of the CFP 125 may be performed repeatedly by compressing the walls 705, 717, applying vacuum and/or compressed air until the desired level of cake moisture content or thickness is achieved.

[000123] Once a desired the level of cake moisture content is achieved, the outlet portal 719, positioned at the bottom of the cell, may be opened allowing the cake to gravitationally fall through the outlet portal 719 and be evacuated from the CFP 125. In alternative embodiments, alternative forms of evacuation may be employed, such as screw conveyors or augers. In some embodiments, the cake may be further washed or rinsed or in some alternative embodiments, one or more desired cake remediation substances may be introduced into the CFP 125 cycle described in FIG. 8a to 8c at any appropriate time before, during or after a CFP cycle, depending on the results desired to be achieved.

[000124] In an alternative embodiment, the moveable wall 717 may include a dynamically fluidized press plate 750 situated on the interior wall of the moveable press wall 717. The dynamic fluidized press plate 750 may cover the entire moveable press wall 717 and may be constructed as a sealed bladder comprising any suitable material sufficiently sturdy enough to handle the pressures that may result from compressing the sludge 750. The dynamically fluidized press plate may be an expandable material that may seal the cell of the CFP 125 by forming a seal along the side walls 705, the interior surface of the inlet portal 701 and the interior surface of the outlet portal 719. Once the moveable wall 717 is contracted and in contact with sludge in the cavity cell, any compressible gas, but preferably any

non-compressible fluid (such as water) may be forced into dynamic fluidized press plate 750 through a fill port 751. As pressure is increased by filling the bladder of the fluidized press plate 750, the moveable press wall 717, the side walls 705, the closed inlet portal 701 and the closed outlet portal 719 may form a sturdy and confined enclosure providing resistance to the increasing pressure, leaving only the filter media covered wall 727 as the path of least (or no) resistance for water to be forced from sludge and through filter media covered wall 727. This pressing by the dynamic fluidized press plate 750 allows for more pressure to be equally exerted over the area of sludge mass versus a solid press plate 717. The dynamic fluidized press plate 750 may also provide a seal for the cell of press chamber, confining the sludge as the dynamic fluidized press plate 750 expands from being filled.

SPILL REMEDIATION SYSTEM

[000125] The reduction of operational weight and footprint size enables multiple systems 100 to be quickly deployed and transportable by a single light duty pickup or SUV vehicle 1007, barge mounted operation, or easily airlifted to remote or isolated locations, and to quickly deploy and respond to emergencies and disasters, which is not practical, if not impossible, by competing technologies.

[000126] The effectiveness and efficiency of the system 100 and processes thereof, coupled with reduced fabrication costs and operational expenses, may allow for waterway and other dewatering projects to move forward that may have been previously slowed or halted due to budgetary constraints. Operations requiring dewatering, such as fracking operations, oil sands operations, mining operations, CAFO and paper mills, will be able to eliminate toxic settling ponds as well as the associated risks of a pond breach. By employing the system 100 and process for financial reasons, which may be a primary driver for business, rather than regulatory or environmental pressure, the system may prevent sludge and tailings pond breaches and the associated environmental impact and remediation costs. Since the system 100 may be mobile, the system may be more cost effective to deploy over an erected settling or detention ponds for operations. Settling ponds and detention ponds may require site preparation and excavation, then constructing the settling pond, lining the settling pond, and providing site oversight and maintenance. The accumulated sedimented sludge may require sufficient dewatering into a transportable condition for disposal. At the end of site operations, the settling pond must be decommissioned and the site remediation.

[000127] Embodiments of system 100 and process thereof may be applied and integrated with spill remediation systems to quickly respond to, contain and remediate waterway oil, toxic material spills, or provide solutions for emergency preparedness to prevent waterway related disasters, emergencies. Spill containment and cleanup integrating the described system 100, may be applied in situations such as floods, oil spills and other toxic spills, and tailings ponds breaches. FIG. 9 depicts an embodiment of a spill remediation system 900 integrating one or more of the components or modules of system 100 described above. The system 900 includes a DFC 101 and a NDC 115 contained within a sorbent supply storage container 901. The equipment of system 900 may be compact enough to be easily fitted directly onto oil tankers or other ships and may be a permanent or semi-permanent system. The system 900 may

also be barge mounted, trucked or air lifted to remote areas.

[000128] The spill containment and remediation system 900 may be used for treating oil spills or toxic spills of hazardous materials. The system be provided with a pelletized or granulated substances or other sorbent material 909, being dispersed over the spill area. The dispersion can be accomplished by employing spray or air cannons 911, or other mechanisms that can quickly and effectively disperse sorbent materials 909 over a spill area. The appropriate substances can include oleophilic-hydrophobic sorbents for oil spills or alternative sorbents, either absorbents or adsorbents, selected to meet the criteria of other toxic or noxious waterway spills having the characteristics known by those skilled in the art for the particular purpose of remediation. Once the sorbent materials 909 are dispersed over the spill area, the sorbents may adsorb or absorb the spilled material. The sorbents containing the spill material and/or water in close proximity may form a slurry.

[000129] The slurry formed by the mixing of the sorbent, spilled material and/or water may be pumped via pump 903 to the DFC 101. The influent 107 of slurry containing the sorbent material and water is pumped into the DFC 101 through the ULF 103, which positions the slurry over the filter media of MSF 105, for solid-liquid separation, in a scenario wherein the sorbent material is solid and water. The MSF 105 or other filter media may be treated or coated with a super-oleophobic material to prevent oil or other substance from building up and blinding the filter media 407. The free water may be released and separated from the sorbents. The water may then be filtrated through the filter media 407 and captured on the drain pan 401 connected to the frame 405 housing the filter media 407 where the collected water may then be discharged back to the waterway or source where the water previously resided.

[000130] The filtered sorbent materials 909 may gravitationally flow down the filter media 407 and into the NDC 115 for further separation of additional surface water retrieval, or alternatively deposited directly into a ship's cargo hold, other container for disposal or downstream asset recovery. The sorbent storage container 901 may also act as an area for placement of the recovered oil laden sorbent material 907. The container 901 may be is fitted with a movable partition 905 positioned within the container 901. As sorbent material 909 is withdrawn for dispersion, the partition 905 may move in the direction of the sorbent material 909, thereby creating a void or space for the recovered material 907 may be stored. The sorbent materials 909 withdrawn from the spill slurry and processed by the system 100 may be placed into the open space 907 in the storage container 901. The partition 905 may continue to shift positions as more sorbent 909 is dispersed creating more space for recovered sorbent material in the container 901. Oil laden sorbent material 907 may be further processed downstream to extract the oil for asset recovery.

MOBILE RESPONSE SYSTEM

[000131] Referring to FIG. 10, depicting an embodiment of mobile response system 1000 integrating the one or more components or modules of system 100, the mobile response system 1000 may be designed to quickly mobilize, contain, remediate or, provide solutions for emergency preparedness to prevent waterway related disasters, emergencies, and spill containment and cleanup including floods, oil spills, toxic chemical spills, and tailing pond breaches, which may threaten lives, property, the

environment and financial loss.

[000132] The mobile response system 100 may be comprised of one or more components and modules from system 100, including but not limited to the DFC 101, NDC 115, MVC 121 and CFP 125. Embodiments of the mobile response system 1000 may further include a slurry conditioning system 1001, having a polymer injection or feed system receiving conditioning reagents from the reagent supply reservoir 1003. Embodiments of system 1000 may also be comprised of a suction pumping system capable of distributing the conditioning reagents to the slurry being inputted into the system 1000. Due to the system's modular design, equipment, components and modules can be quickly configured and deployed to meet specific requirements or stored ready to respond at strategic logistical positions for immediate deployment. Mobile systems 1000, such as the system depicted in FIG. 10 may be capable of processing more than 2,000 GPM and may be fitted on trailers 1005 and towed by a light duty vehicle 1007 such as a truck or SUV.

[000133] The mobile response system 1000 may be deployed downstream to an area of an anticipated river flood crest or shorelines for anticipated high tide. Sediment material from the waterway may be either dredged or pumped to the system 1000. Taking the sediment from the waterway may have an ancillary effect of deepening the waterway, allowing for additional volume of water flow, therefore somewhat mitigating flood cresting. The pumped or dredged slurry may be conditioned or fed directly into the DFC 101 of system 100 and the filtrated free water may be discharged back to the waterway.

[000134] Depending on the constituency factors of the waterway, the resulting sludge can either be deposited into the onboard NDC 115, with the resulting sludge being fed and placed into geo-textile bags or directly fed to geo-textile bags, bypassing the NDC. The geo-bags may then be sufficiently filled and stacked to create a desired barrier height along the waterway banks or shoreline. Due to the compact size and weight of the system 1000 and its modular design, a system can be hovered above the geo-textile bags on a movable platform to enable moving the system from one bag to another in order to efficiently and effectively gravitationally fill the bags in lieu of pumping the dewatered sludge from the system. Placing primary dewatered sludge from the DFC 101 or secondary dewatered sludge from the NDC 115 into bags immediately may form a stable environment within the geo-textile bags, forming a barrier with sufficient integrity and stability. Alternatively, the sludge can be further processed by the NDC 115 and the CFP 125, forming a cake. The resulting cake can then be positioned and stacked with a sufficient angle of repose and integrity to create a barrier or seawall as well. These processes and systems not only provides the ability for quick response, but also solutions that mitigate loss of lives, damage to the environment, property damage, rebuilding costs and disruption to commerce.

UNEXPECTED ADVANTAGES OF THE SEPARATION SYSTEM

[000135] Four of the main bottlenecks in the dewatering process that MAY inhibit efficiency, increase operational footprint, increase manpower requirements and limit easy transport, mobilization, deployment or operation may be due to 1) the HRT and operational footprint required for settling

clarification for effective and efficient primary dewatering; 2) the HRT and operational footprint required to sufficiently dewater sludge for economical transport, disposal or beneficial reuse for effective and efficient secondary and tertiary dewatering; 3) the equipment, energy and operational footprint required to convey sludge between technologies; and 4) the manpower to operate individual technologies and systems. The empty weight, operational weight and footprint required by any one of the first three bottlenecks, much less all three collectively, may severely impact or negates the ability to easily deploy and respond to emergencies and disasters, as well as significantly impact the operational expense, operational weight, footprint and manpower necessary for performing operations requiring dewatering. The system 100 and process described in this application solves all four bottlenecks by separating suspended solids from water, separating additional water contained within the resulting sludge and pressing the sludge into low moisture content cake on a single compact and mobile footprint. The DFC's 101 employment of the MSF 105, NDC 115, MVC 121, CFP 125 or other filtration technology, eliminates the HRT required by settling clarifiers. The DFC 101 is not dependent on a variable or inconsistent settling rate of suspended solids or conditioned flocs (as required for clarification systems) due to the size, specific gravity, or whether the solids may float or stay indefinitely suspended as determined by Stokes Law (equation 10.1), the Ferguson-Clark equation (equation 10.2), and particle order of size for settling shown below:

Equation 10.1: Stoke's Law for settling solids
(Stokes 1851)

$$V = \frac{g \left(\frac{\rho_s}{\rho} - 1 \right) d^2}{18\nu}$$

where:

V = settling velocity of the solid

g = acceleration of gravity

ρ_s = mass density of the solid

ρ = mass density of the fluid

d = diameter of the solid (assuming spherical)

ν = kinematic viscosity of the fluid

Equation 10.2: Ferguson and Church equation for settling solids
(Ferguson and Church 2004).

$$V = \frac{gRd^2}{18\nu + \left(0.75CgRd^3 \right)^{1/2}}$$

where:

V = settling velocity of the solid

g = acceleration of gravity

d = diameter of the solid (assuming spherical)

ν = kinematic viscosity of the fluid

R = specific gravity of the particle in water (1.65 for silica sand)

C = a constant equal to 0.4 for spheres and 1 for typical sand grains

Table 2

Effects of Decreasing Size & SG of Spheres on Settling				
Particle Diameter		Order of Size	Time Required to Settle One	Time Required to Settle One
mm	microns		SG=2.65	SG=1.2
10	10,000	Gravel	0.4 seconds	1.2 seconds
1	1,000	Coarse Sand	3.0 seconds	9 seconds
0.1	100	Fine Sand	34 seconds	5 minutes
0.01	10	Silt	56 minutes	8 hours
0.001	1	Bacteria	4 days	32 days
0.0001	0.1	Colloidal	1 year	9 years
0.00001	0.01	Colloidal	>50 years	>50 years
0.000001	0.001	Colloidal	>50 years	>50 years

[000136] Instead, the DFC 101, NDC 115 and MVC 121 of system 100 may utilize the constant and consistent force of gravity for free or primary water to immediately release fluid and separate the flocs or other solid particles, thereby completing primary dewatering, secondary dewatering while reducing or eliminating HRT.

[000137] The system 100 described in the current application may operate in an unexpected manner when compared with settling clarifiers used by those in the art. A typical lamella settling clarifier processing a 500 GPM slurry flow having 10% suspended solids by volume and a specific gravity of 1.5 requiring 15 minutes of HRT, may necessitate a vessel sturdy enough to hold approximately 7,500 gallons of slurry plus sediment or settled suspended solids. The vessel would have an empty weight of about approximately 37,000 pounds and an operational weight of 102,678 pounds on a 245.5 square foot footprint. Since primary water in system 100 is instantly (or nearly instantly) released from the solids (or flocs) by gravity and filtration, the DFC 101 may only occupy one linear foot width of two foot long filter media, and no HRT, for each 50 to 80 GPM of slurry flow, enabling the DFC 101 and NDC 115 to operate on a 24 square foot footprint, with an empty weight of merely 1,331 pounds, and an operational weight of 2,874 pounds. Overall permitting the employment of lighter, less expensive fabricating materials, along with reducing the associated structural engineering and construction requirements, and related costs. Therefore, a greater than 80% reduction in footprint size, empty weight and operational weight is unexpectedly realized when compared with lamella settling clarifiers requiring HRT of 15 minutes or greater for comparable flow rates. The percent reduction of operational footprint size and weight increases as HRT requirements increase. Furthermore, the DFC's 101 ability to fit or exchange differing MSF porosity size in order to filter smaller, lighter, floating or indefinitely suspended solids or flocs, eliminates the need for downstream polishers which are often necessary for settling clarifiers.

[000138] Second, the system's 100 NDC 115 and CFP 125 modules enable compression, repositioning and reconsolidation of sludge in an enclosed dynamic cell. The use of compression, repositioning and reconsolidation permits and encourages additional capillary formation, while mitigating capillary collapse in sludge, which may be useful for efficient interstitial water release and secondary and/or tertiary dewatering. The ability to exert substantial pressure on the sludge is achievable by plate and frame filter presses or the dynamic fluidized filter presses disclosed herein, due to the enclosed cavity design.

[000139] Unlike the CFP 125 of the present disclosure, belt filter presses have limitations on the amount of pressure that can be exerted on sludge. The opposing belts in a belt filter press are not enclosed on the sides of the belts and excessive pressure will squeeze the sludge out of the sides of the belts as water, having minimal compressibility, pushes sludge towards areas with less pressure (the sides of the belts), therefore limiting the pressure which may be exerted on the sludge, and thus hindering the dewatering results. Geo-textile bags and dewatering cells are limited to the weight of the sludge mass lift in order to exert pressure on sludge, which decreases as water is discharged. The CFP's 125 only pressure limitations are not any limitation on the CFP itself, but rather how much pressure is available to be exerted by a source of pressure on the sludge and how much pressure the sludge can withstand before shearing the polymer chain. This enables the CFP 125 to operate at faster rates with better results, including reduced cake moisture content due to the CFP's 125 ability to exert significantly greater pressure on sludge for a shorter period of time as well as periodically and cyclically repositioning the sludge within an enclosed cell for additional pressings.

[000140] The ability of the CFP 125 to reposition cake is not achievable by other technologies and methodologies, such as dewatering cells, geo-textile bags and belt filter presses. The ability to reposition the cake 751a, 751b substantially increases the ability to more completely and uniformly dewater and dehydrates the entire cake 751a, 751b mass faster, including the core of the cake. Dewatering and dehydrating the core of the cake 751a, 751b helps to prevent in blinding of the filter media. The prolonged exertion of pressure on a cake in a static position used by methods known by those skilled in the art may embed cake particles into pores of filter media. The more pressure that is exerted, the more embedded the solid particles may become. The ability of the CFP 125 of system 100 to release pressure on the cake 751a, 751b by the retraction of press walls 705, 717 and to reposition cake 751a, 751b on different areas of filter media 727 significantly mitigates filter media blinding. This is also a result of the ability of filter media to recoil as pressure on the cake mass is released. The combination of cake movement as pressure is released and filter media recoil, releases pressure on particles which may become stuck or embedded in pores of filter media. As pressure is released, cake 751a, 751b may move away from filter media 727 and smaller particles that become stuck in the pores of filter media 727 will often attach to larger cake particles and be extracted from the pores of the filter media 727 along with larger particles. The expression of compressed air is a further enhancement to backflow and clear filter media.

[000141] The CFP 125 as described herein may also exert significantly greater pressure for a

shorter period of time to achieve better results of uniformly reduced cake moisture content than plate and frame filter presses and belt filter presses. Increases in pressure under a shorter period of time may be achieved by the combination of pressure being expressed in an enclosed cavity, and periodically repositioning the sludge mass. The design of the CFP 125 enables compressing sludge into a cake of any desired thickness with uniformly reduced moisture content throughout the entirety of cake in reduced time. Uniformly reduced moisture content is achieved by exerting a high pressure on sludge in an enclosed dynamically sized cell and periodically or cyclically repositioning the cake enabling reconsolidation of the cake by periodically or cyclically contracting and retracting the press wall or walls.

[000142] Dynamic adjustments of the cell space within the CFP 125 results in efficiencies not achievable by rotary presses, plate and frame filter presses, belt filter presses, centrifuges, dewatering cells or geo-textile bags. This efficiency enables the system to process and discharge sludge at a rate equal to the amount of sludge entering the system, known as dynamic equilibrium, by eliminating HRT required by geo-textile bag and dewatering cells. For example, a 30 cubic yard dewatering cell typically requires 24 hours or longer to sufficiently dewater sludge to form cake that can pass a Paint Filter Test, thus a vessel sturdy enough to hold sludge during the dewatering HRT is required. The vessel would typically have an empty weight of about 6,760 pounds, plus the weight of 30 cubic yards of sludge with a SG of 1.5, or about 75,811 pounds, resulting in an operational weight of about 82,571 and a foot print of 170 square feet. Geo-textile bags can hold about 3.75 cubic yards of comparable sludge per linear foot in a 45 foot circumference bag. Therefore, in order to process a comparable 30 cubic yards of sludge for 24 hours of HRT (even though a geo-textile bag's HRT is considerably longer), would require an 8 foot long bag having a 45 foot circumference, that would weigh about 534 pounds, resulting in an operational weight of 76,345 pounds on a 180 square foot footprint. In order to continuously process slurry for 24 hours, the HRT typically required for dewatering cells, would require the operational weight and footprint of both dewatering cells and bags to be increased by a factor of 12 (Chart 4), or 909,727 pounds and 900,251 pounds respectively.

[000143] The system's 100 ability to more efficiently dewater and dehydrate sludge into cake than rotary presses, centrifuges, plate and frame presses, and belt filter presses, reduces the operational weight and footprint. The MVC 121 and CFP 125 may have a combined empty weight of 1,880 pounds, a combined operational weight of 2,565 pounds and a 24 square foot footprint. A rotary press capable of processing 500 GPM flow rate of the aforementioned slurry, would require an empty weight of 29,162 pounds and an operational weight of 41,162 pounds on a 382.2 square foot footprint. Belt filter press operation capable of processing 500 GPM flow rate of the aforementioned slurry, would require two or more belt filter presses having a combined empty weight of 70,000 pounds and a combined operational weight of 75,710 pounds on a 291.2 square foot footprint.

[000144] Likewise, a plate and frame filter press capable of processing 500 GPM flow rate of the aforementioned slurry, would have an empty weight of 313,518 pounds and an operational weight of 362,906 pounds on a 1,015.8 square foot footprint. When the MVC and CFP are juxtaposed to rotary presses, belt filter presses and plate and frame filter presses, there is a greater than 80% reduction in

empty weight, operational weight and footprint requirements. The reduction in empty weight and operational weight permits the employment of lighter and less expensive fabricating materials, along with reducing the associated structural engineering and construction requirements, and related costs.

[000145] The system's 100 ability to combine primary, secondary and tertiary dewatering on a singular vertically stacked footprint enables gravitational conveyance of sludge between each of the modules, which eliminates the need for pumping, mechanical tipping or mechanical excavating, along with the associated manpower, energy, resources, ancillary equipment and related expenses. This is due in part to the system's 100 employment of the NDC 115, which reduces moisture content within the sludge which is not achievable by settling clarifiers due to their design of sedimented sludge accumulating in a water covered environment, coupled with the formation of sludge blankets trapping interstitial water. The resulting sludge accumulated in a settling clarifier is a saturated and water laden slurry with low viscosity, and therefore not easily transportable or conveyed to downstream dewatering technologies by means other than pumping. The reduced moisture content and higher viscosity of sludge processed by the NDC 115, due to its nested-filter and gutter drain design, enables gravitational discharge and conveyance of resulting sludge, thereby eliminating pumping, mechanical tipping or mechanical excavating, and the associated manpower, resources, ancillary equipment and related expenses. All currently known dewatering cells and boxes employ an open sub-floor design to capture and discharge filtrated water, thereby not allowing for sludge to be gravitationally evacuated through the bottom of the cell, and therefore require tipping or excavation of the sludge for evacuation of sludge.

[000146] The DFC 101 and NDC 115 may have a combined operational footprint of 2,874 pounds and 24 square feet. The MVC 121 and CFP 125 have a combined operational footprint of 2,565 pounds and 24 square feet. The ability to combine all modules onto a singular operational footprint, results in an operational weight of 5,439 pounds on a singular 24 square feet footprint. Preferably the modules have a combined weight of less than 6,000 pounds. Two modules would have a combined weight of less than 12,000 pounds and three modules would have a combined weight of less than 18,000 pounds. A pickup truck or SUV would be able to haul three modules with a combined weight of 18,000 pounds if it has the ability to pull 20,000 pounds. Preferably the modules combined would have a weight of less than 25,000 pounds, more preferably would have a weight of less than 23,000 pounds, more preferably would have a weight of less than 20,000 pounds. A single dewatering unit comprising multiple modules would preferably have a weight of less than 10,000 pounds, more preferably would have a weight of less than 7500 pounds and more preferably has a weight of less than 6,000 pounds. The foot print of multiple modules preferably has a combined foot print of less than 100 square feet, preferably has a foot print of less than 75 square feet and preferably has a foot print of less than 50 square feet. A single dewatering unit comprising multiple modules preferably has a foot print of less than 40 square feet, more preferably has a foot print of less than 30 square feet and most preferably has a foot print of less than 25 square feet. Due to footprint size, empty weight, operational weight, fabrication materials and engineering requirements, the ability to merge any combination of the aforementioned technologies, such as the stacking of a settling clarifier onto a belt filter press, on a single compact and mobile footprint, is

impractical (See Table 1 above). The system's 100 ability to unify primary, secondary and tertiary dewatering onto a single vertically stacked compact footprint, also eliminates the need for pumps, piping, power and conveying mechanisms within and between technologies, along with polishing technology and spill containment equipment, resulting in a reduction of manpower and operational attention.

[000147] Furthermore, due to the compact footprint and immediate proximity of the system, one operator can manage multiple systems simultaneously. Employing PLCs, cameras and communication systems, enables remote attention and management. The design of the entire system 100 eliminates HRT, enabling dynamic equilibrium operation, due to the ability of all modules and components to dewater and discharge processed water and sludge at the same rate as the slurry is received by the system 100.

Dynamic equilibrium operation is accomplished by eliminating the HRT required by settling clarifiers, dewatering cells and geo-textile bags.

Dynamic operation cannot be accomplished by previously known technologies without dimensional scaling by dewatering cells due to their sub-floor design, or by geo-textile bags, as they must be cut open, once a static, natural attenuation dewatering process is completed in order for sludge to be evacuated, or by plate and frame filter presses which operate in extended time batch operation.

[000148] While this disclosure has been described in conjunction with the specific embodiments outlined above, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, the preferred embodiments of the present disclosure as set forth above are intended to be illustrative, not limiting. Various changes may be made without departing from the spirit and scope of the invention, as required by the following claims. The claims provide the scope of the coverage of the invention and should not be limited to the specific examples provided herein.

CLAIMS

1. A separation and filtration system comprising:
a dynamic filtration clarifier (DFC) comprising a uniform laminar flow (ULF) component positioned adjacent to a multi-layer self-cleaning filter (MSF);
the ULF comprises a rotatable axle having a blade extending from the axle, an outlet slot and a discharge plate attached to a lower edge of the outlet slot;
the MSF comprises a frame housing a layer of filter media, a drain pan attached to the frame and an outlet configured to discharge contents of the drain pan from the MSF;
a nested-filter dewatering cell (NDC) connected to the MSF of the DFC, the NDC confined by exterior walls and a partitioning wall separating each cell of the NDC within the exterior walls, wherein each cell of the NDC comprises a nested filter and a directional plate; and
a compression filter press (CFP) having a moveable wall and a moving mechanism configured to compress the moveable wall.
2. The separation and filtration system of claim 1, wherein the blade of the ULF compartmentalizes a section of slurry received by the ULF and outputs the slurry to the discharge plate uniformly as the axle rotates the blades centrifugally.
3. The separation and filtration system of claim 2, wherein the axle rotates the blade downward through a force of gravity and pushes the section of slurry toward the outlet slot.
4. The separation and filtration system of claim 1, wherein the frame further comprises:
an orifice positioned along the frame configured to blow compressed air onto the layer of filter media.
5. The separation and filtration system of claim 1, wherein the frame further comprises:
a channel or groove along an edge of the frame, wherein the edge of the frame operates as an air knife.
6. The separation and filtration system of claim 1, wherein the layer filter media oscillates and recoils.
7. The separation and filtration system of claim 1, wherein the MSF receives a slurry distributed from the ULF onto the layer of filter media and the MSF dewateres a liquid from flocs and suspended solids of the slurry as the slurry flows over the filter media.
8. The separation and filtration system of claim 7, wherein the liquid dewatered from the flocs and the suspended solids pass through the filter media and the liquid is collected by the drain pan.
9. The separation and filtration system of claim 8, wherein the outlet of the MSF further comprises:
an outlet filtration media, wherein the liquid collected by the drain pan is discharged through the outlet filtration media.
10. The separation and filtration system of claim 1, wherein an interior surface of the exterior walls, partitioning walls and nested filter are covered with a filter media.
11. The separation and filtration system of claim 10, further comprising: a gutter drain positioned on the posterior surface of the NDC.

12. The separation and filtration system of claim 11, wherein the gutter drain comprises: a conduit positioned beneath the interior surface of the exterior walls, partitioning walls and nested filter; an evacuation outlet; and an NDC outlet.
13. The separation and filtration system of claim 11, wherein the NDC separates interstitial liquid of a sludge from solid particles of the sludge and the interstitial liquid of the sludge filters through the filter media into the gutter drain.
14. Separation and filtration system of claim 1, wherein a vacuum or compressed air is introduced into each cell of the NDC.
15. The separation and filtration system of claim 1, wherein the NDC further comprises a dynamic fluidized press plate.
16. The separation and filtration system of claim 1, further comprising a metered volume controller (MVC) having an MVC axle, a motor configured to rotate the MVC axle and one or more opposing blades protruding from the MVC axle.
17. The separation and filtration system of claim 1, wherein the CFP further comprises: a pair of fixed side walls; a press wall positioned opposite of the movable, wall wherein a filter media covers the press wall, a closable inlet portal; and a closable outlet portal.
18. The separation and filtration system of claim 1, wherein the moveable wall is covered with a filter media.
19. The separation and filtration system of claim 1, wherein the moveable wall includes a dynamic fluidized press plate comprising a sealed bladder and a fill port.
20. The separation and filtration system of claim 1, wherein the CFP further comprises: an injection manifold having an injection port; and a plurality of nozzles connected to the injection manifold.
21. The separation and filtration system of claim 20, wherein the injection manifold further comprises a portal selected from the group consisting of a compressed air portal, vacuum portal and a combination thereof.
22. The separation and filtration system of claim 1, further comprising: a pump connected to an inlet of the DFC; and a sorbent storage container comprising a partition separating a sorbent material from a recovered material and a spray cannon configured to disperse the sorbent material contained in the sorbent storage container.
23. The separation and filtration system of claim 1, wherein the partition wall shifts positions as the sorbent material is dispersed from the sorbent storage container.
24. A separation and filtration system comprising:
A multi-layer self-cleaning filter (MSF) comprising a frame housing a layer of filter media, a drain pan attached to the frame and an outlet configured to discharge contents of the drain pan from the MSF; and a nested-filter dewatering cell (NDC) connected to the MSF of the DFC, the NDC confined by exterior walls and a partitioning wall separating each cell of the NDC within the exterior walls, wherein each cell of the NDC comprises a nested filter and a directional plate.

25. The separation and filtration system of claim 24, wherein the frame further comprises: an orifice positioned along the frame configured to blow compressed air onto the layer of filter media.
26. The separation and filtration system of claim 24, wherein the frame further comprises: a channel or groove along an edge of the frame, wherein the edge of the frame operates as an air knife.
27. The separation and filtration system of claim 24, wherein the layer filter media oscillates and recoils.
28. The separation and filtration system of claim 24, wherein an interior surface of the exterior walls, partitioning walls and nested filter are covered with a filter media.
29. The separation and filtration system of claim 24, further comprising: a gutter drain positioned on the posterior surface of the NDC.
30. The separation and filtration system of claim 29, wherein the gutter drain comprises: a conduit positioned beneath the interior surface of the exterior walls, partitioning walls and nested filter; an evacuation outlet; and an NDC outlet.
31. The separation and filtration system of claim 29, wherein the NDC separates interstitial liquid of a sludge from solid particles of the sludge and the interstitial liquid of the sludge filters through the filter media into the gutter drain.
32. The separation and filtration system of claim 24 wherein a vacuum or compressed air is introduced into each cell of the NDC.
33. The separation and filtration system of claim 24, wherein the NDC further comprises a dynamic fluidized press plate.
34. A separation and filtration system comprising: a nested-filter dewatering cell (NDC) the NDC confined by exterior walls and a partitioning wall separating each cell of the NDC within the exterior walls, wherein each cell of the NDC comprises a nested filter and a directional plate; and a compression filter press (CFP) adjacent to the NDC, the CFP having a moveable wall and a moving mechanism configured to compress the moveable wall.
35. The separation and filtration system of claim 34, wherein an interior surface of the exterior walls, partitioning walls and nested filter are covered with a filter media.
36. The separation and filtration system of claim 35, further comprising: a gutter drain positioned on the posterior surface of the NDC.
37. The separation and filtration system of claim 34, wherein the gutter drain comprises:
a conduit positioned beneath the interior surface of the exterior walls, partitioning walls and nested filter; an evacuation outlet; and an NDC outlet.
38. The separation and filtration system of claim 35, wherein the NDC separates interstitial liquid of a sludge from solid particles of the sludge and the interstitial liquid of the sludge filters through the filter media into the gutter drain.
39. Separation and filtration system of claim 34, wherein a vacuum or compressed air is introduced into each cell of the NDC.

40. The separation and filtration system of claim 34, wherein the NDC further comprises a dynamic fluidized press plate.
41. The separation and filtration system of claim 34, further comprising a metered volume controller (MVC) between the NDC and the CFP, the MVC having an MVC axle, a motor configured to rotate the MVC axle and one or more opposing blades protruding from the MVC axle.
42. The separation and filtration system of claim 34, wherein the CFP further comprises: a pair of fixed side walls; a press wall positioned opposite of the movable, wall wherein a filter media covers the press wall, a closable inlet portal; and a closable outlet portal.
43. The separation and filtration system of claim 34, wherein the press wall is covered with a filter media.
44. The separation and filtration system of claim 34, wherein the moveable wall includes a dynamic fluidized press plate comprising a sealed bladder and a fill port.
45. The separation and filtration system of claim 34, wherein the CFP further comprises: an injection manifold having an injection port; and a plurality of nozzles connected to the injection manifold.
46. The separation and filtration system of claim 45, wherein the injection manifold further comprises a portal selected from the group consisting of a compressed air portal, vacuum portal and a combination thereof.
47. A method of dewatering comprising:
providing a dewatering system having a weight of less than 25,000 pounds; transporting the dewatering system to a dewatering site; and separating and/or filtering a solid-liquid mass at the dewatering site at a rate exceeding 400 gallons per minute with the dewatering system.
48. The method of claim 47, wherein the weight of the dewatering system is 23,000 pounds or less.
49. The method of claim 47, wherein the weight of the dewatering system is less than 10,000 pounds.
50. The method of claim 47, wherein the size of the dewatering system is 100 inches or less by 80 inches or less.
51. A dewatering device comprising:
dewatering apparatus having a weight of less than 25,000 pounds; and wherein the dewatering apparatus having apparatus for separating and/or filtering a solid- liquid mass at a rate exceeding 400 gallons per minute.
52. The dewatering device of claim 51, wherein the weight of the dewatering system is 23,000 pounds or less.
53. The dewatering device of claim 51, wherein the weight of the dewatering system is 6,000 pounds or less.
54. The dewatering device of claim 51, wherein the size of the dewatering system is 100 inches or less by 80 inches or less.

AMENDED CLAIMS
received by the International Bureau on 14 July 2017 (14.07.2017)

I claim:

1. A separation and filtration system comprising:
a dynamic filtration clarifier (DFC) comprising a uniform laminar flow (ULF) component positioned adjacent to a multi-layer self-cleaning filter (MSF);
the MSF comprises a frame housing a layer of filter media, a drain pan attached to the frame and an outlet configured to discharge contents of the drain pan from the MSF;
a nested-filter dewatering cell (NDC) connected to the MSF of the DFC, the NDC confined by exterior walls and a partitioning wall separating each cell of the NDC within the exterior walls, wherein each cell of the NDC comprises a nested filter and a directional plate; and
a compression filter press (CFP) having fixed side walls, either a moveable wall connected to a moving mechanism configured to compress the moveable wall against one of the fixed side walls or an expandable bladder positioned between the fixed side walls.
2. The separation and filtration system of claim 1, wherein the ULF further comprises a rotatable axle having a blade extending from the axle, an outlet slot and a discharge plate attached to a lower edge of the outlet slot and the blade of the ULF compartmentalizes a section of slurry received by the ULF and outputs the slurry to the discharge plate uniformly as the axle rotates the blades centrifugally.
3. The separation and filtration system of claim 2, wherein the axle rotates the blade downward through a force of gravity and pushes the section of slurry toward the outlet slot.

4. The separation and filtration system of claim 1, wherein the frame further comprises:
an orifice positioned along the frame configured to blow compressed air onto the layer of filter media.
5. The separation and filtration system of claim 1, wherein the frame further comprises:
a channel or groove along an edge of the frame, wherein the edge of the frame operates as an air knife.
6. The separation and filtration system of claim 1, wherein the layer filter media oscillates and recoils.
7. The separation and filtration system of claim 1, wherein the MSF receives a slurry distributed from the ULF onto the layer of filter media and the MSF dewateres a liquid from flocs and suspended solids of the slurry as the slurry flows over the filter media.
8. The separation and filtration system of claim 7, wherein the liquid dewatered from the flocs and the suspended solids pass through the filter media and the liquid is collected by the drain pan.
9. The separation and filtration system of claim 8, wherein the outlet of the MSF further comprises:
an outlet filtration media, wherein the liquid collected by the drain pan is discharged through the outlet filtration media.
10. The separation and filtration system of claim 1, wherein an interior surface of the

exterior walls, partitioning walls and nested filter are covered with a filter media.

11. The separation and filtration system of claim 10, further comprising:

a gutter drain positioned on the posterior surface of the NDC.

12. The separation and filtration system of claim 11, wherein the gutter drain comprises:

a conduit positioned beneath the interior surface of the exterior walls, partitioning walls and nested filter;

an evacuation outlet; and

an NDC outlet.

13. The separation and filtration system of claim 11, wherein the NDC separates interstitial liquid of a sludge from solid particles of the sludge and the interstitial liquid of the sludge filters through the filter media into the gutter drain.

14. Separation and filtration system of claim 1, wherein a vacuum or compressed air is introduced into each cell of the NDC.

15. The separation and filtration system of claim 1, wherein the NDC further comprises a dynamic fluidized press plate.

16. The separation and filtration system of claim 1, further comprising a metered volume controller (MVC) having an MVC axle, a motor configured to rotate the MVC axle and one or more opposing blades protruding from the MVC axle.

17. The separation and filtration system of claim 1, wherein the CFP further comprises:
 - a filter media covering one or more of the fixed side walls;
 - a closable inlet portal; and
 - a closable outlet portal.
18. The separation and filtration system of claim 1, wherein the moveable wall is covered with a filter media.
19. The separation and filtration system of claim 1, wherein the moveable wall includes a dynamic fluidized press plate comprising a sealed bladder and a fill port.
20. The separation and filtration system of claim 1, wherein the CFP further comprises:
 - an injection manifold having an injection port; and
 - a plurality of nozzles connected to the injection manifold.
21. The separation and filtration system of claim 20, wherein the injection manifold further comprises a portal selected from the group consisting of a compressed air portal, vacuum portal and a combination thereof.

22. The separation and filtration system of claim 1, further comprising:

a pump connected to an inlet of the DFC; and

a sorbent storage container comprising a partition separating a sorbent material from a recovered material and a spray cannon configured to disperse the sorbent material contained in the sorbent storage container.

23. The separation and filtration system of claim 21, wherein the partition shifts positions as the sorbent material is dispersed from the sorbent storage container.

24. A separation and filtration system comprising:

A multi-layer self-cleaning filter (MSF) comprising a frame housing a layer of filter media, a drain pan attached to the frame and an outlet configured to discharge contents of the drain pan from the MSF; and

a nested-filter dewatering cell (NDC) connected to the MSF of the DFC, the NDC confined by exterior walls and a partitioning wall separating each cell of the NDC within the exterior walls, wherein each cell of the NDC comprises a nested filter and a directional plate.

25. The separation and filtration system of claim 24, wherein the frame further comprises:

an orifice positioned along the frame configured to blow compressed air onto the layer of filter media.

26. The separation and filtration system of claim 24, wherein the frame further comprises:
a channel or groove along an edge of the frame, wherein the edge of the frame operates as an air knife.
27. The separation and filtration system of claim 24, wherein the layer filter media oscillates and recoils.
28. The separation and filtration system of claim 24, wherein an interior surface of the exterior walls, partitioning walls and nested filter are covered with a filter media.
29. The separation and filtration system of claim 24, further comprising:
a gutter drain positioned on the posterior surface of the NDC.
30. The separation and filtration system of claim 29, wherein the gutter drain comprises:
a conduit positioned beneath the interior surface of the exterior walls, partitioning walls and nested filter;
an evacuation outlet; and
an NDC outlet.
31. The separation and filtration system of claim 29, wherein the NDC separates interstitial liquid of a sludge from solid particles of the sludge and the interstitial liquid of the sludge filters through the filter media into the gutter drain.

32. The separation and filtration system of claim 24 wherein a vacuum or compressed air is introduced into each cell of the NDC.

33. The separation and filtration system of claim 24, wherein the NDC further comprises a dynamic fluidized press plate.

34. A separation and filtration system comprising:

a nested-filter dewatering cell (NDC) the NDC confined by exterior walls and a partitioning wall separating each cell of the NDC within the exterior walls, wherein each cell of the NDC comprises a nested filter and a directional plate; and

a compression filter press (CFP) adjacent to the NDC, the CFP having fixed side walls and either a moveable wall connected to a moving mechanism configured to compress the moveable wall against one of the fixed side walls or an expandable bladder positioned between the fixed side walls.

35. The separation and filtration system of claim 34, wherein an interior surface of the exterior walls, partitioning walls and nested filter are covered with a filter media.

36. The separation and filtration system of claim 35, further comprising:

a gutter drain positioned on the posterior surface of the NDC.

37. The separation and filtration system of claim 34, wherein the gutter drain comprises:
a conduit positioned beneath the interior surface of the exterior walls, partitioning walls
and nested filter;
an evacuation outlet; and
an NDC outlet.
38. The separation and filtration system of claim 35, wherein the NDC separates interstitial
liquid of a sludge from solid particles of the sludge and the interstitial liquid of the sludge filters
through the filter media into the gutter drain.
39. Separation and filtration system of claim 34, wherein a vacuum or compressed air is
introduced into each cell of the NDC.
40. The separation and filtration system of claim 34, wherein the NDC further comprises a
dynamic fluidized press plate having a sealed bladder configured to expand and increase
pressure within the NDC.
41. The separation and filtration system of claim 34 further comprising a metered volume
controller (MVC) between the NDC and the CFP, the MVC having an MVC axle, a motor
configured to rotate the MVC axle and one or more opposing blades protruding from the MVC
axle.

42. The separation and filtration system of claim 34, wherein the CFP further comprises:
a filter media covering one or more of the fixed side walls;
a closable inlet portal; and
a closable outlet portal.
43. The separation and filtration system of claim 34, wherein the moveable wall is covered with a filter media.
44. The separation and filtration system of claim 34, wherein the expandable bladder is a sealed bladder and having a fill port.
45. The separation and filtration system of claim 34, wherein the CFP further comprises:
an injection manifold having an injection port; and
a plurality of nozzles connected to the injection manifold.
46. The separation and filtration system of claim 45, wherein the injection manifold further comprises a portal selected from the group consisting of a compressed air portal, vacuum portal and a combination thereof.

47. A method of dewatering comprising:
- providing the separation and filtration system of claim 34, said separation and filtration system having a weight of less than 25,000 pounds;
 - transporting the separation and filtration system to a dewatering site; and
 - separating and/or filtering a solid-liquid mass at the dewatering site at a rate exceeding 400 gallons per minute with the separation and filtration system.
48. The method of claim 47, wherein the weight of the separation and filtration system is 23,000 pounds or less.
49. The method of claim 47, wherein the weight of the separation and filtration system is less than 10,000 pounds.
50. The method of claim 47, wherein the size of the separation and filtration system is 100 inches or less by 80 inches or less.
51. A dewatering device comprising:
- a dewatering apparatus having a compression filtration press (CFP) having fixed side walls and an expandable bladder positioned between the fixed side walls;
 - a weight of less than 25,000 pounds; and
 - wherein the dewatering apparatus having the dewatering apparatus for separating and/or filtering a solid- liquid mass at a rate exceeding 400 gallons per minute.

52. The dewatering device of claim 51, wherein the weight of the dewatering device is 23,000 pounds or less.

53. The dewatering device of claim 51, wherein the weight of the dewatering device is 6,000 pounds or less.

54. The dewatering device of claim 51, wherein the size of the dewatering device is 100 inches or less by 80 inches or less.

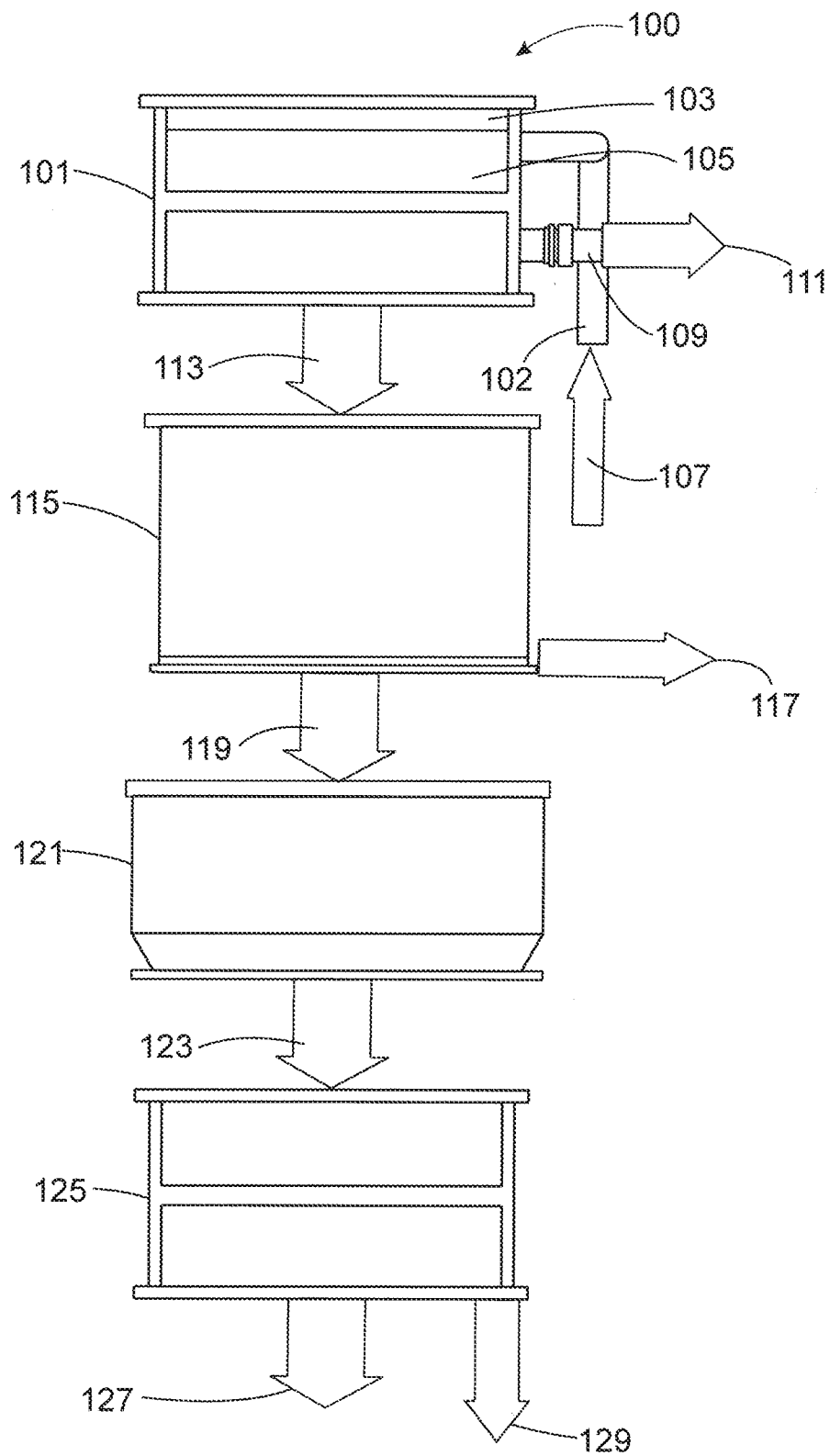


FIG. 1

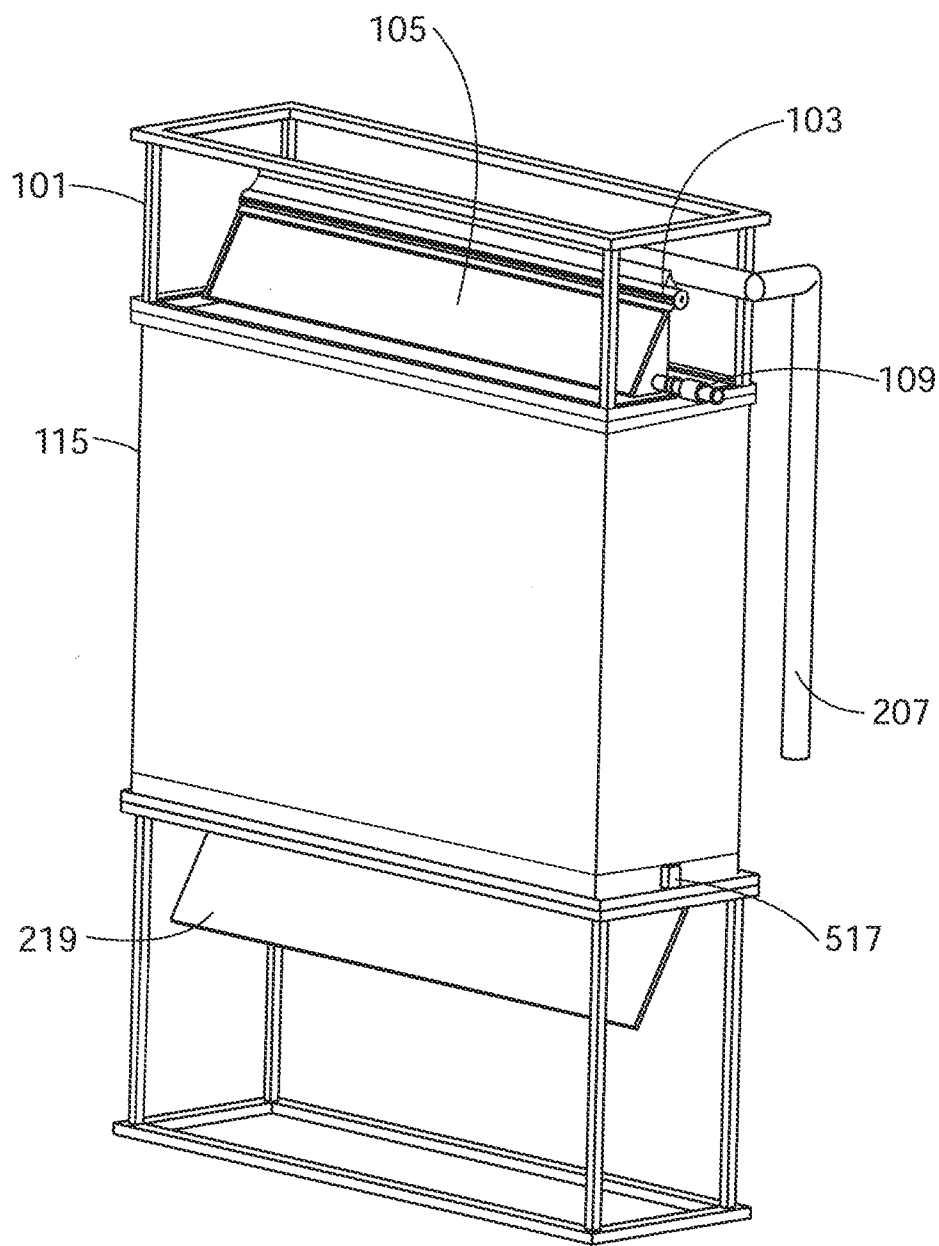


FIG. 2

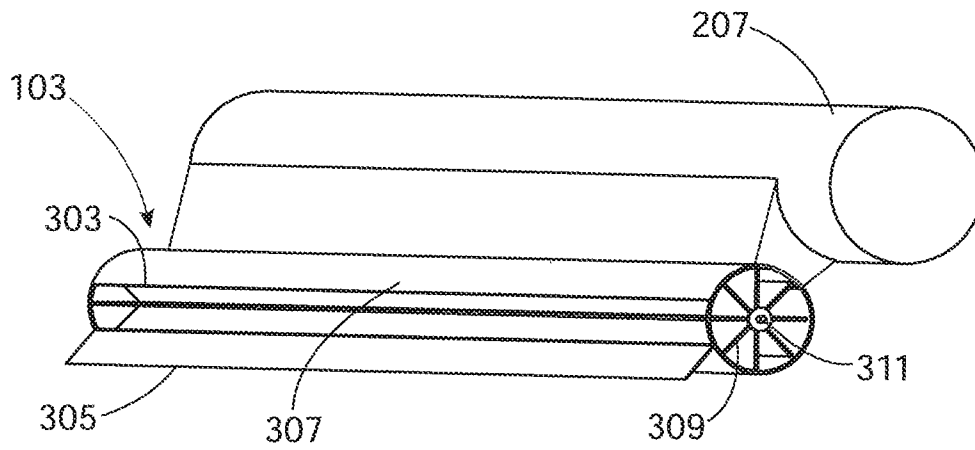


FIG. 3a

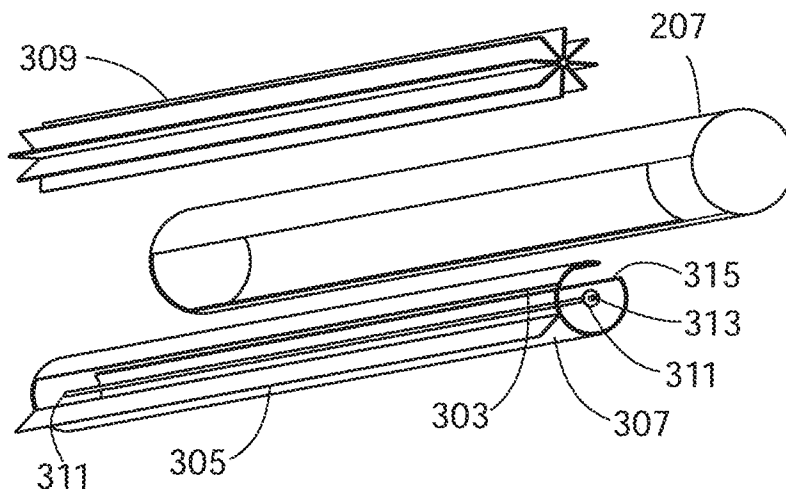


FIG. 3b

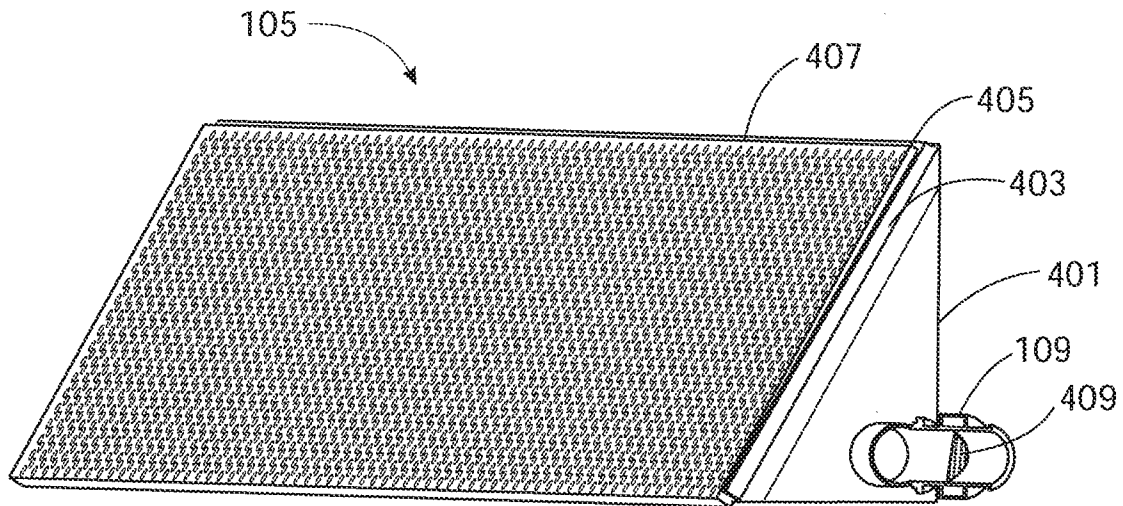


FIG. 4a

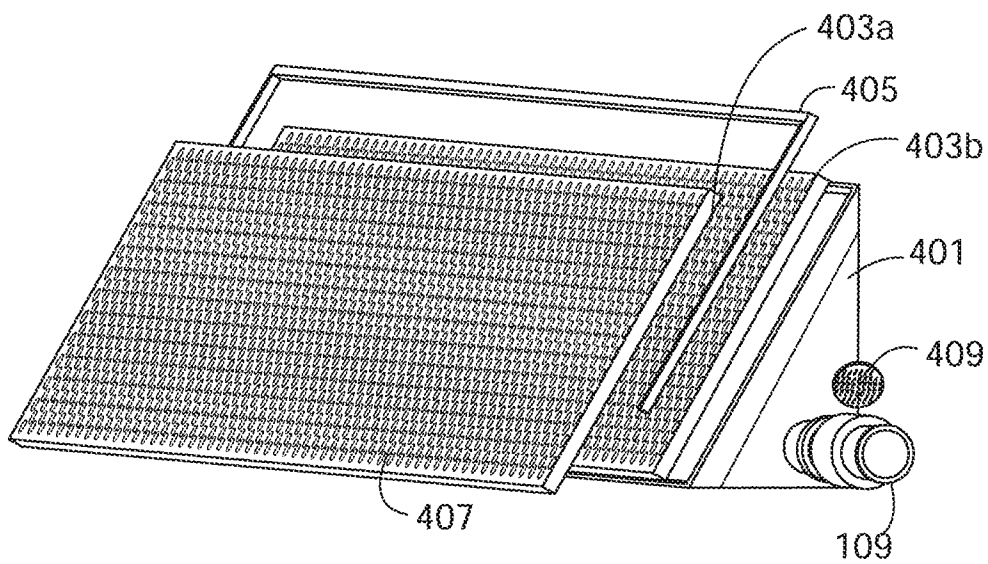


FIG. 4b

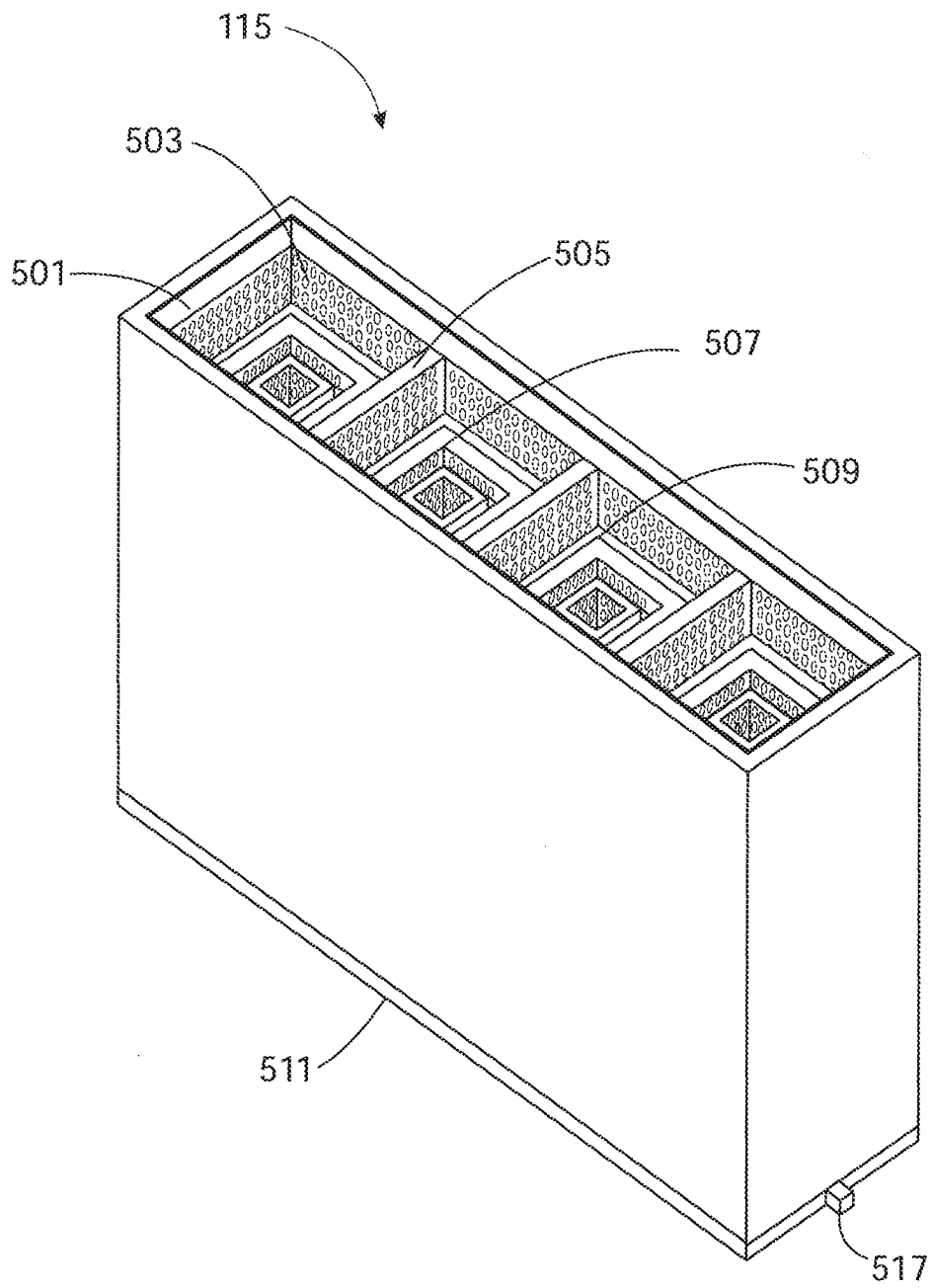
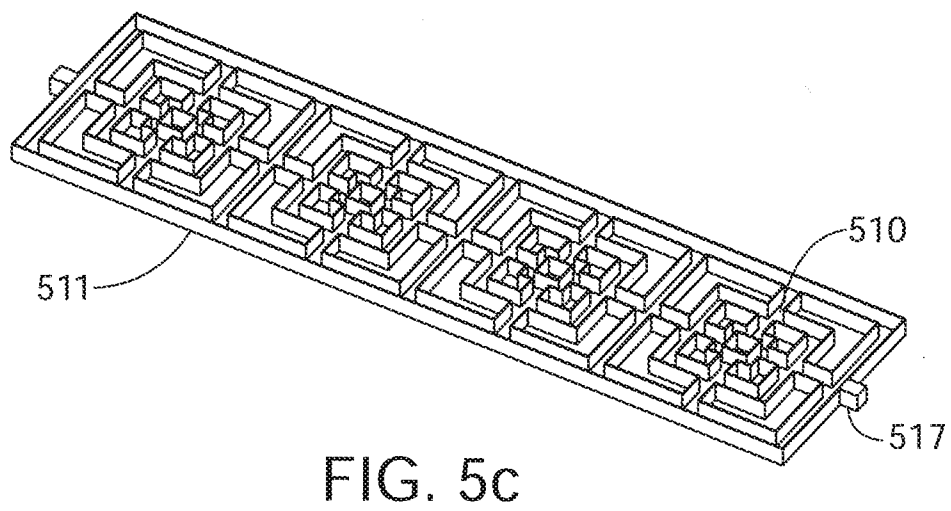
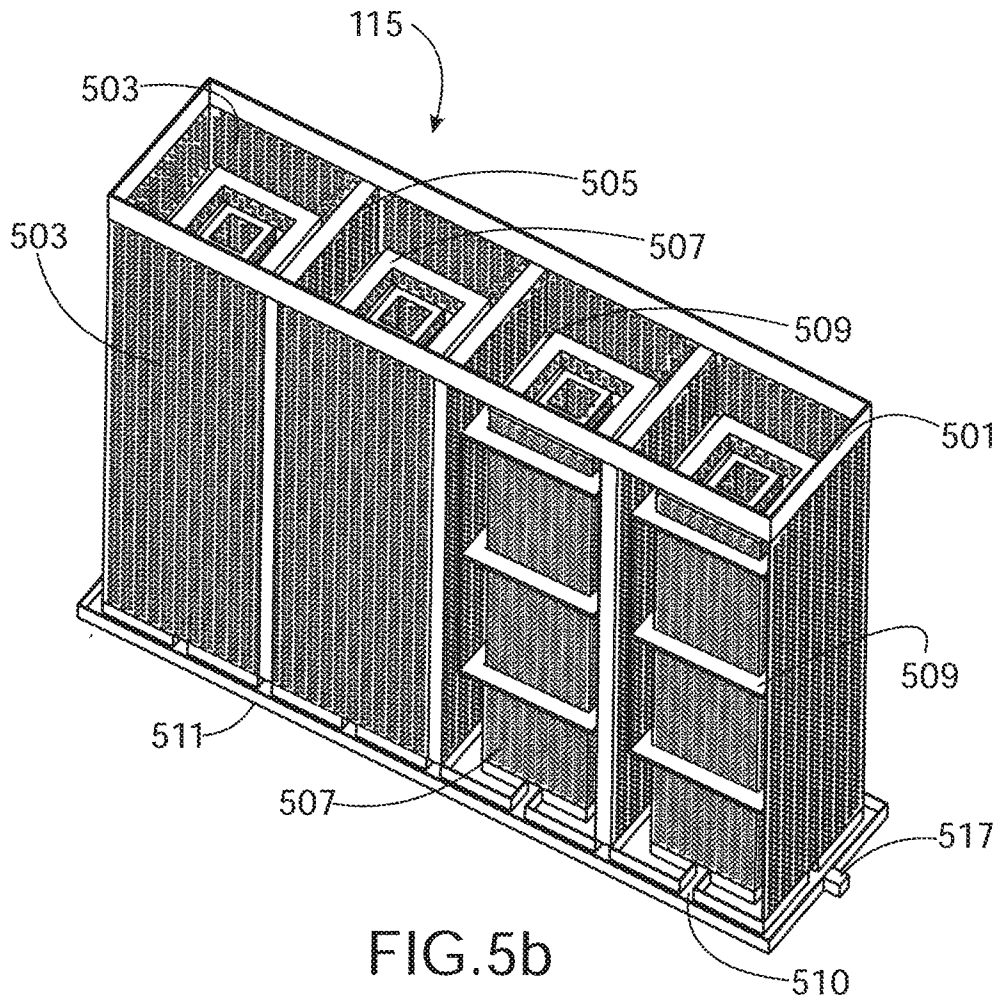


FIG. 5a



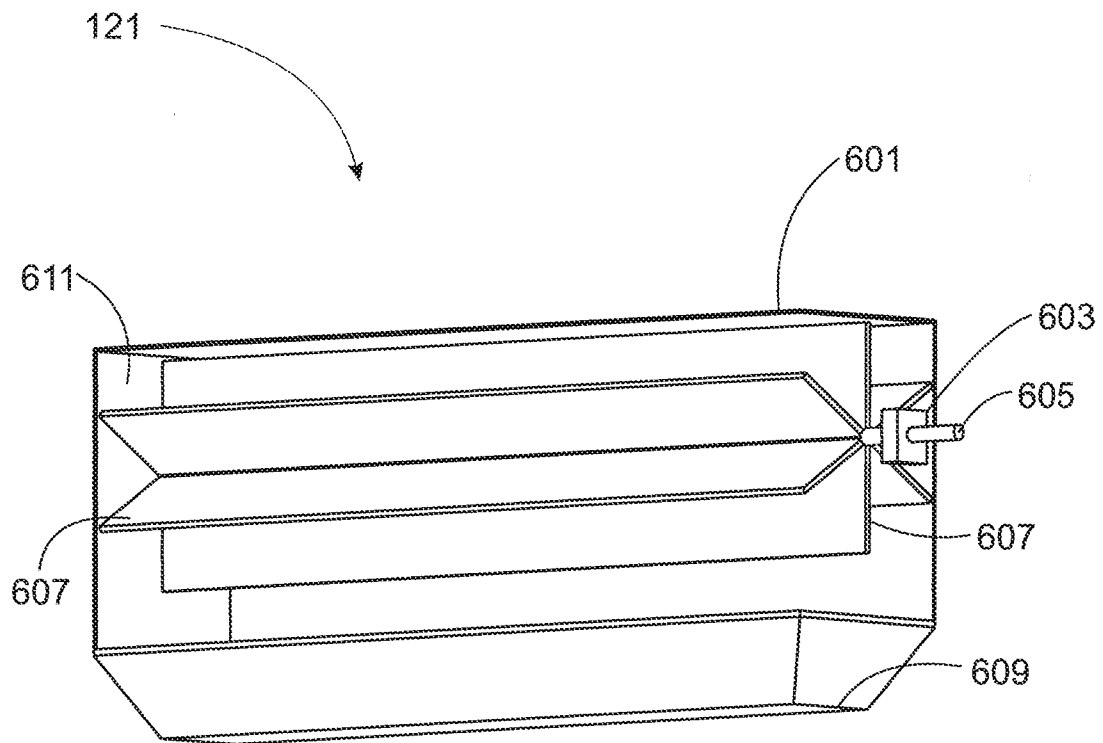


FIG. 6

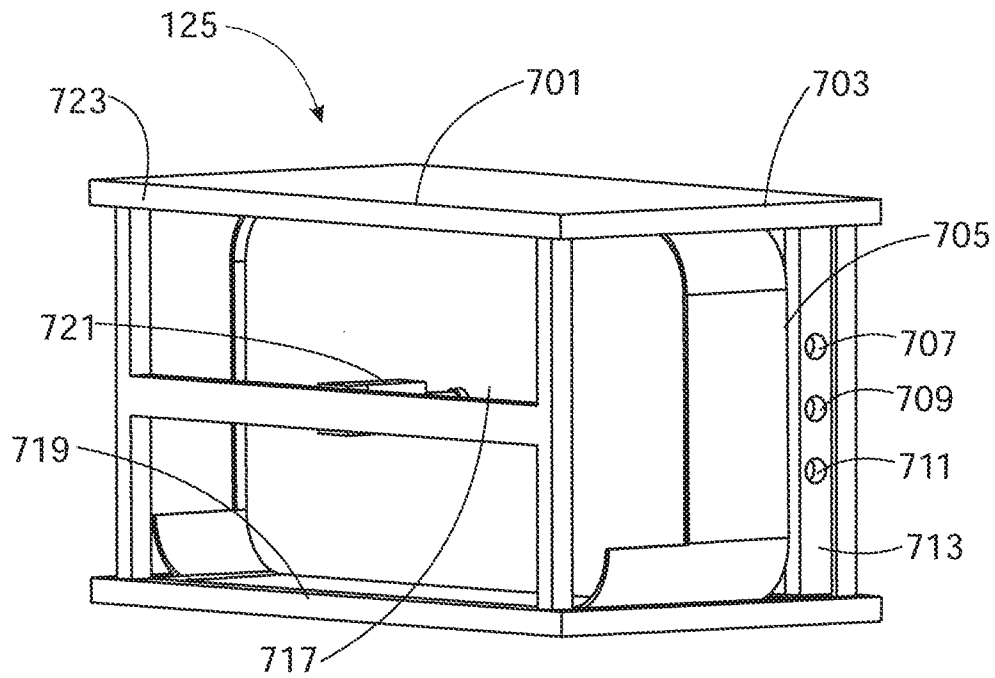


FIG. 7a

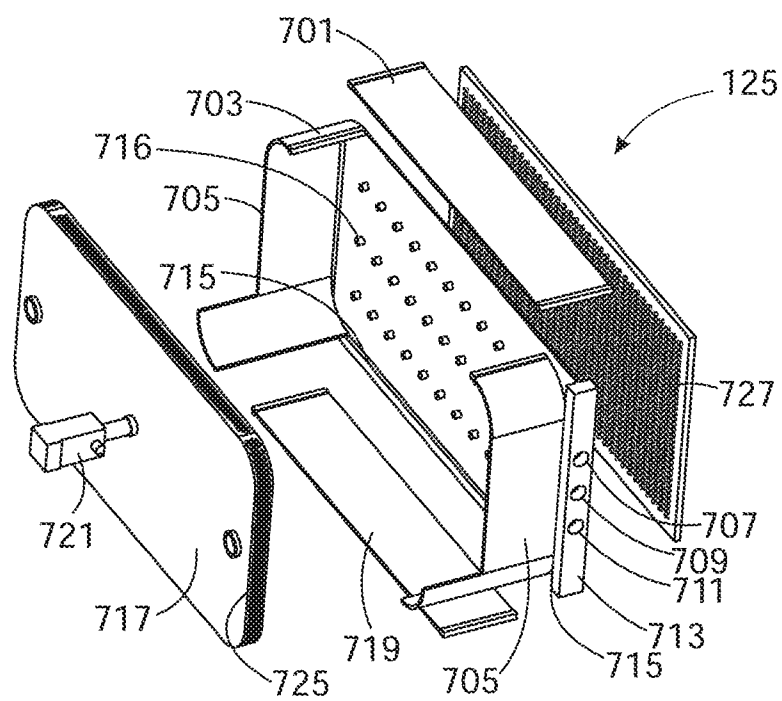


FIG. 7b

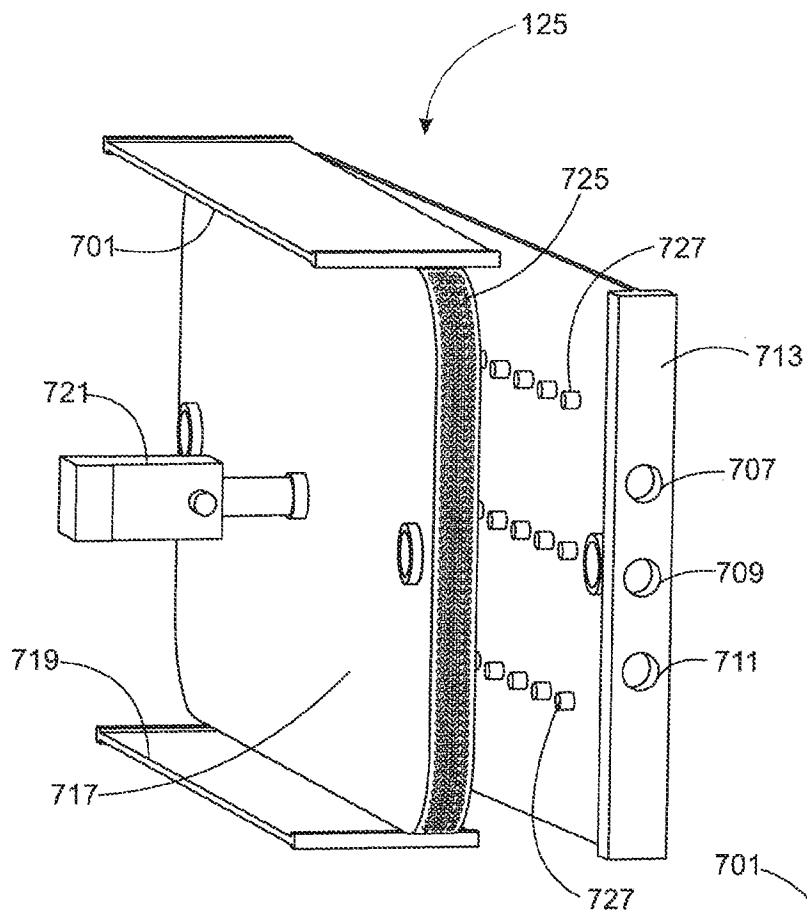


FIG. 7c

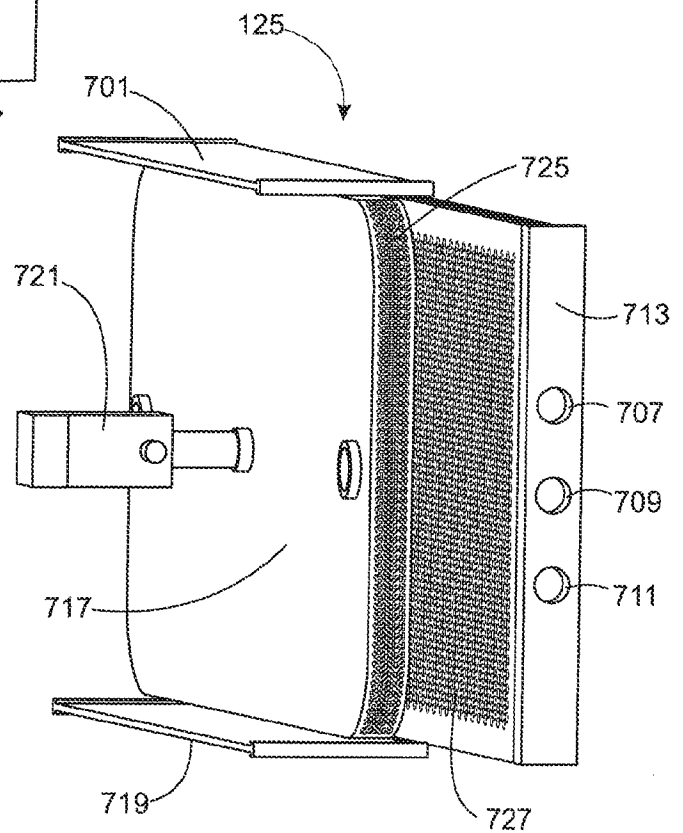


FIG. 7d

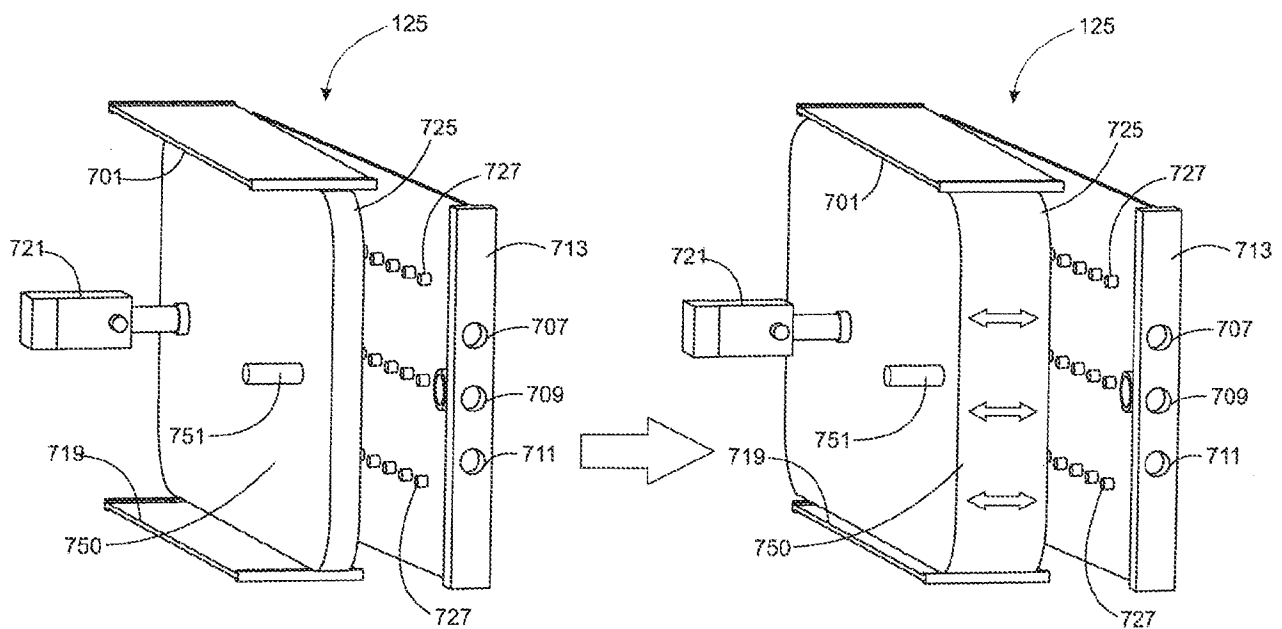


FIG. 7e

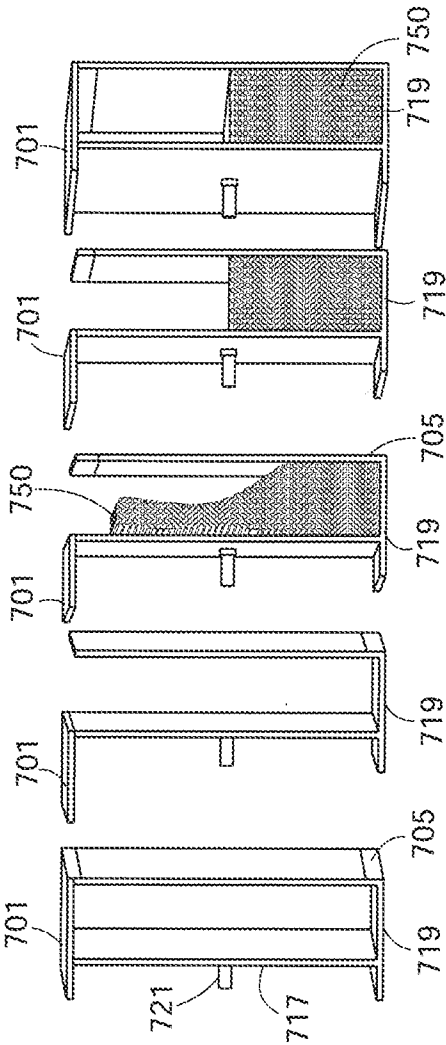


FIG. 8a

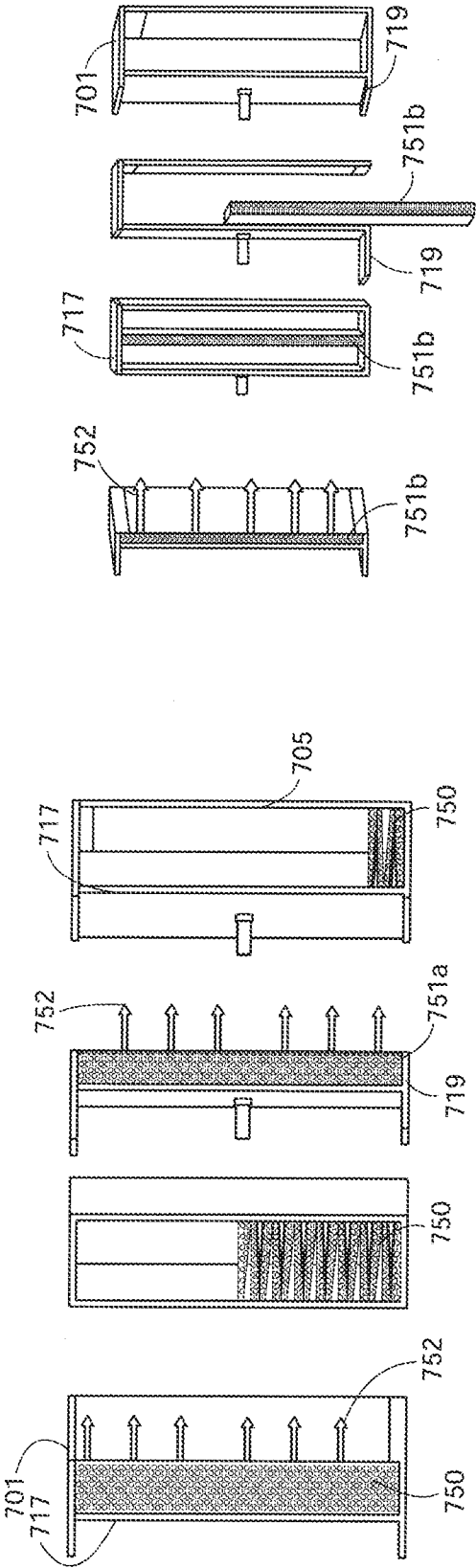


FIG. 8b

FIG. 8c

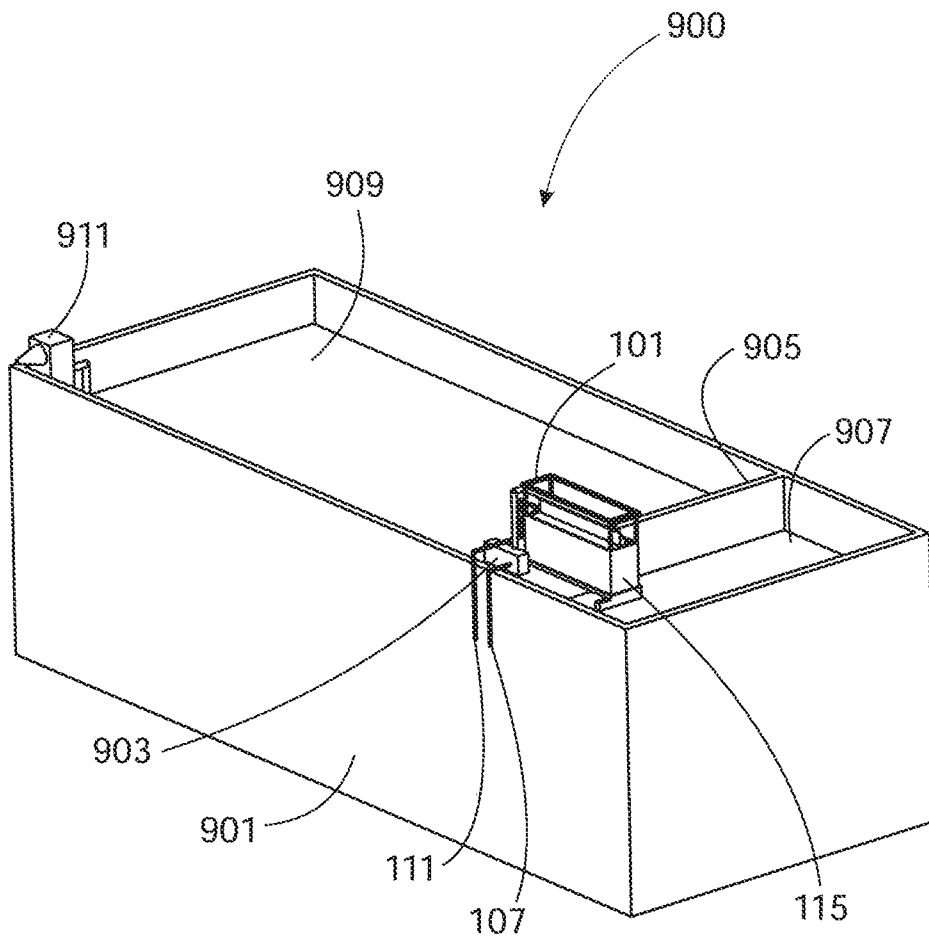


FIG. 9

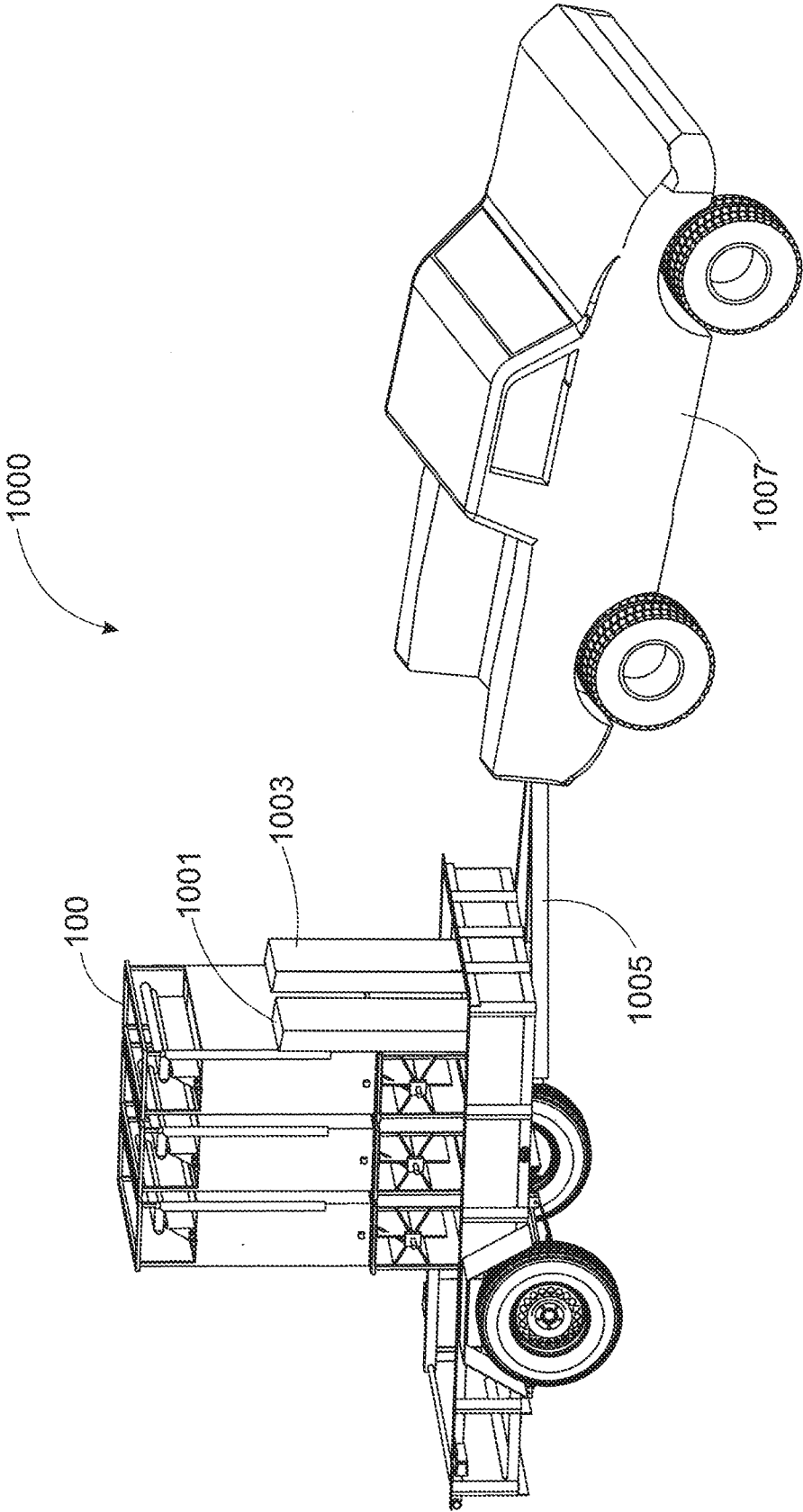


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US17/21287

A. CLASSIFICATION OF SUBJECT MATTER

IPC - C02F 11/12; B01D 33/052, 33/64, 33/70, 33/74, 33/76, 29/11, 29/13, 29/60, 29/76, (2017.01)
 CPC - C02F 11/12, 11/121, 11/122; B01D 33/0003, 33/0006, 33/64, 33/644, 33/74, 33/76, 33/804, 33/806, 29/0029, 29/05, 29/82, 29/88, 29/94, 35/30, 35/301, 35/303

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.
A	WO 2014/176057 A2 (VETTE, P) 30 October 2014; abstract; paragraphs [0007]-[0011], [0017]-[0019], [0025], [0030], [0036], [0041]-[0042]; claim 1	1-46
A	US 4,186,098 A (MORRIS, WE) 29 June 1980; column 2, lines 36-43; column 3, lines 9-15	1-33
A	US 5,403,481 A (KUPKA, M) 04 April 1995; abstract; figure 12; column 2, lines 37-44; column 10, lines 42-48	1-46
A	CN 104,860,504 A (RAO BINQI) 26 August 2015; abstract; paragraph [0023]; figure 1	1-23, 34-46
A	US 9,155,985 B2 (RTE WATER, INC.) 13 October 2015; abstract; column 2, lines 45-53; column 9, lines 15-20; column 10, lines 51-53; column 11, lines 34-54; column 14, lines 3-8	1-46
A	US 5,824,232 A (ASHER, TL et al.) 20 October 1998; abstract; figure 4; column 5, lines 19-37	24-33
A	US 2012/0312755 A1 (RYAN, D et al.) 13 December 2012; figure 3; paragraphs [0030], [0036], [0038], [0053]-[0054]	34-46

☐ 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
 "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

02 May 2017 (02.05.2017)

Date of mailing of the international search report

28 JUN 2017

Name and mailing address of the ISA/

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
 P.O. Box 1450, Alexandria, Virginia 22313-1450
 Facsimile No. 571-273-8300

Authorized officer

Shane Thomas

PCT Helpdesk: 571-272-4300
 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US17/21287

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 examined, the appropriate additional examination fees must be paid.

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 examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-46 are directed a separation and filtering system having a specific filtration cell arrangement

Group II: Claims 47-54 are directed towards a dewatering system having a specific processing parameters.

-***-Continued Within the Next 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.:
1-46

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

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.-***-Continued from Box V: Observations where unity of invention is lacking-***-

The inventions listed as Groups I-II 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:
the special technical features of Group I include A separation and filtration system comprising: a nested-filter dewatering cell (NDC) connected to the MSF of the DFC, the NDC confined by exterior walls and a partitioning wall separating each cell of the NDC within the exterior walls, wherein each cell of the NDC comprises a nested filter and a directional plate, which are not present in Group II; and the special technical features of Group II include a dewatering device comprising: dewatering apparatus having a weight of less than 25,000 pounds; and wherein the dewatering apparatus having apparatus for separating and/or filtering a solid-liquid mass at a rate exceeding 400 gallons per minute, which are not present in Group I.

The common features of Groups I-II are: a separation and filtration system.

These common technical features are disclosed by US 2010/0243575 A1 (NOWLING).

Nowling discloses a separation and filtration device (an apparatus for separating and filtering a solid-liquid mixture; abstract).

Since the common technical features are previously disclosed by Nowling, these common features are not special and so Groups I-II lack unity.