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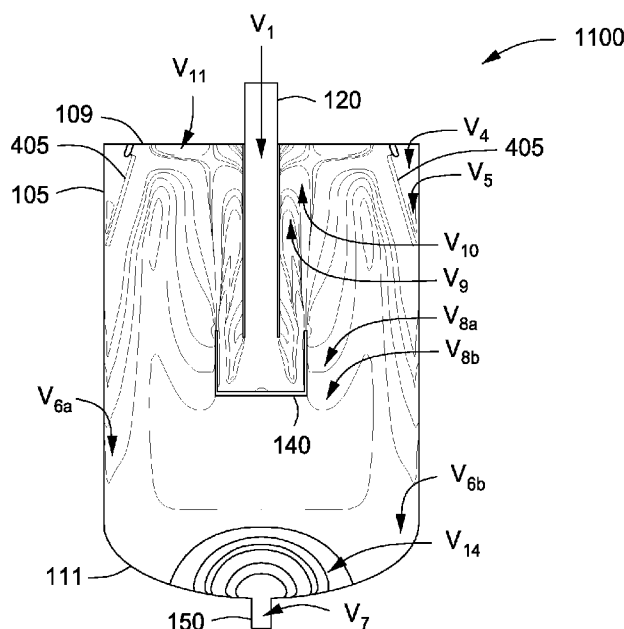


FIG. 11

(57) Abstract: Apparatus and methods for separating particulates from a liquid are provided. The apparatus comprises a vessel and a conduit at least partially disposed within the vessel. The vessel can include a first end, an enclosed second end, and an internal volume. A first end of the conduit can be disposed within the internal volume such that a flow path from the first end of the conduit is directed toward the enclosed second end. A first baffle can be disposed between the first end of the conduit and the enclosed second end such that the direction of the flow path from the conduit is altered by the baffle. An outlet can be disposed on the enclosed second end of the vessel.



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APPARATUS AND METHODS FOR SEPARATING PARTICULATES FROM A LIQUID

BACKGROUND

[0001] Polymers are frequently made into pellets and sold as a final product. Pelletization is typically carried out by heating the polymer to the molten state, extruding the molten polymer through a die, and cutting the extruded polymer into pellets with a blade as the polymer exits the die. The die and the polymer pellets produced therefrom are usually water cooled. A closed-loop water cooling and circulation system has been used to cool the pellets and the die and to carry the newly formed pellets away from the die. The cooled pellets are then separated from the water and the water is directed to a water holding tank where the water is cooled and recirculated to the die.

[0002] Over time, however, polymer particulates accumulate within the water cooling system and/or pellet water loop. After a certain point, the concentration of particulates within the cooling system will necessitate shutting down the cooling system to remove the accumulated particulates, which in turn requires shutdown of the pelletizer. Particulate buildup results in the fouling of heat exchangers, pellet/water separators, pellet dryers, etc.

[0003] There is a need, therefore, for improved apparatus and methods for reducing the accumulation of polymer particulates in water cooling systems. There is also a need for equipment and methods that provide increased efficiency with lower investment costs, while also ensuring there is no significant increase in operating costs.

[0004] The present invention provides advantages not typically associated with prior art apparatuses and methods. First, as shown below, separation efficiency is increased, even at smaller particle sizes. Second, investment costs may be reduced without significantly impacting separation efficiencies. Third, there is the potential to significantly reduced and/or minimize the need for unit shutdown due to particulate build-up within the water cooling system and/or pellet water loop, which significantly improves operating costs. The inventive apparatus and method for separating particulates from a liquid aids in reducing fouling in other equipment in the pellet water loop and/or water cooling system, such as fouling in heat exchangers, pellet/water separators, and pellet dryers.

SUMMARY

[0005] Disclosed is an apparatus comprising a vessel and a conduit at least partially disposed within the vessel. The vessel can include a first end, an enclosed second end, and an internal volume. A first end of the conduit can be disposed within the internal volume such that a flow path from the first end of the conduit is directed toward the enclosed second end. A first baffle

can be disposed between the first end of the conduit and the enclosed second end such that the direction of the flow path from the conduit is altered by the baffle. An outlet can be disposed on the enclosed second end of the vessel.

[0006] The apparatus can also include a vessel and a conduit at least partially disposed within the vessel, wherein the vessel includes a first end, an enclosed second end, and a curved inner wall forming a cylindrical first internal volume. A first end of the conduit can be concentrically disposed within the first internal volume such that a flow path from the first end of the conduit is directed toward the enclosed second end. The apparatus can also include a first baffle having a cylindrical second internal volume, an open end, and an enclosed end. The first end of the conduit can be disposed through the open end of the first baffle and within the second internal volume such that the direction of the flow path from the conduit is reversed by the baffle. An outlet can be disposed on the second end of the vessel.

[0007] Also disclosed herein are methods for using the apparatuses described above. In some embodiments, the method for separating particulates from a liquid may comprise providing the apparatus as described above; introducing a liquid comprising particulates to the internal volume of the vessel through the conduit; flowing the liquid comprising particulates through the conduit towards the first baffle, wherein the flow path of the liquid comprising particulates is altered by the first baffle; recovering at least a portion of the particulates from the first end of the vessel; and recovering a particulate-lean liquid from the outlet of the vessel, wherein the particulate-lean liquid has a reduced concentration of particulates relative to the liquid introduced to the internal volume of the vessel. In some embodiment, the recovering of at least a portion of the particulates from the first end of the vessel may comprise flowing a portion of the liquid and particulates through one or more second outlets disposed on a sidewall of the vessel toward the first end of the vessel. In some embodiments, the recovering of at least a portion of the particulates from the first end of the vessel comprises flowing a portion of the liquid and particulates out of the internal volume from the first end of the vessel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Figure 1 depicts an elevational, cross-sectional view of an illustrative apparatus configured to separate at least a portion of any particulates in a liquid introduced thereto.

[0009] Figure 2 depicts an elevational, cross-sectional view of an illustrative apparatus for containing a liquid.

[0010] Figure 3 depicts an elevational, cross-sectional view of an illustrative apparatus having an overflow weir disposed about the first end of a vessel.

[0011] Figure 4 depicts an isometric view of an illustrative apparatus having a second baffle disposed within an internal volume of a vessel.

[0012] Figure 5 depicts an elevational, cross-sectional view of an illustrative apparatus having two heat exchangers in communication therewith.

[0013] Figure 6 depicts an illustrative polymer pelletization system having an apparatus for containing a cooling liquid.

[0014] Figure 7 depicts an elevational, cross-sectional view of an illustrative apparatus for holding a liquid and further showing illustrative dimensional measurements.

[0015] Figure 8 depicts the simulated velocity contour of an elevational, cross-sectional view of an illustrative apparatus for holding liquid.

[0016] Figure 9 depicts the simulated velocity contour of an elevational, cross-sectional view of an illustrative apparatus for holding liquid.

[0017] Figure 10 depicts the simulated velocity contour of an elevational, cross-sectional view of an illustrative apparatus having a second baffle disposed within an internal volume thereof.

[0018] Figure 11 depicts the simulated velocity contour of an elevational, cross-sectional view of another illustrative apparatus having a second baffle disposed within an internal volume thereof.

DETAILED DESCRIPTION

[0019] Figure 1 depicts an elevational, cross-sectional view of an illustrative apparatus 100 for holding a liquid and configured to separate at least a portion of any particulates that can be present in a liquid introduced thereto. The apparatus 100 can include a vessel or container 105, one or more conduits 120, one or more baffles 140, and one or more outlets 150. The vessel 105 can include a curved inner wall or surface 107, an enclosed (not shown) or open first or "top" end 109, and an enclosed second or "bottom" end 111. The vessel 105 can have an inner cross-sectional shape that can be elliptical, circular, oval, or any combination thereof. For example, the curved inner surface 107 can be elliptical, circular, oval, or any combination thereof. Depending, at least in part, on the particular type of curve or combination of curves used to form the curved inner surface 107, the curved inner surface 107 can form, at least in part, an internal volume 115 having, for example, a cylindrical, spherical, ellipsoidal, spheroidal (*e.g.* prolate or oblate), and/or frustoconical configuration.

[0020] The enclosed second end 111 can have an inner wall or surface 112 having any suitably shaped or contoured profile. For example, the inner surface 112 can be ellipsoidal, hemispherical, flat or planar, frustoconical, or any combination thereof. The inner surface 107 of the vessel 105 can have a circular cross-section forming a cylindrical internal volume 115 between the first end 109 and the enclosed second end 111 and the inner surface of the 112 of the enclosed second end 111 can be an ellipsoidal end cap or head. As such, the apparatus 100

can be formed from conventional, standard, or "off-the-shelf" components such as standard piping and end caps.

[0021] As used herein, the terms "top" and "bottom," "front" and "rear," "left" and "right," and other like terms are merely used for convenience to refer to spatial orientations or spatial relationships relative to one another with respect to the apparatus 100 when viewed from the direction shown in the figure.

[0022] A flow path 125 within the conduit 120 can be in fluid communication with the internal volume 115 of the vessel 105. For example, a first end 123 of the conduit 120 can be disposed within the internal volume 115 and in fluid communication therewith. The conduit 120 can be disposed through the first end 109 of the vessel 105, the enclosed second end of the vessel 111, or a side wall 117 of the vessel 105. The first end 123 of the conduit 120 can be located between the first end 109 and the enclosed second end 111 of the vessel 105. The first end 123 of the conduit 120 can be directed toward the enclosed second end 111 of the vessel 105. As such, the flow path 125 within the conduit 120 can exit the conduit 120 toward the enclosed second end 111. In at least one embodiment, the conduit 120 can be concentrically or co-axially disposed through the first end 109 and within the internal volume 115. In other words, at least a portion of the conduit 120 can be disposed through the first end 109 along a portion of a longitudinal central axis of the vessel 105.

[0023] The outer cross-sectional shape or outer perimeter of the conduit 120 can be any suitable geometrical shape. If the apparatus 100 includes a plurality of conduits 120, the cross-sectional shape of any two of the conduits 120 associated therewith can be the same or different with respect to one another. Illustrative outer cross-sectional shapes of the conduit 120 can include, but are not limited to, circular, oval, elliptical, triangular, rectangular, any other polygon having four or more sides, any other shape having curved sides, or any other geometrical shape having any combination of curved and straight sides.

[0024] In one example, the outer cross-sectional shape of the conduit 120 and the inner cross-sectional shape of the vessel 105 can be the same. For example, both the outer cross-sectional shape of the conduit 120 and the inner cross-sectional shape of the vessel 105 can be circular, elliptical, oval, or the like. In another example, both the outer cross-sectional shape of the conduit 120 and the inner cross-sectional shape of the vessel 105 can be circular and the conduit can be concentrically disposed within the internal volume 115 thereby forming an annular region therebetween. In another example, the outer cross-sectional shape of the conduit 120 and the inner cross-sectional shape of the vessel 105 can be different. For example, the outer cross-sectional shape of the conduit 120 can be elliptical and the inner cross-sectional shape of the vessel 105 can be circular.

[0025] The inner cross-sectional shape of the flow path 125 disposed through the conduit 120 can be any suitable geometrical shape. If the apparatus 100 includes a plurality of conduits 120, the cross-sectional shape of any two of the flow paths 125 associated therewith can be the same or different with respect to one another. Illustrative cross-sectional shapes of the flow path 125 can include, but are not limited to, circular, oval, elliptical, triangular, rectangular, any other polygon having four or more sides, any other shape having curved sides, or any other geometrical shape having any combination of curved and straight sides.

[0026] The baffle 140 or at least a portion of the baffle 140 can be disposed or located between the first end 123 of the conduit 120 and the enclosed second end 111 of the vessel 105. In another example, a portion of the baffle 140 can be disposed or located between the first end 123 of the conduit 120 and the enclosed second end 111 of the vessel 105 and a portion of the baffle 140 can be disposed or located between an outer surface 121 of the conduit 120 and the inner surface 107 of the vessel 105.

[0027] The baffle 140 can be disposed about, adjacent to, proximate to, on, and/or within the first end 123 of the conduit 120. The baffle 140 can be disposed relative to the first end 123 of the conduit 120 such that the flow path 125 changes or alters direction upon exiting the first end 123. For example, the direction of the flow path 125 exiting the conduit 120 can be altered to flow generally toward the first end 109 of the vessel 105. In another example, the direction of the flow path 125 can be reversed toward the first end 109 of the vessel 105. In still another example, the direction of the flow path 125 can be altered to flow generally away from the enclosed second end 111 and toward the first end 109 and/or the curved inner surfaces 107 of the vessel 105.

[0028] The baffle 140 can have any suitable shape, design, or configuration that can alter the direction of the flow path 125 exiting the first end 123 of the conduit 115. For example, the baffle 140 can include a curved inner wall or surface 145, an open first end 147, and an enclosed second end 148. The curved inner wall 145 can be, for example, elliptical, cylindrical, oval, or any combination thereof.

[0029] The baffle 140 can also have any desired inner cross-sectional shape. For example, the inner cross-sectional shape of the baffle 140 can be circular, oval, elliptical, triangular, rectangular, any other polygon having four or more sides, any other shape having curved sides, or any other geometrical shape having any combination of curved and straight sides. Accordingly, the baffle 140 can include an inner volume or cavity in which the first end 123 of the conduit 115 can be at least partially disposed. The enclosed second end 148 of the baffle 140 can have any suitable shape or contoured profile, such as ellipsoidal, hemispherical, flat or planar, frustoconical, or any combination thereof.

[0030] The first end 123 of the conduit 120 can extend into the inner volume or cavity of the baffle 140 a distance ranging from a low of about 1%, about 5%, about 10%, or about 15% to a high of about 40%, about 50%, about 60%, about 70%, about 80%, about 90%, or about 99% of a length of the baffle 140 extending from the first end 147 to the enclosed second end 148. For example, the first end 123 of the conduit 120 can extend into the inner volume or cavity of the baffle 140 a distance ranging from about 5% to about 50%, about 10% to about 40%, about 15% to about 50%, or about 10% to about 25% of a length of the baffle 140 extending from the first end 147 to the enclosed second end 148.

[0031] As shown, a gap or space 141 can be disposed between at least a portion of the first end 123 of the conduit 120 and the enclosed second end 148 of the baffle 140. A gap or space 143 can also be disposed between at least a portion of the outer wall or surface 121 of the conduit 120 and the inner wall or surface 145 of the baffle 140. The gaps or spaces 141, 143 can provide fluid communication between the flow path 125 within the conduit 120 and the internal volume 115 of the vessel 105. As such a fluid, for example a liquid and/or a liquid containing particulates ("liquid/particulate mixture"), can be introduced to the internal volume 115 of the vessel 105 via the conduit 120.

[0032] The outer cross-sectional shape of the conduit 120 and the inner cross-sectional shape of the baffle 140 can be the same. For example, both the outer cross-sectional shape of the conduit 120 and the inner cross-sectional shape of the baffle 140 can be circular, elliptical, oval, or the like. In another example, both the outer cross-sectional shape of the conduit 120 and the inner cross-sectional shape of the baffle 140 can be circular and the conduit 120 can be concentrically disposed within the baffle 140 thereby forming an annular gap or space 143 between the conduit 120 and the inner wall 145 of the baffle 140. The outer cross-sectional shape of the conduit 120 and the inner cross-sectional shape of the baffle 140 can be different. For example, the outer cross-sectional shape of the conduit 120 can be elliptical and the inner cross-sectional shape of the baffle 140 can be circular and a non-uniform or non-annular gap or space 143 can be formed therebetween.

[0033] In another example, the gap or space 143 can be formed between the conduit 120 and the inner wall 145 of the baffle 140 such that the gap or space 143 does not extend around or about the entire outer perimeter of the conduit 120. For example, a plurality discrete flow paths providing fluid communication between the flow path 125 and the internal volume 115 can be formed.

[0034] As shown, a fluid or fluid/particulate mixture flowing through the flow path 125 within the conduit 120 can exit the first end 123 of the conduit toward the enclosed second end 148 of

the baffle 140. The second end 148 can redirect the fluid or fluid/particulate mixture through the annular gap 143 and toward the first end 109 of the vessel 105.

[0035] The baffle 140 can be supported about, adjacent to, proximate to, on, and/or within the first end 123 of the conduit 120 via one or more baffle supports (not shown). The one or more baffle supports can be disposed between the curved inner wall 107 of the vessel 105 and an outer wall 149 of the baffle 140, the outer wall 121 of the of the conduit 120 and the inner wall 145 and/or enclosed second end 148 of the baffle 140, an inner wall or surface 122 of the conduit 120 and the inner wall 145 of the baffle 140, the baffle 140 and the inner surface 112 of the second end 111 of the vessel 105, the baffle 140 and an inner surface of and enclosed first end 109 of the vessel 105, or any combination thereof. The baffle supports can be or include, for example, rods, beams, plates, cables, wires, chains, tubes, poles, straps, and the like.

[0036] The baffle 140 can be integral with the conduit 120. For example, the baffle 140 and conduit 120, depending at least in part on the particular material made from, can be cast, forged, machined, molded, or the like to provide an integrated baffle 140 and conduit 120. The baffle 140 can be connected to the first end 123 of the conduit 120 with one or more fasteners. Illustrative fasteners or fastening systems suitable for connecting the baffle 140 to the conduit 120 can include, but are not limited to, welding, screws, bolts, bolts and nuts, rivets, adhesives, pins, and the like. In still another example the baffle 140 can be threadedly connected to the first end 123 of the conduit 120.

[0037] The outlet 150 can be disposed on the second end 111 of the vessel 105 to provide a flow path from the internal volume 115 to an exterior of the vessel 105. Any number of outlets 150 can be disposed on the second end 111. For example, one, two, three, four, five, or ten outlets can be disposed on the second end 111. The outlet(s) 150 can be disposed at any location or any number of locations about the second end 111. For example, one or more outlets 150 can be centrally disposed on the second end 111. In another example, one or more outlets 150 can be disposed on the second end 111 at locations off center with respect to the second end 111. In still another example, two or more outlets 150 can be disposed on the second end 111 such that at least one outlet is centrally disposed thereon and at least one outlet is not centrally disposed thereon. Although not shown, the outlet 150 can include one or more flow control devices such as a valve to control or adjust the flow of a fluid therethrough.

[0038] The apparatus 100 (*e.g.*, the vessel 105, conduit 120, baffle 140, and outlet 150) can be made from any material or combination of materials. Illustrative materials can include, but are not limited to, metals, metal alloys, polymers, glasses, fiberglass, or any combination thereof. The material(s) used to make any one or more of the particular components of the apparatus 100 can depend, at least in part, on the particular application the apparatus 100 is to be used. For

example, in some applications metals can exhibit more desirable properties such as resistance to failure under high or low temperature and/or high or low pressures than polymers. Desirable properties of the material can include, but are not limited to, rigidity, strength, resistance to corrosion, low cost, and the like. Preferably the apparatus 100 is made from one or more metal or metal alloys such as steel, stainless steel, carbon steel, nickel alloys, and the like.

[0039] The vessel 105 can have any desired size, which can depend at least in part on the particular process or system in which the apparatus 100 can be used. For example, a vessel 105 having a circular cross section, *i.e.* a cylindrical vessel 105, can have a diameter ranging from a low of about 0.1 m, about 0.5 m, about 1 m, or about 2 m to a high of about 5 m, about 8 m, or about 10 m. The length of the sidewall 117 of the vessel 105 can range from a low of about 0.25 m, about 1 m, or about 2 m to a high of about 5 m, about 7 m, about 9 m, or about 11 m. The volume or size of the internal volume 115 can range from a low of about 0.001 m³, about 0.01 m³, about 0.1 m³, about 1 m³, or about 10 m³ to a high of about 65 m³, about 145 m³, about 200 m³, about 300 m³, about 400 m³, or about 500 m³.

[0040] As discussed above, a liquid and/or liquid/particulate mixture can be introduced to the internal volume 115 of the vessel 105 via the conduit 120. The liquid can fill the internal volume 115 to any desired level. In other words, a level or surface 130 of the liquid within the vessel 105 can be located at any point between the enclosed second end 111 and the first end 109. Preferably the surface or level 130 of the liquid is closer to the first end 109 of the vessel than the first end 123 of the conduit 120. As shown in Figure 1, a surface 130 of the liquid is located close to the first end 109 of the vessel 105. Preferably, the surface 130 of the liquid is located between the baffle 140 and the first end 109 of the vessel 105. More preferably, the surface 130 of the liquid is located closer to the first end 109 of the vessel 105 than to the baffle 140. In at least one embodiment, the level 130 of the liquid can exceed the first end 109 of the vessel 105, thereby causing liquid to overflow therefrom.

[0041] The rate the liquid is introduced via the first end 123 of conduit 120 to the internal volume 115 can remain constant or can vary. The liquid can be introduced via the conduit 120 at a rate ranging from a low of about 1 m³/min, about 3 m³/min, about 5 m³/min, about 8 m³/min, or about 10 m³/min to a high of about 15 m³/min, about 18 m³/min, about 20 m³/min, about 25 m³/min, about 30 m³/min, about 35 m³/min, or about 40 m³/min, for example. The rate the liquid is introduced via the conduit 120 to the internal volume 115 can be based, at least in part, on the size of the vessel 105. The rate the liquid is introduced via the conduit 120 to the internal volume 115 can also be based, at least in part, on the particular composition or make-up of the liquid. In another example, the rate the liquid is introduced via the conduit 120 to the

internal volume 115 can also be based, at least in part, on a desired velocity the liquid can have as the liquid flows through the internal volume 115.

[0042] Liquid can be recovered via the outlet 150 at a rate sufficient to maintain and/or adjust the level of the liquid surface 130 within the internal volume 115. As such, the rate the liquid is introduced via the conduit 123 to the internal volume 115 and/or recovered via the outlet 150 can be used to control the level of the liquid therein.

[0043] The liquid can flow through and exit the first end 123 of the conduit 120 toward the enclosed second end 111. The baffle 140, at least partially disposed between the first end 123 and the second end 111, can alter, change, or otherwise redirect the direction or flow of the liquid within the internal volume 115. The baffle 140 can redirect the liquid toward the first end 109 of the vessel 105. The baffle 140 can redirect the liquid upwardly and outwardly from and with respect to the first end 123 of the conduit 120.

[0044] The liquid can flow from the baffle 140 to an area or region within the internal volume 115 located adjacent or proximate the first end 109. After the liquid flows toward the first end 109, the liquid can flow toward the sidewall 117 of the vessel 105 and again toward the enclosed second end 111. Upon reaching the second end 111 the liquid can be removed from the internal volume 115 via the outlet 150.

[0045] The liquid introduced via conduit 120 to the vessel 105 can be any liquid or combination of liquids. For example the liquid can be, but is not limited to, water, hydrocarbons such as ethylene glycol, or a combination thereof. The liquid can include one or more additives such as corrosion inhibitors, defoamers, antifoamers, dispersants, lubricants, film-formers, biocides, viscosity modifiers, pH adjusters, surfactants, lubricants, and the like.

[0046] The liquid introduced via conduit 120 to the vessel 105 can include one or more particulates 133. As used herein, the term "particulates" refers to a discrete mass of solid matter, porous-solid matter semi-solid matter, or any combination thereof. In some embodiments, the particulates or an agglomerate of particulates may comprise an entrapped gas. The particulates may remain individually dispersed in the liquid or they agglomerate together to form larger particulate agglomerates. The particulates 133 can have a uniform size or a range of sizes. For example, the particulates 133 or agglomerates of individual particulates can have an average cross-sectional length ranging from a low of about 0.01 mm, about 0.1 mm, about 0.15 mm, or about 0.2 mm to a high of about 1.5 mm, about 2 mm, about 3 mm, about 4 mm, or about 5 mm. The particulates 133 can be or can be derived from polymers, dust, biomass (*e.g.*, plant matter and/or animal matter), fiberglass, or any combination thereof. The particulates 133 can have any shape. For example, the particulates 133 can be cylindrical, spherical, elliptical, elongated,

bowling pin, egg, oval, disk, flakes, fibers, or the like. In some embodiments, the particulates may be agglomerates or clumps of particles having like or differing compositions.

[0047] The method and apparatuses described herein are useful for separating particulates from a liquid. The method and apparatus may operate to separate polymer particulates of different sizes with different pellet separation efficiencies. The method and apparatus may demonstrate increased pellet separation efficiency for separating particulates or agglomerates of individual particulates that have an average cross-sectional length of greater than 0.55 mm, or greater than 0.6 mm, or greater than 0.7 mm, or greater than 0.75 mm, or greater than 0.8 mm, or greater than 0.85 mm.

[0048] Illustrative polymers can include homopolymers or copolymers of C₂ to C₄₀ olefins, preferably C₂ to C₂₀ olefins, preferably a copolymer of an alpha-olefin and another olefin or alpha-olefin (herein ethylene is defined to be an alpha-olefin). Preferably, the polymers are or include homo polyethylene, homo polypropylene, propylene copolymerized with ethylene and/or butene, ethylene copolymerized with one or more of propylene, butene or hexene, and optional dienes. Preferred examples include polymers such as ultra low density polyethylene ("ULDPE"), very low density polyethylene ("VLDPE"), linear low density polyethylene ("LLDPE"), low density polyethylene ("LDPE"), medium density polyethylene ("MDPE"), high density polyethylene ("HDPE"), polypropylene, isotactic polypropylene, highly isotactic polypropylene, syndiotactic polypropylene, random copolymer of propylene and ethylene and/or butene and/or hexene, elastomers such as ethylene propylene rubber, ethylene propylene diene monomer rubber, neoprene, and combinations thereof. Illustrative biomass particulates 133 can include, but are not limited to, wood and/or plant fibers which can contain cellulose, lignin, or a combination thereof.

[0049] The particulates 133 contained in the liquid can have a density less than, equal to, or greater than the density of the liquid. Preferably the particulates 133 contained in the liquid have a density equal to or less than the density of the liquid. Particulates 133 having a density equal to or less than the density of the liquid can have a greater tendency to accumulate toward or at the surface 130 of the liquid than particulates 133 having a density greater than the liquid. Similarly, particulates 133 having a density less than the density of the liquid can tend to accumulate toward or at the surface 130 of the liquid than particulates 133 having a density equal to or greater than the density of the liquid. Particulates 133 having a density equal to or less than the density of the liquid can have accumulate toward or at the surface 130 of the liquid for an increased residence time relative to particulates 133 having a density greater than the liquid.

[0050] At least a portion of any particulates 133 in the liquid can be removed from the liquid, thereby reducing the concentration of the particulates 133 contained in the liquid. Accordingly, the apparatus 100 can be used to remove or separate the particulates 133 from the liquid. Causing the particulates 133 to collect or otherwise aggregate toward the surface 130 of the liquid can be preferable for applications in which it can be desirable to remove at least a portion of the particulates 133 therefrom. For example, collecting or otherwise aggregating the particulates 133 toward a predetermined location, *e.g.* the surface 130 or near the surface 130 of the liquid, can facilitate the removal of the particulates 133 therefrom because concentration of the particulates 133 per given surface area of the surface 130 and/or per given volume of the liquid generally located toward or adjacent the surface 130 can be greater.

[0051] The flow path of the liquid through the internal volume 115 can cause the particulates 133 to collect or otherwise aggregate toward the surface 130 of the liquid when the surface 130 is located between the baffle 140 and the first end 109 of the vessel 105. As the liquid reaches or flows toward the surface 130 the path of the liquid takes toward the enclosed second end 111 can peak or crest toward the first end 109 and then flow toward the sidewall 117 of the vessel and then flow toward the enclosed second end 111. The particulates 133 can tend to stay or otherwise be left behind at the surface 130 of the liquid as the liquid flows toward the enclosed second end 111. Furthermore, the velocity at which the liquid flows from the first end 109 toward the second end 111 can, for at least a portion of the distance, can have a "downward" velocity less than an "upward" velocity of the particulates 133 that can tend to flow toward the first end 111 within the liquid due to having a density less than the liquid, for example.

[0052] Removing at least a portion of the particulates 133 can be accomplished using any suitable method, system, device, or combination of methods, systems and/or devices. For example, the amount of liquid within the internal volume 115 can be increased such that the surface 130 of the liquid extends beyond the first end 109 of the vessel 105 causing a portion of the liquid to overflow from the vessel 105. As the portion of the liquid overflows from the vessel 105 the accumulated particulates 133 can be carried out of the internal volume 115, thereby separating the particulates 133 from the liquid remaining within in the internal volume 115. The difference between the liquid flow rate introduced via conduit 120 to the internal volume 115 and the liquid flow rate removed via outlet 150 can determine the rate at which the liquid overflows from the first end 109 of the vessel 105. A fluid can be sprayed through a nozzle or other device across the surface 130 of the liquid. The fluid can be sprayed from a central region of the surface 130 of the liquid toward the sidewall 117 of the vessel 105, thereby urging particulates 133 at the surface 130 to move toward the sidewall 117 and thus out of the vessel 105 as the liquid overflows therefrom.

[0053] In another example, a screen or other device can be moved along the surface 130 of the liquid within the internal volume 115, which can collect and remove the particulates 133 from the liquid. In still another example, a hose or other conduit connected to a pump or vacuum system can be used to remove a portion of the collected or accumulated particulates 133 and/or liquid at the surface 130 thereof. In yet another example and as discussed and described in more detail be with reference to Figure 2, one or more outlets can be disposed on the sidewall 117 of the vessel 105 through which a portion of the liquid and at least a portion of the particulates 133 can be recovered.

[0054] By accumulating the particulates 133 toward the first end 109 of the vessel 105, the apparatus 100 can separate a majority of the particulates 133 while only removing a small fraction or portion of the liquid. As such, a majority of the liquid can avoid direct filtration, but remain relatively free or free of accumulated particulates 133. If liquid overflows from the first end 109 of the vessel 105, separated via a conduit connected to a vacuum or pumping system, separated via one or more outlets disposed on the sidewall 117, or otherwise is removed from the internal volume 115, the liquid and particulates 133 can be separated from one another and the liquid having a reduced concentration of particulates 133 can be returned to the internal volume 115, upstream of the apparatus 100, and/or downstream of the apparatus 100. For example, liquid separated from the internal volume 115 along with the particulates 133 can be introduced to a cyclonic separation device, a membrane separation device, a porous medium separation device, a centrifuge separation device, or the like, which can produce a liquid having a reduced concentration of particulates 133, which can be recycled to the internal volume of the vessel 105 via the conduit 120, for example. As such, the apparatus 100 can function as a "pre-concentrator" for a liquid containing a small amount of particulates. The apparatus 100 can separate the majority or bulk of the liquid producing a more concentrated liquid/particulate mixture that can then be further processed in a second separation device such as a cyclone, centrifuge, or the like.

[0055] The concentration of particulates 133 in the liquid introduced to the internal volume 115 via the conduit 120 can range from about 0.00000001 wt% to about 5 wt%. For example, the amount of particulates 133 contained in the liquid can range from a low of about 0.00001 wt%, about 0.0001 wt%, or about 0.001 wt% to a high of about 1 wt%, about 2 wt%, or about 5 wt%. The concentration of particulates 133 in the liquid recovered via outlet 150 can be reduced by about 10%, about 20%, about 30%, about 40%, about 50%, about 60%, about 70%, about 80%, about 90%, about 95%, about 97%, about 99%, or about 99.9% as compared to the liquid introduced to the vessel 105 via conduit 120.

[0056] The amount or number of particulates 133 separated within the apparatus 100 can vary based on the particular size of the particulates 133. For example, larger sized particulates 133 can be separated from the liquid with a greater efficiency than smaller particulates 133 of the same material. In another example, depending on the particular composition and physical properties of the particulates 133, smaller sized particulates 133 can be separated from the liquid with a greater efficiency than larger particulates 133. For example, if the density of the smaller particulates 133 is less than that of the larger particulates 133, the smaller particulates 133 can tend to be more easily separated from the liquid than the larger particulates 133 because those smaller particulates 133 can tend to collect or accumulate more easily toward or at the surface 130 of the liquid. In another example, the temperature of the liquid can be changed, *i.e.* increased or decreased, which can affect the density difference between the liquid and the solid, thereby promoting or improving the separation of the particulates from the liquid.

[0057] The apparatus 100 can be installed into an existing system or a new system. For example, the apparatus 100 can be installed into an existing system that contains a large amount of particulates 133 in a liquid re-circulating therethrough. After the apparatus 100 has been installed and in operation the amount or concentration of particulates 133 in the liquid can reduce as the particulates 133 are separated from the liquid introduced thereto.

[0058] Figure 2 depicts an elevational, cross-section view of another illustrative apparatus 200 for holding a liquid. The apparatus 200 can include the vessel 105 and one or more conduits 120, baffles 140, and outlets 150 as discussed and described above with reference to Figure 1. The apparatus 200 can also include an enclosed first end 209. One or more outlets (two are shown 205, 207) can be disposed on the sidewall 117 of the vessel 105. The enclosed first end 209 can include one or more vents 215 disposed thereon. The vessel 105 can also include one or vortex breakers 220.

[0059] An inner wall or surface 210 of the enclosed first end 209 can have any suitable shaped or contoured profile. For example, the inner surface 210 can be ellipsoidal, hemispherical, flat or planar, frustoconical, or any combination thereof. The conduit 120 can be disposed through the enclosed first end 209. The conduit 120 can be centrally disposed through the enclosed first end 209 along a center longitudinal axis thereof. In another example, the conduit 120 can be connected to a flange or other coupling device (not shown) disposed on the inner surface 210 of the enclosed first end 209. The conduit 120 can be supported within the internal volume 115 of the vessel 105 via connection or attachment to the enclosed first end 209. Alternatively, the conduit 120 may be supported from the tank walls or the second end.

[0060] The outlets 205, 207 can be located closer to the enclosed first end 209 than the enclosed second end 111. The outlets 205, 207 can be disposed on the sidewall 117 at a location between

the baffle 140 and the enclosed first end 209. The outlets 205, 207 can be located closer to the enclosed first end 209 than the baffle 140. The outlets 205, 207 can be disposed on the sidewall 117 of the vessel 105 about a common perimeter. In other words, the outlets 205, 207 can be the same or substantially the same distance from the enclosed second end 111 with respect to one another. The outlets 205, 207 can be disposed on the sidewall 117 of the vessel 105 about different perimeters. In other words, the outlets 205, 207 can be different distances from the enclosed second end 111 with respect to one another. As shown in Figure 2, the outlets 205, 207 are disposed on the sidewall 117 of the vessel 105 on opposing sides thereof and at substantially the same distance from the enclosed second end 111. As such, the surface 130 of the liquid within the internal volume 115 can simultaneously flow through both outlets 205, 207, if the amount of liquid within the internal volume 115 were increased.

[0061] The outlets 205, 207 can be connected to a conduit (not shown) which can direct liquid and/or particulates 133 that can flow through the outlets 205, 207 to disposal, a filtering system, or the like. As shown, the level or surface 130 of the liquid contained in the vessel 105 is slightly below the outlets 205, 207. However, the level 130 of the liquid within the vessel 105 can be increased, causing the liquid to flow through the outlets 205, 207. Particulates 133 contained in the liquid can also flow into the outlets 205, 207. The liquid and, if present, particulates 133 can be introduced to one or more particulate separation units, which can remove at least a portion of the particulates 133, thereby providing a liquid having a reduced concentration of particulates 133. The introduction rate and/or recovery rate of the liquid to/from the internal volume 115 can be controlled such that the flow of the liquid through the outlets 205, 207 can be continuous, intermittent, or a combination thereof.

[0062] The one or more vents 215 can be disposed anywhere about the enclosed first end 209. The vent 215 can be used to release pressure within the internal volume 115 of the vessel 105. In another example, the vent 215 can be used to vent or remove steam or other vapors from the internal volume 115. In yet another example, the vent 215 can be used to introduce a fluid, *e.g.* air, to the internal volume 115 should a vacuum develop or form therein.

[0063] The vortex breaker 220 can be disposed within the internal volume 115. The vortex breaker 220 can be disposed on or about the enclosed second end 111 proximate or adjacent to the location of the outlet 150. The vortex breaker 220 can be partially or completely disposed within the outlet 150. The vortex breaker 220 can include any suitable shape, design, or configuration that can alter or modify a vortex generated from liquid flowing out of the internal volume 115 via the outlet 150. The vortex breaker 220 can prevent or reduce the likelihood of a vortex forming within the internal volume 115. The vortex breaker 220 can reduce the strength of a vortex should a vortex form within the internal volume 115.

[0064] The vortex breaker 220 can include one or more plates, cones, rods, or the like. For example, the vortex breaker 220 can be or include a plate disposed within the internal volume and adjacent or proximate the outlet 150. In another example, the vortex breaker 220 can be or include one or more plates oriented substantially parallel with a longitudinal axis of the outlet and located proximate to, on, and/or at least partially within the outlet 150. For example, the vortex breaker 220 can include four plates connected together to produce a vortex breaker having a "+" shaped cross-section. A portion of the "+" shaped vortex breaker 220 can at least partially be disposed within the outlet 150.

[0065] Figure 3 depicts an elevational, cross-sectional view of yet an illustrative apparatus 300 having an overflow weir 305 disposed about the first end 109 of the vessel 105. The apparatus 300 can include at least one vessel 105 and one or more conduits 120, baffles 140, and outlets 150 as discussed and described above with reference to Figure 1.

[0066] The overflow weir 305 can include at least one outlet 310. The overflow weir 305 can also include at least one vent 315. The overflow weir 305 can include a sloped end or bottom 307 such that liquid that overflows from the first end 109 of the vessel 105 can collect and be directed toward the outlet 310. The overflow weir 305 can be disposed about the outer perimeter of the vessel 105 such that the weir 305 spans the entire perimeter thereof. In other words, the weir 305 can be a 360° weir that can collect liquid and, if present, particulates 133 from about the entire perimeter of the vessel 105. In another example, the weir 305 can be disposed about a portion of the perimeter of the vessel 105. The vent 315 can be similar to the vent 215 discussed and described above with reference to Figure 2.

[0067] Enclosing the first end 109 of the vessel 105 can reduce or prevent undesired contaminants from entering into the internal volume 115. Furthermore, enclosing the first end 109 of the vessel 105 can provide an increased level of safety. For example, enclosing the first end 109 of the vessel 105 can prevent personnel working above the apparatus 100, 200, and/or 300 from falling into the internal volume 115. Furthermore, should a hot liquid and/or a hazardous liquid be contained within the internal volume 115 of the vessel 105, such liquid could be contained therein. As such, the probability or likelihood of personnel coming into contact with the liquid can be reduced.

[0068] The first end 109 of the apparatus 100, 200, and/or 300 can be enclosed or at least partially enclosed using any other suitable system, device, apparatus, or any combination thereof. For example, if it is only desired to prevent an accidental fall by personnel into the internal volume 115 of the vessel 105, screens, boards, nets, or any other suitable safety barrier could be installed. In another example, screen could also be disposed about the first end 109 to

prevent or reduce contamination by dust, leaves, and other potential contaminants blowing, falling, or otherwise entering the internal volume 115 of the vessel 105.

[0069] Figure 4 depicts an isometric view of an illustrative apparatus 400 having a second baffle 405 disposed within the internal volume 115 of the vessel 105. The apparatus 400 can include the at least one vessel 105 and one or more conduits 120, baffles 140, and outlets 150 as discussed and described above with reference to Figures 1-3. The apparatus 400 can also include one or more second baffles (one is shown 405). Although not shown, the first end 109 can be enclosed similar to the apparatus 200 and 300 discussed and described above with reference to Figures 2 and 3.

[0070] The second baffle 405 can be disposed toward the first end 109 of the vessel 105. The second baffle 405 can provide one or more "quite" or "dead" zones 407 within the internal volume 115. As used herein, the terms "quite zone" and "dead zone" are used interchangeably and refer to a zone or zones that have a reduced rate of liquid flow therethrough relative to a rate of liquid flow that would be present within the zone if the second baffle 405 was removed.

[0071] The second baffle 405 can be any configuration or shape capable of producing the one or more dead zones 407 when the liquid is contained within the internal volume 115. For example, the baffle 405 can be a frustoconical ring having a first or "top" end 409 and a second or "bottom" or "base" end 411. The first end 409 can be directed toward the first end 109 of the vessel 105 and the second end 411 can be directed toward the second end 111 of the vessel 105. The first end 409 can be directed toward the enclosed second end 111 of the vessel and the second end 411 can be directed toward the first end 109 of the vessel 105. In another example, the second baffle 405 can be a flat or planar plate, a curved plate, or a combination thereof. For example, the second baffle 405 can be a cylindrical ring.

[0072] If the second baffle 405 includes a frustoconical ring, the angle or slope of the frustoconical ring can range from about 50° to about 85°, with respect to a base of the frustoconical ring. For example, the angle or slope of the frustoconical ring can be about 55°, about 60°, about 65°, about 70°, about 75°, or about 85°, with respect to a base of the frustoconical ring. Preferably, the frustoconical ring has an angle of about 70° to about 80°, for example, about 75°, with respect to a base of the frustoconical ring.

[0073] As depicted in Figure 4, the dead zone 407 can traverse around and between a perimeter of the inner wall 107 of the vessel 105 and an outer wall 413 of the second baffle 405. In another example, the dead zone 407 can traverse along and between only a portion of the perimeter of the inner wall 107 of the vessel 105 and the outer wall 413 of the second baffle 405. In still another example, the second baffle 405 can be shaped such that a plurality of discrete or independent dead zones 407 can be formed between the inner wall 107 of the vessel 105 and the

outer wall 413 of the second baffle 405. For example, the apparatus 200 having two outlets 205, 207 discussed and described above with reference to Figure 2, can include one or more baffles 405 disposed within the internal volume 115 such that two independent dead zones 407 are provided with one dead zone located about or adjacent each outlet 205, 207, but separate or independent from one another.

[0074] The first end 409 of the second baffle 405 can be disposed within the internal volume 115. In other words, the first end 109 of the vessel 105 can extend beyond the first end 409 of the second baffle 405. In another example, a portion of the first end 409 of the second baffle 405 can be disposed within the internal volume 115 and a portion of the first end 409 can be disposed beyond the first end 109 of the vessel 105.

[0075] The second baffle 405 can be made from any material or combination of materials. Illustrative materials can include, but are not limited to, metals, metal alloys, polymers, glasses, fiberglass, or any combination thereof. The material(s) used to make the second baffle 405 can depend, at least in part, on the particular application the apparatus 400 is to be used. Desirable properties of the material can include, but are not limited to, rigidity, strength, resistance to corrosion, cost, and the like. Preferably the second baffle 405 is made from one or more metal or metal alloys such as steel, stainless steel, carbon steel, nickel alloys, and the like.

[0076] Figure 5 depicts an elevational, cross-sectional view of an illustrative apparatus 500 comprising at least one vessel 105 and one or more conduits 120, baffles 140, and outlets 150 as discussed and described above with reference to Figures 1-4 and having one or more heat exchangers (two are shown 505, 520) in communication therewith. The apparatus 500 can include one or more heat exchangers 505, 520 capable of altering or adjusting the temperature of the liquid contained within the internal volume 115. As shown, the apparatus 500 can include a water jacket type heat exchanger 505 and/or a shell-and-tube heat exchanger 520. The water jacket 505 and/or the shell-and-tube heat exchanger 520 can be used to increase and/or decrease the temperature of a liquid within the internal volume 115, or as recovered via the outlet 150, respectively.

[0077] The water jacket 505 can be disposed on the outer surface of the sidewall 117 of the vessel 105. In another example, the water jacket 505 can be disposed on the curved inner surface 107 of the vessel 105 and/or within the sidewall 117 of the vessel 105. A heat transfer medium via line 503 can be introduced to the water jacket 505, flow through the water jacket 505, and be recovered via line 507. The heat transfer medium can indirectly transfer heat to or from the liquid contained within the internal volume 115 of the vessel 105 as it flows through the water jacket 505.

[0078] The shell-and-tube heat exchanger 520 can be in fluid communication with the outlet 150. A heat transfer medium via line 517 can be introduced to the shell-and-tube heat exchanger 520, flow through a shell side of shell-and-tube-heat exchanger 520, and be recovered via line 523. The heat transfer medium can indirect transfer heat to or from the liquid flowing through a tube side of the shell-and-tube heat exchanger 520. In another example, the heat transfer medium introduced via line 517 can flow through the tube side of the shell-and-tube heat exchanger 520 and can indirectly transfer heat to or from a liquid flowing through the shell side of the shell-and-tube heat exchanger 520.

[0079] Any fluid, either liquid, gas, or a combination thereof, suitable for transferring heat to or from the liquid contained within the internal volume 115 of the vessel 105 or as recovered via outlet 150 can be used as the heat transfer mediums in lines 503 and 517. Illustrative heat transfer mediums can include, but are not limited to, water, glycols, air, hydrocarbons, steam, or any combination thereof. The heat transfer medium in lines 503 and 517 can be at any desired temperature, which can depend, at least in part, on the particular process or system in which the apparatus 500 is used. For example, the heat transfer medium can be at a temperature of about 25°C, about 50°C, about 75°C, about 100°C, about 125°C, about 150°C, about 175°C, or about 200°C. As such, if the heat transfer medium is water, the water can be liquid water, steam, or a combination of liquid water and steam. Depending on the particular temperature and pressure, if the water is steam, the steam can be low pressure steam, medium pressure steam, high pressure steam, high pressure superheated steam, and the like.

[0080] Any other device capable of adjusting the temperature of a liquid within the apparatus can be used alone or in combination with the water jacket 505 and/or the shell-and-tube heat exchanger 520. Another suitable heat exchanging devices can be, for example, coiled tubing disposed about the vessel 105 and/or within the internal volume 115 of the vessel 105 through which a heat transfer medium can flow through. Another suitable heat exchanger can include electric heating elements disposed on the side wall 117 of the vessel 105, on the inner surface 107 of the vessel 105, within the internal volume 105 of the vessel 105, about and/or within the outlet 150, or combinations thereof.

[0081] Figure 6 depicts an illustrative polymer pelletization system 600 having an apparatus 630 for holding a cooling liquid. The pelletization system 600 can include one or more extruders 605, die assemblies 606, cooling chambers 607, pellet separation systems 620, apparatus 630 for holding the cooling liquid, and pumps 640. The extruder 605, die assembly 606, and cooling chamber 607 can be referred to collectively as the "pelletizer." The apparatus 630 for holding the cooling liquid can be similar to any one or combination of the apparatus 100, 200, 300, 400,

and 500 discussed and described above with reference to Figures 1-5. The pelletization system 600 can produce polymer pellets from any suitable polymer and/or blends of polymers.

[0082] The formed polymer pellets can have a size ranging from about 1 mm to about 10 mm in a first dimension and from about 1 mm to about 10 mm in a second dimension. For example, the polymer pellets can be spherical with diameters ranging from about 1 mm to about 10 mm. In another example, the polymer pellets can be disk-shaped with diameters ranging from about 1 mm to about 10 mm and a thickness ranging from about 1 mm to about 10 mm. In still another example, the polymer pellets can be cylindrical with diameters ranging from about 1 mm to about 10 mm and lengths ranging from about 2 mm to about 10 mm. The size of polymer pellets can be more generally measured by the total weight of 50 pellets. The pellet weight for the polymer pellets discussed and described herein can range from about 0.5 g/50 pellets to about 5 g/50 pellets.

[0083] A polymer via line 603 can be introduced to the extruder 605, which can heat the polymer and force the polymer through the die assembly 606, thereby forming polymer strands. Rotating knives within the die assembly 606 can cut the polymer strands into pellets as the polymer is extruded therethrough. Cooling water can be introduced via line 643 to the cooling chamber 607 disposed about the die-assembly 606. As shown in Figure 6, the cooling water via line 643 can be introduced to the cooling chamber 607 via the pump 640.

[0084] The cooling water via line 643 can cool the hot, molten polymer pellets formed via the die assembly 606. The cooling water via line 643 can also cool the die assembly 606. The cooling water in line 643 can have any desired temperature. For example, the temperature of the cooling water 643 can range from a low of about 1°C, about 5 °C, or about 10°C to a high of about 25°C, about 40°C, about 50°C, about 60°C, about 70°C, or about 80°C.

[0085] The cooling water in line 643 can contain any number and/or combination of additives. For example, the cooling water in line 643 can include an anti-coagulant such as calcium stearate, to prevent or reduce the likelihood of the formed pellets adhering to one another. The contact time between the pellets and the cooling water can be sufficient to provide pellets having a temperature of from about 0°C to about 70°C. The contact time of the pellets with the cooling water can range from about 30 seconds to about an hour or even more. Cooling the pellets can promote crystallization of the polymer pellets sufficient to reduce or prevent agglomeration in subsequent handling and storage of the pellets.

[0086] The cooled pellets and water mixture can be introduced via line 610 to the pellet separation system 620 which can separate the pellets from the cooling water. The pellet separation system 620 can remove a majority of the pellets from the cooling water. The dried or semi-dry pellets can be conveyed to a vibrating fluidized bed drier within the pellet separation

system 620. Warm, dry air can be used to dry the pellets, thereby removing surface water therefrom. In another example, the pellet separation system 620 can include a centrifugal pellet dryer or spin dryer. For example, the centrifugal pellet dryer or spin dryer can be one manufactured by Gala or Carter Day. The centrifugal spin dryer can separate the majority of the pellets from the water on screens and can then introduced the wet pellets into a spinning basket where additional water can be removed from the pellets by centrifugal force and through contact with a war gas such as air. If desired, the dried pellets can be introduced to a duster within the pellet separation system 620, where the dried pellets can be dusted with an anti-agglomeration agent. As such, semi-wet, dry, and/or dry and dusted pellets via line 623 and cooling water via line 625 can be recovered from the pellet separation system 620.

[0087] In at least one particular configuration, the pellet separation system 620 can be located above the liquid holding apparatus 630. As such, the pump 640 can be used to pump the cooling water upward from the cooling chamber 607 and to the pellet separation system 620. Typical heights for the pellet separation system 620 can range anywhere from 4 m up to about 15 m or 20 m. As such, the pellet separation system 620 can be located above the liquid holding system 630.

[0088] The polymer pelletization system 600 can also include one or more turbines 650 coupled to one or more generators 660.

[0089] The cooling water via line 625 recovered from the pellet separation system 620 located above the apparatus 630 can drop by gravity to the apparatus 630. A turbine 650 can be used to recover a portion of energy that would otherwise be lost from the recovered cooling water in line 635 as the water falls toward the apparatus 630.

[0090] For example, a polymer pelletization system 600 in which the pellet separation system 620 is located about 9.1 m (30 ft) above the liquid holding apparatus 630 that processes about 31,750 kg (70,000 lbs) polymer and requires about 6.44 m³/min (1,700 gpm) can recover a minimum of about 4% of the energy required to operate the pump 640. The basic equation for estimating the amount of electrical power that can be generated from a flow stream of water is:

$$\text{Watts Generated} = \text{GPM} \times \text{head (ft)} \times 0.18 \times \text{efficiency}$$

[0091] The efficiency will usually range from about 0.3 to about 0.5. Using the above equation at the worst efficiency (0.3) there is about 1.8 kW of energy available when the cooling water is circulated throughout the polymer pelletization system 600. The energy required to operate the pump 640 is about 45 kW. As such, about 4% of the energy, using the worst efficiency, could be recovered via the turbine 650. As shown, the turbine 650 can be coupled to the generator 650 to generate electricity which can be used for lighting and other

electrical requirements. In another example, the turbine 650 can be coupled directly to the motor shaft (not shown) of the pump 640 thereby recovering the energy directly to the pump 640. Depending, at least in part, on the particular size of the polymer pelletization system 600, the distance the pellet separation system 620 is located above the liquid holding apparatus 630, and/or the efficiency of the turbine, the amount of energy recovered via the turbine 650 and generator 660 or the turbine 650 coupled directly to the pump 640 can vary.

[0092] In another example, the cooling water via line 625 can be recovered from the pellet separation system 620 and introduced directly to the internal volume 115 of the vessel 105. In other words, the turbine 650 and the generator 660 can be eliminated. The cooling water in line 625 can contain small amounts of polymer particulates 133 formed or produced during formation of the pellets via the die assembly 606. If the polymer particulates 133 are left in the cooling water a sufficient concentration of polymer particulates 133 can build up over time, which can require shutdown of the polymer pelletization system 600. The apparatus 630 can remove at least a portion of the accumulated polymer particulates 133 thereby reducing or eliminating the need for shutting down the polymer pelletization system 600.

[0093] The apparatus 630 for holding the cooling liquid can include one or more outlets (one is shown 205) for removing the collected particulates 133 therefrom via line 633, as discussed and described above with reference to Figure 2. The apparatus 630 can also include a water cooling jacket 505 as discussed and described above with reference to Figure 5. The heat transfer medium can be any cool or refrigerated heat transfer medium capable of providing cooling water via line 635 having a desired temperature. In another example, one or more heat exchangers can be disposed about line 635 and/or line 643.

[0094] Illustrative pelletization systems and processes and/or components thereof can be similar to those discussed and described in U.S. Patent Nos.: 6,426,026; 6,328,919; 6,062,719; 5,414,056; 4,822,546; 4,138,208; and 4,120,625, which are incorporated by reference herein.

[0095] The energy required to operate the polymer pelletization system 600 can be reduced as compared to a polymer pelletization system that employs a conventional or standard liquid holding tank that utilizes a cubic or rectangular internal volume. The energy required to operate the polymer pelletization system 600 can also be reduced as compared to a polymer pelletization system that employs a small round tank that does not have baffles and that has a shorter residence time. The energy required to operate the polymer pelletization system can also be reduced as compared to systems that employ squat, ground-mounted cylindrical tanks, such as those that have cylindrical tanks where $LD < 1$. For example, the energy required to pump or circulate the cooling water from the liquid holding apparatus 630 and throughout the polymer pelletization system 600 can be reduced. The apparatus 630 can reduce the required pump 640

suction head by about 2 m or more, about 4 m or more, about 6 m or more, about 8 m or more, about 10 m or more, about 12 m or more, or about 14 m or more. The particular design of the vessel 105 can increase or raise the surface 130 of the water as compared to conventional or standard liquid holding tank that utilizes a cubic or rectangular internal volume thereby increasing the water head on the pump 640.

[0096] The water head on the pump 640 can be increased for a polymer pelletization system 600, thereby reducing the required pump suction head. The apparatus 630 has a smaller footprint, but a greater height than conventional or standard liquid holding tanks that utilize a cubic or rectangular internal volume designed to hold about the same amount of cooling water therein. The increased height of the apparatus 630 raises the height of the surface 130 of the liquid as compared to conventional or standard liquid holding tanks. Furthermore, the apparatus 630 can be supported on a skirt or base 639 that can raise the surface 130 of the liquid within the internal volume 115 even more. As such the energy required to operate the pump 640 can be reduced.

[0097] For example, a typical polymer pelletization system that requires about $7.98 \text{ m}^3/\text{m}$ (2,109 gpm) cooling water be introduced to the cooling chamber 607 can use a standard or conventional liquid holding tank having a base of about 4.6 m by 4.6 m would place the surface of the water therein about 3 m above the base of the tank and holds approximately 63.5 m^3 of cooling water. The apparatus 630 having a cylindrical inner surface and an internal volume of about 65 m^3 would have a diameter of about 3.5 m and a height of about 7 m. As such, the apparatus 630 alone could raise the water head on the pump by about 4 m. Raising the apparatus 630 via the base 639 can further raise the water head on the pump 640 anywhere from about 1 m to about 10 m for a typical polymerization system. In other words, the apparatus 630 can reduce the required pump suction head by more than about 4 m, more than about 6 m, more than about 10 m, or more than about 14 m, for example. As such, the apparatus 630 can reduce the pump head which reduces the energy required to circulate the cooling water throughout the polymer pelletization system 600. This reduction in energy can be about 5 kW, about 10 kW, about 15 kW, about 20 kW, or about 30 kW, for example.

Prophetic Examples

[0098] Embodiments of the present invention can be further described with the following prophetic examples. Although the simulated examples are directed to specific embodiments, they are not to be viewed as limiting the invention in any specific respect.

Exemplary Dimensions and Scale-Up

[0099] Figure 7 depicts an elevational, cross-sectional view of an illustrative apparatus 700 showing illustrative dimensional measurements. Exemplary dimensional, flow rate, and other values, for two computer simulated examples (Base Case and Scaled-Up Case), for various dimensions of the apparatus 700 and flow rates for liquid water therethrough are shown in Table 1. When designing an apparatus for holding a liquid for a particular application the dimensions shown in Figure 7 and the corresponding values shown in Table 1 represent only an exemplary embodiment and any one or more of the dimensions can be varied without departing from the scope of the invention.

[00100] The particular dimensions for any of the apparatus 100, 200, 300, 400, 500, and/or 630 discussed and described above with reference to Figures 1-6 can be similar to the illustrative dimensions discussed and described with reference to the apparatus 700 depicted in Figure 7. The apparatus 700 has an internal volume 115 of about 64.6 m^3 and is sized to receive about $8.16 \text{ m}^3/\text{min}$ (2,155 gpm) of water or water/particulate mixture with a residence time therein of 7.92 minutes. More particularly, the apparatus 700 has a cylindrical inner surface 107 such that the vessel has a diameter of 3.5 m and an overall height of 7 m. The dimensions and velocities shown in Figure 7 are listed in Table 1 as the "Base Case." A second set of dimensional measurements are also shown in Table 1 and are listed as the "Scaled-Up Case." The Scaled-Up Case has an internal volume of 145 m^3 and is sized to receive about $17.6 \text{ m}^3/\text{min}$ (4,641 gpm) of water and/or a water/particulate mixture with a residence time therein of 8.25 minutes. More particularly, the Scaled-Up Case has a cylindrical inner surface 107 such that the vessel has a diameter of 5.14 m and a height of 7.41 m.

[00101] The dimensions shown in Table 1 for the Base Case and the Scaled-Up Case represent one possible set of dimensional values for apparatus 700 designed to circulate about $489.6 \text{ m}^3/\text{hour}$ (129,300 gph) and $1,056 \text{ m}^3/\text{hour}$ (278,460 gph), respectively, of cooling water therethrough. The velocity of the cooling water can vary as the water flows through the liquid holding apparatus 700. Computer simulations were used to determine the particular and exemplary design of the Base Case liquid holding apparatus 700 such that the dimensions and the flow rates of the water therethrough provided a desired degree or level of particulate separation. The particular dimensions, flow rates, ratios, and other parameters further discussed below can change should any one or more of the particular system in which the system is to be used, the type of liquid and/or particulates used, the desired flow rates, operating temperatures, or the like, change. The Scaled-Up Case was determined based on maintaining certain desired dimensional ratios and/or flow rates of water through the apparatus 700 similar to or within a preferred range with respect to the Base Case values.

Table 1		
Measurement	Base Case	Scaled Up Case
Water Flow Rate (gpm)	2,155	4,641
Water Flow Rate (m^3/s)	0.136	0.293
Diameter, D (m)	3.5	5.14
Average Downward Velocity, V_6 (m/s)	0.0141	0.0141
Outer Diameter of Conduit 120, d_i (in)	18	24
Inner Diameter of Conduit 120* (in)	16.876	22.624
Flow Area within Conduit 120, A_1 (m^2)	0.144	0.259
Velocity of Water through Conduit 120, V_1 (m/s)	0.942	1.129
Diameter of Baffle 140, d (m)	1	1.45
Area of Baffle 140, A_2 (m^2)	0.79	1.64
Flow Area between Baffle 140 and Conduit 120, A_2-A_1 (m^2)	0.64	1.38
Upward Velocity between Conduit 120 and Baffle 140, V_2 (m/s)	0.2121	0.2121
Height of Baffle 140, h_2 (m)	1	1
Distance Between Top 109 of Vessel 105 and Baffle 405, h_5 (m)	0.127	0.170
Flow Area Between Top of Baffle 405 and Vessel Wall 117, A_3 (m^2)	1.06	2.28
Water Flow/Annulus Area A_3 , V_3 (m/s)	0.128	0.128
Top Outer Diameter of Top Baffle 405 (m)	2.65	4.28
Baffle Top Gap, X (m)	0.42	0.43
Gap Annular Area, A_4 (m^2)	4.09	6.33
Water Flow/ Gap Area A_4 (m/s)	0.0333	0.0462
Annular Area at Bottom of Gap, A_5 (m^2)	0.139	0.300
Water Flow/Bottom Gap Area, V_5 (m/s)	0.977	0.977
Distance between Wall 117 of Vessel 105 and the Bottom of Baffle 405, W (m)	0.0127	0.0185
Bottom Diameter of Top Baffle 405 (m)	3.47	5.1
Baffle 405 Angle, θ (degrees)	75	75
Height of Baffle 405, h_6 (m)	1.53	1.53
Distance between Baffle 405 and Baffle 140, h_7 (m)	1.4	1.36
Inner Diameter of Outlet 150 (in)	10.02	15.00
Flow Area of Outlet 150, A_7 (m^2)	0.051	0.114
Velocity of Liquid through Outlet 150, V_7 (m/s)	2.67	2.57
Bottom Head Height, h_4 (m)	0.88	1.28
Total Tank Height, H (m)	7	7.41
Distance between Top of Baffle 140 and Top 109 of Vessel 105, h_1 (m)	3.06	3.06
Height of Baffle 140, h_2 (m)	1	1
Distance between Bottom of Baffle 140 and End of Vessel 105, h_3 + h_4 (m)	2.94	3.34
Straight Side 117 Length of Vessel 105, $h_1+h_2+h_3$ (m)	6.13	6.13
Volume of Vessel 105 (m^3)	64.6	145
Residence Time of Liquid within Vessel 105 (min)	7.92	8.25

Table 1 - continued		
Scaling Verification Numbers to Check	Base Case	Scaled Up Case
H/D	2.00	1.44
d^2/d_i^2	4.78	5.62
D/d	3.50	3.55
Flow Velocity in Lower Tank, V_6 (cm/s)	1.41	1.41

*18 inch Schedule 40 Pipe has an ID of 16.876 inches and 24 inch Schedule 40 Pipe has an ID of 22.624 inches

[00102] Scaling the Base Case apparatus 700 either up or down can include maintaining one or more ratios between two particular dimensions constant or within a predetermined range. Other design considerations can include the particular velocity or flow rate of the cooling water as it flows through the liquid holding apparatus 700.

[00103] A ratio between two lengths that can be considered when designing the liquid holding apparatus 700 can be the ratio of the inner diameter of the vessel 105 (D) to the inner diameter of the baffle 140 (d) or D/d. The ratio of D/d can range from about 2.5 to about 4, about 2.7 to about 3.7, about 2.8 to about 3.6, or about 2.9 to about 3.5. As shown, the Base Case has ratio of D/d of about 3.50. Similarly, the Scaled-Up Case has a ratio of D/d of about 3.55.

[00104] A ratio between two flow areas that can be considered when designing the liquid holding apparatus 700 can be the ratio of the square of the inner diameter of the baffle 140 (d) to the square of the inner diameter of the conduit 120 (d_i) or d^2/d_i^2 . The ratio of d^2/d_i^2 can have a value of greater than about 3, greater than about 4, greater than about 5, or greater than about 6 and less than about 15, less than about 12, or less than about 10. As shown, the Base Case has a ratio of d^2/d_i^2 of about 4.78 and the Scaled-Up Case has a ratio of d^2/d_i^2 of about 5.62. This criteria can be controlled, at least in part, by the desired velocity in the conduit 120 (V_1) and the desired upward velocity (V_2) out of the baffle 140.

[00105] Another ratio between two lengths that can be considered when designing the liquid holding apparatus 700 can be the ratio of the height of the vessel 105 (H) to the inner diameter of the vessel 105 (D) or H/D. The ratio of H/D can be range from a low of about 0.5, about 0.6, about 0.7, about 1, about 1.2, or about 1.4 to a high of about 2.2, about 2.4, about 2.6, or about 3. Preferably, the ratio of H/D is in the range of from about 1 to about 2.7, or from about 1.2 to about 2.5. As shown, the Base Case has a ratio of H/D of about 2 and the Scaled-Up case has a ratio of H/D of about 1.44. For this particular Scaled-Up Case, the H/D ratio was made smaller for the larger tank in order to achieve desired liquid velocities in different zones of the tank. For the Scaled-Up Case, the heights h_1 , h_2 , and h_3 were maintained the same as the Base Case and the diameter of the Scaled-Up Case was increased such that the overall upward or downward

liquid velocity in desired zones was maintained the same. This approach can minimize the size and/or cost of larger tanks without having a significant impact on the separation efficiency.

[00106] The height of the baffle 405 (h_6) can be adjusted based on the distance (h_1) between the top of the baffle 140 and the top 109 of the vessel 105. In some embodiments, h_6 is less than or equal to $0.6h_1$, or less than or equal to $0.55h_1$, or less than or equal to $0.5h_1$. In some embodiments, h_6 is equal to $0.5h_1$.

[00107] One flow rate that can be maintained constant or within a particular range between differently sized liquid holding apparatus 700 can include, for example, the flow rate or velocity (V_2) of cooling water through an annular gap 143 formed between the end of the conduit 120 and the inner walls 145 of the baffle 140. As shown in Table 1, the velocity (V_2) for both the Base Case and the Scaled-Up Case was maintained at about 0.2121 m/s. The velocity (V_2) can range from a low of about 0.05 m/s, about 0.1 m/s, or about 0.15 m/s to a high of about 0.25 m/s, about 0.3 m/s, or about 0.35 m/s.

[00108] Another velocity that can be maintained constant between the Base Case and the Scaled-Up Case can be the flow rate or velocity (V_5) of the cooling water between the bottom of the baffle 405 and the wall 117 of the vessel 105, which for both the Base Case and the Scaled Up Case is 0.977 m/s. The velocity V_5 can range from a low of about 0.1 m/s, about 0.2 m/s, or about 0.3 m/s to a high of about 1.3 m/s, about 1.5 m/s, or about 2 m/s. In some embodiments, the distance between the wall 117 of the vessel 105 and the bottom of the baffle 405 (W) can be adjusted to maintain the desired velocity V_5 .

[00109] The average downward velocity of the cooling water through conduit 120 (V_1) can range from about 0.5 to about 1.5 m/s. As shown the velocity V_1 for the Base Case was 0.942 m/s and the velocity V_1 for the Scaled-Up Case was 1.129 m/s. The particular internal cross-section of the conduit 120 can be used to control or adjust V_1 , for example.

[00110] The velocity (V_3) of the cooling water between the annulus area A_3 between the top of the second baffle 405 and the vessel 105 was kept the same for both the Base Case and the Scaled-Up Case at 0.128 m/s. Depending on the particular design, this velocity (V_3) can range from a low of about 0.05 m/s, about 0.07 m/s, or about 0.1 m/s to a high of about 0.15 m/s, about 0.2 m/s, or about 0.3 m/s.

[00111] The flow velocity (V_6) in the lower tank can be maintained constant between the Base Case and the Scaled-Up Case. As shown the velocity (V_6) for both the Base Case and the Scaled-Up Case was maintained at 1.41 cm/s. This velocity can vary depending on the particular liquid, particulate density, and the temperature. In some embodiments, the velocity V_6 is less than 2 cm/s, or less than 1.8 cm/s, or less than 1.75 cm/s, or less than 1.7 cm/s, or less

than 1.65 cm/s, or less than 1.5 cm/s. Preferably, the velocity V_6 is less than 1.64 cm/s for the conditions (i.e., liquid and polymer particles) simulated in the Examples.

[00112] Figures 8-11 are derived from Computational Fluid Dynamics ("CFD") simulations. CFD simulations are widely used to simulate gas and/or liquid flow fields, and were used to model the flow field of water within the internal volume of four differently configured and/or sized apparatus for holding a liquid.

[00113] Figures 8 and 9 compare the velocity of the cooling water thorough apparatus 800 and 900, respectively, as the cooling water flows through the internal volume thereof. The apparatus 800 and 900 do not include the second baffle 405 discussed and described above with reference to Figures 4 and 7. Apparatus 800 has been scaled down relative to the Base Case shown in Figure 7 and apparatus 900 has been scaled up relative to the Base Case shown in Figure 7. Apparatus 800 has a diameter (D) of 3.2 m, a height (H) of 7 m, holds 56.3 m^3 ($1,988 \text{ ft}^3$) of the cooling water, is designed to receive $8.54 \text{ m}^3/\text{min}$ (2,255 gpm) cooling water, and has a residence time of 6.6 minutes. Apparatus 900 has a diameter (D) of 4.5 m, a height (H) of 10 m, holds 159 m^3 ($5,617 \text{ ft}^3$) cooling water, is designed to receive $17.6 \text{ m}^3/\text{min}$ (4,650 gpm) cooling water, and has a residence time of 9 minutes. The conduit 120 was a 16 inch Schedule 40 pipe and the outlet 150 was 12 inch schedule 40 pipe for both apparatus 800 and 900. Some of the velocities for the simulated velocity contours for the apparatus 800 and 900 are shown in Table 2 below. The velocities shown in Table 2 are in m/s.

Table 2		
	Apparatus 800	Apparatus 900
V_1	≥ 0.6	≥ 0.6
V_6	≤ 0.03	≤ 0.03
V_7	≥ 0.6	≥ 0.6
V_8	≤ 0.03	≤ 0.03
V_9	0.2 to 0.25	0.43 to 0.53
V_{10}	0.18 to 0.25	0.27 to 0.43
V_{11}	0.18 to 0.25	0.24 to 0.33
V_{12}	0.15 to 0.18	0.18 to 0.24
V_{13}	0.03 to 0.06	0.03 to 0.06
V_{14}	0.06 to 0.09	0.06 to 0.09

[00114] The pellet separation efficiency of a water/pellet mixture for both apparatus 800 and 900 and three comparative examples CEx1, CEx2, and CEx3 were also simulated. The liquid holding vessels of comparative examples CEx1 and CEx2 both had a rectangular base of 4.6 m x 3.5 m, a height of 3.35 m, and hold 53.7 m^3 ($1,898 \text{ ft}^3$) of the water/pellet mixture. The liquid holding vessel of comparative example CEx3 had a rectangular base of 4.6 m x 7.2 m, a height of 3.35 m, and holds 120.8 m^3 ($4,266 \text{ ft}^3$) of the water/pellet mixture. The three comparative

examples had a common internal design that included a two vertical baffle plates, one extending from the base toward the middle and the other extending from the top toward the middle. The flow path of the water/pellet mixture followed a horizontal "S" shaped flow path through the vessels. The water/pellet mixture was introduced to the liquid holding vessel of CEx1 at a rate of 8.54 m³/min (2,255 gpm), which is the same as apparatus 800. The water/pellet mixture has a residence time within the liquid holding vessel of CEx1 of 6.3 minutes, which is similar to the 6.6 minute residence time of apparatus 800. The water/pellet mixture was introduced to the liquid holding vessel of CEx2 at a rate of 17.6 m³/min (4,650 gpm), which was the same as apparatus 900. The water/pellet mixture had a residence time within the liquid holding vessel of CEx2 of only 3 minutes, which is about half the residence time of apparatus 800. The water/pellet mixture was introduced to the liquid holding vessel of CEx3 at a rate of 17.6 m³/min (4,650 gpm), which was the same as apparatus 900. The water/pellet mixture has a residence time within the liquid holding vessel of CEx3 of 6.3 minutes, which was about 30% less than that of apparatus 900.

[00115] The pellet separation efficiencies of differently sized polymer particulates for apparatus 800, 900, CEx1, CEx2, and CEx3 are shown in Table 3.

Table 3					
Pellet Size (mm)	Apparatus 800	Apparatus 900	CEx1	CEx2	CEx3
0.1	4%	4%	2%	2%	2%
0.25	6%	6%	3%	3%	3%
0.5	12%	11%	16%	5%	8%
0.75	42%	30%	63%	10%	17%
0.85	85%	71%	82%	13%	21%
1	100%	100%	95%	22%	29%
1.25	100%	100%	98%	43%	48%
1.5	100%	100%	100%	70%	73%
1.75	100%	100%	100%	88%	90%
2	100%	100%	100%	94%	97%

[00116] As shown in Table 3, the particulate separation efficiency for apparatus 800 and CEx1 both had similar separation efficiencies for particulates sized between 0.1 and 0.85, with the CEx1 performing slightly better. For particulates of 1 mm or larger apparatus 800 had 100% separation efficiency with CEx1 performing similarly at 95% for 1 mm particulates and 100% for particulates of 1.5 mm or larger.

[00117] Increasing the water/pellet introduction rate from 8.54 m³/min (2,255 gpm) to 17.6 m³/min (4,650 gpm), however, resulted in a substantial improvement in the separation of the particulates for the apparatus 900 versus that of comparative examples CEx2 and CEx3 for particulates of about 0.75 mm and larger. For example, apparatus 900 had 100% separation

efficiency for particulates 1 mm and greater. In comparison, CEx2 and CEx3 only separated particulates of 1 mm in size with an efficiency of 22% and 29%, respectively. Further, the simulations showed that neither of CEx2 nor CEx3 achieved 100% separation efficiency for particulates up to 2 mm in size.

[00118] Figures 10 and 11 compare the velocity of the cooling water thorough apparatus 1000 and 1100, respectively, as the cooling water flows through the internal volume thereof. The apparatus 1000 and 1100 correspond to the Base Case and the Scaled-Up Case discussed and described above with reference to Figure 7. As such, both apparatus 1000 and 1100 include a second baffle 405. Furthermore, the water/pellet mixture was introduced to apparatus 1000 at a rate of 8.54 m³/min (2,255 gpm) and to apparatus 1100 at a rate of 17.6 m³/min (4,650 gpm). Some of the velocities for the simulated velocity contours for the apparatus 1000 and 1100 are shown in Table 4 below. The average of the velocity contours V₉, and V₁₀ correspond to the velocity V₂ listed in Table 1, which averages to a velocity of about 0.2121 m/s as shown in Table 1. The velocities shown in Table 4 are in m/s.

Table 4		
	Apparatus 1000	Apparatus 1100
V ₁	≥ 0.6	≥ 0.6
V ₄	≤ 0.015	≤ 0.015
V ₅	≤ 0.015	≤ 0.03
V _{6a}	≤ 0.015	≤ 0.015
V _{6b}	≤ 0.03	≤ 0.03
V ₇	≥ 0.6	≥ 0.6
V ₈	≤ 0.015	n/a
V _{8a}	n/a	≤ 0.05
V _{8b}	n/a	≤ 0.03
V ₉	0.21 to 0.24	0.21 to 0.24
V ₁₀	0.14 to 0.24	0.14 to 0.24
V ₁₁	0.12 to 0.17	0.17 to 0.24
V ₁₄	0.04 to 0.06	0.06 to 0.08

[00119] The pellet separation efficiency of a water/pellet mixture for both apparatus 1000 and 1100 were also simulated and the results are shown in Table 5.

Table 5		
Pellet Size (mm)	Apparatus 1000	Apparatus 1100
0.1	2%	2%
0.25	4%	4%
0.5	16%	11%
0.75	42%	36%
0.85	60%	48%
1	93%	89%
1.25	100%	93%

Table 5-Continued		
Pellet Size (mm)	Apparatus 1000	Apparatus 1100
1.5	100%	98%
1.75	100%	100%
2	100%	100%

[00120] As shown in Table 5, both apparatus 1000 and 1100 had similar particulate separation efficiencies, with apparatus 1000 performing slightly better for particles ranging from about 0.5 mm to about 1.25 mm. As shown in Tables 3 and 5, apparatus 800, 900, 1000, and 1100 achieve good particulate separation efficiency for particulates greater than about 0.8 mm in size as compared to conventional designs having a rectangular base. The apparatus 800, 900, 1000, and 1100 require less foot print, *i.e.* land area, than a comparable tank having a rectangular base while taking advantage of available space, *i.e.* vertical space. The apparatus 800, 900, 1000, and 1100 tend to show improved separation efficiency for particulates greater than about 0.8 mm in size than conventional rectangular tanks.

[00121] Tables 3 and 5 show that the apparatus for holding a liquid according to one or more embodiments discussed and described above with reference to Figures 1-11, when used for relatively slow circulation rates, *e.g.*, 8.54 m³/min (2,255 gpm), provide a slightly lower level of separation efficiency for particulates less than about 0.8 mm in size, but equal or better separation for particulates greater than about 0.8 mm. Furthermore, at greater circulation rates, *e.g.*, 17.6 m³/min (4,650 gpm), the apparatus for holding liquid according to one or more embodiments discussed and describe above with reference to Figures 1-11 exhibit greater particulate separation efficiency for particulates ranging from about 0.8 mm up to about 2 mm. Accordingly, a water cooling system according to one or more embodiments discussed and described above with reference to Figures 1-11 can be used in, for example, a polymer pelletization system to reduce or eliminate the need for shutdown due to particulate buildup within the polymer pelletization system.

[00122] All numerical values are "about" or "approximately" the indicated value, and take into account experimental error and variations that would be expected by a person having ordinary skill in the art.

[00123] All patents, test procedures, and other documents cited in this application are fully incorporated by reference to the extent such disclosure is not inconsistent with this application and for all jurisdictions in which such incorporation is permitted.

[00124] While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention can be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

CLAIMS

What is claimed is:

1. An apparatus comprising:
a vessel having a first end, an enclosed second end, and an internal volume;
a conduit at least partially disposed within the vessel, wherein a first end of the conduit is disposed within the internal volume such that a flow path from the first end of the conduit is directed toward the enclosed second end;
a first baffle disposed between the first end of the conduit and the enclosed second end such that the direction of the flow path from the conduit is altered by the baffle; and
an outlet disposed on the enclosed second end of the vessel.
2. The apparatus according to claim 1, wherein the first end of the conduit extends into the internal volume through the first end of the vessel.
3. The apparatus according to claims 1 or 2, wherein the vessel is vertically oriented such that the first end is located above the enclosed second end, and wherein the conduit is concentrically disposed through the first end of the vessel.
4. The apparatus according to any of claims 1 to 3, wherein the vessel further comprises a cylindrical inner wall, an ellipsoidal inner wall, or a combination thereof.
5. The apparatus according to any of claims 1 to 4, further comprising a second baffle disposed within the internal volume between the first end of the vessel and the first baffle.
6. The apparatus according to claim 5, wherein the vessel further comprises a cylindrical inner wall, and wherein the second baffle comprises a frustoconical ring concentrically disposed within the internal volume such that a gap is formed between at least a portion of the cylindrical inner wall and the second baffle.
7. The apparatus according to claim 6, wherein a base of the frustoconical ring is directed toward the enclosed second end.
8. The apparatus according to claims 6 or 7, wherein an inner wall of the frustoconical ring has an angle of from about 70° to about 80° with respect to a base of the frustoconical ring.
9. The apparatus according to any of claims 1 to 8, wherein the first end is enclosed.

10. The apparatus according to any of claims 1 to 9, wherein the first end is enclosed and the vessel further comprises one or more outlets disposed about a sidewall of the vessel between the first baffle and the enclosed first end.
11. The apparatus according to any of claims 1 to 10, further comprising an overflow weir disposed about the first end.
12. The apparatus according to any of claims 1 to 11, further comprising a vortex breaker disposed within the internal volume about an opening of the outlet, within the outlet, or a combination thereof.
13. The apparatus according to any of claims 1 to 12, further comprising one or more heat exchangers in a heat exchanging relationship with the internal volume, the outlet, or both.
14. The apparatus according to any of claims 1 to 13, wherein the first baffle and the conduit are integral with one another.
15. The apparatus according to any of claims 1 to 14, wherein the first baffle and the conduit are connected to one another.
16. The apparatus according to any of claims 1 to 15, wherein the first baffle comprises a body having a cylindrical inner wall forming a cylindrical internal volume, an open first end, and an enclosed second end, and wherein the first end of the conduit extends into the internal volume of the first baffle through the open first end of the baffle.
17. The apparatus according to claim 16, wherein the first end of the conduit extends into the internal volume of the first baffle a distance ranging from about 5% to about 50% of a length between the open first end and the enclosed second end of the first baffle.
18. The apparatus according to claims 16 or 17, wherein the first end of the conduit concentrically extends into the internal volume of the first baffle.
19. The apparatus of claim 1, wherein the vessel further comprises a cylindrical inner wall such that the internal volume is cylindrical.
20. The apparatus of claim 1 or 19, wherein the vessel further comprises a curved inner wall such that the internal volume is cylindrical, and a second baffle disposed within the internal volume between the first end of the vessel and the first baffle, wherein the second baffle

comprises a frustoconical ring concentrically disposed within the internal volume such that a gap is formed between at least a portion of the cylindrical inner wall and the second baffle.

21. An apparatus, comprising:

a vessel having a first end, an enclosed second end, and a curved inner wall forming a cylindrical first internal volume;

a conduit at least partially disposed within the vessel, wherein a first end of the conduit is concentrically disposed within the first internal volume such that a flow path from the first end of the conduit is directed toward the enclosed second end;

a first baffle having a cylindrical second internal volume, an open end and an enclosed end, wherein the first end of the conduit is disposed through the open end of the first baffle and within the second internal volume such that the direction of the flow path from the conduit is reversed by the baffle; and

an outlet disposed on the second end of the vessel.

22. The apparatus according to claim 21, further comprising a second baffle disposed within the first internal volume between the first end of the vessel and the first baffle.

23. The apparatus according to claim 21, wherein the second baffle comprises a frustoconical ring, and wherein a base of the frustoconical ring is directed toward the enclosed second end of the vessel.

24. The apparatus according to any of claims 21 to 23, wherein the conduit further comprises a cylindrical outer surface such that an annulus is formed between a portion of the outer surface of the conduit and an inner wall of the first baffle.

25. The apparatus according to any preceding claim, wherein the conduit comprises a cylindrical inner surface, and wherein a ratio of the square of an inner diameter of the first baffle (d^2) to the square of an inner diameter of the conduit (d_i^2) is greater than about 3.5.

26. The apparatus according to any preceding claim, wherein a ratio of a height of the vessel (H) to an inner diameter of the vessel (D) ranges from about 0.6 to about 3.

27. The apparatus according to any preceding claim, wherein a ratio of an inner diameter of the vessel (D) to an inner diameter of the first baffle (d) ranges from about 2 to about 4.

28. The apparatus according to any of claims 21 to 27, wherein the first end of the vessel is enclosed and the vessel further comprises one or more outlets disposed about a sidewall of the vessel between the first baffle and the enclosed first end.

29. The apparatus according to any of claims 21 to 28, further comprising an overflow weir disposed about the first end.

30. The apparatus according to any of claims 21 to 29, further comprising one or more heat exchangers in a heat exchanging relationship with the internal volume of the vessel, the outlet, or both.

31. A method for separating particulates from a liquid, comprising:
providing the apparatus of any preceding claim;
introducing a liquid comprising particulates to the internal volume of the vessel through the conduit;
flowing the liquid comprising particulates through the conduit towards the first baffle, wherein the flow path of the liquid comprising particulates is altered by the first baffle;
recovering at least a portion of the particulates from the first end of the vessel; and
recovering a particulate-lean liquid from the outlet of the vessel, wherein the particulate-lean liquid has a reduced concentration of particulates relative to the liquid introduced to the internal volume of the vessel.

32. The method according to claim 31, wherein recovering at least a portion of the particulates from the first end of the vessel comprises flowing a portion of the liquid and particulates through one or more second outlets disposed on a sidewall of the vessel toward the first end of the vessel.

33. The method according to claims 31, wherein recovering at least a portion of the particulates from the first end of the vessel comprises flowing a portion of the liquid and particulates out of the internal volume from the first end of the vessel.

34. The method according to any of claims 31 to 33, wherein a residence time of the recovered particulate-lean liquid within the vessel ranges from about 6 minutes to about 10 minutes.

35. The method according to any of claims 31 to 34, wherein the particulates are buoyant in the liquid.

36. The method according to any of claims 31 to 35, wherein the particulates comprise one or more polymers, dust, or biomass.
37. The method according to any of claims 31 to 36, wherein the liquid comprises water.
38. The method according to any of claims 31 to 37, further comprising exchanging heat between the liquid while the liquid is within the internal volume to a heat transfer medium.
39. The method according to any of claims 31 to 38, further comprising:
introducing the recovered liquid to a pelletization system;
recovering a liquid and pellet mixture;
introducing the liquid and pellet mixture to a pellet separation system; and
recovering the liquid from the pellet separation system.

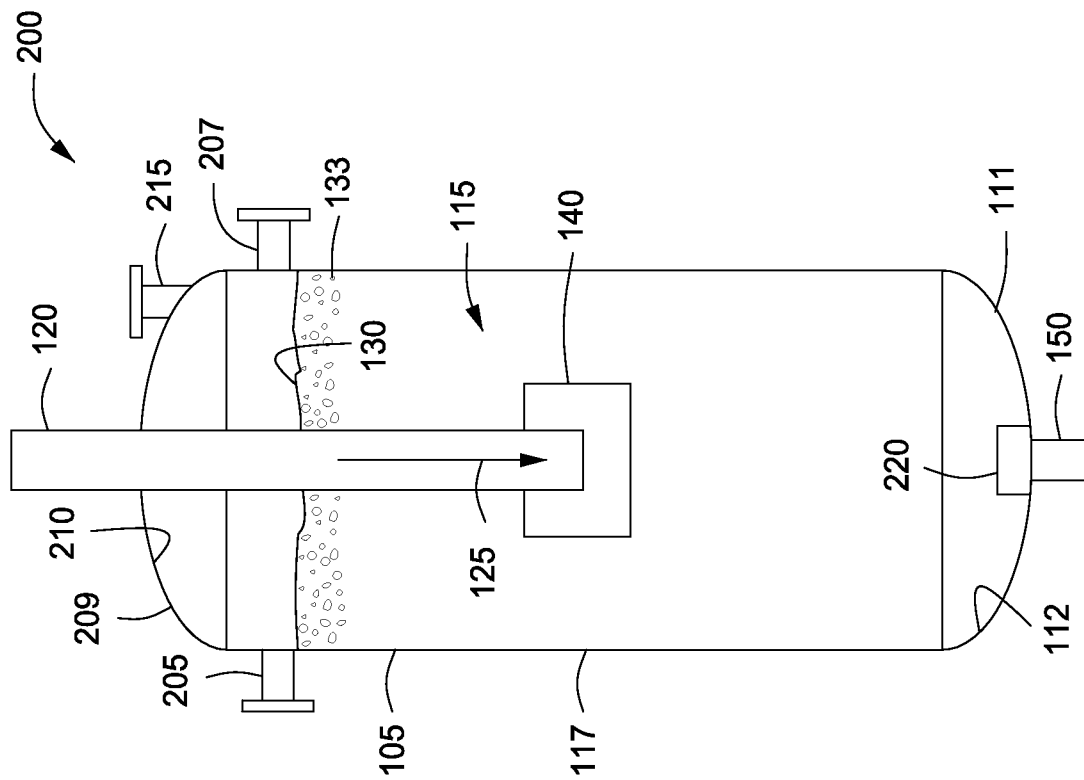


FIG. 2

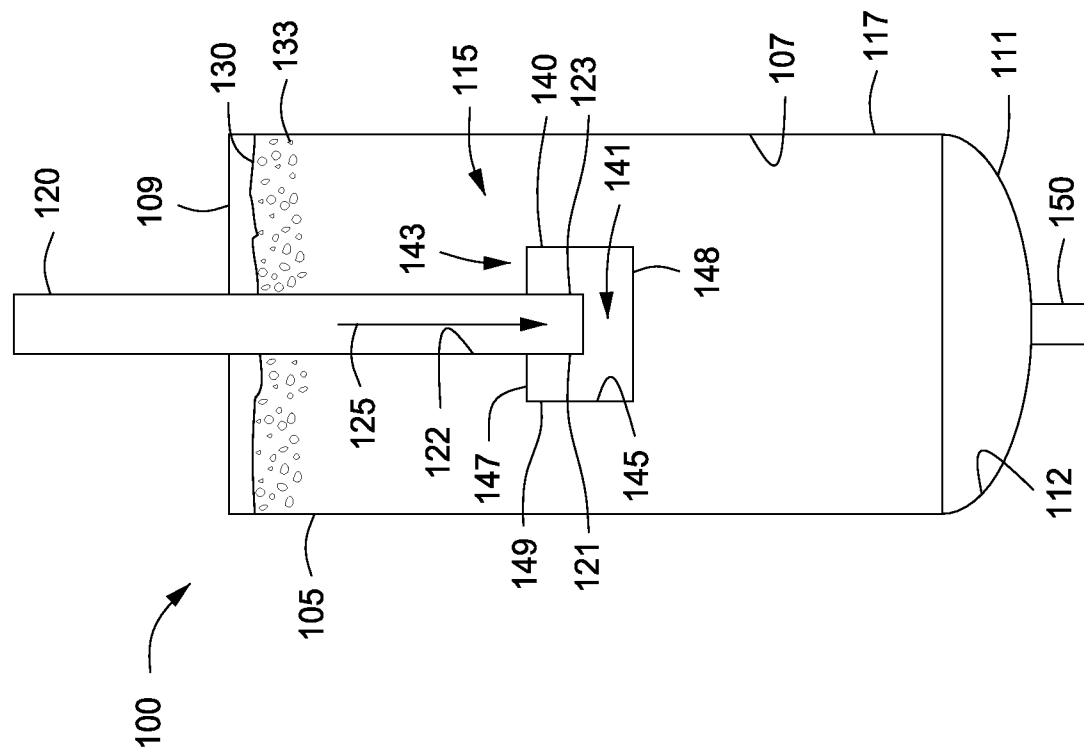


FIG. 1

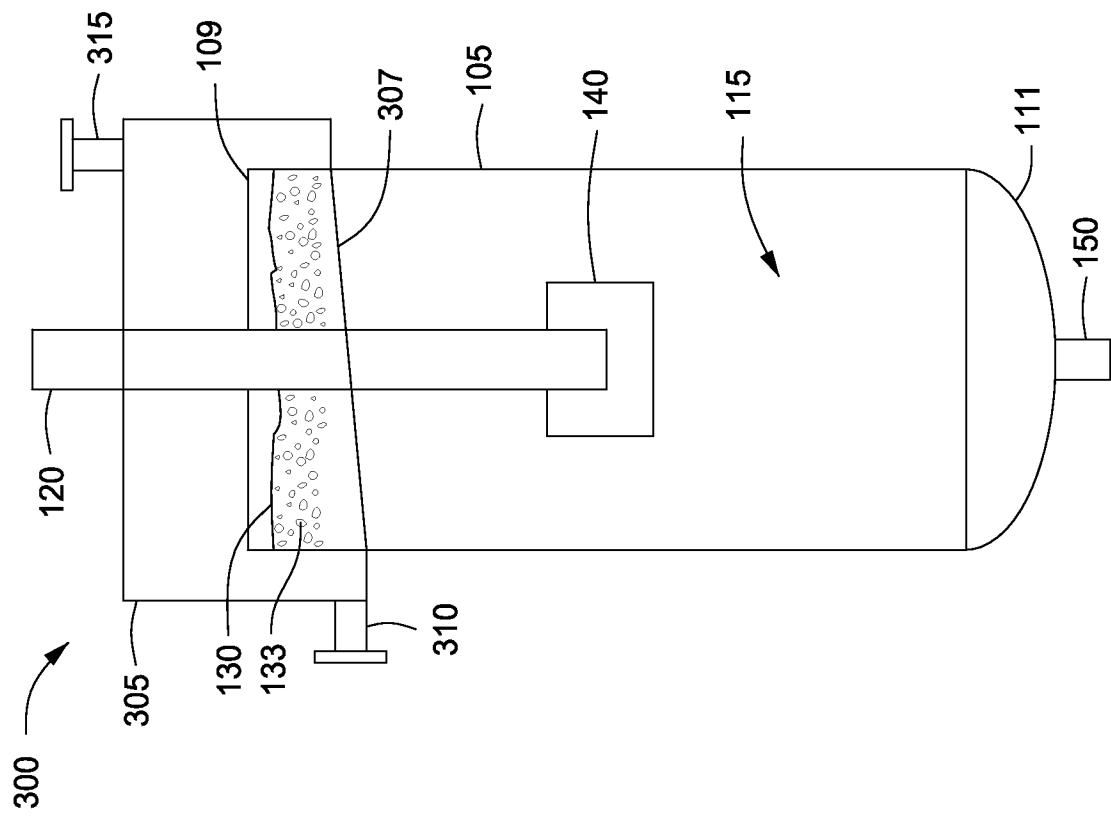


FIG. 3

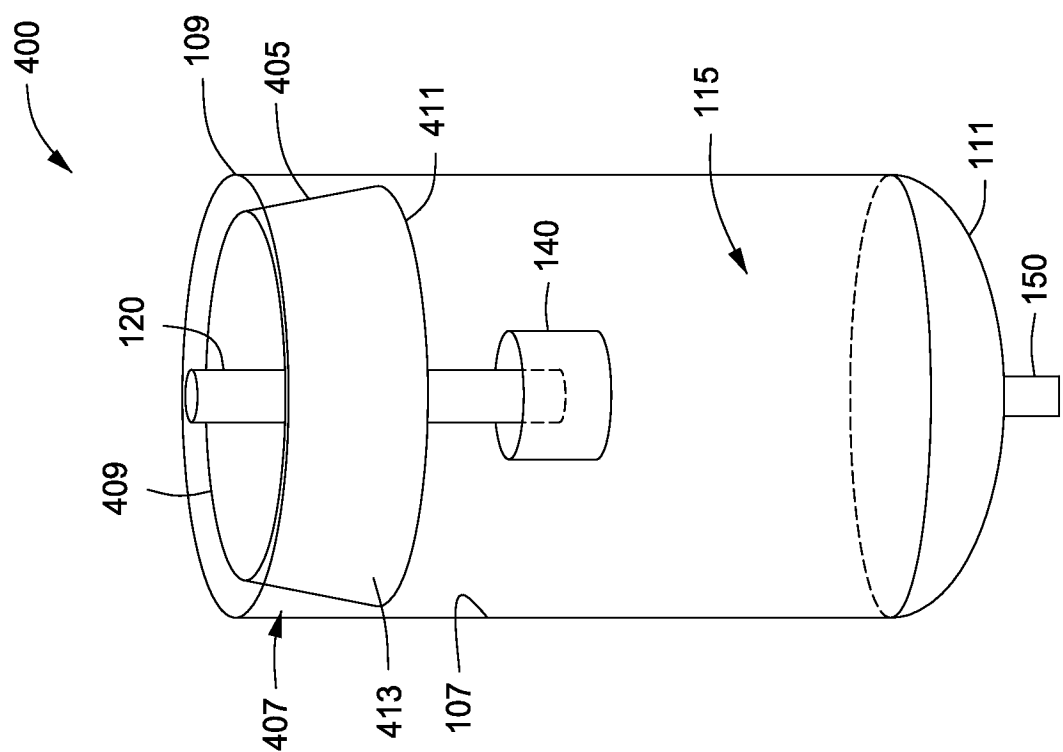


FIG. 4

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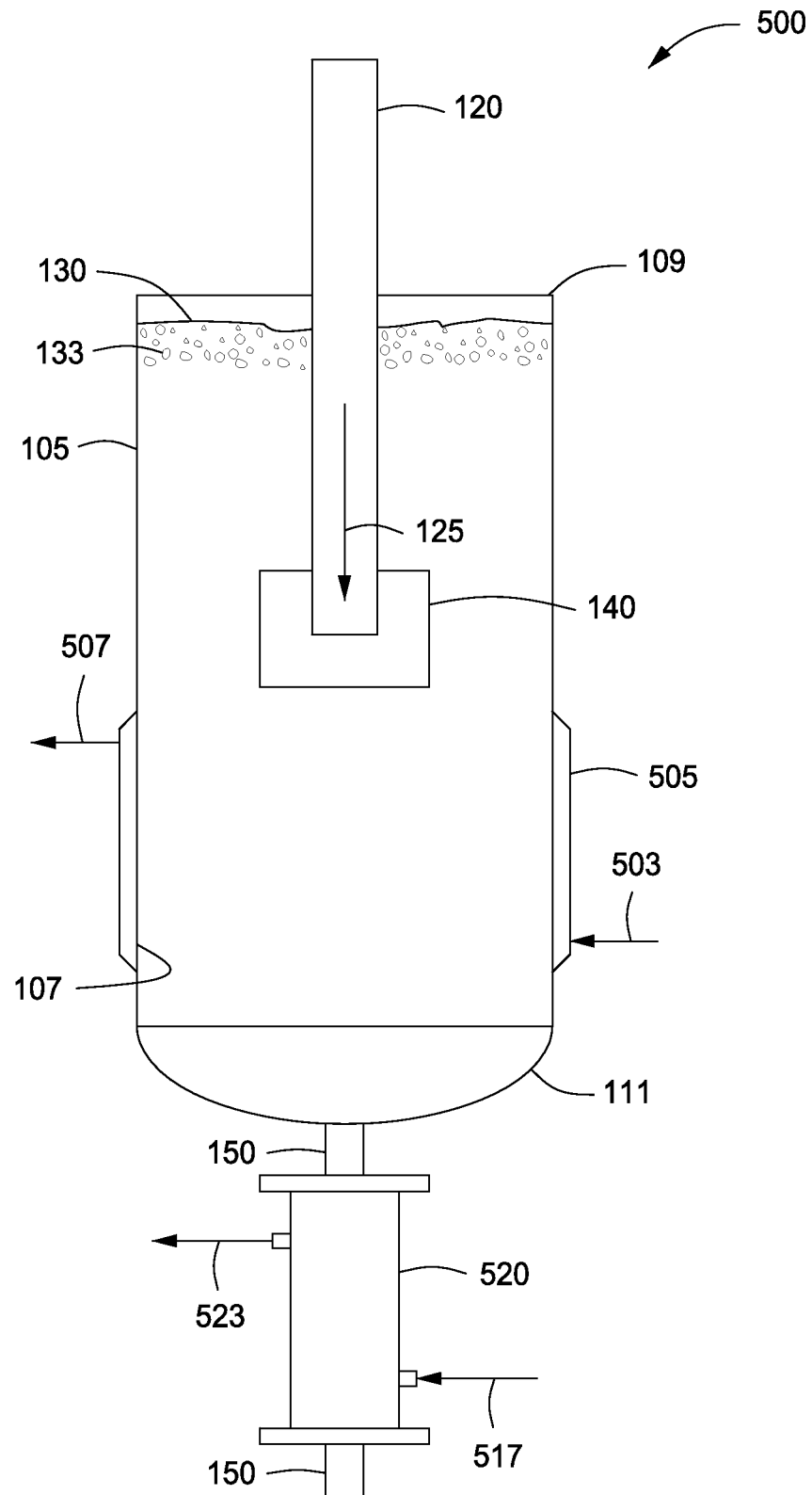


FIG. 5

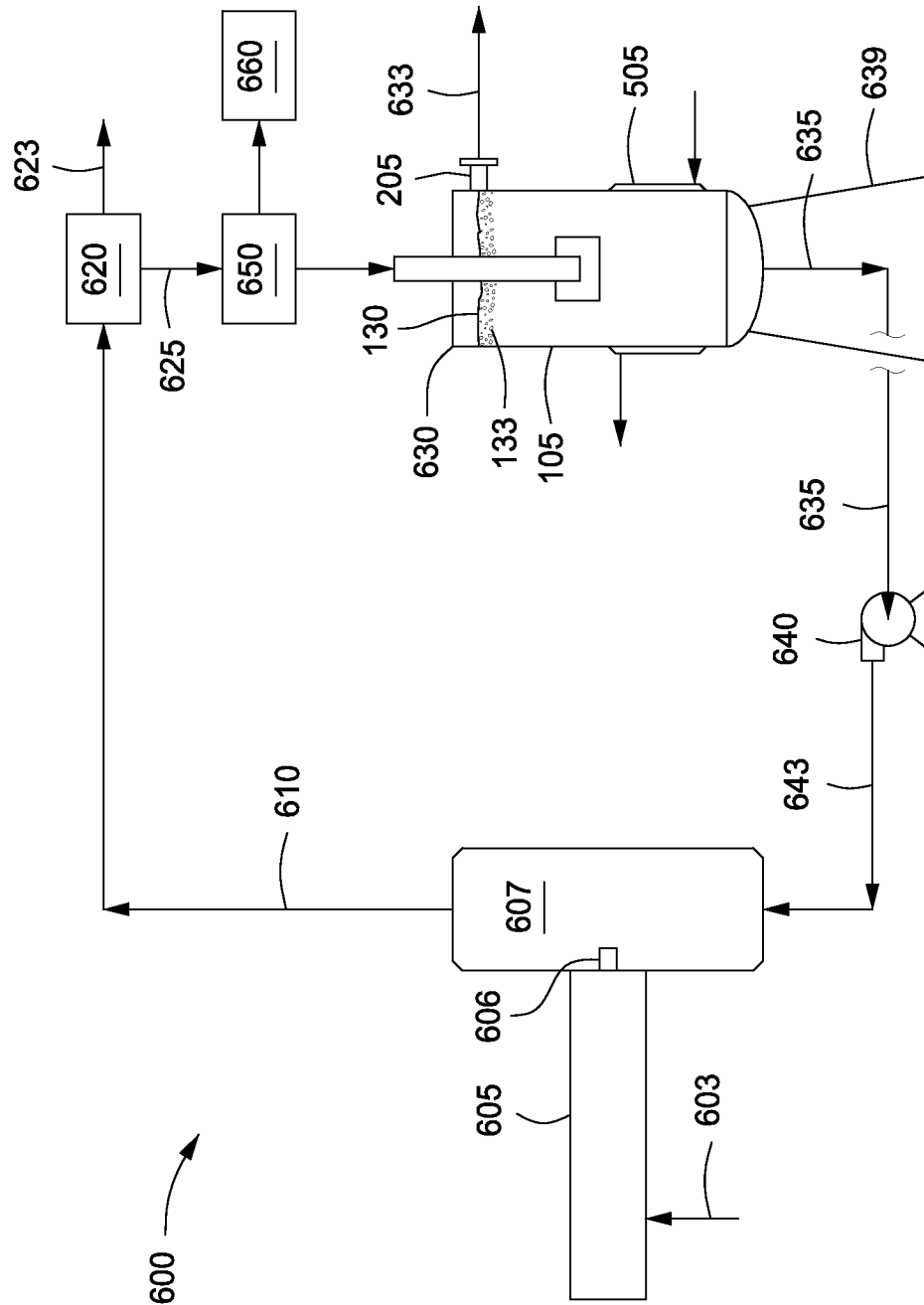


FIG. 6

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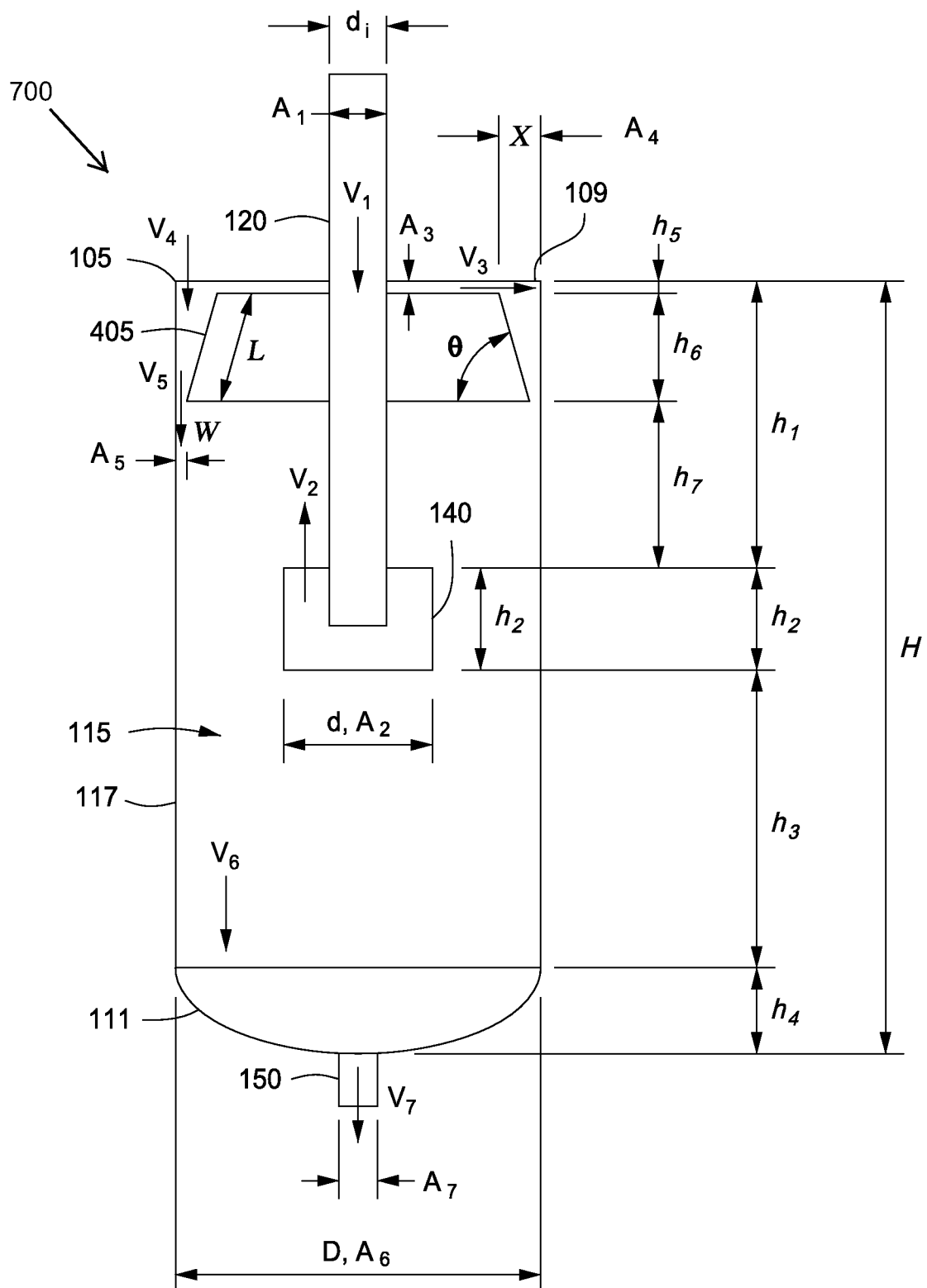


FIG. 7

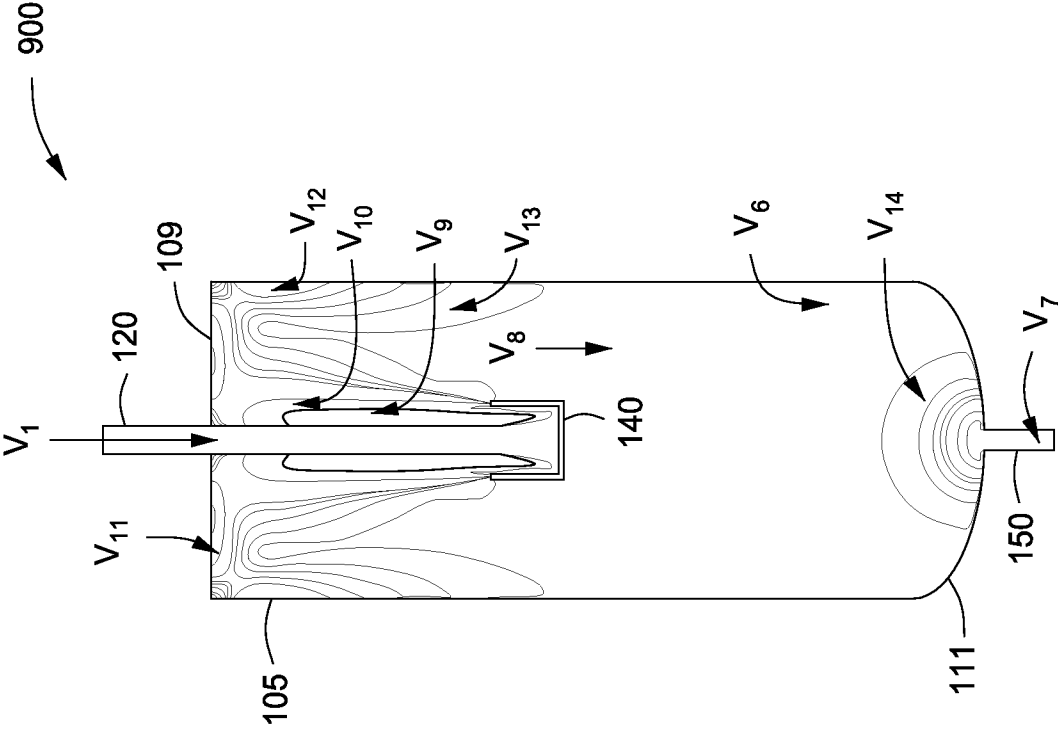


FIG. 9

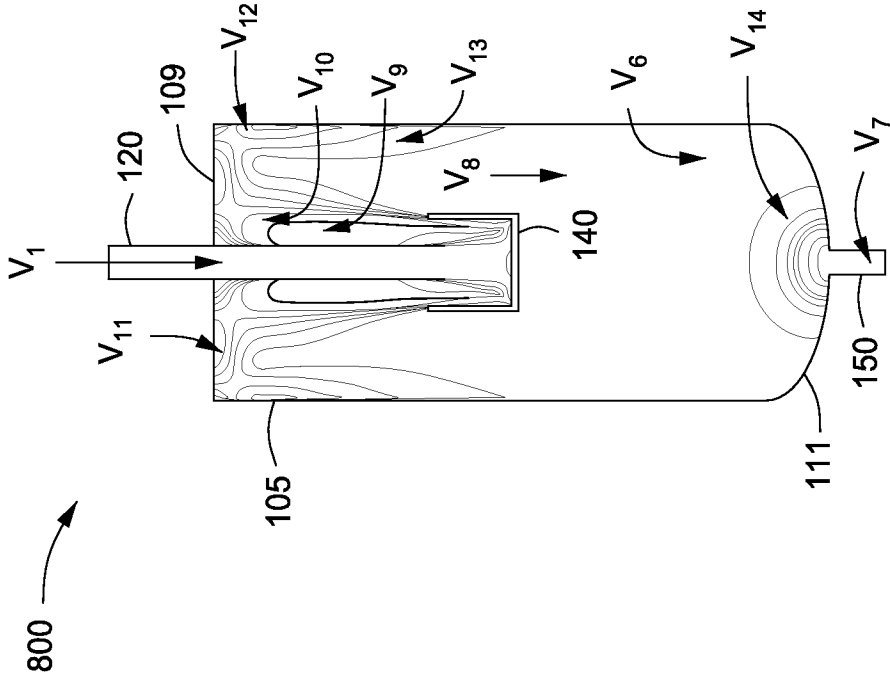


FIG. 8

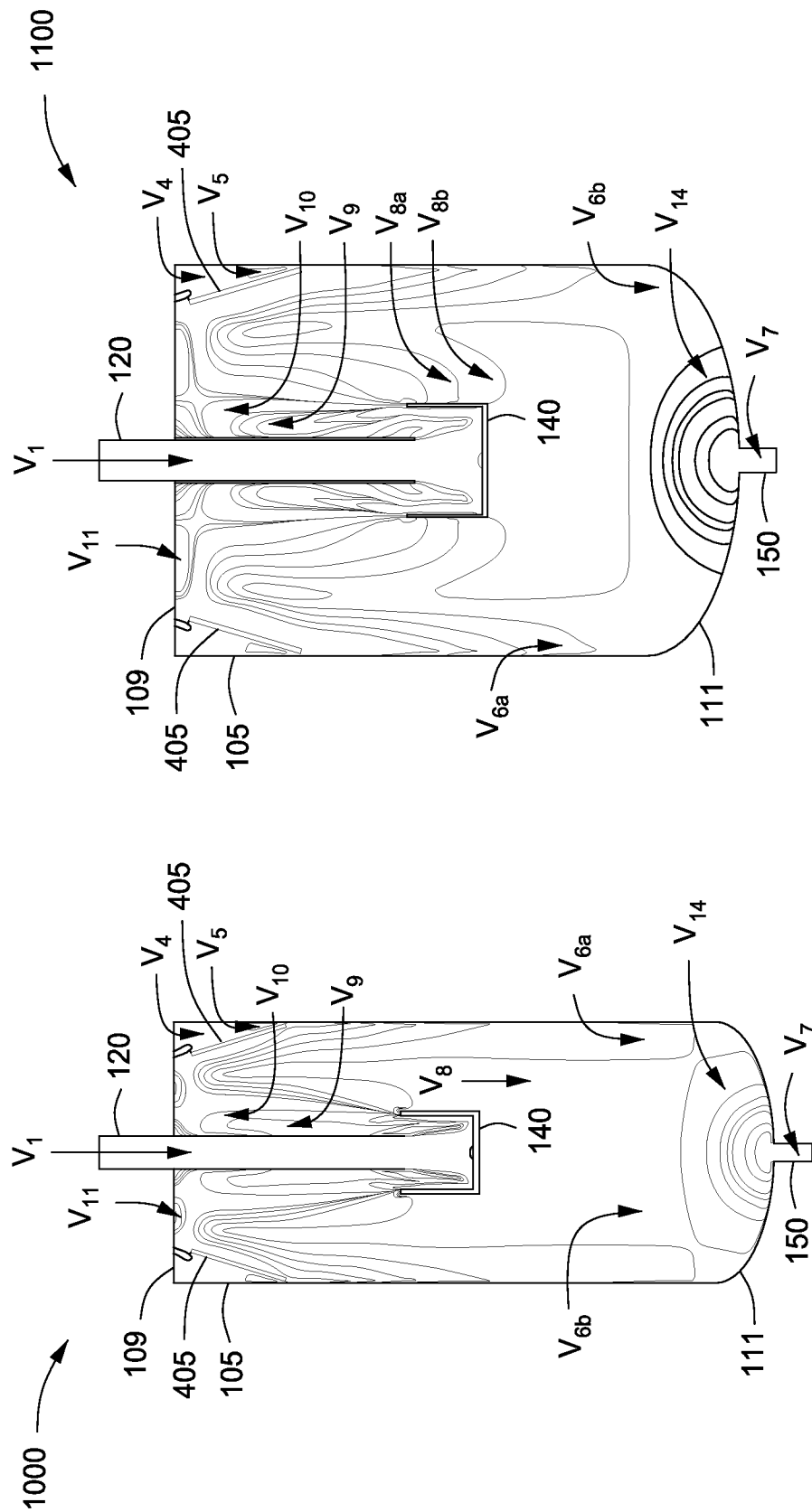


FIG. 11

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2011/029420

A. CLASSIFICATION OF SUBJECT MATTER INV. B01D21/02 B01D21/24 B29B9/06 ADD.		
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) B01D B29B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 865 725 A (CONDOLIOS ELIE ET AL) 11 February 1975 (1975-02-11) abstract; figure 1 paragraphs [0002] - [0004] sentences 25-40, paragraph 5 -----	1-39
X	US 5 730 784 A (SMITH JAMES W [CA] ET AL) 24 March 1998 (1998-03-24) figure 1 -----	1-39
X	WO 01/96246 A1 (HTCI [FR]; BEAULIEU BERNARD [FR]) 20 December 2001 (2001-12-20) abstract; figure 1 ----- -/--	1-39
☒ 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 document 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 29 June 2011		Date of mailing of the international search report 08/07/2011
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Varga, Viktoria

INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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X	DE 10 2006 020273 A1 (JUEBNER MATTHIAS [DE]) 31 October 2007 (2007-10-31) figure 1 -----	1,31
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