(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
26 November 2015 (26.11.2015)

WIPO | PCT

(10) International Publication Number
WO 2015/176688 A1

(51) International Patent Classification:
B24C 9/00 (2006.01)

(21) International Application Number:
PCT/CN2015/079594

(22) International Filing Date:
22 May 2015 (22.05.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

14/284,646	22 May 2014 (22.05.2014)	US
62/119,639	23 February 2015 (23.02.2015)	US
14/670,496	27 March 2015 (27.03.2015)	US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: GARNET EXTRACTION SYSTEM AND METHOD FOR USING THE SAME

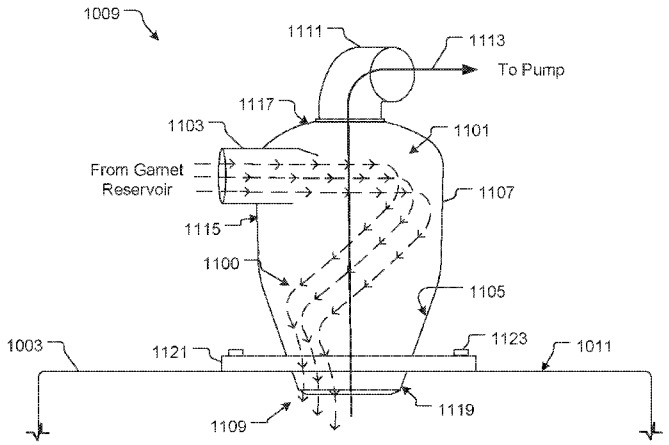

FIG. 11

(57) **Abstract**: A system and method to extract particulate material from a liquid. The system (1001) includes a cylindrical tank forming a hollow cavity and having a top end and a bottom end, a cross-flow separator (1009) rigidly attached to the top end of the cylindrical tank and in fluid communication with the hollow cavity, an inflow line coupled to the cross-flow separator, an outflow line coupled to the cross-flow separator (1009), a pump (1013) in fluid communication with outflow line, and a fluid reservoir (1007) in fluid communication with the inflow line. The method includes capturing particulate matter and liquid in a reservoir, partially separating the particulate matter and liquid within the reservoir, channeling the partially separated particulate matter and liquid to a cross-flow separator positioned above a tank, separating the partially separated particulate matter and liquid within the cross-flow separator, and capturing the particulate matter within the tank.

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GARNET EXTRACTION SYSTEM AND METHOD FOR USING THE SAME

BACKGROUND

1. Field of the Invention

[0001] The present invention relates to a system for extracting a particulate material (e.g., an abrasive material such as garnet) from a body of liquid, and in particular to a closed-loop system for extracting a particulate material (e.g., garnet) from a receptacle of a water jet cutter into which the particulate is delivered following a cutting operation.

2. Description of Related Art

[0002] Water jet cutters produce high pressure jets of water containing abrasive particles to cut a variety of materials (e.g., metals, stone, ceramics, etc.). The water jet with the abrasive material (e.g., garnet) is discharged by the water jet cutter at high pressures via a water jet nozzle. However, before the water jet is discharged, an abrasive particulate such as garnet particles are added to facilitate the cutting of the material. The water jet containing the abrasive particulate is ejected through the water jet nozzle onto a work piece, and the water jet containing the abrasive particulate passes through the work piece into a collection or water jet catch tank below the water jet nozzle.

[0003] One challenge with using water jet cutters is how to remove the abrasive material from the extraction or water jet catch tank after a water jet cutting operation. One known manner for doing so involves "sweeping" the bottom of the catch tank by directing a flow of the water and abrasive particulate slurry into a centrifugal filtration system. The centrifugal filtration system separates out the particulate from the water by pumping the particulate slurry through a centrifugal separator. A catch basin collects the used particulate and the separated water substantially relieved of the abrasive particulate can then be disposed of or re-circulated into the catch tank to repeat the process of sweeping the abrasive particulate slurry into the centrifugal filtration system.

[0004] However, due to the abrasive character of the particulate the water and particulate slurry is abrasive and can damage the particulate filtration system, including the pump used to draw the particulate slurry through the filtration system (especially in areas around seals of the pump), for example, the pump used to draw the particulate slurry from the liquid inside the water jet catch tank through the pump and to push the liquid and abrasive through the filtration system. Additionally, systems for removing abrasive material from a body of water or the catch tank extraction tank of a water jet cutter are bulky and heavy. Moreover, such systems are usually connected via rigid piping sitting on the bottom of to a water jet cutter catch tank and cannot be readily used with more than one cutter. Accordingly, there is a need for an improved system for removing abrasive materials (e.g., garnet) from a body of water, such as the catch or extraction tank of a water jet cutter.

[0005] Although great strides have been made in the area of systems for removing abrasive material, many shortcomings remain.

SUMMARY OF THE INVENTION

[0006] In accordance with one embodiment, a system for extracting a particulate material from a body of liquid is provided. The system includes an Extractor holding chamber with a top end and a bottom end, and a pump operatively coupled to the Extractor holding chamber via one or more valves. An outflow line coupled to the pump and having an outflow opening can be placed in fluid communication with the body of liquid. The system also includes an inflow line coupled to the Extractor holding chamber and having an inflow opening. At least a portion of the inflow line is proximate to the outflow line, so that the inflow opening and the outflow opening are proximate each other. The inflow line, the outflow line, and the Extractor holding chamber define a closed loop. The pump is configured to pump liquid from the Extractor holding chamber , once the Extractor holding chamber has been filled with liquid, to the body of liquid via the outflow line through the pump to unsettle the particulate material in the body of liquid with in the liquid catch tank, the pump configured to draw a generally equal amount of liquid and particulate material into the Extractor holding chamber via the inflow line without the particulate material passing through the pump, said particulate material collected in the Extractor holding chamber . The Extractor holding chamber can be a tank.

[0007] In accordance with another embodiment, a method for using an extraction system to extract particulate material from a liquid catch tank is provided. The method includes inserting a first conduit into a liquid catch tank, the first conduit coupled to a pump via a three-way valve. The method also includes inserting an outflow line into the liquid catch tank, the outflow line comprising one or more nozzles having a distal end, and inserting an inflow line into the liquid tank, the inflow line comprising a collector having a distal end, the collector and the one or more nozzles being proximate each other. The method also includes operating the pump to pull liquid from the Extractor holding chamber through an outflow line out of the one or more nozzles to unsettle the particulate material in the liquid catch tank, the particulate material drawn through the collector and the inflow line into the Extractor holding chamber without passing through the pump. The inflow line, the outflow line, and the Extractor holding chamber define a closed system.

[0008] In yet another embodiment, a system for extracting a particulate material from a water jet catch tank or a liquid catch tank that holds particulate material from a water jet cutting operation is provided. The system includes a Extractor holding chamber, and a pump operatively coupled to the Extractor holding chamber. An outflow line coupled to the pump and having an outflow opening can be placed in fluid communication with the water jet catch tank or a liquid catch tank. The system also includes an inflow line coupled to the Extractor holding chamber and having an inflow opening. At least a

portion of the inflow line is proximate to the outflow line so that the inflow line and the outflow line are proximate each other. The inflow line, the outflow line, and the Extractor holding define a closed loop. The pump is configured to pump liquid from the Extractor holding chamber to the water jet tank via the outflow line to unsettle the particulate material in the water jet catch tank, the pump configured to draw a generally equal amount of water and particulate material into the Extractor holding chamber via the inflow line without the particulate material passing through the pump.

DESCRIPTION OF THE DRAWINGS

[0009] The novel features believed characteristic of the embodiments of the present application are set forth in the appended claims. However, the embodiments themselves, as well as a preferred mode of use, and further objectives and advantages thereof, will best be understood by reference to the following detailed description when read in conjunction with the accompanying drawings, wherein:

FIG. 1 is a perspective view of one embodiment of a system for extracting a particulate material from a body of liquid;

FIG. 2 is a top view of the extraction system of FIG. 1;

FIG. 3 is a side view of the extraction system of FIG. 1;

FIG. 4 is a front view of the extraction system of FIG. 1;

FIG. 5A is an enlarged cross-sectional view of a distal end of an injection assembly in FIG. 4;

FIG. 5B is an enlarged front view of the injection assembly in FIG. 5A;

FIG. 6 is a cross-sectional view taken along line 6-6 in FIG. 3;

FIG. 7 is an enlarged schematic front view of another embodiment of a distal end of an injection assembly of a system for extracting particulate material from a body of liquid;

FIG. 8A is an enlarged perspective view of another embodiment of a distal end of an injection assembly of a system for extracting particulate material from a body of liquid;

FIG. 8B is an enlarged bottom view of the distal end of the injection assembly of FIG. 8A;

FIG. 9 is a simplified schematic of the extraction system of FIG. 1;

FIG. 10 is a simplified schematic of an extraction system in accordance with an alternative embodiment of the present application;

FIG. 11 is a front view of the separator of the system of FIG. 10;

FIGS. 12-14 are simplified schematics of extraction systems in accordance with alternative embodiments of the present application;

FIG. 15 is a top view of the extraction system of FIG. 14;

FIG. 16 is a cross-sectional view of the extraction holding reservoir of the extraction system of FIG. 15 taken at XVI-XVI; and

FIG. 17 is a cross-sectional view of an extraction holding reservoir in accordance with an alternative embodiment of the present application.

While the system and method of use of the present application is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and are herein described in detail. It should be understood, however, that the description herein of specific embodiments is not intended to limit the invention to the particular embodiment disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the present application as defined by the appended claims.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0010] Illustrative embodiments of the system and method of use of the present application are provided below. It will of course be appreciated that in the development of any actual embodiment, numerous implementation-specific decisions will be made to achieve the developer's specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

[0011] The system and method of use will be understood, both as to its structure and operation, from the accompanying drawings, taken in conjunction with the accompanying description. Several embodiments of the system are presented herein. It should be understood that various components, parts, and features of the different embodiments may be combined together and/or interchanged with one another, all of which are within the scope of the present application, even though not all variations and particular embodiments are shown in the drawings. It should also be understood that the mixing and matching of features, elements, and/or functions between various embodiments is expressly contemplated herein so that one of ordinary skill in the art would appreciate from this disclosure that the features, elements, and/or functions of one embodiment may be incorporated into another embodiment as appropriate, unless described otherwise.

[0012] In the following detailed description, terms of orientation such as "top," "bottom," "upper," "lower," "front," "rear," and "end" are used herein to simplify the

description of the context of the illustrated embodiments. Likewise, terms of sequence, such as "first" and "second," are used to simplify the description of the illustrated embodiments. Because other orientations and sequences are possible, however, the present invention should not be limited to the illustrated orientation. Those skilled in the art will appreciate that other orientations of the various components described above are possible.

[0013] FIG. 1 illustrates one embodiment of a system 100 for extracting a particulate material (e.g., abrasive particulate material) from a body of liquid (e.g., water). The system 100 can be used to extract garnet from a Waterjet catch tank or a liquid catch tank (e.g., water jet catch tank) of a water jet cutter. However, one of ordinary skill in the art will recognize that the system 100 can be used to extract other particulate matter (e.g., other abrasive materials) from a body of liquid, and is not limited to the extraction of garnet or abrasive material from a Waterjet catch tank or water jet tank of a water jet cutter. In the illustrated embodiment, the system 100 includes an Extractor holding chamber 10. In one embodiment, the Extractor holding chamber 10 can have a cylindrical shape and be between about 4-7 feet tall and between about 16 and 48 inches in diameter. In one embodiment, the tank 10 can have a cylindrical shape and be between about 34-7 feet tall and between about 20 and 30 inches in diameter. In another embodiment, the Extractor holding chamber 10 can have a cylindrical shape and be about 5 feet tall and about 27 inches in diameter. However, the Extractor holding chamber 10 can have other suitable cross-sectional shapes (e.g., square, oval) and dimensions. In one embodiment, the Extractor holding chamber 10 is made of steel (e.g., carbon steel), or other suitable materials.

[0014] As best shown in FIG. 1, the extracting system 100 can include a bottom door 14 movably couple able to the Extractor holding chamber 10. In the illustrated embodiment, the door 14 is coupled to a bottom end 10a of the Extractor holding chamber 10. A coupling mechanism 16 couples the door 14 to the Extractor holding chamber 10. The coupling mechanism 16 allows movement of the bottom door 14 relative to the Extractor holding chamber 10, where the bottom door 14 may include one or more support members or sleds 14a. In one embodiment, the door 14 can be coupled to the Extractor holding chamber 10 via a hinge unit 15 that allows the door 14 to pivot relative to the bottom end 10a of the Extractor holding chamber 10. In the illustrated embodiment, the bottom door 14 can be moved between an open positions away from the bottom end 10a of the Extractor holding chamber 10 to a closed position adjacent the bottom end 10a of the Extractor holding chamber 10.

[0015] The coupling mechanism 16 can also include an actuation mechanism 16a that facilitates the movement of the bottom door 14 between said open and closed positions relative to the bottom end 10a of the Extractor holding chamber 10. In one embodiment, the actuation mechanism 16a can be a hydraulic assembly that can include

a hydraulic cylinder 16b in fluid communication with a hydraulic pump 16c via a fluid line 16d. In the illustrated embodiment, the hydraulic pump 16c can be manually operated via a pressure release valve 16e to actuate the hydraulic cylinder 16b to move the bottom door 14 between the open position and the closed position relative to Extractor holding chamber 10. In another embodiment, the hydraulic pump 16c can be actuated electronically (e.g., using a computer controller). In still another embodiment, the actuation mechanism 16a can be a pneumatic system. In yet another embodiment, the actuation mechanism 16a can include an electric motor that operates a drive mechanism to move the door 14 relative to the Extractor holding chamber tank 10. However, the actuation mechanism 16a can have other configurations.

[0016] With reference to FIGS. 1 and 2, the extracting system 100 can also include a pump 30, such as a diaphragm pump. However, other suitable pumps can be used. In the illustrated embodiment, the pump 30 can be mounted to a top end or side 10b of the Extractor holding chamber 10. However, in another embodiment, the pump 30 can be mounted to the Extractor holding chamber 10 at another location, or can be separate from (e.g., unmounted on) the Extractor holding chamber 10. In one embodiment, the pump 30 can be an air powered diaphragm pump, such as model number 4157K844 by McMaster Carr. However, other suitable pump types can be used.

[0017] With continued reference to FIGS. 1 and 2, the pump 30 can be in fluid communication with first and second valves 32a, 32b, where the pump 30 is coupled to the first valve 32a via a first fluid line 34a and coupled to the second valve 32b via a second fluid line 34b. In one embodiment, the valves 32a-32b are preferably three-way valves known in the art. Suitable valves 32a-32b are manufactured by McMaster Carr, such as 3-way, four position valve model 45695K35. However, the valves 32a-32b can be other suitable valve types. The fluid lines 34a, 34b can in one embodiment include flexible tubing or hoses (e.g., rubber hoses). In another embodiment, the fluid lines 34a, 34b can include rigid pipe portions including one or more manifold pipes, tubes, and turns.

[0018] The system 100 can have a Extractor holding chamber 10 with at least one `aperture 25 that allows a user to look into the Extractor holding chamber 10, for example, to look at the contents of the Extractor holding chamber 10 (e.g., the level of abrasive material in the Extractor holding chamber 10). The aperture 25 can be covered with glass, Plexiglas, , or other transparent or translucent material that allows a user to see the inside of the Extractor holding chamber 10.

[0019] The first valve 32a is preferably coupled to a first flow passage 36 using a coupling 35 that extends through the top end 10b into the Extractor holding chamber 10. The first flow passage 36 can in one embodiment be a flexible hose portion commonly available in the art. In another embodiment, the first flow passage 36 can be a rigid pipe

portion. The first flow passage 36 can in one embodiment have a one-inch diameter. However, the first flow passage 36 can have other suitable sizes.

[0020] The second valve 32b is preferably coupled via a coupling 37 to a second flow passage 38 (see FIG. 6) that extends through the top end 10b into the Extractor holding chamber 10. The second flow passage 38 can be a T-junction with outlet passages 38a, 38b, as illustrated in FIG. 6. The second flow passage 38 can in one embodiment be a flexible hose portion commonly available in the art. In another embodiment, the second flow passage 38 can be a rigid pipe portion. The second flow passage 38 can in one embodiment have a one-inch diameter. However, the second flow passage 38 can have other suitable sizes.

[0021] In FIGS. 1 and 2, the extracting system 100 can include an air pressure regulator 42 and an air supply hose 44 coupled to the pump 30. In one embodiment, the air pressure regulator 42 is mounted on the Extractor holding chamber 10, or can be separate (e.g.,unmounted) from the tank 10. The air supply hose 44 may be a flexible hose portion commonly available in the art. An air supply system can be coupled to the air pressure regulator 42 in any way known in the art (e.g., quick release coupling between an air supply hose and the air pressure regulator 42).

[0022] Additionally, the extracting system 100 can in one embodiment have a pressure relief valve 12 and pressure gauge 13 coupled to the Extractor holding chamber 10. The pressure gauge 13 allows the user to measure the amount of air pressure in the Extractor holding chamber 10. The pressure gauge 13 in one embodiment can be mounted on the top end 10a of the Extractor holding chamber tank 10, but can be mounted at another location. Additionally, the Extractor holding chamber 10 can have a pressure relief valve 12 to release air from the Extractor holding chamber 10 to ensure a consistent vacuum during in the Extractor holding chamber operation.

[0023] As best shown in FIG. 2, the top end 10b of Extractor holding chamber 10 also shows removable caps 15a, 15b. Removable caps 15a, 15b may in one embodiment have threaded regions to screw onto the corresponding openings on the top end 10b so as to provide a generally airtight seal. Other suitable caps known in the art that can couple to the Extractor holding chamber tank via other suitable mechanisms (e.g., latches) that provide an airtight seal may be used. In one embodiment, when pre-charging the Extractor holding chamber 10, caps 15a, 15b are preferably fastened onto the openings of top end 10b. Caps 15a, 15b may be removed following the completion of the extracting process to allow excess water to be removed from the Extractor holding chamber 10, as described further below.

[0024] In FIG. 3, when the bottom door 14 is in the closed position, the bottom door 14 can be locked in the closed position via a locking mechanism 20. The locking mechanism 20 can include one or more mechanisms for fastening the bottom door 14 to the bottom end 10a of the Extractor holding chamber 10. In the illustrated embodiment,

the locking mechanism 20 can include a locking member 22 (e.g., a hook, pin, bolt, or flange of the locking member 22) attached to the bottom door 14 via a slot (not shown) in the door 14 and a latch 24 (e.g., a Bombay door pivot hook latch) that can be releasably coupled to the locking member 22 by a nut to fix the position of the bottom door 14 in the closed position. The mechanism 20 can include a support plate 26 attached to the Extractor holding chamber 10, coupled to locking member 22 via latch 24. In one embodiment, the support plate 26 can be bolted to the Extractor holding chamber 10. In another embodiment, the support plate 26 can be welded to the Extractor holding chamber 10. In the illustrated embodiment, the locking mechanism 20 includes a latch 24 that can be removably coupled to the Extractor holding chamber 10. Additionally, the locking member 22 can be a bolt secured to the bottom door 14 via a lockout. However, the locking mechanism 20 can have other suitable configurations, such as a hinged locking mechanism. Advantageously, the bottom door 14 can be selectively locked when, for example, the Extractor holding chamber 10 is being filled with water and/or particulate material, but can be selectively unlocked to facilitate the disposal of the particulate material stored in the Extractor holding chamber 10, for example, at a dump site. This allows the easy disposal of the particulate (e.g., garnet) material.

[0025] In FIG. 4, the extraction system 100 includes a first flow line 40 removably coupled to the Extractor holding chamber 10 at the top end 10b thereof. In the illustrated embodiment, the flow line 40 can be coupled to the Extractor holding chamber 10 via first valve 32a. The flow line 40 can be used to remove excess water from tank 10 after the chamber is full of garnet and prior to dumping and to fill or pre-charge the Extractor holding chamber 10 with a liquid (e.g., water) from a water jet catch tank or other body of liquid. The system 100 also includes a second flow line 50 operatively coupled to the pump 30 via the second valve 32b that can be used to direct a fluid from the tank 10, through the pump 30 to a water jet catch tank or other body of liquid. A third flow line 60 can be removably coupled to the Extractor holding chamber 10 via coupling 62 and can direct fluid and abrasive material from a water jet catch tank or other body of liquid to the Extractor holding chamber 10, as further described below. The flow lines 40, 50, 60 can each include one or more sections, where each section can have a length of about five feet. However, in other embodiments, the sections can have other suitable lengths, as needed for the desired extraction application.

[0026] With continued reference to FIG. 4, the second flow line 50 includes an injector head 52 with a nozzle unit 54 attached at a distal end that directs fluid flow out of the second flow line 50 in a desired direction. In a preferred embodiment, injector head 52 includes one or more nozzles. Upon beginning of the extraction process, the pump 30 pumps water from the extraction tank 10 via the first flow passage 36, first fluid line 34a, and second flow line 50 into a water jet tank, so that the water flow is delivered via the injector head 52 and the nozzle unit 54 onto the particulate material (e.g., abrasive material, such as garnet) and unsettles the particulate material in the water jet tank. For

example, Upon beginning of the extraction process, the pump 30 pumps water from the Extractor holding chamber 10 via the first flow passage 36, first fluid line 34a into pump 30 and discharged through 34B into hose 50, and second flow line 50 into a water jet catch tank, so that the water flow is delivered via the injector head 52 and the nozzle unit 54 onto the particulate material (e.g., abrasive material, such as garnet) and unsettles the particulate material in the water jet catch tank.

[0027] In FIG. 5A, an embodiment of the collector 70 and the injector head 52 is shown in an enlarged cross-sectional view with a bypass conduit 56 (e.g., tube) inside. In one embodiment, the collector 70 and the injector head 52 are coupled to each other and in fluid communication via the bypass conduit 56. In addition, a portion of the bypass conduit 56 can extend into the collector 70 and a portion of the bypass conduit 56 can extend into the injector head 52. In one embodiment, the bypass conduit 56 can be a curved rigid pipe portion, but other coupling devices known in the art may also be used.

[0028] Advantageously, the bypass conduit 56 directs liquid flow into the collector 70 that dilutes the abrasive material coming into collector 70 and helps drive the flow of abrasive material and water up the third flow line 60 and into the Extractor holding chamber 10. That is, when water flows from the pump 30 to the second flow line 50, at least a portion of that flow is redirected into the collector 70. This redirected flow adds an additional force to drive the abrasive material from the collector 70 through the third flow line 60 at an increased velocity. For example, this can decrease the time needed to fill the Extractor holding chamber 10 with abrasive material from approximately 4 hours to about 2.5 hours, or less.

[0029] In FIG. 5B, the front view of the collector 70, injector head 52, and nozzle unit 54 is shown. In one embodiment, the nozzle unit 54 comprises at least two nozzles located at a distal end of injector head 52. Nozzle unit 54 operates to unsettle abrasive material and drive the flow of water in a desired direction. Preferably, the nozzle unit 54 can include sectioned-off grooves or openings 54b, 54c that direct the flow of water in different directions. At a nozzle end 54a, a portion of water flow is delivered in a direction (e.g., substantially transverse to the collector 70) to unsettle the abrasive material. At the groove or opening 54b, a portion of water flow is delivered in a direction (e.g., substantially longitudinal to the collector 70) toward the collector 70 to help drive the unsettled abrasive material into the collector 70 and through the third flow line 60. At groove or opening 54c, a portion of water flow is delivered in a direction (e.g., substantially transverse to the collector 70) to help unsettle more of the abrasive material proximate to the collector 70. The structure of the nozzle unit 54 advantageously operates to efficiently unsettle abrasive material and direct it to and through the collector 70.

[0030] In FIG. 6, a cross-sectional view taken along line 6-6 of FIG. 3 is shown, illustrating the first flow passage 36 and the second flow passage 38 as discussed above.

In one embodiment, second flow passage 38 is a T-junction pipe with outlet passages 38a and 38b. Outlet passages 38a, 38b can be directed towards the aperture(s) 25 so that water can strike and clean the windows of the aperture(s) 25 during the precharge process. Additionally, as discussed above, the first flow passage 36 can have a bore 36a (e.g., air relief hole) proximate to the top end 10b of the Extractor holding chamber 10. The bore 36a can facilitate the venting of air in the Extractor holding chamber 10 as water is removed from the Extractor holding chamber 10 via first flow passage 36, valve 32a, fluid line 34a, and pump 30 (e.g., air that may be trapped in the Extractor holding chamber 10 above the end of the flow passages 36, 38, or directed into the Extractor holding chamber 10 via the third flow line 60).

[0031] Furthermore, the bore 36a is sized to allow a sufficient flow of air from the inside of the Extractor holding chamber 10 through the first flow passage 36 and pump 30 to ensure air does not build up within the Extractor holding chamber 10 to the point where there is no fluid connection (e.g., no closed loop connection) between the Extractor holding chamber 10 and the water jet catch tank via the flow lines 50, 60, which can occur if an amount of air accumulates in the Extractor holding chamber 10 that drops the water level in the Extractor holding chamber 10 below the end of the first flow passage 36. However, the bore 36a is preferably sized so as to not allow so much air to flow through the first flow passage 36 and pump 30 that causes the pump 30 to fail (e.g., cavitate). In one embodiment, the bore 36a has a diameter of about 1/8 inch. However, in other embodiments the bore 36a can have a diameter of greater or less than 1/8 inch, such as 1/16 inch or 3/16 inch.

[0032] Also in FIG. 6, one or more seals 18 can be disposed on Extractor holding chamber 10 so that the seals 18 come in contact with the door 14 when the door 14 is in the closed position. Preferably, the seals 18 inhibit the contents in the Extractor holding chamber 10 from leaking out of the bottom end 10a when the door 14 is in the closed position (e.g., the seals 18 prevent the leakage of water or abrasive material through the interface between the bottom door 14 and the Extractor holding chamber 10). In one embodiment, the seals 18 are gaskets. However, a person of ordinary skill in the art may use other seals to prevent the leakage of water or abrasive material.

[0033] With continued reference to FIG. 6, the extraction Extractor holding chamber 10 can include a pair of forklift receivers 12a, 12b that define slots on opposite sides of the Extractor holding chamber 10 to removably receive the forks of a forklift (not shown), thereby allowing the Extractor holding chamber 10 to be portable and easily transported as desired (e.g., to different extracting locations, to a dump site to dispose of the extracted material from the extraction Extractor holding chamber 10). However, in other embodiments the Extractor holding chamber 10 does not include the forklift receivers 12a, 12b and can be transported to a desired location via other suitable mechanisms.

[0034] In FIG. 7, another embodiment of the collector 70' and the injector head 52' for the extraction tank 10 is shown. The system includes an injector head 52' coupled to the second flow line 50. In addition, there is a collector 70' that is coupled to the third flow line 60. The collector 70' can include a filter 74' at a distal portion 70b of the collector 70'. In one embodiment, the filter 74' can be porous so as to regulate and filter the uptake of abrasive material during suction. The injector head 52' can be positioned relative to a collector 70' as discussed below. The injector head 52' can extend through an opening 72 in a proximal portion 70a of the collector 70'. In one embodiment, the injector head 52' can have a distal portion 52a that extends past a distal portion 70b of the collector 70'. In another embodiment, the injector head 52' and the collector 70' are coupled via a flange 55, as illustrated in FIGS. 8A and 8B. However, in another embodiment, the injector head 52' and the collector 70' can be separate from each other (e.g., not connected). Moreover, the injector head 52' can include one or more filter nozzles 54.

[0035] Additionally, a distal end 62 of the third flow line 60 can likewise be coupled to the proximal portion 70a of the collector 70'. In one embodiment the filter 74 can be disposed over an opening of the distal portion 70b of the collector 70'. In one embodiment, the collector 70' can be cone-shaped. In another embodiment, the collector 70' can be cylindrical-shaped. However, in other embodiments, the collector 70' can have other suitable shapes. The collector 70' can be made of metal in one embodiment. In another embodiment, the collector 70' can be of plastic or another suitable material.

[0036] Additionally, the system 100 can include a handle (not shown) coupled to one or both of the second and third flow lines 50, 60. The handle can be used to move the collector 70 to a desired location, as well as to reposition the injector head 52 relative to the collector 70.

[0037] In FIGS. 8A and 8B, another embodiment of a collector 70" and an injector head 52" is shown. The injector head 52" is coupled to the second flow line 50 and the collector 70" is coupled to the third flow line 60. In the illustrated embodiment, the collector 70" has a generally cylindrical shape. However, the collector 70" can have other suitable shapes. The collector 70"includes a filter 74" at the distal end 70b of the collector 70" In the illustrated embodiment, the distal end 52a of the injector head 52" extends forward of the distal end 70b of the collector 70". Additionally, the injector head 52" and collector 70" can be coupled via a flange 55.

[0038] In operation, the tank 10 is first filled with water from a body of liquid (e.g., water jet tank) as follows. Initially, removable caps 15a, 15b are fastened to the top end 10b of Extractor holding chamber 10. The first flow line 40 is placed below the water level of the body of liquid (e.g., water jet tank). The second flow line 50 and the third flow line 60 are placed away from Extractor holding chamber 10 and proximate to the body of liquid. From there, valves 32a, 32b are set to a precharge position, as discussed above. The first valve 32a is actuated to place the first flow line 40 in fluid communication with

the pump 30 via the first valve 32a and first fluid line 34a, and the second valve 32b is positioned so that the second flow line 50 is isolated from the pump 30 and the pump 30 is in fluid communication with the inside of the Extractor holding chamber 10 (e.g., via the second flow passage 38). The pump 30 is operated to pump water from a body of liquid to the Extractor holding chamber 10 via the first flow line 40, first valve 32a, and first fluid line 34a. The air supply hose 44 is connected to the air pressure regulator 42 so that the pump 30 is in fluid communication with the air pressure regulator 42. An air pressure source is also coupled to the air pressure regulator 42 to supply pressurized air to the pump 30. Air is turned on to begin precharge so that water is pulled up first flow line 40 through first fluid line 34a via first valve 32a. For example, Air is turned on to begin precharge so that water is pulled up first flow line 40 through first fluid line 34a via first valve 32abeing drawn into pump 30 and discharged through lines 34b and 32b into the Extractor holding chamber 10. Water enters the tank 10 via the second flow passage 38 and through outlet passages 38a, 38b.

[0039] Once the Extractor holding chamber 10 is filled with water, which can be ascertained when water flows through the third flow line 60 and collector 70, precharge is complete. At this point, the collector 70 and the injector head 52 are placed below the water level of a body of liquid, and preferably below the level of particulate material in the body of liquid. The first valve 32a is positioned to isolate the first flow line 40 from the pump 30 and place the tank in fluid communication with the pump 30 via the first flow passage 36, first valve 32a, and first fluid line 34a. Additionally, the second valve 32b can be actuated to place the pump 30 in fluid communication with the second flow line 50 via the second fluid line 34b and second valve 32b, while isolating the pump 30 from the second flow passage 38. The pump 30 is then operated to pump water from the Extractor holding chamber 10 through the first flow passage 36, first valve 32a, first fluid line 34a and into the second flow line 50 via the second fluid line 34b and the second valve 32b to the injector head 52, which directs the water to the abrasive material to displace the abrasive material from a body of liquid or the waterjet catch tank.

[0040] As discussed above, the injector head 52 uses nozzle unit 54 to deliver water in a desired direction and displace the particulate material (e.g., abrasive material, such as garnet). The displaced particulate material is suctioned through the filter 74, collector 70, and third flow line 60 into the Extractor holding chamber 10 via the suction force created by the flow of water from the Extractor holding chamber 10 to the pump 30. In one embodiment, the collector 70 and injector head 52 are submerged in the particulate material of a body of liquid. Additionally, in one embodiment, suction of the particulate material into the Extractor holding chamber 10 begins when about 10 lbs. of vacuum is achieved by the pump 30, as measured by meters on the Extractor holding chamber 10. Vacuum pressure is measured by the pressure gauge 13. Further, the flow of particulate material through collector 70 and third flow line 60 into the Extractor holding chamber 10 is aided by the bypass conduit 56, which redirects a portion of water from the injector

head 52 to the collector 70. The combination of the suction force from the pump 30, the directed delivery of water from the nozzle unit 54, and the redirected water flow from the bypass conduit 56 function to drive particulate material through the third flow line 60 and into the Extractor holding chamber 10. For example, the redirected water flow from the bypass conduit 56 function to draw or suck particulate material through the third flow line 60 and into the tank 10.As the particulate material and water enter the Extractor holding chamber 10 via third flow line 60, the velocity of the suctioned water and particulate material slows down so that the abrasive material can be collected in the Extractor holding chamber 10.

[0041] The system 100 provides an effective way to drain the Extractor holding chamber tank 10 of excess water when the Extractor holding chamber 10 is substantially full of abrasive material. Removable caps 15a and 15b are taken off from the top end 10b so that the first flow line 40 can be placed through the opening of where either cap 15a or 15b was fastened. Valve 32a is set to a precharge position and excess water drawn from Extractor holding chamber 10. The flow of water travels from first flow line 40 through first fluid line 34a via valve 32a to pump 30. The pump 30 pumps the water through second fluid line 34b to second flow line 50 via second valve 32b. The water is discharged out of injector head 52 and into a body of liquid (e.g., water jet catch tank). This may be done until the Extractor holding chamber 10 is sufficiently drained of excess water.

[0042] Furthermore, the system 100 can effectively dispose of extracted abrasive material by moving bottom door 14 into an open position via coupling mechanism 16. The Extractor holding chamber 10 can be transported using a forklift to an appropriate location and positioned over a receptacle, container, dump site, or other disposal area. Locking member 22 is loosened and latch 24 is removed from the Extractor holding chamber 10. From there, the pressure release valve 16e is opened on the hydraulic pump 16c to allow the hydraulic cylinder 16b to retract via the hydraulic pump fluid line 16c. This causes the bottom door 14 to open relative to the Extractor holding chamber 10, pulling away from the seals 18 and causing extracted abrasive material to fall out of the Extractor holding chamber tank 10. Any abrasive material remaining on the bottom door can be manually removed by a user. To close the bottom door 14, a user pumps the pressure release valve 16e on hydraulic pump 16c to produce pressure on hydraulic cylinder 16b.

[0043] Referring now FIG. 9, a simplified schematic of the operation of system 100 is shown. As depicted, during the pre-charge process, the extraction Extractor holding chamber 10 is initially filled with water and particulate material from a fluid reservoir 901. This can be accomplished by actuating of one or more of the valves 32a-32b so that water can be pumped by the pump 30 and/or a pump 903 from reservoir 901 to the extraction Extractor holding chamber 10 via the first fluid line 1, e.g., flow line 40.

[0044] Once the Extractor holding chamber 10 has been filled with water, the air is substantially removed from an inner chamber 905 formed by the body of Extractor holding chamber 10. Thus, after the pre-charge process, the Extractor holding chamber is substantially air tight and filled with water and particulate matter. It should be appreciated that the air in the Extractor holding chamber 10 can advantageously be vented from the Extractor holding chamber 10 through the first flow passage 36 and pump 30 via at least one bore 36a (e.g., air relief hole) (see FIG. 6) in the first flow passage 36.

[0045] As shown, the fluid carried within the Extractor holding chamber 10 is drawn out in fluid line 2, e.g., flow line 50, in fluid communication with pump 30. The particulate material and the fluid are then drawn from fluid line 3, which in turn causes circulation in fluid line 4.

[0046] Advantageously, the system 100 operates as a closed-loop system wherein the volume of water that is pumped out of the extraction Extractor holding chamber 10 into the fluid reservoir 901 is substantially equal to the volume of water and abrasive material that is drawn or suctioned from the water jet catch tank into the extraction Extractor holding chamber 10. This allows the Extractor holding chamber 10 to remain filled with water and substantially air-tight at all times, so that the flow of water, which slows upon entry into the extraction Extractor holding chamber 10 can allow the abrasive material to settle at the bottom of the Extractor holding chamber 10.

[0047] One of the unique features believed characteristic of the present application is the ability to drawn the particulate material with a pump, yet keep the particulate material from reaching the pump. For example, the particulate material and fluid is drawn into the extraction Extractor holding chamber 10 without passing through the pump 30, thereby inhibiting damage to the components of the pump 30 due to contact the particulate (e.g., abrasive) material, which improves the reliability and life span of the system 100.

[0048] It should be understood that the flow of water and particulate material enters the Extractor holding chamber 10 and the velocity of the water flow slows down due to the difference in diameter of the third flow line 60 and Extractor holding chamber 10. This slowdown in the flow rate of the water that enters the Extractor holding chamber 10 allows substantially all of the particulate material flowing with the water to settle at the bottom of the Extractor holding chamber 10. In one embodiment, the collector 70 can include a filter 74 at a distal end thereof. In one embodiment, the filter 74 can be a screen filter.

[0049] The system 100 can be operated until the Extractor holding chamber 10 is substantially filled with abrasive material. In one embodiment, the Extractor holding chamber 10 can have aperture 25 shown in FIG. 1 that allows a user to determine how full the Extractor holding chamber tank is to decide when to end the extraction operation.

[0050] Accordingly, the system 100 advantageously provides an effective system for removing abrasive material 907 from fluid reservoir 901 that avoids the problem of pumping the abrasive material through a pump, which can damage the pump. Additionally, the system 100 provides a compact and portable device for extracting abrasive material from a water jet catch tank or a body of water, which can be used to remove abrasive material from more than one water jet catch tank. In addition, the Extractor holding chamber 10, as discussed above, can readily be opened to dispose of the collected abrasive material (e.g., at a dump site). Further, to save time, the system 100 enables a user to extract garnet while simultaneously operating a water jet cutter or performing other industrial applications.

[0051] In FIG. 10, a simplified schematic of an extraction system 1001 is shown in accordance with an alternative embodiment of the present application. It will be appreciated that system 1001 is substantially similar in form and function to one or more of the extraction systems discussed above and incorporate the features discussed herein.

[0052] System 1001 includes a Extractor holding chamber 1003 configured to collect particulate matter 1005 from a fluid reservoir 1007. To achieve this feature, system 1001 utilizes a cyclonic separator such as cross-flow separator under vacuum (CFSUV)1009 positioned on a top surface area 1011 of Extractor holding chamber 1003 and configured to separate the particulate matter from the fluid from reservoir 1007. Further detailed description of these features is provided below with reference to FIG. 11.

[0053] System 1001 is further provided with a pump 1013 in fluid communication with the inner Extractor holding chamber 1015 and in fluid communication with reservoir 1007. Accordingly, as depicted, the system 1001 forms a closed-loop system, wherein the fluid passes through one or more fluid lines, valves, and the like, from Extractor holding chamber tank 1003 and reservoir 1007 via pump 1013.

[0054] During the pre-charge process, a pump 1017 can be utilized to fill the inner chamber 1015 with fluid, which in turn allows the pump 1013 to circulate the fluid through the closed loop system. It will be appreciated that pump 1013 could be used in lieu of pump 1017 to pre-charge the system, which can easily be achieved through one or more valves associated with the fluid pipes.

[0055] It should be appreciated that the only a small, if any, amount of particulate matter leaves the fluid chamber 1015, thus preserving the lifespan of pump 1013. It should be understood that the particulate matter has the potential to cause wear and tear on the components of pump 1013. As such, it is highly advantageous to place the pump 1013 in a fluid location the particulate matter is separated from the fluid such that merely fluid enters into the pump.

[0056] In FIG. 11, further detailed features of separator 1009 are illustrated. It will be appreciated that one of the unique features believed characteristic of system 1001 is the use of separator 1009 to separate the fluid from the particulate matter. To achieve this feature, the fluid and particulate matter, as depicted with a plurality of dashed-lined arrows 1100 enters within the contoured cylindrical chamber 1101 via an inlet 1103, spirals along the inner surface 1105 of the body 1107. During the cyclonic spiraling movement, the heaver particulate matter is separated from the fluid, which in turn exits through a bottom opening 1109 and into the chamber 1015 of Extractor holding chamber 1003.

[0057] Separator 1009 further includes a second opening 1111 configured to channel the fluid to pump 1013, as indicated by arrow 1113. In the exemplary embodiment, inlet 1103 is selectively positioned about a side surface area 1115 of the body, while opening 1111 is positioned about a top end 1117 and the bottom opening 1109 is positioned about a bottom end 1119, wherein top end 1117 and bottom end 1119 oppose each other. Accordingly, separator 1009 is configured such that specific gravity of the material being separated which needs to be greater than the liquid is used to separate the fluid from the particulate matter.

[0058] In the preferred embodiment, separator 1009 is secured to top surface 1011 via a flange 1121 attached to and extending from body 1107, which in turn is secured to the top surface via a plurality of fasteners 1123, e.g., threaded bolts.

[0059] Referring now to FIG. 12, a system 1201 is depicted having a plurality of extraction systems, specifically, the embodiments of extraction systems 1001, in fluid communication with each other. It should be understood that not all particulate matter separates during the extraction process and that finer particulate matter can be harvested in a second extraction pass through Extractor holding chamber in accordance with the exemplary embodiment shown.

[0060] As depicted, system 1201 includes a first system 1203 in fluid communication with a second system 1205. It will be appreciated that the features of one or more of the extraction systems discussed above are hereby incorporated in system 1201. Thus, system 1203 includes a Extractor holding chamber 1207 configured to capture particulate matter 1209 from a fluid reservoir 1211. Thereafter, the fluid is channeled to system 1205. System 1205 includes a Extractor holding chamber 1213 configure to capture and store finer particulate matter 1215 for a fluid reservoir 1217. The fluid from system 1205 is then channeled back to reservoir 1211 to form a closed loop system. It will be appreciated that the fluid and particulate matter captured in fluid reservoir is a much finer material than the particulate material carried within fluid reservoir 1211.

[0061] FIG. 13 depicts yet another alternative embodiment contemplated. System 1301 includes a vehicle 1303 and a trailer 1305 configured to carry extraction system 1307. It will be appreciated that system 1307 is substantially similar in form and

function to one or more of the extraction systems discussed above and incorporates the features discussed herein.

[0062] In the exemplary embodiment, it is contemplated carrying system 1307 via trailer 1305, thus allowing the extraction system 1307 to be mobile. This feature allows the user to transport the extraction system to various locations wherein the use of system 1307 is required and remove the trailer shortly after the extraction process.

[0063] Referring now to FIG. 14 in the drawings, an alternative embodiment of the extraction system is shown. It will be appreciated that extraction system 1401 is substantially similar in form and function to one or more of the system discussed above, particularly to system 1001 discussed above. In this embodiment, the system 1401 incorporates the use of a fluid reservoir 1403 in fluid communication with tank 1003. The unique features believed characteristic of this embodiment are more fully discussed below.

[0064] In FIG. 15, a simplified schematic of system 1401 is shown. As depicted, an outlet conduit 1501 is in fluid communication with reservoir 1403 and tank 1003. The pump 1017 can be used as an alternative to pump 1013 to precharge tank 1003 which drives the fluid carried within reservoir 1403 through conduit 1501 to the inner cavity of tank 1003 (not shown). An inlet conduit 1503 is in fluid communication with reservoir 1403 and tank 1003. The pump 1013 drives the fluid from the tank 1003 to the reservoir 1403 via a second conduit 1505 secured to the inside upper sidewall of tank 1507 of reservoir 1403. In the contemplated embodiment, the second conduit 1505 extends around the periphery of the sidewall 1507. One or more jets 1509 are in fluid communication with second conduit 1505 and are configured to inject the fluid from tank 1003 into the cavity 1511 created by sidewall 1507 and bottom surfaces 1513, 1515, 1517, 1519. In the preferred embodiment, the injection jets 1509 are angled relative to side wall 1507 to cause a swirling fluid movement within cavity 1511. This feature provides advantages such as separating the particulate matter from the fluid.

[0065] Another unique feature believed characteristic of reservoir 1403 is the positioning of the bottom surfaces 1513, 1515, 1517, and 1519 relative to the ground surface. The angle of each bottom surface is better shown in FIG. 16, wherein the inclined bottom surfaces cause the particulate matter 1601 to accumulate in a trough 1603 surrounding the bottom surfaces. The particulate matter 1601 is thereafter received by port 1605 in fluid communication with conduit 1501. The suction from pump 1013 1017 causes the particulate matter 1601 to leave cavity 1511 and pass through tank 1003, where it is in turn processed in one or more of the processing methods discussed above. Note that pump 1013 create both a suction drawing material into chamber 1003 and drive water into tank 1507 to create the swirl used to move settled material to collector pipe 1501.

[0066] As depicted in FIG. 15, the injections jets 1509 are positioned at an angle A1 relative to surface 1502 of sidewall 1507, which in turn creates a whirlpool vortex movement, as indicated by arrow V1. This feature provides an efficient method to separate the particulate matter 1601 from the fluid.

[0067] Referring next to FIG. 17, an alternative embodiment of the systems discussed herein is shown. System 1701 is substantially similar in form and function to system 1401 incorporates one or more of the features discussed herein, and vice-versa. In this embodiment, system 1701 is provided with a cutting structure 1703 that sits above the reservoir and is configured to hold an object 1705 thereon during the cutting process. The particulate matter from the object 1705 and the fluid is collected in the reservoir, which in turn is collected via a conduit 1707 positioned alongside the upper inside sidewall and in communication with the particulate matter collected along the bottom. In the contemplated embodiment, the conduit 1707 could extend through the sidewall; however, alternative embodiments could have the conduit extend over the sidewall. A second conduit 1709 is used to provide a fluid return to the injection jets. In one contemplated embodiment, the conduit 1709 could extend around the periphery of the sidewall.

[0068] Although these inventions have been disclosed in the context of a certain preferred embodiments and examples, it will be understood by those skilled in the art that the present inventions extend beyond the specifically disclosed embodiments to other alternative embodiments and/or uses of the inventions and obvious modifications and equivalents thereof. For example, the embodiments disclosed herein are not limited to the extraction of abrasive materials used in water jet cutting applications, but can be employed in the extraction of any particulate material from a liquid body (e.g., dredging operation, industrial particulate material extraction processes). In addition, though the material drawn from a water jet catch tank or body of water is referred to as a particulate material, the material is not limited to an abrasive material (e.g., garnet), but can include other particulate material (e.g., shavings from water jet operation). Further, the term particulate is not meant to limit the material drawn into the extraction Extractor holding chamber 10 to a particular size or shape, and merely describes that the material drawn into the Extractor holding chamber 10 can be in the form of grains (e.g., loose or clumped grains), elongated shavings, or other generally separable particulate slurry. In addition, while a number of variations of the inventions have been shown and described in detail, other modifications, which are within the scope of the inventions, will be readily apparent to those of skill in the art based upon this disclosure. For example, separate pumps can be used to pre-charge the Extractor holding chamber 10 with water and to operate the extraction system 100. It is also contemplated that various combinations or sub combinations of the specific features and aspects of the embodiments may be made and still fall within one or more of the inventions. Accordingly, it should be understood that various features and aspects of the disclosed embodiments can be combine with or

substituted for one another in order to form varying modes of the disclosed inventions. Thus, it is intended that the scope of the present inventions herein disclosed should not be limited by the particular disclosed embodiments described above.

[0069] The particular embodiments disclosed above are illustrative only, as the embodiments may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. It is therefore evident that the particular embodiments disclosed above may be altered or modified, and all such variations are considered within the scope and spirit of the application. Accordingly, the protection sought herein is as set forth in the description. Although the present embodiments are shown above, they are not limited to just these embodiments, but are amenable to various changes and modifications without departing from the spirit thereof.

What is claimed is:

1. A method for using an extractor system to extract particulate material from a liquid tank, comprising: inserting a first conduit into a liquid tank, the first conduit coupled to a pump via a three-way valve; inserting an outflow line into the liquid tank, the outflow line comprising one or more nozzles having a distal end;

inserting an inflow line into the liquid tank, the inflow line comprising a collector having a distal end, the collector and the one or more nozzles being proximate each other; and

operating the pump to pump liquid from an extractor tank through an outflow line out of the one or more nozzles to unsettle the particulate material, the particulate material drawn through the collector and the inflow line into the extractor tank without passing through the pump, wherein the inflow line, the outflow line, and the extractor tank define a closed system.

2. The method of Claim 1, wherein operating the pump comprises directing at least a portion of liquid from the outflow line to the collector through a bypass conduit.

3. The method of Claim 1, wherein operating the pump comprises directing at least a portion of liquid from the one or more nozzles through a plurality of grooves, the plurality of grooves configured to direct at least a portion of liquid in a desired direction.

4. The method of Claim 1, wherein inserting the outflow line and inserting the inflow line occurs simultaneously.

5. The method of Claim 1, further comprising draining the extractor tank of excess liquid, comprising:

inserting the first hose into the extractor tank through an opening in the extractor tank;

drawing liquid through the first hose to the pump via the three-way valve; and

operating the pump to pump liquid through the outflow line into the liquid tank until the extractor tank is substantially drained of excess liquid.

6. A particulate matter extraction system, comprising:

a cylindrical tank forming a hollow cavity and having:

a top end; and

a bottom end;

a cyclonic separator rigidly attached to the top end of the cylindrical tank and in fluid communication with the hollow cavity;

an inflow line coupled to the cyclonic separator;

an outflow line coupled to the cyclonic separator;

a pump in fluid communication with outflow line; and

a fluid reservoir in fluid communication with the inflow line;

wherein the pump is configured to channel fluid through the cylindrical tank, cross-flow separator, and fluid reservoir; and

wherein the cross-flow separator is configured to separate particulate matter from the fluid.

7. The system of claim 6, wherein the cross-flow separator has a contoured body configured to create a whirling effect on the fluid entering the inflow line and wherein the fluid leaves through the outflow line and the particulate matter is separated and enters the hollow cavity through an opening on the bottom of the cross-flow separator.

8. The system of claim 6, the reservoir comprising:

four sidewalls and a bottom surface that form a fluid area for storing fluid and particulate; and a cutting or piping structure secured to four sidewalls.

9. The system of claim 6, further comprising:

a plurality of jet nozzles secured to the upper inside sidewalls and in fluid communication with the outflow line.

10. The system of claim 9, wherein the plurality of jet nozzles are oriented to create a whirling effect in the fluid area.

11. The system of claim 8, wherein the bottom surface is angled.

12. The system of claim 11, wherein the inflow line is coupled to the bottom surface or the top edge of inside wall of the catch tank.

13. The system of claim 6, further comprising:

a door movably coupled to the bottom end;

wherein the door is movable between an open position to a closed position to provide a sealed connection with the tank.

14. A method to extract particulate material from a liquid, comprising:

capturing particulate matter and liquid in a reservoir;

partially separating the particulate matter and liquid within the reservoir;

channeling the partially separated particulate matter and liquid to a cyclonic Cross-flow separator positioned above a tank;

separating the partially separated particulate matter and liquid within the cross-flow separator; and

capturing the particulate matter within the tank.

15. The method of claim 14, further comprising:

injecting a liquid exiting the cross-flow separator into the reservoir with a plurality of injection jets.

16. The method of claim 15, further comprising:

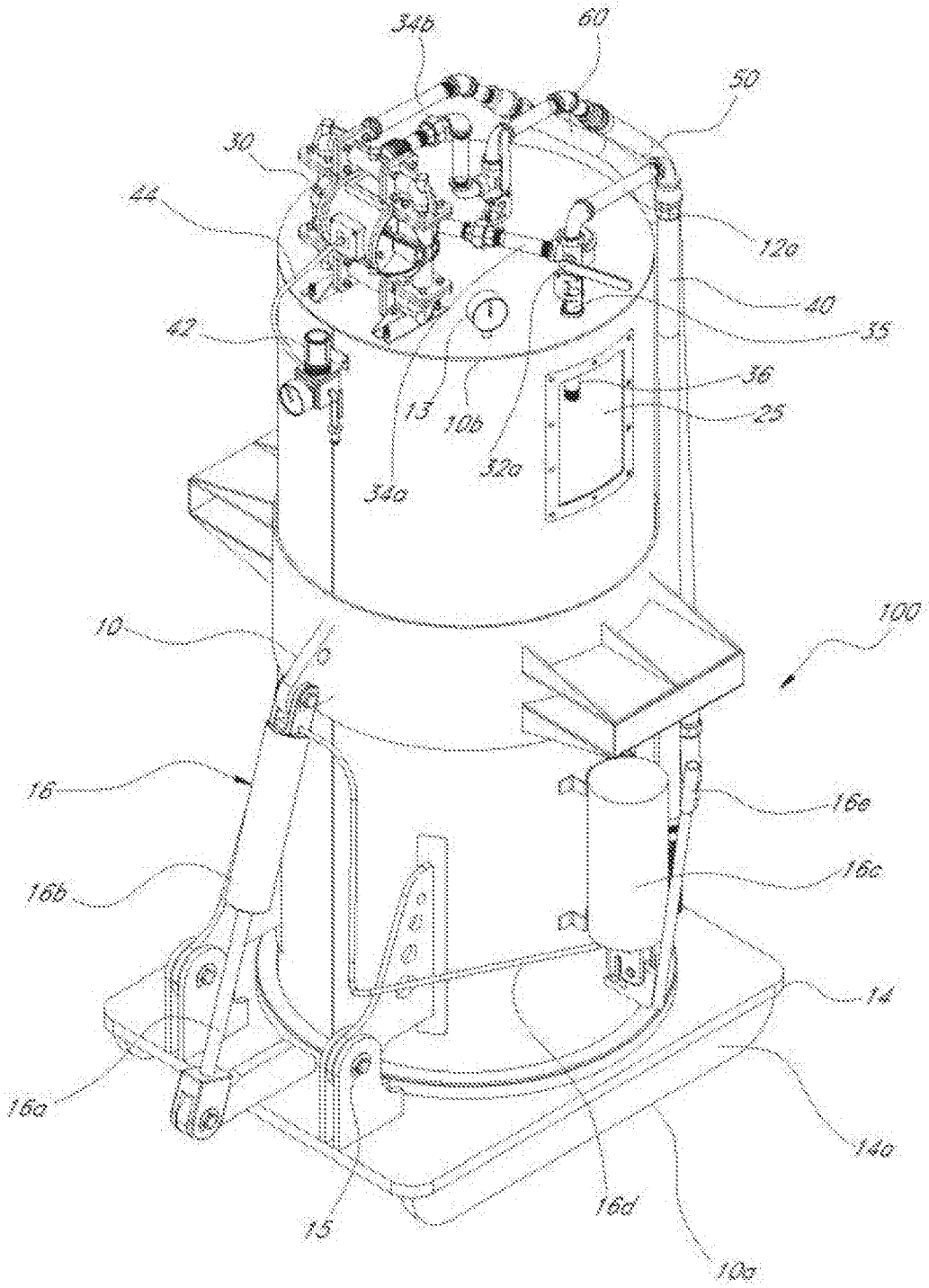
creating a whirling effect via the plurality of injection jets within the reservoir.

17. The method of claim 16, further comprising:

extracting the partially separated particulate matter and liquid from a bottom surface of the reservoir.

18. The method of claim 14, further comprising:

creating a whirling effect via the cross-flow separator.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12a
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42
36
25
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16a
16b
16c
14
14a
16d
15
10a

FIG. 1

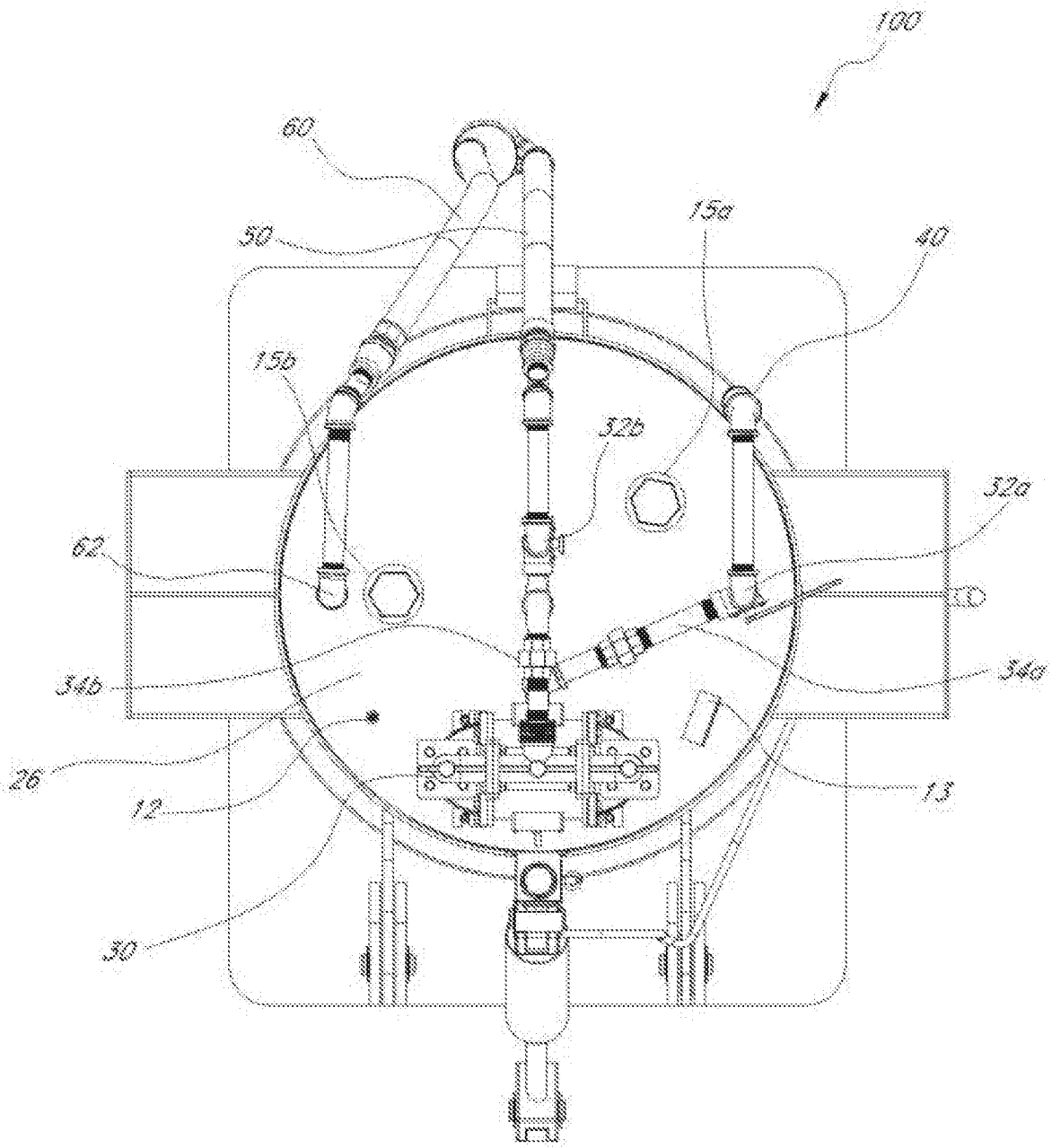


FIG. 2

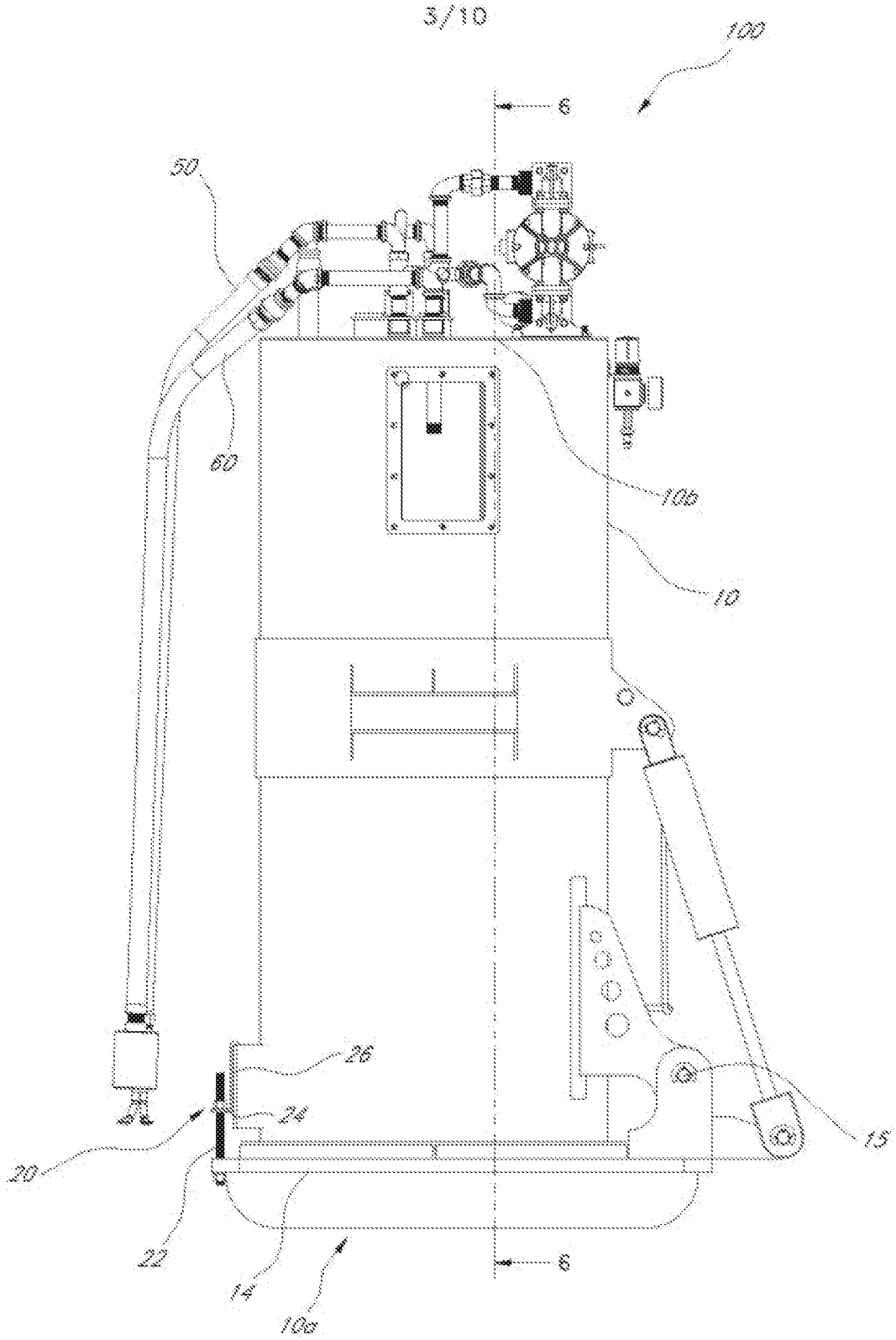
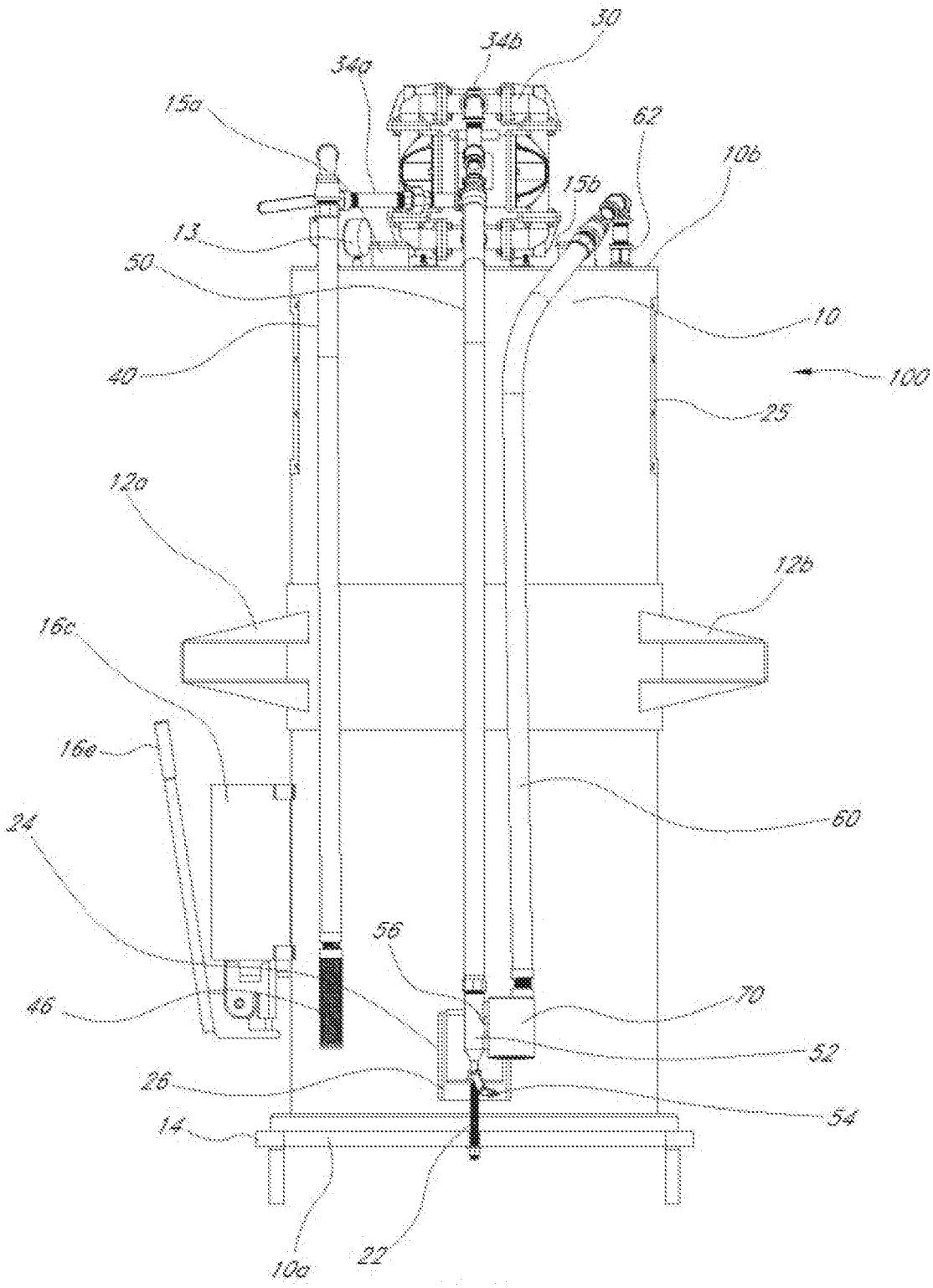


FIG. 3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34b
34a
15a
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10b
15b
13
50
10
40
100
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12b
16c
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24
56
70
46
52
26
54
14
10a
22

FIG. 4

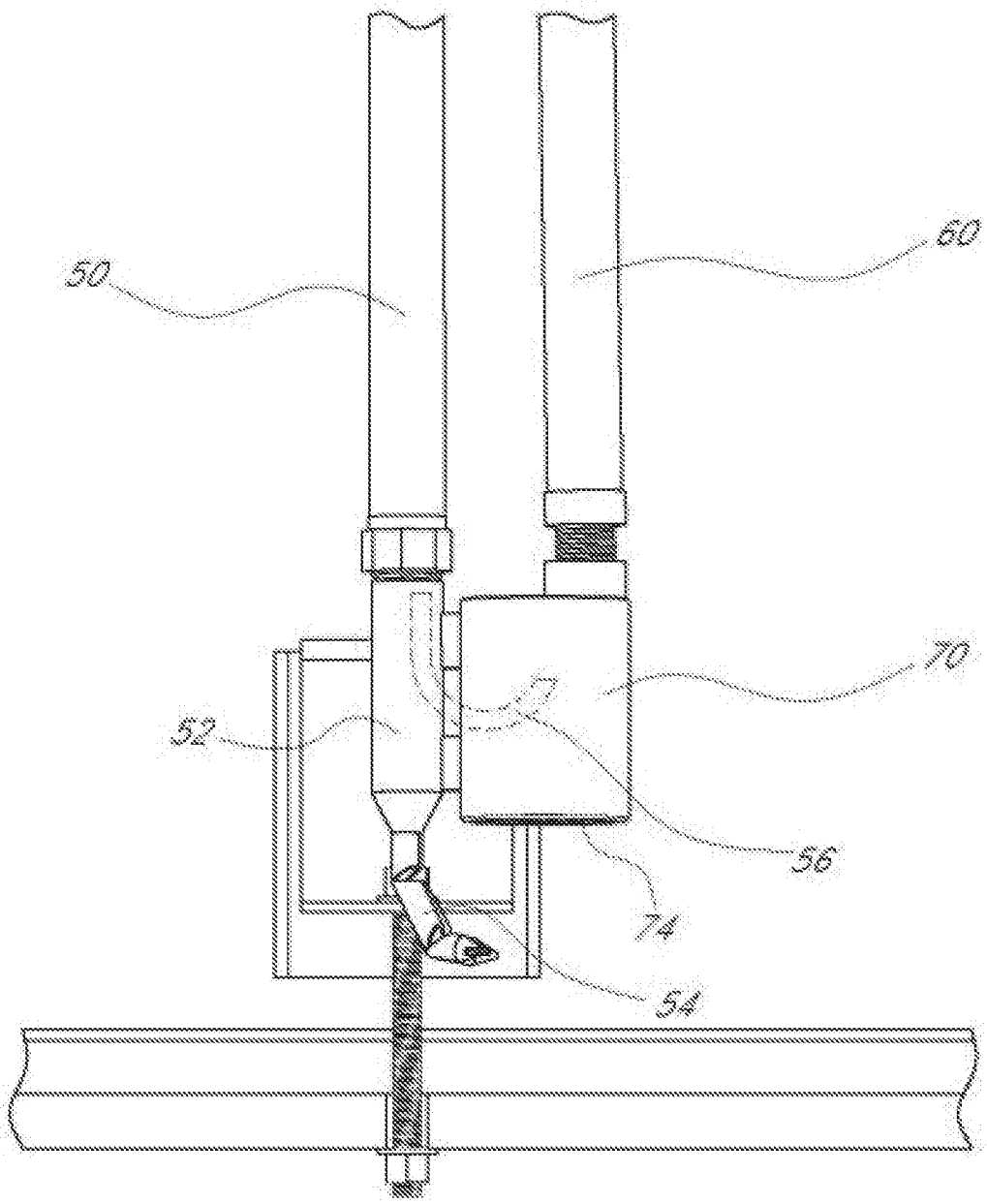


FIG. 5a

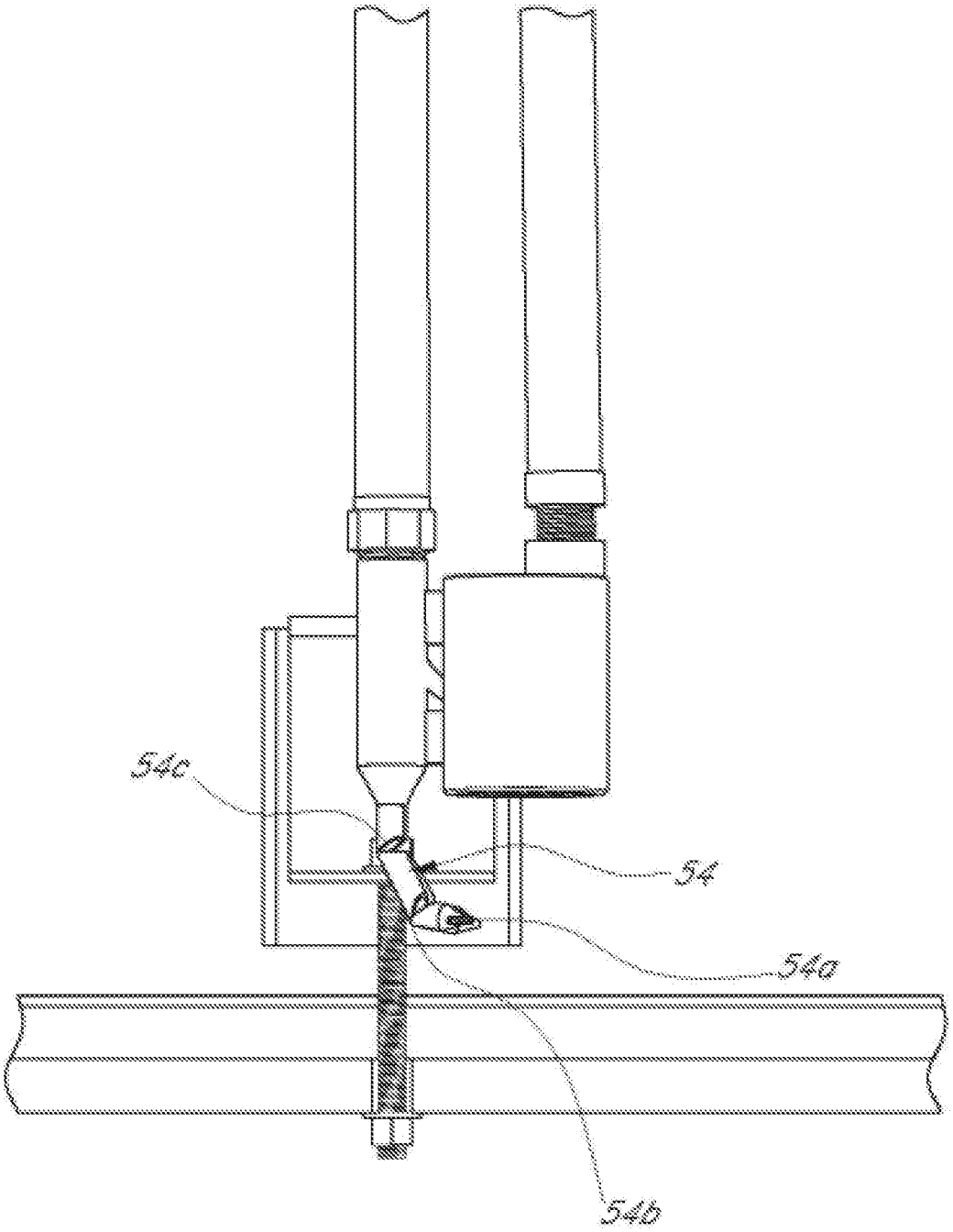
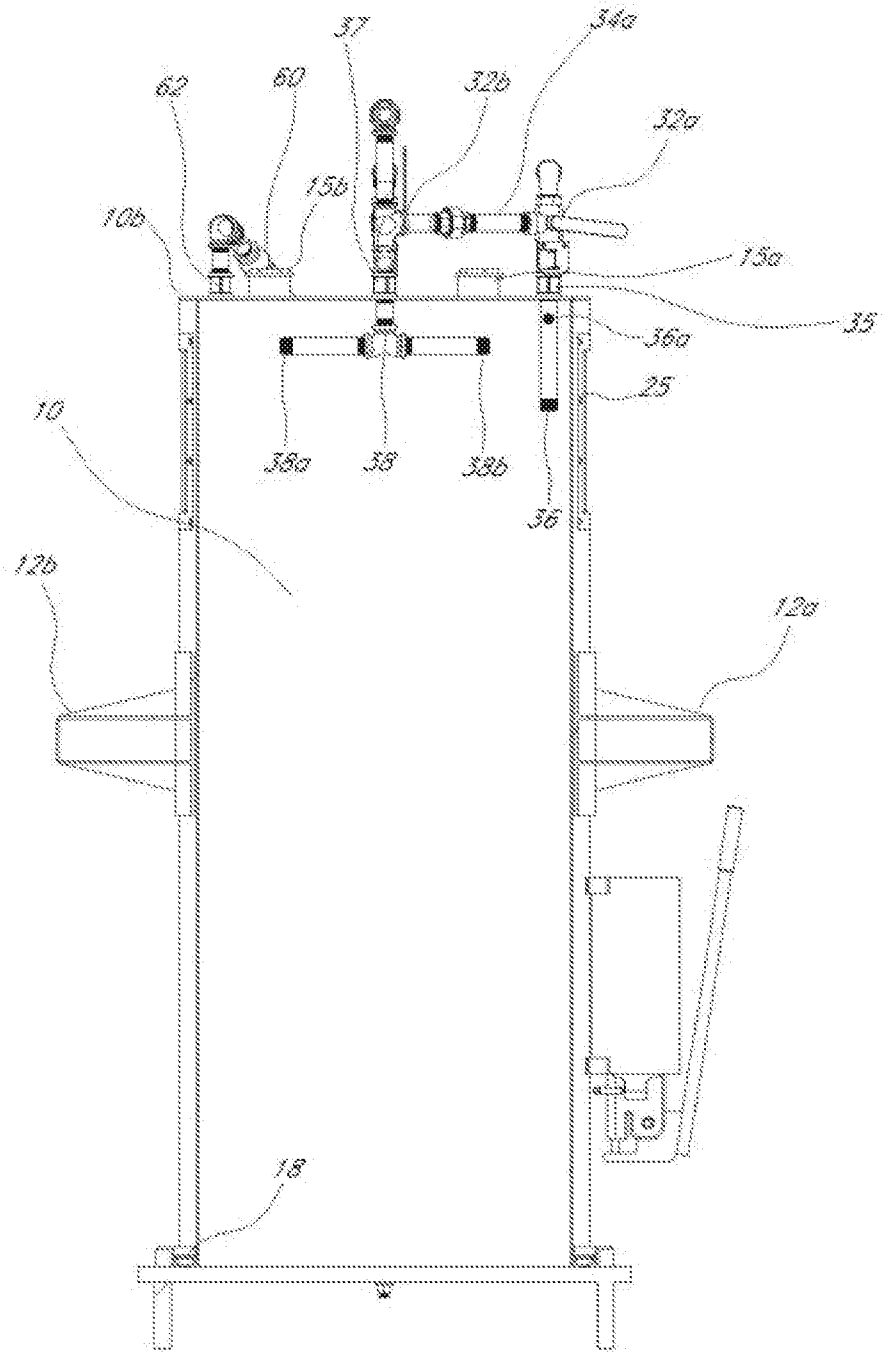


FIG. 5b


37
34a
62
60
32b
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15a
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36a
25
10
38a
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38b
36
12b
12a
16

FIG. 6

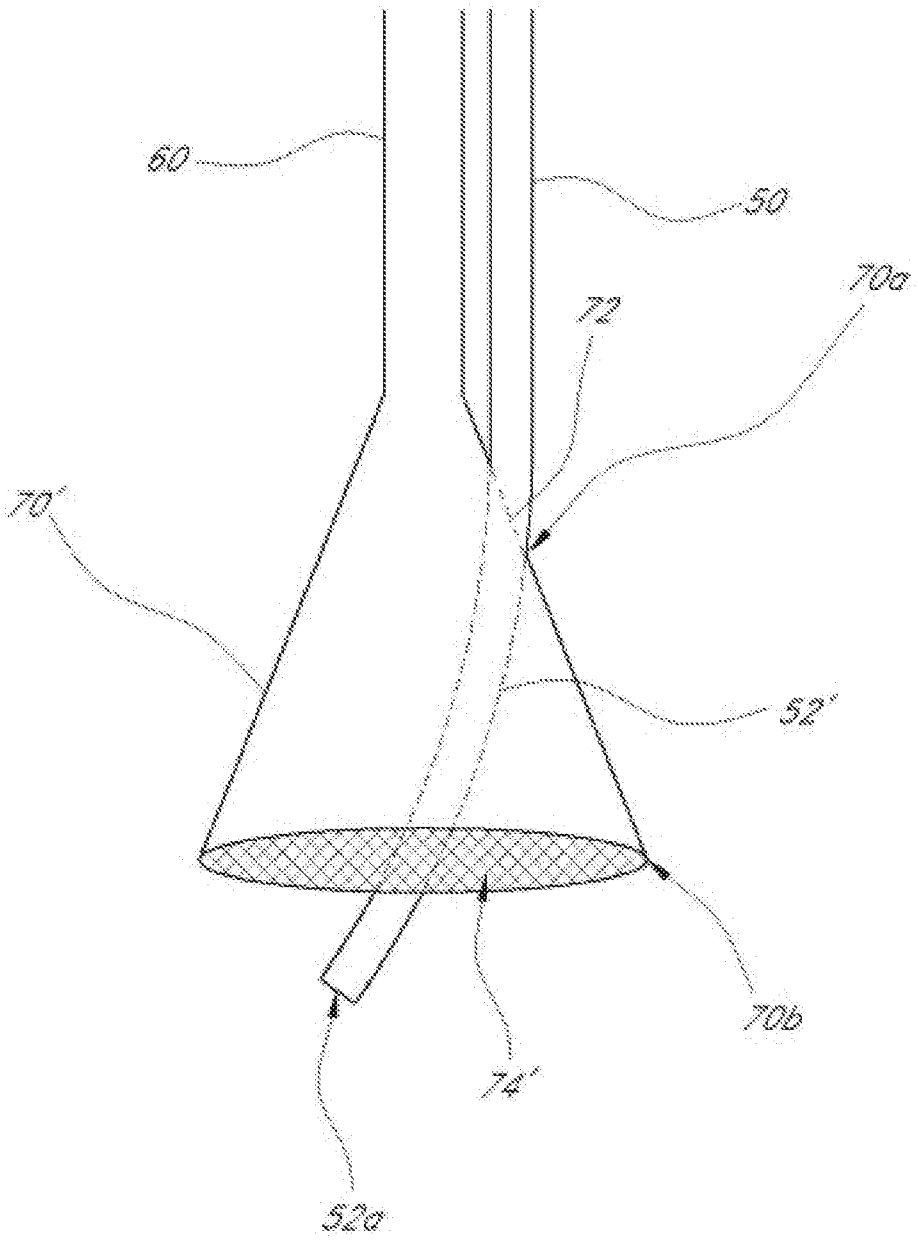

FIG. 7

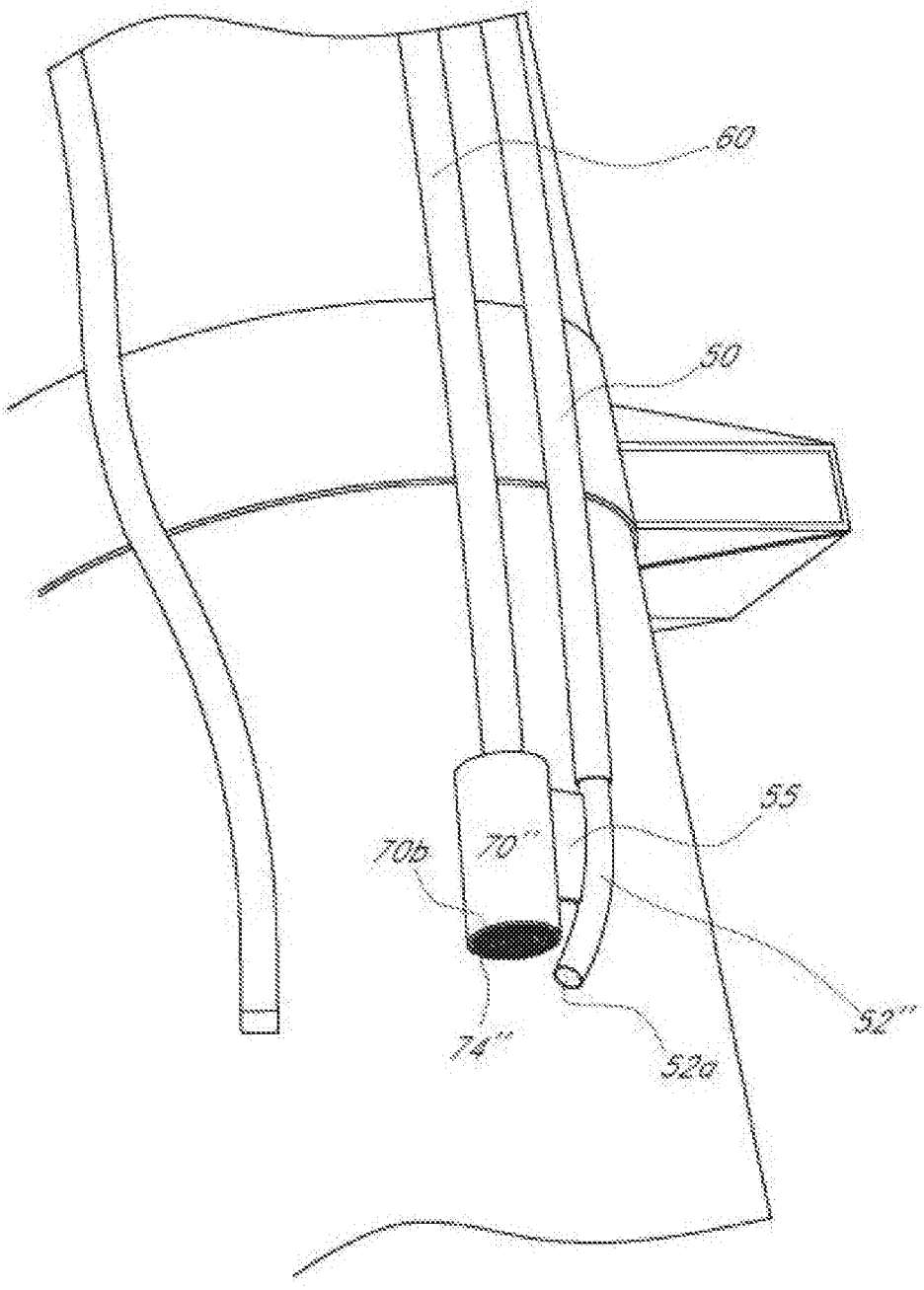

FIG. 8a

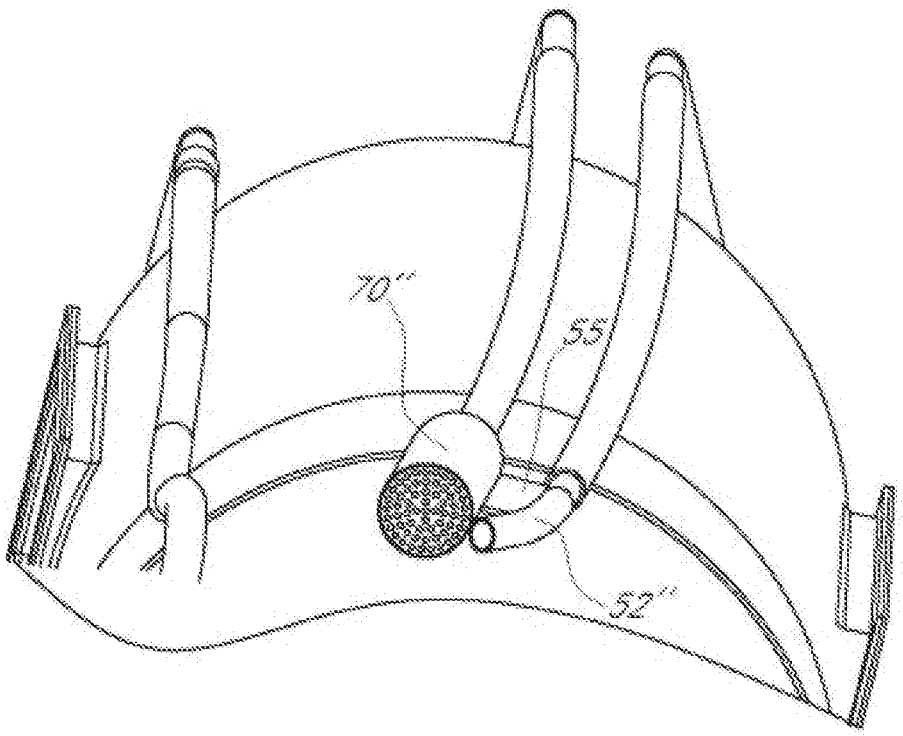

FIG. 8b

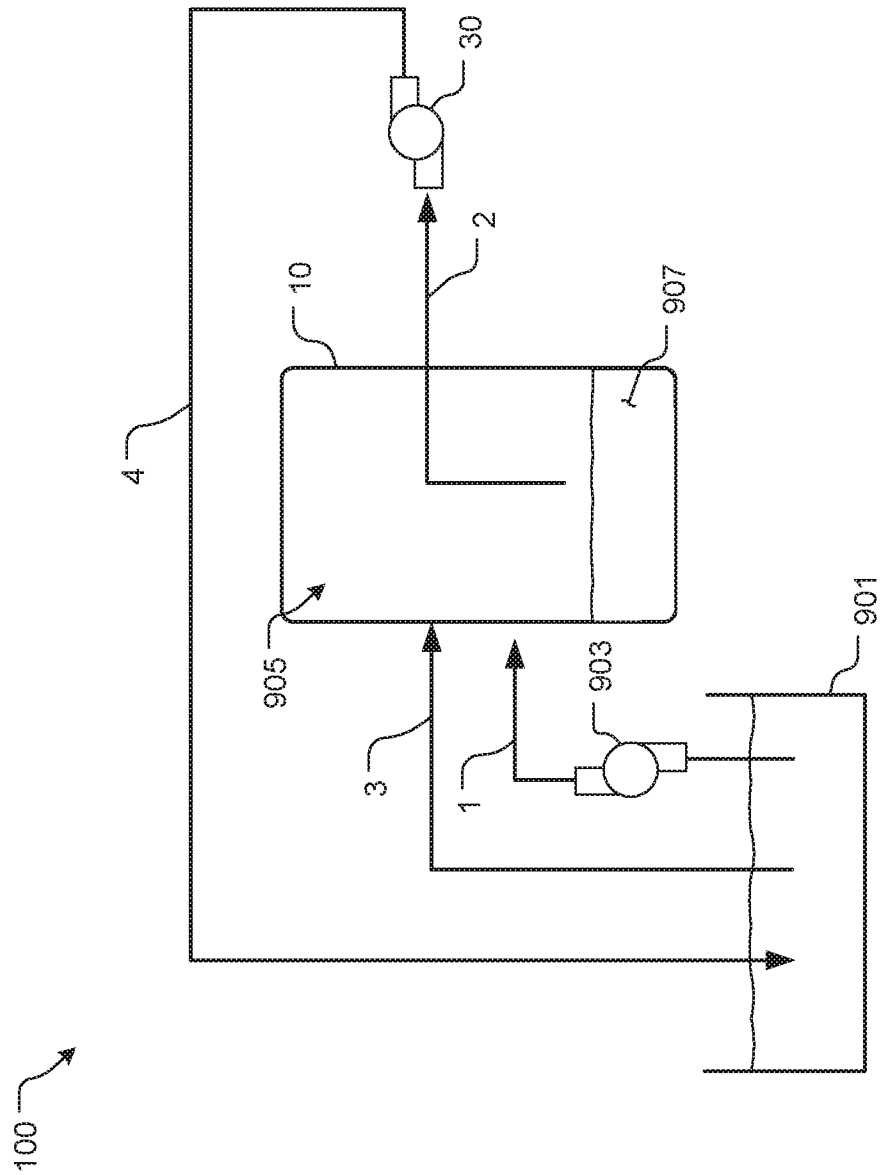

FIG. 9

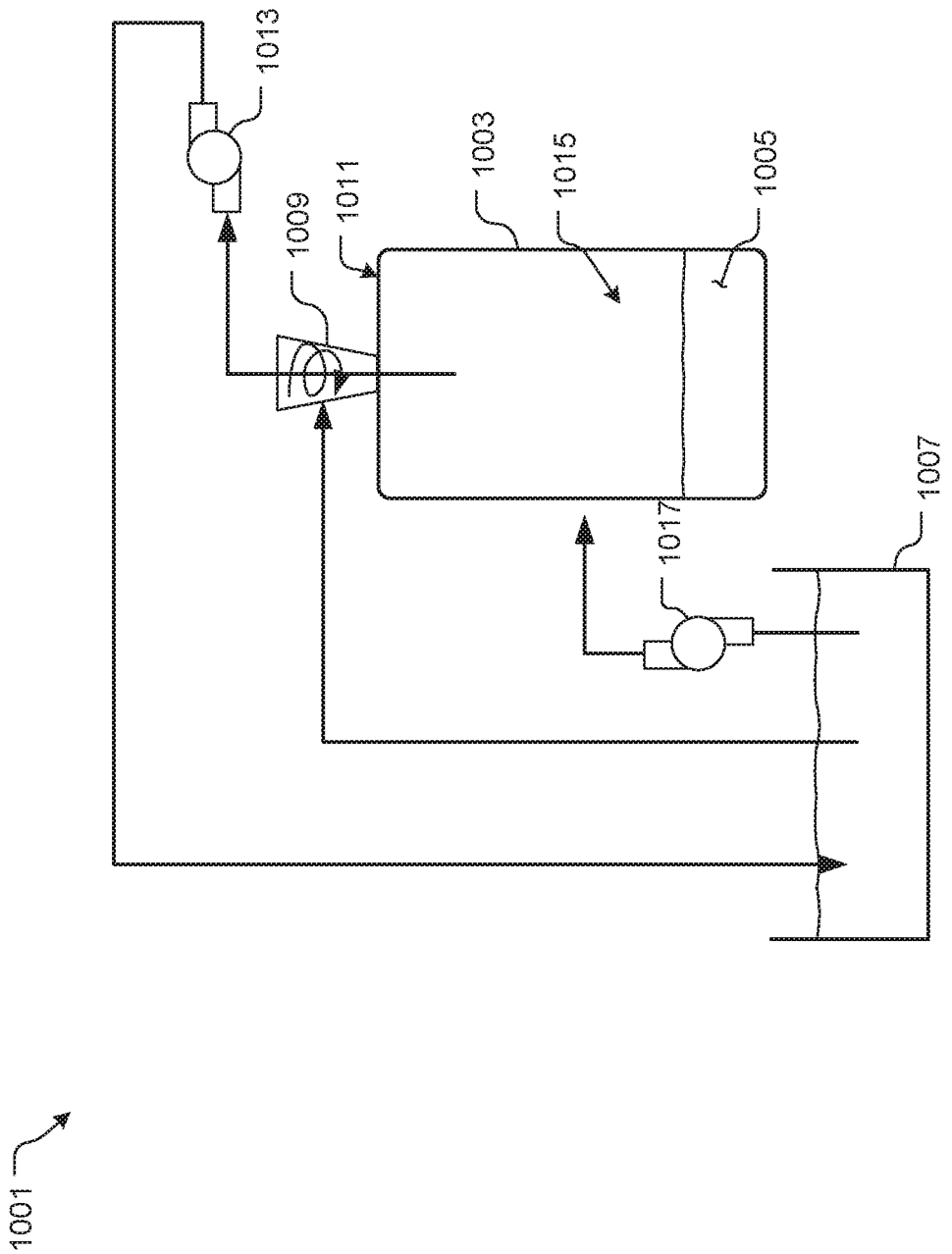

FIG. 10

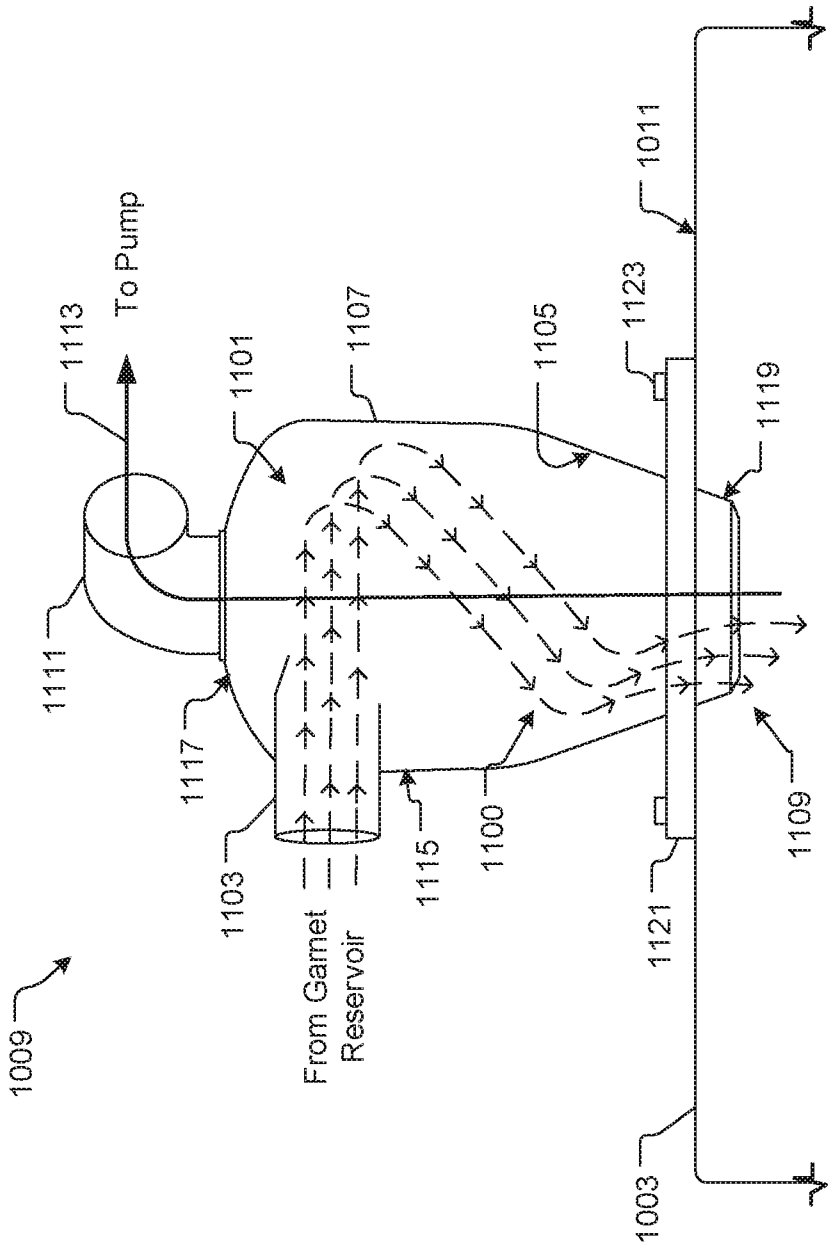
1009
From Garnet Reservoir
1103
1117
1111
1113
To Pump
1101
1107
1105
1123
1011
1119
1109
1121
1100
1115
1003

FIG. 11

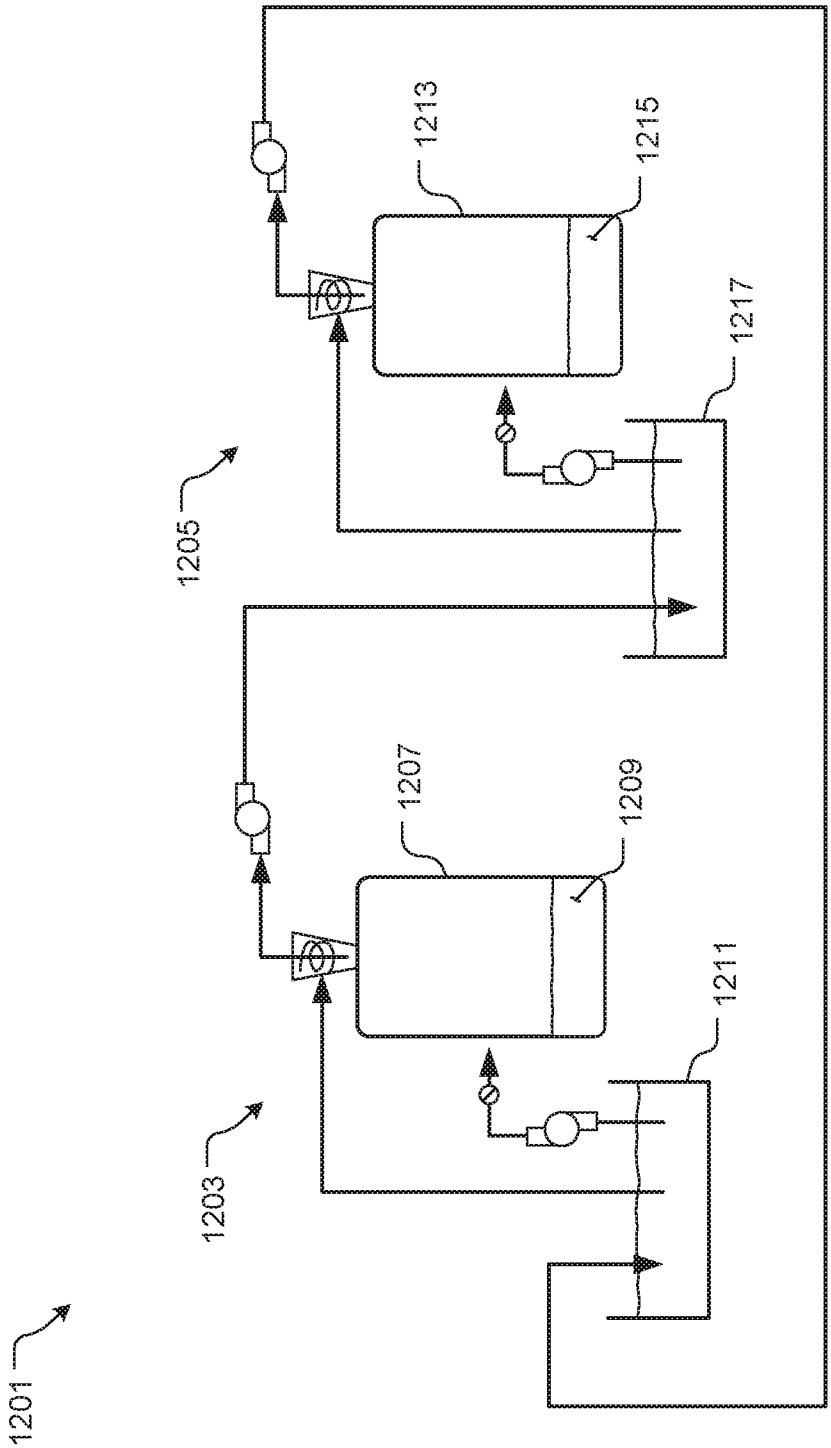

FIG. 12

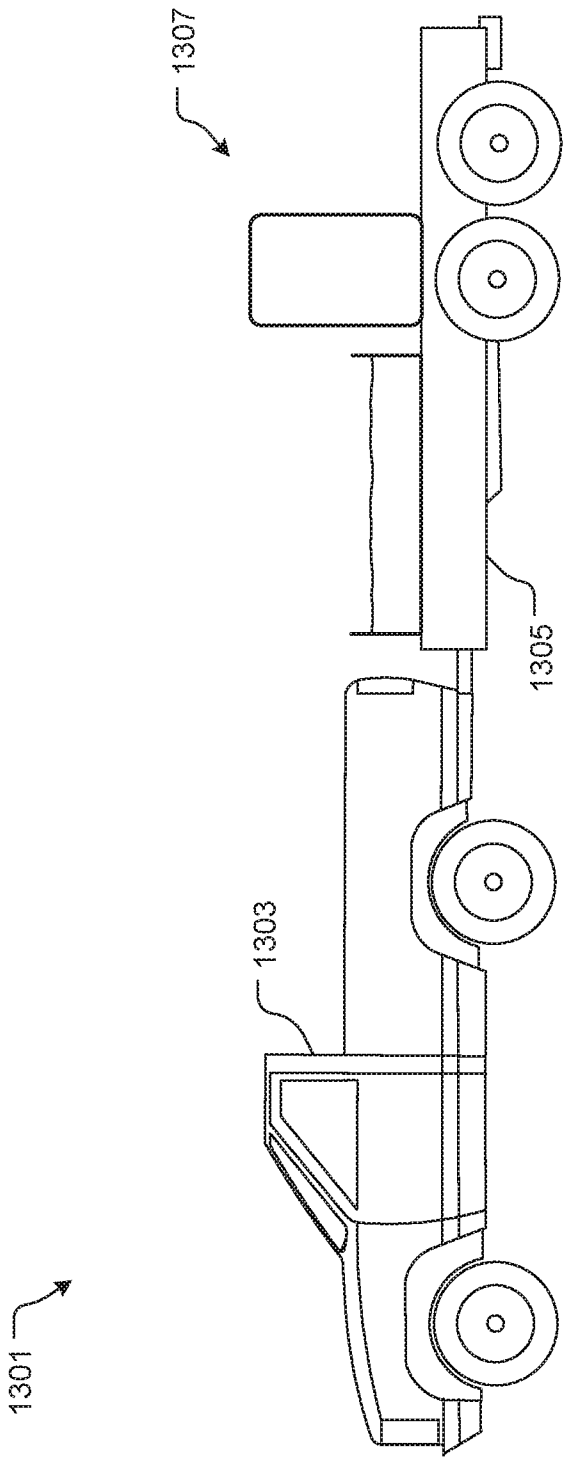

FIG. 13

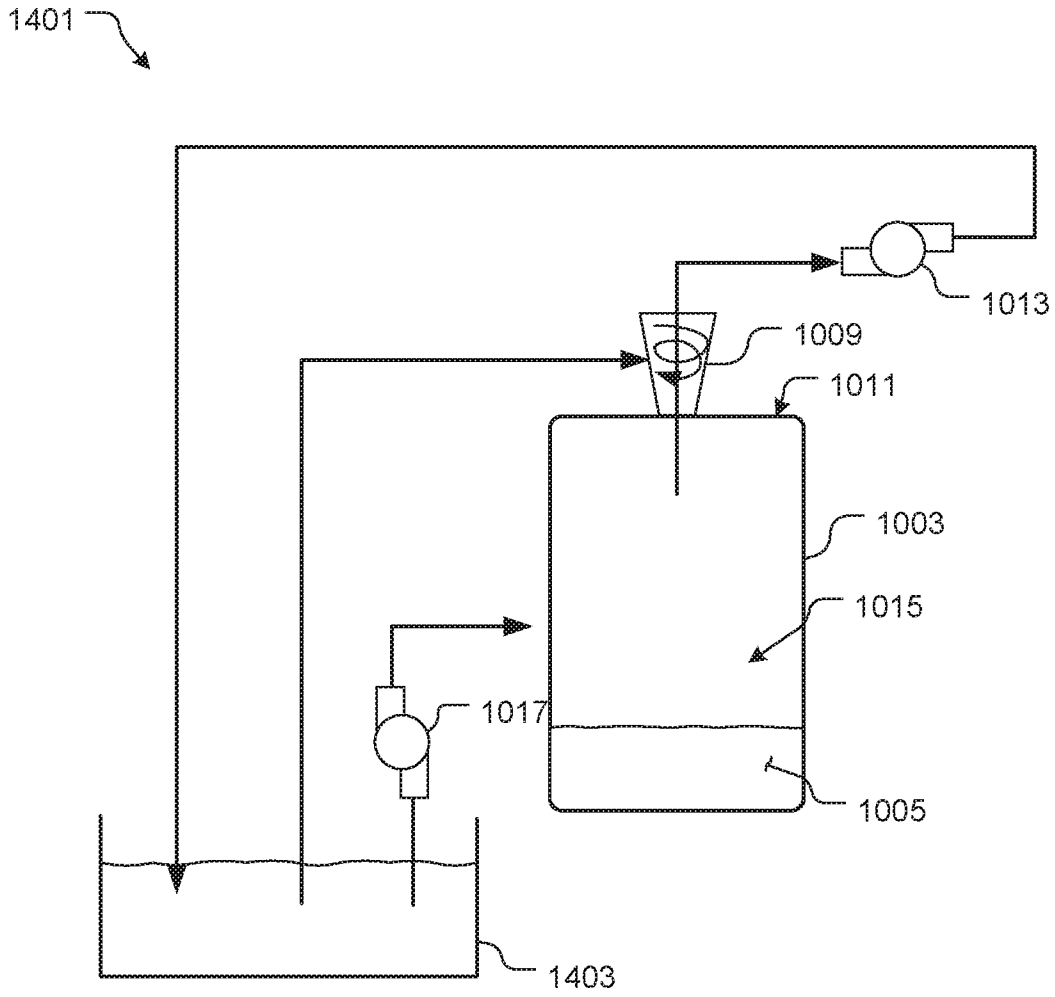

FIG. 14

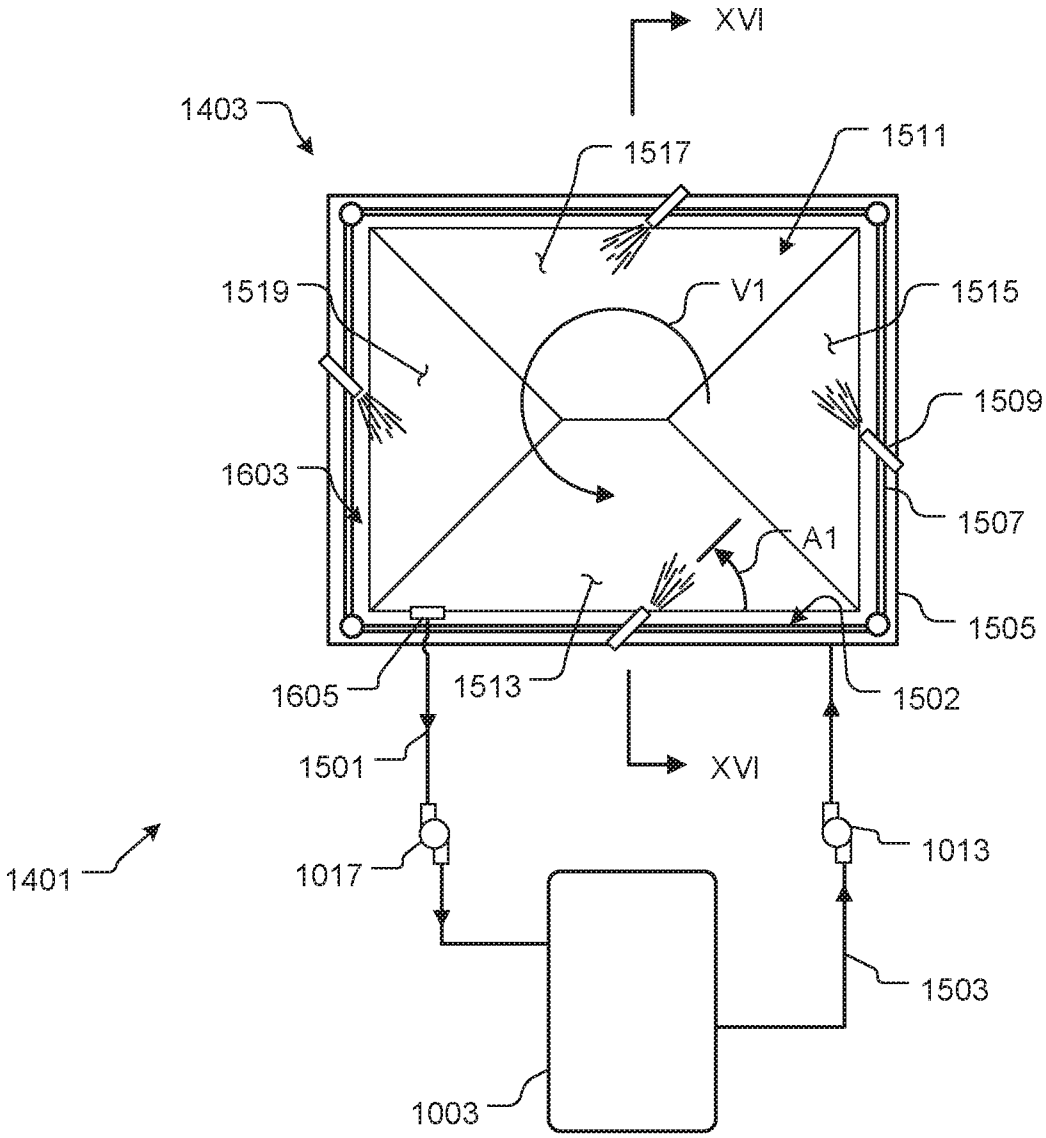
XVI
1403
1517
1511
1519
V1
1515
1509
1603
1507
A1
1505
1605
1513
1502
1501
XVI
1401
1017
1013
1503
1003

FIG. 15

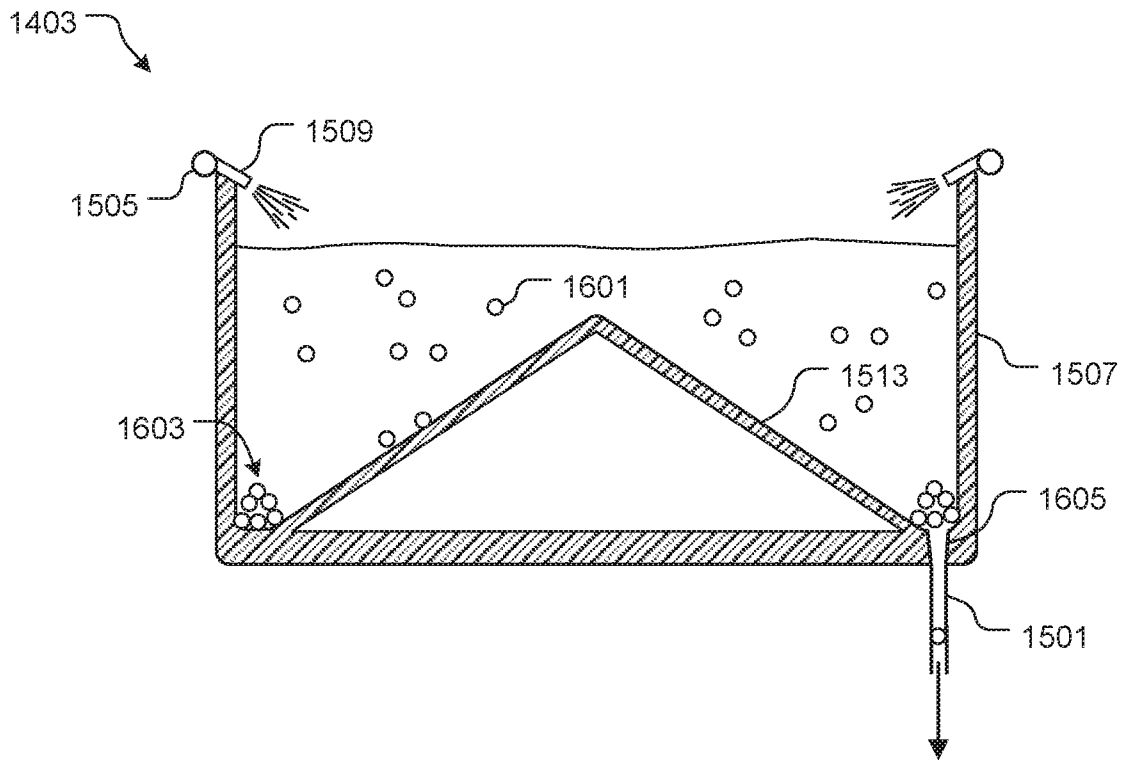

FIG. 16

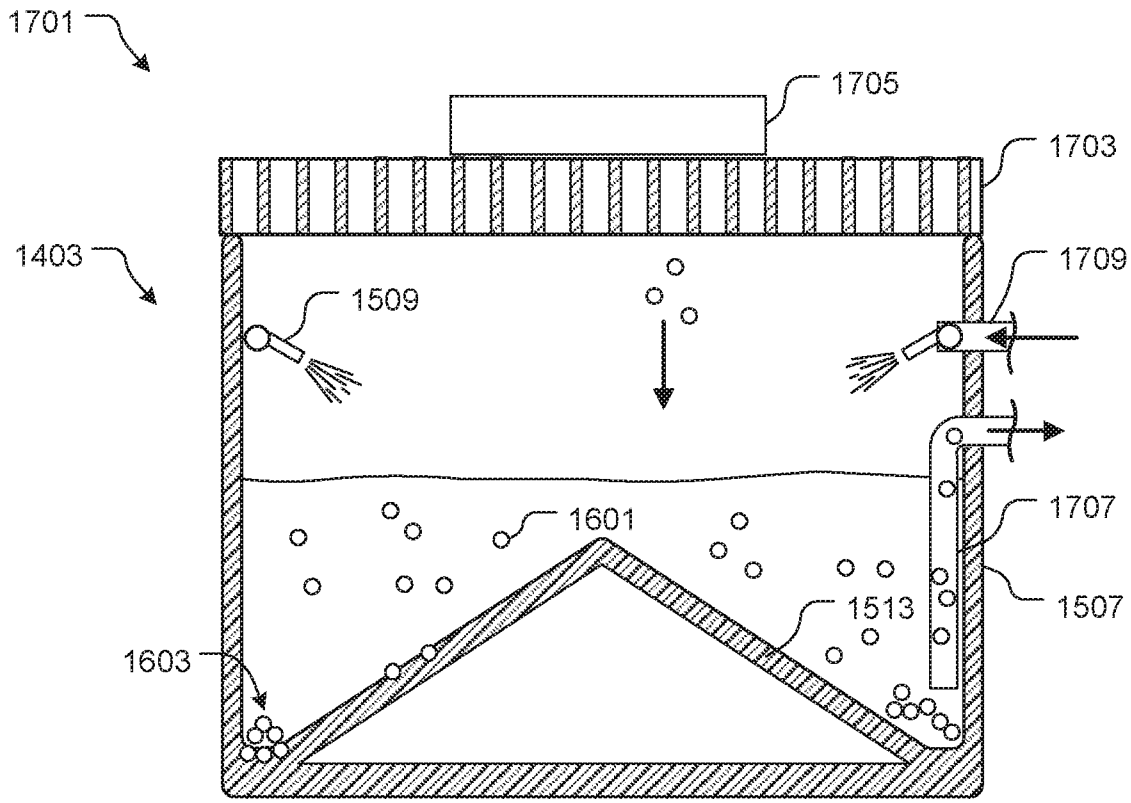

FIG. 17

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/079594

A. CLASSIFICATION OF SUBJECT MATTER

B24C 9/00(2006.01)i

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)

B24C

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 practicable, search terms used)

CNPAT,CNKI,WPI,EPODOC:garnet,abrasive,extract+,cutter?,water w jet,tank,outflow,inflow,cyclonic,separator,pump,valve, cross w flow,injection

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010133206 A1 (SCHADE, GEORGE) 03 June 2010 (2010-06-03) claims 14-18	1-5
PX	US 8926847 B1 (SCHADE, GEORGE) 06 January 2015 (2015-01-06) claims 1-5, columns 11-13, figures 1-13	1-13
A	CN 89102888 C (KAWASAKI JUKOGYO KK.) 19 February 1992 (1992-02-19) pages 7-9, figure 1	1-18
A	US 6969429 B2 (MUHLHAN SURFACE PROTECTION INTERNATIONAL GMBH) 29 November 2005 (2005-11-29) claims 1-18	1-18
A	US 2007066190 A1 (TOWA CORPORATION) 22 March 2007 (2007-03-22) pages 2-4, figure 1	1-18
A	US 2008057840 A1 (HUANG, ZHI ET AL.) 06 March 2008 (2008-03-06) pages 2-3	1-18

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

* Special categories of cited documents:

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"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

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

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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 July 2015	**29 July 2015**
Name and mailing address of the ISA/CN **STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China** Facsimile No. **(86-10)62019451**	Authorized officer **LIU,Jing** Telephone No. **(86-10)82245358**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2015/079594

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
US 2010133206 A1	03 June 2010	US D632709 S1	15 February 2011
US 8926847 B1	06 January 2015	None	
CN 89102888 C	19 February 1992	None	
US 6969429 B2	29 November 2005	US 2005005950 A1	13 January 2005
US 2007066190 A1	22 March 2007	JP 4791787 B2	12 October 2011
		JP 2007083365 A	05 April 2007
		KR 20070033884 A	27 March 2007
		US 7207868 B2	24 April 2007
		TW I300738 B	11 September 2008
		CN 1935459 A	28 March 2007
		SG 131836 A1	28 May 2007
		KR 100796861 B1	22 January 2008
US 2008057840 A1	06 March 2008	US 7455573 B2	25 November 2008