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(54) Title: HIGH PRESSURE CHEMICAL INJECTION UNIT

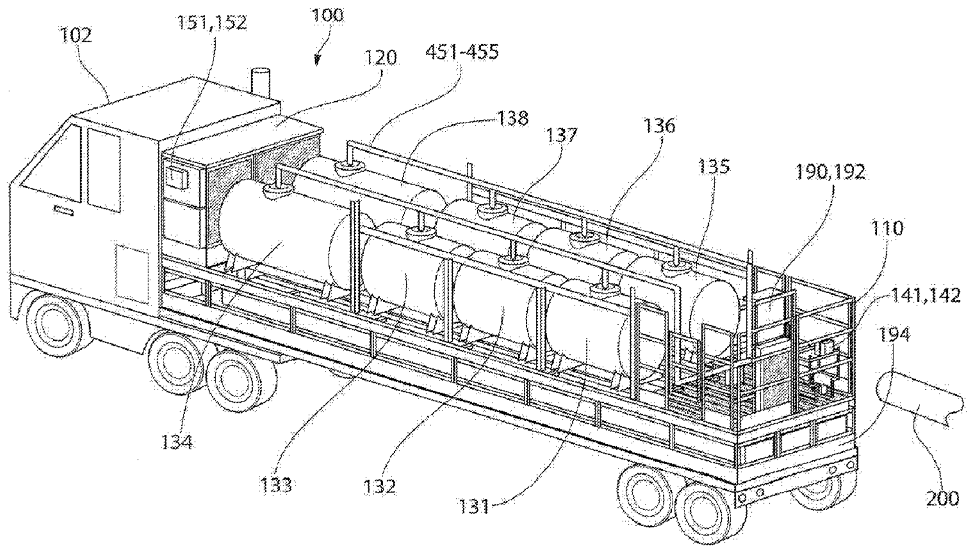

FIG. 1

(57) Abstract: A chemical injection unit includes an engine, a first pump, and a second pump positioned downstream from the first pump. A first hydraulic circuit transmits power from the engine to the first pump, the second pump, or both. Tanks are in fluid communication with the first pump and the second pump. A control panel controls operation of the engine, the first pump, and the second pump to cause liquid to flow from at least one of the tanks to into a pipeline.

WO 2017/190119 A1

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HIGH PRESSURE CHEMICAL INJECTION UNIT

CROSS-REFERENCE TO RELATED APPLICATION

The present application claims priority to US Application Serial No.: 62/329977 , filed April 29, 2016, which is incorporated herein by reference in its entirety

Background

[0001] Pipelines may be used to transport pressurized chemicals, such as methane, over long distances. Over time, such pipelines are subject to corrosion, bacterial buildup, and freezing. Different mobile units exist to pump chemicals into pressurized pipelines to prevent corrosion, bacterial buildup, and freezing. Some units are mounted on a truck and powered by a generator. Other units are integrated with the truck and thus, power to such units are dependent upon the truck. As a result, a failure of the truck may prevent the unit from operating as intended.

Summary

[0002] This summary is provided to introduce a selection of concepts that are further described below in the detailed description. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in limiting the scope of the claimed subject matter.

[0003] A chemical injection unit is disclosed. The chemical injection unit includes an engine, a first pump, and a second pump positioned downstream from the first pump. A first hydraulic circuit transmits power from the engine to the first pump, the second pump, or both. Tanks are in fluid communication with the first pump and the second pump. A control panel controls operation of the engine, the first pump, and the second pump to cause liquid to flow from at least one of the tanks to into a pipeline.

[0004] In another embodiment, the chemical injection unit includes an engine, a first pump coupled to and in fluid communication with a pipeline injection line, and a second pump coupled to and in fluid communication with the pipeline injection line. The second pump is positioned downstream from the first pump in the pipeline injection line. A first hydraulic circuit transmits

power from the engine to the first pump, the second pump, or both. A first set of tanks is coupled to an in fluid communication with a first inlet line and an outlet line. Liquid is introduced into the first set of tanks through the first inlet line, and the liquid flows out of the first set of tanks through the outlet line and into the pipeline injection line, at a point that is upstream from the first pump.

[0005] A method for treating a pipeline is also disclosed. The method includes opening a first valve proximate to an outlet of a first tank, opening a second valve downstream from a first pump, closing a third valve downstream from the first pump, and causing, with the first pump, a first liquid to flow out of the first tank, through the first valve, through the first pump, through the second valve, through a second pump that is downstream from the second valve, and into a pipeline having an internal pressure that is greater than an ambient pressure.

Brief Description of the Drawings

[0006] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the present teachings and together with the description, serve to explain the principles of the present teachings. In the figures:

[0007] FIG. 1 illustrates a perspective view of an injection unit 100, such as a high pressure chemical injection unit, according to an embodiment.

[0008] FIG. 2 illustrates an exploded perspective view of the injection unit, according to an embodiment.

[0009] FIG. 3 is a perspective view of a tank in the injection unit, according to an embodiment.

[0010] FIG. 4 illustrates a schematic view of the injection unit, according to an embodiment.

[0011] FIG. 5 illustrates a flowchart of a method for treating a pipeline, according to an embodiment.

Detailed Description

[0012] Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings and figures. In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the present disclosure. However, it will be apparent to one of ordinary skill in the art that the systems and methods disclosed herein may be practiced without these specific details. In other instances, well-known methods, procedures, components, circuits, and networks have not been described in detail so as not to unnecessarily obscure aspects of the embodiments.

[0013] It will also be understood that, although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first object could be termed a second object, and, similarly, a second object could be termed a first object, without departing from the scope of the present disclosure. The first object and the second object are both objects, but they are not to be considered the same object.

[0014] The terminology used in the description of the invention herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used in the description of the invention and the appended claims, the singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will also be understood that the term "and/or" as used herein refers to and encompasses any and all possible combinations of one or more of the associated listed items. It will be further understood that the terms "includes," "including," "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. Further, as used herein, the term "if" may be construed to mean "when" or "upon" or "in response to determining" or "in response to detecting," depending on the context.

[0015] Attention is now directed to processing procedures, methods, techniques, and workflows that are in accordance with some embodiments. Some operations in the processing procedures, methods, techniques, and workflows disclosed herein may be combined and/or the order of some operations may be changed.

[0016] FIGs. 1 and 2 illustrate a perspective view and an exploded perspective view, respectively, of an injection unit 100, such as a high pressure chemical injection unit according to an embodiment. The injection unit 100 may be configured to pump liquids into a pipeline 200 to protect the pipeline 200 against corrosion, bacterial formations, freezing, and the like. The injection unit 100 may deliver extended treatment batches into the pipeline 200 at pressures up to 350 bar (35 MPa). The injection unit 100 may be mounted on a vehicle (e.g., a truck) 102, and the injection unit 100 may be fully independent from the vehicle 102. The injection unit 100 may be operated while mounted on the vehicle 102, or it may be removed from the vehicle 102 prior to operation.

[0017] The injection unit 100 may include a frame 110. The frame 110 may include two metallic (e.g., steel) structures, with one on top of the other. As part of the frame 110, a lower metallic structure may include a first set of steel beams that are coupled (e.g., welded) to a second set of perpendicular steel beams. The first set of steel beams may include four beams that are about 12 meters long, and the second set of steel beams may include three beams that are about 2 meters long. The lower metallic structure may be anchored to the truck 102. Also, as part of frame 110, an upper metallic structure may include a first set of steel beams that are coupled (e.g., welded) to a second set of perpendicular steel beams. The first set of steel beams may be about 11 meters long, and the second set of steel beams may be about 2 meters long, for example. A plurality of intermediate steel beams may be coupled between the first and second metallic structures. The intermediate steel beams may include 32 beams that are about 30 cm long. In at least one embodiment, the frame 110 may be connected to a 40 inch (102 cm) trailer by one or more (e.g., six) twist locks.

[0018] One or more engines 120 (although one is shown) may be positioned on and/or coupled to the frame 110. The engine 120 may provide power to the injection unit 100. The engine 120 may be independent from the truck's engine (not shown). In one embodiment, the engine 120 may be an industrial FPT turbocharged diesel engine capable of producing 80 kW at 1600 RPM at the flywheel. The engine 120 may produce about 24 volts and 90 amps at the alternator. The engine 120 may be managed by a dedicated control panel that is linked to a programmable logic circuit ("PLC") 192 in the control panel 190 as discussed below.

[0019] One or more tanks (nine are shown: 131-139) may also be may be positioned on and/or coupled to the frame 110. In at least one embodiment, six of the tanks 131-133, 135-137 may have an internal volume from about 0.5 m^3 to about 3 m^3 (e.g., about 1.2 m^3), and the internal volumes may have chemicals stored therein. The respective tanks 131-133, 135-137 may include the same chemicals therein, or different chemicals. Two of the tanks 134, 138 may have internal volumes from about 1 m^3 to about 4 m^3 (e.g., about 2 m^3), and the internal volumes may have clean water stored therein. One additional tank 139 may have may have an internal volume from about 0.05 m^3 to about 1 m^3 (e.g., about 0.1 m^3), and the internal volume may have clean water stored therein that may be used for an emergency shower.

[0020] The chemicals stored in the aforementioned tanks may be or include biocides, corrosion inhibitors, antifreeze, solvents, water, or a combination thereof. Examples of possible biocides may include, but are not limited to, glutaraldehyde, tetrakis (hydroxymethyl) phosphonium sulfate, alkyl benzyl dimethyl ammonium chloride, tri ethylene glycol and/or quaternary ammonium chloride. Corrosion inhibitors may be or include mono-ethylene glycol, 2-butoxy ethanol, 2-aminoethanol, ethanediol, ethoxylated imadazolines, propan-2-ol, quaternary ammonium compounds, benzyl (hydrogenated tallow alkyl) dimethyl, chlorides, salts of carboxylic acid, thioalcohol, mono-ethylene glycol, 2-butoxy ethanol or a combination thereof. Each of the respective tanks 131-133, 135-137 may include the same chemicals therein or different chemicals.

[0021] One or more pumps (two are shown: 141, 142) may also be positioned on and/or coupled to the frame 110. The pumps 141, 142 may be driven by the engine 120. The first pump 141 may be a low pressure centrifugal pump that is configured to transfer the liquids (i.e., cause the liquids to flow). The first pump 141 may have a speed up to about 3500 RPM, a maximum flow rate of about 18 m^3/hour, a maximum head of about 39 meters, and use about 3 kW of power. The first pump 141 may have a pressure from about 0.5 bar to about 4 bar. The first pump 141 may be stopped by the PLC 192 if the pressure delivered by the second pump 142 exceeds 390 bar for more than 2 seconds, or if the flow meter 170 (introduced below) indicates that there is no flow after 5 seconds. In one embodiment, the first pump 141 may a RD 32-16 2P closed impeller centrifugal pump manufactured by Salvatore Robuschi.

[0022] The second pump 142 may be a high pressure piston pump that is configured to increase the pressure of the liquids. The second pump 142 may cause the pressure of the liquid to range from about 3 bar (0.3 MPa) to about 350 bar (35 MPa), or more. The second pump 142 may operate at a pressure that is higher than the first pump 141. The second pump 142 may have a speed up to about 1000 RPM, a flow rate from about 5 liters/minute to about 57 liters/minute, and use about 37 kW of power. The second pump 142 may be stopped by the PLC 192 if the pressure exceeds 380 bar for more than 2 seconds, or if the pressure exceeds 400 bar and/or the flow meter 170 indicates no flow after 5 seconds. In one embodiment, the second pump 142 may be a Pratissoli pump manufactured by Interpump Group S.p.A.

[0023] One or more hydraulic circuits (two are shown: 151, 152) may also be may be positioned on and/or coupled to the frame 110. The hydraulic circuits 151, 152 may be configured to transmit power from the engine 120 to the pumps 141, 142. The first hydraulic circuit 151 may be an open loop circuit including a hydraulic vane pump and a vane motor. The first hydraulic circuit 151 may drive the first pump (e.g., the low pressure pump) 141. The first hydraulic circuit 151 may allow the first pump 141 to have at least two speeds. For example, the first pump 141 may have a low speed for high pressure injection, and a high speed for filling and mixing. The speed of the first pump 141 may be adjusted continuously manually. The first pump 141 may also be operated by two electro-valves that are not proportional (e.g., the user may choose between two or more speeds).

[0024] The second hydraulic circuit 152 may be a closed loop circuit including a variable capacity axial piston pump coupled to a fixed capacity piston motor. The second hydraulic circuit 152 may drive the second pump (e.g., the high pressure pump) 142. The speed of the second pump 142 may be adjusted continuously either manually or by a proportional electro-valve.

[0025] A plurality of pipes (also referred to herein as "lines") 451-455 may be coupled to the frame 110, the tanks 131-139, the pumps 141, 142, the hydraulic circuits 151, 152, or a combination thereof. The liquids may be transferred, through the lines 451-455, from one tank (e.g., tank 131) to another tank (e.g., tank 132), or from one or more of the tanks (e.g., tank 131) to the pipeline 200. In one embodiment, an upper portion of the lines 451-455 may be used to fill the tanks 131-134, while a lower portion of the lines 451-455 may be used for flushing, injecting, or mixing the liquids. The tanks 131-139, lines 451-455, hydraulic circuits 151, 152, etc. may include quick-lock connections to reduce or prevent spills and facilitate disconnections when the lines 451-455 are pressurized.

[0026] A flow meter 170 (see FIG. 4) may be coupled to one or more of the lines 451-455. The flow meter 170 may be a Coriolis flow meter that measures the amount of liquid pumped and helps to regulate the speed of the pumps 141, 142.

[0027] A plurality of valves (see FIG. 4) may be coupled to and/or positioned within the lines 451-455. The valves may be or include ball valves that are controlled and/or monitored by the PLC 192 as introduced below. The valves are described in greater detail with respect to FIG. 4.

[0028] A control panel 190 may also be may be positioned on and/or coupled to the frame 110. The control panel 190 may include a PLC 192 that receives information from and/or controls the operation of the engine 120, the pumps 141, 142, the hydraulic circuits 151, 152, the valves, the flow meter 170, or a combination thereof. The PLC 192 may monitor and record working parameters to prevent abnormal situations. For example, the PLC 192 may continuously monitor injection parameters to be able to detect when one or more hoses or lines 451-455 rupture or leak. The PLC 192 may monitor the positions of the valves before the injection unit 100 is started to enable the startup. The PLC 192 may also monitor the pressure and/or level of the liquids in the tanks 131-139 and the lines 451-455 at various locations, and monitor the hydraulic oil pressure. The PLC 192 may alert a user if the pressure exceeds a predetermined amount.

[0029] The injection unit 100 may include multiple levels of protection against overpressure in the tanks 131-139 and lines 451-455. The first level may be electronic, and the PLC 192 may stop one or more of the pumps 141, 142 via hydraulic shutdown. The second level may be electronic, and the PLC 192 may stop one or more of the pumps 141, 142 by stopping the engine 120. The third level may be mechanical, and a user may actuate a pressure relief valve in one or more of the pumps 141, 142. The fourth level may be mechanical, and may (e.g., automatically) actuate a safety valve in the delivery line.

[0030] One or more containment trays (one is shown: 194) may be positioned beneath the frame 110 and the tanks 131-139. The containment tray 194 may have a capacity from about 1 m^3 to about 12 m^3 (e.g., about 8 m^3), for example. The containment trays 194 may be configured to collect any liquids that spill out of the injection unit 100.

[0031] FIG. 3 is a perspective view of a tank 131 in the injection unit 100, according to an embodiment. The tank 131 may include one or more level indicators 311, 312 to indicate the amount of liquid in the tank 131. For example, the first level indicator 311 may provide a visual indication, and the second level indicator 312 may be electrical (e.g., a sensor). The second level indicator 312 may send a signal to the PLC 192, which may cause the pump(s) 141, 142 to stop, or the PLC 192 may send an acoustic and/or visual signal to the user telling the user to close one or more of the valves, if the liquid level inside the tank 131 is greater than a predetermined amount. The tank 131 may also include a manhole lid 320 for refilling or cleaning the tank 131. The tank 131 may also include a relief valve 331 that activates in case of overflow and closes down in case of overturning during transportation. The tank 131 may also include one or more isolation valves 332, 333 for maintenance purposes. The other tanks 132-139 may include the same features or different features.

[0032] FIG. 4 illustrates a schematic view of the injection unit 100, according to an embodiment. The injection unit 100 may include a plurality of inlets and outlets. As shown, a first inlet 401 may be used to introduce fuel to the engine 120. A second inlet 402 may be used to introduce air into the engine 120. A third inlet 403 may be used to introduce liquid into the tanks 131-134. A fourth inlet 404 may be used to introduce liquid into the tanks 135-138. A fifth inlet 405 may be used to introduce additional liquids into the injection unit 100. The fifth inlet 405 may also be used as a drain to expel liquids from the injection unit 100. A sixth inlet 406 may be used to introduce liquids into an auxiliary tank 410.

[0033] A first outlet 411 may be used to release the exhaust from the engine 120. A second outlet 412 may be used to expel liquid from the first (e.g., low pressure) pump 141. A third outlet 413 may be used as a drain for a filter. A fourth outlet 414 may be used as a drain for a manifold. A fifth outlet 415 may be used as an outlet for the second (e.g., high pressure) pump 142. A sixth outlet 416 may also be used as an outlet for the second (e.g., high pressure) pump 142. The liquid flowing through the sixth outlet 416 may be introduced into the pipeline 200. A seventh outlet 417 and an eighth outlet 418 may be used as a drain.

[0034] The respective tanks 131-138 may include a first valve 421-428 through which the liquid may be introduced into the tanks 131-138, and a second valve 431-438 through which the liquid may exit the tanks 131-138. In addition, the respective tanks 131-138 may include a third valve 441-448 that is part of the visual level. The third valves 441-448 may be used to drain the pressure of the air into the tanks 131-138 before the lids are opened.

[0035] A first inlet line 451 may be coupled to and in fluid communication with the first valves 421-424 and the tanks 131-134. Liquid may flow through the first inlet line 451 and the first valves 421-424 and be introduced into the tanks 131-134. A second inlet line 452 may be coupled to and in fluid communication with the first valves 425-428 and the tanks 135-138. Liquid may flow through the second inlet line 452 and the first valves 425-428 and be introduced into the tanks 135-138. An outlet line 453 may be coupled to and in fluid communication with the second valves 431-438 and the tanks 131-138. Liquid may flow from the tanks 131-138, through the second valves 431-438, and into the outlet line 453.

[0036] The outlet line 453 may be coupled to and in fluid communication with a pipeline injection line 454. A valve 461 may be positioned in the outlet line 453, upstream from the pipeline injection line 454. Another valve 462 may be positioned in the pipeline injection line 454, downstream from the outlet line 453. The first pump 141 may be positioned in the pipeline injection line 454. A valve 463 may be positioned in the pipeline injection line 454 and coupled to an outlet of the first pump 141. The flow meter 170 may be positioned in the pipeline injection line 454 and coupled to and in fluid communication with the first pump 141 and/or the valve 463. The flow meter 170 may be downstream from the first pump 141.

[0037] A return line 455 may be coupled to and in fluid communication with the pipeline injection line 454, the first inlet line 451, and the second inlet line 452. The return line 455 may be coupled to the pipeline injection line 454 at a point that is downstream from the first pump 141 and/or the flow meter 170. The return line 455 may be used to circulate liquids from the pipeline injection line 454, into the first inlet line 451 and/or the second inlet line 452, and back into one of the tanks 131-138. The return line 455 may have a valve 464 positioned therein. Another valve 465 may be positioned between the return line 455 and the first inlet line 451, and yet another valve 466 may be positioned between the return line 455 and the second inlet line 452.

[0038] A valve 467 may be positioned in the pipeline injection line 454, downstream from the flow meter 170 and the pipeline injection line 454. The second pump 142 may be positioned in the pipeline injection line 454, downstream from the return line 455 and the valve 467. The outlet of the second pump 142 may be coupled to and in fluid communication with the pipeline 200.

[0039] FIG. 5 illustrates a flowchart of a method 500 for treating a pipeline 200, according to an embodiment. The method 500 may be viewed together with the schematic view of the injection unit 100 shown in FIG. 4. The method 500 may include introducing liquid into one or more tanks 131-139 via an external pump (not shown) or gravity, as at 502. For example, a pump may cause liquid to flow through the inlet 403, through the valve 421, and into the first tank 131. When the level indicator 312 of the first tank 131 indicates that the liquid reaches a predetermined level, the PLC 192 may turn the pump off, close the valve 421, or a combination thereof. Once the first tank 131 has been filled, the pump may cause liquid to flow through the inlet 403, through the valve 422, and into the second tank 132. The liquid pumped into the second tank 132 may be the same as the liquid pumped into the first tank 131, or it may be a different liquid (e.g., different chemical). Once the level indicator 312 of the second tank 132 indicates that the liquid reaches a predetermined level, the PLC 192 may turn the pump off, close the valve 422, or a combination thereof. This process may occur for the tanks 131-134 one after another. In another embodiment, the pump (not shown) may cause liquid to flow through the inlet 403, through the valves 421-424, and into the tanks 131-134 simultaneously.

[0040] Introducing liquid at 502 may also include causing liquid to flow through the inlet 404, through the valve 425, and into the fifth tank 135. The pump may be the same pump used at 502 or a different pump. Once the level indicator 312 of the fifth tank 135 indicates that the liquid reaches a predetermined level, the PLC 192 may turn the pump off, close the valve 425, or a combination thereof. Once the fifth tank 135 has been filled, the pump may cause liquid to flow through the inlet 404, through the valve 426, and into the sixth tank 136. The liquid pumped into the sixth tank 136 may be the same as the liquid pumped into the fifth tank 135, or it may be a different liquid (e.g., different chemical). Once the level indicator 312 of the sixth tank 136 indicates that the liquid reaches a predetermined level, the PLC 192 may turn the pump off, close the valve 426, or a combination thereof. This process may occur for the tanks 135-138 one after another. In another embodiment, the pump (not shown) may cause liquid to flow through the inlet 404, through the valves 425-428, and into the tanks 135-138 simultaneously.

[0041] The method 500 may also include introducing liquid into the one or more tanks 131-138 using the first (e.g., low pressure) pump 141, as at 504. For example, the first pump 141 may cause liquid to flow through the inlet 405, through the flow meter 170, and through the valves 462, 463. The user may then select to have the liquid flow into the return line 455 by opening the valve 464. The user may then select to have the liquid flow into the first inlet line 451 by opening the valve 465, into the second inlet line 452 by opening the valve 466, or to have the liquid flow into both lines 451, 452 by opening both valves 465, 466. The user may then select which tanks 131-138 to fill by opening one or more or the first valves 421-428. The first (e.g., low pressure) pump 141 may stop when the flow meter 170 detects that the product source has run out or when the level sensor(s) 312 on the tank(s) 131-138 detect(s) that the level has reached a predetermined amount. The user may also select a certain volume of liquid to transfer, and the first pump 141 may stop after this volume has been pumped.

[0042] The method 500 may also include mixing the liquids from two or more tanks 131-138 using the first (e.g., low pressure) pump 141, as at 506. In one example, at least a portion of the liquid from second tank 132 may be combined and mixed with the liquid in the first tank 131. In this example, valves 421, 432, 461-465 may be open, and the valve 467 may be closed. The first (e.g., low pressure) pump 141 may cause the liquid to flow out of the second tank 132, through valves 432, 461, 462, through the first (e.g., low pressure) pump 131, through the flow meter 170, through valves 463, 464, 421, and into the first tank 131. In another embodiment, the tanks 131, 132 may be filled with predetermined amounts of liquid, and then the valves 421, 422, 431, 432 may be opened. Further, the first pump 141 may run to mix the liquids. The PLC 192 may stop the mixing process if the flow meter 170 does not detect any liquid flowing therethrough and/or if any of the tanks 131-138 involved in the mixing process reach their maximum fill level.

[0043] The method 500 may also include flushing or cleaning the pipes/lines 451-455 of the HCPI unit 100, as at 508. This may include opening the valves 434, 438 to draw water from the tanks 134, 138.

[0044] The method 500 may also include injecting the liquids into a pipeline 200, as at 510. In one example, the liquid from the first tank 131 may be injected into the pipeline 200. This may include opening valves 431, 461, 462, 463, 467, and closing valve 464. When this occurs, the liquid may flow through the valves 431, 461, 462, through the first (e.g., low pressure) pump 141, through the valve 463, through the flow meter 170, through the valve 467, through the second (e.g., high pressure) pump 142, through the outlet 416, and into the pipeline 200. The liquid(s) may have a pressure from about 10 bar to about 350 bar when introduced into the pipeline 200. The pipeline 200 may have an internal pressure that is greater than an ambient pressure. For example, the internal pressure may be from about 10 bar to about 350 bar when the liquid(s) is/are introduced thereto. Injecting the liquids may stop when the flow meter 170 detects that the product source has run out, if the pressure sensor in the delivery line detects a pressure above 380 bar for more than 2 seconds, if the pressure sensor in the delivery line detects a pressure above 400 bar (for any length of time), and/or if the flow meter 170 indicates no flow after 5 seconds.

[0045] The method 500 may also include bypassing tank level control, as at 512. The tank level control may be or include the level sensors 312 indicating when the level in the tanks 131-138 is greater than a predetermined amount. The tank level control may be bypassed to perform maintenance, in the event of an emergency, or if the PLC 192 fails. The tank level control may be bypassed by unlocking handles on the valves in the injection unit 100. The handles may be unlocked manually using a key to allow a user to manually override the controls.

[0046] The foregoing description, for purpose of explanation, has been described with reference to specific embodiments. However, the illustrative discussions above are not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many modifications and variations are possible in view of the above teachings. Moreover, the order in which the elements of the methods described herein are illustrate and described may be re-arranged, and/or two or more elements may occur simultaneously. The embodiments were chosen and described in order to best explain the principals of the invention and its practical applications, to thereby enable others skilled in the art to best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated.

CLAIMS

What is claimed is:

1. An injection unit, comprising:

an engine;

a first pump;

a second pump positioned downstream from the first pump;

a first hydraulic circuit configured to transmit power from the engine to the first pump, the second pump, or both;

a plurality of tanks that are in fluid communication with the first pump and the second pump; and

a control panel configured to control operation of the engine, the first pump, and the second pump to cause liquid to flow from at least one of the tanks to into a pipeline.

2. The injection unit of claim 1, wherein the injection unit is configured to be mounted on a vehicle, and wherein the engine of the injection unit is separate from an engine of the vehicle.

3. The injection unit of claim 1, wherein the liquid comprises biocides, corrosion inhibitors, antifreeze, or a combination thereof that is configured to prevent corrosion, bacterial buildup, or freezing within the pipeline.

4. The injection unit of claim 1, wherein the liquid has a pressure from about 10 bar to about 350 bar when the liquid flows into the pipeline.

5. The injection unit of claim 1, wherein the first hydraulic circuit is an open loop circuit comprising a hydraulic vane pump and a vane motor, and wherein the first hydraulic circuit transmits power from the engine to the first pump.

6. The injection unit of claim 5, wherein the first pump has a first speed for injecting the liquid into the pipeline, and a second speed for filling the tanks with the liquid, mixing the liquid in the tanks, or both.

7. The injection unit of claim 5, further comprising a second hydraulic circuit that is a closed loop circuit comprising a variable capacity axial piston pump and a fixed capacity piston motor, wherein the second hydraulic circuit transmits power from the engine to the second pump.

8. The injection unit of claim 1, wherein the first pump comprises a centrifugal pump, wherein the second pump comprises a piston pump, and wherein the first pump operates at a pressure that is less than the second pump.

9. The injection unit of claim 1, further comprising a flow meter in fluid communication with the first pump and the second pump, wherein the flow meter is positioned between the first pump and the second pump.

10. The injection unit of claim 1, wherein the tanks comprise:

a first tank having glutaraldehyde stored therein;

a second tank having glutaraldehyde stored therein;

a third tank having 2-aminoethanol, ethanediol, ethoxylated imadazolines, propan-2-ol, quaternary ammonium compounds, benzyl (hydrogenated tallow alkyl) dimethyl, chlorides, salts of carboxylic acid, thioalcohol, or a combination thereof stored therein;

a fourth tank having 2-aminoethanol, ethanediol, ethoxylated imadazolines, propan-2-ol, quaternary ammonium compounds, benzyl (hydrogenated tallow alkyl) dimethyl, chlorides, salts of carboxylic acid, thioalcohol, or a combination thereof stored therein;

a fifth tank having tetrakis (hydroxymethyl) phosphonium sulfate stored therein;

a sixth tank having tetrakis (hydroxymethyl) phosphonium sulfate stored therein; and

a seventh tank having water stored therein.

an eighth tank having water stored therein.

11. An injection unit, comprising:

an engine;

a first pump coupled to and in fluid communication with a pipeline injection line;

a second pump coupled to and in fluid communication with the pipeline injection line, wherein the second pump is positioned downstream from the first pump in the pipeline injection line;

a first hydraulic circuit configured to transmit power from the engine to the first pump, the second pump, or both; and

a first set of tanks coupled to an in fluid communication with a first inlet line and an outlet line, wherein liquid is introduced into the first set of tanks through the first inlet line, and wherein the liquid flows out of the first set of tanks through the outlet line and into the pipeline injection line, at a point that is upstream from the first pump.

12. The injection unit of claim 11, further comprising:

a second set of tanks coupled to an in fluid communication with a second inlet line, wherein the liquid is introduced into the second set of tanks through the second inlet line, and wherein the liquid flows out of the second set of tanks through the outlet line; and

a return line coupled to and in fluid communication with the first inlet line, the second inlet line, and the pipeline injection line, wherein the return line is coupled to the pipeline injection line at a point between the first pump and the second pump.

13. The injection unit of claim 12, further comprising a flow meter coupled to and in fluid communication with the pipeline injection line, wherein the flow meter is positioned between the first pump and the return line.

14. The injection unit of claim 13, further comprising:

a first valve positioned between the return line and the first inlet line, wherein the liquid in the return line flows into at least one of the first set of tanks when the first valve is open; and

a second valve positioned between the return line and the second inlet line, wherein the liquid in the return line flows into at least one of the second set of tanks when the second valve is open.

15. The injection unit of claim 14, wherein the first hydraulic circuit comprises an open loop circuit including a hydraulic vane pump and a vane motor, and wherein the first hydraulic circuit transmits power from the engine to the first pump; and

further comprising a second hydraulic circuit that comprises a closed loop circuit including a variable capacity axial piston pump and a fixed capacity piston motor, wherein the second hydraulic circuit transmits power from the engine to the second pump.

16. A method comprising:

opening a first valve proximate to an outlet of a first tank;

opening a second valve downstream from a first pump;

closing a third valve downstream from the first pump; and

causing, with the first pump, a first liquid to flow out of the first tank, through the first valve, through the first pump, through the second valve, through a second pump that is downstream from the second valve, and into a pipeline having an internal pressure that is greater than an ambient pressure.

17. The method of claim 16, wherein the first liquid also flows through a flow meter positioned between the first pump and the second valve.

18. The method of claim 16, wherein the first pump and the second valve are in a pipeline injection line, and wherein the third valve is in a return line that is coupled to and in fluid communication with the pipeline injection line at a point between the first pump and the second valve.

19. The method of claim 16, further comprising increasing a pressure of the first liquid using the second pump.

20. The method of claim 16, further comprising:

closing the first valve proximate to the outlet of the first tank;

closing the second valve downstream from the first pump;

opening the third valve downstream from the first pump;

opening a fourth valve proximate to an inlet of the first tank;

opening a fifth valve proximate to an outlet of a second tank; and

causing, with the first pump, a second liquid to flow out of the second tank, through the fifth valve, through the first pump, through the third valve, through the fourth valve, and into the first tank, where the second liquid is combined with the first liquid.

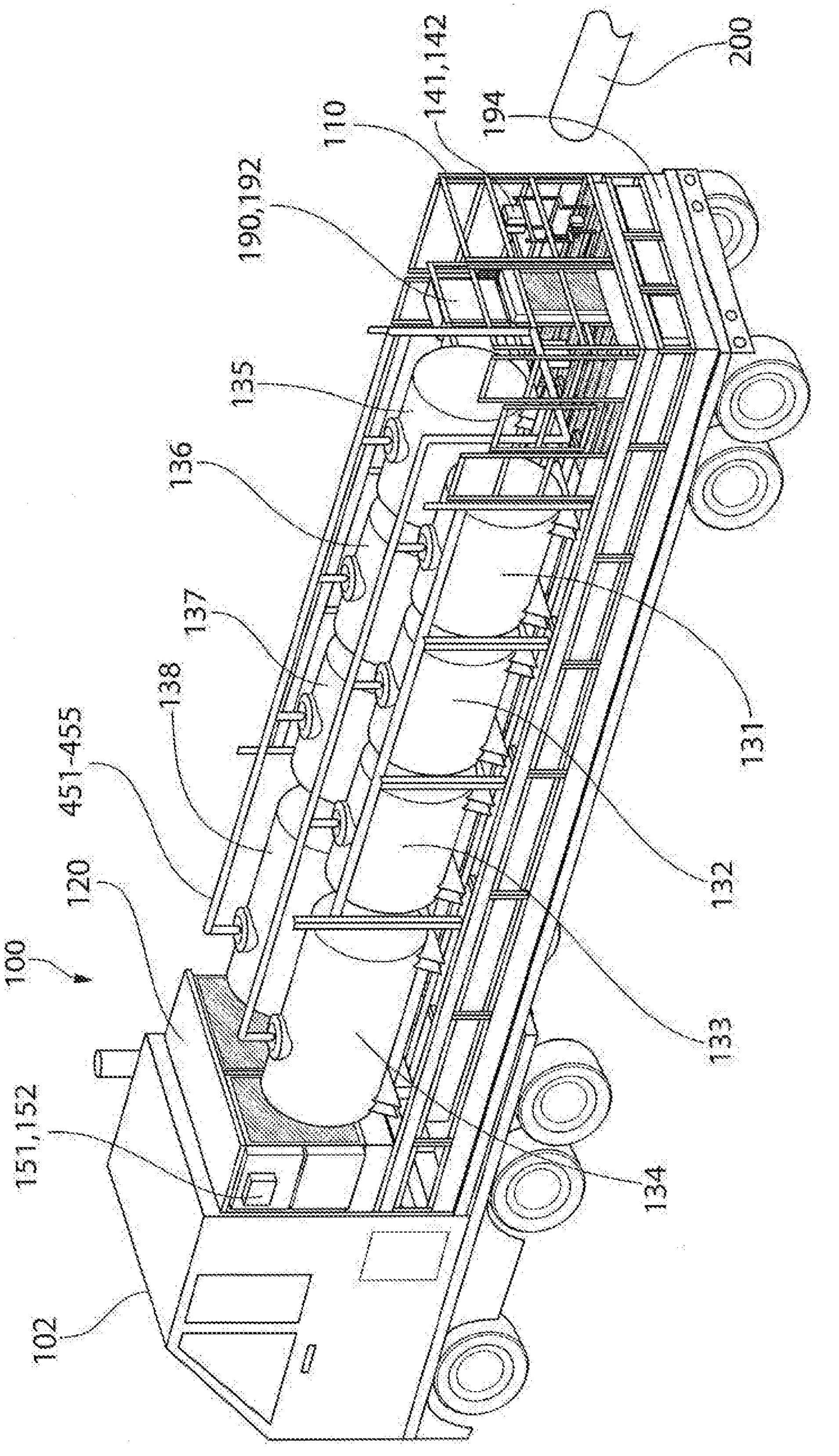
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FIG. 1

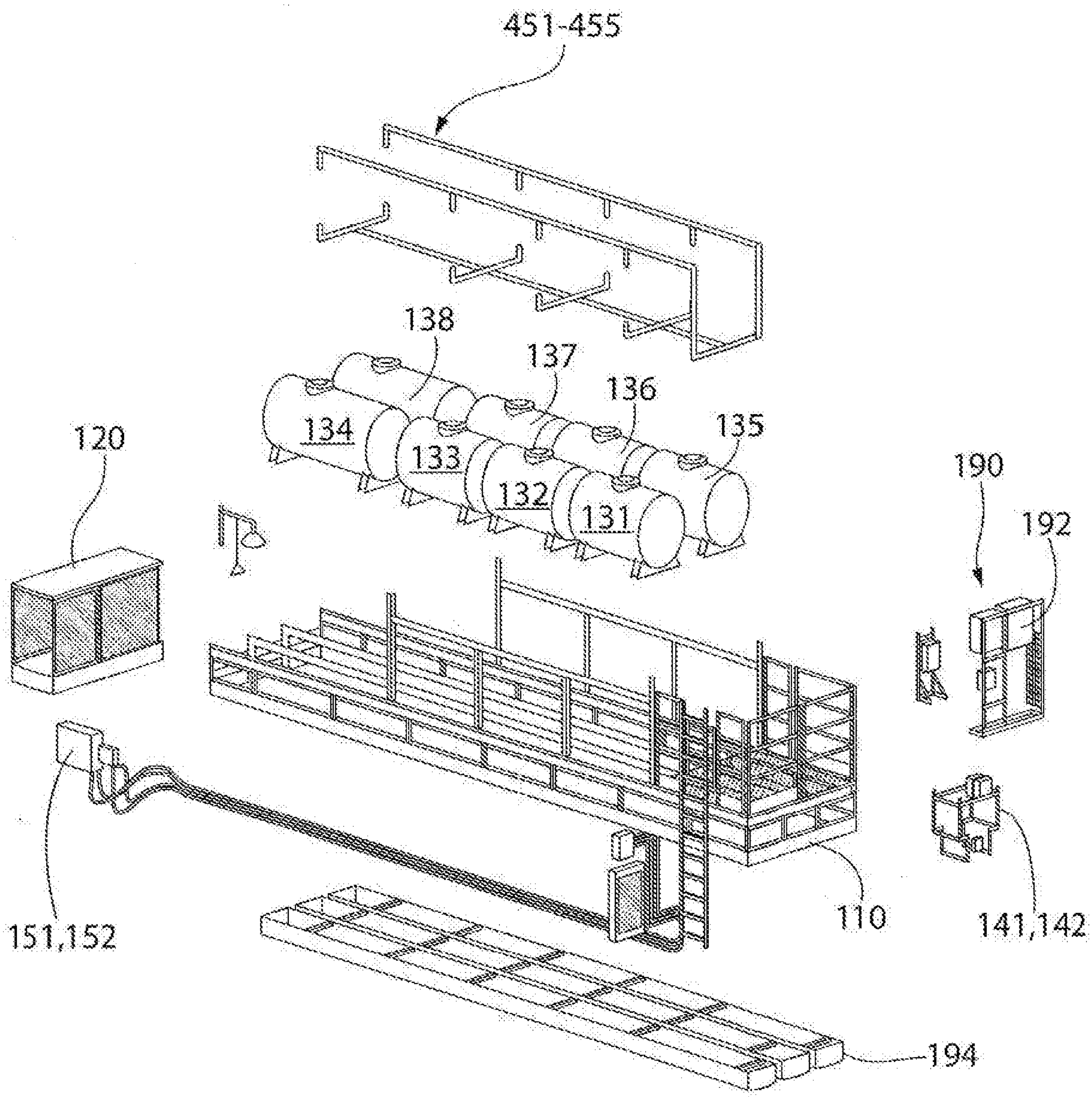
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FIG. 2

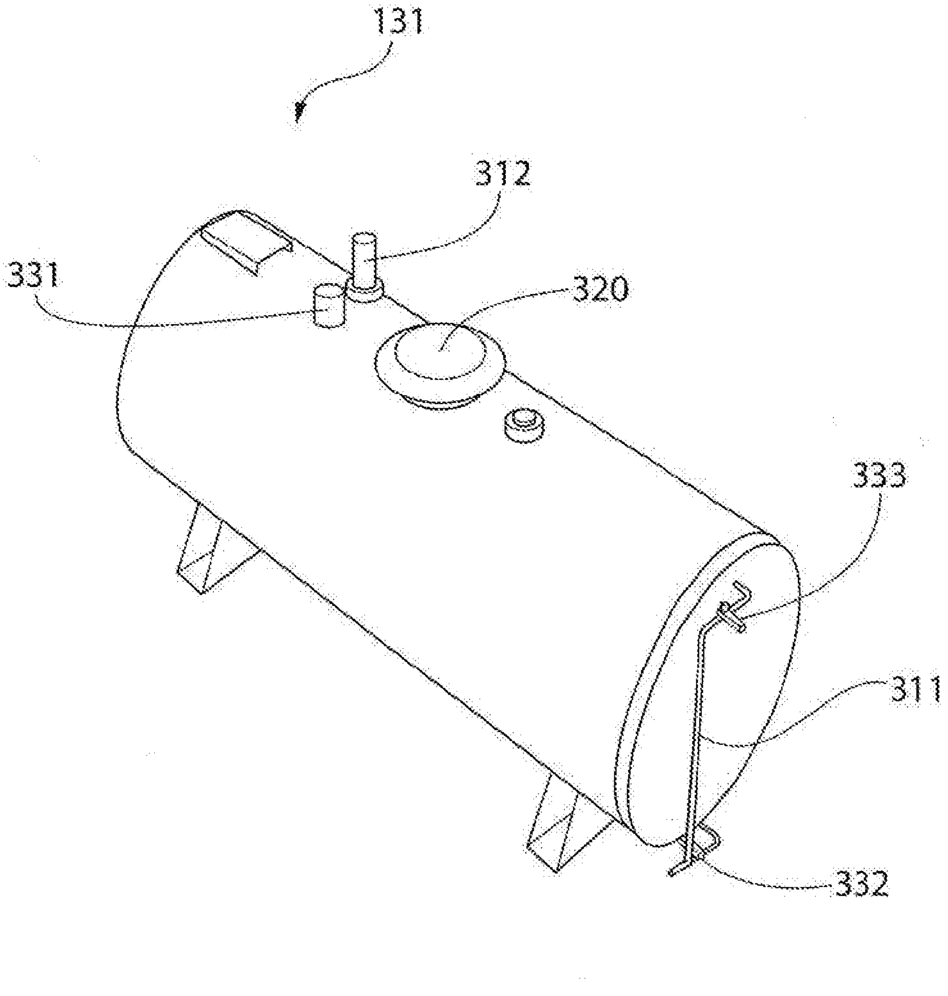

FIG. 3

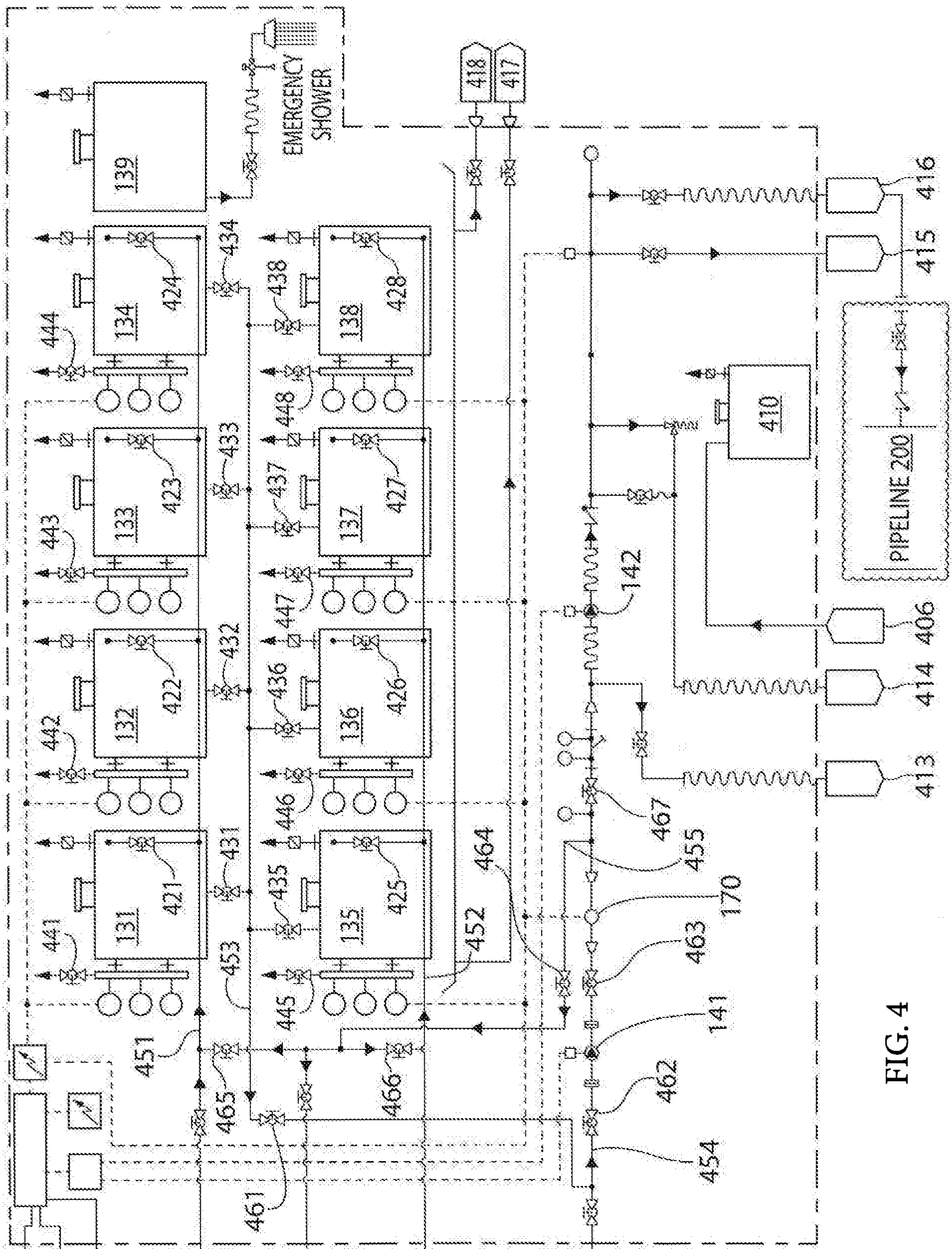
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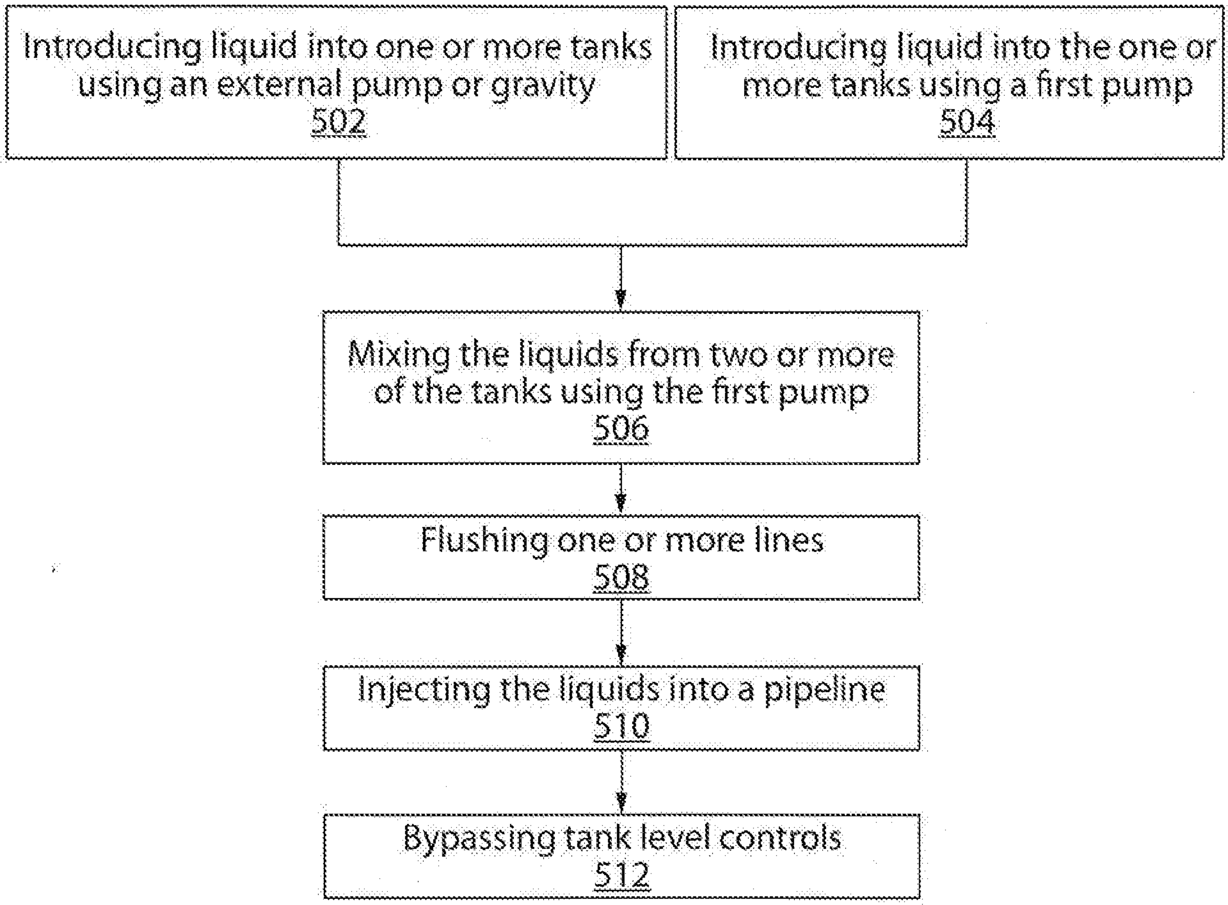
FIG. 4


Introducing liquid into one or more tanks using an external pump or gravity
502
Introducing liquid into the one or more tanks using a first pump
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Mixing the liquids from two or more of the tanks using the first pump
506
Flushing one or more lines
508
Injecting the liquids into a pipeline
510
Bypassing tank level controls
512

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/030328

A. CLASSIFICATION OF SUBJECT MATTER

F04D 13/12(2006.01)i, F04D 13/16(2006.01)i, F04D 13/04(2006.01)i, F04D 15/00(2006.01)i, F04D 15/02(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)
F04D 13/12; A01C 23/00; F02M 1/00; B28C 5/00; A01M 7/00; B01F 15/02; F04D 13/16; F04D 13/04; F04D 15/00; F04D 15/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: injection unit, first pump, second pump, tank, pipeline, return line

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4886367 A (BRAGG et al.) 12 December 1989 See column 1, lines 6-11, column 5, line 35 - column 8, line 58; claims 5-15; and figures 1-4.	1-20
Y	US 2004-0123842 A1 (DANDAN et al.) 01 July 2004 See paragraphs [0016]-[0034]; claim 1; and figure 4.	1-20
A	US 2001-0000996 A1 (GRIMLAND et al.) 10 May 2001 See paragraphs [0022]-[0033]; and figures 6-7.	1-20
A	WO 89-10050 A1 (SAMUELSSON, BENGT) 02 November 1989 See page 3, line 9 - page 6, line 36; and figures 1-3.	1-20
A	US 4769221 A (MARIHART, JOHN R.) 06 September 1988 See column 2, line 56 - column 3, line 61; and figure 1.	1-20

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

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"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
25 July 2017 (25.07.2017)	**25 July 2017 (25.07.2017)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/030328

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WO 89-10050 A1	02/11/1989	AU 3420989 A	24/11/1989
		SE 460395 B	09/10/1989
		SE 460395 C	08/02/1990
US 4769221 A	06/09/1988	None	