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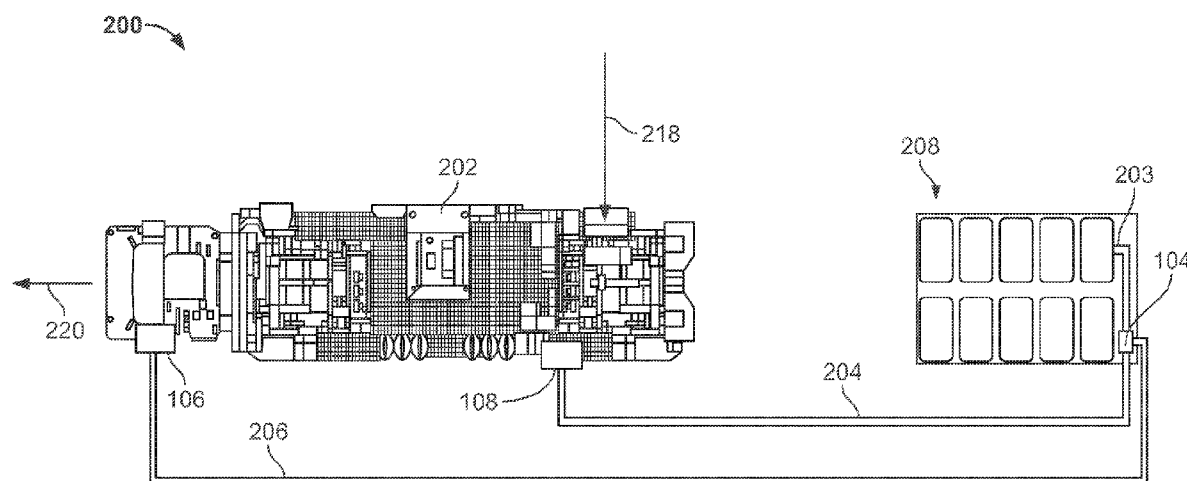


FIG. 2

(57) Abstract: An apparatus includes a primer pump having a pneumatic power inlet, a fluid inlet coupled to receive a fluid from a fluid source and a fluid outlet to output the fluid in response to a pressure at the fluid outlet being less than a pressure at the pneumatic power inlet. The apparatus includes a liquid additive pump having a fluid inlet coupled to the fluid outlet of the primer pump to receive the fluid, wherein the primer pump is to apply a positive pressure at the fluid inlet of the liquid additive pump.

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## DUAL PUMP CONFIGURATION FOR FLUID TRANSFER AND METERING

### BACKGROUND

[0001] The disclosure generally relates to the field of fluid transfer, and more particularly to a dual pump configuration for fluid transfer and metering.

[0002] Metered pump configurations include one or more pumps to provide for fluid transfer and metering of fluid flow volume. Precise metering of the fluid can be needed in certain applications. For example, fluid being transferred through a pump can be a chemical fluid that serves as one of the inputs into a system that produces a fracturing fluid used for hydraulic fracturing to stimulate production of oil and gas wells. The composition of these fracturing fluids needs to include precise amounts of the various inputs (e.g., chemicals, proppants, etc.) in order to be effective during downhole fracturing operations.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0003] Embodiments of the disclosure may be better understood by referencing the accompanying drawings.

[0004] FIG. 1 depicts a schematic diagram of a system that includes a dual pump configuration, according to some embodiments.

[0005] FIG. 2 depicts a schematic diagram of a system application that includes a dual pump configuration, according to some embodiments.

[0006] FIG. 3 depicts a flowchart of operations for creating and operating a dual pump configuration, according to some embodiments.

[0007] FIG. 4 depicts a flowchart of operations to validate operations of the liquid additive pump of the dual pump configuration, according to some embodiments.

[0008] FIG. 5 depicts a schematic diagram of a wellbore and a surface wellbore fluid treatment system, according to some embodiments.

[0009] FIG. 6 depicts an example computer device, according to some embodiments.

### DESCRIPTION

[0010] The description that follows includes example systems, methods, techniques, and program flows that embody aspects of the disclosure. However, it is understood that this disclosure may be practiced without these specific details. For instance, this disclosure refers to a system application to stimulate oil and gas production. But aspects of this disclosure can be also applied to various other types of applications that include a dual pump configuration for fluid transfer and metering. In other instances, well-known structures and techniques have not been shown in detail in order not to obfuscate the description.

[0011] Some embodiments include a dual pump configuration for fluid transfer and metering. The dual pump configuration can include a liquid additive pump for introducing liquids into a fluid

flow and a primer pump that charges or primes the liquid additive pump. The primer pump can be near the fluid source that includes the fluid to be transferred to the liquid additive pump. Thus, the primer pump can serve as a transfer pump for fluid transfer to the liquid additive pump. Because of the transfer pump, the distance of the liquid additive pump can thus be farther from the fluid source.

5 [0012] The liquid additive pump can be various types of a positive displacement pump. The primer pump can also provide positive pressure at the inlet of the liquid additive pump. In some applications, the liquid additive pump can introduce a chemical liquid into a blender that combines various liquids, proppants (e.g., sand), etc. to create a fracking fluid to be used for hydraulic fracturing to simulate production of existing oil and gas wells.

10 [0013] Such a dual pump configuration ensures that the liquid additive pump is primed and metering accurately even in systems in which the fluid source is a large distance from the liquid additive pump. The primer pump can be different types of pumps that charges or primes the liquid additive metering pump. Examples of the primer pump can include an Air-Operated Double Diaphragm (AODD) pump, centrifugal pump, etc.

15 [0014] FIG. 1 depicts a schematic diagram of a system that includes a dual pump configuration, according to some embodiments. FIG. 1 depicts a system 100 that includes a dual pump configuration comprised of a pneumatically powered primer pump 104 (hereinafter referenced as the primer pump 104) and a liquid additive pump 108. The system also includes a fluid source 102, a compressed air source 106, a flowmeter 110, and a computer device 120. An outlet of the fluid source 20 102 is connected to a fluid inlet of the primer pump 104. A fluid outlet of the primer pump 104 is connected to a fluid inlet of the liquid additive pump 108. A fluid outlet of the liquid additive pump 108 is connected to a fluid inlet of the flowmeter 110. A fluid outlet of the flowmeter 110 outputs the fluid. Output of the fluid from the flowmeter 110 can be used for various applications. For example, the fluid output from the flowmeter 110 can be received by an inlet of a blender that is to output a 25 hydraulic fracturing fluid. In another example, the fluid output from the flowmeter 110 can be input into another pump (e.g., centrifugal pump) for further fluid transfer. While depicted such that the flowmeter 110 is connected to the fluid outlet of the liquid additive pump 108, in some embodiments, the flowmeter can be connected at any point after the fluid is output from the fluid outlet of the primer pump 104. For example, the flowmeter 110 can be connected between the fluid outlet of the primer 30 pump 104 and the fluid inlet of the liquid additive pump 108.

[0015] A power inlet of the primer pump 104 is connected to the compressed air source 106. The primer pump 104 can be other types of pneumatically powered pumps. For example, the primer pump 104 can be pneumatically powered piston-driven pump. In some other embodiments, the primer pump 104 can be powered by hydraulics, electricity, etc. For example, the primer pump 104 35 can be a centrifugal pump.

[0016] The primer pump 104 can include a cycle counter 114 that is communicatively coupled to the computer device 120. The flowmeter 110 is also communicatively coupled to the computer

device 120. The computer device 120 can be local or remote to the primer pump 104 and the flowmeter 110. For example, the computer device 120 can be remote such that the computer device 120 is communicatively coupled to the cycle counter 114 and the flowmeter 110 via one or more networks. An example of the computer device 120 is depicted in FIG. 6, which is further described below.

[0017] In some embodiments, the primer pump 104 is an AODD pump. In some applications, the fluid source 102 is a chemical tank having a chemical fluid for the hydraulic fracturing. The chemical tank can also be a large distance (e.g., 100 feet, 200, feet, 500 feet, etc.) from the location where the chemical fluid is metered and subsequently input into a blender for producing the hydraulic fracturing fluid. In operation, the primer pump 104 is pneumatically powered using the compressed air from the compressed air source 106. The primer pump 104 can be configured to boost the flow of liquid from the fluid source 102 at a pressure that is essentially equal to the amount of air pressure input from the compressed air source 106 used to pneumatically power the primer pump 104. As shown, a fluid flow 122 is output from the primer pump 104 to an inlet of the liquid additive pump 108. This fluid flow 122 from an outlet of the primer pump 104 to an inlet of the liquid additive pump 108 results in a positive pressure to be applied at the inlet of the liquid additive pump 108. This positive pressure applied at the inlet of the liquid additive pump 108 causes the liquid additive pump 108 to be primed for operation. In some embodiments, the positive pressure can be a pressure that is greater than a net positive suction head (NPSH) required. In some embodiments, NPSH required refers to the amount of pressure the pump needs to see to pump fluid without cavitation. If NPSH required is too low, the pump will not move fluid. The purpose of the charged fluid is to raise the NPSH available at the inlet of the pump.

[0018] The liquid additive pump 108 can then be electrically or hydraulically powered on from an electrical power source not shown in FIG. 1. The liquid additive pump 108 can be any type of positive displacement pump. The liquid additive pump 108 can be configured to hold backpressure from the fluid received from the primer pump 104 without leaking.

[0019] In operation, the primer pump 104 can output a set amount of volume during each pump cycle. The cycle counter 114 of the primer pump 104 can track the number of pump cycles of the primer pump 104. For example, the cycle counter 114 can be incremented each time a pump cycle is performed by the primer pump 104 to output fluid from its outlet. The liquid additive pump 108 can be coupled to electrical controls (not shown) to control operations (e.g., start, stop, etc.) of the liquid additive pump 108. Once started, the liquid additive pump 108 pumps the liquid received from the primer pump 104 out to the flowmeter 110. The flowmeter 110 can be a magnetic flowmeter, a Coriolis flowmeter, etc. The flowmeter 110 can monitor the volume flow of the liquid as the liquid flows through the flowmeter 110.

[0020] The primer pump 104 can be self-regulated. For example, if the liquid additive pump 108 stalls or is not operational, the conduit between the primer pump 104 and the liquid additive pump

108 primes up to the pressure used to power the primer pump 104. In turn, the primer pump 104 stalls until the liquid additive pump 108 resumes operation. In particular, if the pressure at the fluid outlet of the primer pump 104 is less than the pressure at the pneumatic power inlet, fluid flows from the fluid outlet. However, once the fluid outlet pressure reaches the pneumatic power inlet pressure at the  
5 primer pump 104, the primer pump 104 stalls. Because the primer pump 104 can be self-regulated, no controls are needed to operate the primer pump 104. Accordingly, as configured, operation of the primer pump 104 precludes dry operation of the liquid additive pump 108.

[0021] FIG. 1 is annotated with a series of letters A-C. These letters represent operational stages. Although these stages are ordered for this example, the stages illustrate one example to aid in  
10 understanding this disclosure and should not be used to limit the claims. Subject matter falling within the scope of the claims can vary with respect to the order and some of the operations.

[0022] At stage A, the computer device 120 receives a total liquid volume for a defined time period from the flowmeter 110. For example, the computer device 120 can query the flowmeter 110 for the total liquid volume that the flowmeter 110 measured for a given time period (e.g., one second,  
15 two seconds, 10 seconds, 30 seconds, one minute, etc.). For instance, the computer device 120 can query the flowmeter 110 on a periodic basis.

[0023] At stage B, the computer device 120 receives a total number of pump cycles for the same defined time period from the cycle counter 114. The computer device 120 can also query the cycle counter 114 for the total number of pump cycles of the primer pump 104 for the given time period.  
20 The computer device 120 can also query the flowmeter 110 on a periodic basis. The computer device 120 determines or retrieves a liquid volume per pump cycle for the primer pump 104. For example, the computer device 120 can retrieve a liquid volume per pump cycle for this particular primer pump from a database stored on a local or remote machine-readable medium. For instance, the computer device 120 can retrieve a liquid volume per pump cycle from a database based on the manufacturer and model number for the primer pump 104. In some embodiments, the computer device 120 can receive the liquid volume per pump cycle for the primer pump via user input (e.g., input from field  
25 personnel).

[0024] At stage C, the computer device 120 validates volume output from the liquid additive pump 108. The computer device 120 can determine the total volume being pumped by the primer  
30 pump 104 for a defined time period by multiplying the liquid volume per pump cycle for the primer pump 104 by the number total number of pump cycles tracked by the cycle counter 114 for that defined time period. The computer device 120 can then compare this total volume being pumped by the primer pump 104 for a defined time period (total volume A) to the total volume measured by the flowmeter 110 during the same defined time period (total volume B). If the difference between total  
35 volume B and total volume A is less than a fluid differential threshold, the computer device 120 validates that the volume output from the liquid additive pump 108 is in an acceptable range. Thus, the liquid additive pump 108 is considered to be properly calibrated and functional.

[0025] If the difference between total volume B and total volume A is greater than a fluid differential threshold, the computer device 120 invalidates the volume output from the liquid additive pump 108. The fluid differential threshold can vary depending on one or more of the type of fluid, the type of the primer pump 104, the type of the liquid additive pump 108, the amount of air pressure to power the primer pump 104, length of the conduit from the fluid source 102 and the primer pump 104, length of the conduit from the primer pump 104 to the liquid additive pump 108, etc.

[0026] In response to the volume output from the liquid additive pump 108 not being validated, the computer device 120 can perform any of a number of operations. For instance, the computer device 120 can transmit a notification of the potential issue to field personnel and/or personnel not on site. The computer device 120 can activate an alarm (visual, audio, etc.). In some embodiments, the volume flow can be adjusted to attempt to resolve this issue. For example, the amount of volume per unit of time being pumped by the liquid additive pump 108 can be adjusted (e.g., reduce or increase). In some situations, the notification or alarm can stall the operations of the pumps. Field personnel can also attempt to resolve by changing either or both of the primer pump 104 and the liquid additive pump 108. Additionally, field personnel can attempt to resolve the issue by stopping the pump operations and cleaning the conduits (as further described below).

[0027] The dual pump configuration of FIG. 1 can also include another point of validation of the liquid additive pump 108. For example, the liquid additive pump 108 can include a tachometer to measure the number of revolutions of the motor of the liquid additive pump for the given time period. Also, the amount of volume pumped for a liquid additive pump for a given revolution can be known based on the type (manufacturer, model, etc.) of the pump. The computer device 102 can be communicatively coupled to the tachometer of the liquid additive pump 108. Accordingly, the computer device 120 can validate the total volume for the given time period by multiplying the number of revolutions by the amount of volume pumped for a given revolution for the given time period. The total volume derived from the measurement by the tachometer can be defined as total volume C. The total volume C then be compared to the total volume A and the total volume B (see above) for validation of proper operations. For example, if two of the three total volumes fall within a threshold and the third falls outside the threshold, the device associated with the third total volume that falls outside the threshold is defined to be faulty. For example, assume total volume A (associated with the primer pump 104) and total volume C (associated with the tachometer of the liquid additive pump 108) fall within a threshold and that total volume B (associated with the flowmeter 110) falls outside the threshold. In this example, the flowmeter 110 is defined as faulty.

[0028] In some embodiments, the system 100 does not include the flowmeter 110. Accordingly, total volume C (associated with the tachometer of the liquid additive pump 108) can be compared with total volume A (associated with the primer pump 104), if the difference between total volume C and total volume A is less than a fluid differential threshold, the computer device 120 validates that

the volume output from the liquid additive pump 108 is in an acceptable range. Thus, the liquid additive pump 108 is considered to be properly calibrated and functional.

[0029] Operations depicted as being performed by the computer device 120 can be performed by hardware, software, firmware, or a combination thereof. For example, these operations can be performed by a processor(s) executing instructions stored in machine-readable media in the computer device 120.

[0030] At least some of the operations depicted in the stages A-C can be performed at least partially in parallel and/or in a different order. For example, operations at stage A can be performed at least partially in parallel with operations at stage B. Also, operations at stage B can be performed prior to operations at stage A.

[0031] If the primer pump 104 is an AODD pump, the primer pump 104 can operate dry without damage. Therefore, after the pumping operations are complete and as part of the cleaning operation, operation of the primer pump 104 can be reversed to pump remaining unused fluid back to the fluid source 102. This can include the fluid in the conduit from the primer pump 104 to the liquid additive pump 108, the chemical fluid in the AODD pump, and the fluid in the conduit from the primer pump 104 back to the fluid source 102. This reverse operation of the primer pump 104 allows unused fluids in the conduits and the primer pump 104 to not be wasted. Also, the reverse operation of the primer pump 104 reduces the likelihood that these fluids are spilled. Such cleaning operations can be particularly useful in applications where the fluids can be toxic. Also, these cleaning operations reduce the likelihood of environmental impact or unnecessary exposure to personnel in applications where the fluids are toxic.

[0032] In some embodiments, electrical control is provided to the liquid additive pump 108. However, as described above, the primer pump 104 can be self-regulated, thereby removing the need to have an electrical control for the primer pump 104. Thus, in some embodiments, the primer pump 104 is pneumatically powered (instead of being powered electrically or hydraulically). Additionally, because in some embodiments, the primer pump 104 needs to be only pneumatically powered, the primer pump 104 is not necessarily confined to a particular location. Rather, the primer pump 104 along with a compressed air source can be mobile and located where needed. For example, as described above, the primer pump 104 and the fluid source 102 can be remote from the wellsite for applications for hydraulic fracturing. Because the primer pump 104 can be pneumatically powered, there can be less environmental impact if there is an air leak. Also, because the liquid additive pump 108 is primed by the primer pump 104 and supplied with the fluid via a closed system, there can be reduced maintenance and downtime in comparison to configurations wherein the liquid additive pump can run dry if the liquid additive pump does not remain primed.

[0033] FIG. 2 depicts a schematic diagram of a system application that includes a dual pump configuration, according to some embodiments. FIG. 2 depicts a schematic diagram of at least part of a surface wellbore fluid treatment (SWFT) system 200 that includes a dual pump configuration. The

SWFT system 200 outputs a hydraulic fracturing fluid 220 to be input into a wellbore for downhole fracturing operations. An example wellbore application using the SWFT system 200 is depicted in FIG. 5, which is further described below.

[0034] The SWFT system 200 includes the dual pump configuration as depicted in FIG. 1, which comprises the primer pump 104 and the liquid additive pump 108. In this example, the liquid additive pump 108 and the compressed air source 106 are part of a blender 202. Also in this example, chemical totes 208 are the fluid source that is to supply a chemical fluid for pumping by the dual pump configuration.

[0035] Output from the chemical totes 208 is connected to the fluid inlet of the primer pump 104 via a chemical hose 203. The fluid outlet of the primer pump 104 is connected to the fluid inlet of the liquid additive pump 108 via a chemical hose 204. The power inlet of the primer pump 104 is connected to the compressed air source 106 via an air hose 206. Although not shown, the blender 202 can include the flowmeter 110 that is to receive the chemical fluid prior to the chemical fluid being input into the blender 202. Additionally, the primer pump 104 can include the cycle counter 114, and the computer device 120 can be communicatively coupled to the flowmeter 110 and the cycle counter 114 (as depicted in FIG. 1).

[0036] Fluid flow operations of the SWFT system 200 are similar to the fluid flow operations described above in reference to FIG. 1. The chemical fluid flows from the chemical totes 208 to the primer pump 104 via the chemical hose 203. After being pneumatically powered from the air supplied from the compressed air source 106 via the air hose 206, the primer pump 104 pumps the chemical fluid to the liquid additive pump 108 via the chemical hose 204. In response, the chemical hose 204 primes up to the pressure used to power the primer pump 104. In turn, the primer pump 104 stalls until the liquid additive pump 108 is in operation. In particular, the primer pump 104 can stall until a difference between a pressure at the outlet of the primer pump 104 and the pressure at the inlet of the primer pump 104 exceeds a pressure differential threshold. Once started, the liquid additive pump 108 pumps the chemical liquid received from the primer pump 104 out from its outlet. The chemical fluid output from the liquid additive pump 108 can flow through a flowmeter (as described above in reference to FIG. 1) prior to being input into an inlet of the blender 202.

[0037] The blender 202 receives the chemical fluid from the liquid additive pump 108 and proppants 218. The blender 202 blends the chemical fluid with the proppants 218 to form the hydraulic fracturing fluid 220. The blender 202 outputs the hydraulic fracturing fluid 220. In some embodiments, the blender 202 can be two blending units connected in series. The first blending unit can add a gelling agent to the chemical fluid received from the liquid additive pump 108. The second blending unit can then add a proppant to this combination of the gelling agent and the chemical fluid.

[0038] In some instances, the SWFT system 200 is used at a wellsite where there is limited space around the wellhead. The blender 202 can be closely positioned near the wellhead, while the chemical totes 208 can be remote from the wellhead. The primer pump 104 can be added proximate

to the chemical totes 208. Thus, a length of the chemical hose 204 can be longer than a length of the chemical hose 203. For example, a ratio of a length of the chemical hose 204 to a length of the chemical hose 203 can be 20:1, 25:1, 30:1, 40:1, etc. For instance, a length of the chemical hose 204 can be 100 feet, while a length of the chemical hose 203 can be much shorter (e.g., five feet).

5 [0039] FIG. 3 depicts a flowchart of operations for creating and operating a dual pump configuration, according to some embodiments. Operations of a flowchart 300 are described in reference to the system 100 of FIG. 1. The operations of the flowchart 300 start at block 302.

[0040] At block 302, a fluid inlet of a primer pump is connected to a fluid outlet of a fluid source via a fluid conduit. For example, with reference to the system 100 of FIG. 1, a fluid outlet of the fluid  
10 source is connected to a fluid inlet of the primer pump 104.

[0041] At block 304, a pneumatic power inlet of the primer pump is connected to a pneumatic power source. For example, with reference to the system 100 of FIG. 1, the pneumatic power inlet of the primer pump 104 is connected to the compressed air source 106.

[0042] At block 306, a fluid outlet of the primer pump is connected to a fluid inlet of a liquid  
15 additive pump. For example, with reference to the system 100 of FIG. 1, the fluid outlet of the primer pump 104 is connected to the fluid inlet of the liquid additive pump 108.

[0043] At block 308, a fluid outlet of the liquid additive pump is connected to a fluid inlet of a flowmeter. For example, with reference to the system 100 of FIG. 1, the fluid outlet of the liquid additive pump 108 is connected to the fluid inlet of the flowmeter 110.

20 [0044] At block 310, a power inlet of the liquid additive pump is connected to a power source. For example, with reference to the system 100 of FIG. 1, the power inlet of the liquid additive pump 108 can be connected to an electrical power source.

[0045] At block 312, output of compressed air from the pneumatic power source to power the  
25 primer pump is initiated. For example, with reference to the system 100 of FIG. 1, the compressed air source 106 can be powered on to initiate output of compressed air to the primer pump 104. In turn, the fluid flow 122 from the fluid source 102 can be initiated by pump operations by the primer pump 104.

[0046] At block 314, power is supplied from the power source to the liquid additive pump. For  
30 example, with reference to the system 100 of FIG. 1, a power button on the liquid additive pump 108 can be pressed or selected to power on the liquid additive pump 108. Operations at block 312 and 314 are at least some of the operations to initiate fluid flow through the dual pump configuration. Other operations can include supplying power to the flowmeter 110 and the cycle counter 114. If the dual pump configuration is part of a hydraulic fracturing operation, other operations can include supplying power to the blender, supplying power to other pumps or devices used to supply various proppants to  
35 the blender, etc. Also, if volume output from the liquid additive pump is being validated, operations can also include communicatively coupling the flowmeter 110 and the cycle counter 114 to computer

device 120. Additionally, operations for validating the volume output from the liquid additive pump 108 by the computer device 120 are depicted in FIG. 4 (described below).

[0047] At block 316, a determination is made of whether pumping operations are complete. For example, with reference to the system 100 of FIG. 1, pumping operations can be complete after there is no fluid remaining in the fluid source 102 to pump. In another example, pumping operations can be complete after a defined time period. For hydraulic fracturing operations, pumping operations are complete after personnel shut down output of hydraulic fracturing fluid being output from the blender. If pumping operations are not complete, operations of the flowchart 300 remain at block 316 to again determine if pumping operations are complete. If pumping operations are complete, operations of the flowchart 300 continue at block 318.

[0048] At block 318, the primer pump is reversed to return fluid back to the fluid source that is remaining in the fluid conduit between the liquid additive pump and the primer pump and the conduit between the primer pump and the fluid source. For example, with reference to the system 100 of FIG. 1, the primer pump 104 can reverse its pump operations to pump the fluid back to the fluid source 102. This can include the fluid remaining in the conduit between the liquid additive pump 108 and the primer pump 104, fluid remaining in the primer pump 104, and fluid remaining in the conduit between the primer pump 104 and the fluid source 102. Operations of the flowchart 300 are then complete.

[0049] Operations for validating volume output of the liquid additive pump during the pumping operations are now described in reference to FIG. 4. These operations for validating can be performed at least partially in parallel with some of the operations depicted in FIG. 3. For example, these operations for validating can be performed at any point after operations at block 312 but prior to pumping operations being complete after block 316.

[0050] FIG. 4 depicts a flowchart of operations to validate operations of the liquid additive pump of the dual pump configuration, according to some embodiments. A flowchart 400 is described with reference to the system 100 of FIG. 1. Operations of the flowchart 400 can be performed by software, firmware, hardware or a combination thereof. Operations of the flowchart 400 can be performed periodically or at any point during operation of the dual pump configuration. For example, operations of the flowchart 400 can be performed during a hydraulic fracturing operation, as depicted in FIG. 5, which is further described below. Operations of the flowchart 400 start at block 402.

[0051] At block 402, a total volume output for a defined time period is received from a flowmeter that is connected to a fluid outlet of a liquid additive pump. For example, with reference to FIG. 1, the computer device 120 receives a total liquid volume for a defined time period from the flowmeter 110. For example, the computer device 120 can query the flowmeter 110 for the total liquid volume that the flowmeter 110 measured for a given time period (e.g., one second, two seconds, 10 seconds, 30 seconds, one minute, etc.). Alternatively, the flowrate can be transmitted to

the computer device 120 in real time. The computer device 120 can then determine a total flow volume.

[0052] At block 404, a total number of pump cycles for the defined time period is received from a cycle counter that is counting the number of pump cycles of a primer pump. For example, with  
5 reference to FIG. 1, the computer device 120 receives a total number of pump cycles for the defined time period from the cycle counter 114. The computer device 120 can also query the cycle counter 114 for the total number of pump cycles of the primer pump 104 for the given time period. Alternatively, a pulse generator on the primer pump 104, wherein each pulse corresponds to a pump cycle. The pulses can then be transmitted in real time to the computer device 120. The computer  
10 device 120 can then determine the total number of pump cycles. Also, while described in reference to monitoring a full pump cycle, in some embodiments, the primer pump 104 can be monitored at a finer resolution. For example, the cycle counter 114 can monitor each half pump cycle, each quarter pump cycle, etc.

[0053] At block 406, an amount of liquid volume per pump cycle for the primer pump is  
15 determined. For example, with reference to FIG. 1, the computer device 120 determines or retrieves an amount of liquid volume per pump cycle for the primer pump 104. For instance, the computer device 120 can retrieve a liquid volume per pump cycle for this particular primer pump from a database stored on a local or remote machine-readable medium. The computer device 120 can retrieve a liquid volume per pump cycle from a database based on the manufacturer and model  
20 number for the primer pump 104. In some embodiments, the computer device 120 can receive an amount of liquid volume per pump cycle for the primer pump 104 via user input (e.g., input from field personnel).

[0054] At block 408, a total volume output for the defined time period from the fluid outlet of the primer pump is determined. For example, with reference to FIG. 1, the computer device 120 can  
25 determine the total volume being pumped by the primer pump 104 for the defined time period by multiplying the liquid volume per pump cycle for the primer pump 104 by the number total number of pump cycles tracked by the cycle counter 114 for that defined time period.

[0055] At block 410, a determination is made of whether the liquid additive pump is operating correctly. For example, with reference to FIG. 1, the computer device 120 can make this  
30 determination based on whether volume output from the liquid additive pump 108 is correct. The computer device 120 can compare the total volume being pumped by the primer pump 104 for the defined time period (total volume A) to the total volume measured by the flowmeter 110 during the same defined time period (total volume B). If the difference between total volume B and total volume A is less than a fluid differential threshold, the computer device 120 determines that the liquid  
35 additive pump 108 is operating correctly. Operations of the flowchart 400 are complete in this situation. However, if the difference between total volume B and total volume A is greater than a

fluid differential threshold, the computer device 120 determines that the liquid additive pump 108 is operating incorrectly. Operations of the flowchart 400 continue at block 412 in this situation.

[0056] At block 412, action(s) to correct operation of the liquid additive pump is initiated. One or more actions can be performed. For example, with reference to FIG. 1, the computer device 120 can transmit a notification of the potential issue to field personnel and/or personnel not on site. The computer device 120 can activate an alarm (visual, audio, etc.). In some embodiments, the volume flow can be adjusted to attempt to resolve this issue. For example, the amount of volume per unit of time being pumped by the liquid additive pump 108 can be adjusted (e.g., reduce or increase). In some situations, the notification or alarm can stall the operations of the pumps. Field personnel can also attempt to resolve by changing either or both of the primer pump 104 and the liquid additive pump 108. Additionally, field personnel can attempt to resolve the issue by stopping the pump operations and cleaning the conduits/hoses in the dual pump configuration. Operations of the flowchart 400 return back to block 402.

[0057] FIG. 5 depicts a schematic diagram of a wellbore and a surface wellbore fluid treatment system, according to some embodiments. FIG. 5 depicts an operating environment that comprises a wellsite 500 that includes a wellbore 515 penetrating a subterranean formation 525 for the purpose of recovering hydrocarbons, storing hydrocarbons, disposing of carbon dioxide, injecting wellbore servicing fluids, or the like. FIG. 5 also depicts a surface wellbore fluid treatment (SWFT) system 510, a wellbore servicing apparatus 540 (e.g., a downhole tool or apparatus), or a combination thereof may be deployed.

[0058] The SWFT system 510 for the treatment of a wellbore servicing fluid (WSF) and/or a component thereof (e.g., water) is deployed at the wellsite 500 and is fluidly coupled to the wellbore 515 via a wellhead 560. The wellbore 515 may be drilled into the subterranean formation 525 using any suitable drilling technique. In some embodiments, a drilling or servicing rig 530 may generally comprise a derrick with a rig floor through which a tubular string 535 (e.g., a drill string; a work string, such as a segmented tubing, coiled tubing, jointed pipe, or the like; a casing string; or combinations thereof) may be lowered into the wellbore 515. A wellbore servicing apparatus 540 configured for one or more wellbore servicing operations (e.g., a cementing or completion operation, a clean-out operation, a perforating operation, a fracturing operation, production of hydrocarbons, etc.) may be integrated within the tubular string 535 for the purpose of performing one or more wellbore servicing operations. Additional downhole tools may be included with and/or integrated within the wellbore servicing apparatus 540 and/or the tubular string 535, for example, one or more isolation devices 545 (for example, a packer, such as a swellable or mechanical packer) may be positioned within the wellbore 515 for the purpose of isolating a portion of the wellbore 515.

[0059] The drilling or servicing rig may be conventional and may comprise a motor driven winch and other associated equipment for lowering the tubular string 535 and/or wellbore servicing apparatus 540 into the wellbore 515. Alternatively, a mobile workover rig, a wellbore servicing unit

(e.g., coiled tubing units), or the like may be used to lower the tubular string 535 and/or wellbore servicing apparatus 540 into the wellbore 515 for the purpose of performing a wellbore servicing operation.

[0060] The wellbore 515 may extend substantially vertically away from the earth's surface 550 over a vertical wellbore portion, or may deviate at any angle from the earth's surface 550 over a deviated or horizontal wellbore portion. Alternatively, portions or substantially all of the wellbore 515 may be vertical, deviated, horizontal, and/or curved. In some instances, a portion of the tubular string 535 may be secured into position within the wellbore 515 in a conventional manner using cement 555. Alternatively, the tubular string 535 may be partially cemented in wellbore 515. Alternatively, the tubular string 535 may be uncemented in the wellbore 515. The tubular string 535 can include two or more concentrically positioned strings of pipe (e.g., a first pipe string such as jointed pipe or coiled tubing may be positioned within a second pipe string such as casing cemented within the wellbore). It is noted that although FIG. 5 may exemplify a given operating environment, the principles of the devices, systems, and methods disclosed may be similarly applicable in other operational environments, such as offshore and/or subsea wellbore applications.

[0061] The SWFT system 510 can be coupled to the wellhead 560 via a conduit 565, and the wellhead 560 may be connected to (e.g., fluidly) the tubular string 535. In various embodiments, the tubular string 535 may comprise a casing string, a liner, a production tubing, coiled tubing, a drilling string, the like, or combinations thereof. The tubular string 535 may extend from the earth's surface 550 downward within the wellbore 515 to a predetermined or desirable depth, for example, such that the wellbore servicing apparatus 540 is positioned substantially proximate to a portion of the subterranean formation 525 to be serviced (e.g., into which a fracture 570 is to be introduced). Flow arrows 580 and 575 indicate a route of fluid communication from the SWFT system 510 to the wellhead 560 via conduit 565, from the wellhead 560 to the wellbore servicing apparatus 540 via tubular string 535, and from the wellbore servicing apparatus 540 into the wellbore 515 and/or into the subterranean formation 525 (e.g., into fractures 570). The wellbore servicing apparatus 540 may be configured to perform one or more servicing operations, for example, fracturing the formation 525, hydramjetting and/or perforating casing (when present) and/or the formation 525, expanding or extending a fluid path through or into the subterranean formation 525, producing hydrocarbons from the formation 525, or other servicing operation. In some embodiments, the wellbore servicing apparatus 540 may comprise one or more ports, apertures, nozzles, jets, windows, or combinations thereof suitable for the communication of fluid from a flowbore of the tubular string 535 and/or a flowbore of the wellbore servicing apparatus 540 to the subterranean formation 525. In some embodiments, the wellbore servicing apparatus 540 is actuatable (e.g., opened or closed), for example, comprising a housing comprising a plurality of housing ports and a sleeve being movable with respect to the housing, the plurality of housing ports being selectively obstructed or unobstructed by the sliding sleeve so as to provide a fluid flowpath to and/or from the wellbore servicing apparatus 540

into the wellbore 515, the subterranean formation 525, or combinations thereof. In some embodiments, the wellbore servicing apparatus 540 may be configurable for the performance of multiple wellbore servicing operations.

[0062] In some embodiments, the SWFT system 510 includes the dual pump configuration depicted in FIGS. 1-2 for providing a chemical fluid as input into a blender that is to output a fracturing fluid for hydraulic fracturing operations downhole via the conduit 565. For example, a WSF, such as a particle (e.g., proppant) laden fluid (e.g., a fracturing fluid), may be introduced, at a relatively high-pressure, into the wellbore 515. The particle laden fluids may then be introduced into a portion of the subterranean formation 525 at a rate and/or pressure sufficient to initiate, create, or extend one or more fractures 570 within the subterranean formation 525. Proppants (e.g., grains of sand, glass beads, shells, ceramic particles, etc.) may be mixed with the WSF, for example, so as to keep the fractures open (e.g., to "prop" the fractures) such that hydrocarbons may flow into the wellbore 515 so as to be produced from the subterranean formation 525. Hydraulic fracturing may create high-conductivity fluid communication between the wellbore 515 and the subterranean formation 525, for example, to enhance production of fluids (e.g., hydrocarbons) from the formation.

[0063] FIG. 6 depicts an example computer device, according to some embodiments. The computer device includes a processor 601 (possibly including multiple processors, multiple cores, multiple nodes, and/or implementing multi-threading, etc.). The computer device includes memory 607. The memory 607 may be system memory (e.g., one or more of cache, SRAM, DRAM, zero capacitor RAM, Twin Transistor RAM, eDRAM, EDO RAM, DDR RAM, EEPROM, NRAM, RRAM, SONOS, PRAM, etc.) or any one or more of the above already described possible realizations of machine-readable media.

[0064] The computer device also includes a persistent data storage 609. The persistent data storage 609 can be a hard disk drive, such as magnetic storage device. The computer device also includes a bus 603 (e.g., PCI, ISA, PCI-Express, HyperTransport® bus, InfiniBand® bus, NuBus, etc.) and a network interface 605 (e.g., a Fiber Channel interface, an Ethernet interface, an internet small computer system interface, SONET interface, wireless interface, etc.).

[0065] The computer device also includes a validator 611. The validator 611 can perform validation of operations of the liquid additive pump, as described above. Any one of the previously described functionalities may be partially (or entirely) implemented in hardware and/or on the processor 601. For example, the functionality may be implemented with an application specific integrated circuit, in logic implemented in the processor 601, in a co-processor on a peripheral device or card, etc. Further, realizations may include fewer or additional components not illustrated in FIG. 6 (e.g., video cards, audio cards, additional network interfaces, peripheral devices, etc.). The processor 601, the network interface 605, and the persistent data storage 609 are coupled to the bus 603. Although illustrated as being coupled to the bus 603, the memory 607 may be coupled to the processor 601.

[0066] The flowcharts are provided to aid in understanding the illustrations and are not to be used to limit scope of the claims. The flowcharts depict example operations that can vary within the scope of the claims. Additional operations may be performed; fewer operations may be performed; the operations may be performed in parallel; and the operations may be performed in a different order.

5 It will be understood that at least some of blocks of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by program code. The program code may be provided to a processor of a general purpose computer, special purpose computer, or other programmable machine or apparatus.

[0067] As will be appreciated, aspects of the disclosure may be embodied as a system, method or  
10 program code/instructions stored in one or more machine-readable media. Accordingly, aspects may take the form of hardware, software (including firmware, resident software, micro-code, etc.), or a combination of software and hardware aspects that may all generally be referred to herein as a "circuit," "module" or "system." The functionality presented as individual modules/units in the example illustrations can be organized differently in accordance with any one of platform (operating  
15 system and/or hardware), application ecosystem, interfaces, programmer preferences, programming language, administrator preferences, etc.

[0068] Any combination of one or more machine readable medium(s) may be utilized herein. For example, the computer device 120 of FIG 1 can use any combination of one or more machine  
20 readable medium(s) for storage of program code to validate operations of the liquid additive pump 108, storage of databases that include the amount of volume per pump cycle for different types of primer pumps, etc. The machine readable medium may be a machine readable signal medium or a machine readable storage medium. A machine readable storage medium may be, for example, but not limited to, a system, apparatus, or device, that employs any one of or combination of electronic, magnetic, optical, electromagnetic, infrared, or semiconductor technology to store program code.

25 More specific examples (a non-exhaustive list) of the machine readable storage medium would include the following: a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this document, a machine  
30 readable storage medium may be any tangible medium that can contain, or store a program for use by or in connection with an instruction execution system, apparatus, or device. A machine readable storage medium is not a machine readable signal medium.

[0069] A machine readable signal medium may include a propagated data signal with machine  
35 readable program code embodied therein, for example, in baseband or as part of a carrier wave. Such a propagated signal may take any of a variety of forms, including, but not limited to, electro-magnetic, optical, or any suitable combination thereof. A machine readable signal medium may be any machine readable medium that is not a machine readable storage medium and that can communicate,

propagate, or transport a program for use by or in connection with an instruction execution system, apparatus, or device.

[0070] Program code embodied on a machine readable medium may be transmitted using any appropriate medium, including but not limited to wireless, wireline, optical fiber cable, RF, etc., or any suitable combination of the foregoing. Computer program code for carrying out operations for aspects of the disclosure may be written in any combination of one or more programming languages, including an object oriented programming language such as the Java® programming language, C++ or the like; a dynamic programming language such as Python; a scripting language such as Perl programming language or PowerShell script language; and conventional procedural programming languages, such as the "C" programming language or similar programming languages. The program code may execute entirely on a stand-alone machine, may execute in a distributed manner across multiple machines, and may execute on one machine while providing results and or accepting input on another machine.

[0071] The program code/instructions may also be stored in a machine readable medium that can direct a machine to function in a particular manner, such that the instructions stored in the machine readable medium produce an article of manufacture including instructions which implement the function/act specified in the flowchart and/or block diagram block or blocks.

[0072] While the aspects of the disclosure are described with reference to various implementations and exploitations, it will be understood that these aspects are illustrative and that the scope of the claims is not limited to them. In general, techniques a dual pump configuration as described herein may be implemented with facilities consistent with any hardware system or hardware systems. Many variations, modifications, additions, and improvements are possible.

[0073] In some embodiments, an apparatus includes a primer pump having a pneumatic power inlet, a fluid inlet coupled to receive a fluid from a fluid source and a fluid outlet to output the fluid in response to a pressure at the fluid outlet being less than a pressure at the pneumatic power inlet. The apparatus can also include a liquid additive pump having a fluid inlet coupled to the fluid outlet of the primer pump to receive the fluid, wherein the primer pump is to apply a positive pressure at the fluid inlet of the liquid additive pump. The primer pump can be a pneumatically powered, dual diaphragm pump. The pneumatically powered, dual diaphragm pump can include a cycle counter that is to increment a counter value after at least one of each pump cycle and each half pump cycle. The pneumatically powered, dual diaphragm pump can output a pump cycle volume of the fluid through the fluid outlet for at least one of each pump cycle and each half pump cycle. A computer device can be communicatively coupled to the apparatus, wherein the computer device comprises a processor and a machine-readable medium having program code executable by the processor to cause the computer device to determine a volume output from the fluid outlet of the pneumatically powered, dual diaphragm pump during a defined time period based on the counter value and the pump cycle volume of the fluid in at least each pump cycle and each half pump cycle. The apparatus can further include a

flowmeter that is coupled to receive the fluid being output from the fluid outlet of the primer pump, wherein the flowmeter is to measure a volume output from the fluid outlet of the primer pump during the defined time period. Also, the program code comprises program code executable by the processor to cause the computer device to validate operation of at least one of the liquid additive pump and the flowmeter, in response to a difference between the volume output from the fluid outlet of the pneumatically powered, dual diaphragm pump and the volume output measured by the flowmeter during the defined time period being within a volume differential threshold.

[0074] The pneumatically powered, dual diaphragm pump can include includes a pulse generator to generate a pulse after each pump cycle, wherein the pneumatically powered, dual diaphragm pump is to output a pump cycle volume of the fluid through the fluid outlet for each pump cycle. A computer device can be communicatively coupled to the apparatus, wherein the computer device comprises a processor and a machine-readable medium having program code executable by the processor to cause the computer device to determine a volume output from the fluid outlet of the pneumatically powered, dual diaphragm pump based on a number of pulses generated and the pump cycle volume of the fluid in each pump cycle. The apparatus can further include a flowmeter that is coupled to receive the fluid being output from the fluid outlet of the primer pump, wherein the flowmeter is to measure a volume output from the fluid outlet of the primer pump. The program code can comprise program code executable by the processor to cause the computer device to validate operation of at least one of the liquid additive pump and the flowmeter, in response to a difference between the volume output from the fluid outlet of the pneumatically powered, dual diaphragm pump and the volume output measured by the flowmeter being within a volume differential threshold.

[0075] In some embodiments, a system includes a pneumatically powered pump having a pneumatic power inlet, a fluid inlet coupled to receive a chemical fluid from a chemical fluid source and a fluid outlet to output the chemical fluid in response to a pressure at the fluid outlet being less than a pressure at the pneumatic power inlet. The system can include a blender that comprises a liquid additive pump having a fluid inlet coupled to the fluid outlet of the pneumatically powered pump to receive the chemical fluid, wherein the pneumatically powered pump is to apply a positive pressure at the fluid inlet of the liquid additive pump. The blender can also include a plurality of inlets, wherein one of the plurality of inlets is coupled to a fluid outlet of the liquid additive pump to receive the chemical fluid. The blender can also include an outlet to output a hydraulic fracturing fluid via a conduit for a downhole hydraulic fracturing operation. The pneumatically powered pump can be a pneumatically powered, dual diaphragm pump. The pneumatically powered, dual diaphragm pump can include a cycle counter that is to increment a counter value after at least one of each pump cycle and each half pump cycle, wherein the pneumatically powered, dual diaphragm pump is to output a pump cycle volume of the chemical fluid through the outlet for at least one of each pump cycle and each half pump cycle. The system can also include a computer device that is communicatively coupled to the pneumatically powered, dual diaphragm pump. The computer device

can include a processor and a machine-readable medium having program code executable by the processor to cause the computer device to determine a volume output from the fluid outlet of the pneumatically powered, dual diaphragm pump during a defined time period based on the counter value and the pump cycle volume of the chemical fluid in at least one of each pump cycle and each half pump cycle. The system can include a flowmeter that is coupled to receive the fluid being output from the fluid outlet of the pneumatically powered, dual diaphragm pump, wherein the flowmeter is to measure a volume output from the fluid outlet of the pneumatically powered, dual diaphragm pump during the defined time period. In the system, the machine-readable medium comprises program code executable by the processor to cause the computer device to validate operation of at least one of the liquid additive pump and the flowmeter, in response to a difference between the volume output from the fluid outlet of the pneumatically powered, dual diaphragm pump and the volume output measured by the flowmeter during the defined time period being within a volume differential threshold.

[0076] In the system, the pneumatically powered, dual diaphragm pump can include a pulse generator to generate a pulse after each pump cycle, wherein the pneumatically powered, dual diaphragm pump is to output a pump cycle volume of the fluid through the fluid outlet for each pump cycle. The system can include a computer device that comprises a processor and a machine-readable medium having program code executable by the processor to cause the system to determine a volume output from the fluid outlet of the pneumatically powered, dual diaphragm pump based on a number of pulses generated and the pump cycle volume of the fluid in each pump cycle. The system can also include a flowmeter that is coupled to measure a volume output from the fluid outlet of the pneumatically powered, dual diaphragm pump. The program code can include program code executable by the processor to cause the system to validate operation of at least one of the liquid additive pump and the flowmeter, in response to a difference between the volume output from the fluid outlet of the pneumatically powered, dual diaphragm pump and the volume output measured by the flowmeter being within a volume differential threshold.

[0077] In some embodiments, a method includes connecting a fluid inlet of a dual diaphragm pump to a chemical fluid source with a first fluid conduit. The method can also include connecting a fluid outlet of the dual diaphragm pump to a fluid inlet of a liquid additive pump with a second fluid conduit. The method can include connecting a fluid outlet of the liquid additive pump to a fluid inlet of a blender. The method can also include connecting an outlet of the blender to a tubular string in a wellbore with a third fluid conduit. The method can also include initiating a hydraulic fracturing operation of the wellbore using a hydraulic fracturing fluid that is output from the blender and that is based, at least in part, on a chemical fluid from the chemical fluid source received via a fluid outlet of the liquid additive pump. Initiating of the hydraulic fracturing operation can include pneumatic powering of the dual diaphragm pump through a pneumatic power inlet of the dual diaphragm pump, wherein in response to pneumatic powering of the dual diaphragm pump and in response to a pressure at the fluid outlet of the dual diaphragm pump being less than a pressure at the pneumatic power inlet,

the chemical fluid flows from the fluid outlet of the dual diaphragm to the fluid inlet of the liquid additive pump to prime the liquid additive pump. Initiating of the hydraulic fracturing operation can also include powering the liquid additive pump, wherein in response to powering the liquid additive pump, the chemical fluid is output from the liquid additive pump and into a fluid inlet of the blender.

5 Initiating of the hydraulic fracturing operation can include powering the blender to output the hydraulic fracturing fluid from the outlet of the blender. The dual diaphragm pump can include a cycle counter, wherein the method can include communicatively coupling the cycle counter to a computer device. The method can also include connecting a flowmeter to receive fluid output from the fluid outlet of the dual diaphragm pump and communicatively coupling the flowmeter to the  
10 computer device. The method can also include retrieving, by the computer device, a counter value of the cycle counter during a defined time period and a pump cycle volume of the chemical fluid in each pump cycle of the dual diaphragm pump. The method can then include determining, by the computer device, a first volume output from the fluid outlet of the dual diaphragm pump during the defined time period based on the counter value and the pump cycle volume of the chemical fluid in each pump  
15 cycle of the dual diaphragm pump. The method can also include measuring, by the flowmeter, a second volume output from the fluid outlet of the dual diaphragm pump during the defined time period. The method can include retrieving, by the computer device, the second volume output. The method can also include validating, by the computer device, operation of at least one of the liquid additive pump and the flowmeter, in response to a difference between the first volume output and the  
20 second volume output being within a volume differential threshold.

[0078] The dual diaphragm pump can include a pulse generator to generate a pulse after each pump cycle, wherein the method includes communicatively coupling the pulse generator to a computer device and connecting a flowmeter to receive fluid output from the fluid outlet of the dual diaphragm pump. The method can also include communicatively coupling the flowmeter to the  
25 computer device, and receiving, by the computer device, a number of pulses from the pulse generator and a pump cycle volume of the chemical fluid in each pump cycle of the dual diaphragm pump. The method can include determining, by the computer device, a first volume output from the fluid outlet of the dual diaphragm pump based on the number of pulses and the pump cycle volume of the chemical fluid in each pump cycle of the dual diaphragm pump. The method can include measuring,  
30 by the flowmeter, a second volume output from the fluid outlet of the dual diaphragm pump and receiving, by the computer device, the second volume output. The method can include validating, by the computer device, operation of the liquid additive pump, in response to a difference between the first volume output and the second volume output being within a volume differential threshold.

[0079] Plural instances may be provided for components, operations or structures described  
35 herein as a single instance. Finally, boundaries between various components, operations and data stores are somewhat arbitrary, and particular operations are illustrated in the context of specific illustrative configurations. Other allocations of functionality are envisioned and may fall within the

scope of the disclosure. In general, structures and functionality presented as separate components in the example configurations may be implemented as a combined structure or component. Similarly, structures and functionality presented as a single component may be implemented as separate components. These and other variations, modifications, additions, and improvements may fall within  
5 the scope of the disclosure.

## WHAT IS CLAIMED IS:

1. An apparatus comprising:  
a primer pump having a pneumatic power inlet, a fluid inlet coupled to receive a fluid from a fluid source and a fluid outlet to output the fluid in response to a pressure at the fluid outlet being less than a pressure at the pneumatic power inlet; and  
5 a liquid additive pump having a fluid inlet coupled to the fluid outlet of the primer pump to receive the fluid, wherein the primer pump is to apply a positive pressure at the fluid inlet of the liquid additive pump.
2. The apparatus of claim 1, wherein the primer pump is a pneumatically powered, dual diaphragm pump.
- 10 3. The apparatus of claim 2, wherein the pneumatically powered, dual diaphragm pump includes a cycle counter that is to increment a counter value after at least one of each pump cycle and each half pump cycle, and wherein the pneumatically powered, dual diaphragm pump is to output a pump cycle volume of the fluid through the fluid outlet for at least one of each pump cycle and each half pump cycle.
- 15 4. The apparatus of claim 3, wherein a computer device is communicatively coupled to the apparatus, wherein the computer device comprises,  
a processor; and  
a machine-readable medium having program code executable by the processor to cause the computer device to determine a volume output from the fluid outlet of the  
20 pneumatically powered, dual diaphragm pump during a defined time period based on the counter value and the pump cycle volume of the fluid in at least each pump cycle and each half pump cycle.
5. The apparatus of claim 4, further comprising:  
a flowmeter that is coupled to receive the fluid being output from the fluid outlet of the primer  
25 pump, wherein the flowmeter is to measure a volume output from the fluid outlet of the primer pump during the defined time period.
6. The apparatus of claim 5, wherein the program code comprises program code executable by the processor to cause the computer device to validate operation of at least one of the liquid additive pump and the flowmeter, in response to a difference between the volume output from the fluid outlet  
30 of the pneumatically powered, dual diaphragm pump and the volume output measured by the flowmeter during the defined time period being within a volume differential threshold.
7. The apparatus of claim 3,  
wherein the pneumatically powered, dual diaphragm pump includes a pulse generator to  
generate a pulse after each pump cycle, and wherein the pneumatically powered, dual  
35 diaphragm pump is to output a pump cycle volume of the fluid through the fluid outlet for each pump cycle,

wherein a computer device is communicatively coupled to the apparatus, wherein the computer device comprises,

a processor; and

a machine-readable medium having program code executable by the processor to  
5 cause the computer device to determine a volume output from the fluid outlet of the pneumatically powered, dual diaphragm pump based on a number of pulses generated and the pump cycle volume of the fluid in each pump cycle,

wherein the apparatus further comprises a flowmeter that is coupled to receive the fluid being  
10 output from the fluid outlet of the primer pump, wherein the flowmeter is to measure a volume output from the fluid outlet of the primer pump; and

wherein the program code comprises program code executable by the processor to cause the computer device to validate operation of at least one of the liquid additive pump and the flowmeter, in response to a difference between the volume output from the fluid  
15 outlet of the pneumatically powered, dual diaphragm pump and the volume output measured by the flowmeter being within a volume differential threshold.

8. A system comprising:

a pneumatically powered pump having a pneumatic power inlet, a fluid inlet coupled to receive a chemical fluid from a chemical fluid source and a fluid outlet to output the  
20 chemical fluid in response to a pressure at the fluid outlet being less than a pressure at the pneumatic power inlet; and

a blender comprising,

a liquid additive pump having a fluid inlet coupled to the fluid outlet of the pneumatically powered pump to receive the chemical fluid, wherein the  
25 pneumatically powered pump is to apply a positive pressure at the fluid inlet of the liquid additive pump;

a plurality of inlets, wherein one of the plurality of inlets is coupled to a fluid outlet of the liquid additive pump to receive the chemical fluid; and  
30 an outlet to output a hydraulic fracturing fluid via a conduit for a downhole hydraulic fracturing operation.

9. The system of claim 8, wherein the pneumatically powered pump is a pneumatically powered, dual diaphragm pump.

10. The system of claim 9, wherein the pneumatically powered, dual diaphragm pump includes a cycle counter that is to increment a counter value after at least one of each pump cycle and each half  
35 pump cycle, and wherein the pneumatically powered, dual diaphragm pump is to output a pump cycle volume of the chemical fluid through the outlet for at least one of each pump cycle and each half pump cycle.

11. The system of claim 10, further comprising a computer device that is communicatively coupled to the pneumatically powered, dual diaphragm pump, wherein the computer device comprises,

a processor; and

5 a machine-readable medium having program code executable by the processor to cause the computer device to determine a volume output from the fluid outlet of the pneumatically powered, dual diaphragm pump during a defined time period based on the counter value and the pump cycle volume of the chemical fluid in at least one of each pump cycle and each half pump cycle.

10 12. The system of claim 11, further comprising a flowmeter that is coupled to receive the fluid being output from the fluid outlet of the pneumatically powered, dual diaphragm pump, wherein the flowmeter is to measure a volume output from the fluid outlet of the pneumatically powered, dual diaphragm pump during the defined time period.

13. The system of claim 12, wherein the machine-readable medium comprises program code  
15 executable by the processor to cause the computer device to validate operation of at least one of the liquid additive pump and the flowmeter, in response to a difference between the volume output from the fluid outlet of the pneumatically powered, dual diaphragm pump and the volume output measured by the flowmeter during the defined time period being within a volume differential threshold.

14. The system of claim 9,  
20 wherein the pneumatically powered, dual diaphragm pump includes a pulse generator to generate a pulse after each pump cycle, and wherein the pneumatically powered, dual diaphragm pump is to output a pump cycle volume of the fluid through the fluid outlet for each pump cycle,

wherein the system further comprises a computer device that comprises,

25 a processor;

a machine-readable medium having program code executable by the processor to  
cause the system to determine a volume output from the fluid outlet of the  
pneumatically powered, dual diaphragm pump based on a number of  
pulses generated and the pump cycle volume of the fluid in each pump  
30 cycle; and

a flowmeter that is coupled to measure a volume output from the fluid outlet of the  
pneumatically powered, dual diaphragm pump,

wherein the program code comprises program code executable by the processor to  
cause the system to validate operation of at least one of the liquid additive  
35 pump and the flowmeter, in response to a difference between the volume  
output from the fluid outlet of the pneumatically powered, dual diaphragm

pump and the volume output measured by the flowmeter being within a volume differential threshold.

15. A method comprising:

connecting a fluid inlet of a dual diaphragm pump to a chemical fluid source with a first fluid  
5 conduit;

connecting a fluid outlet of the dual diaphragm pump to a fluid inlet of a liquid additive pump  
with a second fluid conduit;

connecting a fluid outlet of the liquid additive pump to a fluid inlet of a blender; and

connecting an outlet of the blender to a tubular string in a wellbore with a third fluid conduit.

10 16. The method of claim 15, further comprising:

initiating a hydraulic fracturing operation of the wellbore using a hydraulic fracturing fluid  
that is output from the blender and that is based, at least in part, on a chemical fluid  
from the chemical fluid source received via a fluid outlet of the liquid additive pump,  
wherein initiating the hydraulic fracturing operation comprises,

15 pneumatic powering of the dual diaphragm pump through a pneumatic power inlet  
of the dual diaphragm pump, wherein in response to pneumatic powering  
of the dual diaphragm pump and in response to a pressure at the fluid  
outlet of the dual diaphragm pump being less than a pressure at the  
pneumatic power inlet, the chemical fluid flows from the fluid outlet of  
20 the dual diaphragm to the fluid inlet of the liquid additive pump to prime  
the liquid additive pump;

powering the liquid additive pump, wherein in response to powering the liquid  
additive pump, the chemical fluid is output from the liquid additive pump  
and into a fluid inlet of the blender; and

25 powering the blender to output the hydraulic fracturing fluid from the outlet of the  
blender.

17. The method of claim 16, wherein the dual diaphragm pump includes a cycle counter, wherein  
the method comprises,

communicatively coupling the cycle counter to a computer device;

30 connecting a flowmeter to receive fluid output from the fluid outlet of the dual diaphragm  
pump; and

communicatively coupling the flowmeter to the computer device.

18. The method of claim 17, further comprising:

retrieving, by the computer device, a counter value of the cycle counter during a defined time  
35 period and a pump cycle volume of the chemical fluid in each pump cycle of the dual  
diaphragm pump; and

determining, by the computer device, a first volume output from the fluid outlet of the dual diaphragm pump during the defined time period based on the counter value and the pump cycle volume of the chemical fluid in each pump cycle of the dual diaphragm pump.

- 5     19.     The method of claim 18, further comprising:  
measuring, by the flowmeter, a second volume output from the fluid outlet of the dual  
diaphragm pump during the defined time period;  
retrieving, by the computer device, the second volume output; and  
validating, by the computer device, operation of at least one of the liquid additive pump and  
10         the flowmeter, in response to a difference between the first volume output and the  
second volume output being within a volume differential threshold.
20.     The method of claim 16, wherein the dual diaphragm pump includes a pulse generator to  
generate a pulse after each pump cycle, wherein the method comprises,  
communicatively coupling the pulse generator to a computer device;  
15         connecting a flowmeter to receive fluid output from the fluid outlet of the dual diaphragm  
pump;  
communicatively coupling the flowmeter to the computer device; and  
receiving, by the computer device, a number of pulses from the pulse generator and a pump  
cycle volume of the chemical fluid in each pump cycle of the dual diaphragm pump;  
20         determining, by the computer device, a first volume output from the fluid outlet of the dual  
diaphragm pump based on the number of pulses and the pump cycle volume of the  
chemical fluid in each pump cycle of the dual diaphragm pump;  
measuring, by the flowmeter, a second volume output from the fluid outlet of the dual  
diaphragm pump;  
25         receiving, by the computer device, the second volume output; and  
validating, by the computer device, operation of the liquid additive pump, in response to a  
difference between the first volume output and the second volume output being  
within a volume differential threshold.

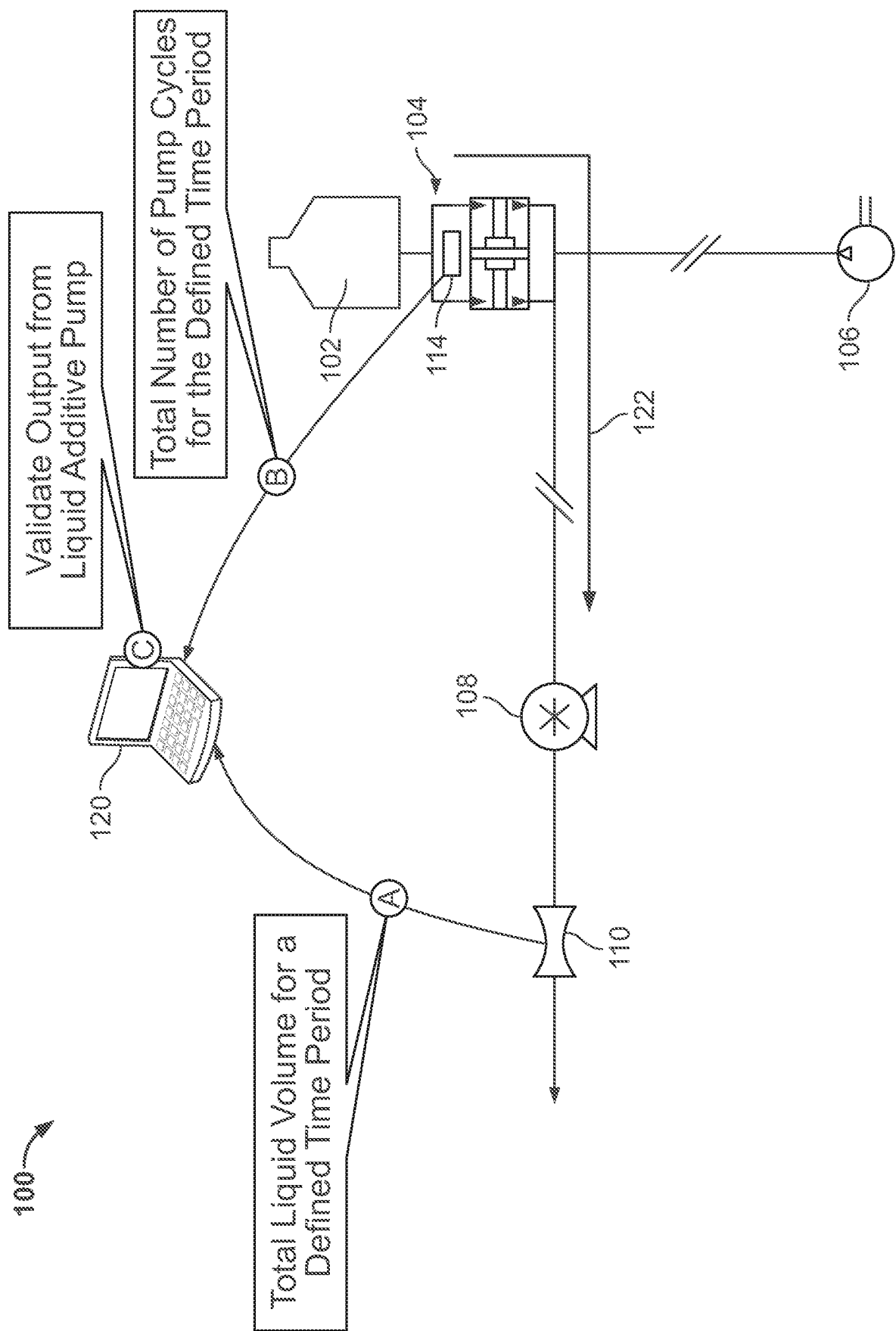
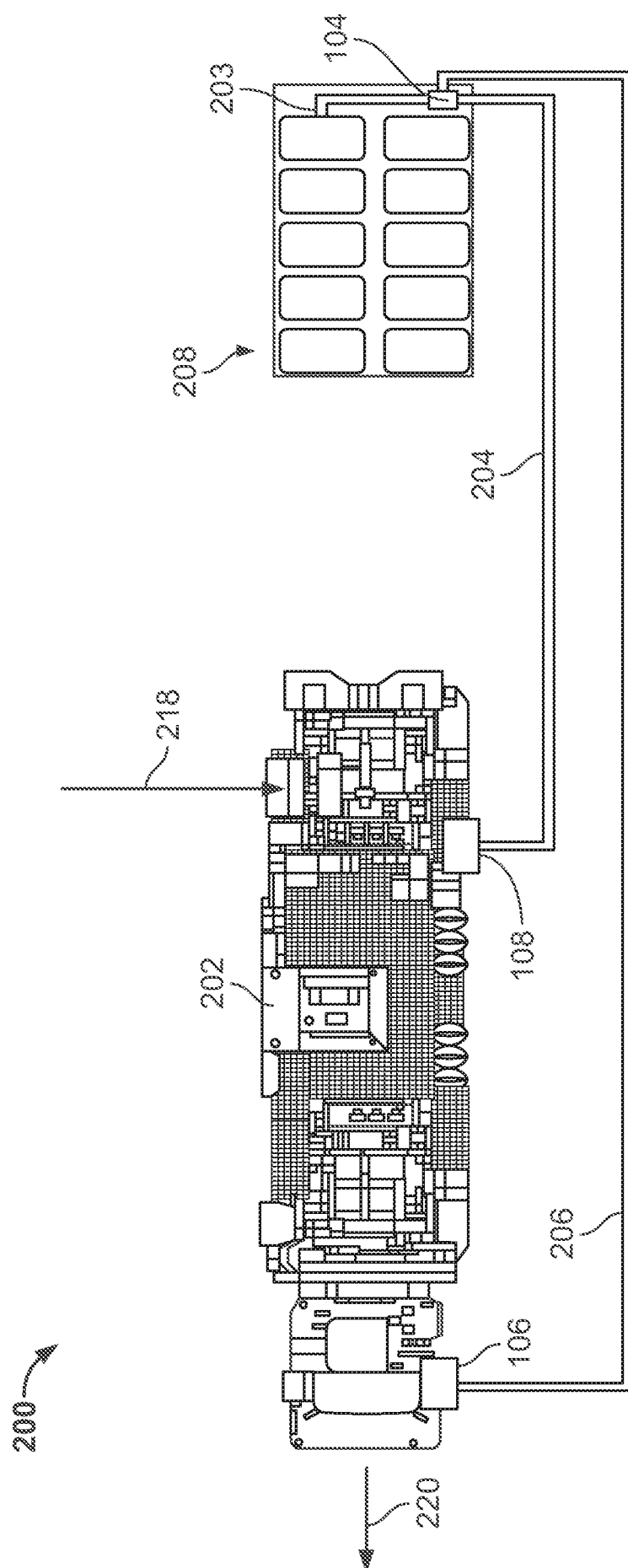


FIG. 1

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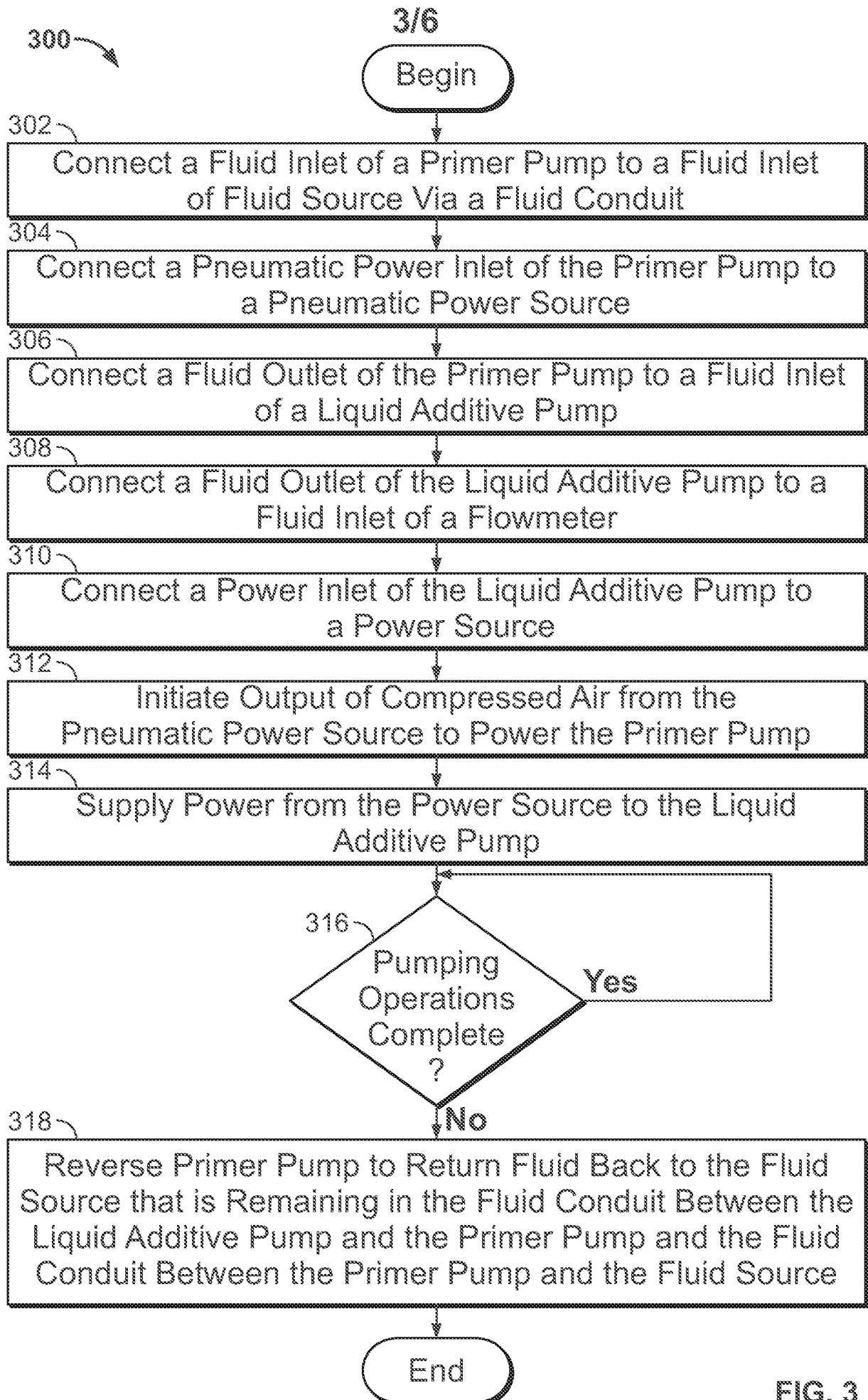


FIG. 3

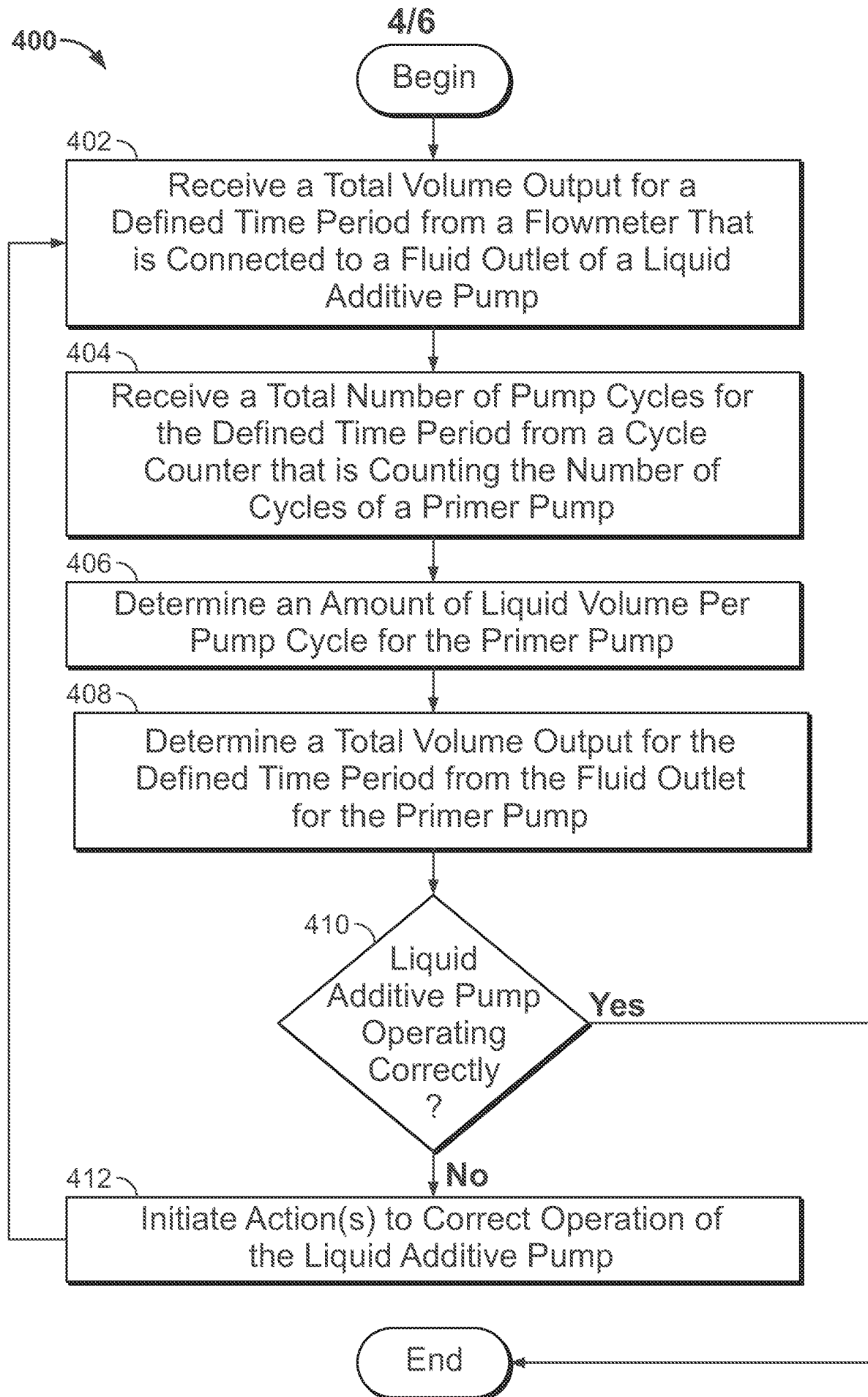


FIG. 4

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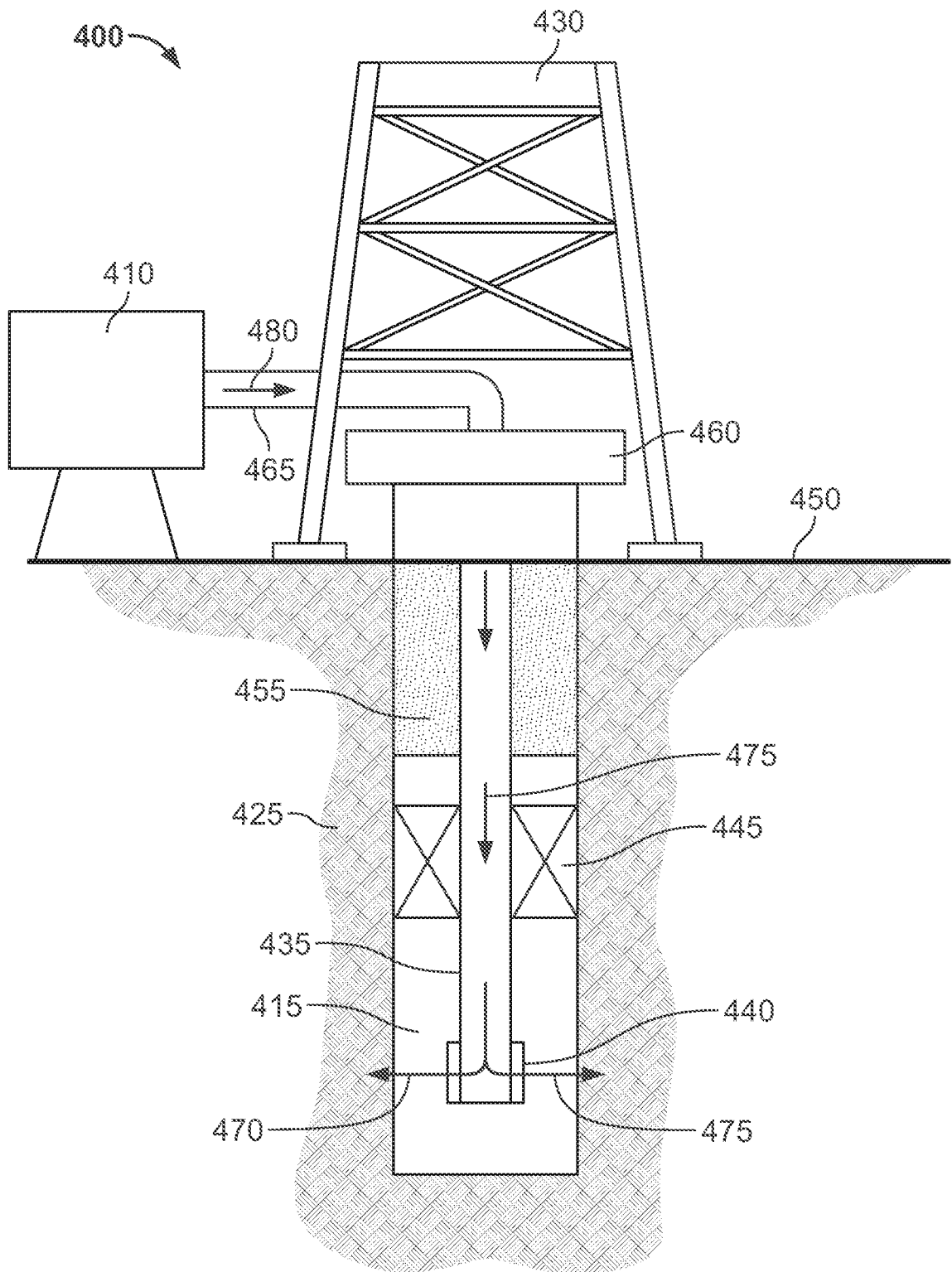


FIG. 5

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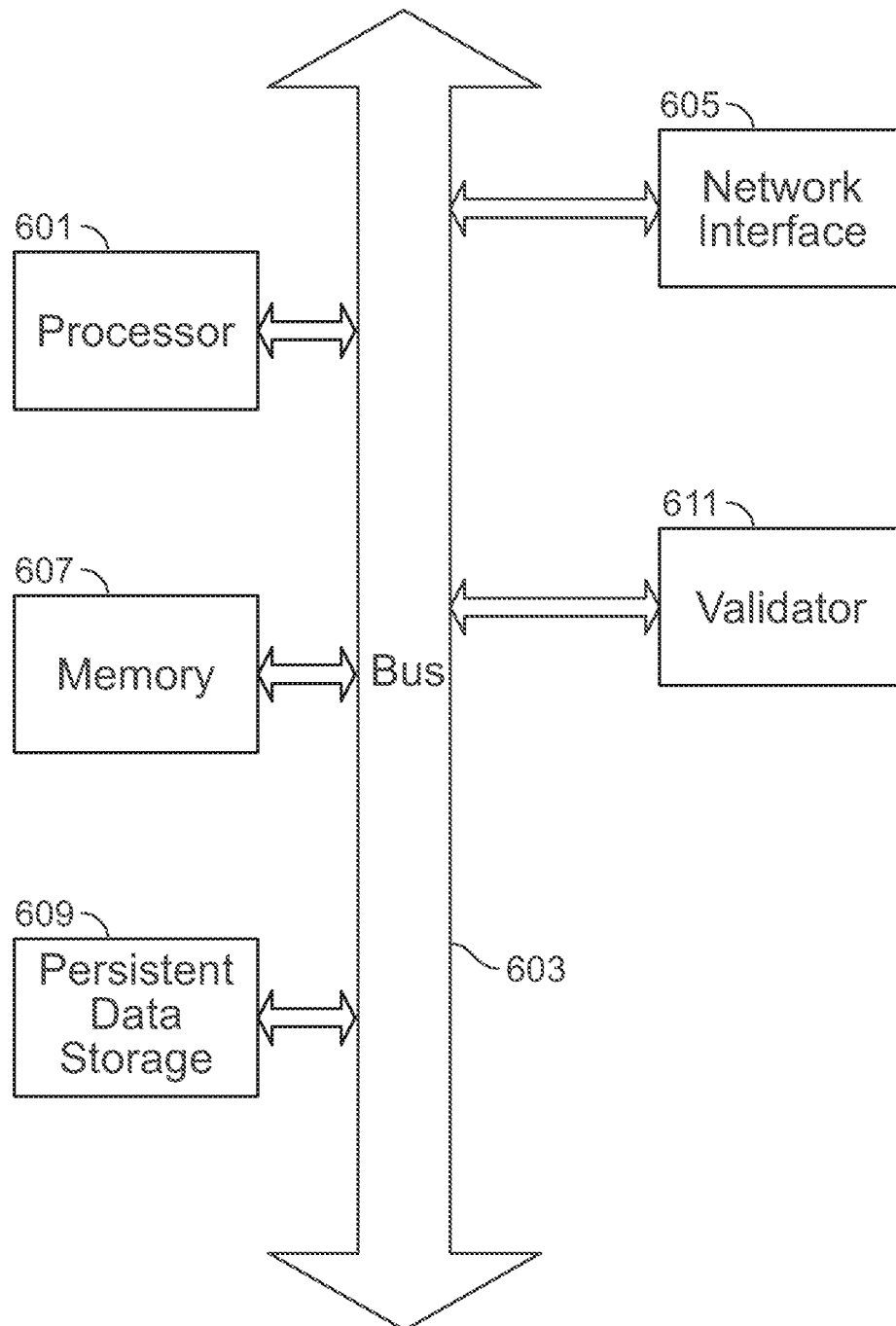


FIG. 6

## INTERNATIONAL SEARCH REPORT

International application No.  
**PCT/US2016/064222****A. CLASSIFICATION OF SUBJECT MATTER****F04B 49/00(2006.01)i, F04B 49/06(2006.01)i, F04B 43/02(2006.01)i, F04B 43/04(2006.01)i, F04B 43/06(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)

F04B 49/00; B01F 7/00; E21B 43/267; B60P 3/22; E21B 43/00; E21B 43/25; E21B 43/26; E21B 43/27; F17D 1/16; F04B 49/06; F04B 43/02; F04B 43/04; F04B 43/06

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) &amp; Keywords: primer pump, liquid additive pump, pneumatic, flow meter, computer device, cycle counter, blender, pressure, pneumatically powered diaphragm pump

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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Further documents are listed in the continuation of Box C.



See patent family annex.

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"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

"&amp;" document member of the same patent family

Date of the actual completion of the international search

18 August 2017 (18.08.2017)

Date of mailing of the international search report

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Name and mailing address of the ISA/KR

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**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International application No.

**PCT/US2016/064222**

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International application No.

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