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(54) **SAND SEPERATION CONTROL SYSTEM
AND METHOD**

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Publication Classification

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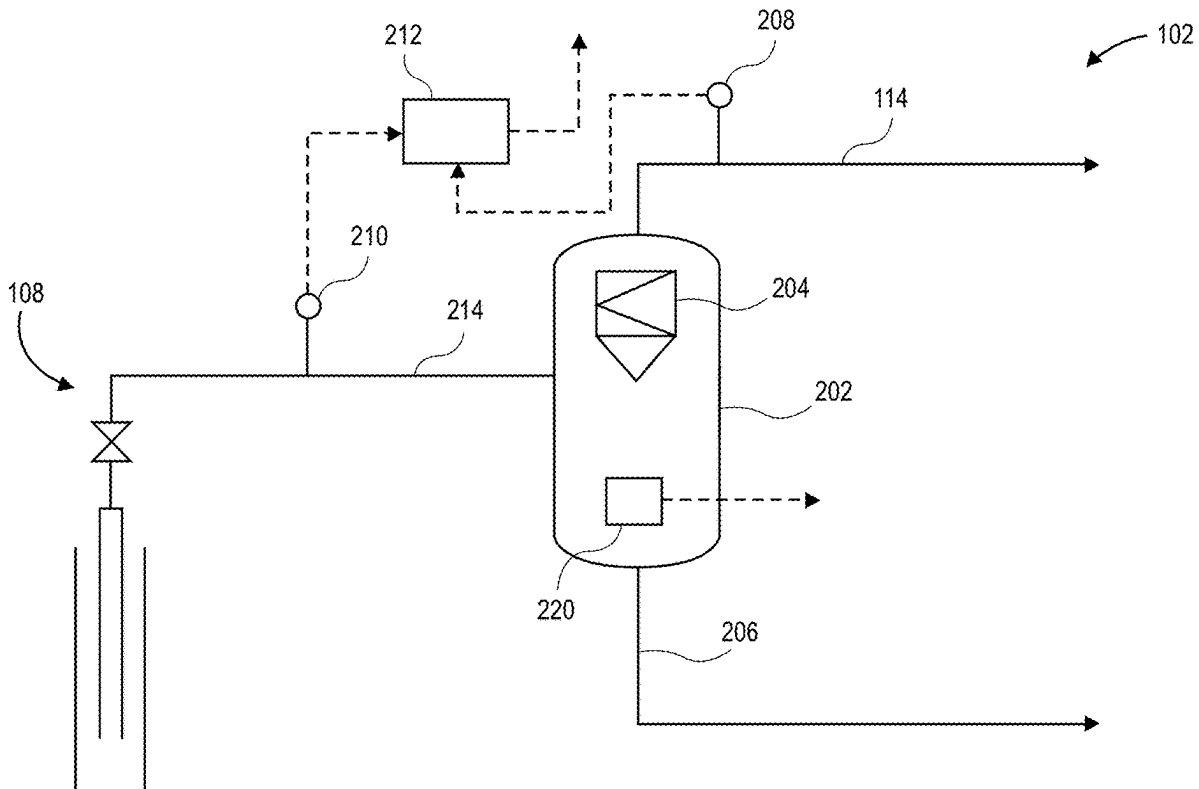
B01D 21/30 (2006.01)

B01D 21/24 (2006.01)

(57)

ABSTRACT

A sand separation system includes one or more separators configured to receive a mixed fluid from one or more wells or wellheads and to separate solids from the mixed fluid to produce the solids and a separated fluid. The system also includes one or more chokes downstream from and in fluid communication with the one or more separators. Each of the one or more chokes is configured to receive the separated fluid from a corresponding one of the one or more separators and to control a flow rate of the separated fluid therethrough. The system also includes one or more multiphase meters downstream from and in fluid communication with the one or more chokes. Each of the multiphase meters is configured to measure one or more first properties of the separated fluid and to adjust the one or more chokes in response to the one or more first properties.



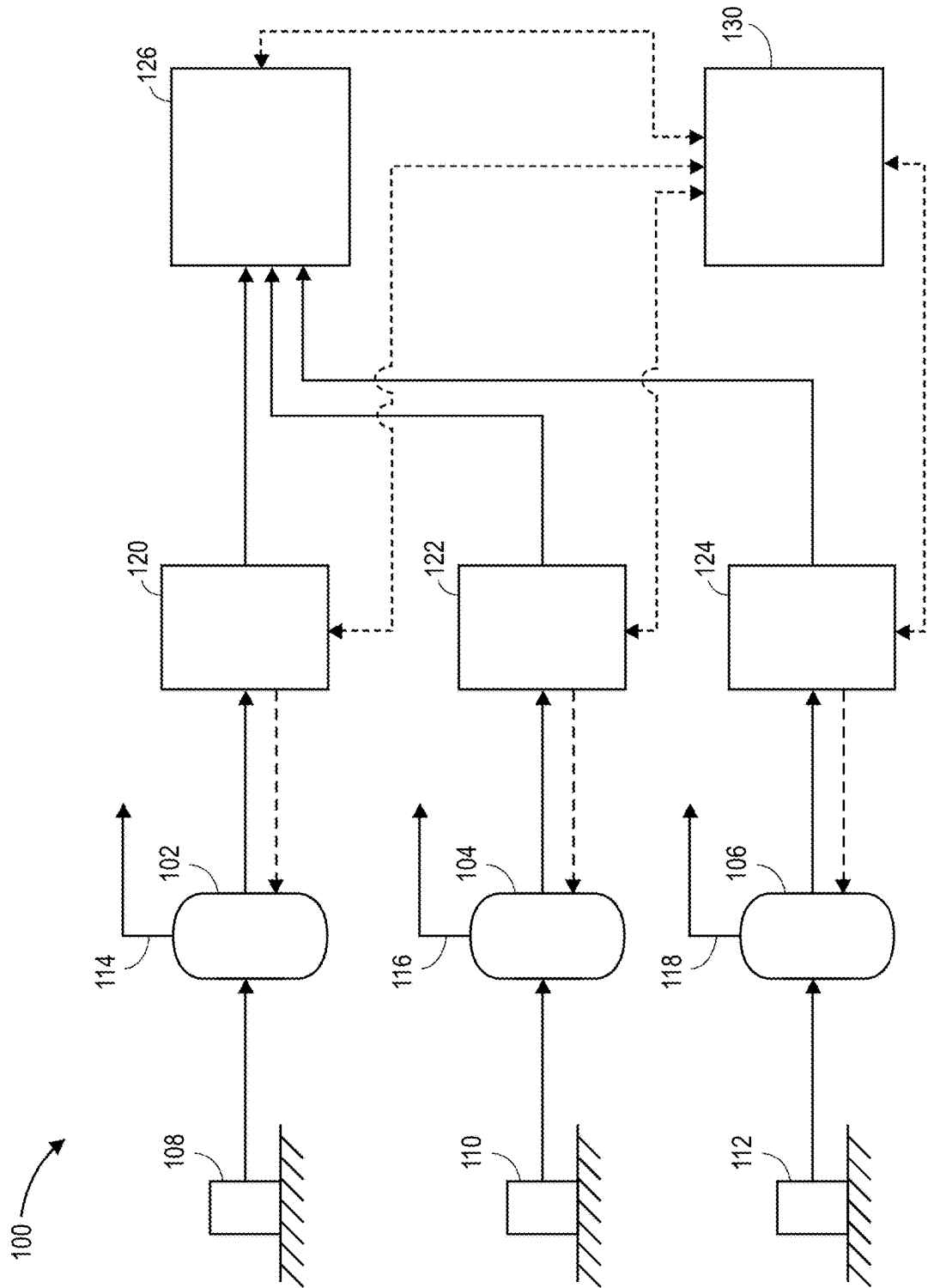


FIG. 1

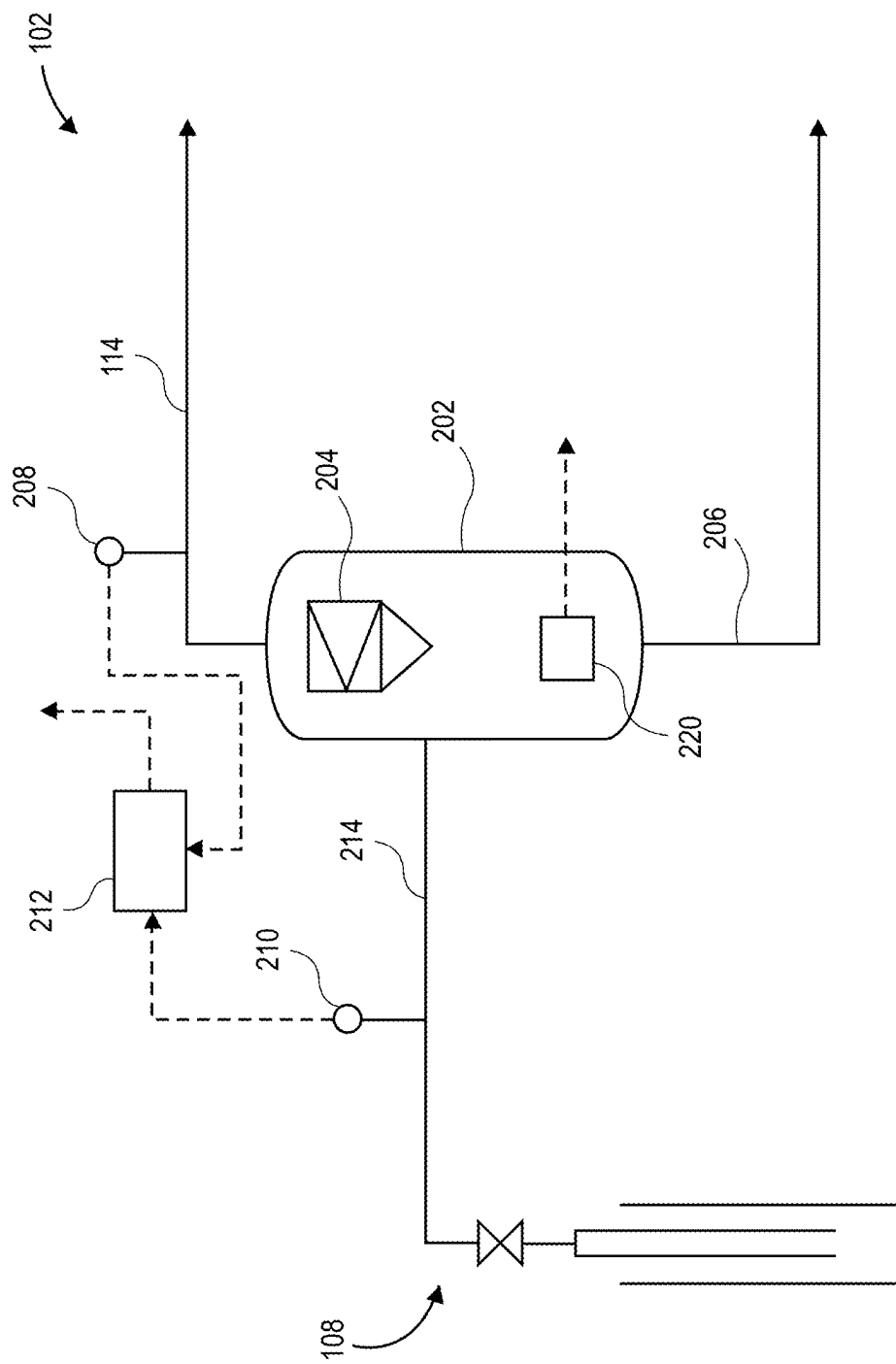
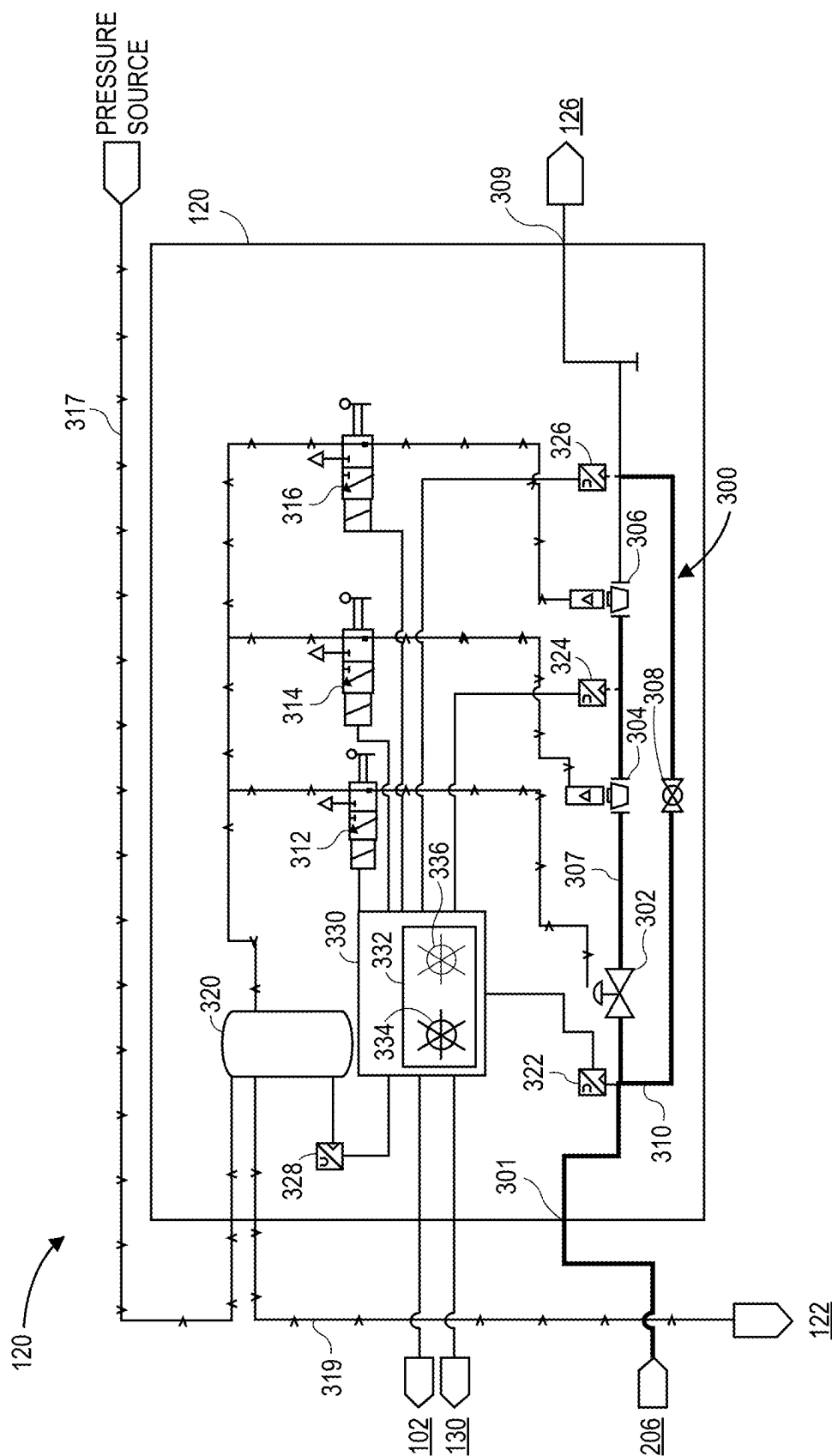


FIG. 2



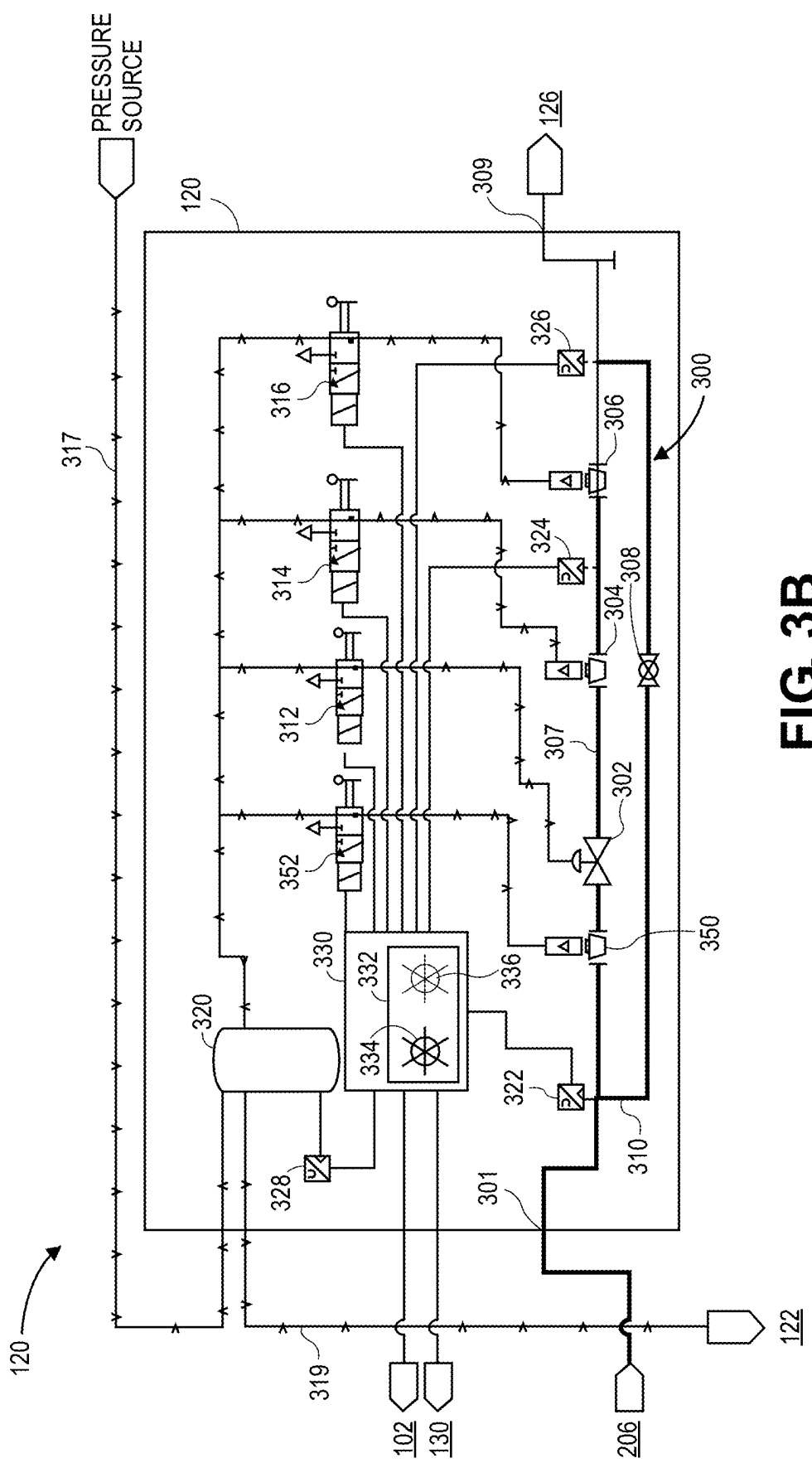


FIG. 3B

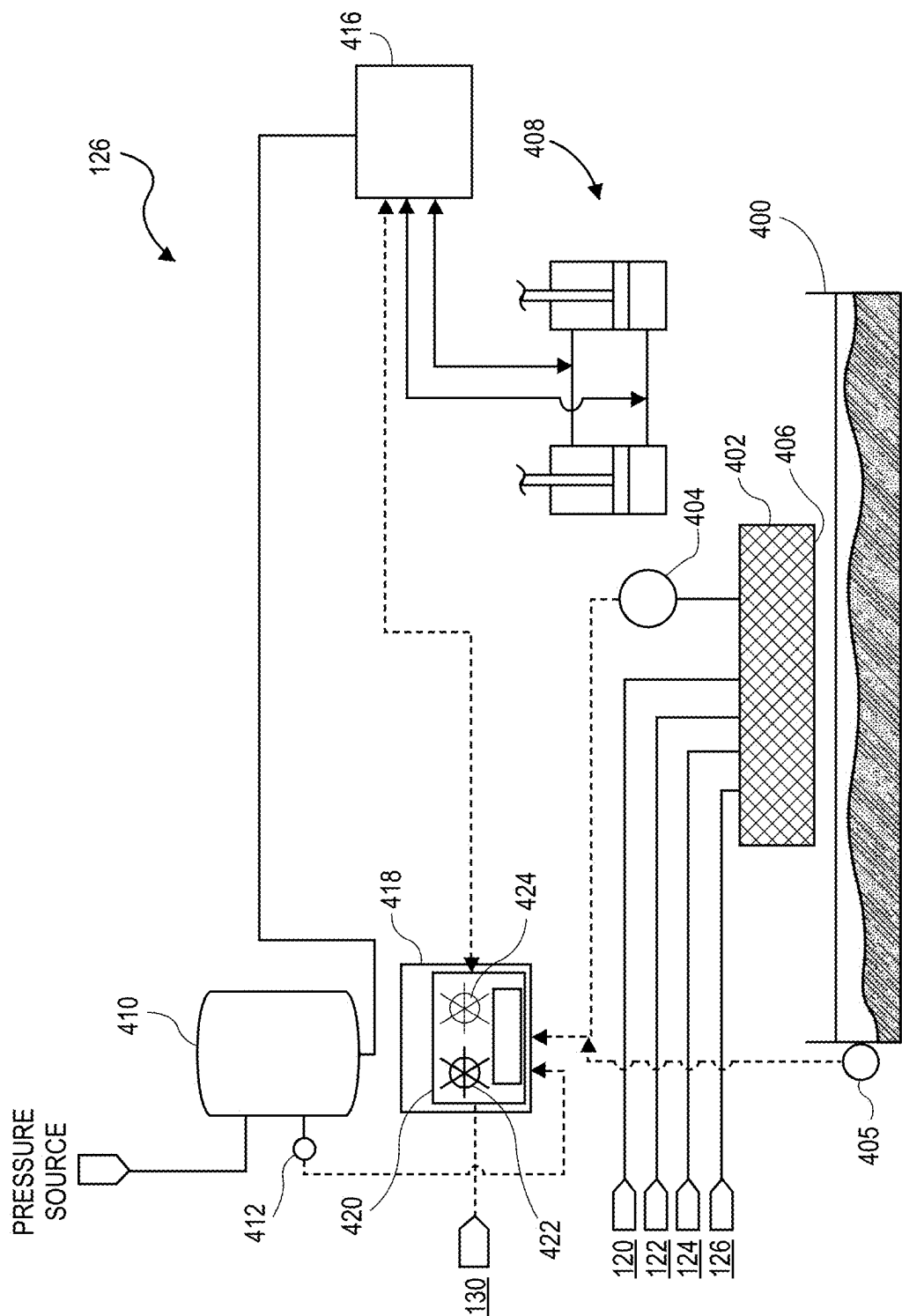


FIG. 4

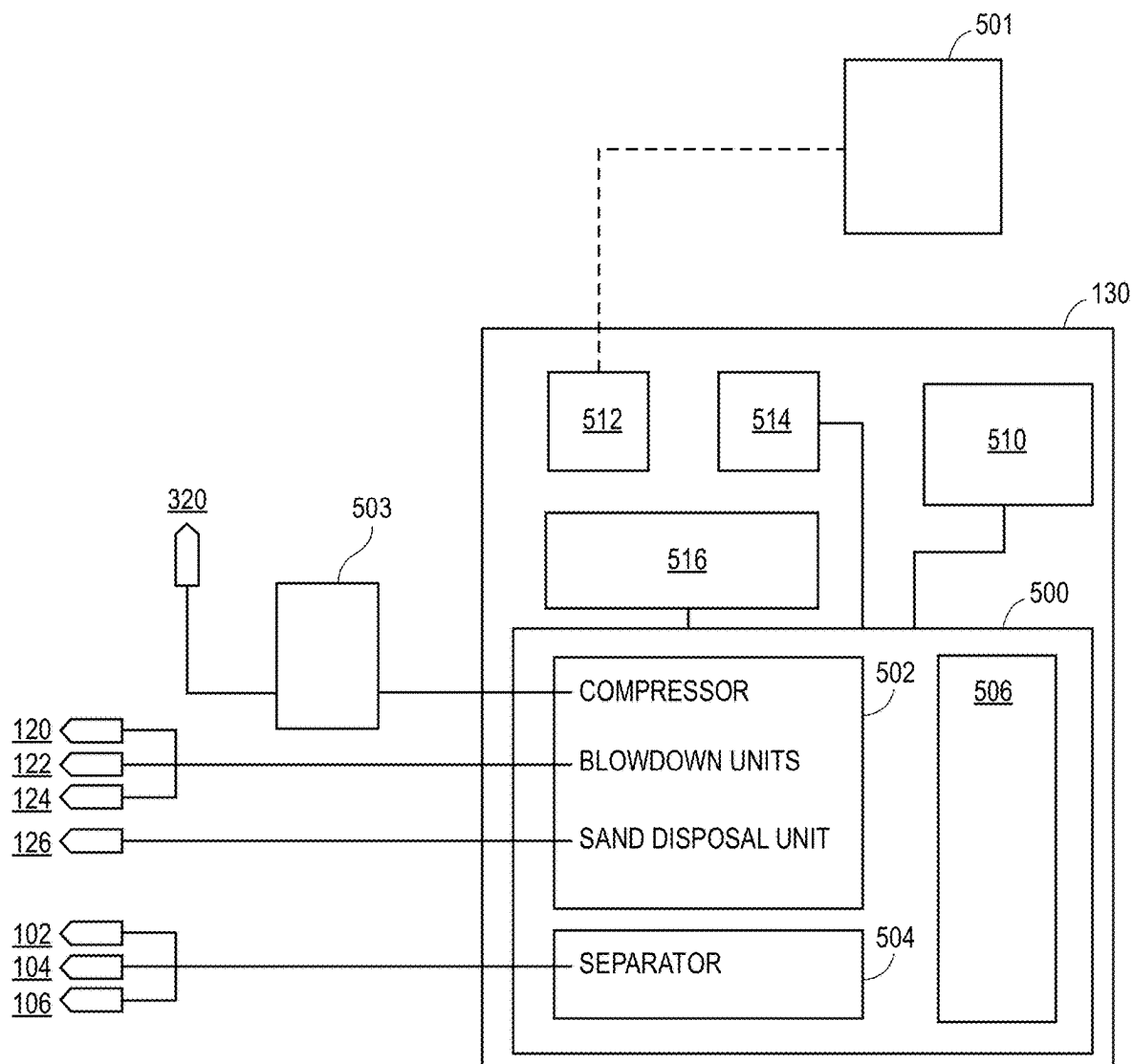


FIG. 5

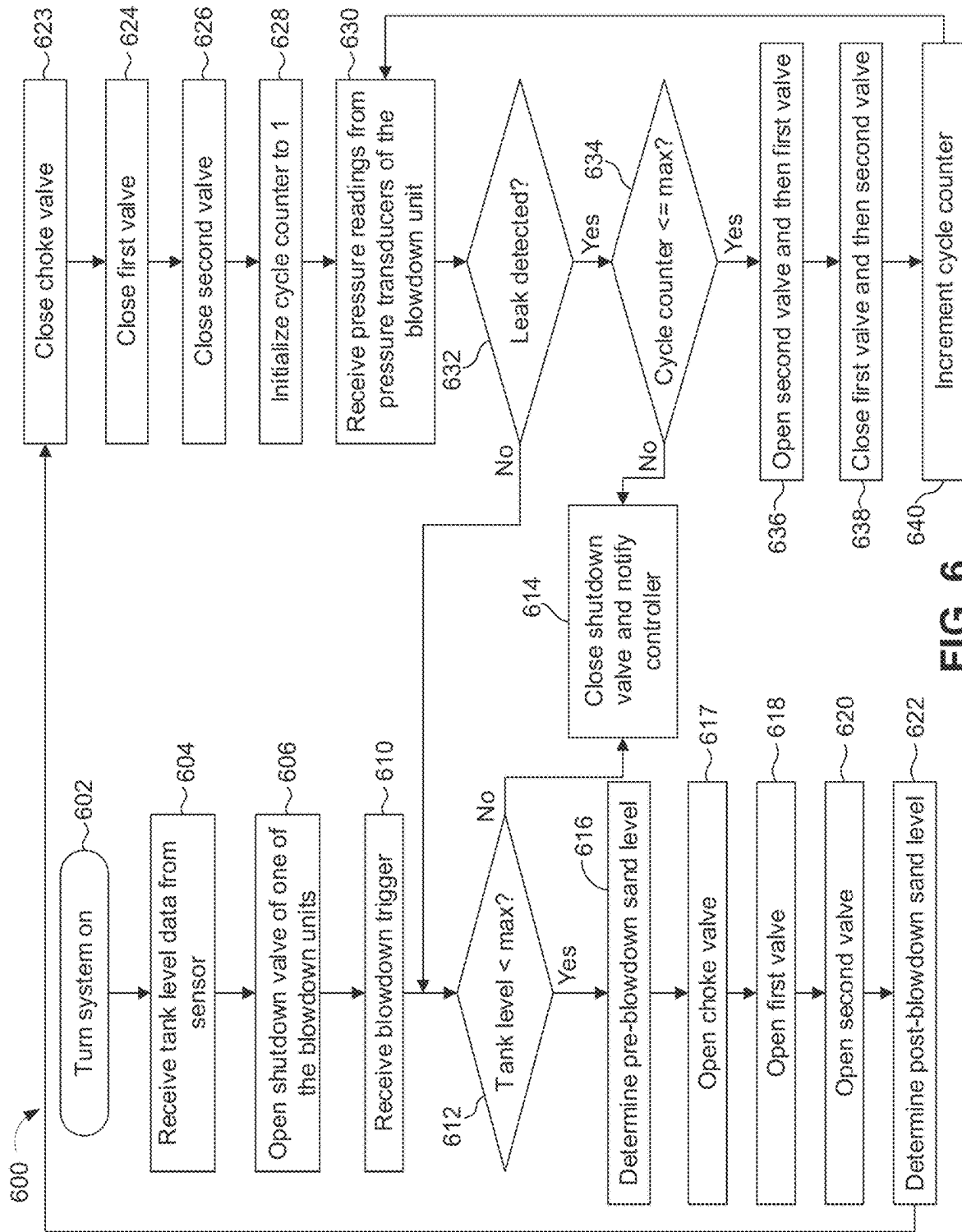
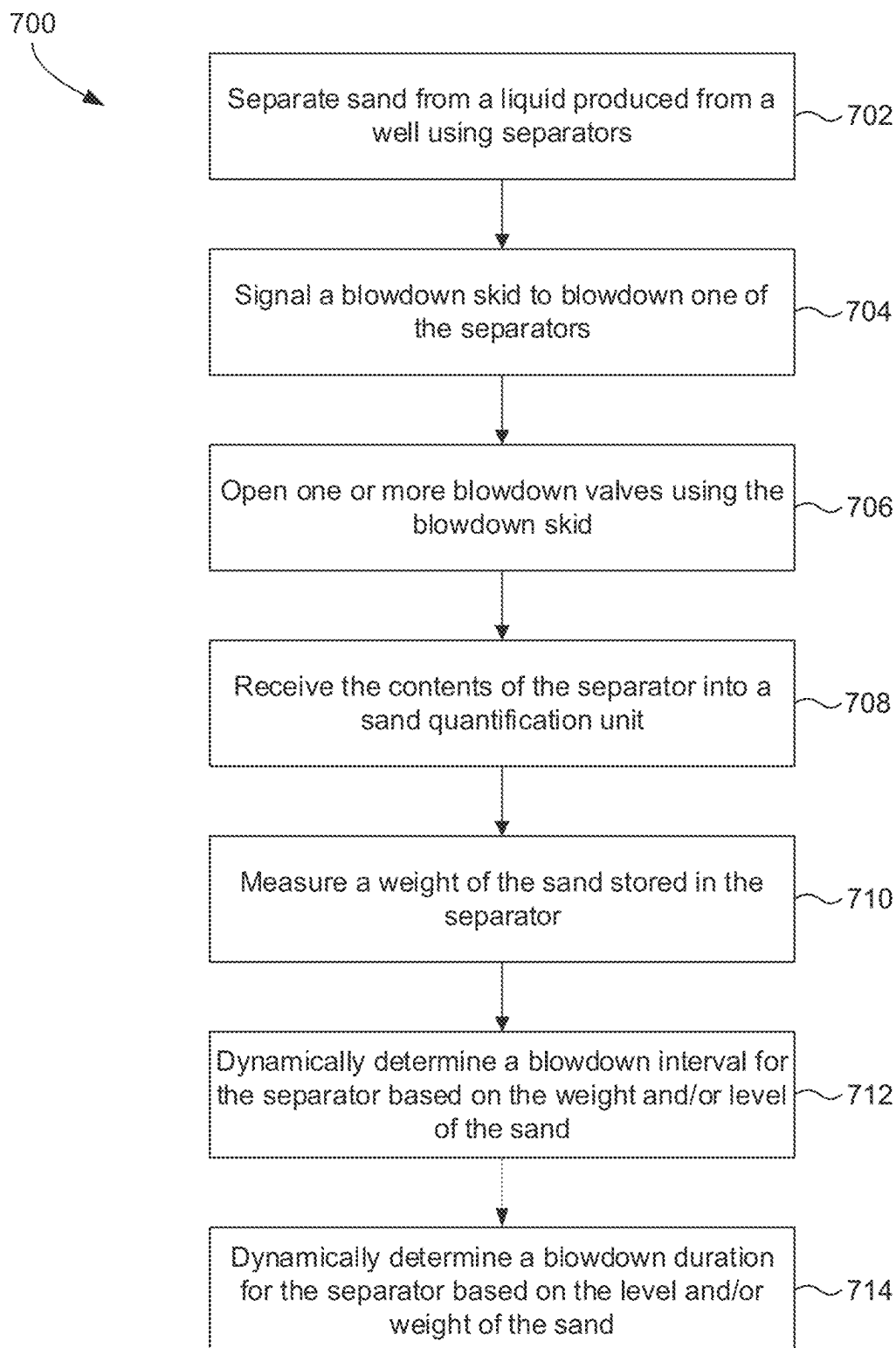


FIG. 6

**FIG. 7**

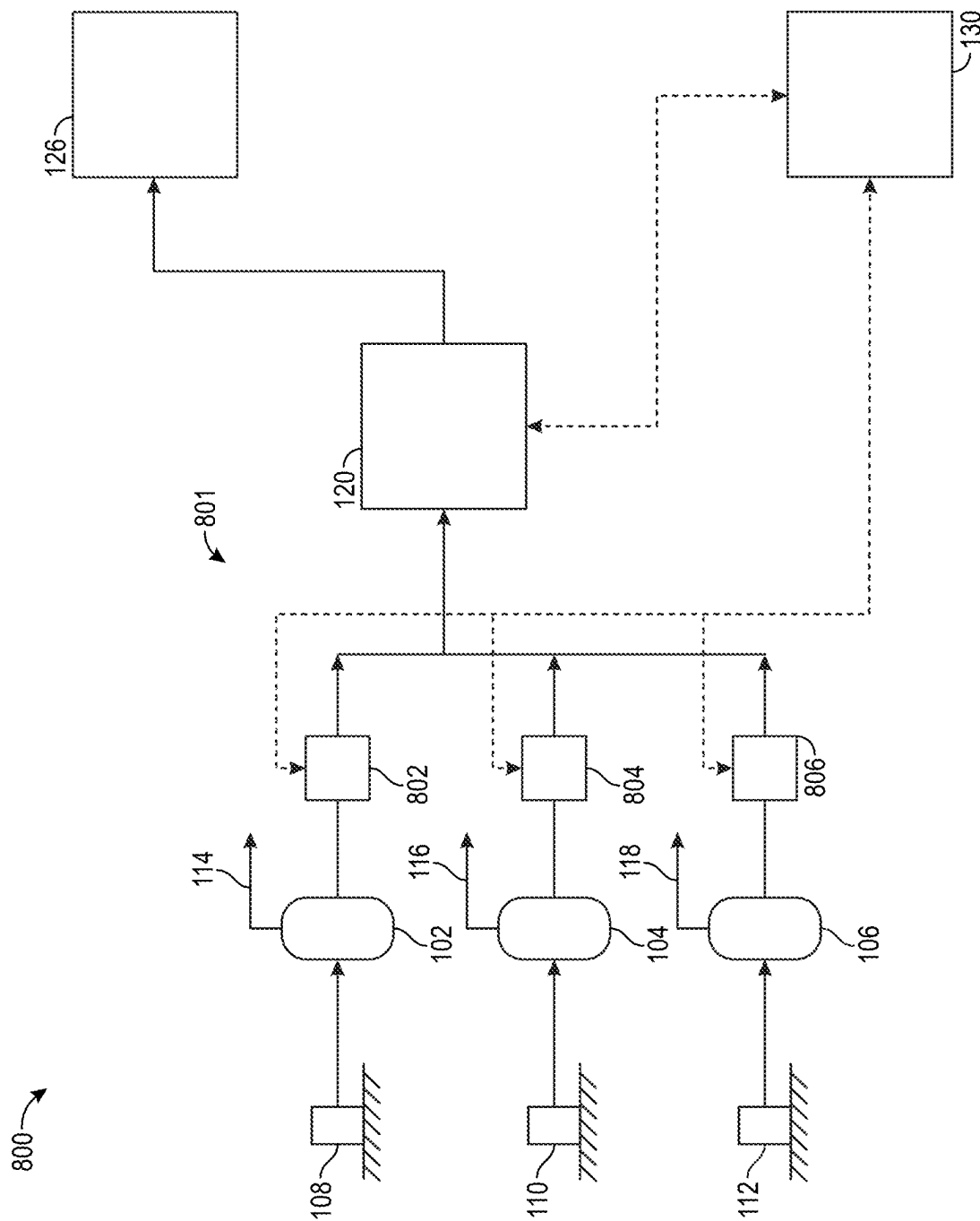


FIG. 8

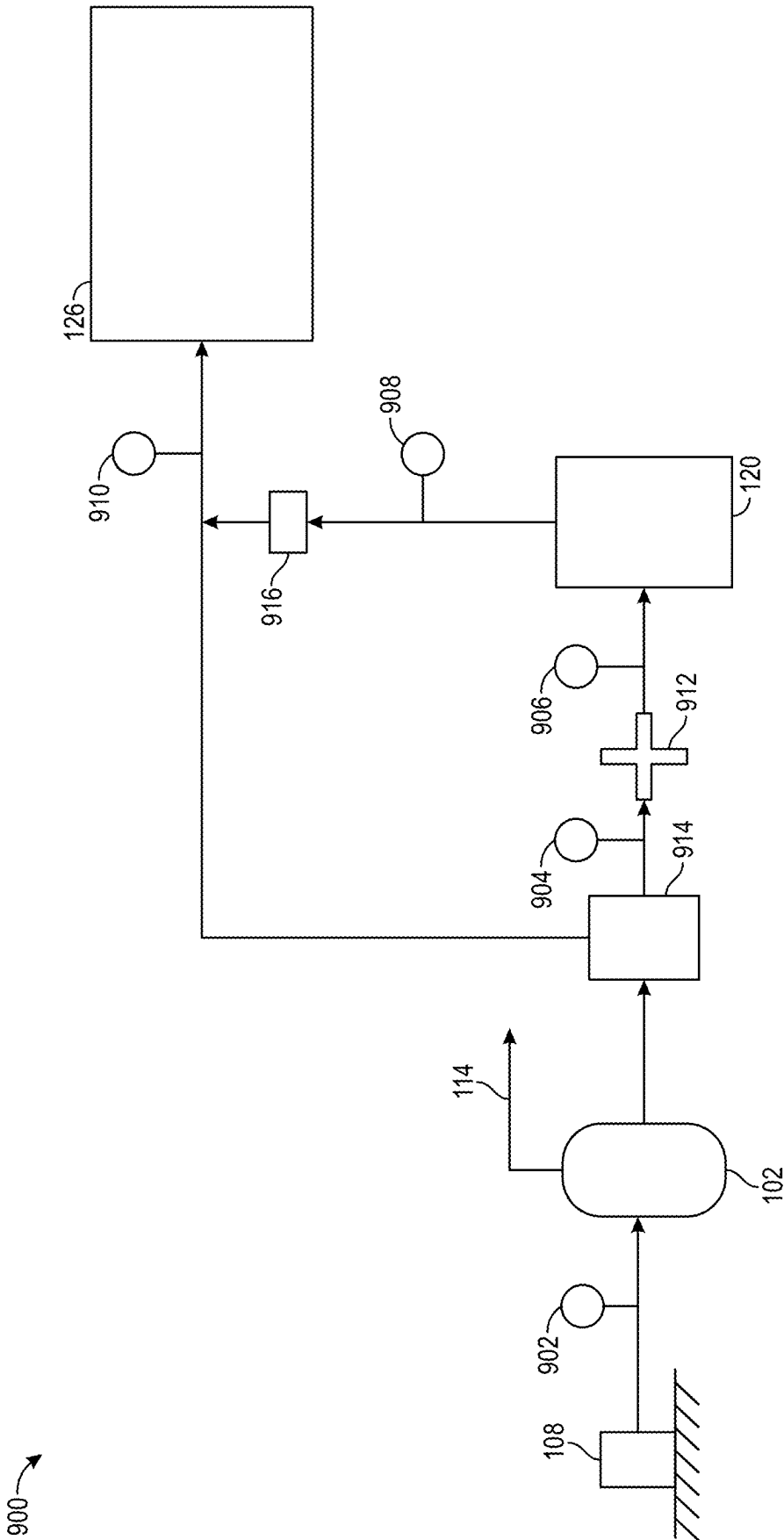


FIG. 9

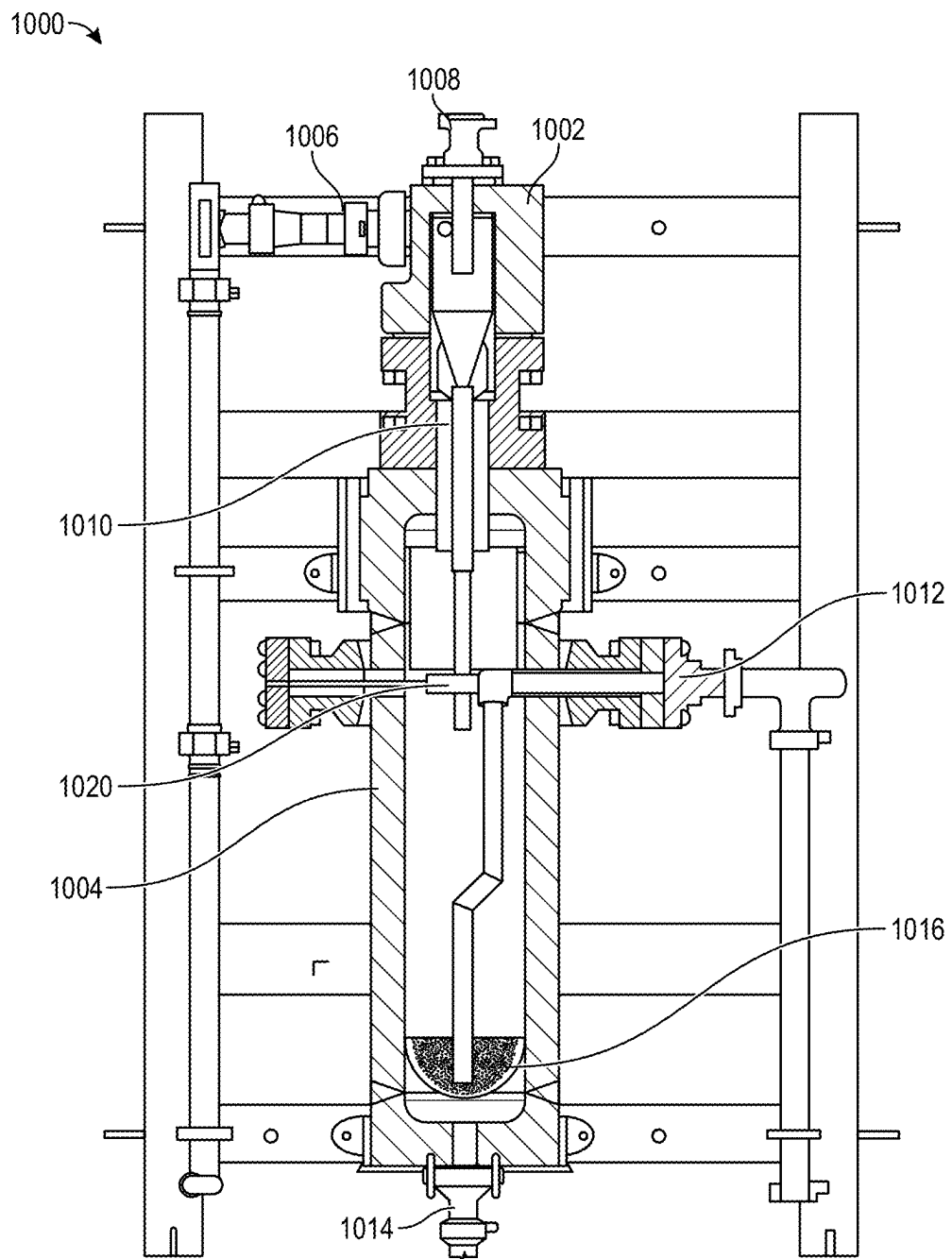


FIG. 10

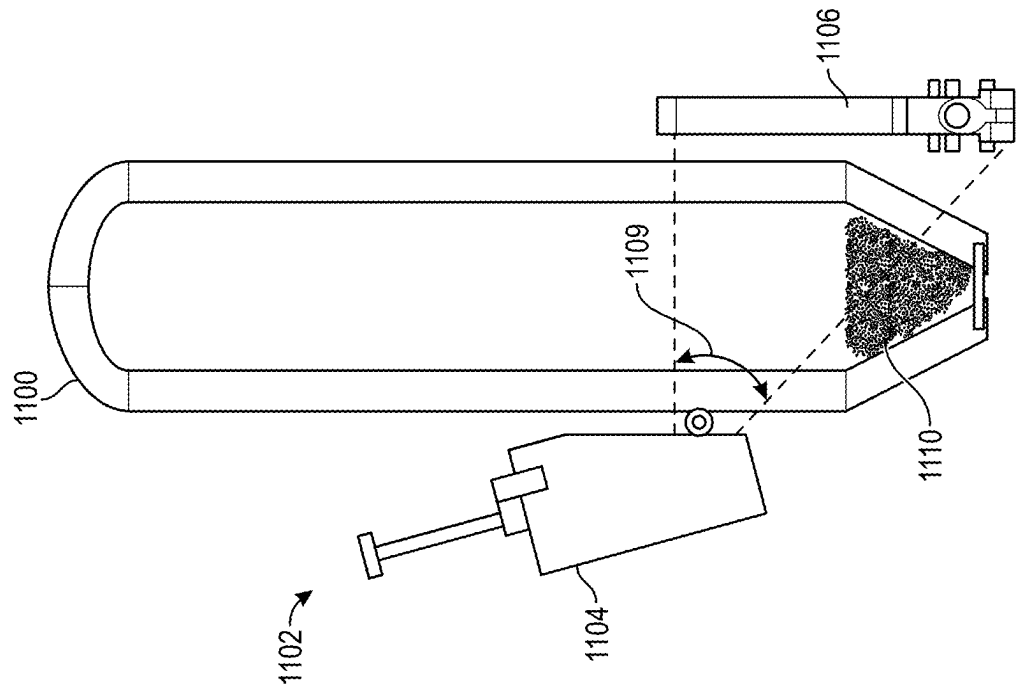


FIG. 11B

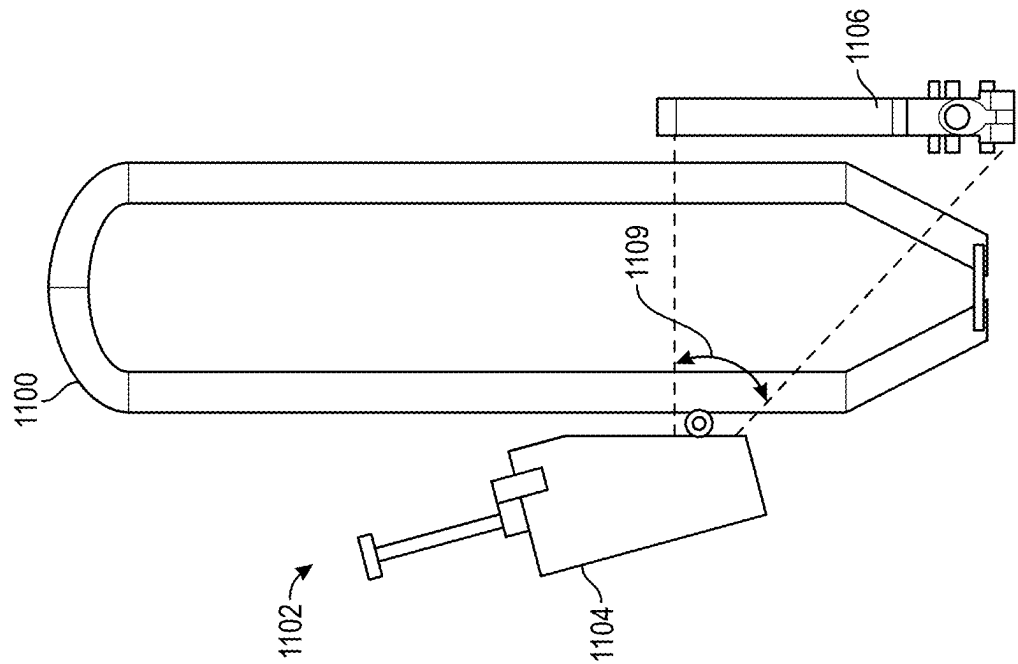


FIG. 11A

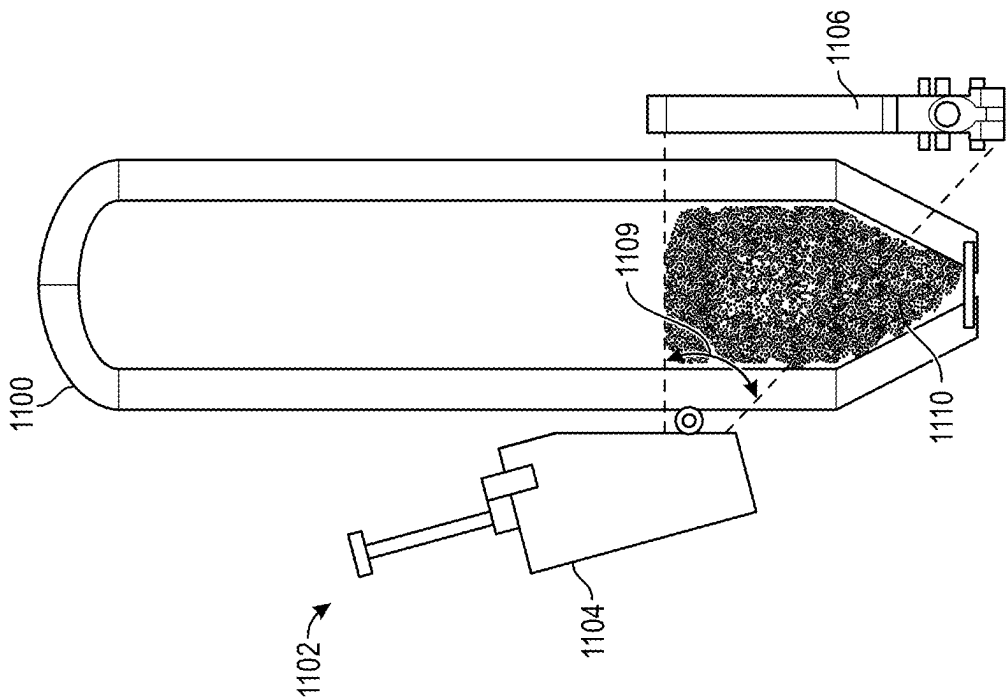


FIG. 11D

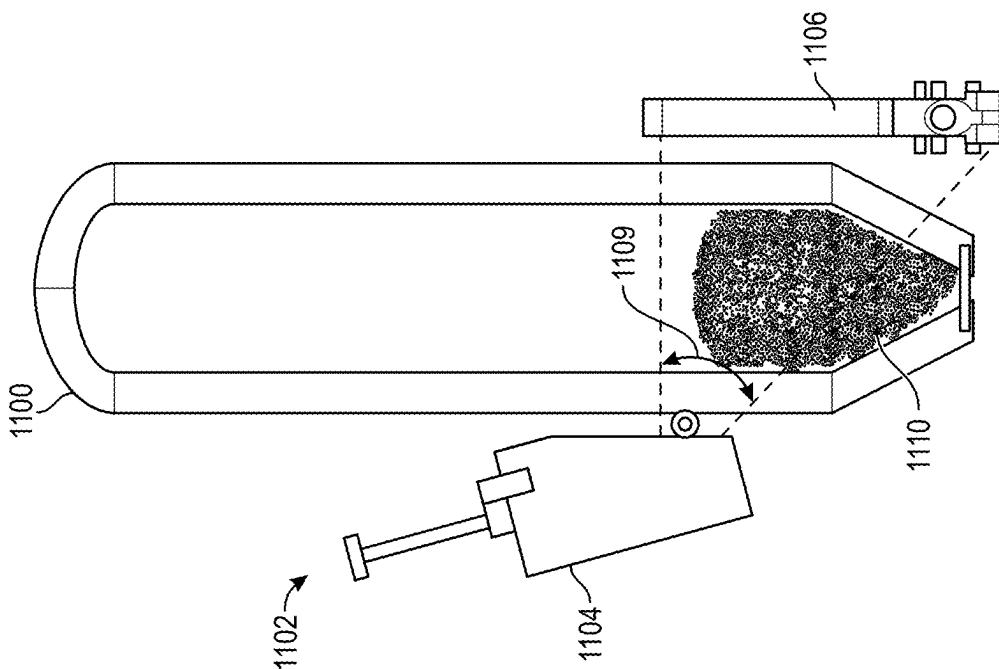


FIG. 11C

1200

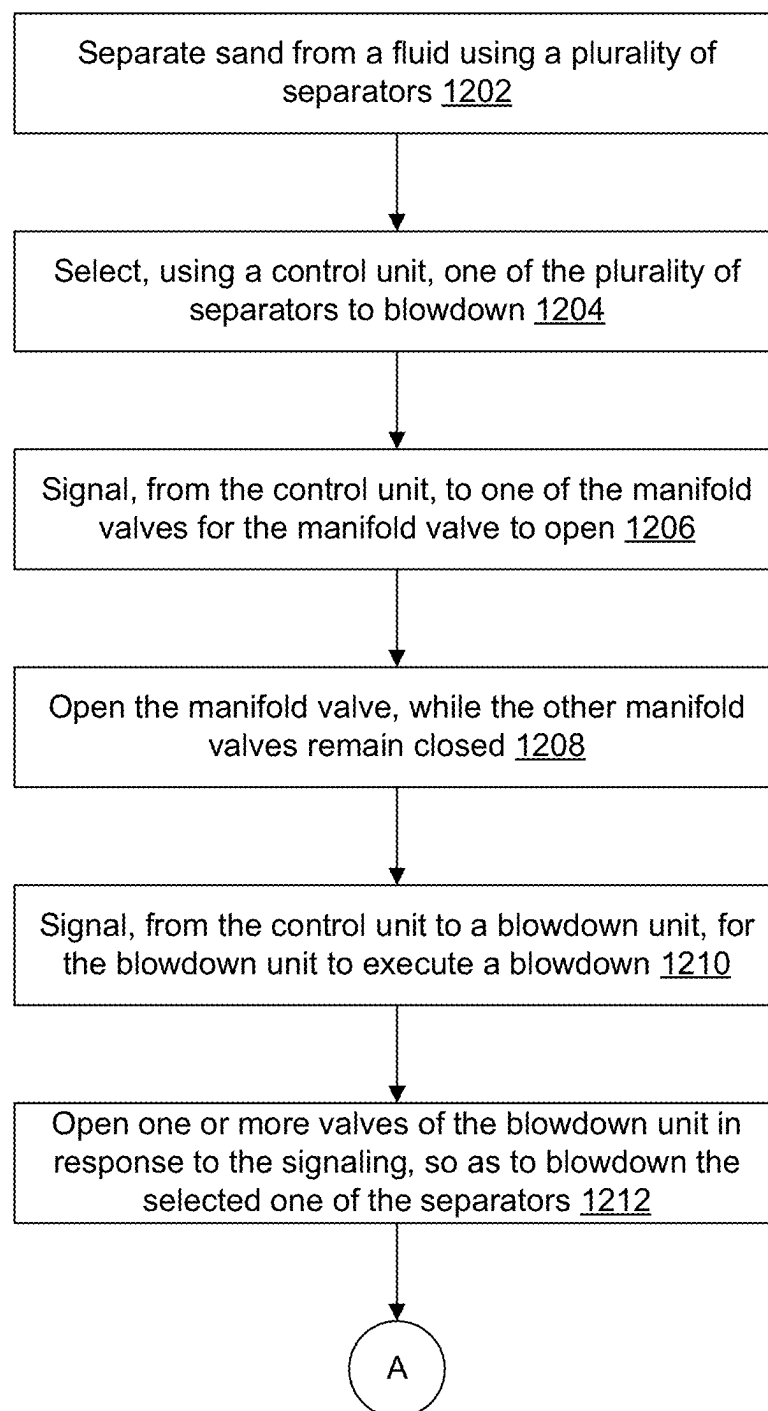


FIG. 12A

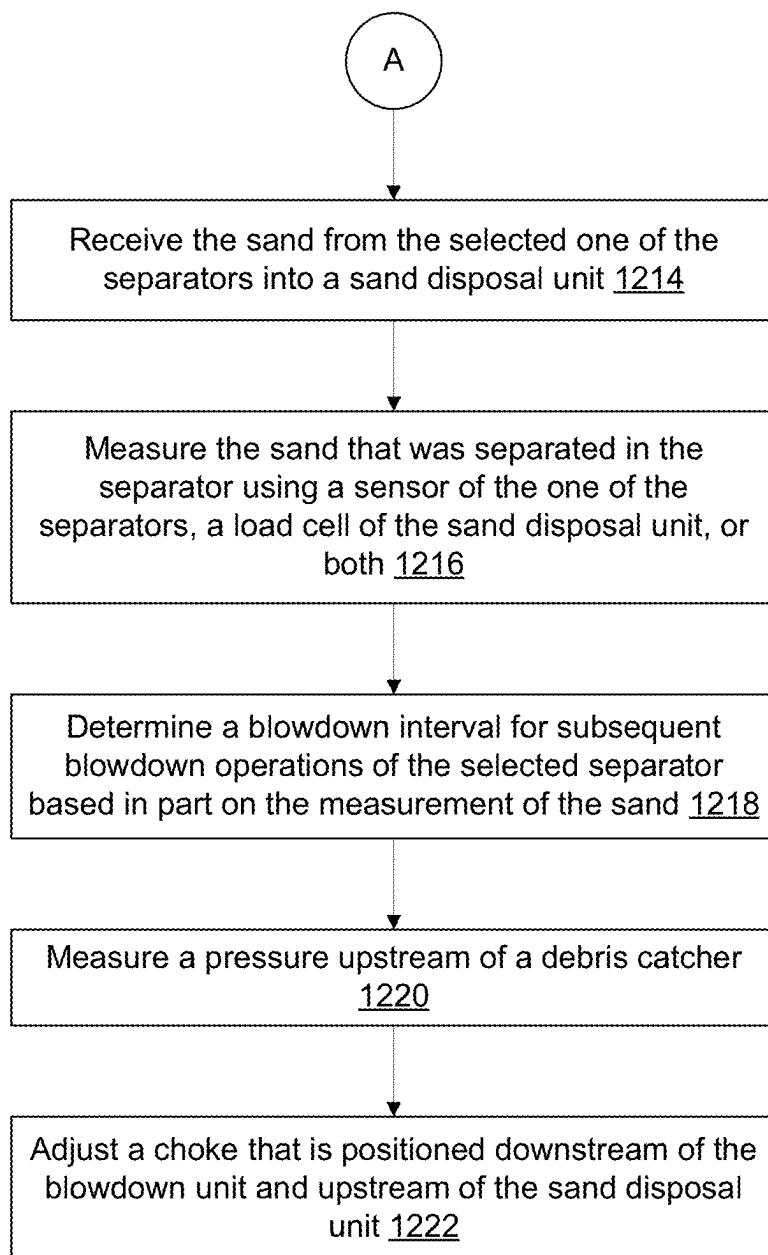
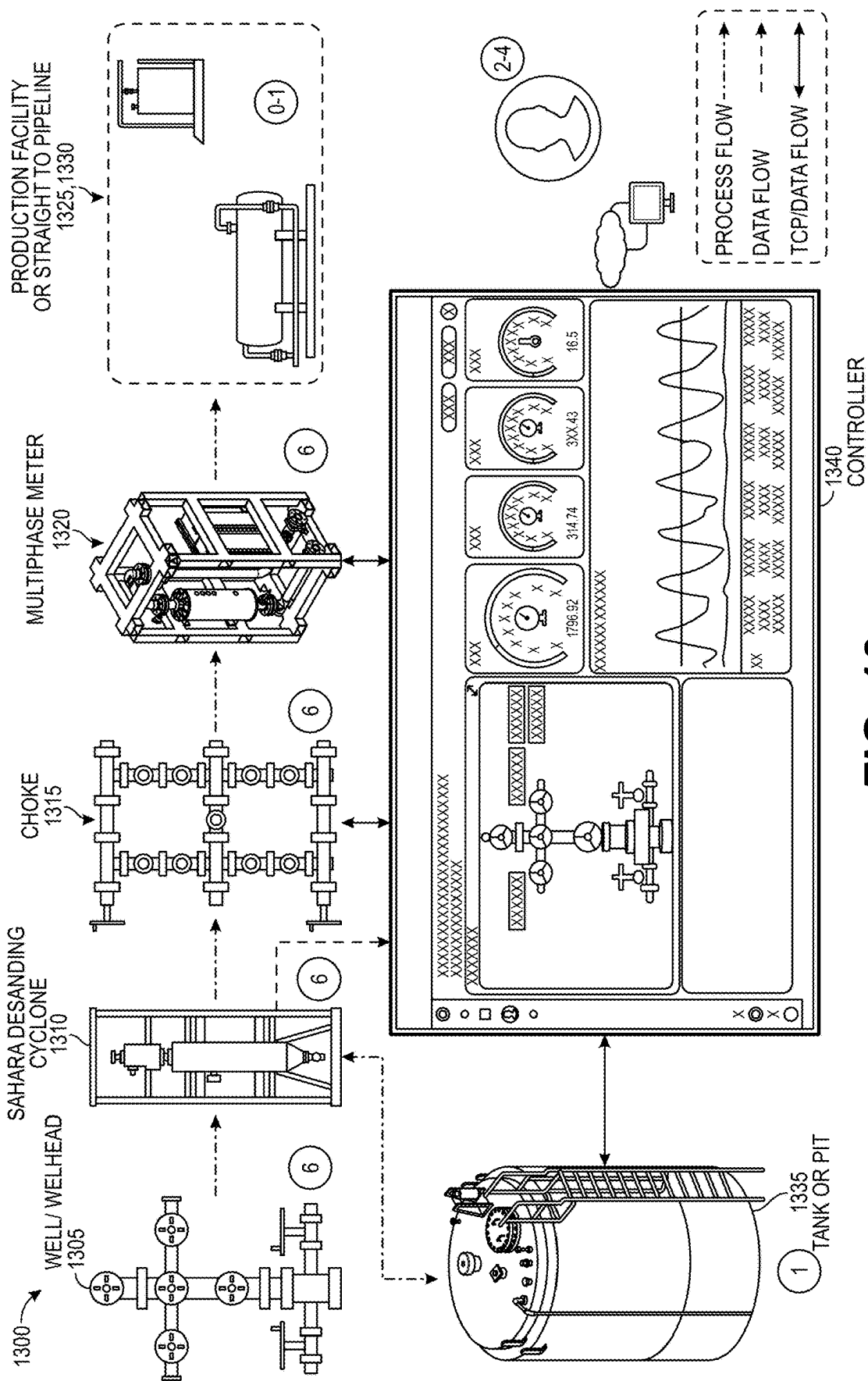
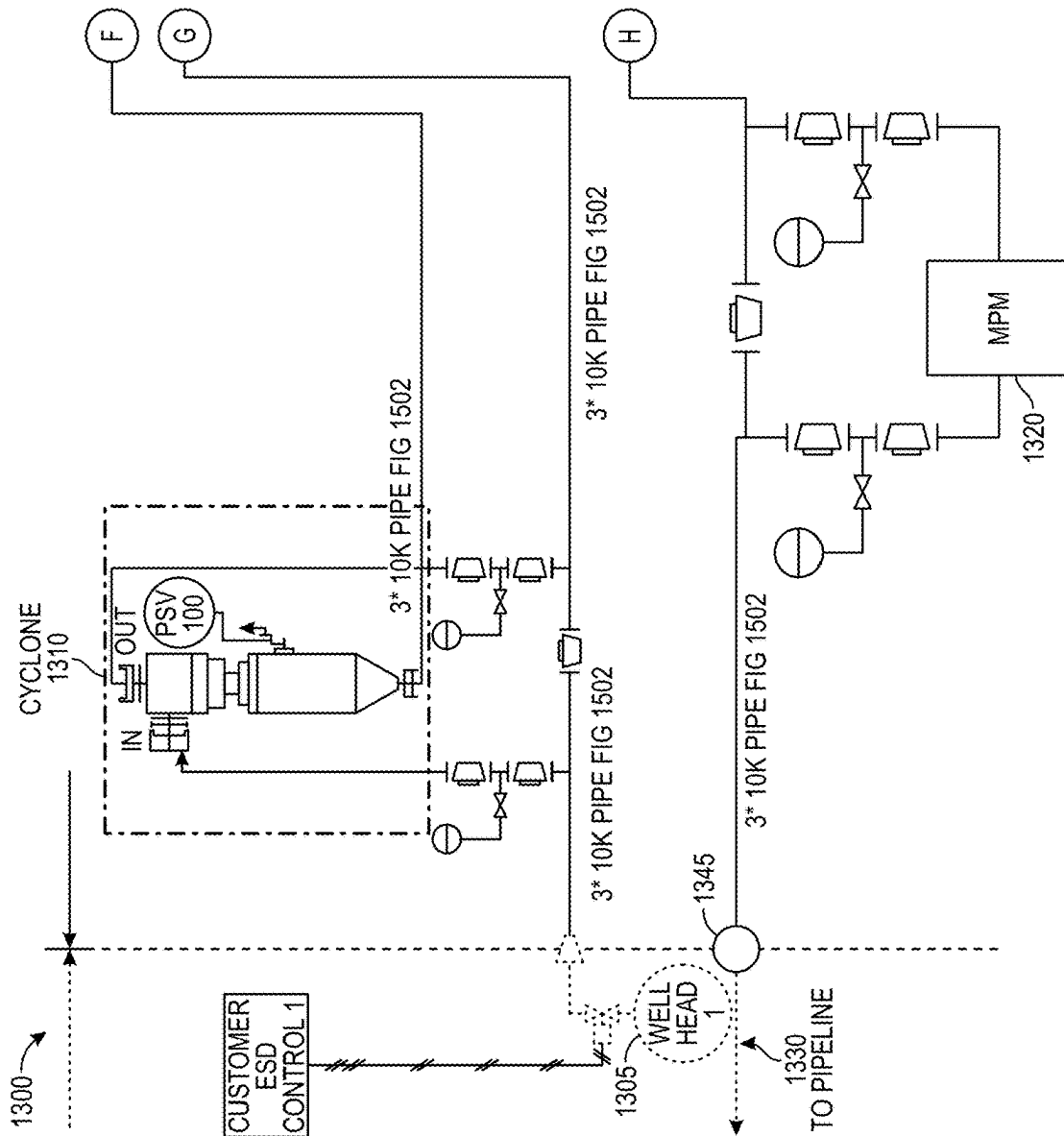
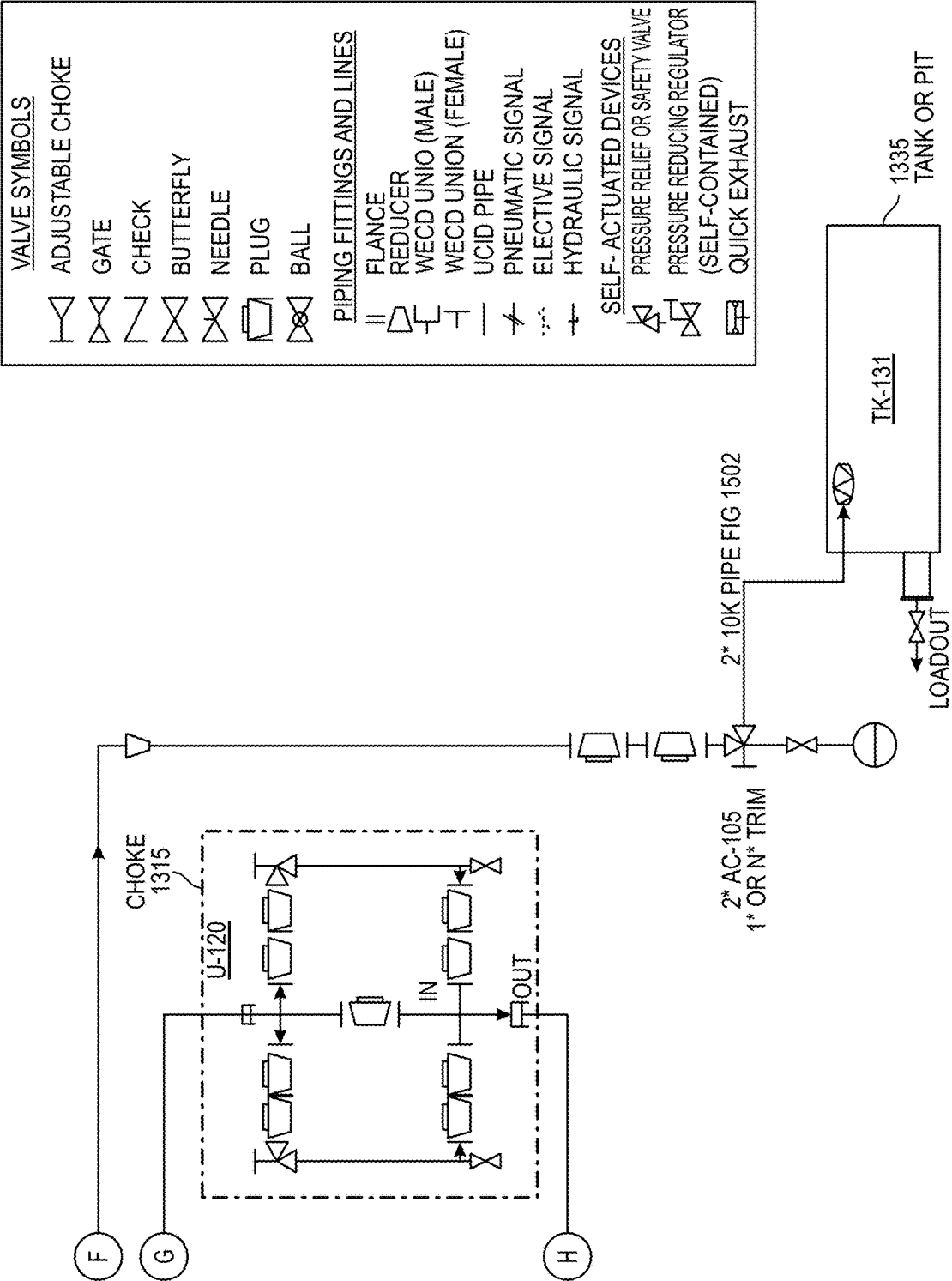


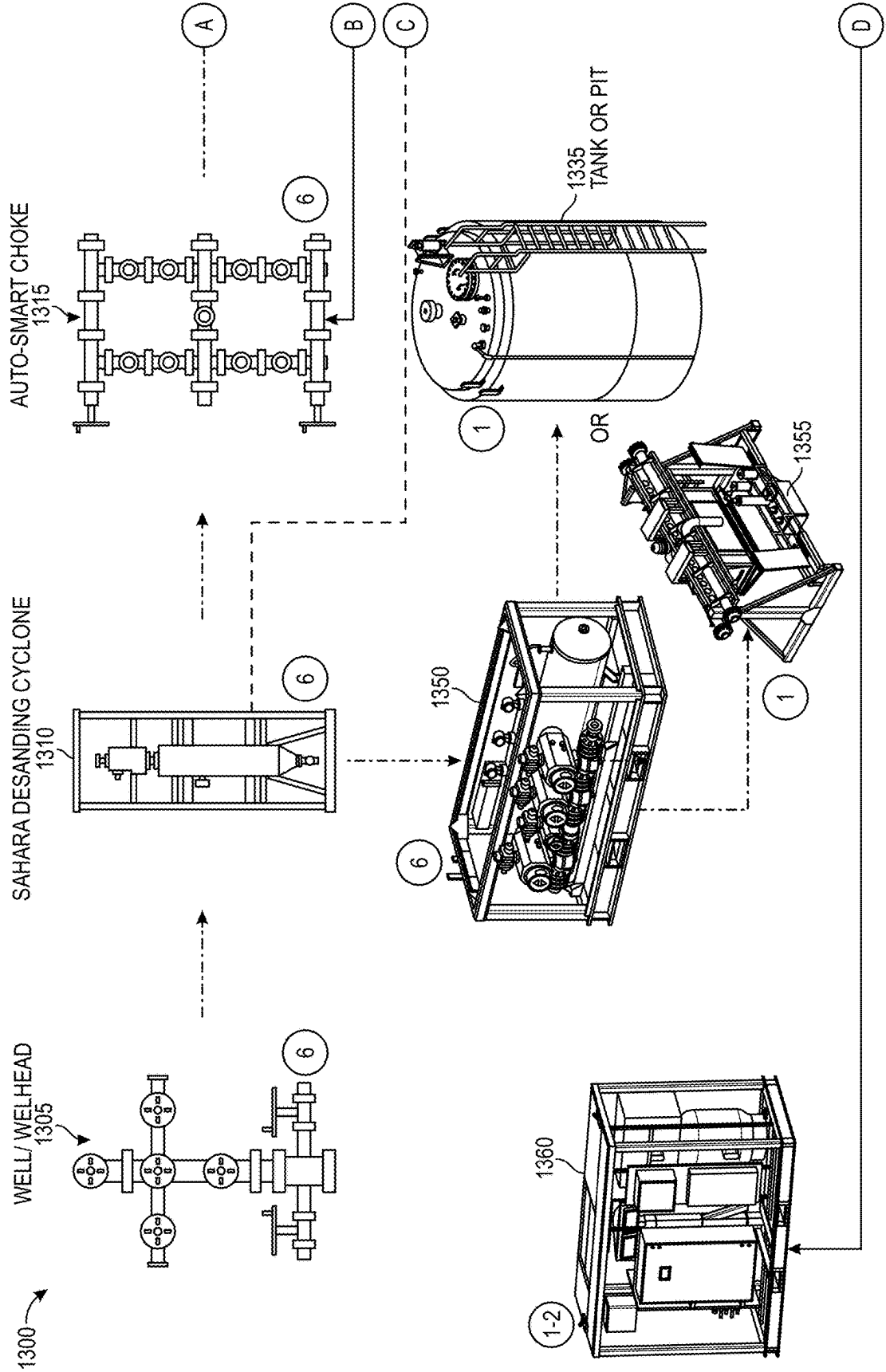
FIG. 12B

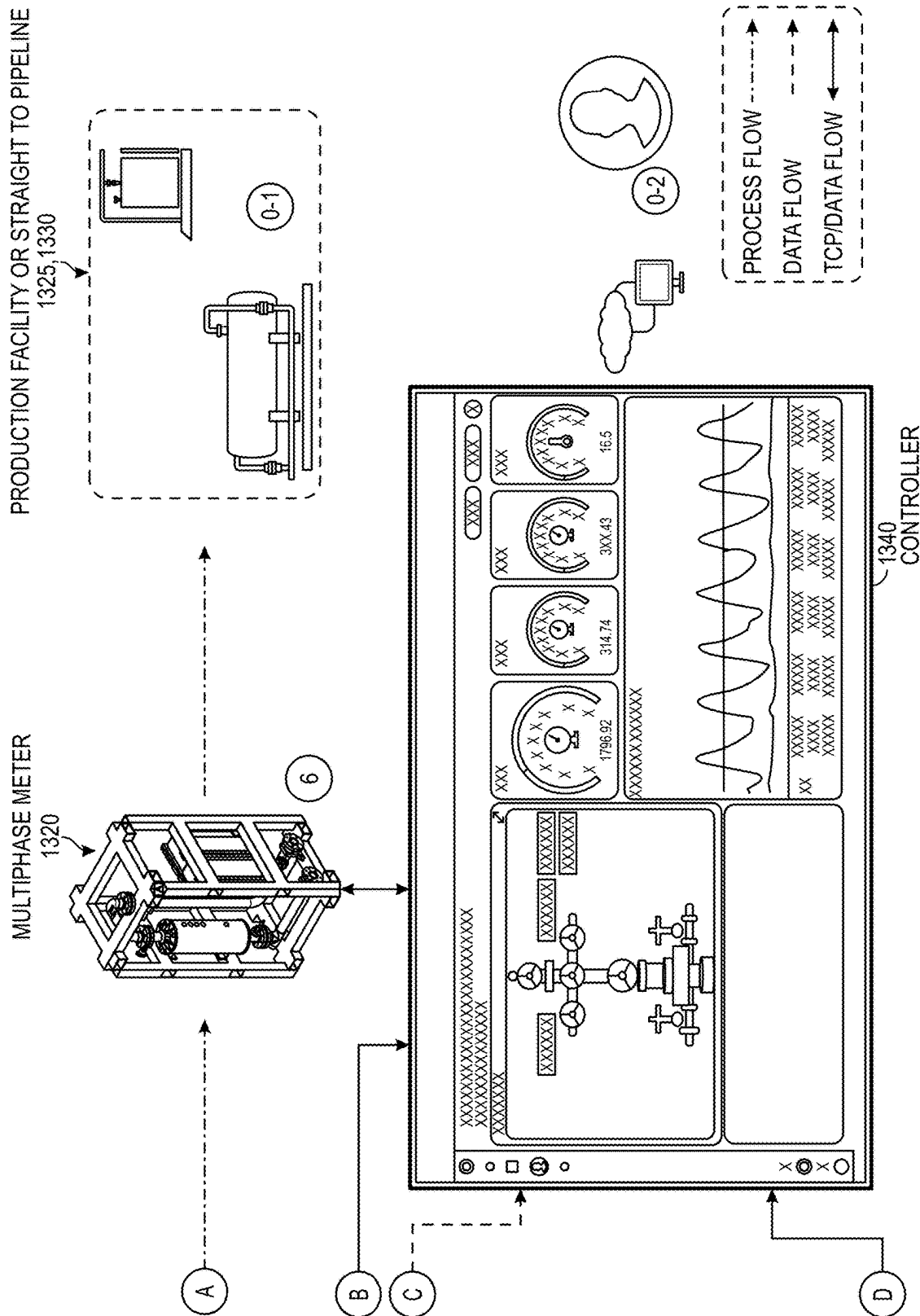




<u>ABERVIATIONS</u>	
AC	ADJUSTABLE CHOKE
CV	CHECK VALVE
DPI	DIFFERENTIAL PRESSURE INDICATOR
DPSH	DIFFERENTIAL PRESSURE SAFETY HIGH
ESD	EMERGENCY SHUT DOWN
MR	MANUAL RELAY (PULL TO CHARGE)
PR	PRESSURE REDUSER
PI	PRESSURE INDICATOR
PSHL	PRESSURE SAFETY HIGH LOW
PSV	PRESSURE SAFETY VALVE
QE	QUICK EXHAUST
SSV	SERVICE SAFETY VALVE
SDV	SHUT DOWN VALVE
PIT	PRESSURE INDICATING TRANSMITTER
PDIT	PRESSURE DIFFERENTIAL INDICATING TRANSMITTER
M	ELECTRIC VALVE ACTUATOR
JB	JUNCTION BOX
	<u>EQUIPMENT CLASSIFICATION</u>
TK	TANKS
U	MISCELLANEOUS EQUIPMENT
V	VESSELS
W	WELL HEAD







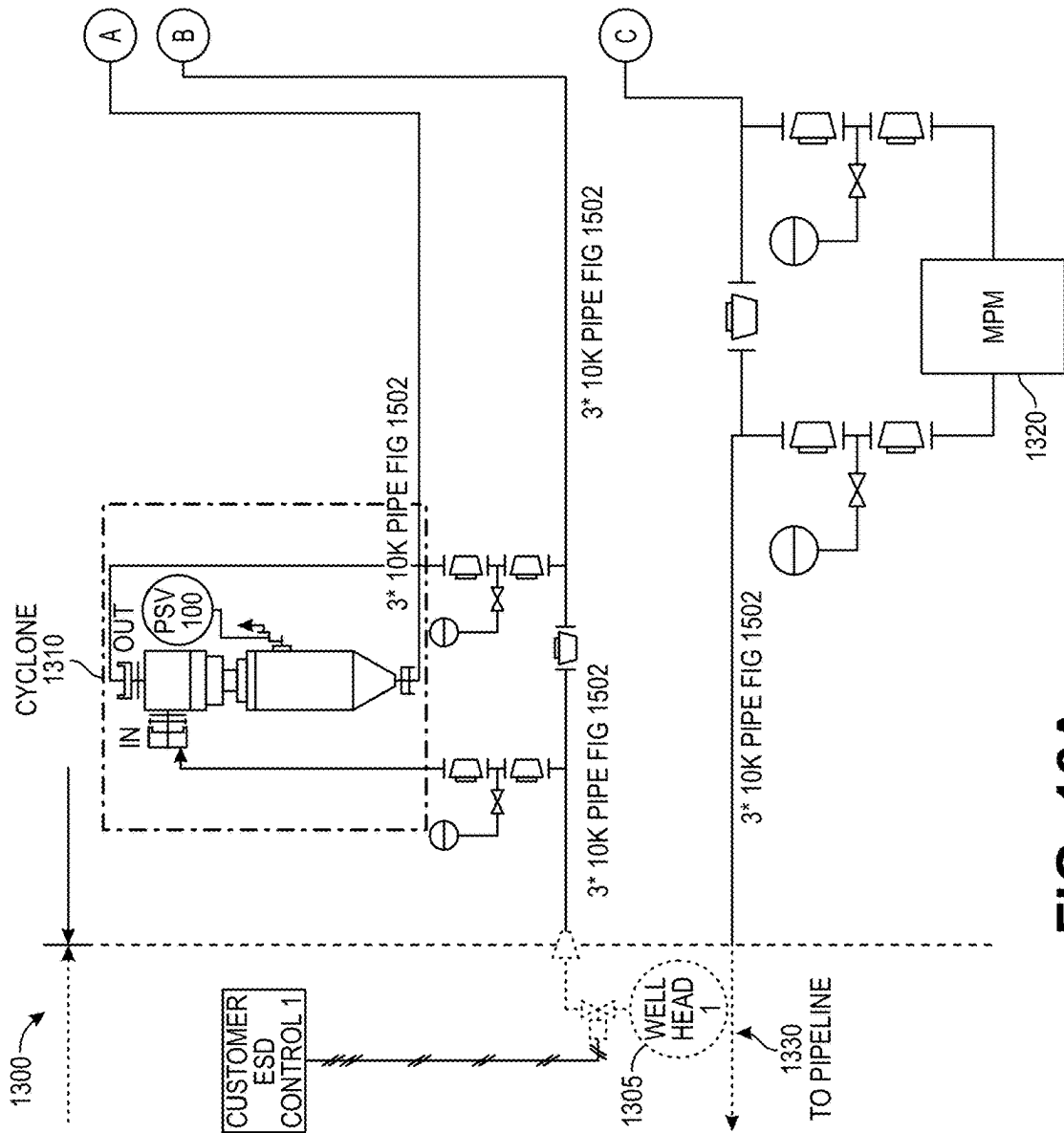


FIG. 16A

ABERVIATIONS	
AC	ADJUSTABLE CHOKE
CV	CHECK VALVE
DPI	DIFFERENTIAL PRESSURE INDICATOR
DPSH	DIFFERENTIAL PRESSURE SAFETY HIGH
ESD	EMERGENCY SHUT DOWN
MR	MANUAL RELAY (PULL TO CHARGE)
PR	PRESSURE REDUSER
PI	PRESSURE INDICATOR
PSHL	PRESSURE SAFETY HIGH LOW
PSV	PRESSURE SAFETY VALVE
QE	QUICK EXHAUST
SSV	SERVICE SAFETY VALVE
SDV	SHUT DOWN VALVE
PIT	PRESSURE INDICATING TRANSMITTER
PDIT	PRESSURE DIFFERENTIAL INDICATING TRANSMITTER
M	ELECTRIC VALVE ACTUATOR
JB	JUNCTION BOX
EQUIPMENT CLASSIFICATION	
TK	TANKS
U	MISCELLANEOUS EQUIPMENT
V	VESSELS
W	WELL HEAD

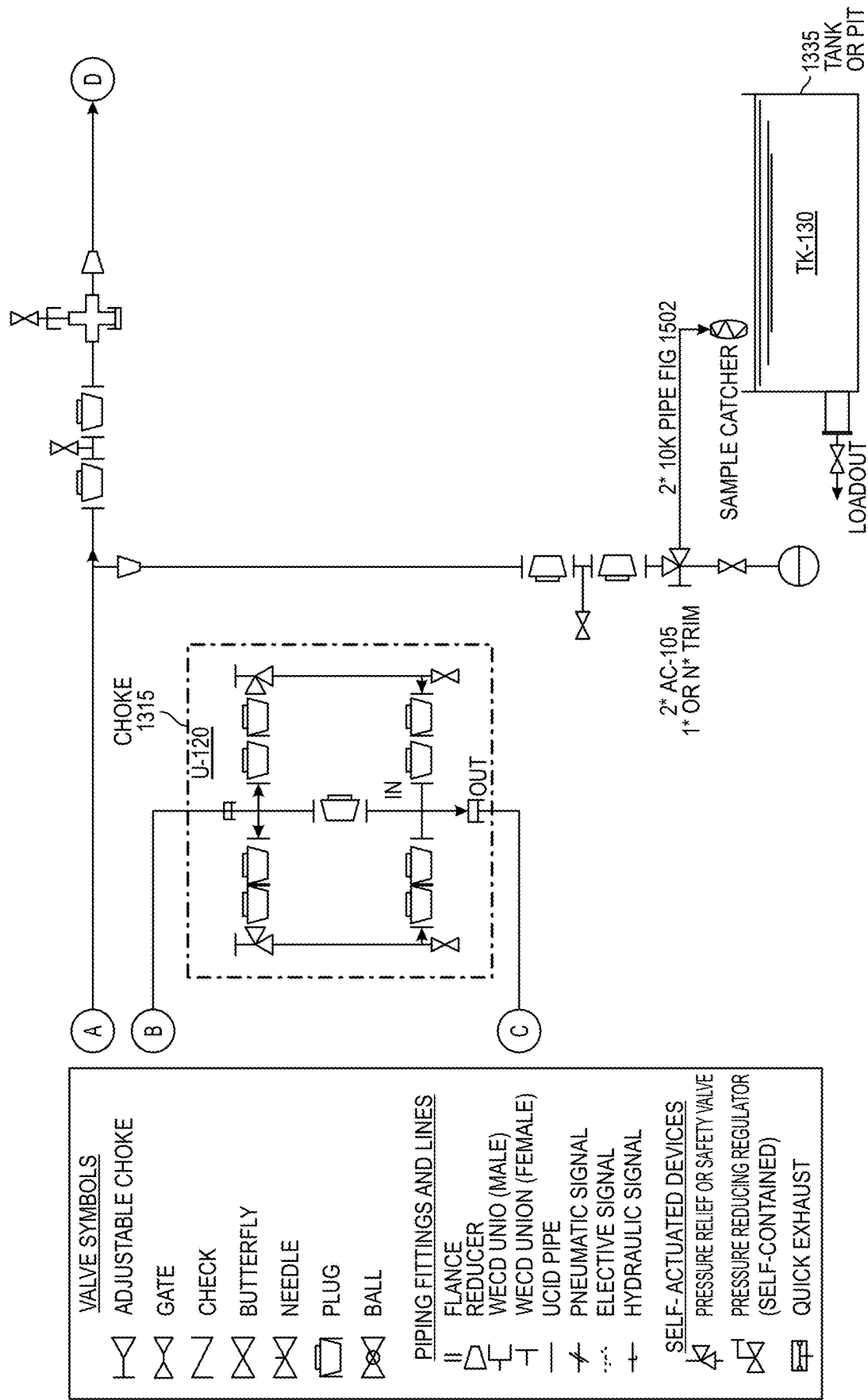


FIG. 16B

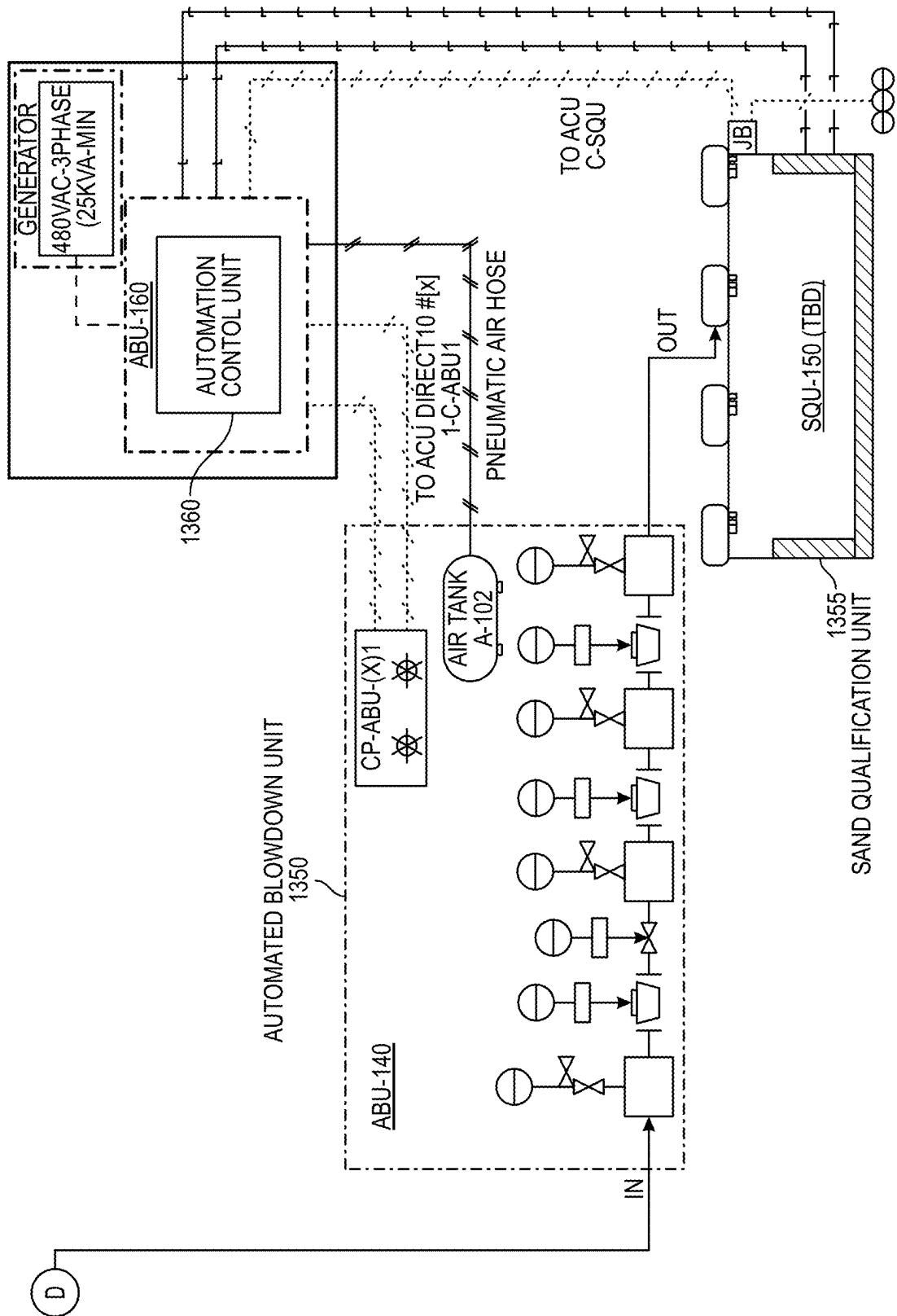


FIG. 16C

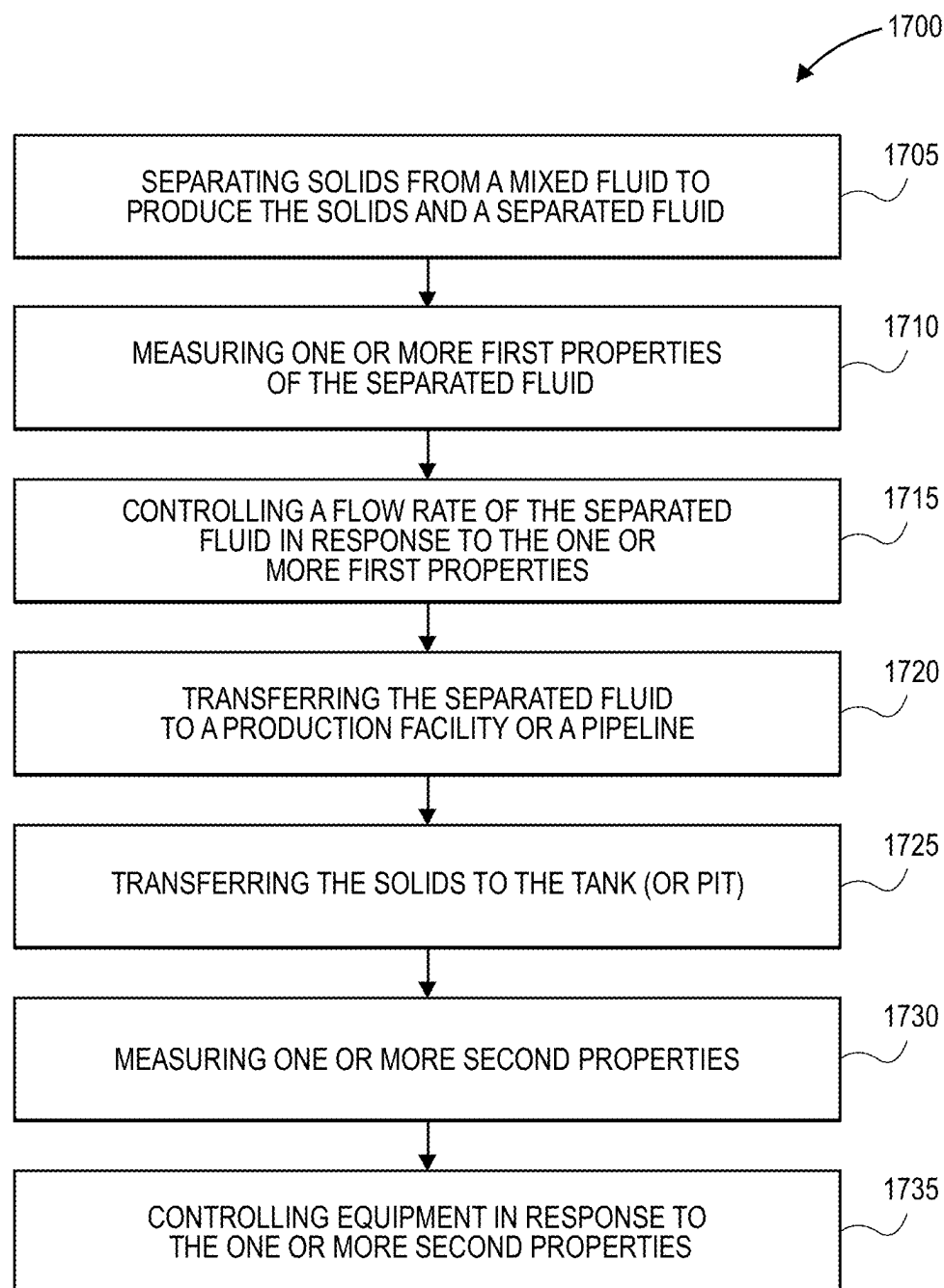


FIG. 17

SAND SEPERATION CONTROL SYSTEM AND METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application No. 63/640,837, filed on Apr. 30, 2024, which is incorporated by reference. This application is also a continuation-in-part of U.S. patent application Ser. No. 18/338,944, filed on Jun. 21, 2023, which is a continuation-in-part of U.S. patent application Ser. No. 17/513,333, which was filed on Oct. 28, 2021 and is a continuation of U.S. patent application Ser. No. 17/096,490, which was filed on Nov. 12, 2020, and claims priority to U.S. Provisional Patent Application Ser. No. 62/957,585, which was filed on Jan. 6, 2020. Each of these applications is incorporated herein by reference in its entirety.

BACKGROUND

[0002] Hydraulic fracturing is a well-treatment process in which preferential flowpaths for hydrocarbons are established in a subterranean rock formation. The flowpaths are established by pumping a fluid at high pressure into a well to initiate fractures in the rock formation. The fracturing fluid may be predominately water, but may also include solids, such as sand or ceramic proppants, which at least partially fill the fractures and keep the fractures open, maintaining the preferential flowpaths through the rock after the process is complete.

[0003] When oil, water, or other fluids are produced/recovered from the well, it may be desirable to remove sand or other solids from the fluid. A separator system may be used for this purpose, and may include one or more separation devices (e.g., cyclonic separators), filters, screens, tanks, etc. The separated solids may be stored in the tank, which is periodically emptied or “blown down,” while the fluids may be further separated (e.g., to separate hydrocarbons from water). Recovered hydrocarbons may be stored or otherwise transported for sale, and recovered water may be stored or otherwise recirculated for use in the well.

[0004] In some cases, it may be desirable to determine the amount of solids separated from the fluid in the separator, and/or the rate at which solids accumulate in the tank. In order to do this, the solids from the separator may be run through a “sock” during blowdown operations, which may catch the solids while allowing the fluid to flow through. The sock is then weighed, which reveals the amount of solids collected therein between blowdown operations. However, such a manual process exposes operations to worker-related delays and calls for the sock to be removed and weighed after each blowdown, which can be time and labor intensive. Moreover, the manual processes are not well-suited to managing blowdown operations in multi-separator and/or multi-well systems.

SUMMARY

[0005] A sand separation system is disclosed. The system includes one or more separators configured to receive a mixed fluid from one or more wells or wellheads and to separate solids from the mixed fluid to produce the solids and a separated fluid. The system also includes one or more chokes downstream from and in fluid communication with the one or more separators. Each of the one or more chokes

is configured to receive the separated fluid from a corresponding one of the one or more separators and to control a flow rate of the separated fluid therethrough. The system also includes one or more multiphase meters downstream from and in fluid communication with the one or more chokes. Each of the multiphase meters is configured to measure one or more first properties of the separated fluid and to adjust the one or more chokes in response to the one or more first properties. The separated fluid is transferred from the one or more chokes or the one or more multiphase meters to a production facility or a pipeline.

[0006] A method for operating a sand separation system is also disclosed. The method includes separating solids from a mixed fluid using a separator to produce the solids and a separated fluid. The mixed fluid is received by the separator from a well or a wellhead. The method also includes measuring one or more first properties of the separated fluid using a multiphase meter. The method also includes controlling a flow rate of the separated fluid using a choke in response to the one or more first properties. The method also includes transferring the separated fluid to a production facility or a pipeline after the flow rate is controlled.

[0007] A sand separation system is disclosed. The system includes one or more separators configured to separate solids from a mixed fluid and to produce the solids and a separated fluid. The system also includes one or more chokes configured to receive the separated fluid from a corresponding one of the one or more separators and to control a flow rate of the separated fluid therethrough. The system further includes one or more multiphase meters configured to measure one or more first properties of the separated fluid and to adjust the one or more chokes in response to the one or more first properties. Additionally, the system includes a controller configured to measure more or more second properties of one or more separators, the one or more chokes, the one or more multiphase meters, the separated fluid, or combination thereof. The controller is configured to adjust the one or more separators and/or the one or more chokes in response to the one or more second properties.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The present disclosure may best be understood by referring to the following description and the accompanying drawings that are used to illustrate embodiments of the invention. In the drawings:

[0009] FIG. 1 illustrates a schematic view of a sand separation system, according to an embodiment.

[0010] FIG. 2 illustrates a schematic view of a well and a separator of the sand separation system, according to an embodiment.

[0011] FIG. 3A illustrates a schematic view of a blow-down unit of the sand separation system, according to an embodiment.

[0012] FIG. 3B illustrates a schematic view of another embodiment of the blowdown unit.

[0013] FIG. 4 illustrates a schematic view of a sand disposal unit of the sand separation system, according to an embodiment.

[0014] FIG. 5 illustrates a schematic view of a central controller of the sand separation system, according to an embodiment.

[0015] FIG. 6 illustrates a flowchart of a method for blowdown and leak detection/mitigation to assist in automatically controlling a sand separation system, according to an embodiment.

[0016] FIG. 7 illustrates a flowchart of a method for automatically controlling a sand separation system, according to an embodiment.

[0017] FIG. 8 illustrates a schematic view of a sand separation system, according to an embodiment.

[0018] FIG. 9 illustrates a schematic view of a sand separation system, according to an embodiment.

[0019] FIG. 10 illustrates a side, cross-sectional view of a separator of any one of the foregoing systems, according to an embodiment.

[0020] FIG. 11A, FIG. 11B, FIG. 11C, and FIG. 11D illustrate side, schematic views of an accumulator for a separator, which may be provided with an external sand-level detector, according to an embodiment.

[0021] FIG. 12A and FIG. 12B illustrate a flowchart of a method for operating a sand separation system, according to an embodiment.

[0022] FIG. 13 illustrates a schematic view of another sand separation system, according to an embodiment.

[0023] FIG. 14A and FIG. 14B illustrate another schematic view of the sand separation system in FIG. 13, according to an embodiment.

[0024] FIG. 15A and FIG. 15B illustrate a schematic view of the sand separation system in FIG. 13 with additional equipment, according to an embodiment.

[0025] FIG. 16A, FIG. 16B and FIG. 16C illustrate another schematic view of the sand separation system in FIG. 15, according to an embodiment.

[0026] FIG. 17 illustrates a flowchart of a method for operating a sand separation system, according to an embodiment.

DETAILED DESCRIPTION

[0027] The following disclosure describes several embodiments for implementing different features, structures, or functions of the invention. Embodiments of components, arrangements, and configurations are described below to simplify the present disclosure; however, these embodiments are provided merely as examples and are not intended to limit the scope of the invention. Additionally, the present disclosure may repeat reference characters (e.g., numerals) and/or letters in the various embodiments and across the Figures provided herein. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed in the Figures. Moreover, the formation of a first feature over or on a second feature in the description that follows may include embodiments in which the first and second features are formed in direct contact, and may also include embodiments in which additional features may be formed interposing the first and second features, such that the first and second features may not be in direct contact. Finally, the embodiments presented below may be combined in any combination of ways, e.g., any element from one exemplary embodiment may be used in any other exemplary embodiment, without departing from the scope of the disclosure.

[0028] Additionally, certain terms are used throughout the following description and claims to refer to particular components. As one skilled in the art will appreciate, various

entities may refer to the same component by different names, and as such, the naming convention for the elements described herein is not intended to limit the scope of the invention, unless otherwise specifically defined herein. Further, the naming convention used herein is not intended to distinguish between components that differ in name but not function. Additionally, in the following discussion and in the claims, the terms “including” and “comprising” are used in an open-ended fashion, and thus should be interpreted to mean “including, but not limited to.” All numerical values in this disclosure may be exact or approximate values unless otherwise specifically stated. Accordingly, various embodiments of the disclosure may deviate from the numbers, values, and ranges disclosed herein without departing from the intended scope. In addition, unless otherwise provided herein, “or” statements are intended to be non-exclusive; for example, the statement “A or B” should be considered to mean “A, B, or both A and B.”

Flowback 1.0

[0029] FIG. 1 illustrates a schematic view of a sand separation system 100, according to an embodiment. The system 100 is described herein in terms of separating sand, but it will be appreciated that in some contexts, “sand” may refer to particulate matter of various types, including, for example, ceramic proppant and the like, which may be injected and recovered from a well. The system 100 may include one or more separators (three shown: 102, 104, 106), which may each be coupled to and configured to receive a mixture of sand and fluids from a well 108, 110, 112, respectively. In the illustrated embodiment, one separator 102-106 is provided for each individual well 108-112, but it will be appreciated that in other embodiments, a single separator 102-106 may receive fluid from two or more wells 108-112 and/or two or more separators 102-106 may receive fluid from a single well 108-112.

[0030] The separators 102-106 may be configured to separate at least a portion of the sand from the fluids produced from the wells 108-112. The separated fluid may be routed through an outlet 114, 116, 118 of each separator 102-106 and delivered, e.g., to a production separator or another device or location. The sand, along with some of the fluid, that is separated from the mixture, may be temporarily stored in the separator 102-106. For example, the separators 102-106 may each provide a hopper, or another type of pressurized tank, which may, during normal operation, fill with the sand as it is separated. Before the sand entirely fills the separator 102-106, it may be removed therefrom, i.e., a “blowdown” process is executed.

[0031] Accordingly, the system 100 may include one or more blowdown units (three are shown: 120, 122, 124). For example, one blowdown unit 120-124 may be provided for each separator 114-116; however, it will be appreciated that this one-to-one configuration is merely an example, and two or more blowdown units 120-124 could be used for a single separator 102-106 and/or a single one of the blowdown units 120-124 could be provided for two or more of the separators 102-106. As will be described in greater detail below, the blowdown units 120-124 may include, among other things, one or more valves that are actuatable to control blowdown of the separators 102-106 associated therewith. Further, as indicated by the dashed lines between the blowdown units 120-124 and the separators 102-106, the blowdown units 120-124 may be configured to communicate with the sepa-

rators **102-104**. For example, the separators **102-106** may be provided with various chokes and/or pressure transducers, which may provide electrical data and/or control signals to the blowdown unit **120-124**.

[0032] When the blowdown units **120-124** initiate a blowdown procedure, one or more valves therein, which are in fluidic communication with the separators **102-106**, are opened, allowing the sand (e.g., as a slurry of sand and fluid) to flow out of the separators **102-106**, through the blowdown units **120-124**, and into a sand disposal unit **126**. In some embodiments, the sand disposal unit **126** may include a sand quantification feature, which may be configured to provide data representing an amount of sand that was stored in the separator **102-106** between blowdowns. For example, the sand disposal unit **126** may provide the sand quantification feature using load cells, e.g., as disclosed in U.S. Provisional Patent Application No. 62/930,175, which is incorporated herein by reference in its entirety. In other embodiments, such a sand quantification feature may be provided within the separator **102-106** itself. For example, the separators **102-106** may include load cells, such as the separators described in U.S. Provisional Patent Publication No. 2019/0388907, which is incorporated herein by reference in its entirety, to the extent not inconsistent with the disclosure herein. In another embodiment, the separators **102-106** may include other types of sensors that are able to detect an amount of sand that is in the separators **102-106**, e.g., as described in U.S. patent application Ser. No. 16/711,561 and/or U.S. Provisional Patent Application No. 62/946,520, which are both incorporated by reference herein in their entirety, to the extent not inconsistent with the present disclosure.

[0033] The system **100** may also include a central controller (or “control system” or “control unit”) **130**, which may communicate at least with the blowdown units **120-124**. The central controller **130** may also communicate with the sand disposal unit **126**, e.g., in cases where the sand disposal unit **126** includes the sand quantification feature. The central controller **130** may be in communication with the blowdown units **120-124** via electric communication and/or the separators **102-106**. For example, the central controller **130** may send signals to the blowdown units **120-124** commanding the blowdown units **120-124** to open individual valves thereof, e.g., to initiate or terminate a blowdown procedure, mitigate valve malfunctioning, shut-off blowdown capabilities, etc. Further, the central controller **130** may be configured to receive feedback signals from the blowdown units **120-124**, e.g., pressure and/or flow measurements at specific locations therein and/or in the separators **102-106**. Additionally, the central controller **130** may include hardware enabling communication with local and/or remote operators, e.g., through a human-machine interface. For example, the central controller **130** may include output devices such as a computer terminal, an antenna for wireless communication, a web portal connection, etc. Additional details relevant to operation of the central controller **130**, according to various embodiments, are discussed below.

[0034] FIG. 2 illustrates a schematic view of the well **108** and the separator **102** of the system **100**, according to an embodiment. The separator **102** may also be representative of at least some embodiments of the separators **104** and **106**. As shown, the separator **102** includes a cyclonic separator **204** in combination with a tank **202**. In some embodiments, the cyclonic separator **204** may be positioned on top of the

tank **202**, such that the tank **202** supports the weight of the cyclonic separator **200**. The tank **202** may receive and temporarily store solids (e.g., sand) separated from the sand/fluid mixture received at an inlet **214** of the separator **200**. The tank **202** may also include a blowdown outlet **206**. The blowdown outlet **206** may connect to the blowdown unit **120**, as noted above, such that the blowdown unit **120** may be considered “downstream” of the blowdown outlet **206**, in the sense that fluid flows toward the blowdown unit **120**.

[0035] The separator **102** may also include one or more pressure transducers (two shown: **208**, **210**). These transducers (or others) **208**, **210** may be in (e.g., electric) communication with a junction **212**. The junction **212**, in turn, may be in communication with the central controller **130**, e.g., via the blowdown unit **120**. That is, in at least one embodiment, the junction **212** may serve as an input for the blowdown unit **120**, which may send signals as an input to the central controller **130**. In other embodiments, the junction **212** may communicate directly with the controller **130** and/or may communicate only with the blowdown unit **120**. The pressure transducer **210** may be positioned at an inlet **214** to the separator **102** and may measure pressure in the mixture of fluid and solids received from the well **108**. The pressure transducer **208** may be positioned in the outlet **114** and configured to measure the pressure of the separated fluid received therein. Various other pressure transducers may be employed, e.g., to measure pressure-drop between the inlet **214** and the outlet **206** and/or outlet **114** and/or across chokes or other flow control mechanisms.

[0036] In at least one embodiment, the separator **102** may include a load cell **220** configured to produce a signal representative of the weight of the sand separated from the incoming fluid by the cyclonic separator **204**. As mentioned above, in at least one embodiment, the load cell **220** may be contained at least partially within the tank **202**. For example, a sand hopper may be suspended within the tank **202** via a linkage that includes the load cell **220**, such that the load cell **220** is configured to measure a weight of the sand without measuring a weight of the tank **202** or the cyclonic separator **204** (or at least a portion of either/both), thereby potentially increasing an accuracy of the weight measurement. At some point, the increasing weight may indicate that the tank **202** is near capacity or otherwise ready to be blown down. In other embodiments, this load cell **220** may be omitted in view of the measurements taken at the sand disposal unit **126**, as described herein.

[0037] FIG. 3A illustrates a schematic view of the blowdown unit **120**, according to an embodiment. The blowdown unit **120** embodiment that is illustrated may also be representative of at least one embodiment of the other blowdown units **122**, **124**. The blowdown unit **120** may include a blowdown valve assembly **300**, which may be coupled to the blowdown outlet **206** of the separator **102** via an inlet **301**. The blowdown valve assembly **300** may be configured to initiate, control, and terminate the blowdown procedure for the separator **102**.

[0038] In an embodiment, the blowdown valve assembly **300** may include a shutdown valve **302**, a first valve **304**, and a second valve **306**. The first and second valves **304**, **306** may be plug valves, or any other suitable type of valve. The valves **302-306** may be in series, such that fluid flows through the valves **302-306** sequentially, one after the other, e.g., through a blowdown line **307** that extends from the inlet **301** and connects the valves **302-306** together. For example,

the shutdown valve **302** may be the first in the series, with the first valve **304** being downstream therefrom, and the second valve **306** being downstream from the first valve **304**. Downstream of the second valve **306**, the blowdown line **307** may be connected to an outlet **309**, which may be connected to the sand disposal unit **126**.

[0039] In addition, in some embodiments, the blowdown valve assembly **300** may include a bypass valve **308**. The bypass valve **308** may be in parallel with the valves **302-306**. For example, a bypass line **310** may connect to the blowdown line **307** upstream of the shutdown valve **302**, and then again to the blowdown line **307** downstream of the second valve **306**.

[0040] The valves **302, 304, 306** may be actuated between open positions (permitting fluid flow therethrough) and closed positions (blocking fluid flow therethrough) via respective control valves **312, 314, 316**. The control valves **312, 314, 316** are in turn coupled to a control power source, which in this embodiment, is an accumulator **320** that contains a pressurized gas (e.g., air) received via a pressure line **317**. The accumulator **320** may also be coupled with a pressure line **319**, which may lead to the accumulator of another one of the blowdown units (e.g., unit **122**, as shown). In other embodiments, the control power source could be a battery or another source of electric power, a hydraulic power source, or any other suitable source of power.

[0041] The control valves **312, 314, 316** are shown in an open configuration, directing pressure from the accumulator **320** to the individual valves **302, 304, 306**. In some embodiments, the first and second valves **304, 306** may be biased to their closed positions. Upon application of the pressure from the accumulator **320** via the control valves **314, 316**, the first and second valves **304, 306** may be individually actuated (e.g., lifted) to the open position, thereby permitting flow therethrough in the blowdown line **307**. Similarly, the shutdown valve **302** may have its closed position as a default and may be opened by application of pressure from the accumulator **320** via the control valve **312**. Actuating the control valves **312, 314, 316** to their closed positions may thus relieve pressure from the accumulator **320** to the valves **302-306**, which may cause them to close, or at least attempt to close, to block fluid flow through the blowdown line **307**. In some embodiments, the bypass valve **308** may be manually operated or operated using a separate control system. The bypass line **310** may thus normally be closed, and may be employed, e.g., in emergency situations.

[0042] The blowdown unit **120** may include one or more pressure transducers. For example, pressure transducers **322, 324, 326** may be positioned to measure pressure in the blowdown line **307**. For example, the pressure transducer **322** may be configured to measure pressure from the blowdown outlet **206**. In some embodiments, this pressure may be higher when the blowdown line **307** is closed (e.g., one or more of the valves **302-304** are closed) as opposed to when at least partially open. Further, the transducer **324** may measure a pressure in the line **307** between the first and second valves **304, 306**. When the first valve **304** is closed, the pressure in the line **307** between the first and second valves **304, 306** may be expected to drop, e.g., to ambient or at least to a pressure that is lower than the pressure at the inlet **301**. Similarly, the pressure transducer **326** may be positioned downstream of the second valve **306** and may be expected to read ambient or some other relatively low

pressure when the first and/or second valves **302, 304** are closed. When the valves **302-306** are open, pressure measured by the transducers **322-326** may be generally equal. In some embodiments, at least the pressure transducer **326** may be replaced or supplemented with a flow meter, so as to detect fluid flow past the second valve **306** and in the outlet **309**.

[0043] Another pressure transducer **328** may be coupled to the accumulator **320** or elsewhere in the control side of the blowdown unit **120**. The pressure transducer **328** may thus be configured to measure the pressure that is available to actuate the valves **302-306**.

[0044] The blowdown unit **120** may further include a junction box **330**. The junction box **330** may be coupled to the pressure transducers **322-328** and configured to receive electrical signals representing the pressures measured by each. Further, the junction box **330** may be coupled to the control valves **312-316** and may be configured to send a control signal thereto, which may cause the control valves **312-316** to actuate between the open and closed positions. Further, the junction box **330** may include or be coupled to a display panel **332**. The display panel **332** may include one or more lights **334, 336**, alarms, digital display panels, etc., configured to indicate a status (blowdown procedure underway, blowdown procedure ready, warning, etc.).

[0045] FIG. 3B illustrates another embodiment of the blowdown unit **300**. In this embodiment, a choke valve **350** may be included to control fluid flow in the line **107**. For example, the choke valve **350** may be a cyclonic valve or another type of valve that integrates a choke therein. Such a cyclonic valve may, for example, provide two plates, each with slots or other openings formed therein that may be rotated into or out of alignment. The choke valve **350** may include a variable cross-sectional flowpath area, which may be, at its largest, smaller than the cross-sectional flowpath area of the line **107**. As such, even when open, the valve **350** may create a pressure drop in the line **107**, which may mitigate or otherwise slow erosion of the valves **302, 304, 306** downstream.

[0046] Further, the position of the valve **350** (e.g., open, closed, partially open, or partially closed) may be modulated through the use of a pneumatic control valve **352**, which may have two or more positions. In some embodiments, the valve **350** may be the first valve (among valves **350, 304, and 306**) to open, and the last of valves **350, 302, 304** to close during normal blowdown operations. As such, the choke valve **350** may experience the highest pressures among the valves **302-306** and **350** of the blowdown valve assembly **300**. The choke valve **350** may, in some embodiments, be considered consumable and regularly replaced, and may prevent or at least forestall the other valves **302-306** from similarly being consumed. Alternatively, the valve **350** may be replaced by a fixed-orifice choke, which may likewise induce a pressure drop in the line **107** upstream of the valves **302-306**. Further, such an orifice could be placed between or downstream of any/all of the valves **302-306**, and embodiments that include multiple orifices are also contemplated herein.

[0047] FIG. 4 illustrates a schematic view of the sand disposal unit **126**, according to an embodiment. The sand disposal unit **126** may include a disposal container **400**, e.g., a tank that may be open to the air and thus at ambient pressure. A basket **402** may be positioned over the container **400** and may be configured to receive sand (and some fluid,

e.g., a slurry) from the separators **102-106** via the blowdown units **120-124**, as indicated. The basket **402** may include a screen or another type of filter media, such that, when a slurry of sand and fluid is received therein, the fluid drains out of the sand and into the container **400**. One or more load cells **404** may be provided to measure a weight of the basket **402**, from which the weight of the sand contained therein may be calculated. Further, a level sensor **405** (e.g., a float, viscosity sensor, etc.) may be positioned in the container **400** and configured to measure a level (or at least indicate when the level reaches a certain elevation) of the contents in the container **400**.

[0048] The basket **402** may include a bottom **406** that is openable via a hydraulic assembly **408** (or any other type of actuator assembly). The hydraulic assembly **408** is shown separate from the basket **402** in this schematic view, but it will be appreciated that the hydraulic assembly **408** may be configured to raise and lower the bottom **406**, e.g., pivotally, with respect to a remainder of the basket **402**. Thus, the hydraulic assembly **408** may be configured to dump the contents of the basket **402** into the container **400**.

[0049] In an embodiment, the sand disposal unit **126** may include an accumulator **410**, which may be coupled to a source of pressurized gas, e.g., air from a compressor. A pressure transducer **412** may be coupled to the accumulator **410**, so as to measure a pressure of the gas contained therein, e.g., to ensure that sufficient pressure is available in the accumulator **410**.

[0050] An air-over-hydraulic (AOH) system **416** may be provided as part of the sand disposal unit **126**. The AOH system **416** may receive pneumatic pressure from the accumulator **410** and may selectively employ the pneumatic pressure to actuate the hydraulic assembly **408** and thereby open and close the bottom **406**. Electrical or mechanical hydraulic options are also available for the system **416**, and thus an AOH embodiment should be considered merely as an example.

[0051] The sand disposal unit **126** may include a junction box **418**, which may be in electrical communication with the load cell(s) **404**, the level sensor **405**, the pressure transducer **412**, the AOH system **416**, and the central controller **130**. The junction box **418** may be operable to receive measurements from the load cell **404**, level sensor **405**, and the pressure transducer **412**, and may transmit these measurements to the central controller **130**.

[0052] In an embodiment, the level sensor **405** may communicate with the central controller **130** (or any other control system, e.g., a processor on-board the sand disposal unit **126**). The level sensor **405** feedback may be used to determine when the tank **400** is nearly full, and shut down blowdowns (and/or shut in the well(s)) to prevent such overflow. The feedback from the level sensor **405** may also serve as a trigger for empty the tank **400**. For example, when the level sensor **405** registers that the tank **400** is nearing full (or otherwise reaches a critical level), a vacuum truck may be notified to empty the tank **400**. Blowdown and/or other well operations may then recommence. As will be described in greater detail below, the level sensor **405** may also be employed to determine blowdown intervals and/or blowdown duration, potentially in combination with weight measurements from the load cell **404** (and/or **220**, FIG. 2).

[0053] Further, the junction box **418** may receive commands from the central controller **130**. For example, such commands may include opening or closing the bottom **406**

of the basket **402**. In an embodiment, the junction box **418** may send an electric signal to the AOH system **416**, which may actuate one or more valves thereof, causing the AOH system **416** to supply fluid to the hydraulic assembly **408**, and thereby open or close the bottom **406**.

[0054] The junction box **418** may also include a panel **420**, including one or more lights (two shown: **422**, **424**) and a weight indicator. The weight indicator may display a weight, which may be representative of the weight of the sand in the basket **402**. The lights **422**, **424** may display a status of the sand disposal unit **126**, e.g., ready for blowdown, ready for empty, emptying, low pneumatic pressure, warning of malfunction, etc.

[0055] FIG. 5 illustrates a schematic view of the central controller **130**, according to an embodiment. In addition to the central controller **130**, FIG. 5 also shows a light tower **501** and a compressor **503**. The compressor **503** may be coupled to any of the accumulators mentioned above and/or act as a source of pressurized fluid (e.g., air) for any other component of the system **100**.

[0056] The central controller **130** may include a programmable logic controller (PLC) **500**, microprocessor, or any other device(s) capable of executing computer-readable instructions and to cause the various components of the system **100** to perform operations. The PLC **500** may in turn include a blowdown control module **502**, a separator control module **504**, and a human-machine interface **506**. The blowdown control module **502** may include connections for the compressor **503**, the blowdown units **120-124**, and the sand disposal unit **126**. These connections may allow for input and output to/from the PLC **500**. For example, via the connection with the compressor **503**, the PLC **500** may control the speed, pressure, etc. of the compressor **503**. Via the connection with the blowdown units **120-124**, the PLC **500** may individually control the blowdown units **120-124**, causing the blowdown units **120-124** to perform a blowdown process (e.g., independently of one another). The PLC **500** may also be able receive sensor measurements from the blowdown units **120-124**, e.g., to determine whether the blowdown units **120-124** (e.g., the blowdown valve assemblies **300** thereof) are operating properly and/or have sufficient pneumatic pressure in the accumulator **320** to actuate the valves **302-306**. Moreover, via the connection with the blowdown units **120-124**, the PLC **500** may be configured to open/close individual valves **302-306** of the blowdown units **120-124**, e.g., using electric signals.

[0057] The PLC **500** may also be configured to communicate with the sand disposal unit **126** via the connection therewith. For example, the PLC **500** may receive sensor measurements therefrom, e.g., the weight of the sand in the basket **402** measured by the load cell(s) **404**. The PLC **500** may also be configured to send electric signals to the sand disposal unit **126**, e.g., so as to cause the bottom **406** to open or close (e.g., via command through the AOH system **416** and the hydraulic assembly **408**).

[0058] The PLC **500** may be in communication with the separators **102-106** via the separator control module **504**. Using this module **504**, the PLC **500** may be able to shutdown operation of the separators **102-106**, control flow rates, etc., via direct communication with the separators **102-106**, individually, e.g., by actuating one or more valves thereof. For example, one or more shutdown valves may be positioned upstream of the individual separators **102-106**, and may be closed to shutdown the separator **102-106**, and

potentially shut-in the well **108-112** to which it is connected. In some embodiments, the PLC **500** may communicate with

the system **100**. In a specific example, the prioritization hierarchy may be or include the following:

Priority	Scenario	Description	Action
1	High level tank	Sensor 405 indicates maximum tank level reached.	Shutdown valves 302 closed in each of the blowdown units 120-124. Provide notification to operator/vacuum truck provider.
2	Critical Leak Detected	Transducer 322 measures a pressure above a threshold and transducer 324 registers flow and/or pressure	Shutdown valve 302 closed in affected blowdown unit 120-124. Provide notification to operator.
3	Minor Leak Detected	Transducer 322 reads pressure below the critical threshold, but above another, lower threshold and/or transducer 324 register flow and/or pressure below critical	Activate leak mitigation routine and issue minor leak detection notification. If cycle counter is exceeded, issue minor leak detected alarm.
4	Blowdown from sensor trigger or internal scale	Setpoint trigger (e.g., weight of separator) received.	Perform blowdown and activate leak detection logic. If multiple calls for blowdown received, blowdown in the order received.
5	Scheduled Blowdown	Regularly scheduled blowdown time reached.	Perform when scheduled and activate leak detection logic.

the load cell **220** in the sensors **102-106** in lieu of or in addition to communicating with the sand disposal unit **126** to determine the amount of sand expelled during a blowdown.

[0059] The PLC **500** may be configured to provide output to and receive input from a local user via the HMI **506**. For example, the HMI **506** may provide for a manually-initiated blowdown, a manual dump of the basket **402**, a read out of the weight of the sand in the basket **402**, calibration (e.g., tare) of the load cell(s) **404**, blow down, a counter of the number of times blowdown operations have occurred, and plots of the historical blowdown (e.g., sand accumulation) data.

[0060] In addition to the PLC **500**, the central controller **130** may include hardware and/or software configured to provide a variety of other functions. For example, the central controller **130** may include a modem **510**, which may be configured to broadcast signals to a remote system and/or receive signals therefrom. This may allow for remote communication with the controller **130** and remote control thereof. For example, the modem **510** may be in communication with the PLC **500** so as to communicate data signals therewith.

[0061] The controller **130** may further include a light-tower controller **512**, which is coupled to the light tower **501** and configured to control the lights thereof. The controller **130** may also include a power source **514**, which may be coupled to an external source of power (e.g., a generator or municipal grid), and may be configured to convert AC power to (e.g., 12V or 24V) DC power. The controller **130** may further include a panel showing a status of the controller **130** and/or various components of the system **100**, e.g., when blowdown is initiated, detection of a malfunction, etc.

[0062] The controller **130** may provide a central control system for the system **100**, able to pass along commands and receive sensor measurements, e.g., system-wide. Thus, the controller **130** may enforce a prioritization hierarchy of commands or processes in response to a detected status of

[0063] FIG. **6** illustrates a flowchart of a method **600** for blowdown and leak detection/mitigation to assist in automatically controlling a sand separation system, e.g., the sand separation system **100**, according to an embodiment. Although a particular order for the steps of the method **600** is described, it will be appreciated that the steps may be executed in a different order and/or steps may be combined or separated.

[0064] The method **600** may begin by turning the system on, as at **602**. For example, the controller **130** may be energized by closing a relay connect the controller **130** to its power source. Likewise, the blowdown units **120-124** may be powered on, e.g., upon receipt of electrical and/or pneumatic power. The wells **108-112** may also be turned on, e.g., to commence production of fluids therefrom and into the separators **102-106**.

[0065] The method **600** may then include receive tank level data, e.g. from the sensor **405** regarding the level of sand, water, etc., contained in the container **400**, as at **604**. Further, the method **600** may include opening the shutdown valve **302** of at least one of the blowdown units **120-124** (e.g., blowdown unit **120**), as at **606**. At this stage, the first and second valves **304, 306** (and/or the choke valve **350**) of the blowdown unit **120** may be or remain closed, thereby preventing blowdown of the corresponding separator **102**.

[0066] The separator **102** may be operated normally, receiving and separating a mixture of sand or other solids and water or other fluids from a well **108**. Eventually, a blowdown trigger may be received, as at **610**. The trigger may be based on one or more pressures measured by the transducers **208** and/or **210** (e.g., a differential therebetween) in the separator **102**. Additionally or alternatively, the trigger may be the expiration of a timer or reaching a predetermined scheduled time for blowdown of the separator **102**.

[0067] Prior to initiating blowdown, however, the method **600** may include determining whether the level in the container **400** exceeds a maximum, as at **612**, e.g., using the

level sensor 405. The maximum may be predetermined or may be dynamic, e.g., varying on how much sand is typically received into the container 400 during a blowdown procedure.

[0068] If the container 400 level is at or above its maximum, the shutdown valve 302 may be returned to the closed position, and the controller 130 may be notified, as at 614. The controller 130 may thus take steps to notify rig personnel that the container 400 is full and should be emptied or drained, thereby avoiding unintended overfilling of the container 400. The controller 130 may also, based on this notification, prevent blowdown procedures from being initiated for other separators 102-106 of the system 100.

[0069] If the container 400 has capacity (e.g., lower than maximum level), the method 600 may proceed to determining a pre-blowdown sand level, as at 616. This may be determined using the sensor 404 (e.g., load cells attached to the basket 402) and/or the level sensor 405 in the tank 400 but could also or instead be derived by the weight of the separator 102.

[0070] The method 600 may then proceed to opening the choke valve 350, as at 617. The method 600 may then proceed to opening the first valve 304, as at 618. After a delay, the second valve 306 may then be opened, as at 620. Accordingly, if the valves 302-306 and 350 are functioning properly, the blowdown unit 120 may thus permit blowdown of the separator 102, such that its contents are emptied into the basket 402 via the blowdown line 307. During or after such blowdown, the sand level may again be determined, as at 622. The differences in the values of sand measured at 616 and 622 may thus be representative of the sand and/or fluids removed from the separator 102 during blowdown.

[0071] After a delay sufficient to allow for blowdown of the separator 102 (measured, e.g., from the opening of the second valve 306), i.e., a “blowdown duration”, the method 600 may include closing the choke valve 350 (if provided), as at 623 and then the first valve 304, as at 624. After a delay, e.g., to allow closure of the first valve 304, the method 600 may proceed to closing the second valve 306, as at 626.

[0072] At this stage, leakage detection and/or mitigation may be initiated. The method 600 may also include initializing a cycle counter, which may count the number of times valve closure is attempted, to one, as at 628. The method 600 may include receiving pressure measurements from one or more of the pressure transducer(s) (e.g., pressure transducer 324) of the blowdown unit 120, as at 630.

[0073] The method 600 may then include determining whether a leak in the valve(s) 304, 306 is apparent, as at 632. For example, if the pressure measurement received from the pressure transducer 324, between the first and second valves 304, 306 is higher than ambient, it may indicate that the first valve 304 is leaking. The second valve 306 may be provided, partially as a redundancy, to prevent unintended blowdown of the separator 102. As such, fluid leaking through the first valve 304 may tend to equalize the pressure between the pressure transducer 322 upstream of the first valve 304 and the pressure measured by the pressure transducer 324 downstream of the first valve 304. If the valve 304 is not leaking, the pressures measured by the pressure transducer 324 and the pressure transducer 326 may be approximately equal. If both the first and second valves 304, 306 are leaking, the pressure transducer 326 may read a pressure value approximately equal to that measured by the pressure transducer 322.

[0074] In some embodiments, pressure may be injected between the first and second valves 304, 306 to facilitate leak detection. For example, low-flow meters, which may be employed as the sensor (e.g., transducer) 324 downstream of the second valve 306, may not be entirely reliable. Accordingly, a fluid or gas may be injected into the line 307 between the first and second valves 304, 306 when the first and second valves 304, 306 are closed. The pressure may be measured using the pressure transducer 322. If the pressure reduces over time, without opening the first and second valves 304, 306, it may be evidence of a leak in either or both of the valves 304, 306.

[0075] If, based on the pressure measurements, the controller 130 determines that leakage is not occurring at 632, no leak mitigation may be called for, and the method 600 may return to awaiting the next blowdown trigger at 610. Otherwise, the method 600 may enter the leak mitigation phase. In this phase, the method 600 may check whether the cycle counter, which was initialized to one in block 628, is less than or equal to a maximum (e.g., two), as at 634. If the cycle counter is less than or equal to the maximum, the method 600 may attempt to wash out the first and/or second valves 304, 306, e.g., in case leakage is occurring because the valve(s) 304, 306 are being prevented from closing fully by sand. Accordingly, for example, the method 600 may include opening the second valve 306 and then opening the first valve 304, as at 636. The method 600 may then include closing the first valve 304 and then closing the second valve 306, as at 638. The method 600 may then proceed to incrementing the cycle counter, as at 640.

[0076] The method 600 may then receive the pressure measurements again at 630, and again determine whether a leak is detected at 632, based on these pressure measurements. If a leak is still indicated, the method 600 may determine if the number of leak mitigation cycles, as recorded by the cycle counter, remains less than the maximum at 634. If it is, another round of wash out attempts occurs at 636, 638. This process of washing out and determining if a leak is apparent may repeat for as many times as the counter allows. When the counter exceeds the maximum, the method 600 may determine that the first valve 304 and/or the second valve 306 is/are damaged, and may thus close the shutdown valve 302 and notify the controller 130, as at 614.

[0077] Further, when a leak is detected, the method 600 may include tolling blowdown of other separators (in this case, the separators 104 and 106). This may permit the leak mitigation process to proceed without interfering with the sand quantification for (or other aspects of) blowdown of the other separators 104, 106. For example, if leak mitigation is being performed for one separator 102 during a regularly scheduled blowdown for another separator 104, the blowdown of the separator 104 may be postponed. However, there may be a maximum tolling for blowdown of the other separator 104, so as to avoid flooding the separator 104. Thus, if leak mitigation for the separator 102 blowdown takes too long, it may be stopped to allow for blowdown of the other separator 104. Similarly, as noted above, sensor-initiated blowdowns may be queued if multiple are received in a short time period, so that blowdown of two separators does not occur simultaneously, in at least some embodiments.

[0078] The foregoing describes detecting leakage in the valves 302-306 of the blowdown valve assemblies 300 of the individual blowdown units 300. However, the method

600 may also include a redundancy measure which may enable checking for system-wide leakage. In particular, the method 600 may include monitoring the sand level in the tank 400 measured by the level sensor 1020 and/or the sand weight in the basket 402 measured by the load cell 404. If either or both of these measurements increase, indicating that sand and/or fluid is being received into the sand disposal unit 126, when none of the blowdown units 120-124 have been signaled to blowdown the separators 102-106, it may be inferred that one or more of the blowdown units 120-124 is permitting leakage. In response, the method 600 may implement the leak mitigation phase, as discussed above, for each of the blowdown units 120-124, further investigate the source of the leakage, shut down the system 100, call for maintenance, or otherwise take actions to avert any potential overfilling of the tank 400.

[0079] FIG. 7 illustrates a flowchart of a method 700 for automatically controlling a sand separation system, e.g., the sand separation system 100, according to an embodiment. Although a particular order for the steps of the method 700 is described, it will be appreciated that the steps may be executed in a different order and/or steps may be combined or separated.

[0080] The method 700 may include separating sand from a fluid produced from a well 108-112 using a plurality of separators 102-106, as at 702. The separators 102-106 may temporarily store the sand therein and provide the separated fluid to a production separator. The method 700 may also include signaling, from a controller 130 to a blowdown unit 120, to blowdown one of the separators (e.g., the separator 102), as at 704. This may be conducted automatically, e.g., at scheduled times or at intervals between blowdowns. In some embodiments, the blowdown may be conducted in response to a sensor-based trigger, e.g., a weight of the separator 102 reaching a particular threshold that indicates it is reaching its sand-storage capacity.

[0081] The method 700 may include opening one or more blowdown valves (e.g., the valves 302-306) coupled to a blowdown outlet 206 of the separator 102 using the blowdown unit 120 in response to the signaling, as at 706.

[0082] The method 700 may then include receiving the stored contents from the separator 102 into a sand disposal unit 126, as at 708. The method 700 may further include measuring a weight of the sand stored in the separator 102, e.g., as represented by a weight of the sand evacuated therefrom during a blowdown and received into the sand disposal unit 126 or directly by measurement from the load cell 220 positioned in the separator 102. For example, the sand disposal unit 126 may include a basket 402 that receives the fluid from the separators 102-106, and filters the sand therefrom, allowing the fluids to drain into the tank 400. The weight of the basket 402 can then be measured, which provides an indication of how much sand was received during a blowdown procedure.

[0083] The method 700 may also include dynamically determining a blowdown interval for subsequent blowdown operations of one or more of the separators 102-106 based in part on the weight of the sand, as at 712. Thus, if sand is being produced from the well 108 more quickly than in previous intervals, the blowdown interval for the separator 102 may be reduced, so as to avoid overfilling the separator 102. On the other hand, if sand is being produced from the well 108 more slowly than in previous intervals, the blowdown interval for the separator 102 may be increased, so as

to avoid unnecessary wear of the valves and other components of the separator 102 and/or blowdown unit 120. In other words, the time between blowdowns may be maximized up to a point, so as to avoid filling the separator 102 fully with sand which may carryover between blowdowns, while avoiding blowing down more frequently than necessary.

[0084] The method 700 may additionally include dynamically determining a blowdown duration for one or more of the separators 102-106 based in part on the weight and/or level of the sand, as at 714. As noted above, “blowdown duration” refers to the amount of time the blowdown line 107 is open in a given blowdown unit 120-124, e.g., with the valves 302, 304, 306 (and 350, if included) open and prior to closing one or more of the valves 302-306 (and 350). For example, if blowdown operations reveal large amounts of sand being introduced to the tank 400 of the sand disposal unit 126, then the blowdown duration may be lengthened (e.g., holding the valves 302-306/350 open longer) so as to more fully clear the separators 102-106 of sand. If sand amount decreases, blowdown duration may be shortened, e.g., to prevent a well from “gasing out” by emptying the separator 102-106 and blowing mostly gas out the blowdown line 107. If consistent readings come in, a test may be performed to ensure the blowdown duration is sufficient, e.g., by performing a longer than normal blowdown and determining if additional sand, and how much, is received in the sand disposal unit 126. If the sand produced during the test is larger than was received in previous blowdown operations, or received at a relatively consistent rate throughout the blowdown duration, it may indicate that a longer blowdown duration is called for. Further, it will be appreciated that the different separators 102-106 may call for different blowdown durations, as the wells to which they are connected may produce sand at different rates.

[0085] In some embodiments, the method 700 may provide leak detection and/or mitigation. For example, the method 700 may include receiving a feedback (e.g., electrical) signal from the blowdown unit 120 that represents that one or more valves 302-306 of the blowdown unit are malfunctioning (e.g., leaking). For example, the signal may be generated by a pressure and/or flow sensor, or two or more sensors in combination. In response to receiving the feedback signal, one or more scheduled blowdown operations for other separators 104-106 may be tolled (e.g., delayed). The leak mitigation efforts may then include attempting to correct operation of the one or more valves 302-306 while the one or more scheduled blowdown operations are tolled.

[0086] In an embodiment, the method 700 may include determining that a maximum tolling time has been reached for the one or more scheduled blowdown operations, and in response to determining that the maximum tolling time has been reached, shutting down the separators 102. This may prevent the other separators 104, 106 from overfilling by delaying blowdown thereof too long.

[0087] In some embodiments, to detect leakage, rather than (or in addition to) relying on sensor readings related to fluid evacuating as part of the blowdown from the separator 102, the method 700 may include injecting a pressurized fluid between the first and second valves 304, 306 when the first and second valves 304, 306 are closed. The feedback signal may thus be representative of the pressure between the first and second valves 304, 306. As the first and second

valves **304**, **306** being closed should retain the pressure until one or other are opened, the feedback signal represents that at least one of the first valve **304** or the second valve **306** is malfunctioning when the feedback signal represents a pressure that lowers over time.

Flowback 2.0

[0088] FIG. 8 illustrates a schematic view of a sand separation system **800**, according to an embodiment. The system **800** may be similar to the system **100** and may include the separators **102**, **104**, **106**, which may be connected to the wells **108**, **110**, **112**, respectively, as discussed above. In addition, the system **800** may include the blowdown unit **120**, control system **130**, and sand disposal unit **126**.

[0089] However, the system **800** may be configured such that the multiple separators **102**, **104**, **106** (and potentially others) feed the single blowdown unit **120**, e.g., instead of feeding separate blowdown units as in FIG. 1. To permit such several-to-one flow from the separators **102**, **104**, **106** to the blowdown unit **120**, a manifold valve assembly **801** may be provided. In particular, the manifold valve assembly **801** may include a plurality of manifold valves **802**, **804**, **806**, e.g., one for each of the separators **102**, **104**, **106**, and positioned downstream thereof. The manifold valves **802**, **804**, **806** may be controlled via communication with the control system **130**, and may be independently operable (e.g., opened, closed, choked, etc.) with respect to one another, responsive to signals from the control system **130**. Downstream of the manifold valves **802**, **804**, **806**, the outlet flows from the manifold valves **802**, **804**, **806** may be combined into a single input into the blowdown unit **120**. As such, the valves of the blowdown unit **120**, as discussed above, may be configured to control blowdown operations of the several separators **102**, **104**, **106** (and/or others) by selectively permitting or blocking fluid flow through the separators **102**, **104**, **106**. In at least some embodiments, the manifold valves **802**, **804**, **806** may be positioned in close physical proximity to the separators **102**, **104**, **106** so as to reduce the potential sand build up in the line. Accordingly, the manifold valves **802**, **804**, **806** may be discrete, separate valves positioned near the respective separators **102**, **104**, **106**. In other embodiments, the manifold valves **102**, **104**, **106** may be provided as a centralized manifold and connected to the separators **102**, **104**, **106** with sections of pipe coming from each separator **802**, **804**, **806**.

[0090] The control system **130** may be configured to maintain the manifold valves **802**, **804**, **806** in a closed position as a default, as blowdown operations may be intermittent, while normal operation may be generally continuous except when interrupted by blowdown. The control system **130** may determine a blowdown duration and frequency for the individual separators **102**, **104**, **106** based on historical sand-production rates (e.g., as measured by a load cell within the separator **102**, **104**, **106**, in the sand disposal unit **126**, or elsewhere). Further, the controls system **130** may coordinate the blowdown times for the separators **102**, **104**, **106**, e.g., to avoid two separators **102**, **104**, **106** being blowdown at the same time. For example, the control system **130** may signal to the manifold valve **802** to open, and then for the blowdown unit **120** to execute a blowdown operation, resulting in the blowdown of the separator **102**, while the other manifold valves **802**, **804**, **806** remain closed and prevent blowdown thereof. As such, the manifold valves

802, **804**, **806** may permit a selection of which separator **102**, **104**, **106** to blowdown, while using a single blowdown unit **120**.

[0091] It will be appreciated that a single system **800** may include several blowdown units, e.g., each connected to two or more separators, and all or some of these blowdown units may be controlled by the control system **130** and/or one or more additional control systems **130**. In such cases, manifold valves may be provided for each of the separators, e.g., to permit the control system **130** to select which separator to blowdown, so as to coordinate blowdown timing as between the different separators, taking into consideration leak mitigation, etc., as discussed above.

[0092] FIG. 9 illustrates a schematic view of a sand separation system **900**, according to an embodiment. The system **900** may be similar to the system **100**. The system **900** may include one or more separators, e.g., the separator **102**, which may be connected to the well **108**. In addition, the system **800** may include the blowdown unit **120** and the sand disposal unit **126**. Although not shown, the system **900** includes a control system (e.g., the control system **130**), which may communicate with sensors and actuators to control the system **900**.

[0093] The system **900** may include one or more pressure sensors, e.g., pressure sensors **902**, **904**, **906**, **908**, **910** as shown. The system **900** may also include a debris catcher **912**, a bypass valve system **914**, and an adjustable choke **916** that is downstream of the blowdown unit **120**. The adjustable choke **916** may be provided to mitigate the erosion of the valve train within the blowdown unit **120**. For example, the adjustable choke **916** may reduce the pressure drop across the blowdown unit **120**, e.g., such that the blowdown unit **120** does not step the pressure down from wellhead to ambient, but to some intermediate pressure upstream of the adjustable choke **916**. The adjustable choke **916** may then step the pressure down to ambient.

[0094] Having this choke **916** also allows the operator (and/or control system) to finely tune the blowdown duration. They can set this time, and then adjust to choke **916** to allow more or less flow through the system **900** during the time the blowdown unit **120** permits blowdown (e.g., the time that the first valve **302** of FIG. 3A is open). This provides a tool to combat “gas out”, a situation in which the separator **102** is fully evacuated of liquid and large amounts of gas begin to flow through the system, which may surge the well **108**.

[0095] It will be appreciated that the choke **916** may be used in embodiments that do not include a debris catcher **912**, and the debris catcher **912** may be used in embodiments that do not include a choke **916**.

[0096] The bypass valve system **914**, which may include one or more bypass valves, adjustable chokes, etc., may be positioned between the separator **102** and the blowdown unit **120**. The bypass valve system **914** may be coupled to the sand disposal unit **126**, and may normally permit fluid to flow from the separator **102** to the debris catcher **912**, but may be modulated to redirect fluid directly to the sand disposal unit **126**, bypassing the blowdown unit **120**, e.g., in response to signals from the control system **130** (e.g., FIG. 3A) or manually by operation of a user.

[0097] The debris catcher **912** may also be between the separator **102** and the blowdown unit **120**, e.g., downstream of the bypass valve system **914**. The pressure sensor **902** may be positioned between the wellhead **108** and the sepa-

rator 102. The pressure sensor 904 may be positioned between the separator 102 or downstream thereof on outlet 114 (e.g., FIG. 1) and the debris catcher 912. In other embodiments, the pressure sensor 904 may be placed in any position upstream of the debris catcher 912. In some embodiments, the pressure sensor 904 may be redundant to the pressure sensor 902 and could be omitted. The pressure sensor 906 may be positioned between the debris catcher 912 and the blowdown unit 120. In some embodiments, the pressure sensor 906 may be provided as part of the blowdown unit 120 (e.g., pressure transducer 322 of FIG. 3A). The pressure sensors 908 may be positioned between the blowdown unit 120 and the adjustable choke 916. The pressure sensor 910 may be positioned between the adjustable choke 916 and the sand disposal unit 126.

[0098] In some embodiments, during initial flowback, significant amounts of solids are produced from the well 108. As this may be the first time the well 108 is opened, pieces of completions devices, plug parts, large particles of debris, etc., that are left in the well from the completions and drilling processes can be brought to surface. The trash can be dense metal, and large mass. The separator 102 separates these large pieces and captures them in its accumulator. When the blowdown unit 120 performs a blowdown of the separator 102, these pieces of debris or “trash” are pushed through the primary blowdown valve, which can damage the primary blowdown valve or prevent the primary blowdown valve from functioning correctly, e.g., become packed off, stuck open or closed, etc.

[0099] Accordingly, the debris catcher 912 may be provided to prevent such separated trash from reaching the blowdown unit 120 and damaging the valves therein. As shown, the debris catcher 912 may be a ball catcher device. The debris catcher 912 may have a removable filter element (e.g., a metal screen) that is received perpendicular to the direction of flow, which may be removed when it is packed off (fouled with trash).

[0100] The pressure sensors 902-910 may be configured to provide signals that the control system 130 uses to determine when the debris catcher 912 is packed off. For example, when not under blowdown conditions, the pressure sensor 902 may record measurements approximately equal to wellhead pressure. The pressure sensor 904 may read slightly lower pressures, as the separator 102 may produce a small amount of pressure drop, and the pressure sensor 906 may read a generally equal pressure. The pressure sensors 908 and 910 may read equal, generally atmospheric pressures.

[0101] During a normal blowdown operation, the pressure sensors 902 and 904 may be generally unchanged, observing wellhead pressure and slightly below wellhead pressure, respectively. Further, pressure sensors 904 and 906 may read a generally consistent, equal pressure. Further, the pressure recorded by the pressure sensor 908 may be generally higher than the pressure recorded at the pressure sensors 910, as the adjustable choke 916 may produce a pressure drop in the fluid flowing therethrough from the blowdown unit 120 to the sand disposal unit 126 during the blowdown.

[0102] When the debris catcher 912 is plugged, the pressure read by the pressure sensor 906 may be substantially lower than what is read during the normal blowdown operation. For example, in normal operations, the pressure read by pressure sensor 906 may be between about 55% and about 65% of the wellhead pressure. During a blowdown, if the pressure read by the pressure sensor 906 is outside of this

range, e.g., below the range, the debris catcher 912 may be plugged. In addition, the pressure sensors 904, 908, 910 may vary in pressure readings from a normal blowdown operation, as the total flow allowed through the debris catcher 912 is reduced. Accordingly, at least partially in response to the change (e.g., reduction) in pressure sensed by the pressure sensor 906 downstream of the debris catcher 912, the control system 130 (e.g., FIG. 3A) connected thereto may determine that the debris catcher 912 is fouled. The control system 130 may then take an appropriate mitigation action, such as stopping blowdowns with unit 120, engaging the bypass valve 914 to route blowdown fluid directly to the sand disposal unit 126, scheduling maintenance, producing a visual or audible warning, etc.

[0103] FIG. 10 illustrates a side, cross-sectional view of a separator 1000 of any one of the foregoing systems, according to an embodiment. For example, the separator 1000 may be an embodiment of one or more of the separators 102-106 of FIG. 3A. The separator 1000 may include a cyclone 1002 and an accumulator 1004, which may be positioned below the cyclone 1002 and configured to receive solids (e.g., particulate matter such as sand) that is separated from a flow of fluid in the cyclone 1002. An inlet 1006 may provide the particulate-laden fluid to the cyclone 1002, and a fluid outlet 1008 may receive the fluid flow from the cyclone 1002. The separated solids (and some of the fluid) may drop out of the cyclone 1002 via a solids outlet 1010.

[0104] A blowdown outlet 1012 and a drain 1014 may be coupled to the accumulator 1004. During blowdown operations, sand and other solids 1016 may be evacuated from the accumulator 1004 via the blowdown outlet 1012, as lower pressure downstream draws a slurry of the solids 1016 and liquid from within the accumulator 1004 out through the blowdown outlet 1012. The accumulator 1004 also contains a level sensor 1020 therein. The level sensor 1020 may be a load cell measuring the weight of the sand, a density or viscosity measurement device, and/or a device that measures an electromagnetic tomography. Accordingly, the level sensor 1020 may provide a signal that permits a binary determination of whether or not sand has reached the level sensor 1020, as this may represent a measurable change in density and/or viscosity surrounding the level sensor 1020, or the weight of the sand in the accumulator 1004. The level sensor 1020 may be positioned toward the top of the accumulator 1004, such that solids reaching the level sensor 1020 may provide a trigger for the control system 130 (e.g., FIG. 3A) to initiate a blowdown.

[0105] FIGS. 11A, 11B, 11C, and 11D illustrate side, schematic views of an accumulator 1100 for a separator, which may be provided with an external sand-level detector 1102, according to an embodiment. The external sand-level detector 1102 may be a nuclear emitter 1104 and receiver 1106 combination. The detector 1102 may employ nuclear densitometry to determine sand level within the accumulator 1100, without requiring a penetration of the pressure vessel or exposing the detector 1102 to the high-pressure environment therein. In particular, the nuclear emitter 1104 may be placed on one lateral side of the accumulator 1100, and the receiver 1106 may be placed on the opposite lateral side of the accumulator 1100. As sand builds up in the accumulator 1100, the sand shields the receiver 1106 from the radiation emitted by the emitter 1104. This reduction can be measured.

[0106] In at least some embodiments, the detector 1102 may provide an analog scale that may provide indications of

potentially several sand levels, as the sand fills the accumulator **1100** during use. For example, the receiver **1106** may be formed as a long rod, as shown. The emitter **1104** may emit radiation on, e.g., a 45-degree field **1109**. As the sand accumulates (e.g., proceeding from FIGS. **11A** to **11B**, **11C**, and **11D**, sand **1110** is shown accumulating), more of the field is obstructed by the sand **1110**, and less radiation reaches the receiver **1106**.

[0107] In another embodiment, a smaller, point source may be employed as the emitter **1104**, with a more concentrated “beam of radiation” that would pass through the vessel to the receiver **1108** (in this embodiment, a point receiver rather than a long rod). When sand built up and breaks the beam of radiation, the detector **1102** would signal to the controls system **1130** that the accumulator **1100** is full (or nearly full).

[0108] FIGS. **12A** and **12B** illustrate a flowchart of a method **1200** for operating a sand separation system, e.g., any one or a combination of the systems **100**, **800**, **900** discussed above, according to an embodiment. The method **1200** may include separating sand from a fluid using a plurality of separators **102-106**, as at **1202**. The separators **102-106** each temporarily store the sand therein, e.g., in an accumulator (e.g., the accumulator **1004** of FIG. **10**). A plurality of manifold valves **802-806** are each coupled to a respective one of the separators **102-106**, e.g., in the configuration of FIG. **8**.

[0109] The method **1200** may also include selecting, using a control unit (or control “system”) **130**, one of the plurality of separators (e.g., the separator **102**) to blowdown, as at **1204**.

[0110] The method **1200** may further include signaling, from the control unit **130**, to one of the manifold valves (e.g., valve **802**), the one of the manifold valves being coupled to the separator **102**, for the manifold valve **802** to open, as at **1206**.

[0111] The method **1200** may include opening the manifold valve **802**, as at **1208**, while the other manifold valves **804**, **806** remain closed.

[0112] The method **1200** may also include signaling, from the control unit **130** to a blowdown unit **126**, for the blowdown unit **120** to execute a blowdown, as at **1210**.

[0113] The method **1200** may include opening one or more valves (e.g., valves **302**, **304**, **306**) of the blowdown unit **120** in response to the signaling, so as to blowdown the selected one of the separators **102**, as at **1212**.

[0114] The method **1200** may include receiving the sand from the selected one of the separators into a sand disposal unit **126**, as at **1214**. The sand passes through the manifold valve **802** that is opened and through the blowdown unit **126** (via the open valves **302**, **304**, **306** thereof).

[0115] The method **1200** may also include measuring the sand that was separated in the separator **102** using a sensor of the one of the separators, a load cell of the sand disposal unit, or both, as at **1216**. In at least some embodiments, the control unit **130**, e.g., as part of the method **1200**, may determine that it is time to execute a blowdown operation based on measuring the sand that was separated in the one or more separators **102** using the sensor of the one or more separators. For example, the sensor may be the level sensor **1020** and/or the nuclear detector **1102**. As noted above, the nuclear detector **1102** may include the nuclear emitter **1104** that emits a field of radiation **1109**. Thus, the method **1200** may include detecting a level of the sand in the accumulator

based on the sand obstructing at least a portion of the field of radiation, e.g., as part of the measuring at **1216**.

[0116] In another embodiment, measuring the sand that was separated in the separator uses the level sensor **1020** positioned at least partially in an accumulator **1004** of the separator **1000** (e.g., a representative example of the separator **102**). The level sensor **1020** may thus provide a signal representing whether or not a sand level in the accumulator has reached the level sensor **1020**.

[0117] The method **1200** may include determining a blowdown interval for subsequent blowdown operations of the selected separator **102** based in part on the measurement of the sand, as at **1218**. The blowdown interval may include a safety interval, which may be determined based on collected production information. The safety interval may be set as a function of sand production rate and accumulator capacity, and may thus be set to avoid overfill in the case that the level sensor fails to trigger. That is, the safety interval may be set at a time that is less than the accumulator capacity (the amount of sand that can be contained in the separator before an overfill) divided by recent/past sand production rate. The method **1200** may thus determine that it is time to blowdown the separator based on either the level sensor determining that the sand has reached a blowdown/trigger level, or at the expiration of the safety interval since the last blowdown of the separator, whichever comes first.

[0118] For example, a previous blowdown quantification may show that a well is producing 100 kg/hr of sand. The internal level sensor is set at an elevation at which the accumulator contains 200 kg of sand. Therefore, the level sensor **1020** or another may be expected to trigger within the next two hours of operating time. By comparison, the accumulator **1004** holds 400 kg of sand. Because sand production rates can vary, a safety interval may be set to force the blowdown at some time after the trigger, but before the time at which overfill may be expected based on recent production rates (e.g., the 100 kg/hr). In this example, three hours to force a blowdown may be a suitable safety interval, to ensure that the 400 kg accumulator is not overfilled, although different operators may select different safety intervals. Accordingly, using such a safety interval, the separator (s) may be blowdown and emptied every three hours, or upon the level sensor being triggered, whichever comes first.

[0119] In an embodiment, the method **1200** may include measuring a pressure downstream of a debris catcher, the debris catcher positioned between the separator and the blowdown unit, as at **1220**. The method **1200** may also include determining that the pressure measured upstream of the debris catcher is out of a predetermined range (e.g., below a certain threshold percentage of wellhead pressure, e.g., less than about 70%, less than about 65%, less than about 60%, or less than about 55% thereof). In response to determining that the pressure measured upstream of the debris catcher **912** is out of the predetermined range, the method **1200** may include the control unit **130** executing one or more mitigation actions in response to the debris catcher being plugged. The mitigation actions may include opening a bypass valve that routes fluid to the sand disposal unit and not to the blowdown unit or the debris catcher, or cleaning out a filter screen of the debris catcher.

[0120] At **1222**, the method **1200** includes adjusting a choke **916** that is positioned downstream of the blowdown unit **120** and upstream of the sand disposal unit **126**, to tune

the blowdown operation and reduce a pressure drop across the blowdown unit **126**, as described above.

Flowback 3.0

[0121] Flowback 3.0 may eliminate permanent facilities at wellpad locations as well as all the equipment used in conventional flowback operations. Flowback 3.0 may be monitored remotely. As described in greater detail below, one or more multiphase meters may have a data feed sending the flow parameters through data transmission methods.

[0122] Flowback 3.0 may be performed with or without eFlowback (e.g., an automation control unit (ACU), an automatic blowdown unit (ABU), and/or a sand quantification unit (SQU)). Flowback 3.0 differs from conventional flowback techniques because it uses the multiphase meter(s) that allow the removal/omission of the facility separator that is required to separate the fluids so as to measure them separately (after which they are just recombined and sent to the pipeline).

[0123] FIGS. 13, 14A, and 14B illustrate schematic views of a sand separation system **1300**, according to an embodiment. The system **1300** may include one or more wells or wellheads **1305**. In the example shown, the system **1300** may include six wells or wellheads **1305**.

[0124] The system **1300** may also include one or more separators **1310**. The separators **1310** may be or include high-efficiency de-sanding cyclones (HEDCs). An example of the separators **1310** may be found in U.S. Pat. Nos. 11,839,883; 11,235,263; U.S. Patent Pub. No. 2022/0097081, U.S. Patent Pub. No. 2022/0347700, or a combination thereof, which are incorporated by reference herein. Each separator **1310** may be downstream from and/or in fluid communication a corresponding one of the wells or wellheads **1305**. Thus, continuing with the example above, the system **1300** may include six separators **1310**, each configured to receive a mixed fluid from one of the wells/wellheads **1305**. The mixed fluid may include a fluid (e.g., water and/or hydrocarbons) with solids (e.g., sand) therein. The separators **1310** may be configured to separate the solids from the mixed fluid to produce (1) the solids and (2) a separated fluid.

[0125] This initial debottlenecking provided by the separators **1310** allows for nearly unrestricted flow from the wells/wellheads **1305** to the production facility **1325** or pipeline **1330**. The restriction from downhole to anywhere (e.g., the separators **1310** or the pipeline or the facility, etc.) may be created by the high solid percentage returns due to the high momentum/velocity of the fluid coming from the formation. Without the separator or some equivalent desanding technology, the well may be restricted, or the massive quantities of sand may destroy or render the facilities downstream of the wellhead inoperable so flow is restricted to minimize the sand returns and spread them out over time. A second restriction may be the separators' ability to process the high fluid rates during early stages of flowback, as they are greater than the specifications of the separators to separate. For this reason, the wells either need to be restricted, or additional equipment (e.g., tanks/flares, etc.) may be used to handle the temporary additional flowrates. Thus, these options are two separate, but closely-related, debottlenecking opportunities.

[0126] Prior to the separators **1310**, the wells or wellheads **1305** had to be severely restricted during flowback to reduce the solids (e.g., sand) return coming out of the wells or

wellheads **1305**. As may be seen in FIGS. 14A and 14B, the system **1300** may not include a facility separator. The system **1300** does include the desanding separators **1310**, but that is one of the de-bottlenecking technologies that allows for unrestricted flow. This is the separator that is the other bottleneck.

[0127] The system **1300** may also include one or more chokes (also referred to as choke valves) **1315**. Each choke **1315** may be downstream from and/or in fluid communication with a first (e.g., separated fluid) outlet of a corresponding one of the separators **1310**. Thus, continuing with the example above, the system **1300** may include six chokes **1315**, each configured to receive the separated fluid from one of the separators **1310**. The chokes **1315** may be configured to control (e.g., choke) the volume and/or rate of the separated fluid flowing therethrough.

[0128] The system **1300** may also include one or more multiphase meters (MPMs) **1320**. Each multiphase meter **1320** may be downstream from and/or in (e.g., electrical and/or fluid) communication with a corresponding one of the separators **1310** and/or chokes **1315**. Thus, continuing with the example above, the system **1300** may include six multiphase meters **1320**, each configured to measure one or more first properties of the separated fluid. The first properties may be or include volume, flowrate, sand content, sand volume, other solids content, or a combination thereof. Based on the real-time data being measured and/or received from the multiphase meters **1320** (and other on-site data), the chokes **1315** may be manually or automatically adjusted (e.g., opened, closed, or throttled) to control (e.g., optimize) efficiency, pipeline capacity, downhole consideration, or other factors.

[0129] The multiphase meters **1320** may be nuclear or non-nuclear. The multiphase meters **1320** may eliminate the requirement to have facility and/or temporary separators on-site to separate and measure the three flow streams (i.e., gas, oil and/or condensate, and water). Separators may only operate properly within their design range, so early stage flowback (e.g., 0-30 days) when fluid and gas rates are often flowing back significantly higher than those the separators and meters are designed to handle may force the operators to hold back flow and/or restrict production from the wells and/or wellheads **305**. Flowback 3.0 may eliminate this limitation and allow for a fully debottlenecked flowback.

[0130] The separated fluid output from the choke(s) **1315** and/or the multiphase meter(s) **1320** may then be transferred to a production facility **1325** or a pipeline **1330**.

[0131] The system **1300** may also include one or more tanks (or pits) **1335**. The tank (or pit) **1335** may be downstream from and/or in fluid communication with second (e.g., solids) outlets of the separators **1310**. As the solids (e.g., sand) accumulate(s) in the lower section of the separators **1310**, it may be manually or automatically (i.e., eFlowback) purged from the separators **1310** to the tank (or pit) **1335**.

[0132] The system **1300** may also include a controller **1340**. The controller **1340** may be in communication with the separators **1310**, the chokes **1315**, the multiphase meters **1320**, the tanks (or pits) **1335**, or a combination thereof. The controller **1340** may be configured to measure and/or receive one or more second properties from the separators **1310**, the chokes **1315**, the multiphase meters **1320**, and/or the tanks (or pits) **1335**. The second properties may be or include flowrate (oil, water, gas, and sand), differential pressure,

static pressure, sand volume accumulated, pressure, temperature, conductivity, solidity, electromagnetic properties, or combination thereof. The controller 1340 may also be configured to generate and transmit signals to control (e.g., modify) the separators 1310, the chokes 1315, the multiphase meters 1320, the tanks (or pits) 1335 in response to the second properties.

[0133] Reference number 1345 in FIG. 14A indicates where a production separator (also called a facility separator) would be located on each well pad in a conventional system. The system 1300, however, may allow for the omission of such a production separator, which saves space and cost.

[0134] FIGS. 15A, 15B, and 16A-16C illustrate schematic views of the sand separation system 1300 including additional equipment, according to an embodiment. The sand separation system 1300 may also include one or more automated blowdown units (ABUs) 1350. The automated blowdown units 1350 may be downstream from and/or in fluid communication with the second (e.g., solids) outlets of the separators 1310. Thus, continuing with the example above, the system 1300 may include six automated blowdown units 1350, each configured to receive the solids from a corresponding one of the separators 1310. The automated blowdown units 1350 may allow for the extraction and/or evacuation of sand from the separator 1310 either manually, or timed, or from feedback from sensors in the sand quantification units 1355 (described below) using algorithms, or other advanced methods such as artificial intelligence (AI) or machine learning (ML). This is done in a way to minimize excess fluids and emissions.

[0135] The sand separation system 1300 may also include one or more sand quantification units (SQUs) 1355. The sand quantification unit 1355 may be downstream from and/or in fluid communication with the automated blowdown units 1350. The sand quantification unit 1355 may be configured to receive the solids from the automated blowdown units 1350 and to measure and/or quantify (e.g., weigh) the solids.

[0136] The sand separation system 1300 may also include one or more automated control units (ACUs) 1360. The automated control unit 1360 may be configured to manage blowdown timing for various wells based on the method being used. It may also or instead be used to control and record information from the other eFlowback components such as the ABU 1350 and the SQU 1355. It may also provide pressurized air or power to activate the valves and sensors on that allow eFlowback to function as designed.

[0137] FIG. 17 illustrates a flowchart of a method 1700 for operating a sand separation system (e.g., the system(s) of FIGS. 13-16), according to an embodiment. More particularly, the method 1700 may combine the HEDC(s) 1310 with the MPMs 1320, which may de-bottleneck production and/or flowback. The method 1700 may de-bottleneck the opening of a well and/or substantially reduce the capital costs and ongoing maintenance costs of a well pad.

[0138] An illustrative order of the method 1700 is provided below; however, one or more steps of the method 1700 may be performed in a different order, simultaneously, repeated, or omitted.

[0139] The method 1700 may include separating the solids from the mixed fluid to produce the solids and the separated fluid, as at 1705. The separation may be performed by the separator(s) 1310.

[0140] The method 1700 may also include measuring one or more first properties of the separated fluid, as at 1710. The one or more first properties may be measured by the multiphase meter(s) 1320. As mentioned above, the first properties may be or include volume, flowrate, sand content, sand volume, other solids content, or a combination thereof.

[0141] The method 1700 may also include controlling a flow rate of the separated fluid in response to the one or more first properties, as at 1715. The flow rate may be controlled using the choke(s) 1315.

[0142] The method 1700 may also include transferring the separated fluid to a production facility or a pipeline, as at 1720. The separated fluid may be transferred after the flow rate is controlled.

[0143] The method 1700 may also include transferring the solids to the tank (or pit) 1335, as at 1725. The solids may be transferred from the separator(s) 1310 to the tank (or pit) 1335.

[0144] The method 1700 may also include measuring one or more second properties, as at 1730. The second properties may be measured by the controller 1340. As mentioned above, the one or more second properties may be of or related to the separator(s) 1310, the choke(s) 1315, the multiphase meter(s) 1320, the tank (or pit) 1335, the separated fluid, or a combination thereof.

[0145] The method 1700 may also include controlling the separator(s) 1310, the choke(s) 1315, the multiphase meter(s) 1320, and/or the tank (or pit) 1335 in response to the one or more second properties, as at 1735.

[0146] In an embodiment, a performance of the separator(s) 1310 may be evaluated based upon the one or more first properties, the one or more second properties, or both. In another embodiment, one or more nozzles and/or inserts of the separator(s) 1310 may be selected, installed, removed, or modified based upon the one or more first properties, the one or more second properties, or both.

[0147] As used herein, the terms “inner” and “outer”; “up” and “down”; “upper” and “lower”; “upward” and “downward”; “above” and “below”; “inward” and “outward”; “uphole” and “downhole”; and other like terms as used herein refer to relative positions to one another and are not intended to denote a particular direction or spatial orientation. The terms “couple,” “coupled,” “connect,” “connection,” “connected,” “in connection with,” and “connecting” refer to “in direct connection with” or “in connection with via one or more intermediate elements or members.”

[0148] The foregoing has outlined features of several embodiments so that those skilled in the art may better understand the present disclosure. Those skilled in the art should appreciate that they may readily use the present disclosure as a basis for designing or modifying other processes and structures for carrying out the same purposes and/or achieving the same advantages of the embodiments introduced herein. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the present disclosure, and that they may make various changes, substitutions, and alterations herein without departing from the spirit and scope of the present disclosure.

What is claimed is:

1. A sand separation system, comprising:
one or more separators configured to receive a mixed fluid from one or more wells or wellheads and to separate solids from the mixed fluid to produce the solids and a separated fluid;
one or more chokes downstream from and in fluid communication with the one or more separators, wherein each of the one or more chokes is configured to receive the separated fluid from a corresponding one of the one or more separators and to control a flow rate of the separated fluid therethrough; and
one or more multiphase meters downstream from and in fluid communication with the one or more chokes, wherein each of the multiphase meters is configured to measure one or more first properties of the separated fluid and to adjust the one or more chokes in response to the one or more first properties, and wherein the separated fluid is transferred from the one or more chokes or the one or more multiphase meters to a production facility or a pipeline.
2. The sand separation system of claim 1, wherein the one or more separators provide de-bottlenecking and allow for unrestricted flow of the mixed fluid from the one or more wells or wellheads to the production facility or the pipeline.
3. The sand separation system of claim 1, wherein the sand separation system does not include a separator between the one or more chokes or the one or more multiphase meters and the production facility or the pipeline.
4. The sand separation system of claim 1, further comprising a tank or pit downstream from and in fluid communication with the one or more separators, wherein the tank or pit is configured to receive the solids from the one or more separators.
5. The sand separation system of claim 4, further comprising a controller in communication with the one or more separators, the one or more chokes, the one or more multiphase meters, and the tank or the pit.
6. The sand separation system of claim 5, wherein the controller is configured to measure more or more second properties of one or more separators, the one or more chokes, the one or more multiphase meters, the tank or the pit, the separated fluid, or combination thereof, and wherein the controller is configured to adjust the one or more separators and/or the one or more chokes in response to the one or more second properties.
7. The sand separation system of claim 1, further comprising an automatic blowdown unit in communication with the one or more separators, wherein the automatic blowdown unit is configured to permit the solids stored in the one or more separators to exit the one or more separators.
8. The sand separation system of claim 7, further comprising a sand quantification unit in communication with the automatic blowdown unit, wherein the sand quantification unit is configured to measure and/or quantify the solids.
9. A method for operating a sand separation system, the method comprising:
separating solids from a mixed fluid using a separator to produce the solids and a separated fluid, wherein the mixed fluid is received by the separator from a well or a wellhead;
measuring one or more first properties of the separated fluid using a multiphase meter;

controlling a flow rate of the separated fluid using a choke in response to the one or more first properties; and
transferring the separated fluid to a production facility or a pipeline after the flow rate is controlled.

10. The method of claim 9, wherein the separator provides de-bottlenecking and allows for unrestricted flow of the mixed fluid from the well or wellhead to the production facility or the pipeline.

11. The method of claim 9, wherein the separated fluid flows from the choke to the production facility or the pipeline without having additional solids removed therefrom by a second separator.

12. The method of claim 9, further comprising transferring the solids to a tank or a pit.

13. The method of claim 9, further comprising:
measuring one or more second properties of the separator, the multiphase meter, the choke, or a combination thereof using a controller; and

controlling the separator, the multiphase meter, the choke, or a combination thereof in response to the one or more second properties.

14. The method of claim 9, further comprising evaluating a performance of the separator based upon the one or more first properties.

15. The method of claim 9, further comprising quantifying the solids exiting the separator and controlling the separator.

16. A sand separation system, comprising:

one or more separators configured to separate solids from a mixed fluid and to produce the solids and a separated fluid;

one or more chokes configured to receive the separated fluid from a corresponding one of the one or more separators and to control a flow rate of the separated fluid therethrough;

one or more multiphase meters configured to measure one or more first properties of the separated fluid and to adjust the one or more chokes in response to the one or more first properties; and

a controller configured to measure more or more second properties of one or more separators, the one or more chokes, the one or more multiphase meters, the separated fluid, or combination thereof, and wherein the controller is configured to adjust the one or more separators and/or the one or more chokes in response to the one or more second properties.

17. The sand separation system of claim 16, further comprising a tank or pit configured to receive the solids from the one or more separators.

18. The sand separation system of claim 16, wherein the one or more chokes are downstream from the one or more separators and the one or more multiphase meters are downstream from the one or more chokes.

19. The sand separation system of claim 16, wherein the separated fluid is transferred from the one or more chokes or the one or more multiphase meters to a production facility or a pipeline.

20. The sand separation system of claim 19, wherein the sand separation system does not include a separator between the one or more chokes or the one or more multiphase meters and the production facility or the pipeline.

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