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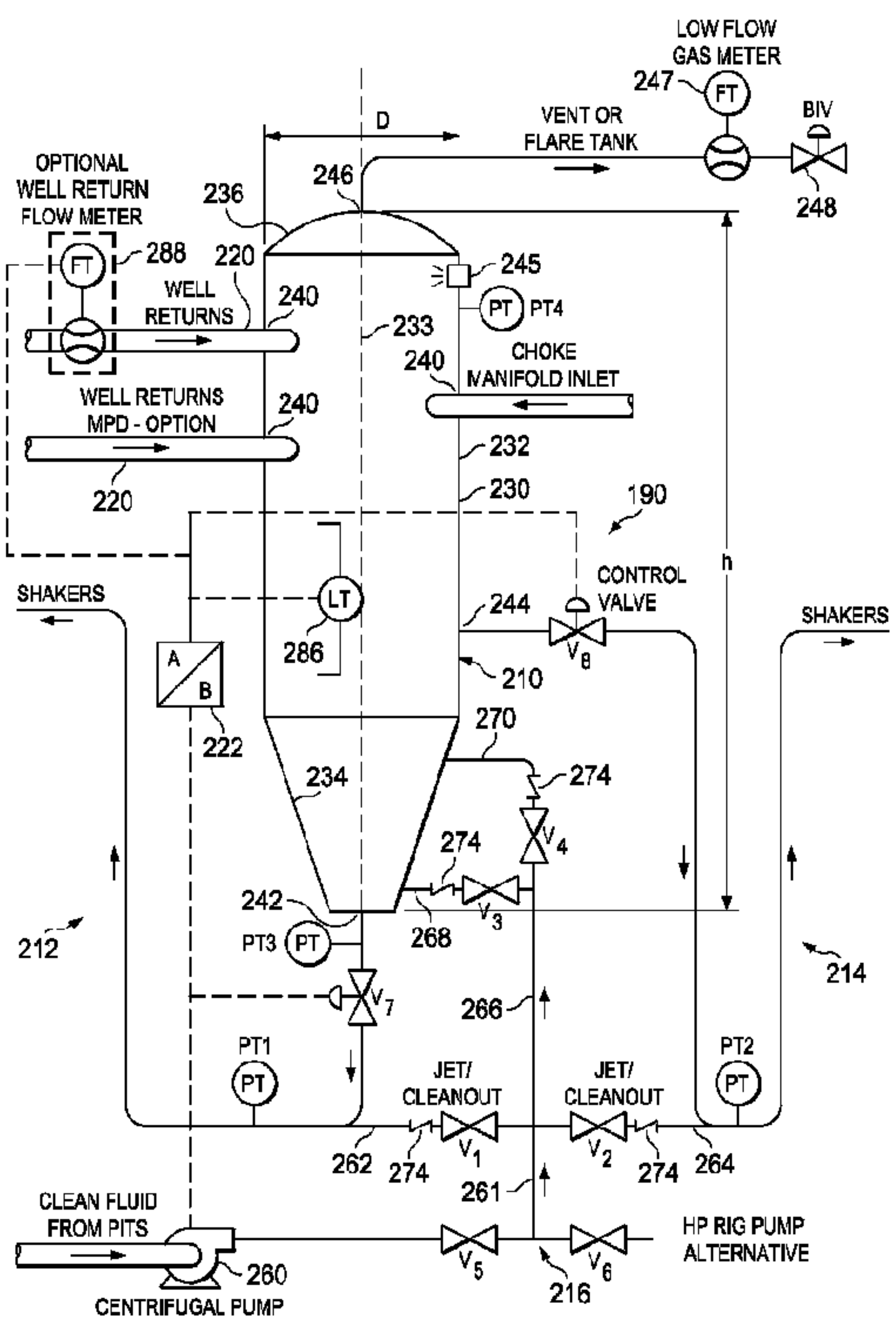

(57) Abrégé/Abstract:
A mud-gas separator is arranged for both well control and drilling process. In some aspects, the mud-gas separator includes a main housing including a bottom portion and a side portion. The mud-gas separator also includes a gas vent associated with the main housing and configured to vent gas from well returns introduced into the main housing. It also includes a first mud outlet formed within the bottom portion of the main housing and configured to pass mud from well returns introduced into the main housing and includes a second mud outlet formed within the side portion of the main housing and configured to pass mud from well returns introduced into the main housing.

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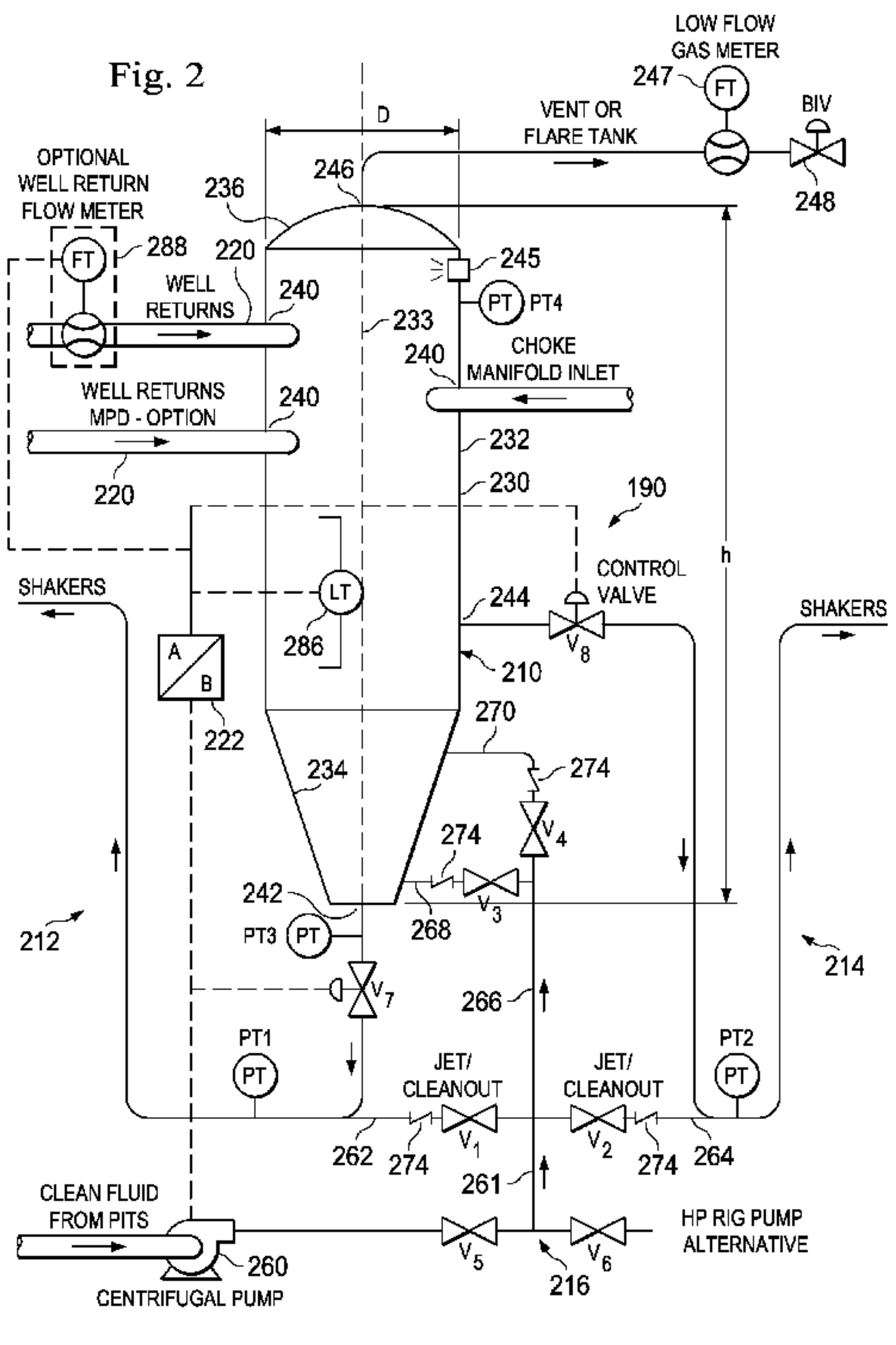
Fig. 2



(57) Abstract: A mud-gas separator is arranged for both well control and drilling process. In some aspects, the mud-gas separator includes a main housing including a bottom portion and a side portion. The mud-gas separator also includes a gas vent associated with the main housing and configured to vent gas from well returns introduced into the main housing. It also includes a first mud outlet formed within the bottom portion of the main housing and configured to pass mud from well returns introduced into the main housing and includes a second mud outlet formed within the side portion of the main housing and configured to pass mud from well returns introduced into the main housing.

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DUAL PURPOSE MUD-GAS SEPARATOR AND METHODS

Background of the Disclosure

Some underground drilling processes require that operators circulate drilling fluid, known as mud, to a bottom hole assembly cutting through subterranean formations. The mud, along with cuttings from the drilling process, flow back up the wellbore to the surface. The mud is cleaned, and cuttings are removed before recirculating the mud back down into the wellbore.

Gas encountered while drilling becomes mixed in the mud and is carried to the surface within the mud. When operators are aware that mud contains gas, the mud is typically directed to a separator before the mud is cleaned and recirculated. Since the separator may slow the recirculating process, it is typically brought on-line only when gas is known to be in the mud. This knowledge, however, is typically gained only after compressed gas has been released from the return pipe at the shakers, causing an explosion of mud as the gas escapes the confines of the return pipes.

The present disclosure is directed to systems and methods that overcome one or more of the shortcomings in the prior art.

Summary

In an exemplary aspect, the present disclosure is directed to an apparatus that includes a main housing including a bottom portion and a side portion. A gas vent is associated with the main housing and configured to vent gas from well returns introduced into the main housing. A first mud outlet is formed within the bottom portion of the main housing and configured to pass mud from well returns introduced into the main housing, and a second mud outlet is formed within the side portion of the main housing and configured to pass mud from well returns introduced into the main housing.

In an aspect, the apparatus includes a first u-tube connected to and extending from the first mud outlet toward a shaker and includes a second u-tube connected to and extending from the first mud outlet toward a shaker. A sparge system may be associated with the first u-tube and configured to introduce high pressure fluid into the first u-tube from a location upstream of a bottom of the first u-tube.

In another exemplary aspect, the present disclosure is directed to a method that includes introducing well returns into a main housing, monitoring a fluid level within the main housing, controlling a first valve to reduce flow through a bottom of the main housing

when the fluid level is below a threshold, and controlling a second valve to increase flow through a side of the main housing when the fluid level is above a threshold.

In an aspect, monitoring a fluid level within the main housing includes detecting the fluid level with a level transducer. In an aspect, monitoring a fluid level within the main housing includes detecting pressure differentials with pressure sensors and determining whether a fluid level is above or below a stored threshold level.

In an exemplary aspect, the present disclosure is directed to an apparatus that includes a main housing configured to receive well returns and includes a gas vent associated with the main housing and configured to vent gas from the well returns. A first mud outlet is formed within the main housing and configured to vent mud from well returns introduced into the main housing, and a second mud outlet is formed within main housing and configured to vent mud from well returns introduced into the main housing. The first mud outlet and the second mud outlet are disposed at different elevations within the main housing.

Brief Description of the Drawings

The present disclosure is best understood from the following detailed description when read with the accompanying figures. It is emphasized that, in accordance with the standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of the various features may be arbitrarily increased or reduced for clarity of discussion.

FIG. 1 is an illustration of an apparatus as a drilling rig according to one or more aspects of the present disclosure.

FIG. 2 is a diagram of an apparatus as a mud-gas separator according to one or more aspects of the present disclosure.

FIG. 3 is a block diagram of an apparatus as a sensing and control system of the mud-gas separator according to one or more aspects of the present disclosure.

FIG. 4 is a flow chart showing an exemplary method according to one or more aspects of the present disclosure.

Detailed Description

It is to be understood that the following disclosure provides many different embodiments, or examples, for implementing different features of various embodiments. Specific examples of components and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. 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. 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.

The present disclosure is directed to apparatuses and methods having a unique arrangement that separates gas from mud of well returns. The apparatus disclosed herein may enable continuous mud-gas separation during drilling, and is suitable for use in well control conditions, when return flow unexpectedly deviates. The apparatus is arranged with a redundant, secondary outlet to be used when, for example, a primary outlet becomes plugged or the apparatus becomes flooded, as may occur during well control conditions. The shape and arrangement of the apparatus may permit it to be used not only when compressed gas is known to be contained within the mud, but also be used to continuously during drilling to separate mud and gas from well returns. This may result in more efficient mud-gas separation with a decreased chance of inadvertent high pressure gas release. In addition, some embodiments of the apparatus are instrumented to indicate performance and to identify and rectify problems. Accordingly, the apparatus disclosed herein has a dual purpose because it is used as a separator for standard drilling processes and for conventional well control processes.

Referring to FIG. 1, illustrated is a schematic view of an apparatus 100 demonstrating one or more aspects of the present disclosure. The apparatus 100 in the example shown is or includes a land-based drilling rig. However, one or more aspects of the present disclosure are applicable or readily adaptable to any type of drilling rig, such as jack-up rigs, semisubmersibles, drill ships, coil tubing rigs, well service rigs adapted for drilling and/or re-entry operations, and casing drilling rigs, among others within the scope of the present disclosure.

The apparatus 100 includes a mast 105 supporting lifting gear above a rig floor 110. The lifting gear includes a crown block 115 and a traveling block 120. The crown block 115 is coupled at or near the top of the mast 105, and the traveling block 120 hangs from the crown block 115 by a drilling line 125. One end of the drilling line 125 extends from the lifting gear to drawworks 130, which is configured to reel out and reel in the drilling line 125 to cause the traveling block 120 to be lowered and raised relative to the rig floor 110. The other end of the drilling line 125, known as a dead line anchor, is anchored to a fixed position, possibly near the drawworks 130 or elsewhere on the rig.

A hook 135 is attached to the bottom of the traveling block 120. A top drive 140 is suspended from the hook 135. A quill 145 extending from the top drive 140 is attached to a saver sub 150, which is attached to a drill string 155 suspended within a wellbore 160. Alternatively, the quill 145 may be attached to the drill string 155 directly. It should be understood that other conventional techniques for arranging a rig do not require a drilling line, and these are included in the scope of this disclosure.

The drill string 155 includes interconnected sections of drill pipe 165, a bottom hole assembly (BHA) 170, and a drill bit 175. The bottom hole assembly 170 may include stabilizers, drill collars, and/or measurement-while-drilling (MWD) or wireline conveyed instruments, among other components. The drill bit 175, which may also be referred to herein as a tool, is connected to the bottom of the BHA 170 or is otherwise attached to the drill string 155. One or more pumps 180 may deliver drilling fluid to the drill string 155 through a hose or other conduit 185, which may be fluidically and/or actually connected to the top drive 140. This embodiment includes a system 200 that may be referred to as a telescoping washpipe system disposed between the top drive 140 and the quill 145. The system 200 is described more fully further below.

Still referring to FIG. 1, the top drive 140 is used to impart rotary motion to the drill string 155. However, aspects of the present disclosure are also applicable or readily adaptable to implementations utilizing other drive systems, such as a power swivel, a rotary table, a coiled tubing unit, a downhole motor, and/or a conventional rotary rig, among others.

A mud-gas separator 190 and shakers 195 connect to the wellbore 160. The mud-gas separator 190 is configured to receive well returns, including mud, cuttings, and gas, from the wellbore 160 and to remove the gas from the mud in a controlled manner. The mud flows to the shakers 195 that separate solids from liquids by utilizing a vibrating system outfitted with specially designed and sized screens. The shakers 195 remove drilled solids and well cuttings returned from the wellbore during the drilling process. The flow of mud is represented by arrows shown the wellbore 160. Clean mud is pumped from the surface down through the drill string 165 as represented by the arrow within the drill string 165 adjacent the BHA 170. The mud then flows from the bottom of the wellbore 160 toward the surface, carrying cuttings and material, including gas, from the bottom of the wellbore 160. The mud, the cuttings, and any other material make the well returns. At the surface, the well returns are captured at the wellbore head and sent to the mud-gas separator 190.

The apparatus 100 also includes a control system 200 configured to control or assist in the control of one or more components of the apparatus 100. For example, the control system 190 may be configured to transmit operational control signals to the drawworks 130, the top drive 140, the BHA 170 and/or the pump 180, and the mud gas separator 190. The control system 200 may be a stand-alone component installed near the mast 105 and/or other components of the apparatus 100. In some embodiments, the control system 200 is physically displaced at a location separate and apart from the drilling rig.

FIG. 2 shows a stylized illustration of a schematic of the mud-gas separator 190, also referenced as an apparatus. The mud-gas separator 190 includes a hollow main housing 210, a primary U-tube 212, a secondary U-tube 214, a sparge system 216, an input line 220, and a sensing and control system 222 (Fig. 3).

The main housing 210 includes a chamber wall 230 having a body portion 232, a conical portion 234, and a cap 236. In the embodiment shown, the body portion 232 is a cylindrically shaped portion. The conical portion 234 extends downwardly from the body portion 232 and forms a funnel. The cap 236 is disposed on the upper end of the body portion 232.

The body portion 232 is the main body of the main housing 210 and, in the embodiment shown, is a cylindrical portion having a central axis 233 and having an axial height h greater than its diameter d. In some embodiments, the body portion 232 is not cylindrical, but may be oval, rectangular, or other shape in cross-section. The conical portion 234 extends from the bottom of the body portion 232 and forms a funnel shaped to ease discharge of mud from the main housing 210. As such, it includes walls that taper together to direct mud from the main housing 210. The cap 236 is disposed at the top of the body portion and covers and maintains the body portion 232 and seals or caps the main housing 210.

The hollow main housing 210 also includes a well return inlet 240, a primary mud outlet 242, a secondary mud outlet 244, and a gas vent 246. The well return inlet 240 connects to the input line 220, which connects either directly or indirectly to the wellbore 160 in Fig. 1. The well returns include mud, gas, cuttings, and any other matter from the wellbore. The well returns flow into the main housing 210 through the well return inlet 240. In the embodiment shown, the well return inlet 240 is formed in the wall of the body portion 232. In this example, it is disposed at a height greater than both the primary and secondary mud outlets 242, 244. Although it is shown disposed in the upper half of the body portion 232, in other embodiments, the well return inlet 240 is disposed elsewhere in the system, including through the cap 236. The well return inlet 240 may include multiple inlet ports for the well returns. Here, there are two inlets. In addition, there may be additional inlets, such as the inlet 240 from a choke manifold (not shown).

The primary mud outlet 242 is disposed at a bottom end of the conical portion 234. The primary u-tube 212 connects to the primary mud outlet 242 and is configured to receive mud and cuttings of the well returns that pass through the conical portion 234.

The secondary mud outlet 244 is disposed in the body portion 232 at a location above the conical portion 234 and below the well return inlet 240. The secondary mud outlet 244 connects to the secondary u-tube 214 and passes mud and cuttings of the well returns when the level of mud and cuttings in the chamber is sufficiently high. In the exemplary embodiment shown, the secondary mud outlet 244 is disposed in the lower half of the body portion 232.

The gas vent 246 extends from the upper portion of the main housing 210, and in this embodiment, extends from the cap 236. Other embodiments may include the gas vent 246 at an upper portion of the body portion 232. The gas vent 246 may vent to the atmosphere, or may connect via a tube or carrier to a flare tank or other location about the rig apparatus 100. The flare tank may minimize the spray and impact of pressure spikes due to compressed gas being pumped into the main housing 210 through the well return inlet 240. The size of the main housing and the sizes of the primary and secondary u-tubes 212, 214 may be determined based upon the drilling application since the mud-gas separator 190 is designed to balance the expected well returns with a sufficient flow to ensure the cuttings progress through the entire primary or secondary u-tubes 212, 214.

In the exemplary embodiment shown, a gas meter 247 is disposed along a vent conduit or at the gas vent 246 to measure or quantify gas obtained from the drilling mud. In some embodiments, this is a low flow gas meter. This enables rig operators to track gas volume vented during drilling. This may also provide rig operators with totalizer values, which are often tracked as the total volume of gas retrieved during a well drilling process for a single well. This information may be recorded or stored in the control system 200 or elsewhere about the rig.

The primary u-tube 212 extends from the primary mud outlet 242 at the bottom of the conical portion 234. As understood by its name, it is formed as a u-shape extending substantially vertically downward from the primary mud outlet 242 to a u-shaped curve and then extends primarily vertically upward. The primary u-tube 212 leads to the shakers 195 (Fig. 1) and is configured to convey mud and cuttings from the main housing 210 for processing at the shakers 195.

The secondary u-tube 214 extends from the secondary mud outlet 244 and extends in a direction substantially vertically downward to a u-shaped curve and then extends substantially vertically to an upward height. The secondary u-tube 214 also leads to the shakers 195 (Fig. 1).

The sparge system 218 is configured and arranged to flush solids and to force mud through the primary and secondary u-tubes 212, 214. It is configured to keep solids from collecting, unplugging a blockage, or adding extra fluid for cuttings transport. In the embodiment shown, the sparge system 218 includes a high pressure pump 260 and a series of flow lines leading to different aspects of the mud-gas separator 190. The pump 260 may be any type of pump, and in some embodiments, is a centrifugal pump. In may be fluidicly connected to a fluid source such as clean fluid from the drilling pits at the rig site. As can be seen, the series of flow lines includes a main line 261, a primary flow line 262 connecting to the primary u-tube 212, a secondary flow line 264 connecting to the secondary u-tube 214, and a chamber flow line 266.

The primary flow line 262 is directed to intersect the bend forming the u-shape of the primary u-tube 212 so that a portion of an axis of the primary u-tube 212 and a portion of an axis of the primary flow line 262 coincide. In other embodiments, however, the primary u-tube 212 and the primary flow line 262 intersect at any acute angle, and in some embodiments, the angle is between 0 and 30 degrees.

The secondary flow line 264 is directed to intersect the bend forming a u-shape of the secondary u-tube 214 so that a portion of an axis of the secondary u-tube 214 and a portion of an axis of the secondary flow line 264 coincide. Like the primary u-tube 212 and the primary flow line 262 discussed above, the secondary u-tube 214 and the secondary flow line 264 intersect at any acute angle, and in some embodiments, the angle is between 0 and 30 degrees.

The chamber flow line 266 connects to the main housing 210 and is configured to introduce high pressure flow or high fluid volume into the main housing 210 to assist with flow from the main housing 210, to assist with cleaning of the main housing 210 or to remove a clog or build-up that may affect flow from the main housing 210. In the example shown, the chamber flow line 266 includes a conical portion line 268 and a body portion line 270.

The conical portion line 268 intersects the conical portion 234 and is disposed to introduce fluid into the conical portion 234 at a location above the primary mud outlet 242. The conical portion line 268 may be disposed to provide a nozzle jetting effect as well as a cyclone effect on the conical portion 234 in order to clean sides of the conical portion 234 and to help move along the mud and cuttings. This may be done as a part of routine maintenance or may be done in response to a low flow or high flow condition. The body portion line 270 intersects the body portion 232 of the main housing 210. It also is disposed to clean sides of the body portion 232 and to help move along the mud and cuttings.

The input line 220 extends to an upper portion of the main housing 210 and is in fluid communication with the wellbore so that mud, cuttings, and gas from the wellbore are directed into the main housing 210 of the mud-gas separator 190. As an alternative or as a supplement to the pump 260, the main line 261 also may be fluidicly connected to a rig pump or other auxiliary pump at the rig site.

The sensing and control system 222 includes valves, sensors, and a controller that manage the operation of the mud-gas separator 190. In some embodiments, the control is performed manually based on detected information, while in other embodiments, the control is performed automatically based on pre-stored settings.

Fig. 3 is a block diagram showing an example of the sensing and control system 222. The sensing and control system 222 includes sparge system valves 280, u-tube control valves 282, pressure sensors 284, a level transducer 286, a well return flow meter 288, and a controller 290.

The sparge system valves 280 include in this exemplary embodiment, a series of valves, referenced as V1, V2, V3, V4, and V5, that control flow through the series of flow lines. These are also shown in Fig. 2. The valve V1 is disposed and configured to control flow through the primary flow line 262, the valve V2 is disposed and configured to control flow through the secondary flow line 264, the valve V3 is disposed and configured to control flow through the conical portion line 268, and the valve V4 is disposed and configured to control flow through the body portion flow line 270. The valve V5 is disposed and configured to control flow through the main line 261, controlling fluid access to the series of flow lines. An optional valve V6 controls flow from an alternative rig pump that would supplement or replace flow from the pump 260. Downstream of each of the valves V1, V2, V3, and V4 is an associated non-return or one-way valve 274 (Fig. 2) that prevents reverse flow through each of the flow lines. These may be standard check valves, such as ball valves, proportional valves, or some other valves configured to permit fluid flow in only one direction.

The u-tube control valves 282 are shown in Fig. 3 as valves V7 and V8, and are shown in Fig. 2 disposed to control flow through the primary and secondary u-tubes 212, 214, respectively. These valves V7, V8 may be proportional valves that may be controlled by the controller 290 in order to control and regulate flow through the main housing 210.

The pressure sensors 284 are shown and referenced as PT1, PT2, PT3, and PT4. With reference to Fig. 2, the pressure sensor PT1 measures pressure in the primary u-tube 212. In this embodiment, the pressure sensor PT1 is disposed to measure pressure downstream of the intersection with the primary flow line 262. The pressure sensor PT2 measures pressure in the secondary u-tube 214, and in the exemplary embodiment shown, is disposed to measure pressure downstream of the intersection with the secondary flow line 264. The pressure sensor PT3 measures pressure at the base of the conical portion 234. It may be disposed in the primary u-tube 212 adjacent the primary mud outlet 242 or at the bottom of the body portion 232. The pressure sensor PT4 is disposed above the typical fluid level of the main housing 210 and is configured to measure vessel pressure of the main housing 210.

The level transducer 286 is disposed within the body portion 232 and is configured to detect the level of fluid or mud within the main housing 210.

Embodiments having the well return flow meter 288 detect the flow of well returns into the main housing 210. Accordingly, the flow or volume of mud and cuttings into the main housing 210 may be controlled based on the detected flow, as deviations from expected flow may require operators to rectify flow control conditions. Monitoring the flow into the main housing 210 may enable tracking and regulation to ensure that the main housing 210 does not overflow.

The controller 290 may be configured to receive data from the pressure sensors 284, the level transducer 286, and/or the well return flow meter 288, and based upon the received data, control the sparge system valves 280 and the u-tube control valves 282. The controller 290 may include a processor and memory. The processor may be, for example, an integrated circuit with power, input, and output pins capable of performing logic functions. In various embodiments, the processor may be a targeted device controller or a microprocessor configured to control the valves based on data received at the processor. It may receive and process data and may issue control signals to the sparge system valves 280, the u-tube control valves 282, the pump 260, or other components. The memory may be a semiconductor memory such as RAM, FRAM, or flash memory that interfaces with the processor. In some embodiments, the processor writes to and reads from the memory, and performs other common functions associated with managing semiconductor memory. The processor may read and execute control programs stored in the memory for the operation of the mud-gas separator 190. In some embodiments, the controller 290 is associated with or forms a part of the control system 200 in Fig. 1. The controller 290 may have stored therein fluid level thresholds used to control the operation mud-gas separator 190. In addition, the controller 290 may be configured to calculate fluid levels from data received from sensors, such as pressure sensors or load sensors.

This fluid level thresholds stored in the controller 290 may be pre-programmed during initial manufacturing or may be set by the operator based on the well plan, the terrain type, and based on other factors, including expected well control parameters. The thresholds may include a high threshold and a low threshold, but also may include multiple high and low thresholds. The controller 290 may be configured to create different alerts or take different actions for each threshold.

The mud-gas separator 190 is arranged to operate on a continuous basis while drilling. That is, it may be used not only with well control processes, but also when continuously drilling. In addition, some embodiments of the mud-gas separator 190 are instrumented and provide feedback to the controller 290.

The operation of the mud-gas separator 190 is described below with reference to the flow chart 400 of Fig. 4. Fig. 4 begins at a step 402, with a step of introducing well returns through the well return inlet 240 into the main housing 210. The sloping walls of the conical portion 234 guide the mud and cuttings to the primary mud outlet 242 at the bottom of the conical portion 234. At a step 404, the mud and cuttings flow through the primary mud outlet 242 and into the primary u-tube 212, on their way to the shakers 195. Also at the step 404, the gas from the well returns is vented through the upper portion of the main housing 210 to atmosphere or to a flare tank or other location.

During operation of the mud-gas separator 190, as indicated by a step 406, the sensing and control system 222 continuously monitors the fluid level and the pressures for high fluid level or over-pressure conditions. At step 408, the controller 290 queries whether the fluid level exceeds a high preset fluid level threshold. This threshold may be stored within the controller 290, and may be set by the operator or during initial manufacturing. If at step 408 the fluid level does exceed the preset high threshold, then the method proceeds to a step 410.

At step 410, the controller 290 alerts an operator or takes action to reduce the fluid level. To alert the operator, the controller may activate, for example, a visual or audible indicator. In some embodiments, the indicator is a flashing light, such as an LED bulb, and in other embodiments, the indicator is an alert on an operator user interface that indicates that the fluid level exceeds the high threshold. In some embodiments, the alert signals the operator to take action to avoid an overflow condition. This may include decreasing the fluid level in the main housing 210. The operator may do this by controlling, either manually or by initiating instructions to the controller 290, the u-tube control valves 282, or the sparge system 218.

In some instances, the operator may open the secondary control valve V8 to allow flow through the secondary u-tube 214 to avoid the overflow condition. The secondary u-tube 214 may also be opened in emergency flooding conditions or as a backup during well control.

In some instances, the fluid level exceeding the high threshold level may indicate that the flow through the primary u-tube 212 is slower than desired to keep up with the flow into the main housing 210. This may be a consequence of cuttings not having the transport velocity to pass beyond the primary u-tube 212. As such, they may fall to the bottom of the tube and occlude the tube. Therefore, in some instances, the operator may respond by controlling the sparge system 218 to inject high pressure clean fluid through the primary u-tube 212 to loosen and increase the flow velocity through the primary u-tube 212. This may help keep solids from collecting, unplug a blockage, or may add extra fluid to transport cuttings. When the fluid level falls back below the high threshold level, the controller 290 may close the secondary control valve V8. This may ensure that gas is not inadvertently allowed to pass through the secondary u-tube 214 to the shakers.

While described as the operator taking action, in some embodiments, the controller 290 automatically responds by controlling the valves in the manner described to ensure that an overflow condition does not occur.

If at step 408, the fluid level is not above the high fluid level threshold, then the method proceeds to step 412, where the controller 290 determines whether the fluid level is below a preset threshold. If the fluid level is below a preset threshold, then the controller 290 operates to either alert the operator to take corrective action or takes corrective action itself, at a step 414.

The controller 290 may alert the operator with an indicator in the manner described above, or may take action itself. The fluid below a low threshold may indicate a low mud or fluid condition. In order to avoid pushing gas through the primary or secondary mud outlets 242, 244, the operator or the controller 290 may close the primary control valve V7 so that the gas is forced to exit through the gas vent 246 and not through the u-tubes 212. In addition, the controller 190 may activate the sparge system 218 to add additional fluid into the main housing 210 through one or both of the valves V3 and V4.

After corrective action, when the fluid level again becomes higher than the low threshold, the controller 290 may again open the control valve V7 to again allow flow through the primary u-tube 212. This may help maintain the fluid level within a desired range that provides a suitable operation enabling separation of gas and mud before the gas arrives at the shakers.

The alert to the operator may also enable the operator to take other well control actions to ensure that the well control is properly balanced with the proper amount of mud and being pumped into the wellbore.

If at step 412, the fluid level is not below a low threshold, then the method returns to the beginning and continuously monitors by performing the method again. Likewise, after taking corrective action, the method still returns to the beginning and continuously monitors pressure levels. In some embodiments, the controller does not operate the valves during certain drilling conditions.

Determining the fluid levels at step 406 may include direct measurement using the fluid level transducer 286 or using other sensors, including the pressure sensors 284 to calculate a secondary or redundant fluid level measurement. Density of the fluid and head pressure allows a secondary check on the level transducer 286, providing a redundant fluid level check. In some embodiments, the pressure sensors 284 measure pressure directly, while in other embodiments, the pressure sensors 284 are load cells or radar transmitters. Based on data detected by the sensors, the controller 290 may warn of problems or failures of the primary measurement device, which is the level transducer 286.

If plugging appears to occur within the conical portion, the sparge system 218 may inject fluid into the conical portion line 268. This may help flush solids and keep mud and cuttings moving through the primary mud outlet 242. As indicated above, in some instances the pump 260 is supplemented by or replaced with a rig pump or other auxiliary pump. The lines are designed to have a nozzle effect as well as cyclone effect in order to clean sides of the conical portion and keep the cuttings moving. In addition, well operators may operate the sparge system 218 during routine maintenance to remove build-up of mud or cuttings in the man housing 210 and/or the primary or secondary u-tubes 212, 214.

In some embodiments, the controller 290 monitors the flow of the well returns into the main housing 210 with the well return flow meter 288. If the controller 290 detects that the well return flow is insufficient to maintain cutting transport velocity through the primary u-tube 212, the controller 290 may automatically activate the pump 260 and open one or more of the valves V1, V2 to provide supplementary pressure and flow through the primary u-tube 212 and/or secondary u-tube 214 in order to maintain suitable velocity through the u-shape so that cuttings do not become entrapped. In some embodiments, the pump 260 is controlled with an on/off/auto configuration where it may be manually controlled to be automatically operated when in auto mode.

While not described in detail, the main housing 210 may include multiple inlets and may include conventional gas busting internal elements, such as agitators, for example. Conventional fluid diverters and gas demisters can also be used.

In view of all of the above and the figures, one of ordinary skill in the art will readily recognize that the present disclosure introduces an apparatus including a main housing including a bottom portion and a side portion; a gas vent associated with the main housing and configured to vent gas from well returns introduced into the main housing. The apparatus may also include a first mud outlet formed within the bottom portion of the main housing and configured to pass mud from well returns introduced into the main housing; and a second mud outlet formed within the side portion of the main housing and configured to pass mud from well returns introduced into the main housing.

In an aspect, the apparatus includes a first u-tube connected to and extending from the first mud outlet toward a shaker; and a second u-tube connected to and extending from the first mud outlet toward a shaker. In an aspect, the apparatus includes a sparge system associated with the first u-tube and configured to introduce high pressure fluid into the first u-tube from a location upstream of a bottom of the first u-tube. In an aspect, the apparatus includes a sparge system configured to introduce high pressure fluid into the main housing to increase fluid flow and to clean the main housing. In an aspect, the apparatus includes a sensing system configured to determine a fluid level within the main housing, the sensing system being configured to alert an operator to a high level condition. In an aspect, the apparatus includes a sensing system configured to determine a fluid level within the main housing, the sensing system being configured to alert an operator to a low level condition. In an aspect, the apparatus includes a sensing system configured to determine a fluid level within the main housing, the sensing system being arranged to perform at least one of: close a primary valve to reduce drainage from the main housing through the first mud outlet, and open a secondary valve to increase drainage flow through the second mud outlet. In an aspect, the sensing system comprises a fluid level transmitter configured to detect fluid levels in the main housing. In an aspect, the sensing system comprises pressure sensors configured to indicate pressure differentials to determine a fluid level in the main housing. In an aspect, the main housing comprising a bottom portion sloping toward the first mud outlet in a manner that directs mud and cuttings of the well returns to the first mud outlet.

The present disclosure also introduces a method including: introducing well returns into a main housing; monitoring a fluid level within the main housing; controlling a first valve to reduce flow through a bottom of the main housing when the fluid level is below a threshold; and controlling a second valve to increase flow through a side of the main housing when the fluid level is above a threshold.

In an aspect, monitoring a fluid level within the main housing comprises detecting the fluid level with a level transducer. In an aspect, monitoring a fluid level within the main housing comprises detecting pressure differentials with pressure sensors and determining whether a fluid level is above or below a stored threshold level. In an aspect, the method includes venting gas from the well returns through a gas vent disposed in an upper portion of the main housing; and flowing mud from the well returns through a first mud outlet disposed at the bottom of the main housing into a u-tube. In an aspect, the method includes injecting a high pressure fluid into the u-tube to increase the fluid velocity through the u-tube. In an aspect, the method includes injecting a high pressure fluid into a conical portion of the main housing to increase the flow through the bottom of the main housing. In an aspect, the method includes directing mud from the well returns through a mud outlet disposed at a bottom of a sloping side wall. In an aspect, the sloping side walls form a conical portion leading to the mud outlet.

The present disclosure also introduces an apparatus including a main housing configured to receive well returns; a gas vent associated with the main housing and configured to vent gas from the well returns; a first mud outlet formed within the main housing and configured to vent mud from well returns introduced into the main housing; and a second mud outlet formed within main housing and configured to vent mud from well returns introduced into the main housing, wherein the first mud outlet and the second mud outlet are disposed at different elevations within the main housing.

In an aspect, the apparatus includes a first u-tube connected to and extending from the first mud outlet toward a shaker; and a second u-tube connected to and extending from the first mud outlet toward a shaker. In an aspect, the apparatus includes a sparge system associated with the first u-tube and configured introduce high pressure fluid into the first u-tube, the sparge system being associated with the u-tube to introduce fluid from a location upstream of a bottom of the first u-tube. In an aspect, the apparatus includes a sensing system configured to determine a fluid level within the main housing, the sensing system being configured to perform at least one of: close a primary valve to reduce drainage from the main housing through the first mud outlet, and open a secondary valve to increase drainage flow through the second mud outlet.

The foregoing outlines features of several embodiments so that a person of ordinary skill in the art may better understand the aspects of the present disclosure. Such features may be replaced by any one of numerous equivalent alternatives, only some of which are disclosed herein. One of ordinary skill 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. One of ordinary skill in the art should also realize that such equivalent constructions do not depart from the present disclosure, and that they may make various changes, substitutions and alterations herein without departing from the present disclosure.

THE CLAIMS

What is claimed is:

1. An apparatus (100), including:

a main housing (210) including a bottom portion and a side portion;

a gas vent (246) associated with the main housing (210) and configured to vent gas from well returns introduced into the main housing (210);

a first mud outlet (242) formed within the bottom portion of the main housing (210) and configured to pass mud from well returns introduced into the main housing (210);

a second mud outlet (244) formed within the side portion of the main housing (210) and configured to pass mud from well returns introduced into the main housing (210); and

a sparge system configured to introduce high pressure fluid into a main vessel to increase a flow of fluid in the main vessel.

2. The apparatus of claim 1, including:

a first u-tube connected to and extending from the first mud outlet toward a shaker; and

a second u-tube connected to and extending from the second mud outlet toward a shaker.

3. The apparatus of claim 2, including a sparge system associated with the first u-tube and configured to introduce high pressure fluid into the first u-tube from a location upstream of a bottom of the first u-tube.

4. The apparatus of claim 1, 2, or 3, including:

a sensing system configured to determine a fluid level within the main housing, the sensing system being configured to alert an operator to one of a high level condition and a low level condition.

5. The apparatus of claim 1, 2, or 3, including a sensing system configured to determine a fluid level within the main housing, the sensing system being arranged to perform at least one of:

close a primary valve to reduce drainage from the main housing through the first mud outlet, and

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open a secondary valve to increase drainage flow through the second mud outlet.

6. The apparatus of claim 5, wherein the sensing system includes a fluid level transmitter configured to detect fluid levels in the main housing.

7. The apparatus of claim 5, wherein the sensing system includes pressure sensors configured to indicate pressure differentials to determine a fluid level in the main housing.

8. The apparatus of one of claims 1-6, wherein the main housing includes a bottom portion sloping toward the first mud outlet in a manner that directs mud and cuttings of the well returns to the first mud outlet.

9. A method including:

introducing well returns into a main housing (210);

monitoring a fluid level within the main housing (210);

controlling a first valve to reduce flow through a bottom of the main housing (210) when the fluid level is below a threshold;

controlling a second valve to increase flow through a side of the main housing (210) when the fluid level is above a threshold; and

controlling a sparge system configured to introduce high pressure clean fluid into a separation zone to increase a flow of fluid in the separation zone when additional fluid is desired in the separation zone.

10. The method of claim 9, wherein monitoring a fluid level within the main housing includes detecting the fluid level with a level transducer.

11. The method of claim 9, wherein monitoring a fluid level within the main housing includes detecting pressure differentials with pressure sensors and determining whether a fluid level is above or below a stored threshold level.

12. The method of claim 9, 10, or 11, including:

venting gas from the well returns through a gas vent disposed in an upper portion of the main housing; and flowing mud from the well returns through a first mud outlet disposed at the bottom of the main housing into a u-tube.

13. The method of claim 12, including injecting a high pressure fluid into the u-tube to increase the fluid velocity through the u-tube.

14. The method of claim 12, including injecting a high pressure fluid into a conical portion of the main housing to increase the flow through the bottom of the main housing.

15. The method of claim 9, 10, or 11, including directing mud from the well returns through a mud outlet disposed at a bottom of a sloping side wall.

16. The method of claim 15, wherein the sloping side walls form a conical portion leading to the mud outlet.

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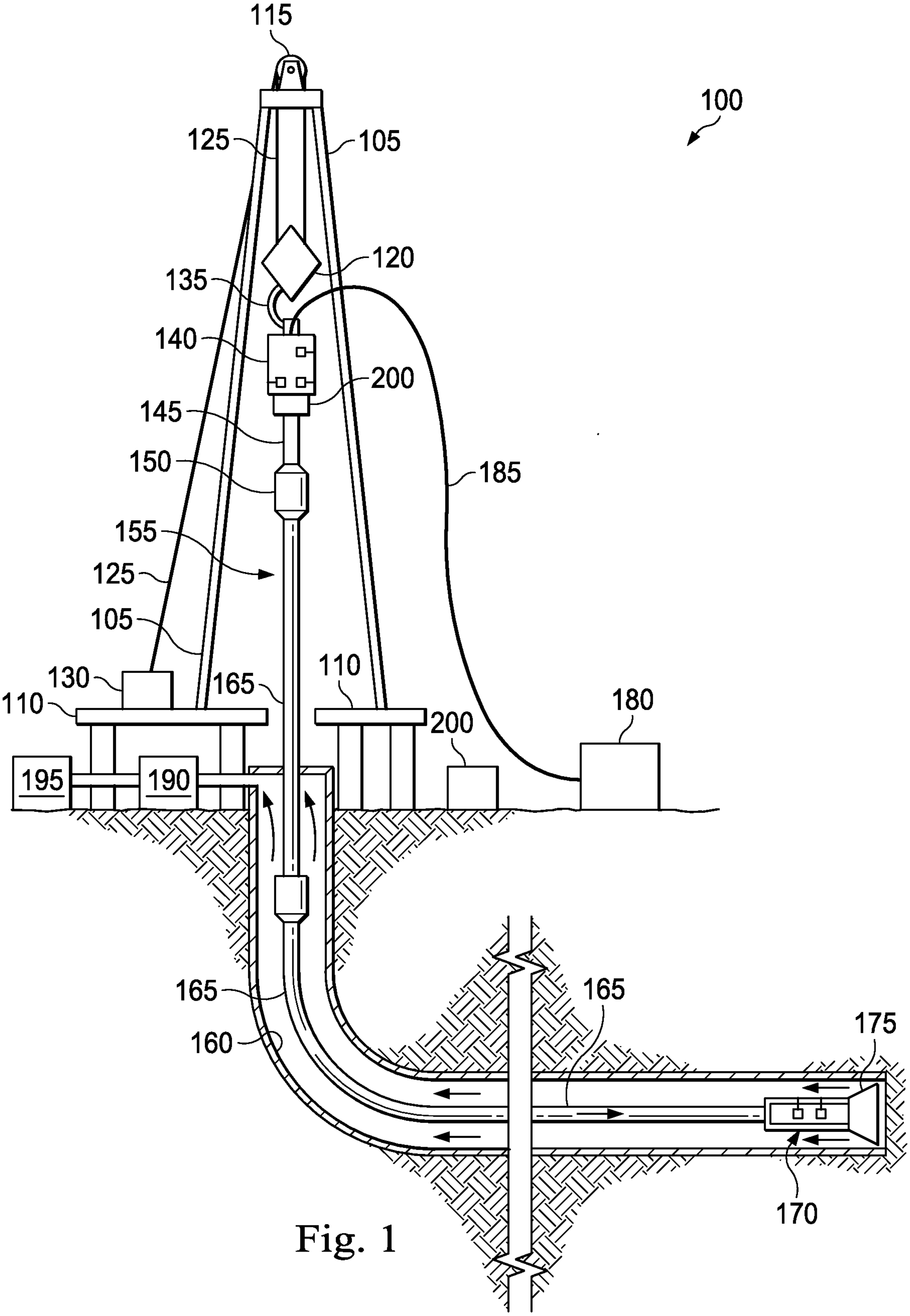
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Fig. 1

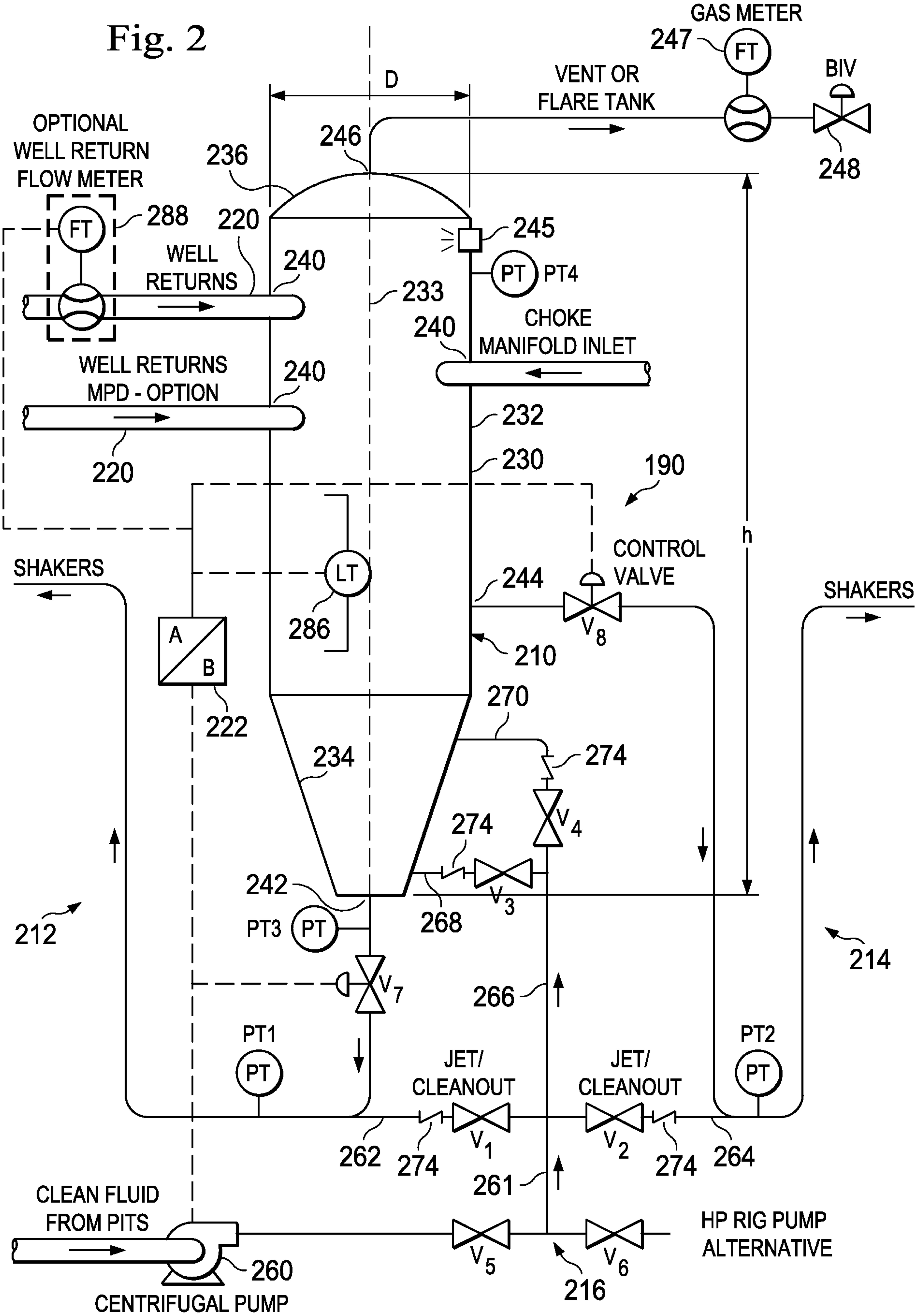
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Fig. 2

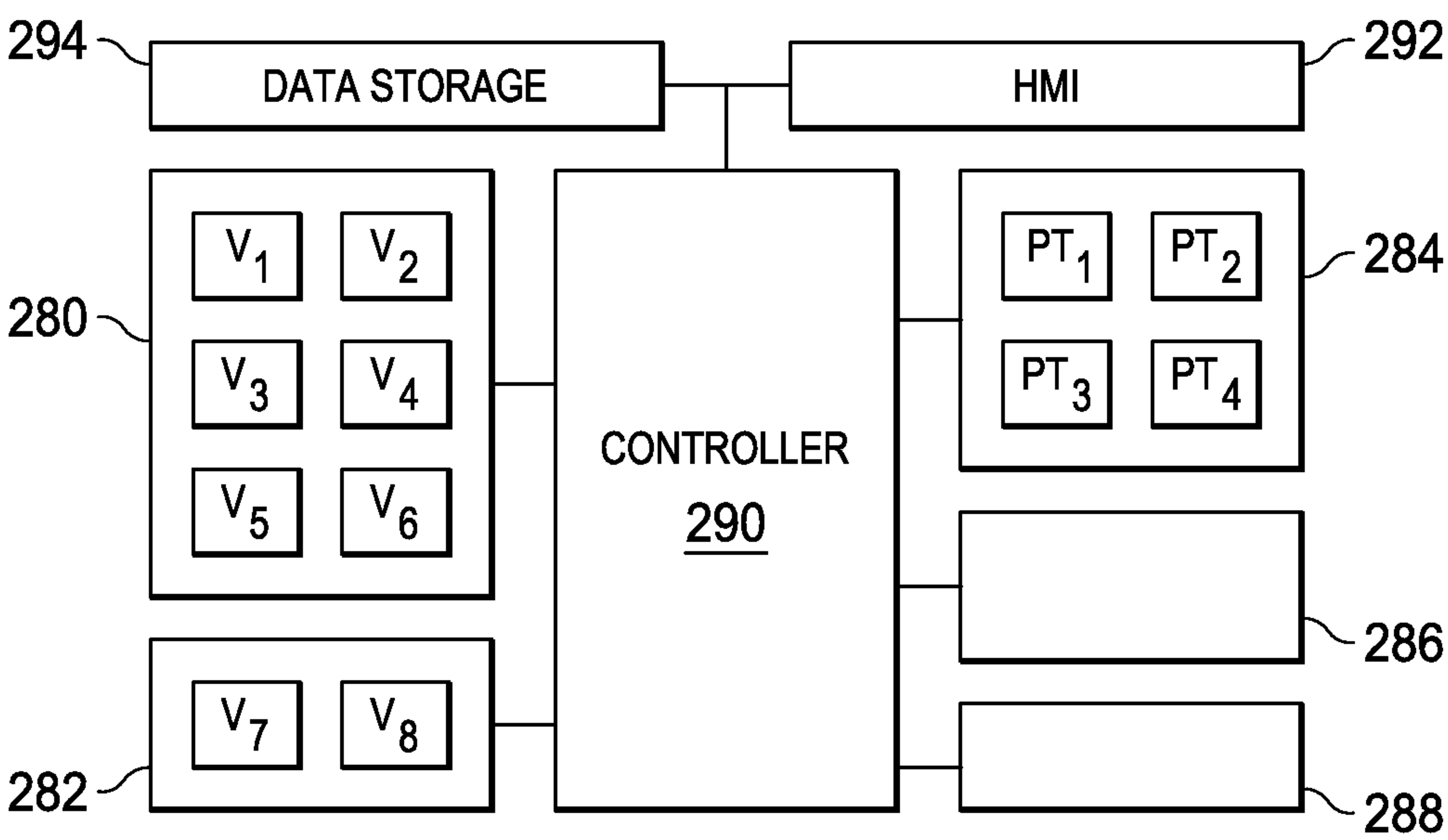
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Fig. 3

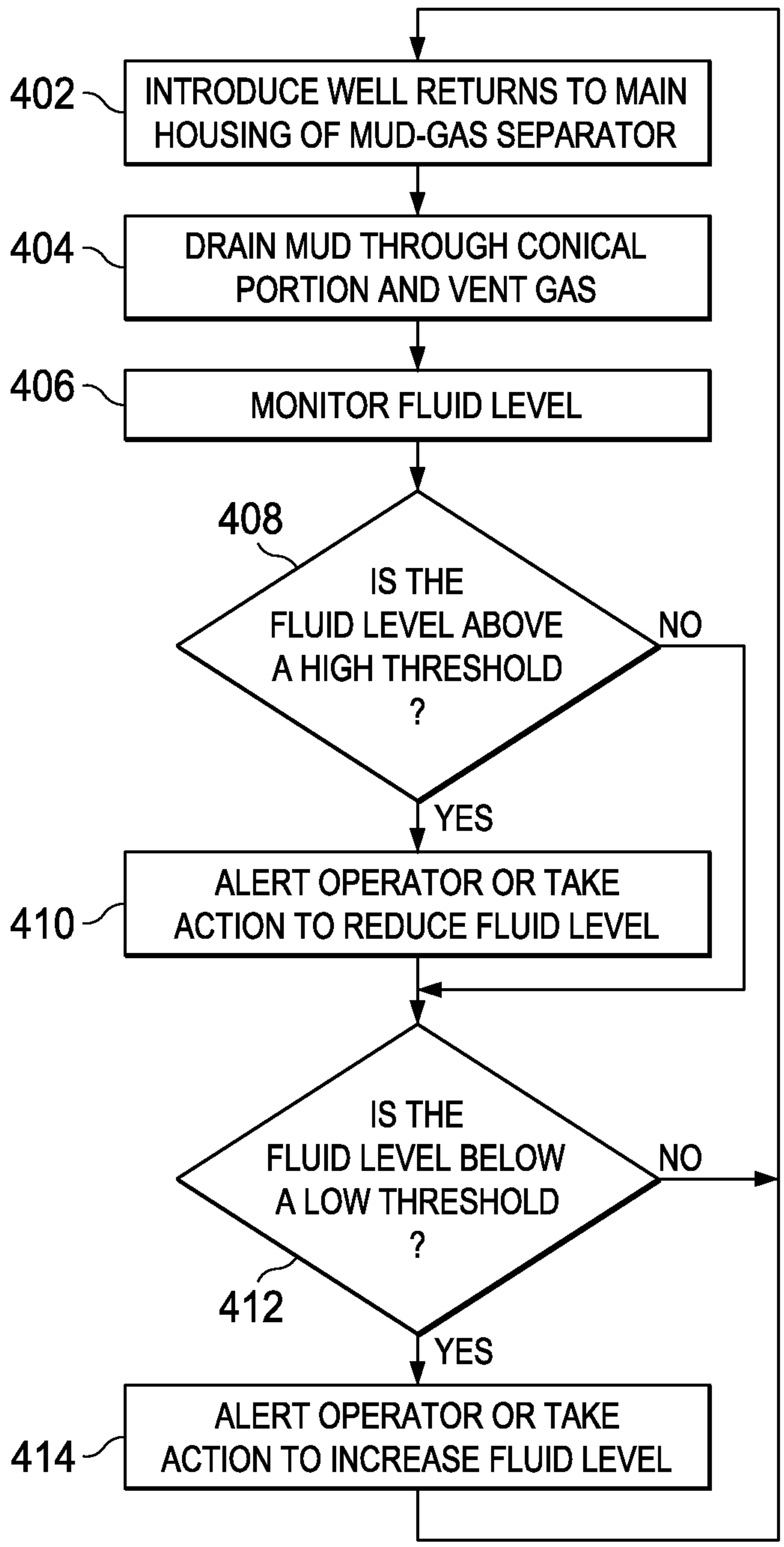
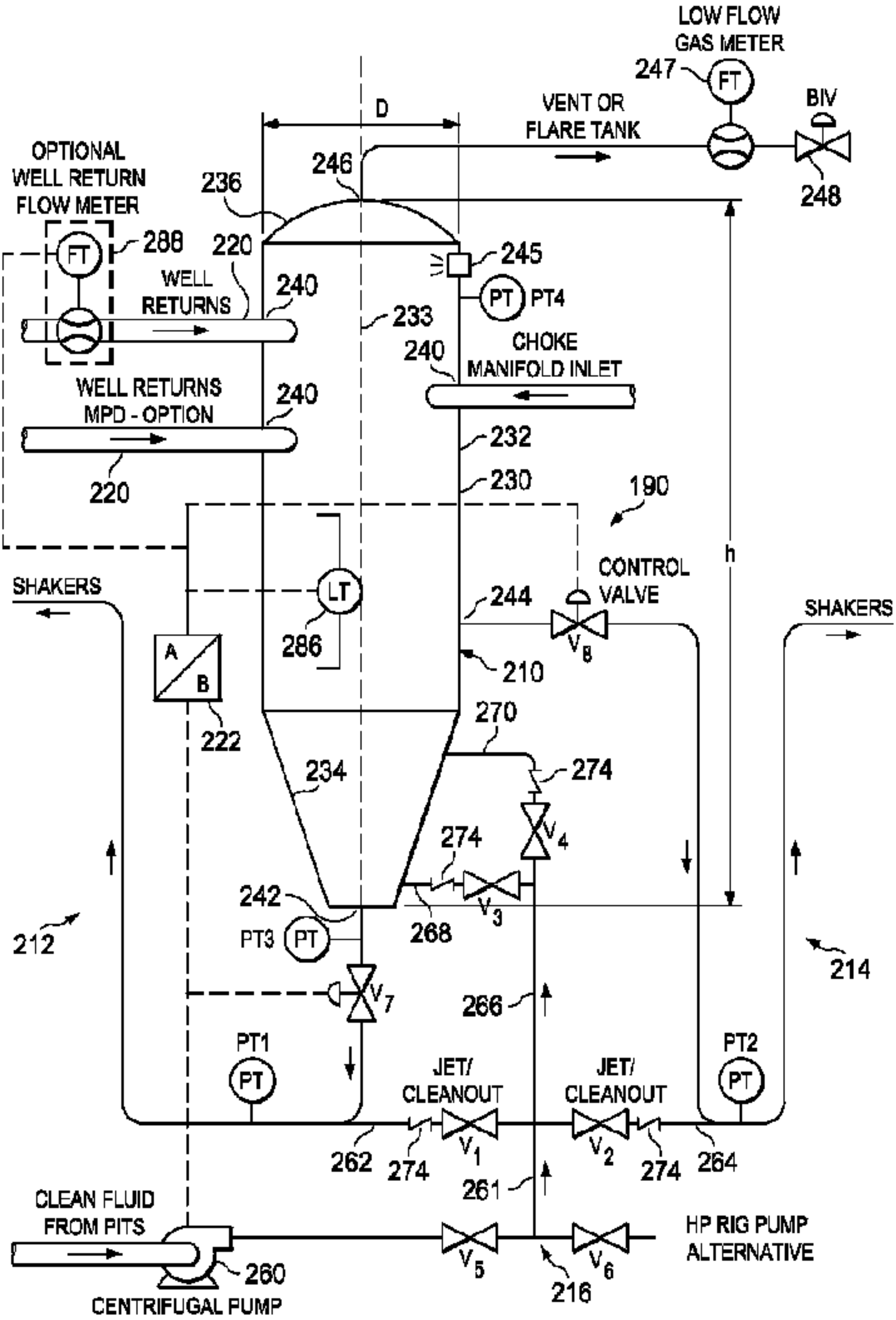

402
INTRODUCE WELL RETURNS TO MAIN HOUSING OF MUD-GAS SEPARATOR
404
DRAIN MUD THROUGH CONICAL PORTION AND VENT GAS
406
MONITOR FLUID LEVEL
408
IS THE FLUID LEVEL ABOVE A HIGH THRESHOLD ?
NO
YES
ALERT OPERATOR OR TAKE ACTION TO REDUCE FLUID LEVEL
410
IS THE FLUID LEVEL BELOW A LOW THRESHOLD ?
NO
412
YES
ALERT OPERATOR OR TAKE ACTION TO INCREASE FLUID LEVEL
414

Fig. 4



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