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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
13 April 2017 (13.04.2017)

(10) International Publication Number
WO 2017/062877 A1

(51) International Patent Classification:
E21B 21/08 (2006.01)

(21) International Application Number:
PCT/US2016/056141

(22) International Filing Date:
7 October 2016 (07.10.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/238,685 7 October 2015 (07.10.2015) US

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

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

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(54) Title: DRILLING SYSTEM INCLUDING A PRESSURE INTENSIFIER

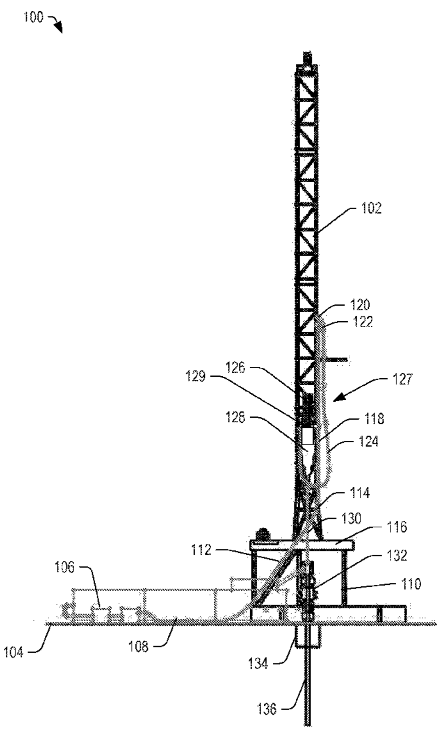

FIG. 1

(57) Abstract: In some embodiments, a drilling system can include a top drive and one or more pressure intensifiers coupled between a mud pump and the top drive to increase fluid pressure of drilling fluid driven down into a hole. In some aspects, the one or more pressure intensifiers may be coupled to a traveling block ahead of a top drive or may be coupled to at least one of a drill floor, a mast, a crown, a setback, and an offset of a drilling rig. Further, in some aspects, the drilling system may include a mud pump coupled to a mud tank and configured to pump the drilling fluid through a low pressure conduit to the one or more pressure intensifiers.

WO 2017/062877 A1

Published:

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

Drilling System Including a Pressure Intensifier

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a non-provisional of and claims priority to U.S. Provisional Patent Application No. 62/238,685 filed on October 7, 2015 and entitled "Drilling System Including a Pressure Intensifier", which is incorporated herein by reference in its entirety.

FIELD

[0002] The present disclosure is generally related to drilling systems, and more particularly, to mud circulation systems for land and offshore drilling rigs.

BACKGROUND

[0003] Wells (boreholes or wellbores) are routinely drilled into the earth both on land and offshore, such as for the recovery of hydrocarbons, water, geothermal energy, or minerals from one or more subsurface formations. The drill bit may be coupled to the lower end of a drill string, which may be formed from a plurality tubular pieces with a bottom hole assembly positioned at the bottom. In certain embodiments, the bottom hole assembly or down hole assembly may be formed of multiple components including mud motors and a drill bit.

[0004] In certain embodiments involving vertical borehole drilling operations, the drill string and bit may be rotated by a top drive or rotary table driving a Kelly. In offshore drilling operations, the rotary table or top drive may be supported by a seabed-supported drilling platform or suitably-adapted floating vessel. During the drilling process, a drilling fluid (commonly referred to as "drilling mud" or simply "mud") may be pumped under pressure from mud pumps to an input manifold of the top drive or to an input of a swivel suspended below the traveling block. The drilling fluid may pass down through the drill string, out the drill bit into the wellbore, and then upward back to the surface through the annular space (sometimes referred to as the wellbore annulus) between the drill string and the wellbore. The drilling fluid carries borehole cuttings to the surface, cools the drill bit, and forms a protective cake on the borehole wall (to stabilize and seal the borehole wall).

[0005] In certain embodiments, holes are commonly made by rotating the drill string by the top drive or Kelly. Another way of advancing the wellbore may include a downhole mud motor. One of the common ways to power the mud motor is to make use of the hydraulic pressure of the mud in the drill string.

[0006] One common example of a downhole motor is in the form of a progressive cavity motor (displacement pump or Moineau pump) that may include a generally cylindrical stator and an elongate rotor, which can rotate within the stator. The rotor of the progressive cavity motor can include one or more helical vanes or lobes extending along and about a length of a central shaft. In the typical operation of a downhole motor, drilling fluid flowing downward through the drill pipe assembly may pass through the progressive cavity motor, causing the rotor to rotate within the stator and thus rotating a drive shaft to rotate the drill bit.

SUMMARY

[0007] In some embodiments, a drilling system can include a top drive and one or more pressure intensifiers coupled between a mud pump and the top drive to increase fluid pressure of drilling fluid driven down into a hole. In some aspects, the one or more pressure intensifiers may be coupled to a traveling block ahead of a top drive or may be coupled to at least one of a drill floor, a mast, a crown, a setback, and an offset of a drilling rig. Further, in some aspects, the drilling system may include a mud pump coupled to a mud tank and configured to pump the drilling fluid through a low pressure conduit to the one or more pressure intensifiers.

[0008] In other embodiments, a system can include one or more mud pumps configured to pump drilling fluid through one or more hoses, associated connectors, and associated fittings. The one or more hoses may have a first internal diameter within a bend ratio determined by a confined space of a mast of a drilling rig. The system may also include one or more pressure intensifiers coupled between the one or more mud pumps and a drill

string to increase fluid pressure of the drilling fluid within a well bore. In one aspect, the drill string has a second internal diameter that is less than the first internal diameter. In another aspect, the one or more pressure intensifiers are coupled to a traveling block ahead of a top drive of a drilling rig or are coupled to at least one of a drill floor, a mast, a crown, a setback, and an offset of a drilling rig.

[0009] In still other embodiments, a drilling system can include a drilling rig and traveling equipment coupled to the drilling rig and configured to couple to a drill string extending into a well bore. The drilling system may also include one or more pressure intensifiers coupled between a mud pump and traveling equipment to increase fluid pressure of drilling fluid driven through the drill string.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Fig. 1 is a diagram of a drilling rig including a pressure intensifier, in accordance with certain embodiments of the present disclosure.

[0011] Fig. 2 is a diagram of a drill rig including a pressure intensifier on the drill floor of the drilling rig, in accordance with certain embodiments of the present disclosure.

[0012] Fig. 3 is a perspective view of a portion of the drill rig including a portion of the traveling block and the pressure intensifier mounted above the top drive, in accordance with certain embodiments of the present disclosure.

[0013] Fig. 4 is side view of the portion of the drill rig of Fig. 3.

[0014] Fig. 5 is a flow diagram of a method of intensifying pressure in a drill string of a drill rig, in accordance with certain embodiments of the present disclosure.

[0015] Fig. 6 is a perspective view of a rig system including plurality of frames that serve a dual purpose of transporting drilling equipment and forming a portion of the drill rig, in accordance with certain embodiments of the present disclosure.

[0016] In the following discussion, the same reference numbers are used in the various embodiments to indicate the same or similar elements.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0017] Drilling mud may be pumped from a mud tank at a first pressure, such as between 2,000 and 7,500 pounds per square inch (PSI), by one or more mud pumps, and into the hole to drive the drill bit. The drilling mud may flow from the mud pit through a mud pump and through a flow line to the substructure. The flow line may extend up the substructure to a stand pipe manifold, and then may continue up the mast or derrick to a gooseneck. The mud flows through a gooseneck and through a hose to an intake manifold of a top drive or to an intake of a Kelly swivel coupled to a Kelly. Then, the drilling mud can flow down through the drill string to the bottom hole assembly that can include a mud motor.

[0018] However, the bends and turns of mud conduit, the fittings, and the distance from the pump to the down-hole mud motor may dissipate the hydraulic pressure of the drilling mud. Since the hydraulic pressure drives the mud motor, dissipation of fluid pressure undermines the drilling process.

[0019] However, increasing or maintaining the hydraulic pressure of the drilling mud to the mud motor encompasses a wide range of engineering considerations. For example, because the hose bends approximately 180 degrees within the confines of the mast or derrick, the minimum bend radius of the hose becomes a critical design consideration. Moreover, increasing the pressure rating of the hose requires increasing the wall thickness, which tends to increase the bend radius and reduces the internal diameter (ID) which in turn increases the pressure drop substantially at higher flow rates. Thus, hydraulic pressure and fluid flow that can be transmitted to the drill bit (where it is most effective) is limited by material considerations and by the dimensions of the drill rig system, which are constrained by transportation dimension limits of the drilling rigs.

[0020] Embodiments of the present disclosure enable the drilling industry to find better ways to significantly reduce the operational cost of drilling wells, while at the same time drilling wells faster and farther, especially horizontally. Further, drilling industry economics may reward improvements in the design of wells that can reduce cost by utilizing fewer costly casing strings, yet reach farther and allow production of more hydrocarbons. While advanced well designs utilizing new technologies (such as expanded tubulars to reduce the number of casing strings) could bring needed improvements to the design of wells, such improvements have not been realized because the capabilities of conventional drilling rigs and drilling rig systems are limited. In particular, such improvements to the design of wells require larger hole diameters, which can result in the creation of substantially more cuttings while reducing the annular velocity of the drilling fluid. Reducing the annular velocity of the drilling fluid may be mean that the drilling fluid cannot carry the cuttings and thus may limit or endanger the diameter and length of the well section that may be drilled, unless higher volumes of drilling fluid can be pumped to the drill bit. Conventionally, higher volumes require higher fluid velocities inside the drilling rig system as well as in the drill pipe, which results in higher overall pressure drop, reducing the effective horsepower available at the drill bit.

[0021] In certain embodiments of the present disclosure, a fluid conveyance system can include one or more mud pumps, one or more hoses coupled to the mud pumps, and one or more pressure intensifiers coupled to the hoses. The fluid conveyance system can use a lower pressure hose or hoses configured to convey fluid (such as mud or drill fluid) from the one or more pumps to the one or more pressure intensifiers. The one or more pumps may be configured to provide high fluid volume at low pressure, such as by delivering the fluid through hoses, associated connectors and fittings having a relatively large internal diameter that are within a bend radii determined by the confined space of the mast or derrick of the drilling rig. While a conventional hose could be used, the fluid conveyance assembly uses hoses that provide a lower pressure drop at higher flow rates, thereby increasing the efficiency. Moreover, the pressure intensifier may receive the fluid from one or more hoses and may increase the pressure for delivery to the mud motor at higher hydraulic pressure, thereby increasing the effective horsepower delivered to the drill string and to the drill bit.

[0022] Embodiments of the present disclosure can eliminate significant limitations of conventional drilling rigs, enabling a large increase in effective horsepower at the drill bit. Increasing the effective horsepower at the drill bit becomes especially important in drilling long horizontal wells, as the amount of mechanical rotational horsepower that can be conveyed from the top drive on the drilling rig all the way to the drill bit may be limited.

[0023] In some embodiments, a drilling system can include one or more pressure intensifiers that can be mounted to, integrated with, or otherwise coupled to the traveling equipment of a drilling system. The drilling system may also include one or more low pressure hoses configured to deliver drilling fluid from one or more mud tanks to the one or more pressure intensifiers. The low pressure hoses can be made with thinner walls, larger ID and favorable bend radii, substantially increasing the flow rate that can be delivered to the drill string and reducing the pressure drop and associated inefficiency of conventional delivery systems. The one or more pressure intensifiers can then increase the hydraulic pressure of the drilling fluid through the drill string to the bit, increasing the effective horsepower transmitted to the bit at higher flow rates.

[0024] Embodiments of the present disclosure can include one or more pressure intensifiers that can be mounted to, integrated with, or otherwise coupled to the traveling equipment of a drilling system to increase the hydraulic pressure of the drilling mud delivered through the drill string to the drill bit or bottom hole assembly, thereby increasing the effective horsepower of the bottom hole assembly. The effective horsepower refers to a combination of mechanical horsepower effecting rotation of the drill string and fluid horsepower effecting rotation of the drill bit via a motor that is part of the bottom hole assembly, combined with sufficient flow to cool the bit and carry the cuttings all the way back to the surface. In some embodiments, the bottom-hole assembly may also incorporate under-reamers, which can be used to expand the diameter of the hole cut by the bit to enable the use of expanded tubulars and other advanced well and completion designs.

[0025] It should be understood that embodiments of systems and methods described below can include one or more pressure intensifiers located between the top of the drill string and one or more mud pumps on the ground that are configured to deliver drilling fluid from a mud tank. The pressure intensifier can increase the pressure of the drilling mud that is pumped into the drill string, providing increased pressure to the mud motor downhole. By increasing the fluid pressure at the mud motor, the effective power available to the drill bit is increased. Further, the increased fluid flow reduces heating of the drill bit, and debris and cuttings can be carried back to the surface at a rate that can reduce the likelihood that the debris may settle to the drill location, even with larger diameter wells. In certain embodiments, the pressure intensifier may be configured to deliver drilling mud at a pressure of 10,000 PSI or more to the top of the drill string, which may be many times greater than the fluid pressure supplied by conventional mud pumps as measured at the top of the drill string.

[0026] In some embodiments, multiple larger internal diameter hoses can provide more than double the flow rate of conventional systems. Further, in some embodiments, the pressure intensifier may be configured to rapidly alter the pressure and the pressure gradient within open-hole sections of the well while it is being drilled. In an example, the one or more pressure intensifiers can be controlled to rapidly change the fluid characteristics entering the drill string, to change the drilling mud density, to change from mud to cement, to change from water to another completion fluid, or any combination thereof. One or more pressure intensifiers can be incorporated in the integrated traveling equipment, which allows efficient pressure intensification at moderate flow rates while providing redundancy or providing high pressure intensification at high flow rates during certain aspects of the well drilling process.

[0027] It should be understood that embodiments of the present disclosure include a pressure intensifier that can be controlled to rapidly change the pressure and the pressure gradient within the open-hole section of the well while it is being drilled. The pressure intensifier can enable both controlled pressure and controlled pressure gradients and may provide additional safety reserve capacity for responding to unexpected kicks of pressure encountered while drilling through certain layers of the geological formations in the earth.

[0028] Additionally, in addition to increasing the effective horsepower at the bit and providing some improved ability to better manage the drilling fluid column while drilling, the one or more pressure intensifiers can increase the efficiency of the drilling operation by eliminating a significant portion of the pressure losses in the circulation of the drilling fluid, which is essential to drilling. As a result, the one or more pressure intensifiers make it possible to drill existing wells faster and farther, and enable the drilling of new well designs that cost less and produce more. One possible example of a drilling system including one or more pressure intensifiers is described below with respect to Fig. 1.

[0029] Fig. 1 is a diagram of a drilling system 100 including a pressure intensifier, in accordance with certain embodiments of the present disclosure. The system 100 may include a mast 102. The mast 102 may rest on the ground 104 and may be centered over a cellar 134 of a well. The drilling system 100 may include one or more mud pumps 106 configured to pump drilling fluid (drilling mud) from one or more mud tanks through a flow line 108 to a substructure 110 of the drilling rig. The drilling fluid flows up the substructure 110 through a conduit 112 and to a stand pipe manifold (generally indicated at 114). The drilling fluid then flows up the mast or derrick through one or more stand pipes 118, through one or more goosenecks 120, and through one or more pressure intensifiers 122. The pressure intensifier 122 drives the drilling fluid at an increased pressure through one or more hoses 124 to an intake manifold of the top drive 128, which may be coupled to a traveling block 126. In some embodiments, a pressurized expansion or storage tank 129 may be incorporated in the traveling block 126 to act as an accumulator or to provide a modest reserve of drilling fluid to respond to certain events in the borehole and to selectively increase (or decrease) the weight applied to the traveling block (by pumping fluid into or out of the tank 129). In alternative embodiments, the pressurized expansion or storage tank 129 may be coupled to the mast 102 adjacent to the pressure intensifier 122.

[0030] In the illustrated embodiment, the pressure intensifier 122 may be coupled to the mast 102 between the gooseneck 120 and the intake manifold of the top drive 128, which is coupled to the drill string 130. The drilling mud flows down through the drill string 130, which extends through the BOP 132 and downhole through the well casing to the bottom-hole assembly that can include a mud motor.

[0031] The pressure intensifier 122 may increase the fluid pressure of the drilling fluid to a selected pressure as measured at the intake manifold of the top drive 128. In certain embodiments, the pressure intensifier 122 may deliver the drilling fluid at a pressure of 10,000 PSI or more to the intake manifold of the top drive 128. By increasing the fluid pressure at the intake manifold of the top drive 128. The increased hydraulic pressure can increase the power delivered through the top drive 128, increase the hydraulic pressure of the fluid delivered through the drill string 130, and increase the effective horsepower of the mud motor down hole.

[0032] In an example, the pressure intensifier 122 may include a hydraulic intensifier including a fixed ram through which the mud under high pressure is driven, a hollow inverted sliding cylinder mounted over the fixed ram and including mud under high pressure, and an inverted fixed cylinder surrounding the sliding cylinder and including mud from the mud pumps 106. In this example, a large quantity of mud at relatively low pressure from the mud pumps 106 may enter the inverted fixed cylinder. The weight of the mud presses the sliding cylinder in a direction, compressing the mud inside the sliding cylinder increasing its pressure and forcing the mud through the fixed ram toward the intake manifold of the top drive 128. In another embodiment, the pressure intensifier 122 may include a high pressure pump. In still another embodiment, the pressure intensifier 122 may include a device including one or more movable elements configured to increase pressure of the fluid flow into the intake manifold of the top drive 128.

[0033] In some embodiments, the pressure intensifier 122 may attach to the mast 102, which can be significantly closer to the intake manifold of the top drive than the mud pumps 106. In certain embodiments, a flow line 108 may extend from the mud pumps (usually equipped with a surge dampener) to the base of the substructure 110. The flow line 108 may be several hundred feet long with numerous curves and elevation changes, all of which can reduce the hydraulic horsepower available. The conduit 112 may deliver the drilling fluid from the flow line 108 to a mud manifold 114 and associated valves, which may be located above the drill floor 116 so that an operator standing on the drill floor 116 can operate the valves. The standpipe 118 extends from the manifold 114 to the gooseneck 120, which may be about 86 feet above the drill floor 116. In some embodiments, the hose 124 may be approximately 90 feet long and may drape down from the gooseneck 120 to a mud intake manifold of the top drive 128. By inserting the pressure intensifier 122 after the couplings at the base of the substructure 110, after the manifold 114, or after the gooseneck 120, the pressure of the drilling mud at the intake manifold of the top drive 128 may be increased, providing more pressure down hole for driving the mud motors.

[0034] In some embodiments, the traveling block 126, the pressure intensifiers 122, the pressurized expansion or storage tank 129, the top drive 128, and the tubular handling mechanisms (such as elevators and casing running tools) may be incorporated in a series of linked frames, which can interface to guide rails within the drilling rig mast 102 or derrick. This linked frame assembly (generally indicated at 127) can be referred to as the integrated travelling equipment, but may be separated for transportation in different mast sections in certain embodiments. Separating the segments may allow the pressure intensifier 122 to be omitted, or optionally removed for service during certain rig operations that do not require pressure intensification. Thus, re-configuration, maintenance, or exchange of the pressure intensifier can be facilitated by providing an easy connection for readily and quickly removing and replacing the pressure intensifier 122. Further, the linked frame provides a strong, stable traveling equipment unit that may incorporate common features such as electrical power systems and some plumbing for drilling and other fluids.

[0035] In the illustrated example of Fig. 1, the pressure intensifier 122 is coupled to the mast 122 near the gooseneck 120. In other embodiments, the pressure intensifier 122 may be located closer to the drill floor 116. One possible example of such an embodiment is described below with respect to Fig. 2.

[0036] Fig. 2 is a diagram of a drilling system 200 including a pressure intensifier 202 coupled to the drill floor 116, in accordance with certain embodiments of the present disclosure. In certain embodiments, the drilling system 200 may include all of the elements of the drilling system 100 of Fig. 1; however, the pressure intensifier 122 may be replaced with a pressure intensifier 202, which may be mounted to the drill floor 116.

[0037] By moving the pressure intensifier 202 to the drill floor 116, a larger pressure intensifier 202 may be used which can increase the fluid pressure at the intake manifold of the top drive 128. In certain embodiments (such as in Fig. 1), the pressure intensifier 202 may be coupled between the manifold 114 and the gooseneck 120.

[0038] In certain embodiments, by increasing the pressure of the drilling mud provided to the mud motor down hole, several advantages may be achieved. First, the increased fluid pressure can increase the power available to the drill bit, which enhances drilling efficiency. Further, the increased fluid pressure can assist in cooling the drill bit during drilling operations. Additionally, the increased fluid pressure can assist in removing debris from the drill bit and up the annulus of the well bore to be removed by the mud cleaning system. Such increased fluid pressure can enhance drilling efficiencies and can improve overall drilling operations. In addition, such increased fluid pressure can increase the fluid flow down hole to facilitate debris removal even in wider well bores. Other embodiments are also possible.

[0039] In the examples of Figs. 1 and 2, the pressure intensifiers 122 and 202 were described as being coupled to the mast 102 and the drilling floor 116, respectively. However, it may also be possible to install the pressure intensifier between the traveling block 126 and the top drive 128 as part of the traveling equipment. One possible example of such an implementation is described below with respect to Fig. 3.

[0040] Fig. 3 is a perspective view of a portion of the drill rig system 300 including a portion of the traveling block 126 and one or more pressure intensifiers 302, in accordance with certain embodiments of the present disclosure. In the illustrated example, the one or more pressure intensifiers 302 may include four pressure intensifying elements, which may each deliver high pressure drilling mud to an intake manifold of the top drive 128. In certain embodiments, the four pressure intensifying elements may deliver drilling fluid to the intake manifold of the top drive 128 sequentially (one at a time, or two at a time), making it possible to maintain a substantially constant fluid pressure to the top drive 128.

[0041] Fig. 4 is side view 400 of the portion of the drill rig system 300 of Fig. 3. In the illustrated example, the mud hose 124 extends from the gooseneck 120 (in Figs. 1 and 2) in a downward direction to a local minimum and then extends back up to couple to the pressure intensifier 302. The pressure intensifier 302 may be configured to increase the pressure of the drilling mud supplied to an intake manifold of the top drive 128. Other embodiments are also possible.

[0042] In the illustrated embodiments of Figs. 1-4, the pressure intensifier 122 has been shown coupled to the mast 102 in Fig. 1; the pressure intensifier 202 has been shown coupled to the drill floor 116 in Fig. 2; and the pressure intensifier 302 has been shown coupled to the traveling block 126 in Figs. 3 and 4. It should be appreciated that the pressure intensifier may be coupled to the mast 102, to the crown of the mast 102, to an offset coupled to one of the mast 102 and the crown, to the drill floor 116, to the traveling block 126, or elsewhere, depending on the implementation. Other embodiments are also possible, including positioning the pressure intensifier on the ground adjacent to the substructure 110 and between the mud motors 106 and the mast 102. In other embodiments, the pressure intensifier may be positioned on a portion of the set back of the drilling rig or between the manifold 114 and the stand pipe 118. Other embodiments are also possible.

[0043] Fig. 5 is a flow diagram of a method 500 of intensifying pressure in a drill string of a drill rig, in accordance with certain embodiments of the present disclosure. At 502, the method 500 may include pumping mud from a mud pit to a drill rig system at a first pressure using at least one first mud pump on the ground. The mud pump 106 may drive drilling fluid from the mud tank into a stand pipe 118 extending up the mast of the drilling rig.

[0044] At 504, the method 500 may further include driving the mud into an intake manifold of a top drive at a second pressure using a pressure intensifier coupled to at least one of a mast, a crown, an offset coupled to one of the mast and the crown, a drill floor, a mud manifold, a traveling block, and a substructure of the drill rig system. In certain embodiments, the second pressure may be greater than the first pressure. In certain embodiments, the second pressure may be at 10,000 PSI or more. In each embodiment, the pressure intensifier may be positioned between the mud pumps and the top drive to intensify the pressure of the drilling mud driven down hole within the drill pipe to the mud motors.

[0045] At 506, the method 500 may include selectively controlling the pressure intensifier to deliver the drilling mud to the intake manifold of the top drive at a selected pressure. In certain embodiments, the pressure intensifier may increase the pressure of the drilling mud during certain phases of drilling, such as when the drill bit is about to punch through a segment of rock to enter a chamber, which may be filled with pressurized gas. In some embodiments, the pressure intensifier may drive the drilling mud at a selected pressure and may selectively increase the pressure to a higher pressure level when more horse power is wanted at the drill bit and may selectively vary the pressure based on the particular drilling operation. Other embodiments are also possible.

[0046] Fig. 6 is a perspective view of a rig system 600 including a plurality of frames that serve a dual purpose of transporting drilling equipment and forming a portion of the drill rig, in accordance with certain embodiments of the present disclosure. In the illustrated example, the rig system 600 includes a rear frame portion 602 that can be used to transport and secure a blowout preventer (BOP) 604. The rear frame portion 602 may be coupled to base boxes 606 and 608 and to a draw works skid 610. A center frame portion 612 may be used to transport and secure the traveling block 126, and may be coupled to the base boxes 606 and 608 and to the rear frame portion 602.

[0047] In some embodiments, other frame elements may be used to transport and secure the pressure intensifiers 122, the pressurized expansion or storage tank 129, the top drive 128, and the tubular handling mechanisms (such as elevators and casing running tools), and so on. In the illustrated example, a bottom mast section 614 (which may form a portion of the mast 102 of the drilling rig system in Figs. 1-4) is being moved via a flatbed trailer into alignment with an end of the center trunk 612, in accordance with certain embodiments of the present disclosure.

[0048] In some embodiments, the bottom mast section 614 may be moved into position adjacent to the center trunk 612 and may be connected to the center trunk 612 at connection points that can be readily accessed by a worker standing on the ground or on a ladder. In certain embodiments, ladder-type elements may be incorporated into the sides of at least one of the center trunk 612 and the bottom mast portion 614 to facilitate the assembly. In some embodiments, the center trunk 612 may be raised slightly to align the center trunk 612 to the bottom mast section 614 to facilitate the assembly.

[0049] In some embodiments, the drilling rig or rig system 600 may include a frame assembly including a plurality of frames configured to couple to one another to form the drilling rig. The frames may be formed from structural steel and may be configured to interlock and bolt together in a particular configuration and arrangement to form the drilling rig.

[0050] The frame assembly may include a first frame configured to secure a traveling block, a second frame configured to secure at least one of the one or more pressure intensifiers, and a third frame configured to secure at least one of a fluid storage, a top drive, and a tubular handling and casing mechanism. Further, each of the frame elements (i.e., the first frame, the second frame, and the third frame) may form part of at least one of a base, a trunk and a mast of the drilling rig.

[0051] In some embodiments, the frame elements may serve the dual purpose of protecting, securing and storing certain components of the rig during transportation and storage, and then forming portions of the drill rig during drilling operations. The frames, for example, may secure and protect the one or more pressure intensifiers, the fluid storage, the top drive, and various other elements, including, for example, tubular handling and casing running mechanisms. In some embodiments, the frame elements may serve to unify and interconnect the power subsystems and plumbing, while allowing separation for re-configuration, maintenance or exchange, depending on the phase of the drilling, well construction or completion operations being performed by the drilling rig system.

[0052] In certain embodiments, the integrated traveling equipment and frames are strong and secure and robustly interfaced to the mast or derrick of the drilling rig, while allowing separation or removal for transportation in different mast sections. This modular configuration allows for optimal location of the individual and combined weight of the integrated traveling equipment during rig up, and particularly during mast raising operations.

[0053] It should be understood that only one possible implementation showing some portions of the drilling rig are depicted in Fig. 6. Other frame elements and other sections of the drill rig may also be included that can be interconnected to form the rig.

[0054] In conjunction with the systems, methods, and devices described above with respect to Figs. 1-6, a drilling rig system is described that may include a pressure intensifier positioned between mud pumps and a top drive of the drilling rig. In some embodiments, the pressure intensifier may be coupled to at least one of a mast, a crown, an offset coupled to one of the mast and the crown, a drill floor, a traveling block, and a set back of the drill rig system. In certain embodiments, the pressure intensifier may be coupled to the ground. In certain embodiments, the pressure intensifier may be coupled to the traveling block and between a mud hose and the intake manifold of the top drive to increase the fluid flow pressure of the drilling mud delivered down the drill string to the mud motor.

[0055] Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the scope of the invention.

WHAT IS CLAIMED IS:

1. A drilling system comprising:
a top drive; and
one or more pressure intensifiers coupled between a mud pump and the top drive to increase fluid pressure of drilling fluid driven down into a hole.

2. The drilling system of claim 1, wherein the one or more pressure intensifiers comprise at least one of a mechanical pressure-increasing device, an electrical pressure-increasing device, a hydraulic pressure-increasing device, and a pneumatic pressure-increasing device.

3. The drilling system of claim 1, wherein the one or more pressure intensifiers comprise a mud pump.

4. The drilling system of claim 1, wherein the one or more pressure intensifiers are coupled to a traveling block ahead of a top drive.

5. The drilling system of claim 1, wherein the a one or more pressure intensifiers are coupled to at least one of a drill floor, a mast, a crown, a setback, and an offset of a drilling rig.

6. The drilling system of claim 1, further comprising a mud pump coupled to a mud tank and configured to pump the drilling fluid through a low pressure conduit to the one or more pressure intensifiers.

7. The drilling system of claim 6, further comprising:

a drilling rig including:

a mast;

a crown coupled to a top portion of the mast and coupled to the traveling block;

a drill floor coupled to a lower portion of the mast and including a hole through which the drilling pipe extends; and

a conduit extending from the mud pump to the one or more pressure intensifiers; and

wherein the one or more pressure intensifiers are coupled to one of the mast and the drill floor.

8. The drilling system of claim 6, further comprising:

a drilling rig including:

a mast;

a set back coupled to the mast; and

a conduit extending from the mud pump to the one or more pressure intensifiers; and

wherein the one or more pressure intensifiers are coupled to the set back.

9. The drilling system of claim 1, further comprising a storage tank coupled to the one or more pressure intensifiers and configured to store a reserve of the drilling fluid to respond to certain events during drilling of the hole.

10. The drilling system of claim 9, wherein the storage tank is coupled to a traveling block and configured to selectively increase or decrease an amount of the reserve of the drilling fluid to adjust a weight applied to the traveling block.

11. A system comprising:

one or more mud pumps configured to pump drilling fluid through one or more hoses, associated connectors, and associated fittings, the one or more hoses having a first internal diameter within a bend ratio determined by a confined space of a mast of a drilling rig; and

one or more pressure intensifiers coupled between the one or more mud pumps and a drill string to increase fluid pressure of the drilling fluid within a well bore.

12. The system of claim 11, wherein the drill string has a second internal diameter that is less than the first internal diameter.

13. The system of claim 11, wherein the one or more pressure intensifiers comprise at least one of a mechanical pressure-increasing device, an electrical pressure-increasing device, a hydraulic pressure-increasing device, and a pneumatic pressure-increasing device.

14. The system of claim 11, wherein the one or more pressure intensifiers are coupled to a traveling block ahead of a top drive of a drilling rig.

15. The system of claim 11, wherein the a one or more pressure intensifiers are coupled to at least one of a drill floor, a mast, a crown, a setback, and an offset of a drilling rig.

16. A drilling system comprising:

a drilling rig;

traveling equipment coupled to the drilling rig and configured to couple to a drill string extending into a well bore; and

one or more pressure intensifiers coupled between a mud pump and traveling equipment to increase fluid pressure of drilling fluid driven through the drill string.

17. The drilling system of claim 16, wherein the drilling rig includes a frame assembly including a plurality of frames configured to couple to one another to form the drilling rig.

18. The drilling system of claim 17, wherein the plurality of frames further include:
a first frame configured to secure a traveling block;
a second frame configured to secure at least one of the one or more pressure intensifiers; and
a third frame configured to secure at least one of a fluid storage, a top drive, and a tubular handling and casing mechanism; and
wherein the first frame, the second frame, and the third frame form part of at least one of a base, a trunk and a mast of the drilling rig.

19. The drilling system of claim 16, wherein the one or more pressure intensifiers comprise at least one of a mechanical pressure-increasing device, an electrical pressure-increasing device, a hydraulic pressure-increasing device, and a pneumatic pressure-increasing device.

20. The drilling system of claim 16, wherein the one or more pressure intensifiers are coupled to a traveling block ahead of a top drive.

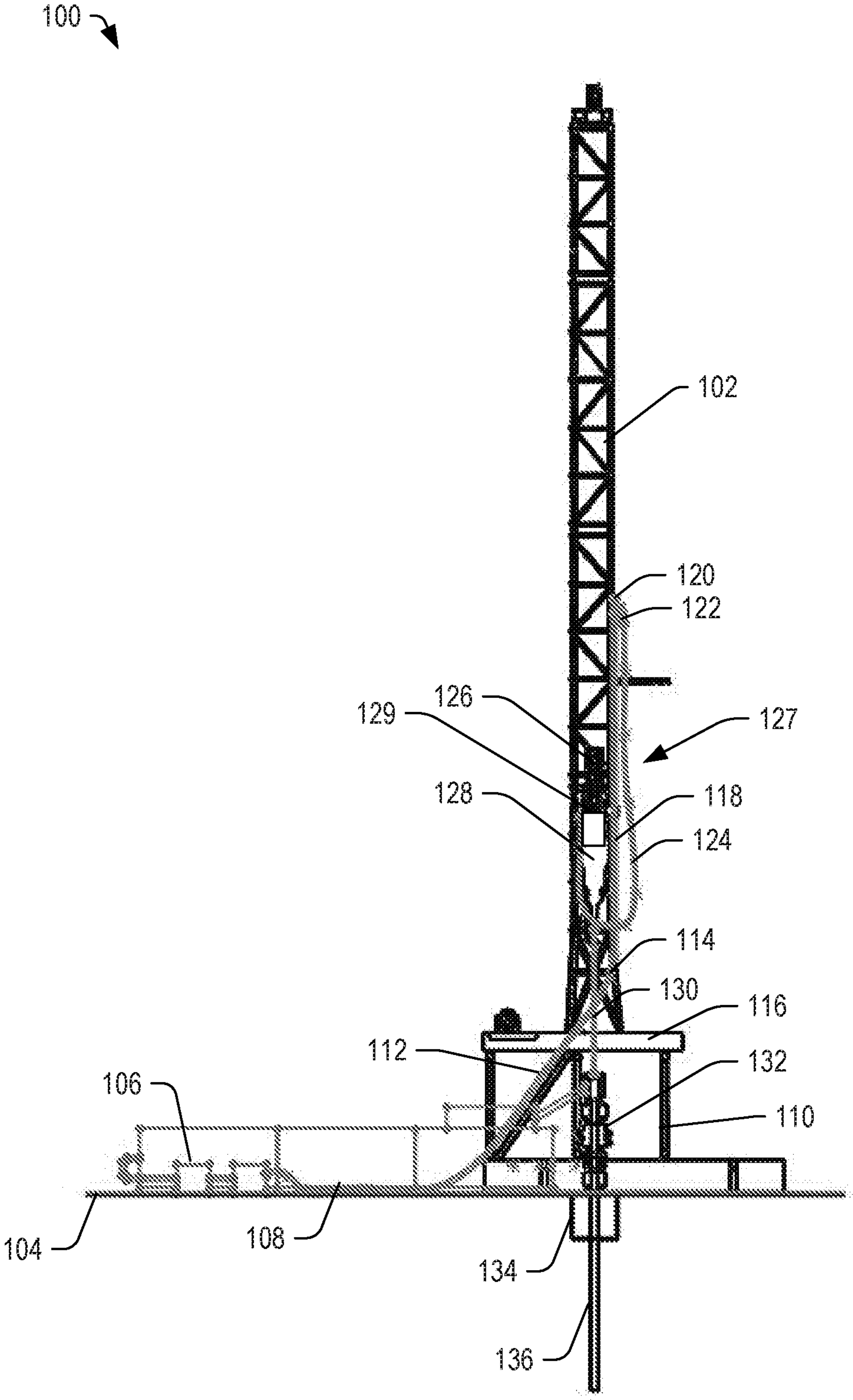
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FIG. 1

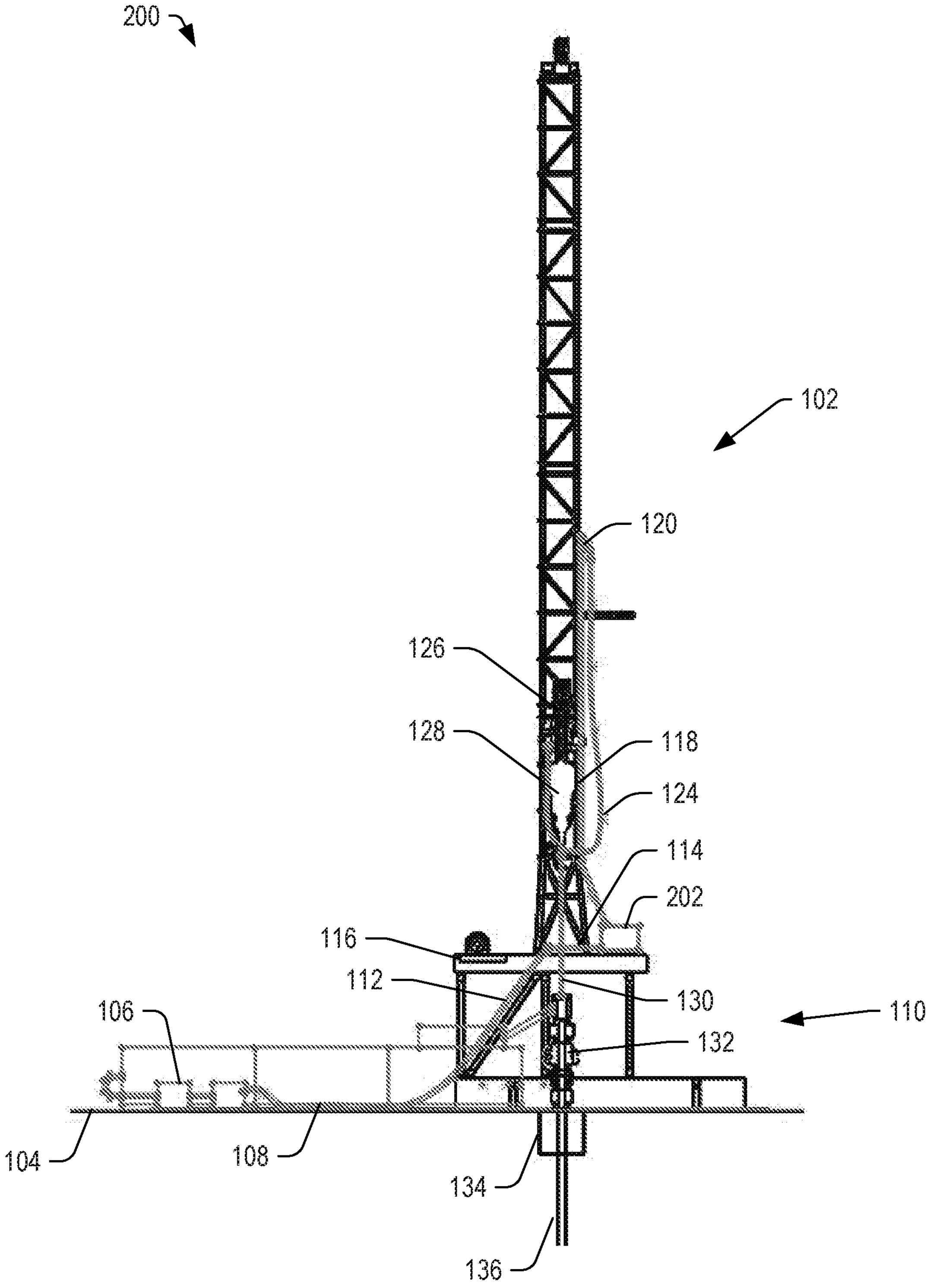
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FIG. 2

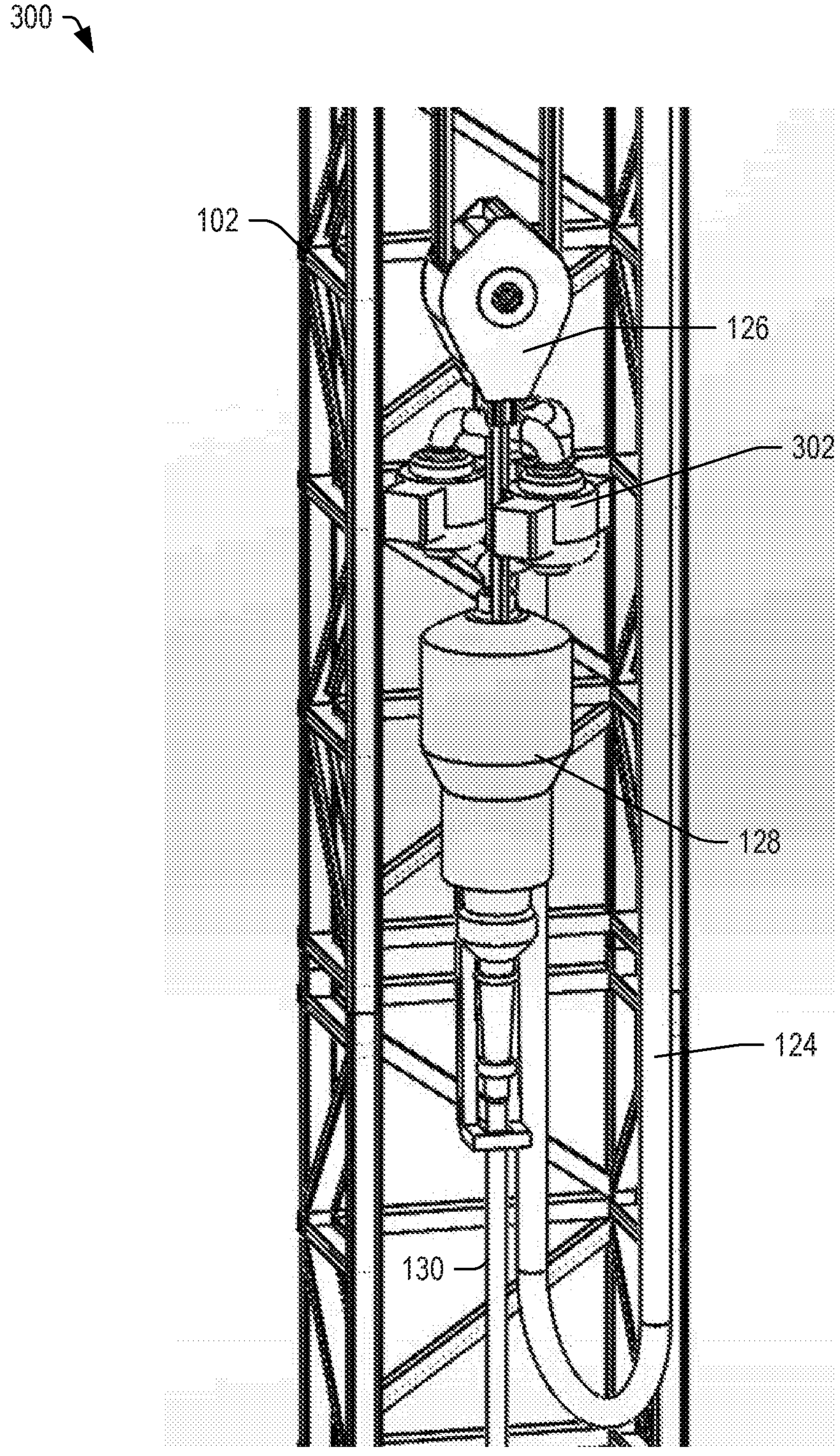

FIG. 3

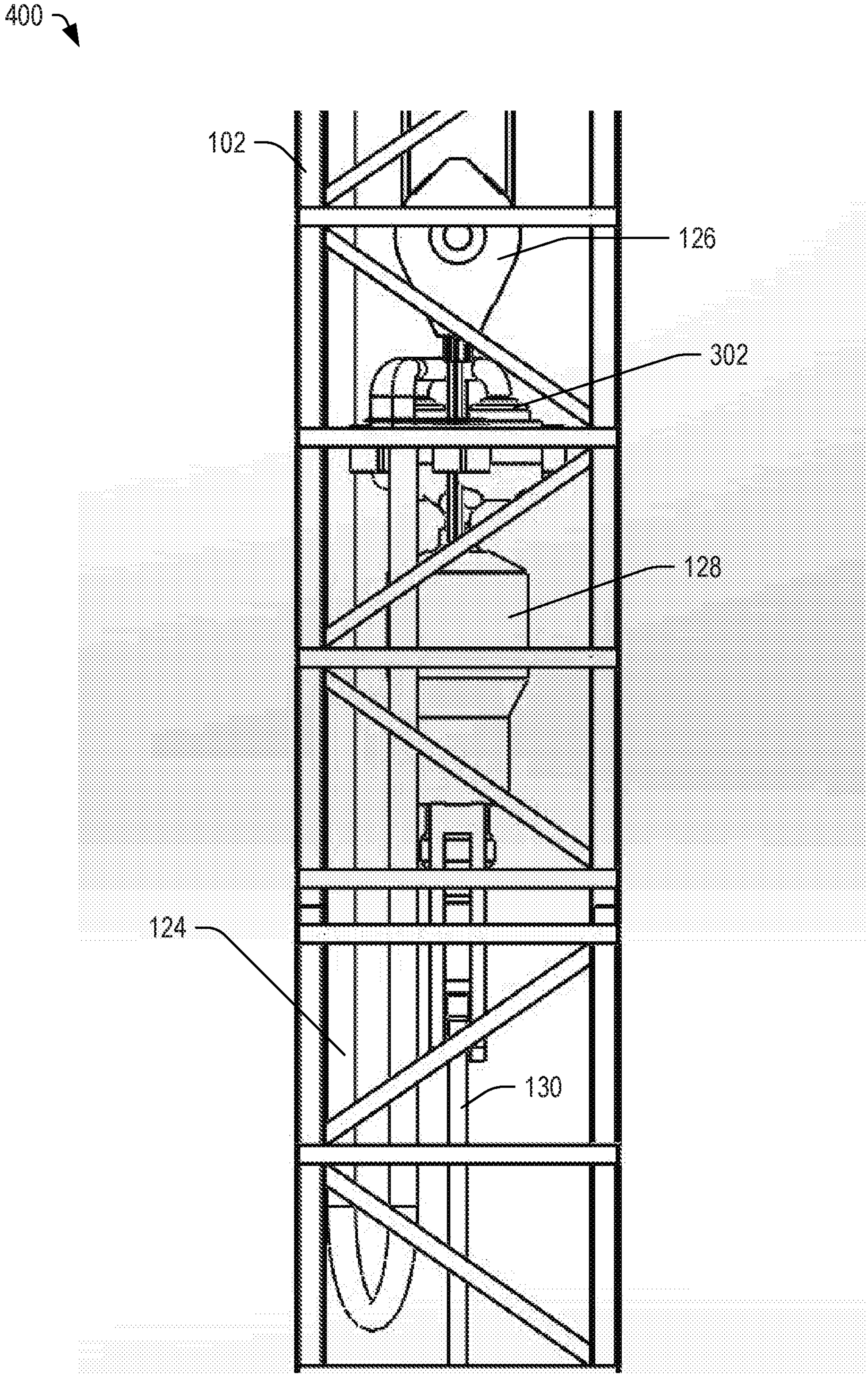

FIG. 4

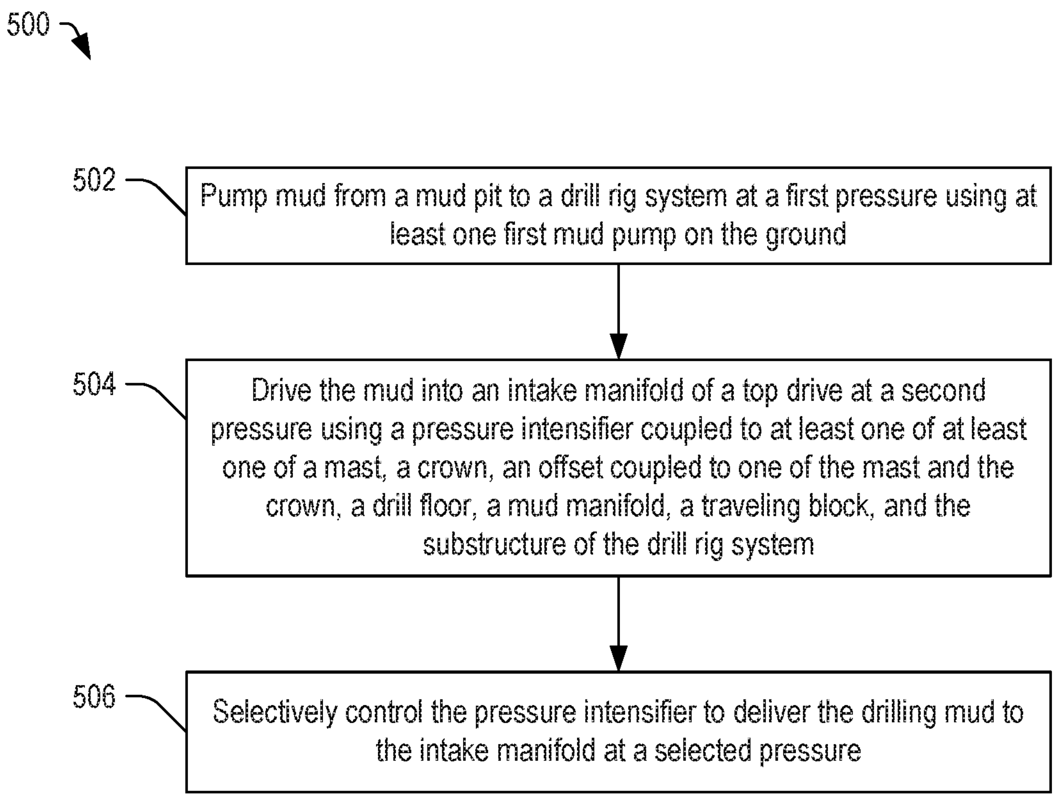
500
502
Pump mud from a mud pit to a drill rig system at a first pressure using at least one first mud pump on the ground
504
Drive the mud into an intake manifold of a top drive at a second pressure using a pressure intensifier coupled to at least one of at least one of a mast, a crown, an offset coupled to one of the mast and the crown, a drill floor, a mud manifold, a traveling block, and the substructure of the drill rig system
506
Selectively control the pressure intensifier to deliver the drilling mud to the intake manifold at a selected pressure

FIG. 5

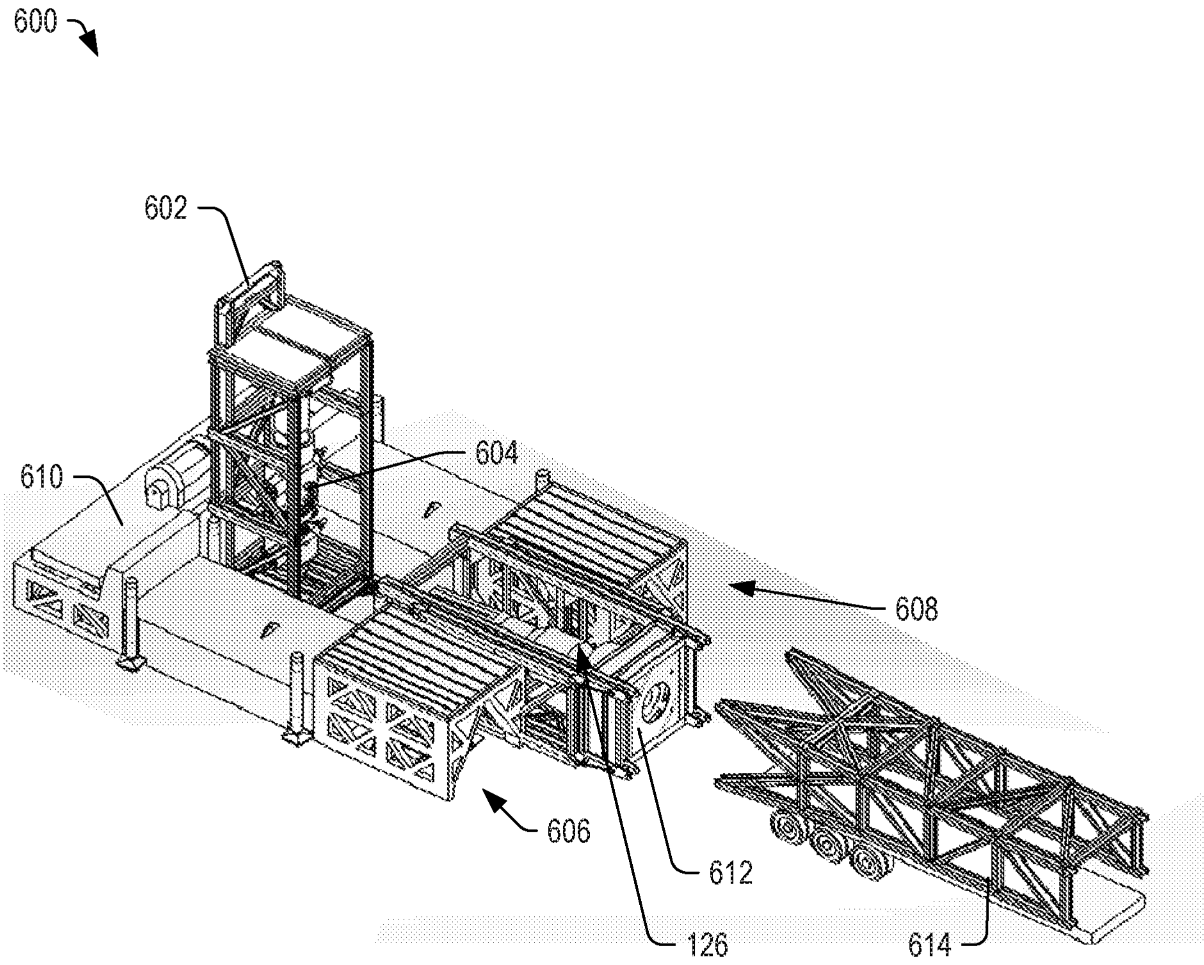

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 16/56141

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - E21B 21/08 (2016.01)
CPC - E21B 21/08
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - E21B 21/08 (2016.01)
CPC - E21B 21/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
IPC(8) - E21B 7/00, 21/00, 21/01, 21/06, 21/08 (2016.01)
CPC - E21B 7/00, 21/00, 2021/007, 21/01, 21/06, 21/08

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase; GOOGLE (PATENTS, SCHOLAR) Search Terms Used: drilling, borehole, mud, fluid, pump, intensifier, booster, pressure, rig, traveling block, drill floor, mast, crown, setback, offset

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y -- A	US 2,244,476 A (RATCLIFFE) 03 June 1941 (03.06.1941) entire document	1-4, 6, 8, 16, 17, 19, 20 -- 5, 7, 9, 18 -- 10-15
Y -- A	US 2014/0240140 A1 (SWITZER et al) 28 August 2014 (28.08.2014) entire document	5, 7, 18 -- 10 15
Y -- A	US 2,764,103 A (MERCIER) 25 September 1956 (25.09.1956) entire document	9 -- 10-15
A	US 2015/0000978 A1 (LY) 01 January 2015 (01.01.2015) entire document	1-20
A	US 2,113,647 A (DAVIDSON et al) 12 April 1938 (12.04.1938) entire document	1-20

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 December 2016	10 JAN 2017

Name and mailing address of the ISA/US	Authorized officer:
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