US 20130133899A1

(19) United States
(12) Patent Application Publication
Holliday et al.
(10) Pub. No.: US 2013/0133899 A1
(43) Pub. Date: May 30, 2013

(54) **TOP DRIVE WITH AUTOMATIC POSITIONING SYSTEM**

(76) Inventors: **Keith A. Holliday**, Houston, TX (US); **Todd Mironuck**, Longview (CA); **Paul Nicholson**, Montgomery, TX (US); **Dan Flaherty**, Alberta (CA)

(21) Appl. No.: **13/306,458**

(22) Filed: **Nov. 29, 2011**

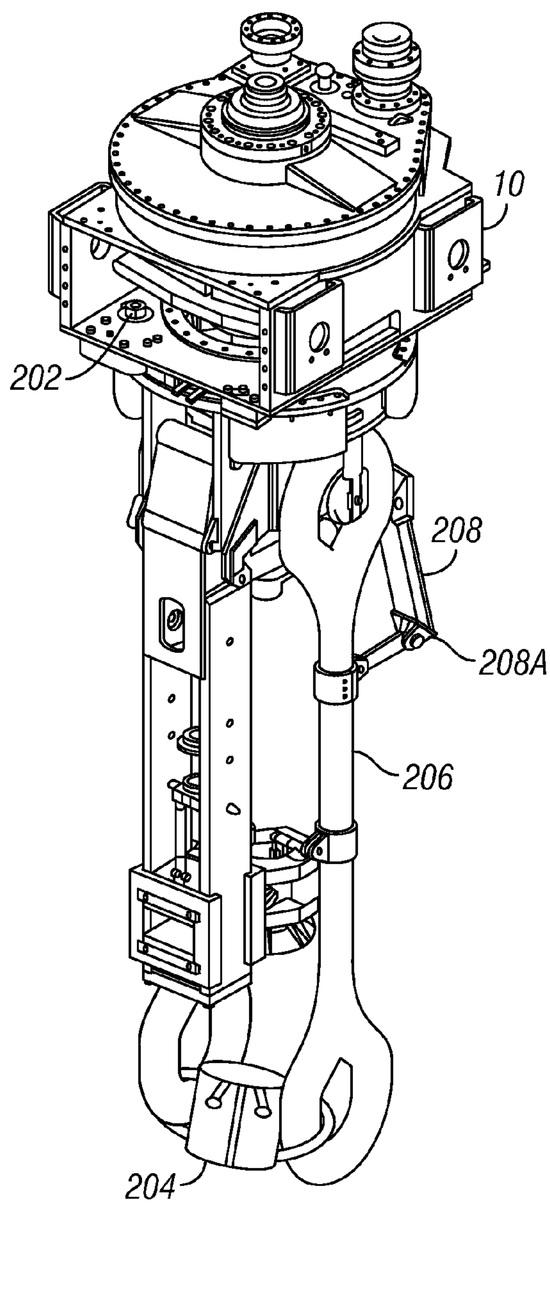
Publication Classification

(51) **Int. Cl.**
E21B 19/16 (2006.01)

(52) **U.S. Cl.**
USPC **166/380**; 166/77.51

(57) **ABSTRACT**

An automatic top drive positioning system includes a top drive having a pipe handling system rotator gear, a drive motor rotationally coupled to the rotator gear and a rotational position sensor rotationally coupled to the rotator gear. A controller is configured to operate the drive motor to automatically move the rotator gear to a selected rotational orientation based on measurements from the rotational position sensor.



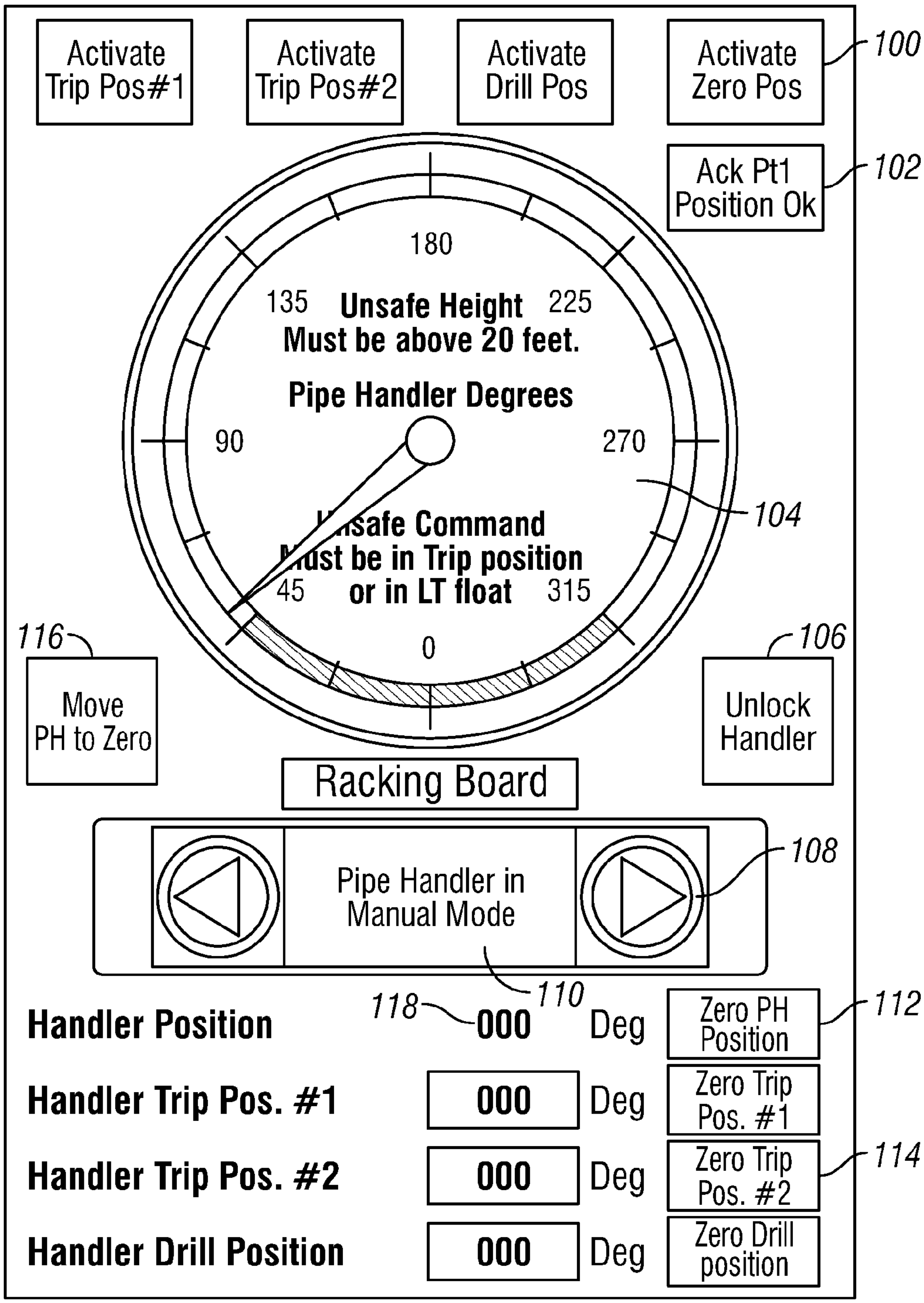

Activate Trip Pos#1
Activate Trip Pos#2
Activate Drill Pos
Activate Zero Pos
100
Ack Pt1 Position Ok
102
180
135
225
Unsafe Height
Must be above 20 feet.
Pipe Handler Degrees
90
270
104
Unsafe Command
Must be in Trip position
or in LT float
45
315
0
116
Move PH to Zero
106
Unlock Handler
Racking Board
108
Pipe Handler in Manual Mode
110
118
Handler Position
000 Deg
Zero PH Position
112
Handler Trip Pos. #1
000 Deg
Zero Trip Pos. #1
Handler Trip Pos. #2
000 Deg
Zero Trip Pos. #2
114
Handler Drill Position
000 Deg
Zero Drill position

FIG. 1

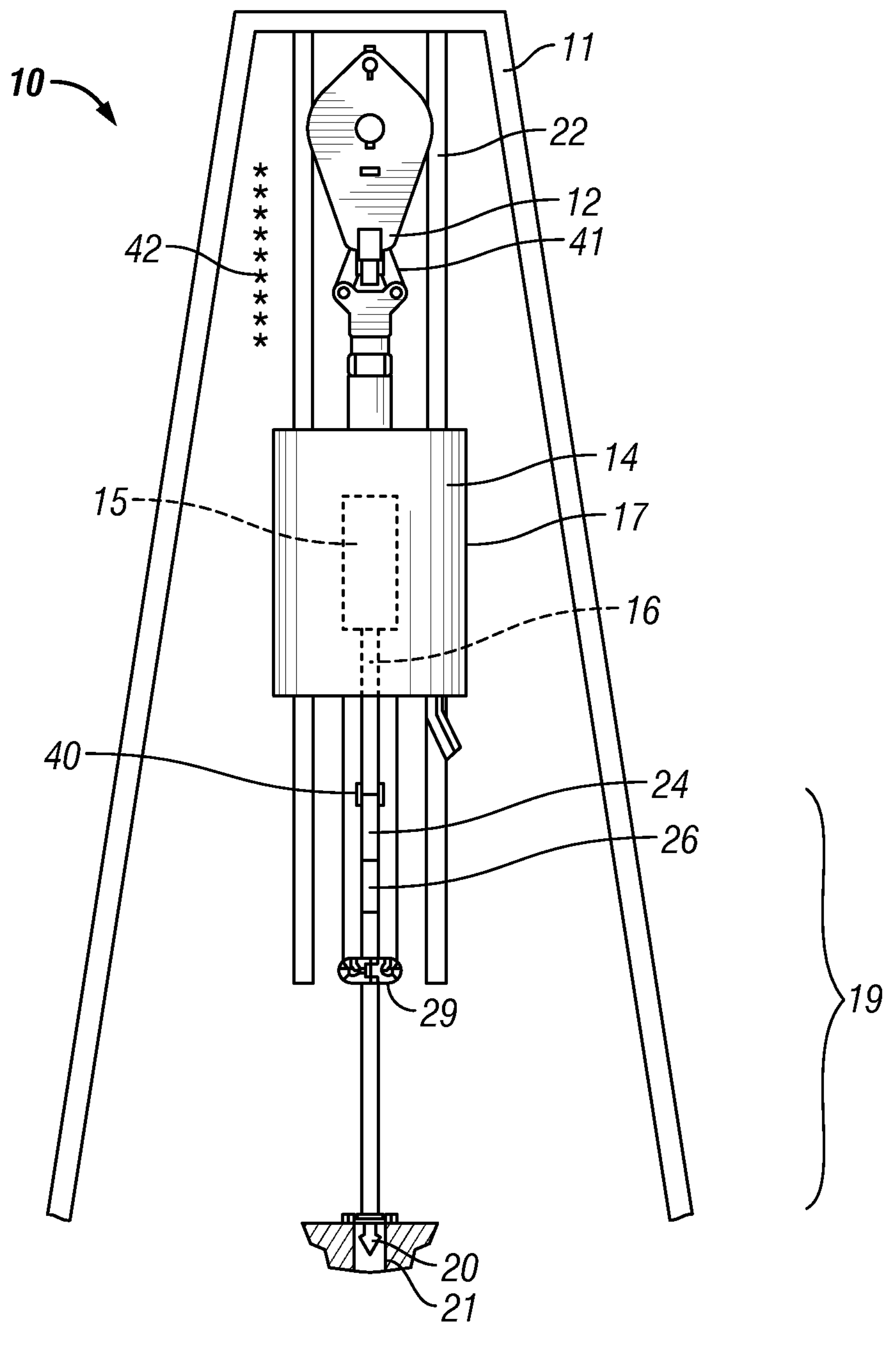


FIG. 1A
(Prior Art)

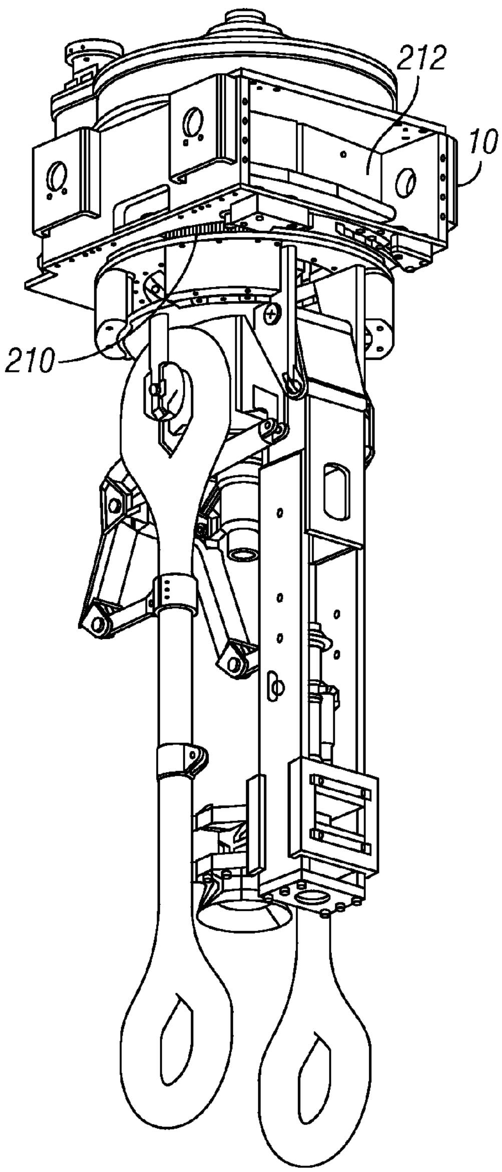


FIG. 2A

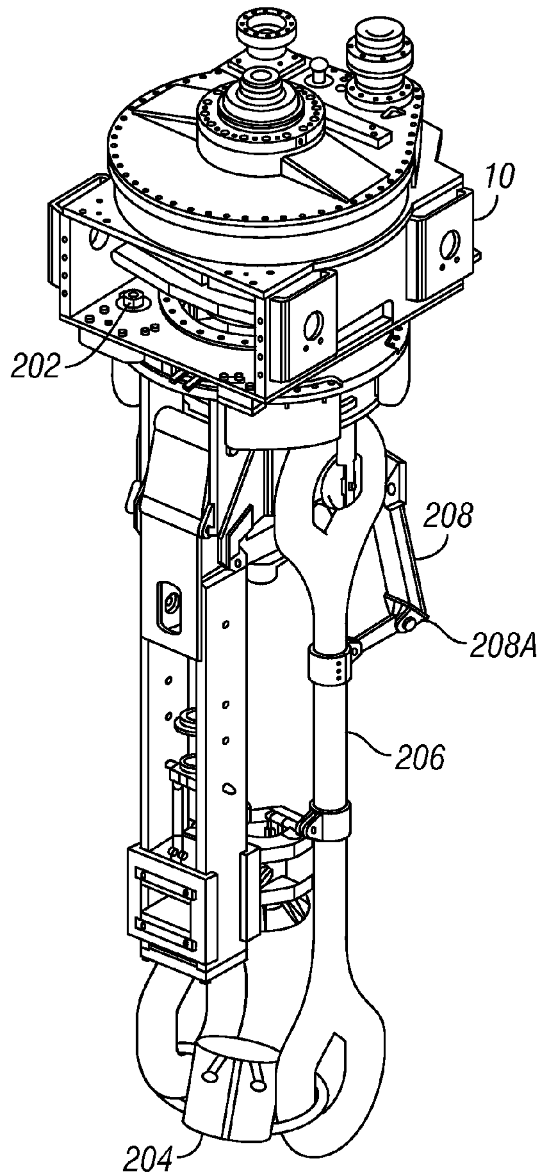


FIG. 2B

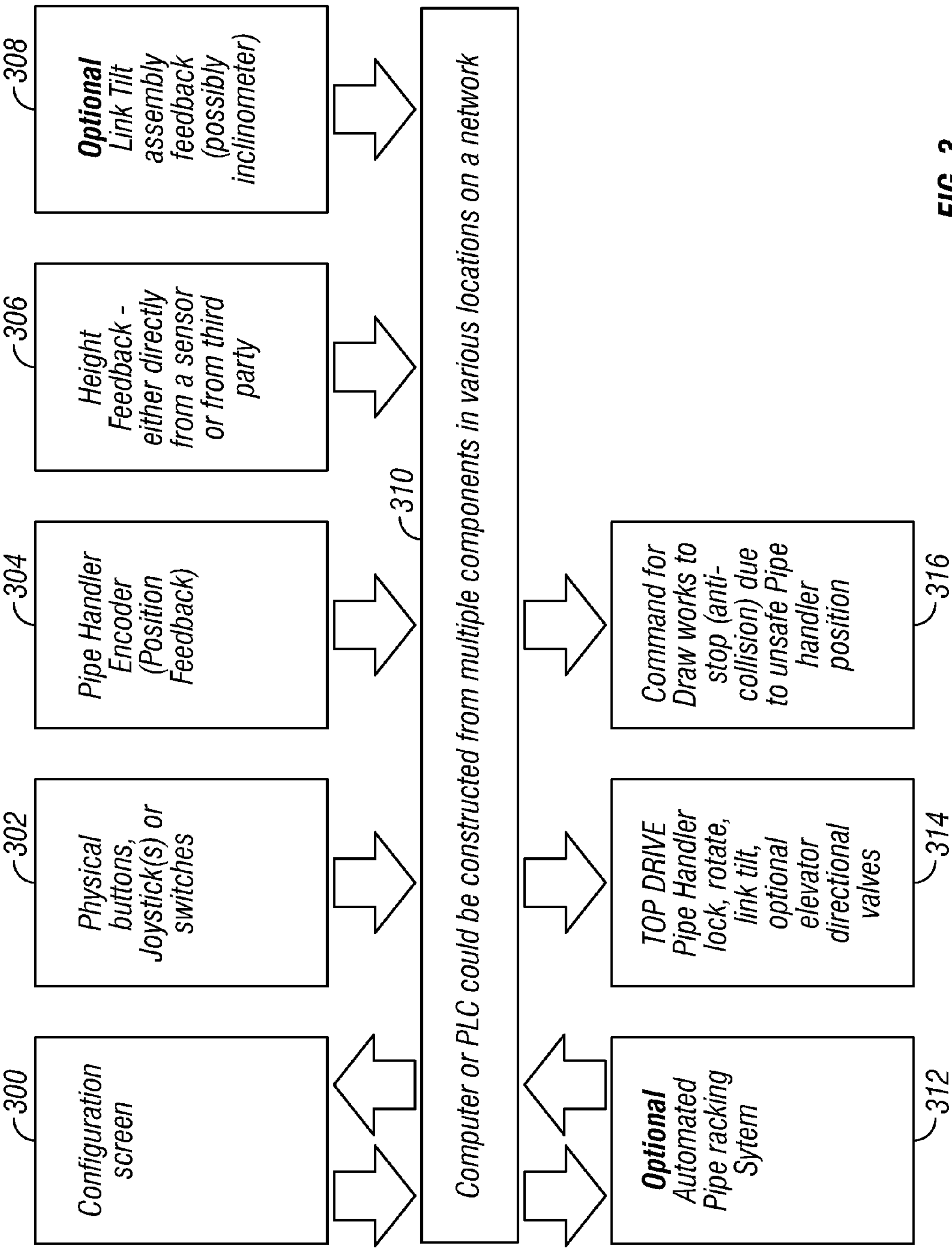

300
Configuration screen
302
Physical buttons, Joystick(s) or switches
304
Pipe Handler Encoder (Position Feedback)
306
Height Feedback - either directly from a sensor or from third party
308
Optional Link Tilt assembly feedback (possibly inclinometer)
310
Computer or PLC could be constructed from multiple components in various locations on a network
312
Optional Automated Pipe racking Sytem
314
TOP DRIVE Pipe Handler lock, rotate, link tilt, optional elevator directional valves
316
Command for Draw works to stop (anti-collision) due to unsafe Pipe handler position

FIG. 3

TOP DRIVE WITH AUTOMATIC POSITIONING SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Not applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not applicable.

BACKGROUND

[0003] FIG. **1** illustrates a top drive system **10** which is structurally supported by a derrick **11**. The top drive system **10** has a plurality of components including a top drive **14**, (shown schematically) a main shaft **16**, a housing **17**, a drill string **19** and a drill bit **20**. The components are collectively suspended from a traveling block **12** (moved by a "drawworks" not shown) that allows them to move upwardly and downwardly on rails **22** connected to the derrick **11** for guiding the vertical motion of the components. Reactance to torque generated during operations with the top drive or its components (e.g. during drilling) is transmitted through the rails **22** to the derrick **11**.

[0004] The main shaft **16** extends through the motor housing **17** and connects to items below the shaft ("stem" or "shaft" can include stems and shafts). The shaft **26** may be non-threadedly connected to an upper end of an IBOP assembly **24** which is the first in a series of items and/or tubular members collectively referred to as the drill string **19**. An opposite end of the drill string **19** is threadedly connected to a drill bit **20**.

[0005] During operation, a motor **15** (shown schematically) encased within the housing **17** rotates the main shaft **16** which, in turn, rotates the drill string **19** and the drill bit **20**. Rotation of the drill bit **20** produces a wellbore **21**. Drilling fluid pumped into the top drive system **10** passes through an interior passage or conduit in the main shaft **16**, the drill stem **18**, the drill string **19**, the drill bit **20** and enters the bottom of the wellbore **21**. Cuttings removed by the drill bit **20** are cleared from the bottom of the wellbore **21** as the pumped fluid passes out of the wellbore **21** up through an annulus formed by the outer surface of the drill bit **20** and the walls of the wellbore **21**. A typical elevator **29** is suspended from the top drive system to perform "pipe tripping" operations as will be explained in more detail.

[0006] A variety of items can be connected to and below the main shaft **16**; for example, and not by way of limitation, the items shown schematically as items **24** and **26** which, in certain aspects, and not by way of limitation, may be an upper internal blowout preventer **24** and a lower internal blowout preventer **26**. In other systems according to the present invention the item **24** is a mud saver apparatus, a load measuring device, a flexible sub, or a saver sub. A connection assembly **40** can non-threadedly connect the item **24** to the main shaft **16**. The shaft **16** may be a drill stem or a quill.

[0007] In typical top drive drilling operations, top drive elevators **29** are set to have a pipe handler (explained below) oriented in one rotational direction to trip pipe (move the drill string into and out of the wellbore) and in another for drilling. The trip pipe orientation limits the extension travel of the elevators **29**. Limiting the elevator extension allows the elevators **29** to clear a racking board **42** and/or parts in relation to the racking board **42**, and this may include parts of the derrick **11**. Such orientation allows the top drive **10** to travel up to or down from the racking board **42** and crown (top of the derrick **11**) without the possibility of interference between the top drive pipe handling equipment and other items. The tripping rotational orientation also allows the elevators **29** and associated pipe handling equipment to extend out as close as possible to the derrick man/racking board **42** without interference between the elevators **29** and racking board **42** or the derrick **11**. Height of the top drive system **10** above the derrick floor may be determined by any known type of sensor **41**, either in drawworks (not shown) or other convenient location proximate the derrick **11**.

[0008] There is a pre-determined "safe" zone of pipe handler rotational orientation in which the top drive and pipe handler can be rotated from a preset "trip" position. The safe tripping zone allows the pipe handler to be orientated in various trip positions to allow ease of pipe handling, including inserting and removing pipe to/from the elevators **29** for tripping pipe in and out of the wellbore without the risk of making contact with the racking board and/or other parts of the derrick **11**.

[0009] There is also a predetermined "drilling position", ordinarily oriented 180 degrees from the "zero" or pipe trip position, which allows the elevators **29** to be retracted far enough to allow the top drive system **10** to reach the drill floor without the elevators interfering with the drill floor. In such retracted position it is possible for the elevators **29** to make contact with the racking board **42** if the top drive system **10** were lifted sufficiently, so without proper monitoring, hoisting or lowering the top drive system **10** can result in damage to equipment and/or personnel.

[0010] In ordinary drilling operations, the top drive system **10** is hoisted up to the elevation level of the racking board **42** using the drawworks and the top drive pipe handling system, a "stand" of drill pipe can then be extended out to an operator situated in the derrick (the "derrick man") and rotationally orientated based on hand signals and/or radio signals to the drilling unit operator ("driller") as to orientate the elevators in the precise direction needed for ease of the derrick man to install or remove pipe to/from the elevators. The precise location that the elevators need to be rotated to depends on which side of derrick **11** the pipe is being racked or removed from as well as factors such as the configuration of the derrick. The pipe handling system can be rotated from the trip position to the drilling position to allow the top drive to move all the way to the drill floor with the elevators retracted (extended close to horizontal) to prevent the elevators **29** from contacting the drill or derrick floor.

[0011] Using hand signals or radio signals to communicate between the derrick man and the driller can be inefficient and sometimes dangerous. There exists a need for an automatic system to determine rotational position of the pipe handling portions of a top drive, and automatic controls to prevent unsafe orientation and positioning of the various top drive components during operations.

SUMMARY

[0012] One aspect of the invention is an automatic top drive positioning system including a top drive having a pipe handling system rotator gear, a drive motor rotationally coupled to the rotator gear and a rotational position sensor rotationally coupled to the rotator gear. A controller is configured to operate the drive motor to automatically move the rotator gear

to a selected rotational orientation based on measurements from the rotational position sensor.

[0013] Other aspects and advantages of the invention will be apparent from the description and claims which follow.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. **1**A shows a top drive in a drilling unit derrick.

[0015] FIG. **1** shows an example control screen for an automatic pipe handling system.

[0016] FIG. **2**A shows an oblique view of an example top drive according to the invention.

[0017] FIG. **2**B shows another view of the example top drive.

[0018] FIG. **3** show an example block diagram of an automatic system according to the invention.

DETAILED DESCRIPTION

[0019] A top drive with automatic pipe handing system may be used in a derrick as explained with reference to FIG. **1**A. FIG. **1** shows an example operator console or control panel **103** that may be used with a system according to the invention. The operator console **103** may be a "touch screen" such as one sold by GE Fanuc Automation Americas, Inc. or similar control panel, although the type of control panel or operator console is not a limitation on the scope of the invention. The example operator console **103** shown in FIG. **1** may include certain displays and controls as follows. At **100** the top four "buttons" or touch screen windows may activate "set" positions so an automatic pipe handler (explained with reference to FIGS. **2**A and **2**B) will automatically stop rotation at any rotational position selected. At **102**, during power up the drilling unit operator ("driller") may acknowledge, by pressing a suitable control window on the touch screen (or an actual switch or electronic control button, for purposes of the invention any such device is usable, the invention is not limited by the type of operator console or diplay) that the pipe handler rotational orientation matches the orientation displayed by an indicator **101**, which may be an actual gauge or may be a computer display or combination display/touch screen. At **104** a gauge on the operator console **103** may display the actual rotational position of the pipe handler with reference to the indicator **101**. Error messages may appear on the display if there is an error, e.g., if the pipe handler is in an incorrect rotational position with respect to its elevation above the drill floor. At **106** a control may be provided on the operator console or control panel to "unlock" the pipe handler and allow the automatic positioning system to function. At **108**, two arrow keys shown on the example operator console may be used to choose the direction to rotate the pipe handler. At **110**, a control window or button on the operator console may be provided to select between manual and automatic operating mode. At **112**, a calibration control may be provided. For example, a system controller (see FIG. **3**) may be programmed such that when the button or window shown is actuated for a selected time (e.g., 2 seconds) to set the pipe handler actual position to zero when the pipe handler position is actually at zero degrees. Zero degrees may be defined as the above described trip position, although it is to be understood that any value of angle may be selected to correspond to the trip position. The trip position is generally considered to be the rotational orientation at which the elevators (**29** in FIG. **1**A) extend directly toward the racking board (**42** in FIG. **1**A).

[0020] At **114**, the displayed bottom three control windows (buttons) allow the system operator (e.g., the driller) to set the pipe handler stop positions to selected rotational orientations. The numerical entry buttons allow the operator to enter rotation stop positions in degrees with respect to a reference, usually the trip position. The stop positions could also be transmitted to the controller (FIG. **3**) by an automated pipe racking system. The display at **118** shows the actual pipe handler orientation in degrees. A control window or button on the operator console at **116** may send a control signal to the controller (FIG. **3**) to operate the pipe handler to rotate the pipe handler orientation to zero degrees.

[0021] FIGS. **2**A and **2**B show oblique views of a top drive according to the invention. The top drive **10** is shown in simplified form to illustrate the relevant parts of a system according to the invention. At **210** a pipe handler rotator gear rotates pipe handling components of the top drive rotationally coupled to the rotator gear **210**, including links **206**, elevators **204** and link cylinders **208**. The foregoing parts of the top drive **10** are capable of rotating 360 degrees in either direction, independently of other operating parts of the top drive **10**. The top drive links **206** are typically coupled rotationally to the pipe handler rotator gear **210**. A pipe handler rotate motor **212** rotates the pipe handler rotator gear **210**, and is in signal communication with the controller (FIG. **3**). The links **206** may be coupled to the elevators **204** that are used to lift the drill string (**19** in FIG. **1**A) from and lower it into the wellbore when "tripping" pipe. In the present example, a rotary position encoder **202** (or a "rotational position sensor") of any type known in the art may be used to measure the rotational orientation or position of the pipe handler rotator gear **210**. The links **206** may be moved from a vertical orientation toward horizontal by the link cylinders **208**. The position of the link cylinders **208** may be measured by a sensor **208**A, such as a linear position sensor (e.g. a linear variable differential transformer).

[0022] An example system configuration is shown in block diagram form in FIG. **3**. At **310** a general purpose programmable computer or programmable logic controller (PLC), for convenience referred to as a "controller", may provide operating signals to operate certain parts of the system described with reference to FIGS. **2**A and **2**B, i.e., the pipe handler rotate motor and the link cylinders. At **300**, the operator console shown in FIG. **1** may be used so the operator can provide control input to control operation of the system. At **302**, the system controls may be separate buttons or other physical switches, or may be part of a touch screen as explained with reference to FIG. **1**. Input from the rotary position encoder (**202** in FIG. **2**B) is shown conducted to the controller **310** at **304**. At **306**, height of the top drive above the drill floor may be measured by a sensor (**41** in FIG. **1**A) in the drawworks or other part of the lifting system (see FIG. **1**A). Extension of the link tilt cylinders as measured by the linear sensor (**208**A in FIG. **2**B) may also be used as input to the controller **310**. During pipe tripping operations, the controller **310** may provide control signals to operate the pipe handler rotate motor (**212** in FIG. **2**A) and receive signals from the rotary encoder (**202** in FIG. **2**A) to move the pipe handler rotator gear (**210** in FIG. **2**A) to a selected rotary orientation, typically so that a "stand" of the drill string (**19** in FIG. **1**A) may be oriented toward the racking board, or removed from the racking board (**42** in FIG. **1**A). The controller **310** may also provide a control signal **316** to operate the drawworks (shown as traveling block **12** in FIG. **1**A) to move the top drive

(**10** in FIG. **1**A) to a selected elevation above the drill floor. For example, the top drive may be elevated to a height at which a stand of the drill string may be moved toward the racking board (**42** in FIG. **1**A). The stand of drill string may be then be manually unlatched by a "derrick man", or remotely (**314** in FIG. **3**) unlatched by the driller from the elevators (**204** in FIG. **2**B) and racked into the racking board manually by the derrick man or automatically by an optional separate automated pipe racking system (typically supplied by a different operator than the top drive) **312**. The pipe racking system may provide signals to the controller (**310** in FIG. **3**) to allow the automated pipe handler to rotate to the orientation requested by the automatic pipe racking system **312**. Such orientation may be displayed (e.g., on the operator console screen **114** in FIG. **1**). As explained with reference to FIG. **1**A, the elevation may be measured by a suitable sensor (**41** in FIG. **1**A). The controller **310** may then send a control signal to the link cylinders (**208** in FIG. **2**B) to extend toward horizontal so that the stand of drill string may be moved toward the racking board (**42** in FIG. **1**A). In the present example, the controller **310** may be programmed to stop operation of the drawworks if the pipe handler rotate gear and/or the link cylinders are determined to be in a position that might cause collision between components of the top drive and the derrick or racking board.

[0023] A top drive and pipe handler automated control system according to the various aspects of the invention may save pipe trip time, increase safety and reduce the possibility of damage to drilling unit components.

[0024] While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the attached claims.

What is claimed is:

1. An automatic top drive positioning system, comprising:

a top drive comprising a pipe handling system rotator gear, a drive motor rotationally coupled to the rotator gear and a rotational position sensor rotationally coupled to the rotator gear; and

a controller in signal communication with the rotator gear and the drive motor, the controller configured to operate the drive motor to automatically move the rotator gear to a selected rotational orientation based on measurements from the rotational position sensor.

2. The automatic top drive positioning system of claim **1** further comprising link cylinders coupled to elevator links coupled to the top drive, the link cylinders configured to move elevator links coupled to the top drive in a direction transverse to a direction of motion of the top drive during drilling operations.

3. The automatic top drive positioning system of claim **2** further comprising at least one sensor coupled to the link cylinders in signal communication with the controller, at least one sensor configured to measure an elevation of the top drive above a drill floor in signal communication with the controller, and wherein the controller is configured to automatically operate the rotator gear and the link cylinders such that an elevation of the top drive and a rotational orientation of the rotator gear prohibit interference between any part of the top drive and a drilling derrick.

4. A method for operating a top drive, comprising:

measuring a rotational position of a pipe handler rotate gear having elevator links rotationally coupled thereto;

automatically rotating the pipe handler rotate gear such that the elevator links are disposed in a selected rotational orientation with respect to a drilling derrick.

5. The method of claim **4** further comprising measuring an elevation of the elevator links above a drill floor and at least one of automatically rotating the pipe handler rotate gear to an orientation such that interference between the elevator links and the drilling derrick is avoided when the top drive is elevated in the drilling derrick.

6. The method of claim **4** further comprising automatically operating link extension cylinders to enable elevator extension when the rotator gear is within a selected range of rotational orientations.

7. The method of claim **5** further comprising automatically retracting the link extension cylinders when the rotate gear in within a selected range of rotational orientation.

* * * * *