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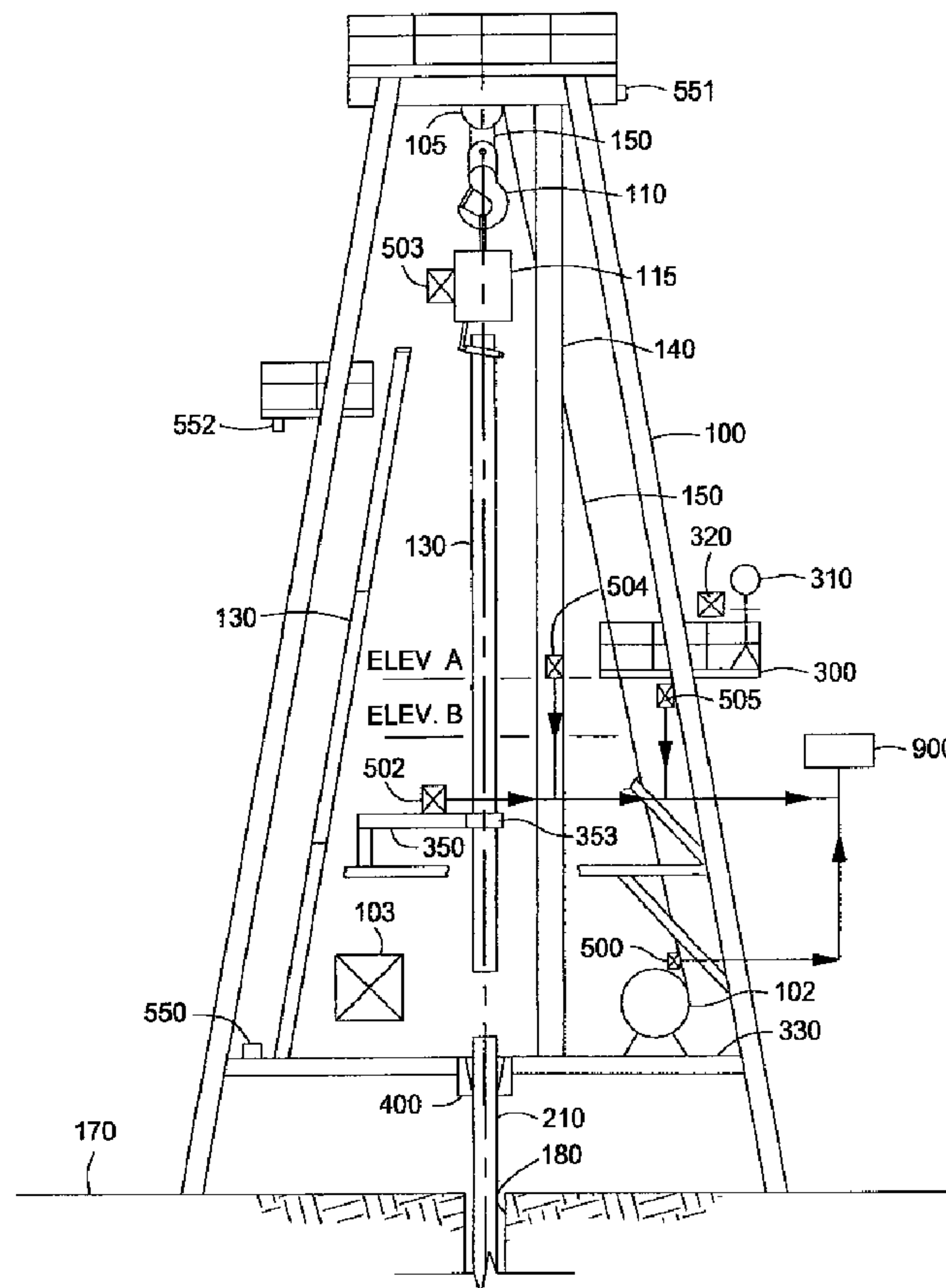
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(54) Title: TUBULAR RUNNING APPARATUS



(57) Abrégé/Abstract:

Methods and apparatus are provided to prevent collisions between one drilling tool and another drilling tool during drilling operations. If the drilling tools reach a certain proximity to one another, a controller takes action to prevent a collision.



ABSTRACT OF THE DISCLOSURE

Methods and apparatus are provided to prevent collisions between one drilling tool and another drilling tool during drilling operations. If the drilling tools reach a certain proximity to one another, a controller takes action to prevent a collision.

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TUBULAR RUNNING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

Embodiments of the present invention generally relate to an apparatus and method for facilitating the connection of tubulars. More particularly, the invention relates to a safety device for preventing well components from colliding. More particularly still, the invention relates to a monitoring system which prevents and/or alerts an operator when a collision between well components is imminent.

Description of the Related Art

In the construction and completion of oil and gas wells, a drilling rig is constructed on the earth's surface to facilitate the insertion and removal of tubular strings into a wellbore. The drilling rig includes a platform and power tools such as a hoisting system, an aligning/stabbing tool and a spider to engage, assemble, and lower the tubulars into the wellbore. The hoisting system suspends above the platform from a pulley that is operated by a draw works that can raise or lower the hoisting system in relation to the floor of the rig. The hoisting system includes an elevator, a traveling block, bails, top drive, etc. The aligning/stabbing tool for aligning tubulars comprises a positioning head which is mounted on a telescopic arm which can be hydraulically extended and retracted and pivoted in a horizontal plane to position the tubular. The spider mounts to the platform floor. The elevator and spider both have slips that are capable of engaging and releasing a tubular, and are designed to work in tandem.

5 One or more operators perform the construction process on a platform of the drilling rig. The operators monitor the drilling instrumentation, the rig floor and the derrick while assembling tubular strings with the remote control power tools. The distance between an operator and the aligning/stabbing makes it difficult for the operator to judge the location of drilling tools in relation to other drilling tools. The operator's view
10 of the drilling tools is further obstructed by the drilling tools relative to each other or impaired by adverse weather and poor lighting. These factors sometimes cause an operator to make a mistake thereby causing a collision between the power tools.

If the hoisting system is raised and lowered with the path of the hoisting system obstructed by a power tool, severe damage to the hoisting system or the power tool
15 can occur. Falling objects from the derrick can cause damage to other equipment, personal injury, or death. Thus, a collision may cause loss of rig time, repair costs, and replacement costs.

There exists a need for an improved method and apparatus for monitoring the distance between drill rig power tools. Further, there exists a need for a monitoring system that
20 prevents and/or alerts the operator when collisions between drilling tools is imminent.

SUMMARY OF THE INVENTION

Embodiments of the present invention generally relate to methods and apparatus to prevent inadvertent collisions between one drilling tool and another drilling tool during drilling operations. One or more sensors, and/or a controller are used to detect the

5 location of drilling tools. If the drilling tools reach a certain proximity to one another the controller takes action to prevent a collision.

In one embodiment, the apparatus for preventing well component collisions includes a first component moveable in a substantially vertical plane toward and away from a drill rig floor, a second component moveable toward and away from the well center, and a
10 sensing member for monitoring the location of the first component and a controller.

In another embodiment, an apparatus for preventing well component collisions comprises a first component moveable along a first predetermined path; a second component moveable along a second predetermined path, wherein the first and second predetermined paths intersect in at least one location; and a sensing member
15 for monitoring the location of the first component relative to the second component.

In another embodiment, a method for preventing a collision between a first and a second component at a well comprises moving the first component substantially along a first path; moving the second component substantially along a second path, wherein the first and second paths intersect in at least one location; sensing the location of the
20 first component; transmitting the location of the first component to a controller; and preventing the collision between the first component and the second component.

In another embodiment, an anti-collision system comprises a first sensor for monitoring the location of a first component; a second sensor for monitoring the location of a second component; and a controller for receiving data from the first and the second
25 sensor and controlling functions of the first and second component in order to prevent a collision.

- 5 In another embodiment, an anti-collision system comprises a calculator having a first algorithm for calculating the location of a first component and a second algorithm for calculating the location of a second component. The system also includes a controller communicatively connected with the calculator and at least one of the first and second components in order to prevent a collision.
- 10 In another embodiment, a method for preventing a collision between a first and a second component at a well comprises sensing the location of the first component relative to the second component; transmitting the location to a controller; and utilizing the information transmitted to the controller to move the first component to a predetermined location while avoiding a collision between the components.

15 **BRIEF DESCRIPTION OF THE DRAWINGS**

So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate
20 only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

Figure 1 is a schematic view of a drilling rig having an anti-collision system.

Figure 2 illustrates a schematic diagram of an anti-collision system.

- 5 Figure 3 is a flow chart of a typical operation of tubular string or casing assembly with use of the safety system disclosed.

DETAILED DESCRIPTION

In one embodiment, a monitor system is provided for use with a drilling rig during assembly and disassembly of tubulars in the ground or subsea surface. The system
10 may be utilized to prevent collisions of drilling rig power tools during tubular assembly and disassembly.

Figure 1 illustrates a side view of a drilling rig 100 on a surface 170 above a wellbore 180. The drilling rig 100 includes a draw-works 102 with a cable 150 attached to a pulley system 105, for raising and lowering a hoisting system 115. The hoisting
15 system 115 is shown schematically and could include any type of hoisting system, such that disclosed in U.S. Patent No. 6,742,596 and U.S. Patent Serial Number 2004/0003490 assigned to Weatherford/Lamb, Inc. The drilling rig 100 further includes a platform 300 with an operator 310 and a control panel 320 to operate one or more tools 350. The platform 300 and operator 310 are located anywhere on the
20 drilling rig 100, or offsite if desired. Typically, another operator (not shown) operates the draw-works 102 and the hoisting system 115, however one operator could do operate both the hoisting system 115 and the tool 350. In one embodiment there is no operator and the system is completely automated. The draw-works 102 consists of a wheel or spool for winding and unwinding the cable 150. The cable 150 attaches to a
25 pulley system 105, at the top of the drill rig 100, for raising and lowering the hoisting system 115. If the hoisting system 115 includes a top drive (not shown) a railing

5 system 140 is necessary to prevent rotation of the hoisting system 115. The center of the drill rig floor 330 includes an opening with a spider 400. The spider 400 holds a tubular string 210. A stack of unassembled tubulars 130 is shown on the drilling rig 100. It should be understood that the unassembled tubulars 130 can be stacked anywhere, and in any configurations so long as the hoisting system 115 is able to lift
10 the tubulars 130.

The drilling rig 100 assembles or disassembles tubular strings 210 for use in the wellbore 180. For exemplary purposes the assembly of a tubular string 210 is described. The spider 400 holds the assembled tubular string 210 so that the top end is above the drill rig floor 330. The hoisting system 115 grips one of the unassembled
15 tubulars 130 from the stack and positions the tubular over the spider 400. A tool 350 aligns the tubular 130 with the tubular string 210. The tool 350 includes a gripping end 353, for aligning the tubular 130. An example of an aligning tool can be found in U.S. Patent No. 6,591,471, assigned to Weatherford/Lamb, Inc. The tubular 130 connects to the tubular string 210. With the tubulars 130 and 210 connected the spider 400
20 disengages the tubular string 210. With the spider 400 disengaged, the hoisting system 115 supports the tubular string 210 and prevents it from falling into the wellbore 180. The operator 310 retracts the tool 350 and the other operator lowers the hoisting system 115 until only the end is above the drill rig floor 330. The spider 400 reengages the tubular string 210. The hoisting system 115 disengages the tubular
25 string 210 and is brought back to the top of the drilling rig 100. This process is repeated until the tubular string 210 is complete. Further, the drill rig 100 may include other tools 103 (shown schematically) such as a power tong and or a tailing in and

- 5 stabbing device. An example of a power tong is disclosed in U.S. Patent Publication Number 2002/0189804 assigned to Weatherford/Lamb, Inc. Examples of a tailing in and stabbing device are disclosed in U.S. Patent Application serial number 11/119,958, titled "Tailing In and Stabbing Device," filed on May 2, 2005, and U.S. Patent Application Publication No. 2004/0131449.
- 10 The hoisting system 115 is larger than the diameter of the tubular 130. Therefore, the hoisting system 115 will collide with the tool 350, if the tool 350 is not retracted to a safe location before the hoisting system 115 passes the tool 350. In Figure 1, elevation A represents an arbitrary elevation, set by the user, at which the tool 350 may be retracted without damage while the hoisting system 115 is traveling down.
- 15 Elevation B represents an arbitrary elevation, set by the user, at which a collision is imminent if the hoisting system 115 is not stopped and it is unsafe to retract the tool 350. One or more sensors 500, 502, 503, 504 and 505 are located on the drilling rig 100 to monitor the location of the hoisting system 115 and the tool 350. Data collected by these sensors 500, 502, 503, 504 and 505 are relayed to a controller 900. The
- 20 controller 900 is adapted to prevent collision between the hoisting system 115 and the tool 350. Further, the system for preventing collision may be adapted to prevent a collision between any tools on the drill rig 100, including the power tong and/or the tailing in and stabbing device 103.

5 The controller 900 includes a programmable central processing unit that is operable with a memory, a mass storage device, an input control unit, and an optional display unit. Additionally, the controller 900 includes well-known support circuits such as power supplies, clocks, cache, input/output circuits and the like. The controller 900 is capable of receiving data from the sensors 500, 502, 503, 504 and 505 and other
10 devices and capable of controlling devices connected to it. One of the functions of the controller 900 is to prevent collisions between the hoisting system 115 and the tool 350 as described below.

A sensor 500 is placed near the cable 150 of the draw-works 102. The sensor 500 monitors the amount of hoisting cable 150 being let out or pulled in by the draw-works
15 drum 102. The sensor 500 may comprise a wheel counter in engagement with the cable 150, a sensor for detecting revolutions of the draw-works 102 drum, a sensor for detecting the revolutions of the drive shaft (not shown) or drive mechanism (not shown) of the draw works drum or any other type of device for measuring the amount of cable 150 extending from the draw works 102 drum. The wheel counter measures
20 the amount of revolutions the wheel in engagement with the cable 150 makes during operation. As shown in fig. 2, the sensor 500 sends data to the controller 900. The sensor 900 is programmed with information regarding the pulley ratio and start location of the hoisting system 115. The pulley ratio determines the distance of travel toward the rig floor for a particular cable extension from the draw-works drum 102. For
25 example, if the pulley ratio is 10 to 1, then for every 10 feet of cable extended from the draw-works drum 102 the hoisting system 115 will travel 1 foot toward the drill rig floor 330. Thus, the controller 900 is configured to calculate the location of the hoisting

5 system 115 as the cable 150 is wound and unwound from the draw-works drum 102. The sensor 500 may be used alone or in conjunction with one or more sensors described below in order to prevent a collision on the platform as discussed below.

A sensor 502 attaches to the tool 350. The sensor 502 detects the position of the tool 350 and relays the data to the controller 900. In one embodiment, the sensor 502 is a
10 mechanical sensor attached to the tool 350, as is known in the art, such as a linear potentiometer, a position transducer, a piston, etc. (fig. 2). The sensor 502 detects when the tool 350 is extended to an unsafe location and when the tool is in a safe location and relays this data to the controller 900.

In another embodiment, the sensor 502 is a position sensor as part of a wireless
15 positioning system. As is known in the art, wireless position sensors use signals, such as radio waves to triangulate the location of the sensor 502. The sensor 502 is used in conjunction with location tracking components. In one embodiment, three location tags 550, 551 and 552 attach to the drilling rig 100 at three separate locations. The location tags 550, 551 and 552 can be placed anywhere on the drilling rig 100
20 although it is preferred to have them spaced apart both horizontally and vertically. The three location tags 550, 551 and 552 can then triangulate the location of the sensor 502 thus determining the location of the tool 350 and relay the data to the controller 900. Further, the sensor 502 can be used in conjunction with previously existing location tracking components, such as the GPS satellites, or Wi-Fi networks.

25 Another position sensor 503 attaches to the hoisting system 115 and is incorporated as a part of the wireless positioning system. The location tags 550, 551 and 552

5 locate the sensor 503 as the hoisting system 115 moves up and down and relay this data to the controller 900.

In another embodiment, if the hoisting system 115 has a top drive dolly (not shown), a sensor 504 placed on the rail 140 detects when the dolly moves below elevation A and/or elevation B. The sensor 504 can be any type of sensor known in the art, such
10 as a strain gauge, a switch activated by the dolly, etc. The sensor 504 relays this data to the controller 900.

In another embodiment, a sensor 505 is placed on the drill rig 100. The sensor 505 consists of a camera which sends data to the controller 900. The camera views the location of both the tool 350 and the hoisting system 115. The controller 900 is
15 equipped with corresponding detection software which determines the location of the hoisting system 115 and/or the tool 350.

Regardless of the type of sensor, or if no sensor is used, the controller 900 performs the function of preventing the hoisting system 115 from colliding with the tool 350. The sensors 500, 503, 504 or 505 locate the hoisting system 115, and at least one method
20 of locating the hoisting system 115 is used. In one embodiment, upon the hoisting system 115 reaching elevation A, the controller 900 sends a signal through hydraulic, pneumatic, or electric transmission to the tool 350. The signal will override the tool controller 320 and retract the tool 350. Further, the controller 900 can be designed to send a signal directly to a piston 351 which retracts tool 350. This embodiment does
25 not require the use of a second sensor 502 on the tool 350, because regardless of the location of the tool 350 the controller 900 will retract the tool 350. Additionally, if the

5 gripping end 353 is activated and gripping a tubular, the controller 900 can be programmed to not automatically retract the tool 350 until the tubular is safely supported.

In yet another embodiment, the hoisting system 115 sensor 500, 503, 504 or 505 operate in conjunction with the sensor 502 on the tool. The sensors 500, 503, 504 or
10 505 relay data to the controller 900 indicating the location of the hoisting system 115. If the sensors 500, 503, 504 or 505 indicate to the controller 900 that the hoisting system 115 reached the elevation B and sensor 502 indicates to the controller 900 that the tool 350 is in an unsafe position, the controller 900 will override the control to the draw-works drum 102 and stop the hoisting system 115 before a collision occurs. In
15 this embodiment the controller 900 can also raise the hoisting system 115 to a safe location and retract the tool 350.

In yet another embodiment, the hoisting system sensors 500, 503, 504 or 505 operate in conjunction with the sensor 502 on the tool 350. The sensors 500, 503, 504 or 505 relay data to the controller 900 indicating the location of the hoisting system 115. If the
20 sensor 500, 503, 504, or 505 indicate to the controller 900 that the hoisting system 115 has reached the elevation A and sensor 502 indicates to the controller 900 that the tool 350 is in an unsafe position, the controller 900 retracts the tool 350. If the tool 350 fails to retract and the hoisting system 115 reaches elevation B, the controller 900 will stop the hoisting system 115, as described above.

25 In yet another embodiment, the controller 900 prevents the extension of the tool 350 when the hoisting system 115 is in an unsafe position. When the controller 900

5 detects, through use of sensors 500, 503, 504, or 505, the hoisting system 115 is below elevation A, the controller 900 will override the tool controls 320. The controller 900 prevents extension of the tool 350 until the hoisting system 115 moves above elevation A.

The sensors 500, 501, 502, 503 504 and 505 are incorporatable into the drilling rig 100
10 at any time, making it easy to place the system on a working drilling rig 100. Further, the anti-collision system can be incorporated to prevent moveable components from colliding with immovable components. To further communicate the unsafe position of the tool 350 to the operator 310, the sensors 500, 501, 502, 503, 504, and 505 may set off an alarm (not shown), consisting of an audible and/or visual signal.

15 In yet another embodiment, rather than using a sensor to determine the position of the hoisting system 115 and/or the tool 350, the controller 900 may track or calculate the position without a sensor. For example, the position of the components may be determined by keeping track of expected linear movement from a known starting/stopping point as the controller 900 manipulates the hoisting system 115
20 and/or the tool 350. Thus, the controller 900 knows the locations of the components at anytime during operation. The controller 900 is programmed so that the components of the drill rig 100 such as the hoisting system 115, the tool 350 and the other tools 103 will not collide with one another. Further, the anti-collision system may work the same as the embodiments described above but the controller 900 does not need
25 sensors.

5 Figure 3 is a flow chart illustrating a typical operation of a string or casing assembly with the anti-collision system in place. At a first step 600, the closed spider 400 holds the tubular string 210 and is thereby prevented from moving in a downward direction. At step 610, the hoisting system 115 engages the tubular 130 from a stack of tubulars. At step 620, the hoisting system 115 moves the tubular 130 into position above the
10 tubular string 210. At step 630, tool 350 extends to engage the tubular 130, and thereafter, aligns the tubular 130 with the tubular string 210. At step 640, the tubular 130 connects to the tubular string 210 by any known method, such as threading or welding the tubulars 130 and 210 together. At step 650, the operator 310 retracts the tool 350 into a safe position. At step 660, the spider 400 disengages the tubular string
15 210, thus the weight of the string is supported by the hoisting system 115. At step 670, the hoisting system 115 lowers the tubular string 210 into the wellbore 180 until only a small portion of the tubular string 210 extends above the spider 400. At step 680, the spider 400 reengages the tubular string 210. At step 690, the hoisting system 115 disengages the tubular string 210 and raises up to the top of the drilling rig 100.
20 At step 695, if the well is complete the method is complete, however if more tubulars 130 need to be assembled the process starts over again at step 600.

Step 700 follows step 640 as an alternative method based on the operators 310 action. At step 700, the spider 400 disengages the tubular string 210. At step 705, the operator 310 retracts tool 350 to a safe position. After step 705 the flow charts next
25 step is step 670 described above. The alternative choice after step 700 is step 710. At step 710, the operator 310 lowers the hoisting system 115 and the tubular string 210 without retracting the tool 350. At step 715, the hoisting system 115 reaches the

5 elevation A as detected by sensor 500, 503 or 504 and relayed to controller 900. One alternative after step 715 is step 720, the controller 900 automatically retracts the tool 350 as described above. After step 720, with the tool 350 retracted the next step is back to step 670, lowering the hoisting system 115. An alternative route after step 715 is step 725, the sensor 502 detects the tool 350 is in an unsafe position and relays this data to controller 900. In the next step 730 the controller 900 retracts the tool 350. After step 730, with the tool 350 retracted the next step is back to step 670, lowering the hoisting system 115. In yet another alternative after step 715, in step 735 the hoisting system 115 reaches the elevation B as detected by sensor 500, 503 or 504 and relayed to controller 900. At step 740 the controller 900 stops the hoisting system 115 from moving down. At step 745 the controller 900 or the operator raises the hoisting system 115 to the elevation A. At step 750 the controller 900 or operator retract the tool 350. After step 750, with the tool 350 retracted the next step is back to step 670, lowering the hoisting system 115. The above-described steps may be utilized in running any drill string in a drilling operation, in running casing to reinforce the wellbore, or for assembling strings to place wellbore components in the wellbore. The steps may also be reversed in order to disassemble the tubular string.

While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

Claims:

1. An apparatus for preventing well component collisions on a rig, comprising:
 - a triangulating positioning system having a first tracking tag, a second tracking tag, and a third tracking tag, wherein each tracking tag is coupled to the rig;
 - a first component moveable along a first predetermined path;
 - a second component moveable along a second predetermined path, wherein the first and second predetermined paths intersect in at least one location;
 - a first sensing member for monitoring the location of the first component relative to the second component, wherein the first sensing member is a position sensor attachable to the first component and is trackable by each of the tracking tags; and
 - a second sensing member for monitoring the location of the second component relative to the first component, wherein the second sensing member is a position sensor attachable to the second component and is trackable by each of the tracking tags.
2. The apparatus of claim 1, wherein in the first path comprises a substantially vertical path toward and away from a rig floor.
3. The apparatus of claim 1, wherein the second path comprises a substantially horizontal path toward and away from a well center.

4. The apparatus of claim 1, wherein the first component lowers a tubular towards a wellbore surface and the second component aligns the tubular over the wellbore surface in a horizontal plane.
5. The apparatus of claim 1, wherein the first component is a top drive.
6. The apparatus of claim 1, wherein a controller is operable to receive data from the first sensing member and transmit data for controlling functions of the first component and the second component.
7. The apparatus of claim 1, wherein a controller is operable to receive data from the first sensing member and the second sensing member and transmit data for controlling functions of the first component and the second component.
8. The apparatus of claim 1, wherein the first sensing member is attachable to a cable from a draw-works which operates the first component.
9. A method for preventing a collision between a first component and a second component on a rig at a well, comprising:
 - moving the first component substantially along a first path, wherein a first sensor is coupled to the first component;

moving the second component substantially along a second path, wherein a second sensor is coupled to the second component, wherein the first and second paths intersect in at least one location;

triangulating the location of the first component using a first tracking tag, a second tracking tag, and a third tracking tag, wherein each tracking tag is coupled to the rig;

triangulating the location of the second component using the first tracking tag, the second tracking tag, and the third tracking tag;

transmitting the triangulated location of the first and second components to a controller; and

preventing the collision between the first component and the second component.

10. The method of claim 9, wherein the first component is for raising and lowering a tubular over a well center and the second component for aligning the tubular over a well center.

11. The method of claim 9, further comprising the controller moving the second component to a safe location upon the first component reaching a predetermined elevation.

12. The method of claim 9, further comprising transmitting an unsafe location of the second component to the controller and moving the second component to a safe location upon the first component reaching a predetermined elevation.
13. The method of claim 9, further comprising stopping the first component upon reaching a predetermined elevation if the second component is in an unsafe location.
14. The method of claim 9, further comprising controlling functions of the first and second component with the controller.
15. The method of claim 14, further comprising the controller preventing a collision between the first component and second component.
16. A well component anti-collision system comprising:
 - a plurality of tracking tags spaced apart from each other;
 - a first sensor for triangulating the location of a first component using the plurality of tracking tags;
 - a second sensor for triangulating the location of a second component using the plurality of tracking tags; and
 - a controller for receiving data from at least one of the first sensor, the second sensor, and the plurality of tracking tags, and for controlling functions of the first and second components in order to prevent a collision between the first and second components on a rig.

17. A method for preventing a collision between a first and a second component at a well, comprising:

triangulating the location of the first component relative to the second component;

transmitting the location to a controller;

measuring an amount of cable spooled from a draw-works;

transmitting the amount of cable to the controller to calculate the location of the second component relative to the first component using a pulley ratio of the draw-works; and

utilizing the information transmitted to the controller to move the first component to a predetermined location while avoiding a collision between the components.

18. An apparatus for preventing well component collisions on a rig, comprising:

a first component moveable along a first predetermined path;

a second component moveable along a second predetermined path;

a first sensor disposed on the first component;

a second sensor disposed on the second component; and

a plurality of tracking tags coupled to the rig, each tracking tag vertically and horizontally spaced apart from the other tracking tags and positioned at separate locations, wherein the first and second sensors and the tracking tags are operable to triangulate the location of the first and second components, respectively, to prevent collision between the first and second components along the first and second predetermined paths.

19. The apparatus of claim 18, wherein the first sensor and the tracking tags triangulate the location of the first component relative to the second component.
20. The apparatus of claim 18, wherein the second sensor and the tracking tags triangulate the location of the second component relative to the first component.
21. The apparatus of claim 18, wherein the tracking tags transmit the location of the first and second sensors to a controller.
22. The apparatus of claim 18, wherein the first and second sensors transmit the location of the tracking tags to a controller.
23. The apparatus of claim 18, wherein the first component is an elevator or a top drive.
24. The apparatus of claim 23, wherein the second component is a tailing in and stabbing device or a power tong.
25. The apparatus of claim 18, wherein the first predetermined path is parallel to a vertical plane.
26. The apparatus of claim 1, wherein the first component is an elevator.

27. The apparatus of claim 26, wherein the second component is a tailing in and stabbing device or a power tong.
28. The apparatus of claim 1, wherein the first predetermined path is parallel to a vertical plane.
29. The method of claim 9, wherein the first component is an elevator or a top drive.
30. The method of claim 29, wherein the second component is a tailing in and stabbing device or a power tong.
31. The method of claim 9, wherein the first path is parallel to a vertical plane.
32. A well component anti-collision system for preventing collisions on a rig comprising:
- a plurality of tracking tags spaced apart from each other;
 - a plurality of sensors spaced apart from each other, wherein the plurality of tracking tags and sensors are configured to triangulate the location of a first component and a second component; and
 - a controller for receiving data from at least one of the tracking tags and sensors for controlling operation of the first and second components to prevent a collision between the first and second components on the rig.

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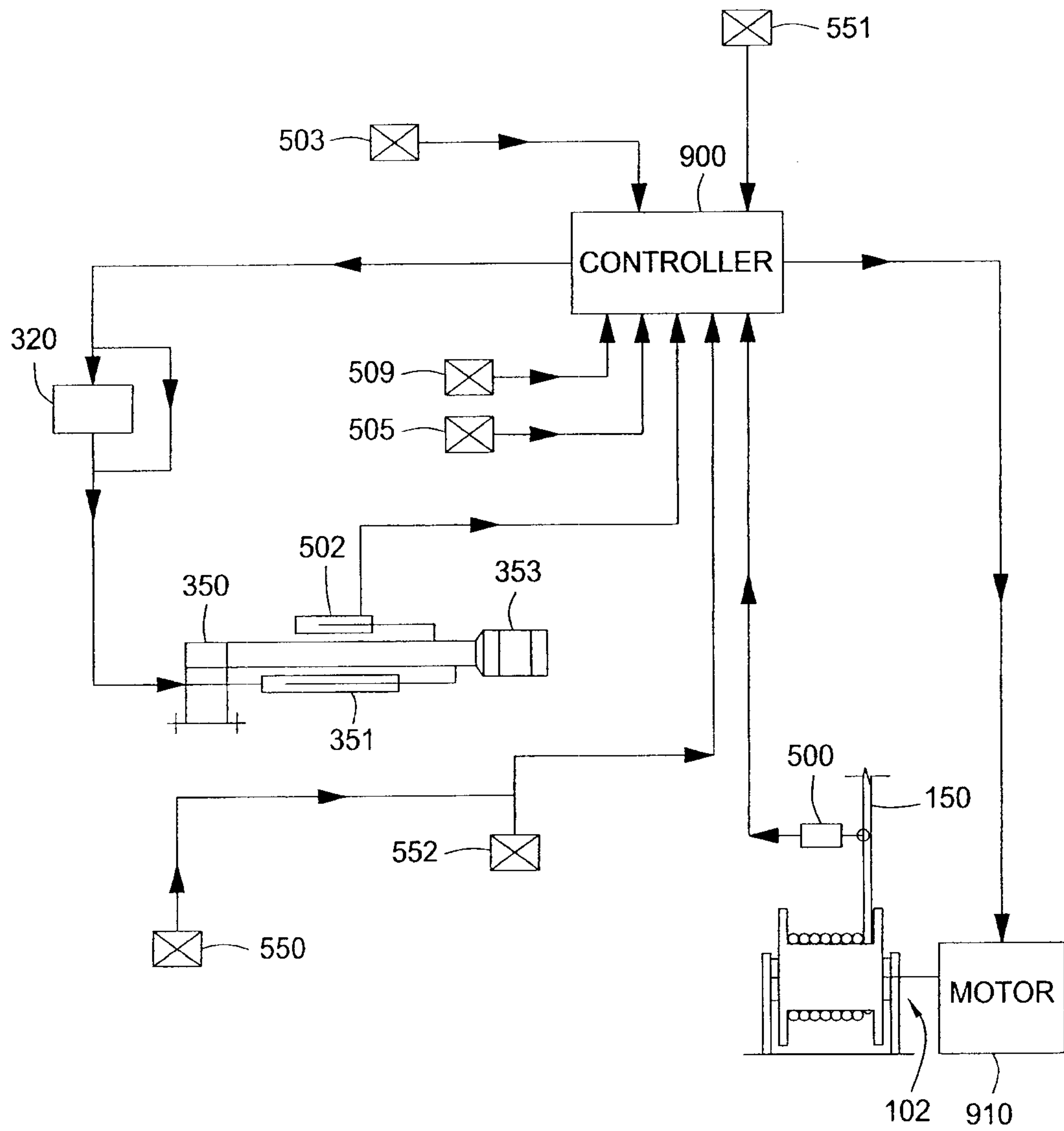


FIG. 2

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FIG. 3

