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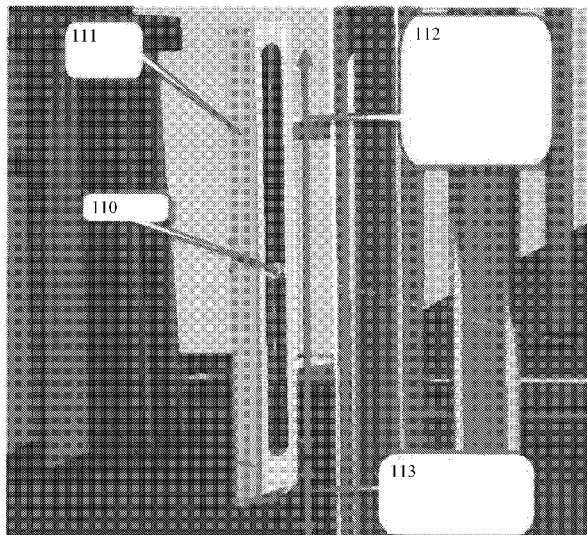


FIGURE 1

(57) Abstract: A tool joint assist system for making and breaking pipe joints of tubulars in a drill string relative to an onshore or offshore drilling rig, the tool joint assist system comprising a height indicator that is observable by an operator relative to the tubulars; a height adjustment input device operable by the operator; a mover of the height indicator; and a computer comprising a processor, a non-transitory storage medium, a transmitter/receiver, and a set of computer readable instructions stored in the non-transitory storage medium and when executed by the processor: (i) receive an input from the height adjustment input device to move the vertical position of the height indicator relative to the tubulars; (ii) and transmit a command to the mover of the height indicator to move the height indicator to the instructed vertical position.



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Published:

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TITLE OF INVENTION

TOOL JOINT ASSIST FOR IRON ROUGHNECK

CROSS REFERENCE PARAGRAPH

This application claims the benefit of U.S. Provisional Application No. 62/810874 entitled “Tool Joint Assist for Iron Roughneck,” filed February 26, 2019, the disclosure of which is incorporated herein by reference.

TECHNICAL FIELD

[0001] The present disclosure relates to pipe handling and drilling operations via onshore and offshore drilling rigs, for drilling wells for the exploration and production of hydrocarbons. In particular, the invention relates to systems and methods for determining the position of an iron roughneck relative to a tool joint on a drillpipe connection, to make sure the automated iron roughneck gets a correctly positioned grip on the drillpipe when making/breaking a tubular connection.

BACKGROUND ART

[0002] During drilling operations, drill string is run into a well bore and is made up of a series of connected drill pipes. As the drill string is tripped into the wellbore, additional pipes are added to the top of the drill string to lengthen the string. The drill string is lowered in the wellbore until only an uppermost portion of the drill string sticks up above the drill floor. The distance the upper end of the drill string extends above the drill floor is called the “stick-up height.” When the drill string is positioned at an appropriate “stick-up height” for making up a new section of drill pipe to the drill string, pipe handling equipment position the new section of drill pipe in axial alignment with the drill string immediately above the string. The new section of drill pipe is lowered until the pin end of the new section stings into the box end of the drill string. The new section of drill pipe is then rotated relative to the drill string so as to engage the threads of the pin and box ends to form a pipe joint. An iron roughneck is then positioned

at the pipe joint to apply sufficient torque to make up the joint. Typically, the threads are engaged by a low-torque pipe spinner and the joint is made up by mechanical tongs of an iron roughneck, which apply high-torque to the joint to ensure a complete and durable connection where the shoulders of the box and pin fully engage.

[0003] Because not all drill pipe sections are the same length and there is there substantial variability in the drilling process, the “stick-up height” varies each time a new pipe joint is to be made up in the drill string. Variable “stick-up height” presents a problem as the low-torque pipe spinner and the iron rough neck must be properly positioned relative to the joint. In particular, the low-torque pipe spinner must be positioned to engage the new pipe section, and the iron roughneck must be positioned so that its upper jaws engage the pin end of the new pipe section and its lower jaws engage the box end of the uppermost section of the drill string.

[0004] Current systems use optical cameras or arms with proximity switches to obtain data regarding the position of the pipe joint relative to an iron roughneck. Typically, these systems use a digital input from proximity switches, or computer to process camera images of the pipe joint and control the position of the iron roughneck relative to the pipe joint.

[0005] U.S. 9,464,492 discloses a system for determining the position of a downhole drill pipe relative to a pipe handling device. The system comprises: an imaging means arranged to capture an image of the drill pipe in a region of the pipe for engagement by the device; and a processor operable to analyze said captured image and to determine therefrom the position of the drill pipe relative to said device. A processor is operable to analyze captured images and to provide control signals to a control means of the position of the wrench.

[0006] U.S. 9,657,539 discloses an automated roughneck including a backup tong and a makeup tong. The makeup tong and backup tong may be selectively movable relative to one another. The makeup tong and backup tong may include spinner and gripper assemblies respectively adapted to make up and break out threaded connections. A positioning sensor may be positioned on an upper surface of makeup tong, wherein the positioning sensor may scan drill string to detect tool joint as makeup tong and backup tong are moved vertically. The

positioning sensor may instead be located at any other location on automated roughneck or any other surrounding structure. The positioning sensor may be any sensor capable of detecting the location of tool joint in order to position makeup tong and backup tong. The positioning sensor may be, for example, an optical sensor such as a camera, infrared range finder, or sound based sensor such as an ultrasonic sensor. Multiple positioning sensors may be utilized.

[0007] WO 2016/106294 discloses a system and method for positioning oilfield tubulars on a drilling floor (2), having an automated tubular handling system, to permit alignment and automated make up and break out of threading operations between a stationary tubular and a moving tubular, utilizing image information from radially offset cameras, processing the image information to recognize the tubulars within the image and develop position information for said tubulars, combining the position information from the two camera systems to develop three dimensional information for each of the tubulars, developing instructions for the automated tubular handling system to bring the stationary and moving tubulars into vertical alignment and lowering the moving tubular into threaded contact, and engaging an automated hydraulic torque wrench to make up the threaded connection.

[0008] Camera image data sometimes proves unreliable in situations where the edges and boundaries of the box and pin ends of the drill pipe are obscured. The edges and boundaries are particularly obscured when tripping drill string out of the wellbore because the pipe is worn, covered in dirt, soil, and minerals. When automated camera systems, or the proximity switches arms fail to ensure proper alignment of the iron roughneck, drilling operators are forced to have drill rig personnel make a visual inspection of the iron roughneck position. This requires personnel to be physically present on the drill rig floor, which is not optimal for safety reasons.

[0009] While prior automated systems position the iron roughneck relative to the pipe joint based on image data, there remain a need to provide a more accurate and automatic means to adjust the lifting height of the stand.

SUMMARY OF INVENTION

[0010] In accordance with the teachings of the present disclosure, disadvantages and problems associated with existing drill rig control systems are alleviated.

[0011] According to one aspect of the invention, there is provided a tool joint assist system for making and breaking pipe joints of tubulars in a drill string relative to a drilling rig, the tool joint assist system comprising: a height indicator that is observable by an operator relative to the tubulars; a height adjustment input device operable by the operator; a mover of the height indicator; and a computer comprising a processor, a non-transitory storage medium, a transmitter/receiver, and a set of computer readable instructions stored in the non-transitory storage medium and when executed by the processor: (i) receive an input from the height adjustment input device to move the vertical position of the height indicator relative to the tubulars; (ii) and transmit a command to the mover of the height indicator to move the height indicator to the instructed vertical position.

[0012] A further aspect of the invention provides a tool joint assist method for making and breaking pipe joints of tubulars in a drill string relative to a drilling rig, the tool joint assist method comprising: displaying to an operator a height indicator relative to the tubulars; receiving an input of the operator to move the height indicator relative to the tubulars; and moving the height indicator relative to the tubulars in response to the input of the operator.

[0013] According to another aspect of the invention, there is provided a tool joint assist system for joining tubulars in a drill string relative to a drilling rig, the tool joint assist system comprising: a pipe handling device; a roughneck with upper and lower tongs; a height indicator that is observable by an operator relative to the tubulars; a height adjustment input device operable by the operator; a mover of the height indicator; and a computer comprising a processor, a non-transitory storage medium, a transmitter/receiver, and a set of computer readable instructions stored in the non-transitory storage medium and when executed by the processor: (i) receive an input from the height adjustment input device to move the vertical position of the height indicator relative to the tubulars; (ii) transmit a command to the mover of the height indicator to move the height indicator to the instructed vertical position; and (iii) transmit a command to move the roughneck to a vertical position relative to the tubulars corresponding to the

instructed vertical position.

BRIEF DESCRIPTION OF DRAWINGS

[0014] A more complete understanding of the present embodiments may be acquired by referring to the following description taken in conjunction with the accompanying drawings, in which like reference numbers indicate like features.

[0015] FIG. 1 is a perspective view of a line-laser in a line-laser housing for shining a laser beam on the tubulars of a drill string.

[0016] FIG. 2 is a perspective view of tubulars of a drill string at a well center of a drill rig, wherein a laser beam is shining on the elevator upset of a tubular.

[0017] FIG. 3 is a perspective view of an iron roughneck positioned on a drill rig floor relative to a drill string at the well center, wherein a laser beam is shining on the elevator upset of a tubular.

[0018] FIG. 4 is a perspective view of a line-laser in a line-laser housing shining a laser beam on the tubulars of a drill string at the well center of a drill rig floor, and an iron roughneck is also shown.

[0019] FIG. 5 is a flow chart of an algorithm for making and breaking pipe joints of tubulars in a drill string relative to a drilling rig.

[0020] The objects and features of the invention will become more readily understood from the following detailed description and appended claims when read in conjunction with the accompanying drawings in which like numerals represent like elements.

[0021] The drawings constitute a part of this specification and include exemplary embodiments to the invention, which may be embodied in various forms. It is to be understood that in some instances various aspects of the invention may be shown exaggerated or enlarged to facilitate an understanding of the invention.

DESCRIPTION OF EMBODIMENTS

[0001] Preferred embodiments are best understood by reference to FIGS. 1-5 below in view of the following general discussion. The present disclosure may be more easily understood in the context of a high level description of certain embodiments.

[0022] FIG. 1 illustrates an embodiment of the invention comprising a tool joint laser (TJL). A line-laser 110 is positioned within a line-laser housing 111. The purpose of the TJL is to indicate the height from the drillfloor to the elevator-upset in the tool string. The TJL uses this information to correct the height of the automated iron roughneck, to make sure the automated iron roughneck correctly grips the drilling tubulars. The TJL system has a line-laser 110 with an optical lens that is located on drillfloor, wherein the laser is mounted inside a protecting casing or line-laser housing 111. The optical lens of the line-laser 110 points out of the line-laser housing 111.

[0023] FIG. 2 shows a flat laser beam points at the drillpipe that is in the well-center. The laser beam can be moved vertically by an electrical actuator mounted inside the line-laser housing 111. (See FIG. 1). Line-laser 110 can be moved by an electrical actuator up/down (vertically) within a vertical position range 112. The position sensor measures the height on the line-laser 110 relative to the line-laser housing. The distance 113 is between a fixed position at the drillfloor to the lowest position of the line-laser 110. As shown in FIG. 2, the distance 116 is from the elevator upset to the top of the tool joint box. From the controls on the driller's chairs in the driller's cabin, there is a position sensor mounted on the actuator, inside the line-laser housing 111 that measures the vertical position of the line-laser 110 within the range 112. The line-laser position may be sent to the drilling control system for the iron roughneck. The iron roughneck control system may use this vertical position to calculate the distance 118 from the drillfloor up to the line-laser at all times. This height or position may also be displayed via an indicator or in the HMI in the driller's cabin. From a selection switch or the HMI screen, the driller may insert the distance of the elevator-upset at the tool-joint to the top of the tool joint box. The drilling control system will then calculate the following numbers to get the drillpipe stickup height 118:

Drillpipe Stickup height 118 = Fixed position from drill floor to the lowest position of the line-laser 113 + Distance up to elevator upset within range vertical position 112 + Distance from elevator-upset to top of tool joint box 116. (See FIGS. 5 and 6).

[0024] According to various aspects of the invention, the TJL system may comprise components and functions. Line laser 110 may have a replaceable lens to make sure that the laser-line is not more than 36" at well-center. The type of lens may be selected according to the distance between the laser and the well-center. Electrical actuators may adjust the vertical position of the laser. A position sensor may measure the vertical position, and send the position to the drilling control system. A casing or line-laser housing 111 may be provided where the laser, actuator and the position sensor are mounted therein. The casing may have an adjustable cover that will prevent mud and dust to enter the casing. The drilling control system for the iron roughneck may be updated to receive the vertical position from the laser. The drilling control system for the iron roughneck may also control when the laser will be turned on or off. A new function icon or button for selecting a TJL Mode from the operator's panels or screens may be provided. A selection switch or input box (HMI) on the drilling control system for the iron roughneck to set the distance from elevator-upset to top of tool joint box may also be provided.

[0025] The control of the TJL height may be controlled by the joystick movement at the driller's chair. This joystick normally controls the iron roughneck up and down. But when the TJL system is activated, the drillpipe stickup height may be sent to the iron roughneck control system, and the iron roughneck will then follow the height on the TJL. To make sure that the upper and lower clamp on the iron roughneck are clamping correctly on the drillpipe, the TJL ensures that the centerline 119 between the upper and lower clamps is at the same height as the split 120 between the two drill-pipes. (See FIG. 3).

[0026] Safety on the drill floor should always be a primary concern. When the iron roughneck is operating, it is standard for people to move away from the drill floor because of the danger of being hit by the iron roughneck. The TJL line-laser may include a safety feature wherein it will only be activated when the iron roughneck is turned on. This safety feature ensures that there are no people on the drillfloor that can be hit by the line-laser beam. (See FIG. 4).

[0027] The TJL system may assist in stand building operations at the well center and the mousehole. At the well center, when the drillpipe is lifted into the well-center and the height on the TJL is on and set to a normal height, the pipe handling machine may lower the drillpipe until the line-laser is at the elevator-upset and then set the slips. The vertical position may then be verified by the driller and the TJL position can be adjusted, if necessary. The pipe handling machine or top-drive may lower the upper joint into the lower joint. And the driller may activate the auto make-up sequence for the iron roughneck. At the mousehole, when the drillpipe is lifted into the mouse hole, the height on the TJL may be set to a correct height that fits the length of drillpipe in the mouse hole. The vertical position may be verified by the driller and the TJL position may be adjusted if necessary. The pipe handling machine or top-drive lowers the upper joint into the lower joint and the driller activates the auto make-up sequence for the iron roughneck. The TJL system may increase the stand building speed by providing a reference point on the pipe to which the iron roughneck may go directly.

[0028] When tripping in, the TJL system may be set to an acceptable height and the top-drive may lower the drillpipe until the line-laser is at the elevator-upset and then set the slips. The pipe handling machine may then lower the upper stand into the lower joint. And then activate the auto make up sequence for the iron roughneck.

[0029] When tripping out, the TJL system may be set to an acceptable height and the top-drive may pull out the drill-string until the line-laser is at the elevator-upset and then set the slips. The driller may then activate the auto make-up sequence for the iron roughneck. This may save time because the iron roughneck will go directly to the correct position on the drill string.

[0030] The Tool Joint Laser system may provide several advantages and savings. The TJL may increase safety by avoiding a need for people to be on the drill floor to verifying the tool-joint height. With the TJL systems, the trip in/out speed may increase because the driller will have a reference point to use for setting the height on the stand before he closes the power slips. No time need be used for adjusting the iron roughneck after it reaches the well-center. The drill pipe stick-up height may always be set and verified before the iron roughneck starts the auto sequence. The position from the TJL system may be used for the vertical pipe handling system, to increase the speed on tripping in Auto-mode, because it will get the correct drill pipe stick-

up height. It can then run the joint all the way in auto mode. The TJL may be used even if the drill-pipes are full of mud. The drill pipe stick-up height may be verified by the driller so as to avoid gripping on a wrong location on the drill pipe.

[0031] FIG. 5 illustrates a flow chart for a process algorithm for an embodiment of the invention.

The process begins with the pipe handling machine positioning 168 drill string tubulars for make-up or brake-out relative to a drill string. The driller turns on the tool joint laser and observes 170 the line-laser beam shining on the drill string tubular. The driller then determines 172 whether the line-laser beam is shining on the elevator upset. If not, the driller raises or lowers 178 the line-laser until the line-laser beam is shining on the elevator upset. If the line-laser beam is shining on the elevator upset, then the TJL calculates 174 the drill pipe stickup height based on the vertical position of the line-laser. The driller then commands 176 the auto sequence for the iron roughneck to perform an operation on the drill string tubulars at the stickup height. If the operator must adjust the vertical position will the Iron-Roughneck in auto-mode, automatically adjust the vertical position on the Iron-Roughneck as it moves forward to well-center. That means that there might be a time saving for tripping, since the Iron-Roughneck will always have the correct vertical position when it reaches the well-center.

[0032] The description is presented to enable any person skilled in the art to make and use the invention and is provided in the context of a particular application and its requirements. Various modifications to the disclosed embodiments will be readily apparent to those skilled in the art, and the general principles defined herein may be applied to other embodiments and applications without departing from the spirit and scope of the present invention. Thus, the present invention is not intended to be limited to the embodiments shown but is to be accorded the widest scope consistent with the principles and features disclosed herein.

[0033] If used herein, the term “substantially” is intended for construction as meaning “more so than not.”

[0034] Having thus described the present invention by reference to certain of its preferred embodiments, it is noted that the embodiments disclosed are illustrative rather than limiting in nature and that a wide range of variations, modifications, changes, and substitutions are contemplated in the foregoing disclosure and, in some instances, some features of the present

invention may be employed without a corresponding use of the other features. Many such variations and modifications may be considered desirable by those skilled in the art based upon a review of the foregoing description of preferred embodiments. Accordingly, it is appropriate that the appended claims be construed broadly and, in a manner, consistent with the scope of the invention.

[0035] Although the disclosed embodiments are described in detail in the present disclosure, it should be understood that various changes, substitutions and alterations can be made to the embodiments without departing from their spirit and scope.

INDUSTRIAL APPLICABILITY

[0002] Tool joint assist systems and methods of the present invention have many industrial applications including but not limited to drilling well bores for the oil and gas industry.

WHAT IS CLAIMED IS:

1. A tool joint assist system for making and breaking pipe joints of tubulars in a drill string relative to a drilling rig, the tool joint assist system comprising:
 - a height indicator that is observable by an operator relative to the tubulars;
 - a height adjustment input device operable by the operator;
 - a mover of the height indicator; and
 - a computer comprising a processor, a non-transitory storage medium, a transmitter/receiver, and a set of computer readable instructions stored in the non-transitory storage medium and when executed by the processor: (i) receive an input from the height adjustment input device to move the vertical position of the height indicator relative to the tubulars; (ii) and transmit a command to the mover of the height indicator to move the height indicator to the instructed vertical position.
2. The tool joint assist system for making and breaking pipe joints of tubulars in a drill string relative to a drilling rig as claimed in claim 1, wherein the height indicator comprises: a line-laser capable of shining a laser beam on the tubulars; and wherein the mover of the height indicator comprises an actuator.
3. A tool joint assist method for making and breaking pipe joints of tubulars in a drill string relative to a drilling rig, the tool joint assist method comprising:
 - displaying to an operator a height indicator relative to the tubulars;
 - receiving an input of the operator to move the height indicator relative to the tubulars; and
 - moving the height indicator relative to the tubulars in response to the input of the operator.
4. A tool joint assist method for making and breaking pipe joints of tubulars in a drill string relative to a drilling rig, as claimed in claim 3, wherein displaying to an operator a height indicator relative to the tubulars comprises: shining a laser beam on the tubulars.

5. A tool joint assist method for making and breaking pipe joints of tubulars in a drill string relative to a drilling rig, as claimed in claim 3, wherein moving the height indicator relative to the tubulars in response to the input of the operator comprises: moving a line-laser so as to move the laser beam shining on the tubulars.
6. A tool joint assist method for making and breaking pipe joints of tubulars in a drill string relative to a drilling rig, as claimed in claim 3, further comprising presenting a graphic user interface via a display, and wherein receiving an input from the operator comprises receiving the input through the graphic user interface.
7. A tool joint assist method for making and breaking pipe joints of tubulars in a drill string relative to a drilling rig, as claimed in claim 3, further comprising: commanding an iron roughneck to move to a vertical position relative to the tubulars and based on a vertical position of the height indicator relative to the tubulars.
8. A tool joint assist system for joining tubulars in a drill string relative to a drilling rig, the tool joint assist system comprising:
 - a pipe handling device;
 - a roughneck with upper and lower tongs;
 - a height indicator that is observable by an operator relative to the tubulars;
 - a height adjustment input device operable by the operator;
 - a mover of the height indicator; and
 - a computer comprising a processor, a non-transitory storage medium, a transmitter/receiver, and a set of computer readable instructions stored in the non-transitory storage medium and when executed by the processor: (i) receive an input from the height adjustment input device to move the vertical position of the height

indicator relative to the tubulars; (ii) transmit a command to the mover of the height indicator to move the height indicator to the instructed vertical position; and (iii) transmit a command to move the roughneck to a vertical position relative to the tubulars corresponding to the instructed vertical position.

9. The tool joint assist system for making and breaking pipe joints of tubulars in a drill string relative to a drilling rig as claimed in claim 8, wherein the height indicator comprises: a line-laser capable of shining a laser beam on the tubulars; and wherein the mover of the height indicator comprises an actuator.
10. The tool joint assist system for making and breaking pipe joints of tubulars in a drill string relative to a drilling rig as claimed in claim 8, wherein the set of computer readable instructions when executed by the processor further: transmit a graphic user interface to the display, wherein the graphic user interface is capable of presenting a captured image of the tubulars and an height icon, wherein the graphic user interface is capable of receiving an input from an operator to adjust the vertical position of the height icon relative to the tubulars in the captured image.
11. The tool joint assist system for making and breaking pipe joints of tubulars in a drill string relative to a drilling rig as claimed in claim 8, wherein the set of computer readable instructions when executed by the processor further: transmits the height icon to the display for display at a vertical position relative to the tubulars based on an input received from the a height adjustment input device.

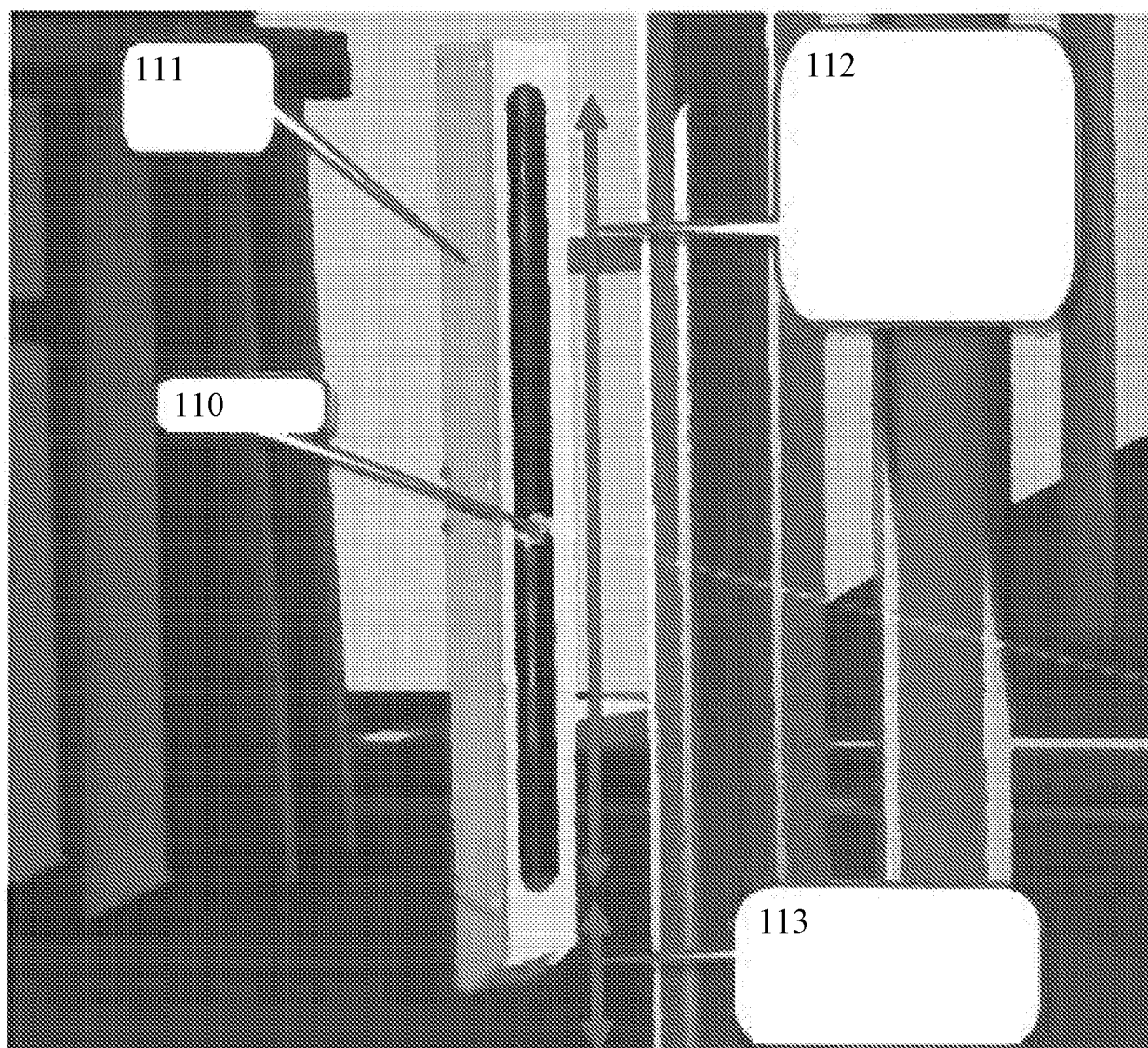


FIGURE 1

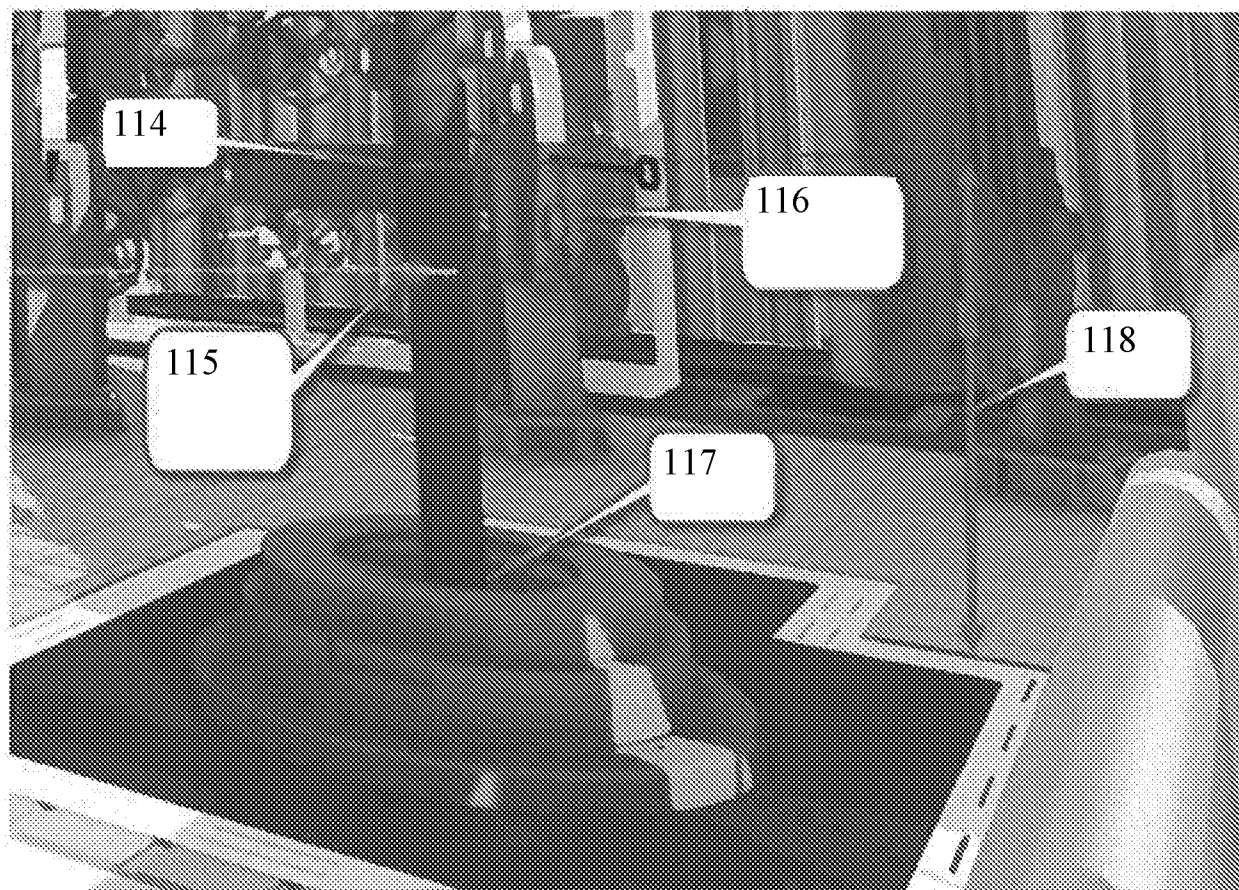


FIGURE 2

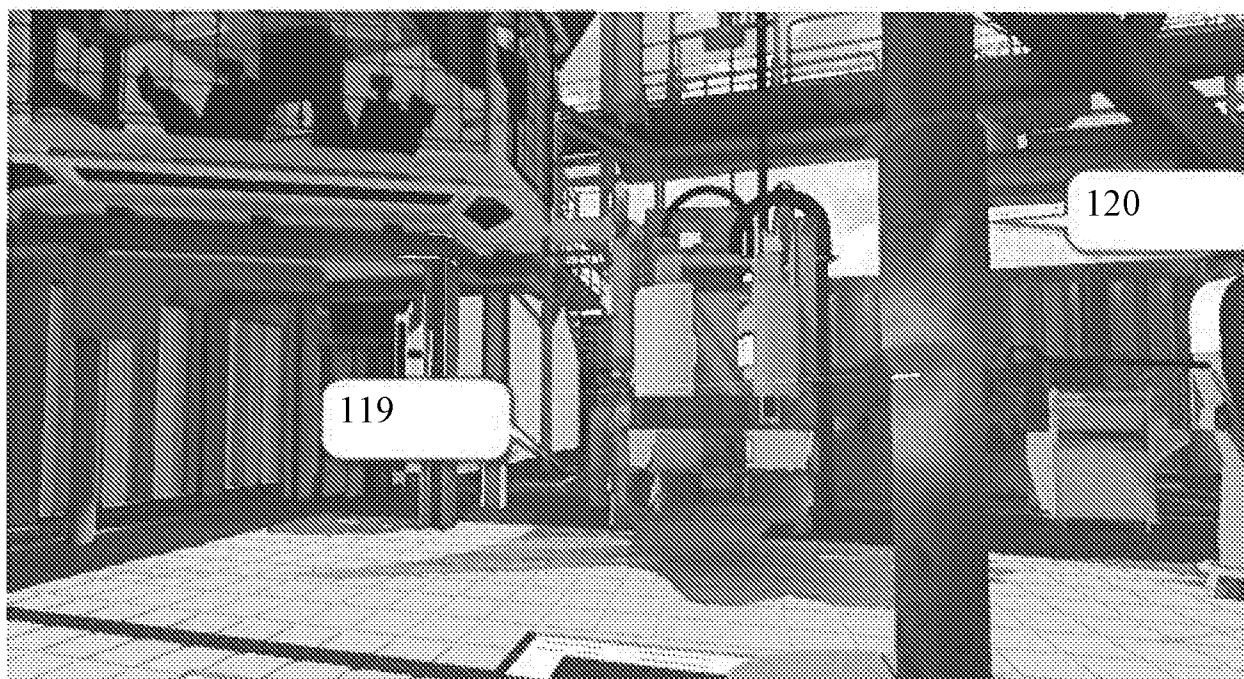


FIGURE 3



FIGURE 4

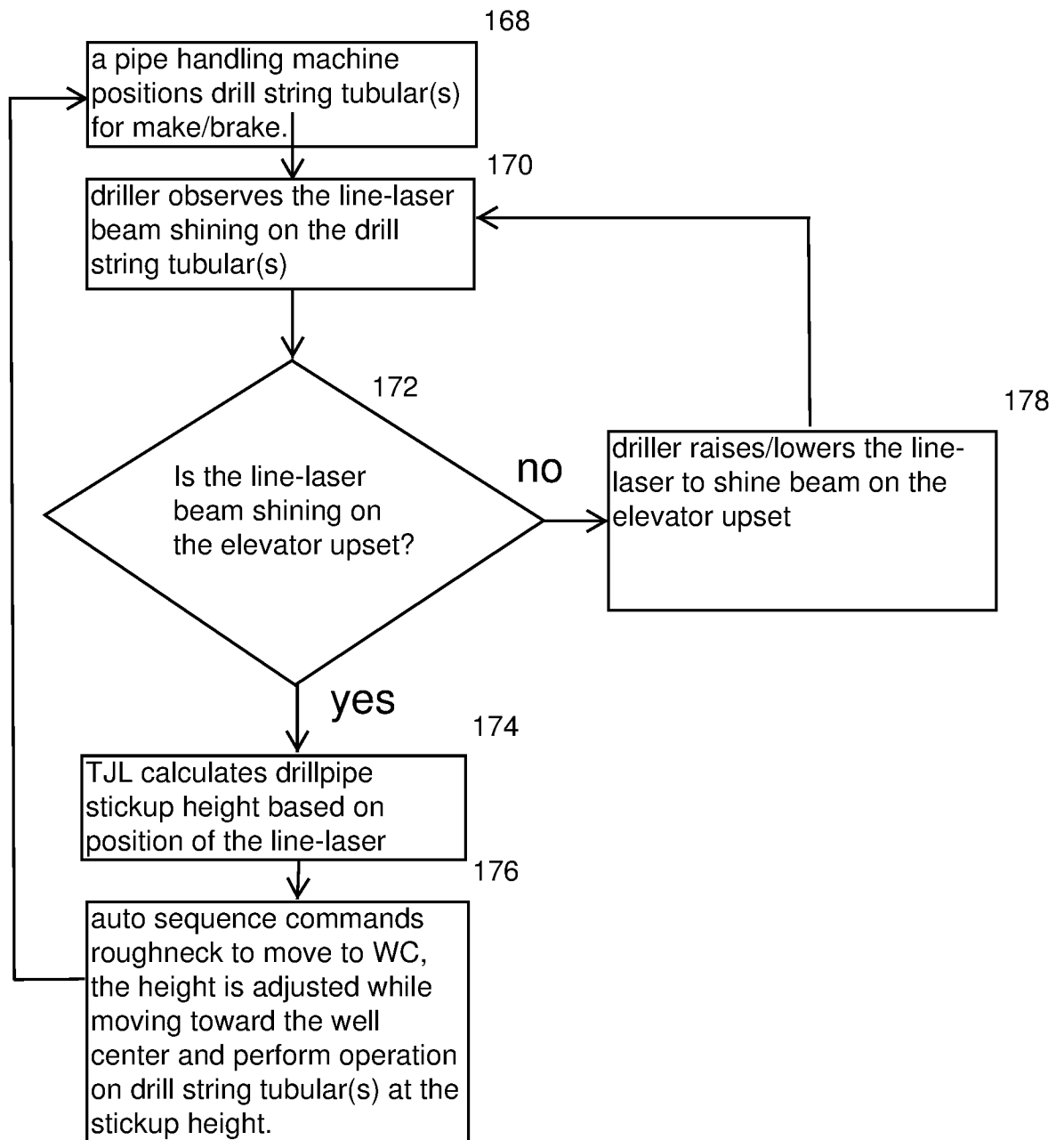


FIGURE 5

A. CLASSIFICATION OF SUBJECT MATTER**E21B 19/16(2006.01)i, E21B 41/00(2006.01)i**

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)

E21B 19/16; B23P 015/26; B25B 11/00; E21B 19/14; E21B 19/24; G06F 17/50; G06K 9/20; E21B 41/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & keywords: tool joint assist system, height indicator, height adjustment input device, mover, computer

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008-0282847 A1 (HALSE, HELGE-RUBEN) 20 November 2008 paragraphs [0019]-[0026] and figures 1-3	1,3,6-8,10-11
Y		2,4-5,9
Y	WO 2019-013644 A1 (PIPE PILOT AS.) 17 January 2019 page 13 and figure 4a	2,4-5,9
A	US 2017-0306710 A1 (NATIONAL OILWELL VARCO NORWAY AS.) 26 October 2017 paragraph [0073]	1-11
A	US 2005-0050726 A1 (MARK WILSON ANDERSON et al.) 10 March 2005 figure 1	1-11
A	US 2013-0275100 A1 (CANRIG DRILLING TECHNOLOGY LTD.) 17 October 2013 figure 2	1-11



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

19 June 2020 (19.06.2020)

Date of mailing of the international search report

19 June 2020 (19.06.2020)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

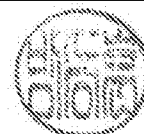


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