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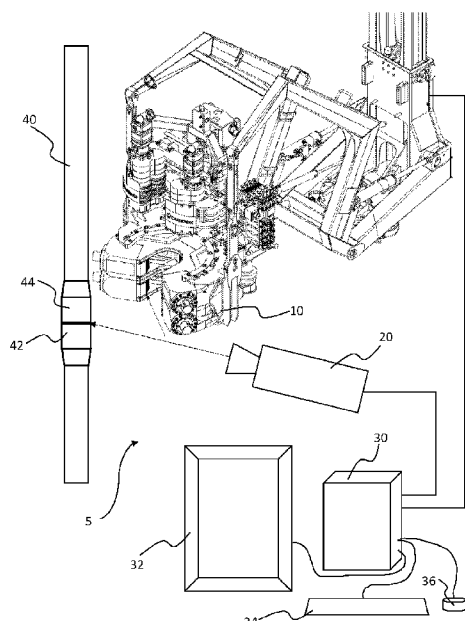


FIGURE 1

(57) Abstract: A tool joint assist system for making and breaking pipe joints of tubulars in a drill string relative to a drilling rig, the tool joint assist system comprising: a roughneck with upper and lower tongs; a camera positioned relative to the roughneck to be capable of capturing an image of tubular and the roughneck; a computer comprising a processor, a non-transitory storage medium, a display, a transmitter/receiver, and a set of computer readable instructions stored in the non-transitory storage medium and when executed by the processor: (i) present a captured image of the tubular, roughneck and an indicator of a proposed height of the roughneck relative to the tubular; receive an instruction from an operator to adjust the indicated proposed height relative to the tubular in the captured image; and (ii) command the roughneck to move to the adjusted height.

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## OPTICAL TOOL JOINT ASSIST FOR IRON ROUGHNECK

### CROSS REFERENCE PARAGRAPH

[1] This application claims the benefit of U.S. Nonprovisional Application No. 16/193,295, entitled "OPTICAL TOOL JOINT ASSIST FOR IRON ROUGHNECK," filed November 16, 2018, the disclosure of which is hereby incorporated herein by reference.

### TECHNICAL FIELD

[2] The present disclosure relates to pipe handling and drilling operations for hydrocarbons and other formation fluids and gases. In particular, the invention relates to a system and method for determining the position of an iron roughneck relative to a pipe joint.

### BACKGROUND ART

[3] 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.

- [4] 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.
- [5] Current systems use optical cameras to obtain data regarding the position of the pipe joint relative to an iron roughneck. Typically, these system use a computer to process camera images of the pipe joint and control the position of the iron roughneck relative to the pipe joint.
- [6] 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.
- [7] 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.

[8] 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.

[9] 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 covered in dirt, soil, and minerals. When automated camera systems 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.

[10] While prior automated systems position the iron roughneck relative to the pipe joint based on image data, they do not provide a visual check to the drilling operator for visual confirmation the position is correct. In view of prior systems, there is a need for a pipe joint control system that provides a remote visual check of the iron roughneck during make-up and break-out operations.

#### SUMMARY OF INVENTION

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

- [12] 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 roughneck with upper and lower tongs; a camera positioned relative to the roughneck to be capable of capturing an image of tubular and the roughneck; a computer comprising a processor, a non-transitory storage medium, a display, a transmitter/receiver, and a set of computer readable instructions stored in the non-transitory storage medium and when executed by the processor: (i) present a captured image of the tubular, roughneck and an indicator of a proposed height of the roughneck relative to the tubular; receive an instruction from an operator to adjust the indicated proposed height relative to the tubular in the captured image; and (ii) command the roughneck to move to the adjusted height.
- [13] 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: capturing an image of a tubular and a roughneck; presenting the captured image on a display to a drilling rig operator; presenting, in the captured image, an indicator of a proposed height of the roughneck relative to the tubular; and receiving an acknowledgment from the drilling rig operator that the proposed height of the roughneck is approved.
- [14] 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 camera positioned relative to the pipe handling device to be capable of capturing an image of a tubular being handled by the pipe handling device; a computer comprising a processor, a non-transitory storage medium, a display, a transmitter/receiver, and a set of computer readable instructions stored in the non-transitory storage medium and when executed by the processor: capture an image of a tubular; present the captured image on a display to a drilling rig operator; present, in the captured image, an indicator of a proposed height of the pipe handling device; and receive an acknowledgment from the drilling rig operator that the proposed height of the pipe handling device is approved.

### BRIEF DESCRIPTION OF DRAWINGS

- [15] 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.
- [16] FIG. 1 is a schematic illustration of a tool joint assist system having a roughneck, a camera and a computer for making and breaking pipe joints of tubulars in a drill string relative to a drilling rig.
- [17] FIG. 2 is an example of a graphical user interface via a display presenting an image captured by the camera of FIG 1, wherein a pipe joint is shown in the image.
- [18] FIG. 3 is an example of a graphical user interface via a display presenting a real-time video stream via the camera of FIG 1 of a pipe joint and a “red line” indicator of a proposed height of the roughneck.
- [19] FIG. 4 is a flow chart of an algorithm for making and breaking pipe joints of tubulars in a drill string relative to a drilling rig.
- [20] 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.
- [21] 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

- [1] Preferred embodiments are best understood by reference to FIGS. 1-4 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.
- [22] FIG. 1 is a perspective view a tool joint assist system 5 of the invention wherein an iron roughneck 10 is positioned adjacent a drill string 40 and a camera 20 is positioned to capture an image of the drill string 40. A computer 30 comprises a display 32, a key board 34 and a

mouse 36. The computer 30 receives a signal feed from the camera 20, wherein the signal feed comprise an image of the drill string 40 above the drilling rig floor. The computer 30 also provides a command signal to the iron roughneck 10 to raise/lower the iron roughneck relative to the drill string 40.

[23] FIG. 2 shows a graphic user interface GUI 50 of the tool joint assist system 5, which may be illuminated on the display 32 of the computer 30. The GUI 50 comprises a video image 52 of the scene at the drill rig floor where the drill string 40 and the iron roughneck 10 are located. The GUI 50 provides icon and navigation buttons that allow the user to navigate and control the system. In particular, the GUI 50 allows the user to zoom in/out of the image 52 and change the configuration of the image 52. Such control may be done by controlling the camera 20 or it may be done by simply modifying the way the image 52 is displayed in the GUI 50.

[24] FIG. 3 shows a graphic user interface GUI 50 of the tool joint assist system 5 with a video image 52 of the scene at the drill rig floor where the drill string 40 and the iron roughneck 10 are located. The tool joint assist system 5 may use a high resolution camera 20, or a plurality of cameras, to capture images of target drill string 40. The capturing of images may be triggered by the computer 30 when the roughneck 10 is ready to make up/break out pipe connections/joints. These images may be presented to the operator with “a red line” 54 representing the current height configuration for the roughneck 10. The operator can easily adjust the height setting up or down, using the operator mouse 36, or any other interface device such as a joystick known to persons of skill, before the correct stickup height is confirmed. The operator adjustment may dynamically adjust the height indicator in the presented image as the iron roughneck 10 is repositioned vertically relative to the drill string 40. The tool joint assist system 5 helps the operator to set a correct stick-up height for the roughneck 10. The tool joint assist system 5 is especially helpful where the operator cannot see directly from the control chair the opening of the roughneck thongs, either due to other machines blocking the view or the physical placement of the roughneck 10 on the drill floor. The image which the operator sees is a clear picture of the pipe, with no machine obstructing the view. The tool joint assist system 5 may offer a graphical view of the drill string and a presentation of the stick-up height integrated in the overall control system, which is controllable from the operator chair. The tool

joint assist system 5 enables fast operation and precise stick-up height adjustment of the iron roughneck 10.

- [25] The tool joint assist system 5 may comprise one or more digital cameras located either in safe area (DCR) or in ATEX approved camera housings on the drill floor. A computer based system interfaces the cameras, and use vision software to evaluate the images and assist the operator set correct stick-up or tool joint height. The tool joint assist system 5 may enable the drill rig control system to assist the operator to adjust the stick-up or tool joint height, in order to position the iron roughneck 10 at the correct height during auto cycle operation. With the camera based system, the need for a direct visual check of the stick-up height positioning by personnel on the drill floor is highly reduced and in most cases eliminated. The tool joint assist system 5 may therefore assist the operator in efficient and safe make-up and break-out operations.
- [26] The tool joint assist system 5 may provide: high quality images from camera(s); integration to the overall drill rig control system; precise height adjustment of the roughneck relative to the drill string; no mechanical wear; fast and efficient auto cycle operation of the iron roughneck; a tool joint finder computer interfacing with the roughneck control system; easy configuration and storage of pre-defined pipe profiles. The tool joint assist system 5 may provide safety enhancements such as: a reduced need for personnel on drill floor; and a confirmation of stick-up height before the roughneck obstructs a direct view by the operator.
- [27] The tool joint assist system 5 may accommodate drilling tubular pipe diameters Ø89 to Ø254 mm SI (3½" to 10" Imperial (US)). The working area range may be about 600 mm ± 300 mm of camera height SI (23" ± 11½" Imperial (US)). The design temperature minimum/maximum, which may only be relevant for ATEX housing, may be -20°C to +40°C SI (-4°F to +104°F Imperial (US)). The system may be classified suitable for ATEX Zone 1.
- [28] According to a further embodiment of the invention, there is provided a method for make-up and break-out drill pipe joints. A sequence of steps for the method, includes: (1) the roughneck is in an idle condition; (2) the operator confirms sequence start; (3) the tool joint assist system captures an image of the stick-up / tool joint and proposes a height setting for the roughneck; (4) the operator adjusts the height setting for the roughneck to match the detected

stick-up / tool joint height; and (5) the tool joint assist system commands the roughneck to move to the adjusted height setting prior to clamping onto the drill string.

- [29] FIG. 4 illustrates a flow chart for a process algorithm for an embodiment of the invention. The process begins with the roughneck being positioned 62 in an idle condition. In particular, the roughneck is parked away from the well center to clear the way for pipe handling operation. For example, if pipe is being tripped into the wellbore, the drill string is lowered until a portion of the drill string extends above the drill floor to a stick-up height, and a new section of pipe tubular may be positioned directly over the drill string to be made-up thereto. In another example, if pipe is being tripped out of the wellbore, the drill string is raised until a pipe joint is positioned above the drill floor within a working range of the roughneck, to break-out an upper section from the drill string. In either case, the operator confirms 64 a start of the roughneck auto sequence. For tripping in, it is a make-up auto sequence, and for tripping out, it is a break-out auto sequence. The auto sequence then positions 66 the roughneck at a proposed height by using sensors, camera(s), etc., to identify the stick-up height or the height of the tool joint. Positioning by the auto sequence may be accomplished by any known system or method, such as those disclosed in US 9,464,492; US 9,657,539; and WO 2016/106294, the entire disclosures of which are incorporated herein by reference. The tool joint assist system then captures 68 an image of the stick-up or tool joint and the roughneck. The tool joint assist system then presents 70 a graphic user interface GUI to the operator so the operator may view the captured image and an indicator of the proposed roughneck height with reference to the stick-up or tool joint. The operator may then determine 72 whether the proposed height is the same as the actual stick-up height or height of the tool joint shown in the image. If the heights are not the same (NO), then the operator adjusts 78 the proposed height setting to align with the top of the stick-up or the seam of the tool joint in the captured image. The tool joint assist system then commands 80 the roughneck to move to the adjusted height position. Algorithm steps 68 and 70 are then repeated and the operator again determines 72 whether the adjusted height is the same as the actual stick-up height or height of the tool joint shown in the image. If the heights are the same (YES), then the operator confirms 74 continuation of the roughneck auto sequence. The auto sequence then commands 76 the roughneck to perform the operation

(make-up or break-up) on the drill string. Finally, the auto sequence then commands 62 the roughneck to return to a position for an idle condition.

[30] Returning again to FIG. 1, display 32 may comprise any type of display device for displaying information related to the GUI, such as for example, an LCD screen ( e.g., thin film transistor (TFT) LCD or super twisted nematic (STN) LCD), an organic light-emitting diode (OLED) display, or any other suitable type of display. In some embodiments, display 32 may be an interactive display (e.g., a touch screen) that allows a user to interact with the GUI. In other embodiments, display 32 may be strictly a display device, such that all user input is received via other input/output devices.

[31] A keyboard and mouse are illustrated in FIG. 1. However, input/output devices may include any suitable interfaces allowing a user to interact with the GUI. For example, input/output devices may include a touch screen, physical buttons, joystick, sliders, switches, data ports, keyboard, mouse, voice activated interfaces, or any other suitable devices.

[32] The processor may include a microprocessor, a microcontroller, a digital signal processor (DSP), an application specific integrated controller (ASIC), electrically-programmable read-only memory (EPROM), or a field-programmable gate array (FPGA), or any other suitable processor(s), and may be generally operable to execute instructions for the GUI, as well as providing any other functions of the system. Memory may comprise any one or more devices suitable for storing electronic data, e.g., RAM, DRAM, ROM, internal flash memory, external flash memory cards ( e.g., Multi Media Card (MMC), Reduced-Size MMC (RS-MMC), Secure Digital (SD), MiniSD, MicroSD, Compact Flash, Ultra Compact Flash, Sony Memory Stick, etc.), SIM memory, and/or any other type of volatile or non-volatile memory or storage device. The computer code instructions for the system may comprise application software, firmware, and/or any other type of computer-readable instructions and/or any related, required, or useful applications, plug-ins, readers, viewers, updates, patches, or other code for executing the application may be downloaded via the Internet or installed in any other known manner.

[33] The systems and methods disclosed herein may be used for making and breaking pipe joints of tubulars in a drill string relative to a drilling rig. They may also be used during pipe handling operations while racking stands of tubular sections. Certain drilling rigs are capable of building

stands of pipe during tripping or drilling operations. Likewise, certain drilling rigs are capable of disassembling stands of pipe during tripping or drilling operations. The systems and methods of the present invention may be applied to any situation in which a roughneck is made to engage a pipe joint for make-up or break-out operations.

[34] Further, the present invention may be applied to other pipe handling operations, such as when a top drive is used to join sections of tubular pipe to a drill string. The auto sequence of the top drive may be used to lower a section of tubular pipe to a drill string suspended by a spider in the drill floor. However, because sections of tubular pipe vary in length and the stick-up height of the suspended drill string varies, the auto sequence may not lower the section of tubular pipe to a proper height for engagement of the tubulars. The systems and methods of the present invention may be used to present the drilling operator an image of the tubulars and an indicator of the proposed height of the lower pin end of the section of tubular pipe. The drilling operator may then adjust the indicator of the height of the lower pin end, so that the top drive may be commanded to position the height of the lower pin end at the adjusted height. The auto sequence may then be commenced to thread the tubulars via the top drive.

[35] 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.

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

[37] 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.

[38] 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

[2] Tool joint assist systems for drilling rigs 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:

- Claim 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 roughneck with upper and lower tongs;
  - a camera positioned relative to the roughneck to be capable of capturing an image of tubular and the roughneck;
  - a computer comprising a processor, a non-transitory storage medium, a display, a transmitter/receiver, and a set of computer readable instructions stored in the non-transitory storage medium and when executed by the processor: (i) present a captured image of the tubular, roughneck and an indicator of a proposed height of the roughneck relative to the tubular; receive an instruction from an operator to adjust the indicated proposed height relative to the tubular in the captured image; and (ii) command the roughneck to move to the adjusted height.
- Claim 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 camera comprises a digital camera capable of capturing digital images of tubular and the roughneck in real time.
- Claim 3. 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 set of computer readable instructions when executed by the processor further present a graphic user interface via the display, wherein the graphic user interface is capable of presenting a captured image of the tubular, roughneck and an indicator of a proposed height of the roughneck relative to the tubular, wherein the graphic user interface is capable of receiving an instruction from an operator to adjust the indicated proposed height relative to the tubular in the captured image.
- Claim 4. 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 set of computer readable

instructions when executed by the processor further adjust, in the presented image, a position of the indicator of the proposed height of the roughneck relative to the tubular.

Claim 5. 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 set of computer readable instructions when executed by the processor further adjusts the position of the indicator in response to a received instruction from an operator to adjust the indicated proposed height relative to the tubular in the captured image.

Claim 6. 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 set of computer readable instructions further comprises a roughneck auto sequence for commanding the roughneck to perform a make-up or break-out operation.

Claim 7. 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:  
capturing an image of a tubular and a roughneck;  
presenting the captured image on a display to a drilling rig operator;  
presenting, in the captured image, an indicator of a proposed height of the roughneck relative to the tubular; and  
receiving an acknowledgment from the drilling rig operator that the proposed height of the roughneck is approved.

Claim 8. 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 7, wherein the capturing an image comprises capturing a real-time video stream.

Claim 9. 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 7, wherein presenting the captured image and

the indicator of a proposed height comprises presenting a graphic user interface via the display, and wherein receiving an acknowledgment from the drilling rig operator comprises receiving the acknowledgment through the graphic user interface.

Claim 10. 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 7, further comprising: receiving an instruction from the drilling rig operator to adjust the indicated proposed height relative to the tubular in the captured image.

Claim 11. 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 10, further comprising: adjusting the position of the indicator in the image in response to a received instruction from the drilling rig operator to adjust the indicated proposed height relative to the tubular.

Claim 12. 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 11, further comprising: commanding the roughneck to move to the height of adjusted position of the indicator in the image.

Claim 13. 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 11, further comprising: instructing the roughneck to execute a roughneck auto sequence for a make-up or break-out operation.

Claim 14. 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 camera positioned relative to the pipe handling device to be capable of capturing an image of a tubular being handled by the pipe handling device;  
a computer comprising a processor, a non-transitory storage medium, a display, a transmitter/receiver, and a set of computer readable instructions stored in the non-

transitory storage medium and when executed by the processor:

- capture an image of a tubular;
- present the captured image on a display to a drilling rig operator;
- present, in the captured image, an indicator of a proposed height of the pipe handling device; and
- receive an acknowledgment from the drilling rig operator that the proposed height of the pipe handling device is approved.

Claim 15. The tool joint assist system for joining tubulars in a drill string relative to a drilling rig as claimed in claim 14, wherein the set of computer readable instructions when executed by the processor further: capture a real-time video stream.

Claim 16. The tool joint assist system for joining tubulars in a drill string relative to a drilling rig as claimed in claim 14, wherein the set of computer readable instructions when executed by the processor further: present a graphic user interface via the display, and receive the acknowledgment from the drilling rig operator through the graphic user interface.

Claim 17. The tool joint assist system for joining tubulars in a drill string relative to a drilling rig as claimed in claim 14, wherein the set of computer readable instructions when executed by the processor further: receive an instruction from the drilling rig operator to adjust the indicated proposed height in the captured image.

Claim 18. The tool joint assist system for joining tubulars in a drill string relative to a drilling rig as claimed in claim 14, wherein the set of computer readable instructions when executed by the processor further: adjust the position of the indicator in the image in response to a received instruction from the drilling rig operator to adjust the indicated proposed height.

Claim 19. The tool joint assist system for joining tubulars in a drill string relative to a drilling rig as claimed in claim 14, wherein the set of computer readable instructions when executed

by the processor further: command the pipe handling device to move to the height of adjusted position of the indicator in the image.

Claim 20. The tool joint assist system for joining tubulars in a drill string relative to a drilling rig as claimed in claim 14, wherein the set of computer readable instructions when executed by the processor further: instructs the pipe handling device to execute an auto sequence for a make-up or break-out operation.

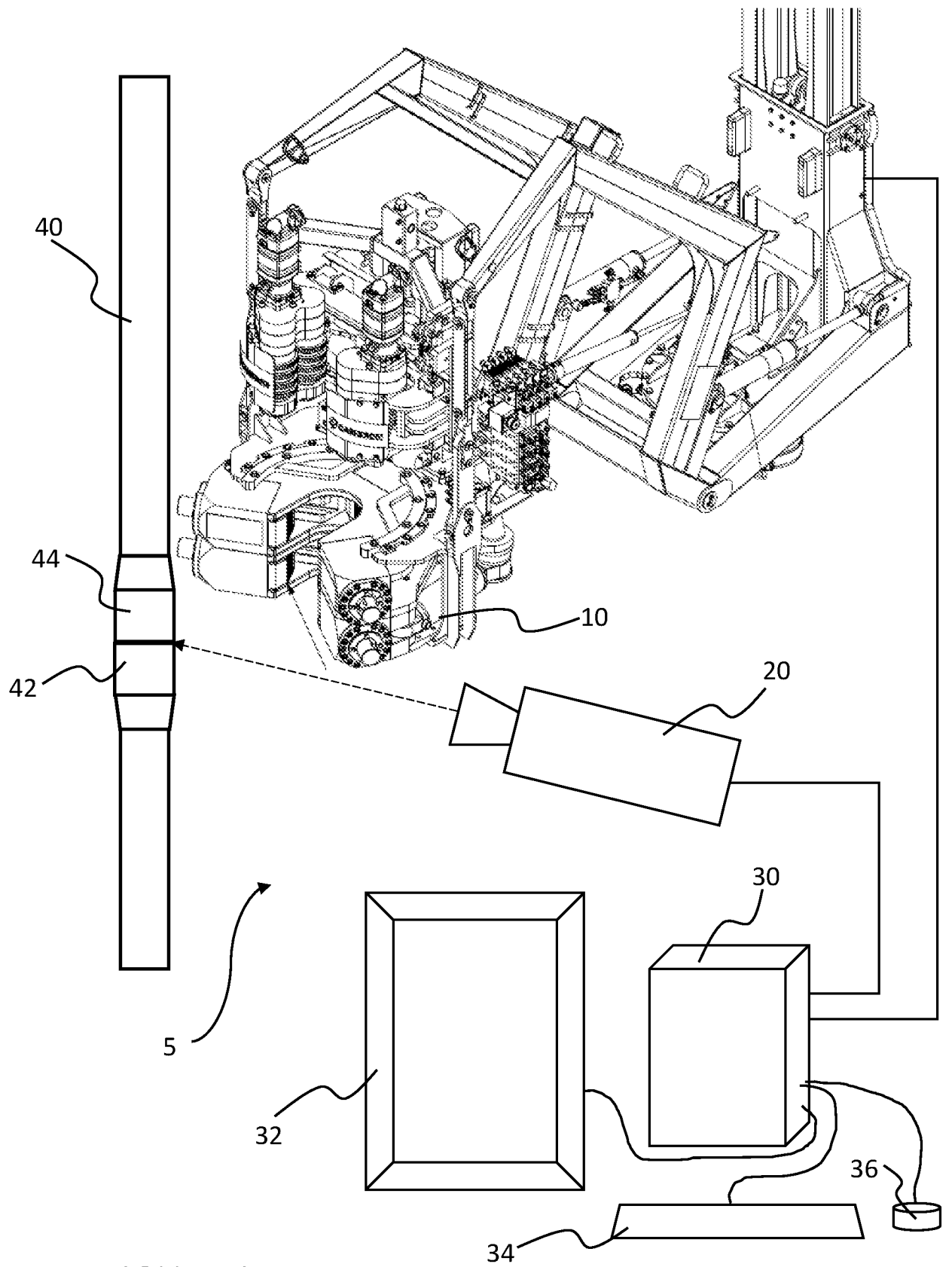


FIGURE 1

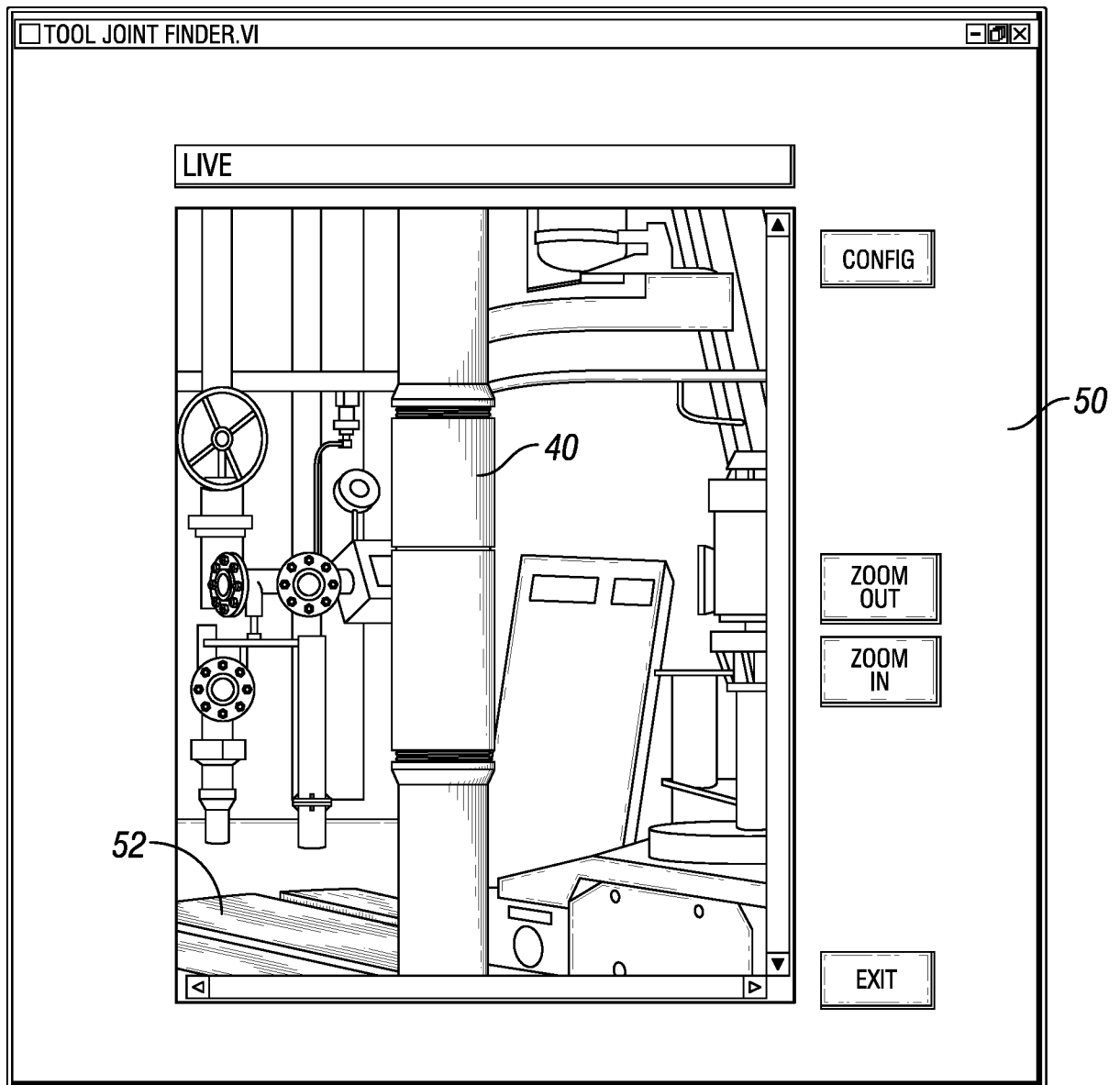


Figure. 2

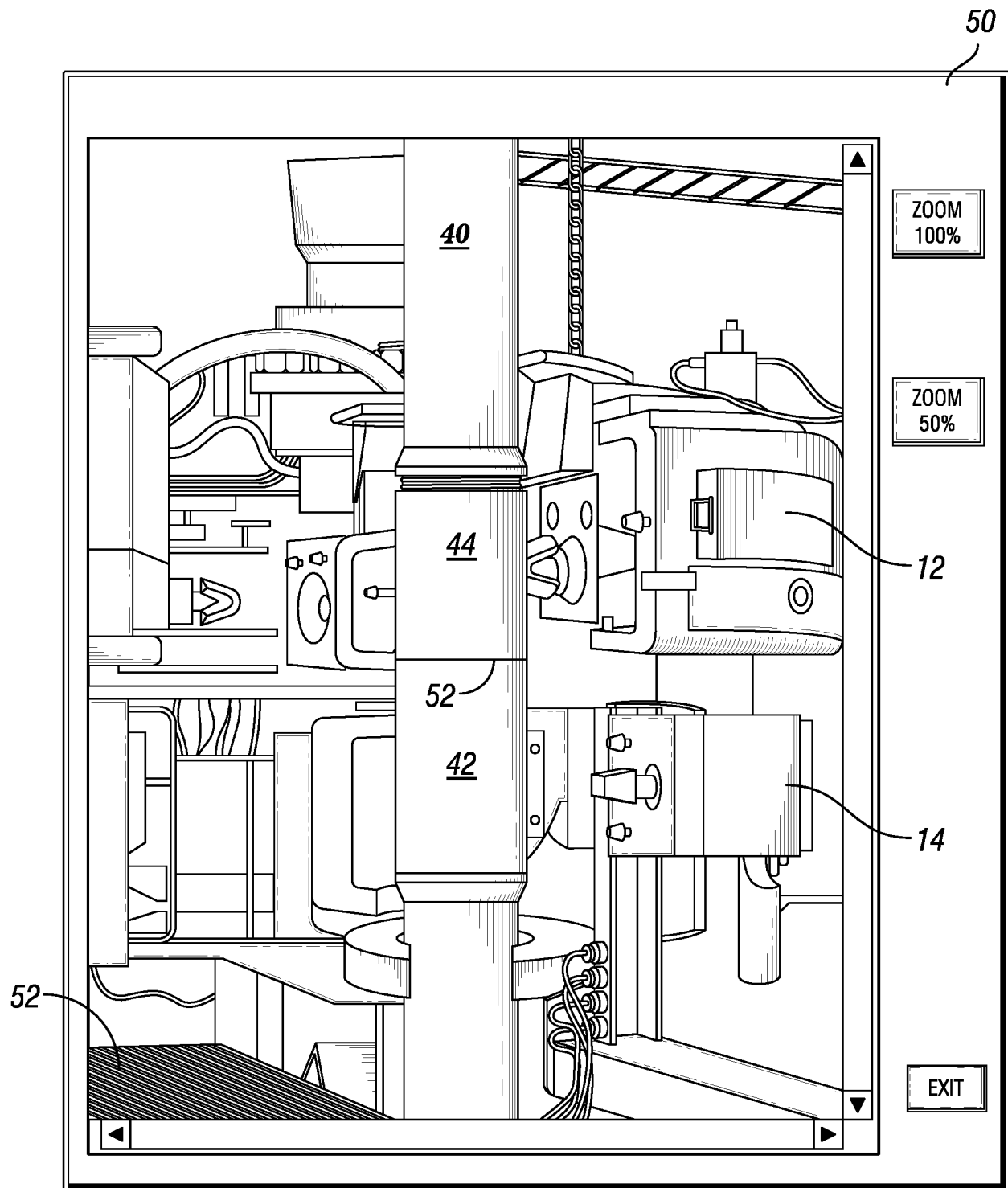


Figure. 3

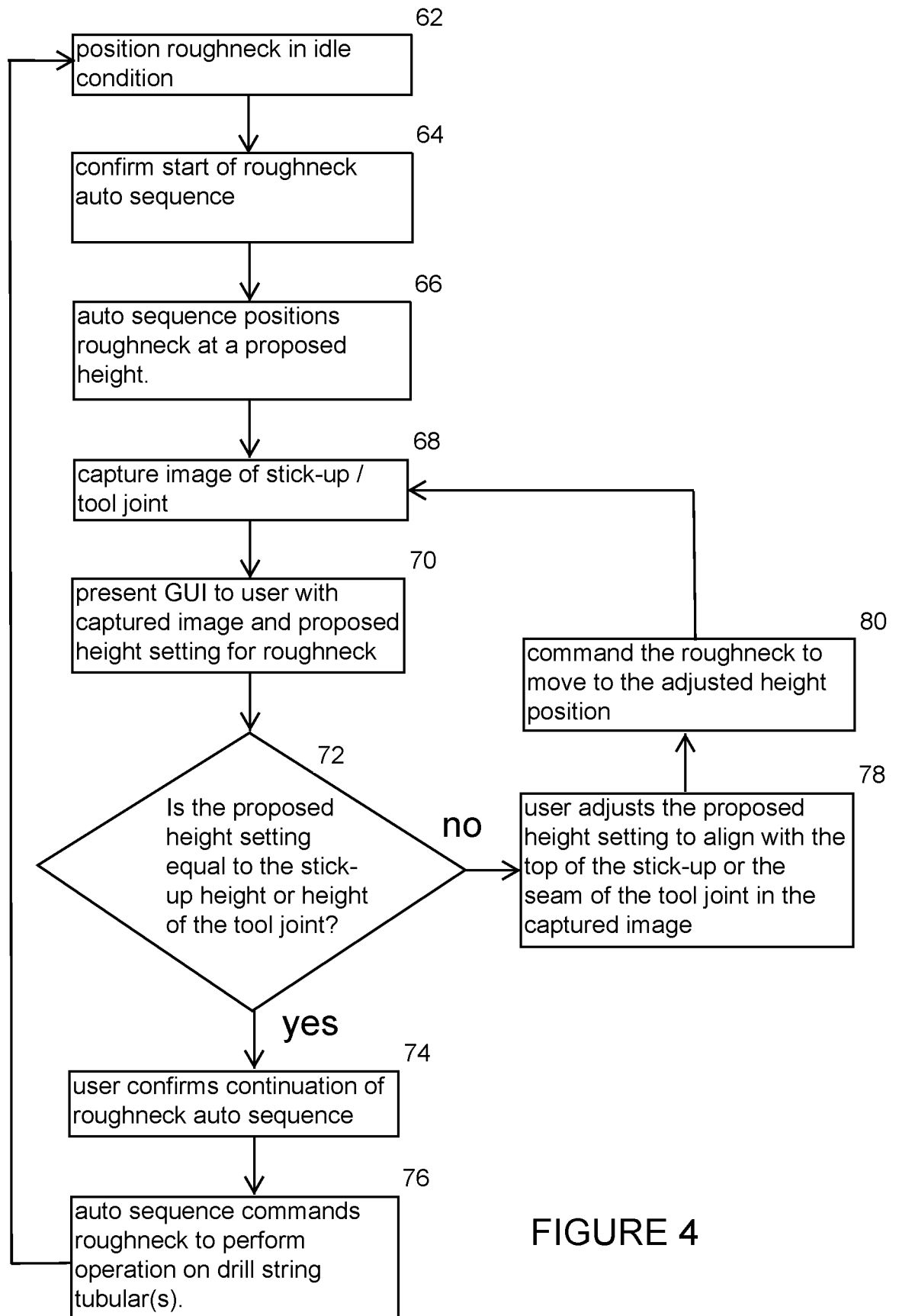


FIGURE 4

**A. CLASSIFICATION OF SUBJECT MATTER****E21B 19/16(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; E21B 19/14; E21B 41/00; E21B 44/00; E21B 7/20; H04N 13/02

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) &amp; keywords: tool joint assist system, drilling string, roughneck, camera, computer, indicator, proposed height

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                     | Relevant to claim No. |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| X         | WO 2017-218439 A1 (SCHLUMBERGER TECHNOLOGY CORPORATION et al.)<br>21 December 2017<br>paragraphs [0002], [0035]–[0044] and figures 3–7 | 1–20                  |
| A         | US 2013-0345878 A1 (AUSTEFJORD et al.) 26 December 2013<br>paragraphs [0047]–[0049] and figure 1                                       | 1–20                  |
| A         | WO 2017-210033 A1 (SCHLUMBERGER TECHNOLOGY CORPORATION et al.)<br>07 December 2017<br>figure 3                                         | 1–20                  |
| A         | US 2009-0159294 A1 (ABDOLLAHI et al.) 25 June 2009<br>paragraphs [0070]–[0073] and figures 8–9                                         | 1–20                  |
| A         | US 2013-0271576 A1 (CANRIG DRILLING TECHNOLOGY LTD.) 17 October 2013<br>paragraph [0016] and figure 2                                  | 1–20                  |



Further documents are listed in the continuation of Box C.



See patent family annex.

\* Special categories of cited documents:

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"E" earlier application or patent but published on or after the international filing date

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"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

"&amp;" document member of the same patent family

Date of the actual completion of the international search

04 March 2020 (04.03.2020)

Date of mailing of the international search report

**05 March 2020 (05.03.2020)**

Name and mailing address of the ISA/KR

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

**PCT/US2019/060758**

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| US 2013-0345878 A1                        | 26/12/2013          | BR 112012027302 A2<br>BR 112012027302 B1<br>BR 112012027304 A2<br>CA 2796300 A1<br>CA 2796300 C<br>DK 2563706 T3<br>DK 2564014 T3<br>EP 2563706 A2<br>EP 2563706 B1<br>EP 2564014 A2<br>EP 2564014 B1<br>US 2013-0120577 A1<br>US 9303473 B2<br>US 9464492 B2<br>WO 2011-135310 A2<br>WO 2011-135310 A3<br>WO 2011-135311 A2<br>WO 2011-135311 A3<br>WO 2011-135311 A8 | 02/08/2016<br>26/11/2019<br>02/08/2016<br>03/11/2011<br>08/01/2019<br>26/10/2015<br>19/10/2015<br>06/03/2013<br>22/07/2015<br>06/03/2013<br>15/07/2015<br>16/05/2013<br>05/04/2016<br>11/10/2016<br>03/11/2011<br>27/09/2012<br>03/11/2011<br>27/09/2012<br>21/02/2013 |
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