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# (54) LIGHT-WEIGHT SINGLE JOINT MANIPULATOR ARM

LEICHTGEWICHTIGER EINZELGELENK-MANIPULATORARM

BRAS MANIPULATEUR LÉGER DE JOINT UNIQUE

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## Description

### BACKGROUND OF THE INVENTION

#### Field of the Invention

**[0001]** The present invention provides a device and a method for manipulating tubular segments for make up and installation of a tubular string in a well.

#### Description of the Related Art

**[0002]** Tubular strings installed in wells are made up by threadably coupling individual tubular segments at a well site. For example, a string of drill pipe is made from threadably coupling joints of drill pipe to rotate and advance a drill bit downhole. A casing string is made up by threadably coupling casing segments to line a drilled borehole to prevent collapse and to facilitate cementing. A production string is made up and run through casing strings to provide a conduit from the formation to the surface for producing oil or gas.

**[0003]** Valuable rig time is consumed in retrieving, positioning and threadably coupling segments of pipe into a string. Since hundreds of segments may be made up and run into a borehole, saving just seconds per connection results in a substantial savings in rig time.

**[0004]** The amount of time required to engage and rotate the pipe segment and make up the threaded connection to the pipe string is only a portion of the rig time consumed in making a connection. The time consumed in obtaining and positioning each add-on segment atop the string for make up is determined in part by the efficiency of tools used to retrieve and manipulate the segment.

**[0005]** Tools are available for manipulating and positioning segments for make up into a string. Existing tools typically consist of a single joint elevator suspended by a rope slung beneath a main string elevator. Suspending the single joint elevator by a rope imposes many limitations on the efficiency of the process of adding pipe segments to the pipe string. These existing systems require rig personnel to swing or carry the single joint elevator to the receiving door and place it onto the pipe segment to be added onto the string. Also, once the pipe segment is coupled to the rope and hoisted above the rig floor, the pipe segment will generally not hang vertical due to the force of gravity, and it is difficult and awkward to maneuver the pipe segment into a vertical position atop the pipe string suspended in the borehole. Finally, once the pipe segment is threadably coupled to the pipe string in the borehole, the single joint elevator must be removed from the path of the string elevator or top drive, and rig personnel are required to carry the elevator back to the receiving door or other location on the rig floor.

**[0006]** An improved method and apparatus are needed for manipulating segments to be made up into a pipe string. The method and apparatus would preferably provide more precise, safe and efficient manipulation of segments and save time in making up the string. The apparatus would preferably be light-weight, so that it can be easily removed from the path of the string elevator or top drive, but sufficiently robust to support and manipulate tubular segments.

**[0007]** GB2340858A discloses an apparatus for facilitating the connection of tubulars using a top drive. The apparatus comprises an elevator provided on bails which are hanged from the top drive. A pair of piston and cylinders are arranged between the bails and the top drive for moving the elevator from below the top drive to an out of the way position. This document is considered the closest prior art and corresponds to the preamble of claim 1.

**[0008]** US 2005/098352 A1 discloses a pipe handling device for use with a top drive. The device comprises a link arm having a first end pivotally connectable to move with the top drive and an outboard end pivotally connectable to a pipe elevator segment, and a drive system to drive the outboard end of the link arm at least between a lower position and a raised position.

**[0009]** US 4,489,794 discloses an apparatus having an elevator supported by elevator links which are hanged from a derrick. The apparatus further comprises a power actuated means for swinging the lower ends of the elevator links laterally so as to shift the suspended elevator to a side of the well axis.

**[0010]** US 2004/216924 A1 discloses an apparatus having a clamping head for engagement with a tubular. The clamping head is mounted on a pair of mechanical bails which are hanged from the top drive. A pair of pistons and cylinders are arranged between the bails and the top drive to swing the bails. Upon swinging the bails, the clamping head also swings to the side of the connection location so as to align with a tubular that is to be added to the string.

### SUMMARY OF THE PRESENT INVENTION

**[0011]** In accordance with an aspect of the present invention there is provided an apparatus for manipulating tubular segments for being made up into a tubular string, the apparatus having the features of claim 1 below.

**[0012]** One embodiment of the present invention comprises a single joint manipulator arm having a swing arm supporting a single joint elevator for securing a pipe segment to the swing arm. The swing arm is a strong and generally light-weight arm positionable with one or more cylinders or other actuators for rotatably aligning the segment with the string. In a first embodiment, the present invention provides a single joint manipulator arm that is pivotably securable to one or more bails that support a string elevator for lifting and lowering the pipe string into the borehole after each joint or stand of new pipe is threadably coupled into the string. The present invention provides a light-weight single joint manipulator arm that is easily and efficiently removed from the path of the string

elevator or spider elevator. In a second embodiment, the present invention provides a single joint manipulator arm that is pivotably securable to a sub threadably coupled to a top drive shaft or quill. In this embodiment, the manipulator arm is pivotably secured to the sub above other components, such as a fill-up and circulation tool, or it is pivotably secured to a sub positioned below a top drive shaft and above a casing running tool.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0013]** Fig. **1** is a side elevation view of one embodiment of a single joint manipulator arm of the present invention in its aligned position and suspended from the bails on a rig.

**[0014]** Fig. **2** is a side elevation view of the single joint manipulator of Fig. **1** in its removed or "luffing" position.

**[0015]** Fig. **3** shows the single joint manipulator arm of Fig. **1** coupled to a casing segment at the staging area.

**[0016]** Fig. **4** shows the single joint manipulator arm of Fig. **1** after the bails and the string elevator are elevated and the single joint manipulator arm and casing segment controllably rotated clockwise from its position shown in Fig. **3.**

**[0017]** Fig. **5** is a side elevation view of the single joint manipulator arm of Fig. **1** after the bails and the string elevator are elevated from the position in Fig. **4,** and the single joint manipulator arm and casing segment controllably rotated further clockwise to suspend the casing segment adjacent to the axis of the well.

**[0018]** Fig. **6** is a side elevation view of the single joint manipulator arm of Fig. **1** after being rotated further clockwise from its adjacent position shown in Fig. **5** to generally suspend the segment in a vertical position aligned with the string in the well.

**[0019]** Fig. **7** is a side elevation view of the single joint manipulator of Fig. **1** illustrating a safety fuse used for preventing tool failure from excessive load being applied.

**[0020]** Fig. **8** is a perspective view of the single joint manipulator arm of Fig. **1** showing a bifurcated pivoting attachment to the bails and powered rotation using a pair of actuators.

**[0021]** Fig. **9** is a perspective view of a modified lower portion of the single joint manipulator arm of the present invention comprising a slew actuator for angular displacement of the stand-offs to position a tubular segment secured within the single joint elevator.

**[0022]** Fig. **10** is a perspective view of an alternative embodiment of the single joint manipulator arm of the present invention pivotably supported by a sub that is threadably coupled to and suspended from a top drive. The sub also supports a casing running tool that is operated by the top drive to releasably engage and support the pipe string and a fill-up and circulation tool.

**[0023]** Fig. **11** is a perspective view of another alternative embodiment of the single joint manipulator arm of the present invention pivotably supported by a sub that is threadably coupled to and suspended from a top drive. The sub supports a fill-up and circulation tool that is aligned with the top drive and positioned to enter the proximal end of a pipe string secured within the string elevator.

**[0024]** Fig. **12** is a high-level method flowchart describing one embodiment of a method of the present invention.

## DETAILED DESCRIPTION OF THE PRESENT INVENTION

**[0025]** The present invention provides an apparatus and method for manipulating casing segments to assemble a casing string in a borehole. A single joint manipulator arm may be used to safely and reliably manipulate casing segments as they are made up into a casing string and installed in a well. The embodiments disclosed below describe the manipulation of casing segments to assemble a casing string using the present invention. It is to be understood, however, that other types of tubular segments, including drill pipe and production tubing, may be similarly manipulated to assemble strings without departing from the scope of the invention. For the reason, the terms "pipe", "tubular" and "casing" are used interchangeably, as are the terms "segment" and "joint."

**[0026]** In one embodiment, an apparatus and method of the present invention are used to assemble and run a casing string. Once assembled, the casing string will include a plurality of casing segments threadedly coupled end-to-end and installed in a well. The rig on which this embodiment may be used includes a hoist movably suspending a pair of bails that, in turn, suspend a string elevator. A swing arm, having a proximal end, and a distal end is pivotally coupled at its proximal end to the bails at a location above the string elevator. The swing arm supports a single joint elevator at its distal end, which may be a hinged-body type elevator or a horseshoe elevator. The pivoting swing arm is angularly positionable relative to the bails using one or more actuators, such as cylinders. Control of the swing arm and the hoist enable the operator to efficiently retrieve a casing segment from a staging area and to move the casing joint into abutting alignment with the string for being threadably coupled into the string.

**[0027]** A segment of large casing to be lifted using the manipulator arm may weigh 2,000 pounds (980 kg). A casing string may weigh 400,000 pounds (181,600 kg). The string elevator is very heavy compared to the single joint manipulator arm, and the moment imposed on the bails by the light-weight single joint manipulator arm and the casing segment do not significantly deflect the string elevator and the heavy bails from the vertical orientation.

**[0028]** Fig. **1** is a side elevation view of one embodiment of a single joint manipulator arm **10** the present invention. A perspective view of this same embodiment is shown in Fig. **8.** A string elevator **12** is secured to a pair of bails **14, 114** at lifting ears **16, 116.** The string elevator **12** is sized and configured for coupling to and supporting a casing string by securing the proximal end of the casing string (not shown in Figs. **1** or **8** - see element

**36** in Figs. **3-6).** The bails **14, 114** are configured for supporting the weight of the string elevator and the casing string, and are coupled at their supported ends to a block suspended by a draw works (not shown).

**[0029]** The single joint manipulator arm **10** of the present invention comprises a swing arm **18** pivotally coupled at swing arm pivots **28b, 128b** to bails **14, 114.** The swing arm **18** includes an upper portion **20** that forms an angle to the swing arm and provides offset clearance around the string elevator **12** when the swing arm **18** is generally vertical (see Fig. **6).** Single joint elevator **22** is supported from stand-off members **52** and **152** pivotally coupled to the distal end **17** of the swing arm **18** for releasably securing and supporting a casing segment (not shown in Figs. **1** and **8** see Figs. **3-6).**

**[0030]** Typically, an internally threaded coupling is used to threadably couple two casing segments end-to-end. This coupling structure provides an external circumferential shoulder that a single joint elevator **22** may engage to support the add-on casing segment. However, it is within the scope of the present invention to use a single joint elevator adapted for securing integral connection segments by clamping along the length of the body of the pipe segment in place of the horseshoe elevator shown in Fig. **1** or the hinged-body type elevator shown in Fig. **9.** The string elevator, horseshoe elevator and hinged-body type elevator shown in the drawings are included in the disclosed embodiment of the present invention for illustration only.

**[0031]** The generally light-weight swing arm **18** of the single joint manipulator arm of the present invention may be extendable, such as by axially telescoping. As shown in Figs. **1** and **8,** the length of the swing arm **18** may be adjustable in length by telescoping an inner beam member **26** from within an outer beam member **24,** then securing the outer and inner beam members **24, 26** by, for example, inserting a pin **28** through a pair of alignable holes **27.** The use of tubular or squared tubular steel may provide a good strength to weight ratio.

**[0032]** The swing arm **18** is controllably rotatable about the pivots **28b, 128b** using an actuator, such as a pair of pneumatic or hydraulic cylinders **21, 121.** The cylinders **21, 121** each comprise a piston (not shown) coupled to selectively extendable and retractable rods **23, 123,** respectively, that are axially positionable with respect to cylinders **21, 121.** The rods **23, 123** in Figs. **1** and **8** are shown in the extended condition to position the swing arm **18** in a substantially vertical position generally parallel to the bails **14, 114.**

**[0033]** Fig. **2** is a side elevation view of the single joint manipulator arm **10** in a substantially horizontal or luffing position. The rods **23** and **123** (the latter not shown in Fig. **2)** are shown retracted into the cylinders **21** and **121** (the latter not shown in Fig. **2)** to position the swing arm **18** generally perpendicular to the bails **14** and **114** (the latter not shown in Fig. **2).** The luffing position illustrated in Fig. **2** serves two purposes. Casing segments are sometimes presented to the rig floor at a receiving door in a substantially horizontal condition. The luffing position shown in Fig. **2,** or a position near horizontal, may be suitable for coupling the elevator **22** supported by the single joint manipulator arm **10** to casing segments presented in this condition. Also, the luffing position removes the single joint manipulator arm **10** and the supported elevator **22** from obstructing the full descent of the string elevator **12** (or, in other embodiments, a casing running tool or a top drive) as it lowers a casing string into the borehole after an add-on casing segment is made up into the casing string.

**[0034]** Receiving doors, or staging areas, on some rigs present add-on pipe segments to the rig floor in a position angled between vertical and horizontal (see Fig. **3).** In use on these rigs, the cylinders **21** and **121** (the latter not shown in Fig. **3)** may be used to position the elevator **22** supported by the single joint manipulator arm **10** to a suitable angled position between vertical and horizontal for coupling to the presented casing joint **30.** When the single joint manipulator arm **10** is moved to the desired initial position, a presented casing segment **30** is secured to the single joint manipulator arm **10** at the presented end **32** by securing the segment in the single joint elevator **22.**

**[0035]** Figs. **3-6** are sequential side elevation views of the single joint manipulator arm **10** of Fig. **1** showing the process of manipulating a casing segment from an initial position in a staging area (Fig. **3)** to an aligned position for rotatably coupling to a casing string in a well (Fig. **6).** To retrieve a casing segment from the staging area of a rig, an actuating member first moves the swing arm outwardly away from vertical to position an end of the swing arm in proximity to a staging area wherein casing joints are presented. Fig. **3** shows one embodiment of the single joint manipulator arm **10** in an initial position for retrieving a casing segment **30** from a rig staging area **35.** The horseshoe elevator **22** is engaged just below a collar **32** of the presented casing segment **30.** Once the segment is secured to the swing arm **18,** the hoist raises the bails **14, 114** (the latter not shown in Fig. **3)** the swing arm **18** and the casing segment **30.** As the casing segment **30** is raised, it slides along ramp **37,** and the swing arm **18** controllably rotates in the clockwise direction against the damping force of cylinders **21** and **121** (the latter not shown in Fig. **3).** This clockwise rotation of the swing arm **18** against the damping force controllably moves the casing segment **30** in the direction of the casing string **34** (see Fig. **6).** A damping member, such as a hydraulic, pneumatic or inert gas-charged cylinder, is used to dampen and control movement of the swing arm as it rotates from the initial position the equilibrium position. The damping member provides controlled and manageable movement in manipulating the casing segment.

**[0036]** Fig. **4** is a side elevation view of the single joint manipulator arm **10** of Fig. **3** showing the bails **14** and **114** (the latter not shown in Fig. **3)** elevated from their initial position shown in Fig. **3,** and the single joint manipulator arm **10** rotated further clockwise against the

damping force of the cylinders. The casing segment **30** in Fig. **4** is shown substantially raised along ramp **37** from its initial position shown in Fig. **3.** As the bails **14** and **114** (the latter not shown in Fig. **3)** raise the single joint manipulator arm **10** and the casing segment **30** along ramp **37** in staging area **35,** the weight of the casing segment **30** increasingly urges the swing arm **18** to rotate clockwise. The cylinders **21** and **121** (the latter not shown in Fig. **4)** dampens the rate of clockwise swing of the swing arm **18,** and the damping action provided by cylinders **21** and **121** will prevent rapid or uncontrolled swing of the casing segment **30** across the rig floor after the casing segment **30** clears the ramp **37.**

**[0037]** Fig. **5** is a side elevation view of the single joint manipulator arm **10** of Figs. **3** and **4** showing the bails **14** and **114** (the latter not shown in Fig. **5)** raised from the position shown in Fig. **4** and the swing arm **18** rotated further clockwise from its position shown in Fig. **4.** The casing segment **30** shown in Fig. **5** hangs from single joint elevator **22** substantially vertically in an equilibrium position, but it is not aligned with the casing string **34** in the well supported by the spider **36** because of the offset provided by the angled portion **20** at the top of the swing arm **18.** As shown in Fig. **5,** this equilibrium position is not aligned with the casing string **34,** and the casing segment **30** hangs offset from alignment with the top connection with the casing string **34.** The casing segment **30** hangs slightly suspended from the single joint elevator **22** like a pendulum, and the single joint elevator **22** imparts generally negligible torque on the casing segment **30.** The equilibrium position of the swing arm **18** shown in Fig. **5** and the amount of offset is determined by the dimensions and weights of both the single joint manipulator arm **10** and the casing segment **30** when cylinders **21** and **121** (the latter not shown in Fig. **5)** are inactive. Since the casing segment **30** is generally significantly heavier than the swing arm **18,** the casing segment **30** will generally hang near vertically below the pivots **28b** and **128b** (the latter not shown in Fig. **5)** securing the pivot arm **18** to the bails **14** and **114** (the latter not shown in Fig. **5).**

**[0038]** Fig. **6** is a side elevation view of the single joint manipulator arm **10** of Figs. **3-5** with the casing segment **30** vertically positioned above and axially aligned with the casing string **34,** positioned to be lowered by the hoist (not shown in Fig. **6)** to engage the casing string **34.** The swing arm **18** has been rotated slightly further clockwise from its equilibrium position shown in Fig. **5** by energizing the cylinders **21** and **121** (the latter not shown in Fig. **6)** to extend the rods **23** and **123** (not shown in Fig. **6)** to rotate the swing arm **18** from its equilibrium position of Fig. **5** to the aligned position shown in Fig. **6.** Energizing the cylinders **21, 121** to extend the rods **23, 123** rotates the swing arm **18** further clockwise from its position shown in Fig. **5** and slightly vertically lifts the casing segment from its equilibrium shown position of Fig. **5** as it vertically aligns the single joint elevator **22** and the casing segment **30** with the casing string **34.** The capacity to rotate the single joint manipulator arm **10** clockwise from its equilibrium position shown in Fig. **5** provides substantially all of the rotational movement required to position casing segment **30** may be alignment with the casing string **34.** A lower, distal end **33** of the casing joint **30** is positioned to be threadably coupled with the proximal end of casing string **34.** The string elevator **12** is substantially axially aligned with casing string **34** so that the hoist (not shown) and bails **14** and **114** may be lowered, along with the string elevator **12,** to provide abutting contact for casing make up.

**[0039]** Once the casing segment **30** has been brought into aligned contact with the casing string **34,** a power tong or other torquing device engages and axially rotates casing segment **30** to make up the threaded connection between the casing segment **30** and the casing string **34.** After the connection is made, the single joint elevator **22** is released from the casing segment **30** and the swing arm **18** is rotated counterclockwise using cylinders **21** and **121** to its luffing position shown in Fig. **2.** The hoist (not shown in Fig. **2)** and bails **14** and **114** may then be lowered to bring the string elevator **12** to the proximal end **32** of the casing joint **30.** The string elevator **12** may be engaged with the proximal end **32** of the casing segment **30,** and the entire casing string **34** is lifted by the hoist (not shown) and the string elevator **12** to allow disengagement of the spider **36.** The string elevator **12** is then lowered until the proximal end **32** of the casing segment **30** reaches the same elevation as previously occupied by the proximate end of the casing string **34** shown in Fig. **6.** The spider **36** is then engaged to support the casing string **34** in the well, and the string elevator **12** may be disengaged from the casing segment **30.**

**[0040]** The process described above in connection with Figs. **3-6** is repeated with additional casing segments until the casing string **34** achieves the desired length.

**[0041]** To further enhance safety, the apparatus may include a safety fuse, such as a shear pin, that will audibly shear if the swing arm supports a load that is substantially heavier than a segment of the casing being made up and run into the well. Fig. **7** is a side elevation view of one embodiment of the single joint manipulator arm **10** for illustrating a load safety fuse **50.** A pair of stand-offs **52, 152** (the latter not shown in Fig. **7)** are secured at their first ends **52a, 152a** (the latter not shown in Fig. **7)** to the lower portion **17** of the swing arm **18** at pivot **54.** A sacrificially failing safety link **58** is pivotally coupled to the swing arm **18** at pivot **58a** located generally intermediate the pivotal coupling **54** of the stand-offs **52, 152** and angled portion **20.** The safety link **58** is coupled between pivot **58a** and shackle **57** which is, in turn, coupled to the first ends **56a, 156a** of cables **56** and **156** (elements **156a** and **156** not shown in Fig. **7** - see Fig. **8).** The second ends **56b** and **156b** of cables **56** and **156** are coupled and supported to the second ends **52b** and **152b** of stand-off members **52** and **152.** The safety link **58** generally is held by stand-offs **52, 152** at an angle to the swing arm

**18.** As shown in Fig. **7,** that angle is about 20 degrees, with the stand-offs **52, 152** being supported substantially in positions perpendicular to the swing arm **18.** The weight of the single joint elevator **22** biases the stand-offs **52, 152** generally downwardly when the single joint manipulator arm **10** is vertical, pulling cables **56** and **156** taut.

**[0042]** The safety link **58** comprises a sacrificially failing member that is designed to fail under a predetermined load. Thus, the safety link **58** is designed to withstand the load produced in cables **56** and **156** when the weight of segment of casing is supported by the single joint elevator **22.** A load significantly heavier than that of a casing segment plus the elevator **22** will cause the sacrificial member to fail, such as a shear failure, without dropping the load. The sound of the sacrificial failure is loud enough to alert the rig operator. In response to the sacrificial failure of the safety link **58,** the stand-offs **52, 152** will slightly rotate about pivot **54** counterclockwise (in Fig. **7)** but will remain coupled by safety link **58** to avoid dropping the casing segment coupled to the single joint elevator **22.**

**[0043]** Fig. **8** is a perspective view of the embodiment of the single joint manipulator arm **10** in Figs. **1-7.** The lifting ear **16** on the bail **14** is accompanied by a second lifting ear **116** on bail **114.** These bails are movably suspended from a block (not shown), and are capable of supporting very heavy loads, such as a casing string. The angled portion **20** of the swing arm **18** comprises a pair of generally parallel prongs **18a, 18b** that are pivotally coupled to bail clamps **29, 129,** respectively, at swing arm pivots **28b, 128b,** respectively. The bail clamps **29, 129** are secured to bails **14, 114,** respectively, using fasteners. The hydraulic cylinder **21** is accompanied by a second generally parallel hydraulic cylinder **121** for balanced damping of swinging loads applied to swing arm **18.** The cylinders **21** and **121** comprise extendable and retractable piston rods **23, 123** that are pivotally coupled to swing ears **25, 125,** respectively, of the swing arm **18.** Cylinders **21, 121** are each pivotally coupled to bail clamps **29, 129,** respectively, at pivots **28a, 128a,** respectively. These pivoting cylinder couplings on bail clamps **29, 129** are each secured to the bails at a spaced distance above swing arm pivots **28b, 128b** that pivotally secure the prongs **18a, 18b** of swing arm **18** to the bail clamps **29, 129,** respectively. The swing ears **25, 125** are offset from the swing arm so that pivoting of the swing arm **18** toward its equilibrium position (see Fig. **5)** under the force of gravity rotates the swing ears **25, 125** away from the cylinders **21, 121** and requires substantial extension of the rods **23, 123** from cylinders **21, 121,** respectively, for rotation. The resistance to extension of the rods **23, 123** from cylinders **21, 121** substantially dampens the rate of rotation of the swing arm **18** as compared to unrestrained swinging of the swing arm **18.** Similarly, force imposed by powered retraction of rods **23, 123** into the cylinders **21, 121** pulls against swing ears **25, 125,** respectively, to controllably rotate the swing arm **18** to the desired angular orientation, either to an initial position (see, for example, Fig. **3)** for coupling the single joint elevator **22** to a presented casing segment **30,** or to the luffmg position (see Fig. **2)** for either coupling the single joint elevator to a horizontally presented casing segment or for removing the swing arm **18** from obstructing the descent of the string elevator **12** to the spider **36.**

**[0044]** In the embodiments discussed in connection with Figs. **1-8,** hydraulic cylinders **21, 121** provide a dual function. According to a first function, the cylinders **21, 121** substantially slow and dampen movement of the swing arm **18** under the load of a casing segment secured in the elevator **22** as the single joint elevator and the load is lifted from a staging area. According to a second function, cylinders **21, 121** are used as actuators to rotate the swing arm **18** beyond its equilibrium (shown in Fig. **5)** to selectively position the swing arm **18** and thereby align the casing segment with the casing string, and also to rotate the swing arm **18** to the luffing position or to an angle for securing the elevator to a presented casing segment. Other embodiments may employ independent devices to actuate the swing arm **18** to align with the casing string and to dampen movement of the swing arm under load. For example, it is within the scope of the present invention for one cylinder may be used as an actuator to rotate the swing arm and another cylinder may used to dampen swing rotation of the swing arm.

**[0045]** As previously mentioned, the swing arm **18** may comprise a telescoping portion. The outer beam **24** may slidably receive an inner beam **26.** In other embodiments, a swing arm may be axially extendable without these beams being concentric as in the embodiments of Figs. **1-8.** For example, it is within the scope of the present invention for one beam to secure to the other using a slot on one beam and a bolt or pin on the other beam that is receivable and securable within the slot to lock the beams together to form a single load-bearing member.

**[0046]** An advantage of an extendable swing arm is that it provides the ability to adjust the length of the swing arm to manipulate different lengths of casing segments, to adjust the single joint manipulator arm to cooperate with the height of the spider at the rig floor, or generally to accommodate different drilling rig configurations. Additional versatility is realized by use of the embodiments of the tool of the present invention shown in Figs. **9-12.** The single joint manipulator arm can be adapted for use with fill-up and circulation tools, pipe gripping assemblies and slew actuators that enhance the capacity of the tool to manipulate and position tubular segments for make-up into a tubular string.

**[0047]** Fig. **9** is a perspective view of a modified lower portion of the single joint manipulator arm of the present invention comprising a slew actuator for angular displacement of the stand-offs to position a tubular segment secured within the single joint elevator. Fig. **9** shows an alternate embodiment of the single joint manipulator arm **10** of the present invention having enhanced capacity to manipulate and position tubular segments supported in the single joint elevator **22.** Fig. **9** shows a lower portion

**20** of the single joint manipulator arm of the present invention equipped with a slew actuator. A pair of stand-offs **52** and **152** are pivotally secured at their first ends **52a, 152a** (the latter not shown in Fig. **9)** to the lower portion **17** of the swing arm **18.** The second ends **56b** and **156b** of cables **56** and **156** are coupled to the second ends **52b** and **152b** of stand-offs **52** and **152.** The stand-offs **52, 152** are supported by cables **56** and **156** in positions generally perpendicular to the swing arm **18.** The weight of the single joint elevator **22** and any tubular segment secured therein biases the stand-offs **52, 152** generally downwardly when the single joint manipulator arm **10** is vertical, thereby pulling cables **56** and **156** taut.

**[0048]** The enhanced capacity for manipulation and positioning of tubular segments provided by the slew actuator shown in Fig. **9** is best understood by consideration of the ranges of controlled movement, relative to a classic x-y-z three-dimensional coordinate system, provided by the single joint manipulator arm. As seen in Figs. **3 - 6,** the cylinders **21** and **121** provide controlled rotation of the swing arm **18** and the supported casing segment **30** in the x-y plane. This movement of the tubular segment **30** secured in the elevator **22** is primarily along the x-axis when the cylinders **21** and **121** position the swing arm **18** in the generally vertical orientations shown in Figs. **5** and **6.** Vertical displacement of the tubular segment secured in the elevator **22** along the y-axis is provided by the rig hoist (not shown) that raises and lowers the draw-works, block and the sub and/or bails to which the single joint manipulator arm is secured. The slew actuator shown in Fig. **9** provides for controlled movement along the z-axis.

**[0049]** Fig. **9** shows the components of one embodiment of the single joint manipulator arm equipped with a slew actuator providing enhanced positioning and manipulation of the suspended tubular joint. The slew actuator housing **42** generally surrounds a slew actuator **43,** which may be a cylinder, for positioning a slew rod **44** generally perpendicular to the pivotable stand-offs **52** and **152.** While the actual movement of stand-offs **52** and **152** is radial about stand-off pivots **46a** and **46b,** respectively, the movement of a tubular segment (not shown in Fig. **9)** secured in the elevator **22** upon actuation of the slew actuator **43** is substantially along the z-axis as defined above. Accordingly, this embodiment of the present invention provides superior control and manipulation of casing segments for being made up into a casing string.

**[0050]** Fig. **10** is a perspective view of one embodiment of the single joint manipulator arm **10** of the present invention secured to and supported by a top drive and supporting a fill-up and circulation tool and a pipe gripping assembly. The single joint manipulator arm **10** is pivotably secured to an enlarged portion of a sub **88** that is threadably coupled at its inlet **88a** (above the sub **88)** to a top drive and supports a casing running tool **104** from its discharge **88b** (below the sub **88).** In this embodiment, the discharge **88b** of the sub **88** supports a casing running tool **104** having a gripping assembly sized for being received into a casing segment (not shown). The casing running tool **104** comprises a plurality of pipe gripping shoes **105** that are deployable and retractable radially outwardly to grip and release the internal wall of a casing segment to support the casing string or to rotate the casing segment to make up the connection with the casing string.

**[0051]** The embodiment in Fig. **10** also comprises a fill-up and circulation tool **100** supported underneath the casing running tool. The elastomeric seal **103** is sized for engaging the internal wall of a casing string (not shown in Fig. **10)** upon insertion. The seal enables pressurization of the casing string so that pressurized fluid introduced into the bore of the casing string through the bore **101** of the fill-up and circulation tool **100** can be circulated down the casing string and back to the surface through the annulus formed between the casing string and the borehole.

**[0052]** Fig. **11** is a perspective view of another embodiment of the present invention. The single joint manipulator arm **10** of the present invention is secured to and supported by a top drive, and supports a fill-up and circulation tool **100** comprising an elastomeric seal **103.** A bore **101** formed by aligned bores in the top drive, sub **88** and the fill-up and circulation tool **100** provides a conduit for introducing fluid into the casing string. The single joint manipulator arm **10** is pivotably secured to an enlarged portion of a sub **88** that is threadably coupled at its inlet **88a** (above the sub **88)** to a top drive and supports the fill-up and circulation tool **100** from its discharge **88b** (below the sub **88).** In this embodiment, a pair of bails **14, 114** is suspended from a support ring **89** that is rotatably supported by the top drive.

**[0053]** Fig. **12** is a flowchart describing one embodiment of a high-level method of manipulating casing segment to assemble a casing string. In step **60,** the swing arm is rotated to an initial position. A hydraulic cylinder or other actuator is used to rotate the pivot arm away from vertical and to a desired angle according to the orientation of a selected joint in the staging area. In step **62,** the hoist is lowered as necessary to position a first elevator, such as a horseshoe elevator, near a proximate end of the targeted casing segment. In step **64,** the single joint elevator is coupled to the proximate end of the targeted joint. In step **66,** the hoist is raised to begin moving the joint into a suspended position. As the joint is lifted along the ramp to leave the staging area, the swing arm rotates clockwise toward an equilibrium position, and the rotation is dampened in step **68.** Once the swing arm and the casing segment are substantially vertical and the joint is suspended in the offset position, the joint is then aligned with the casing segment by powered rotation of swing arm and lowered to abut the casing string in steps **70** and **72.** Once the distal end of the joint is in contact with the upper end of the casing string, the joint is threadably coupled to the casing string in step **74.** A power tong may be used to rotate the joint to threadedly couple the joint to the casing string. Then, in step **76,** the hoist is

lowered while the single joint elevator is disengaged from the proximate end of the joint. Lowering the hoist brings the string elevator near the proximate end of the casing string and, in step **78,** the string elevator engages the proximate end of that uppermost joint of the casing string. In step **80,** the casing string is lifted up slightly. This releases the load on the spider so the spider is released according to step **82.** In step **84,** with the casing string released by the spider, the hoist is lowered to install the casing string further into the borehole to about the position of the casing string prior to connecting the additional joint in step **74.** The spider slips are moved into contact with the casing string to support it in the well. In the step **86,** if the string has achieved the desired length, work stops. Otherwise the process repeats as the swing are is rotated to an initial position in step **60.**

**[0054]** Embodiments of the invention provide a safe and efficient way to assemble a casing string. A highly maneuverable single joint manipulator arm retrieves a casing joint from a variety of angles to access a staging area. The single joint manipulator arm then positions the casing joint into alignment with the casing string in a controlled manner using a damper. A casing string may also be assembled quickly and efficiently, minimizing the time and expense associated with casing make up.

**[0055]** The terms "comprising," "including," and "having," as used in the claims and specification herein, shall be considered as indicating an open group that may include other elements not specified. The terms "a," "an," and the singular forms of words shall be taken to include the plural form of the same words, such that the terms mean that one or more of something is provided. The term "one" or "single" may be used to indicate that one and only one of something is intended. Similarly, other specific integer values, such as "two," may be used when a specific number of things is intended. The terms "preferably," "preferred," "prefer," "optionally," "may," and similar terms are used to indicate that an item, condition or step being referred to is an optional (not required) feature of the invention.

**[0056]** The terms "segment" and "joint" are used interchangeably to refer to individual portions of casing. The term "casing" is used to refer to casing, production tubing, drill pipe and all other tubulars that may be coupled end-to-end and installed in a well.

**[0057]** While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the claims.

## Claims

**1.** An apparatus, for manipulating tubular segments (30) for being made up into a tubular string (34), the apparatus comprising:

a swing arm (18) having a proximal end pivotally coupled to a hoist at a location above a string elevator (12) or a casing running tool;
an actuator (21, 121) pivotally secured to the swing arm (18) for rotating the swing arm (18);
a damper (21, 121) pivotally secured to the swing arm (18), for damping rotation of the swing arm (18);
a single joint elevator (22) secured to a distal end (17) of the swing arm (18) for releasably supporting a tubular segment (30), the swing arm (18) being rotatable to align the tubular segment (30) with another tubular segment to form a tubular string (34); and **characterized by**
a sacrificially failing link coupled between the single joint elevator (22) and the swing arm (18), the single joint elevator (22) being pivotable about the distal end (17) of the swing arm (18) between a first position with the sacrificially failing link intact and a second position assumed upon failure of the sacrificially failing link.

**2.** The apparatus of claim 1, wherein the actuator (21, 121) is a hydraulic or a pneumatic cylinder.

**3.** The apparatus of claim 2, wherein the cylinder also functions as the damping member.

**4.** The apparatus of claim 1, wherein the damper (21, 121) comprises a hydraulic or a pneumatic cylinder.

**5.** The apparatus of claim 1, wherein the single joint elevator (22) comprises a horseshoe elevator or a hinged-body elevator.

**6.** The apparatus of claim 1, further comprising:

a safety link pivotally secured to the swing arm (18) with the sacrificially failing link coupled to the safety link and also to the swing arm (18) such that the safety link supports the single joint elevator (22) upon failure of the sacrificially failing link.

## Patentansprüche

**1.** Vorrichtung zum Manipulieren von schlauchförmigen Segmenten (30) zum Zusammensetzen zu einem schlauchförmigen Strang (34), wobei die Vorrichtung umfasst
einen Schwenkhebel (18) mit einem nahen Ende, das drehbar an eine Winde gekoppelt ist an einem Ort über einem Strangaufzug (12) oder einem Laufwerkzeug für ein Bohrloch;
einen Regler (21, 121) zum Rotieren des Schwenk-

hebels (18), der drehbar am Schwenkhebel (18) befestigt ist;
einen Dämpfer (21, 121) zum Dämpfen der Rotation des Schwenkhebels (18), der drehbar am Schwenkhebel (18) befestigt ist;
einen Einzelgelenk-Aufzug (22), der an einem entfernten Ende (17) des Schwenkhebels (18) befestigt ist zum lösbaren Tragen eines schlauchförmigen Segments (30), wobei der Schwenkhebel (18) rotiert werden kann, um das schlauchförmige Segment (30) mit einem weiteren schlauchförmigen Segment einzufluchten, so dass ein schlauchförmiger Strang (34) gebildet wird; und **gekennzeichnet durch**
eine ausfallende Opferverbindung, die zwischen den Einzelgelenk-Aufzug (22) und den Schwenkhebel (18) gekoppelt wird, wobei der Einzelgelenk-Aufzug (22) um das entfernte Ende (17) des Schwenkhebels (18) drehbar ist zwischen einer ersten Stellung, in der die ausfallende Opferverbindung intakt ist und einer zweiten Stellung, die nach Ausfall der ausfallenden Opferverbindung, eingenommen wird.

**2.** Vorrichtung gemäß Anspruch 1, worin der Regler (21, 121) ein hydraulischer oder pneumatischer Zylinder ist.

**3.** Vorrichtung gemäß Anspruch 2, worin der Zylinder auch als Dämpfelement funktioniert.

**4.** Vorrichtung gemäß Anspruch 1, worin der Dämpfer (21, 121) einen hydraulischen oder pneumatischen Zylinder umfasst.

**5.** Vorrichtung gemäß Anspruch 1, worin der Einzelgelenk-Aufzug (22) einen Hufeisen-Aufzug oder einen Kippaufzug umfasst.

**6.** Vorrichtung gemäß Anspruch 1, zudem umfassend eine Sicherheitsverbindung, die drehbar am Schwenkhebel (18) befestigt ist, wobei die ausfallende Opferverbindung an die Sicherheitsverbindung gekoppelt ist und auch an den Schwenkhebel (18), so dass die Sicherheitsverbindung den Einzelgelenk-Aufzug (22) bei Ausfall der ausfallenden Opferverbindung trägt.

**Revendications**

**1.** Appareil, pour manipuler des segments tubulaires (30) pour être assemblés en une colonne de production (34), l'appareil comprenant :

un bras oscillant (18) possédant une extrémité proximale accouplée de façon pivotante avec un appareil de levage dans un emplacement au-dessus d'un élévateur de rame (12) ou un outil de pose de tubage ;
un actionneur (21, 121) fixé de façon pivotante au bras oscillant (18), pour faire tourner le bras oscillant (18) ;
un amortisseur (21, 121) fixé de façon pivotante au bras oscillant (18), pour amortir la rotation du bras oscillant (18) ;
un élévateur de simple longueur de tube (22) fixé à une extrémité distale (17) du bras oscillant (18) pour supporter un segment tubulaire (30) de façon libérable, le bras oscillant (18) étant rotatif pour aligner le segment tubulaire (30) avec un autre segment tubulaire pour former une colonne de production (34) ; et **caractérisé par**
une liaison de rupture sacrificielle accouplée entre l'élévateur de simple longueur de tube (22) et le bras oscillant (18), l'élévateur de simple longueur de tube (22) pivotant autour de l'extrémité distale (17) du bras oscillant (18) entre une première position avec la liaison de rupture sacrificielle intacte et une seconde position prise lors de la rupture de la liaison de rupture sacrificielle.

**2.** Appareil selon la revendication 1, dans lequel l'actionneur (21, 121) est un vérin hydraulique ou pneumatique.

**3.** Appareil selon la revendication 2, dans lequel le vérin sert également d'élément amortisseur.

**4.** Appareil selon la revendication 1, dans lequel l'amortisseur (21, 121) comprend un vérin hydraulique ou pneumatique.

**5.** Appareil selon la revendication 1, dans lequel l'élévateur de simple longueur de tube (22) comprend un élévateur en U ou un élévateur à corps articulé.

**6.** Appareil selon la revendication 1, comprenant en outre :

une liaison de sécurité fixée de façon pivotante au bras oscillant (18) avec la liaison de rupture sacrificielle accouplée avec la liaison de sécurité et également au bras oscillant (18) de sorte que la liaison de sécurité supporte l'élévateur de simple longueur de tube (22) lors de la rupture de la liaison de rupture sacrificielle.

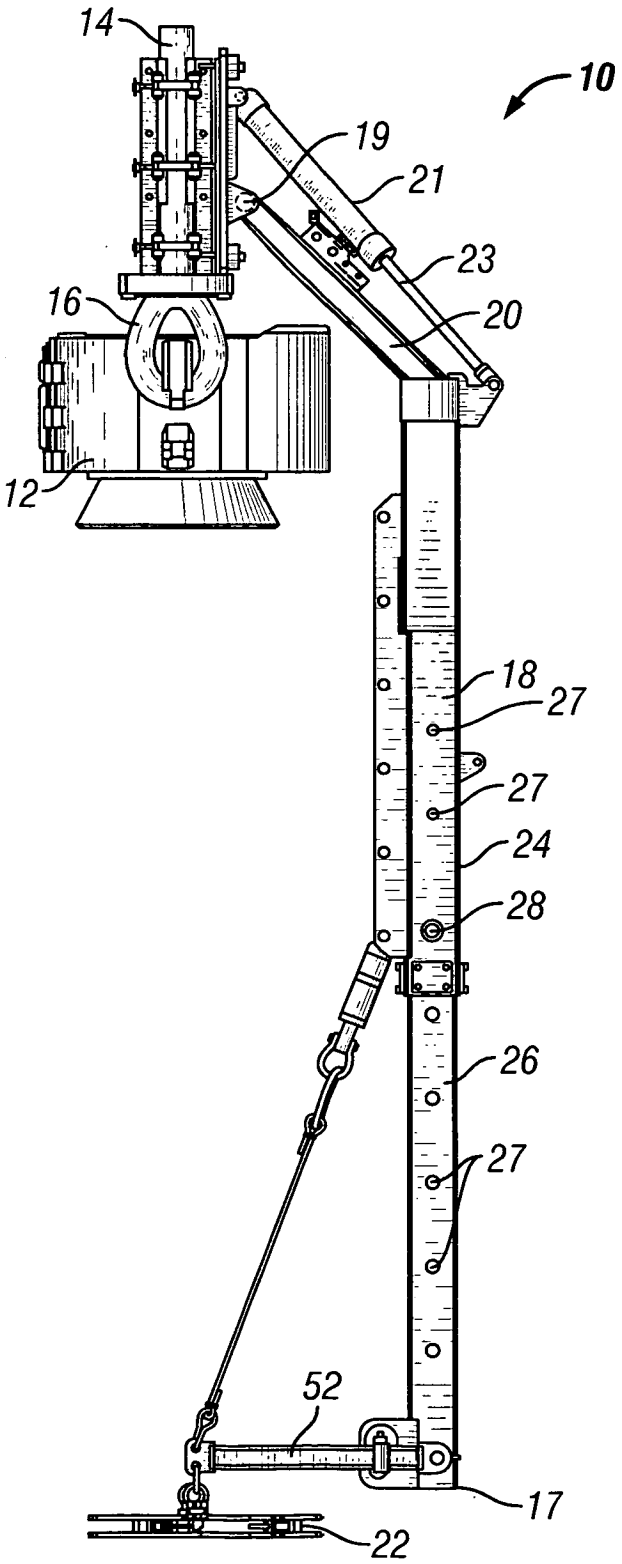



FIG. 1

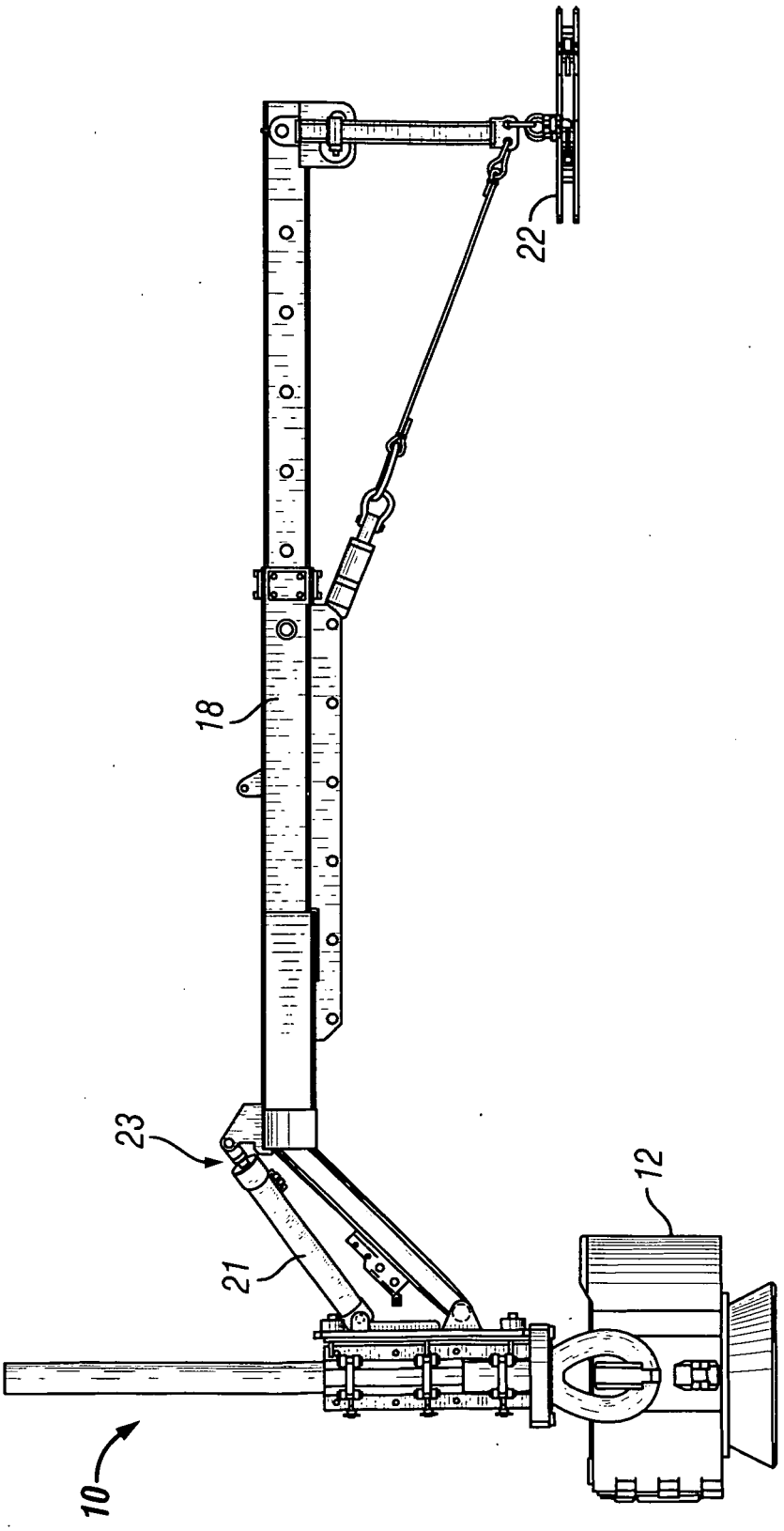



FIG. 2

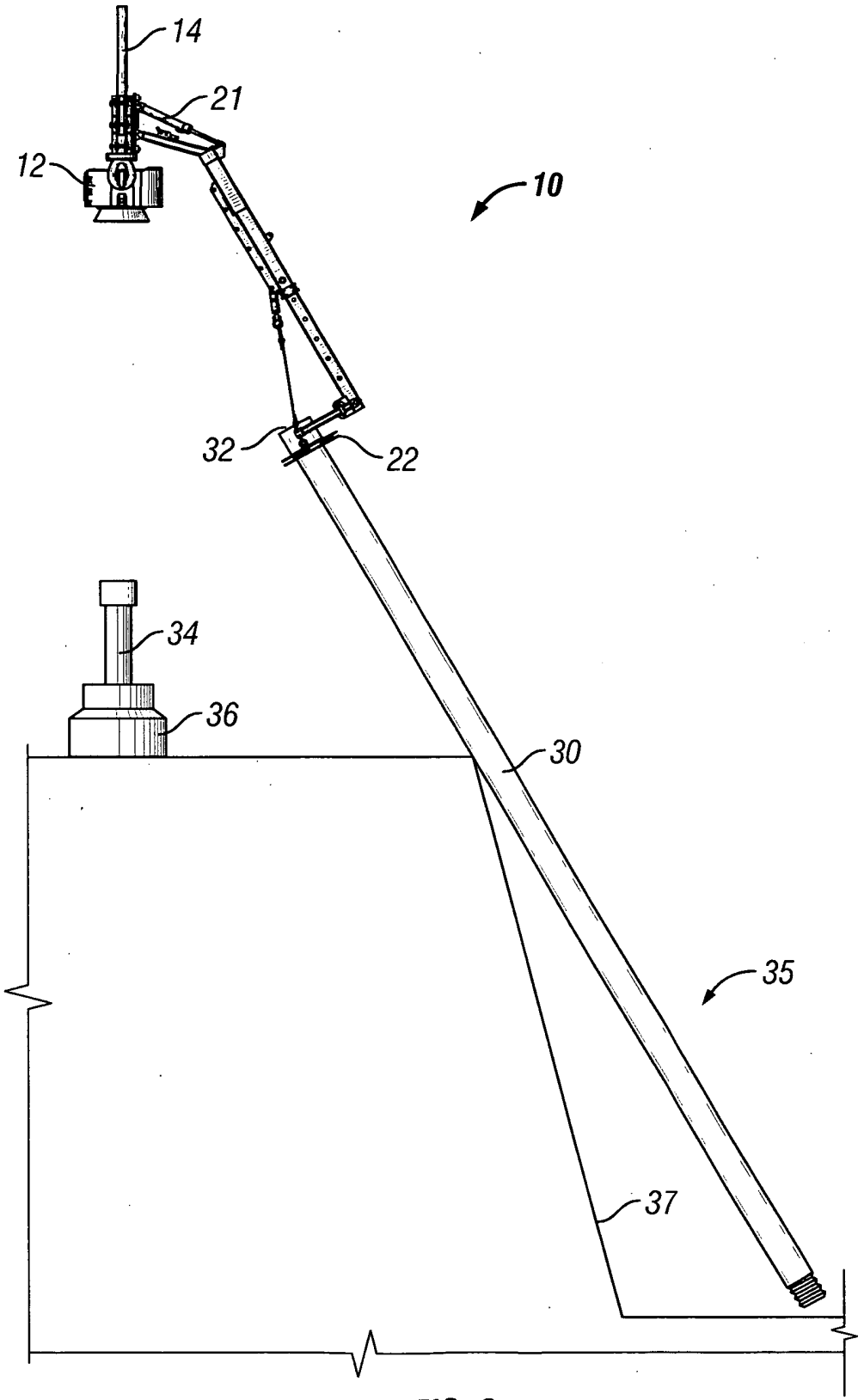



FIG. 3

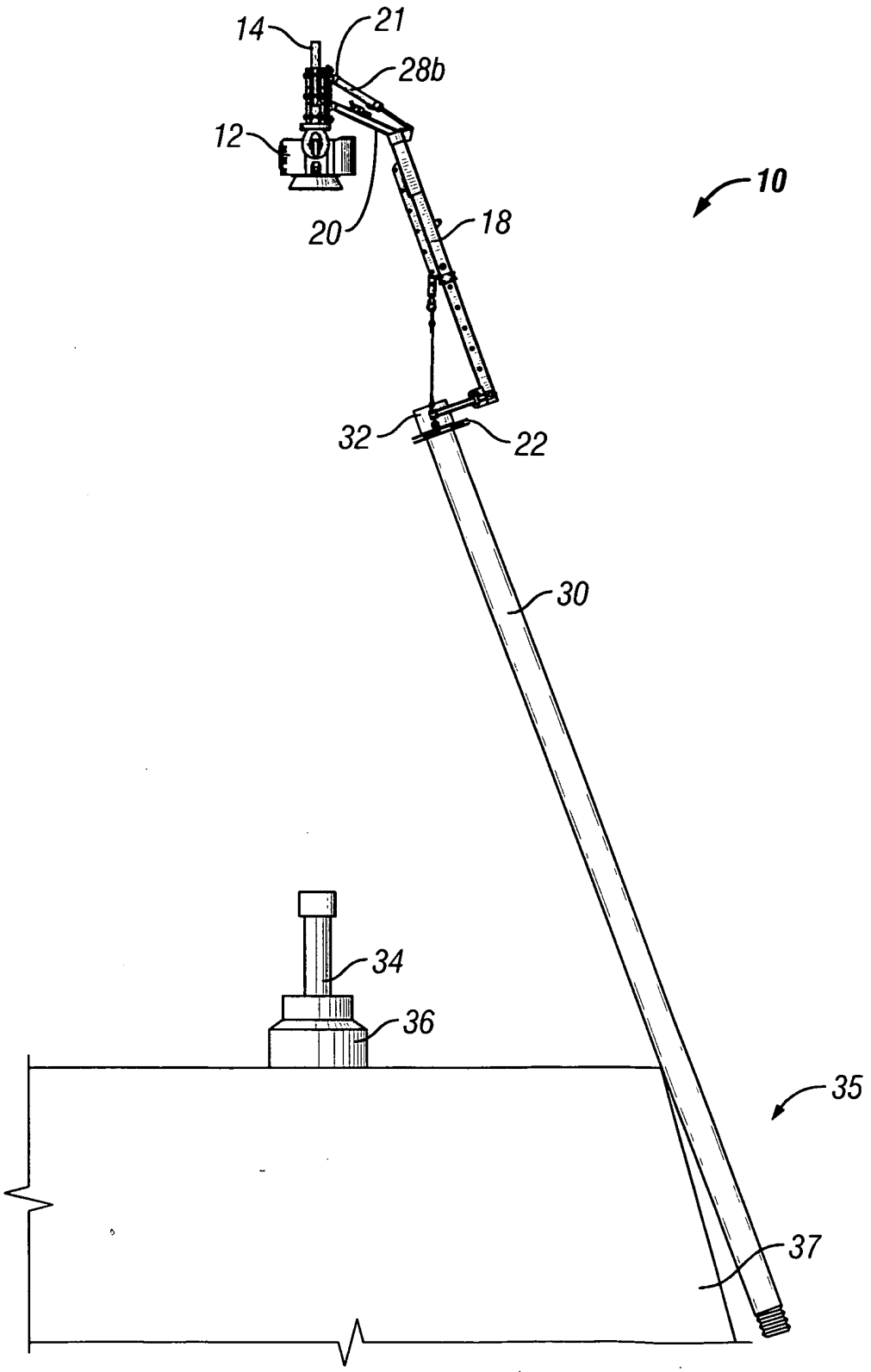



FIG. 4

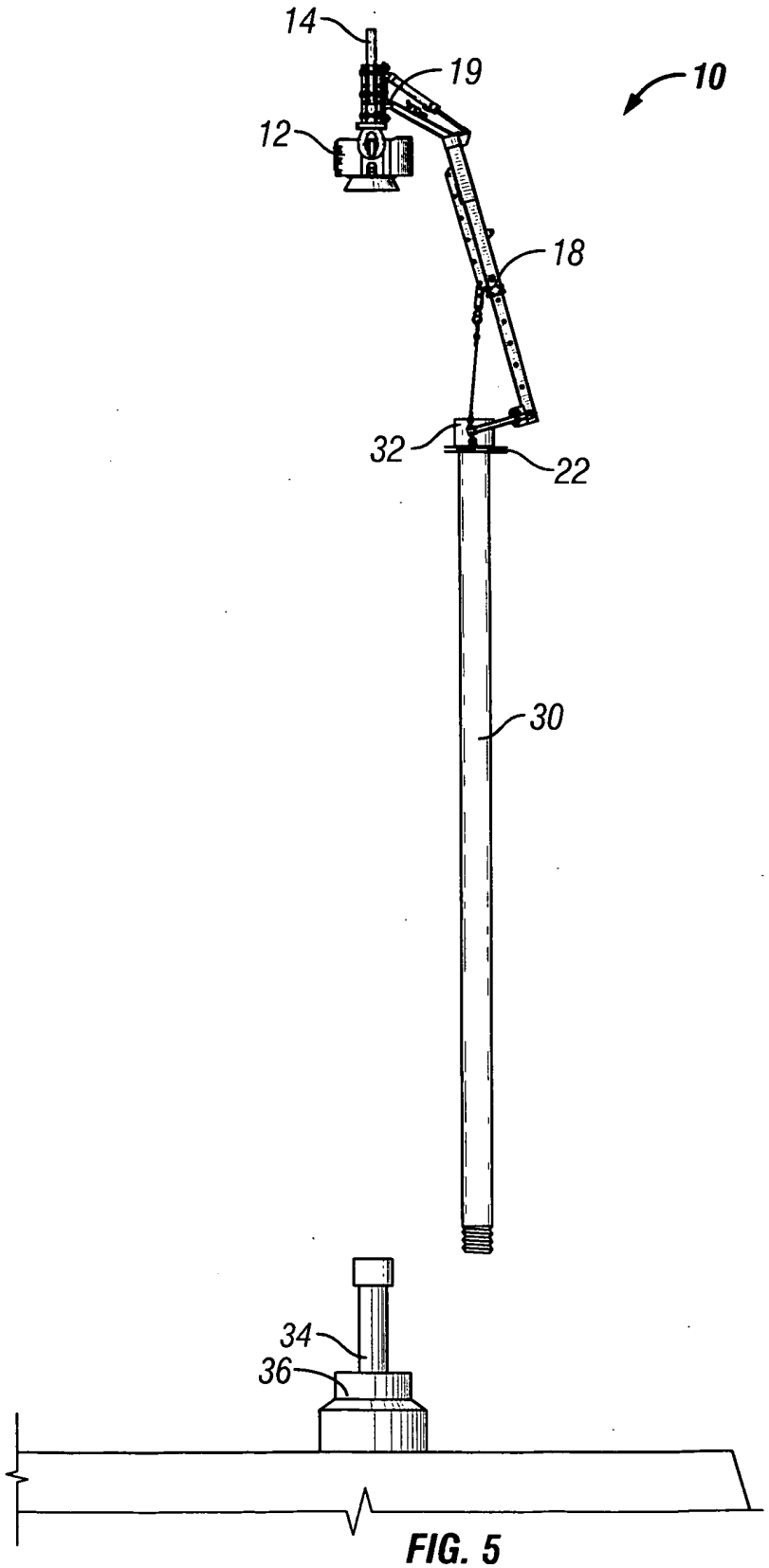



FIG. 5

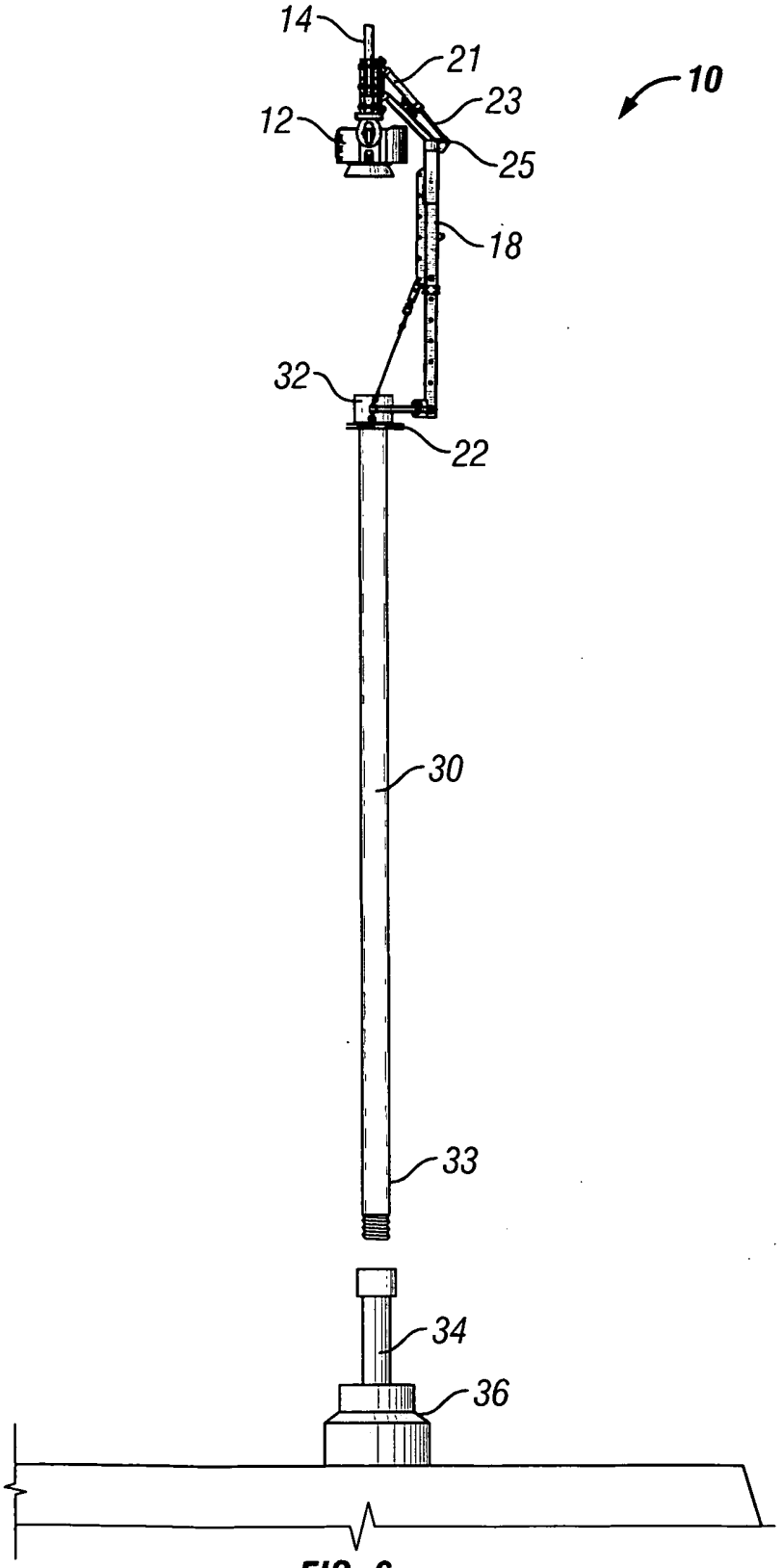



FIG. 6

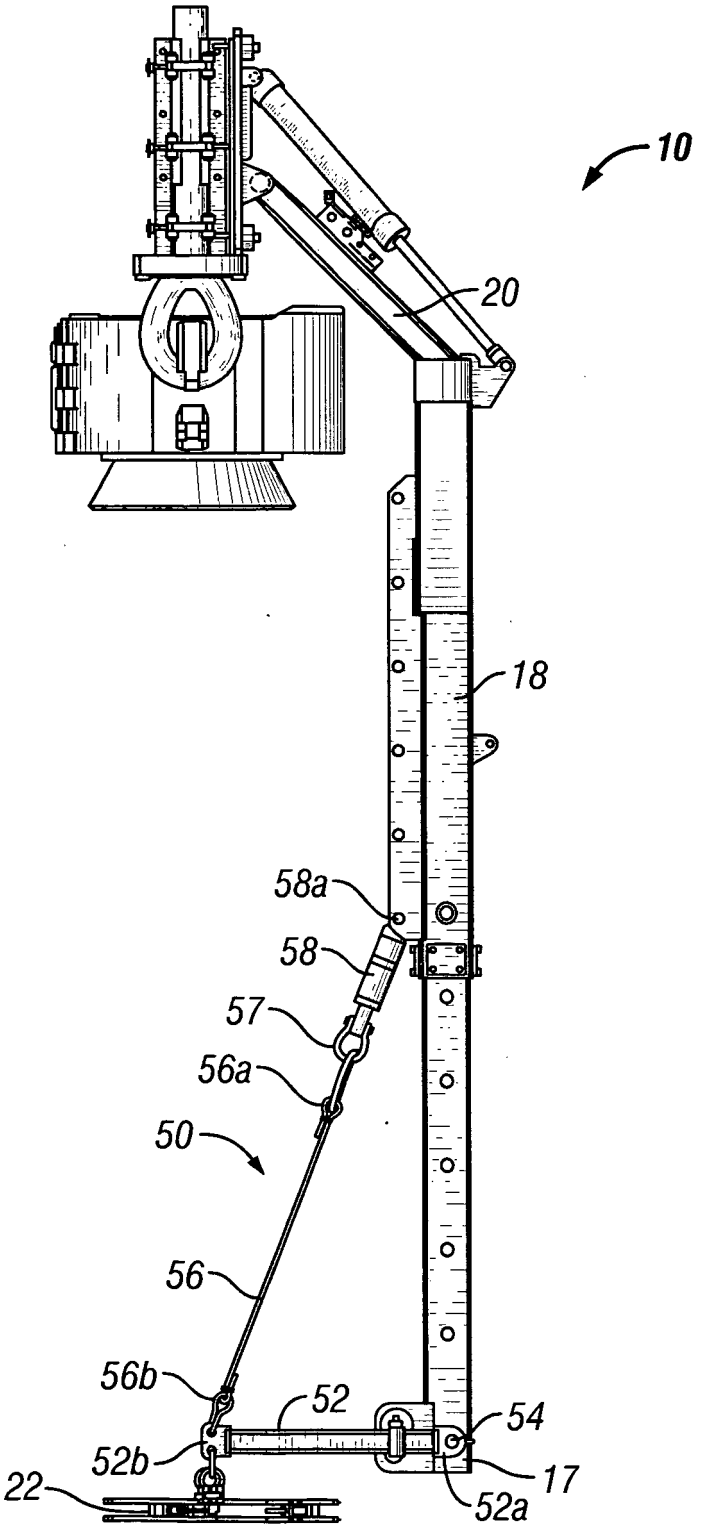
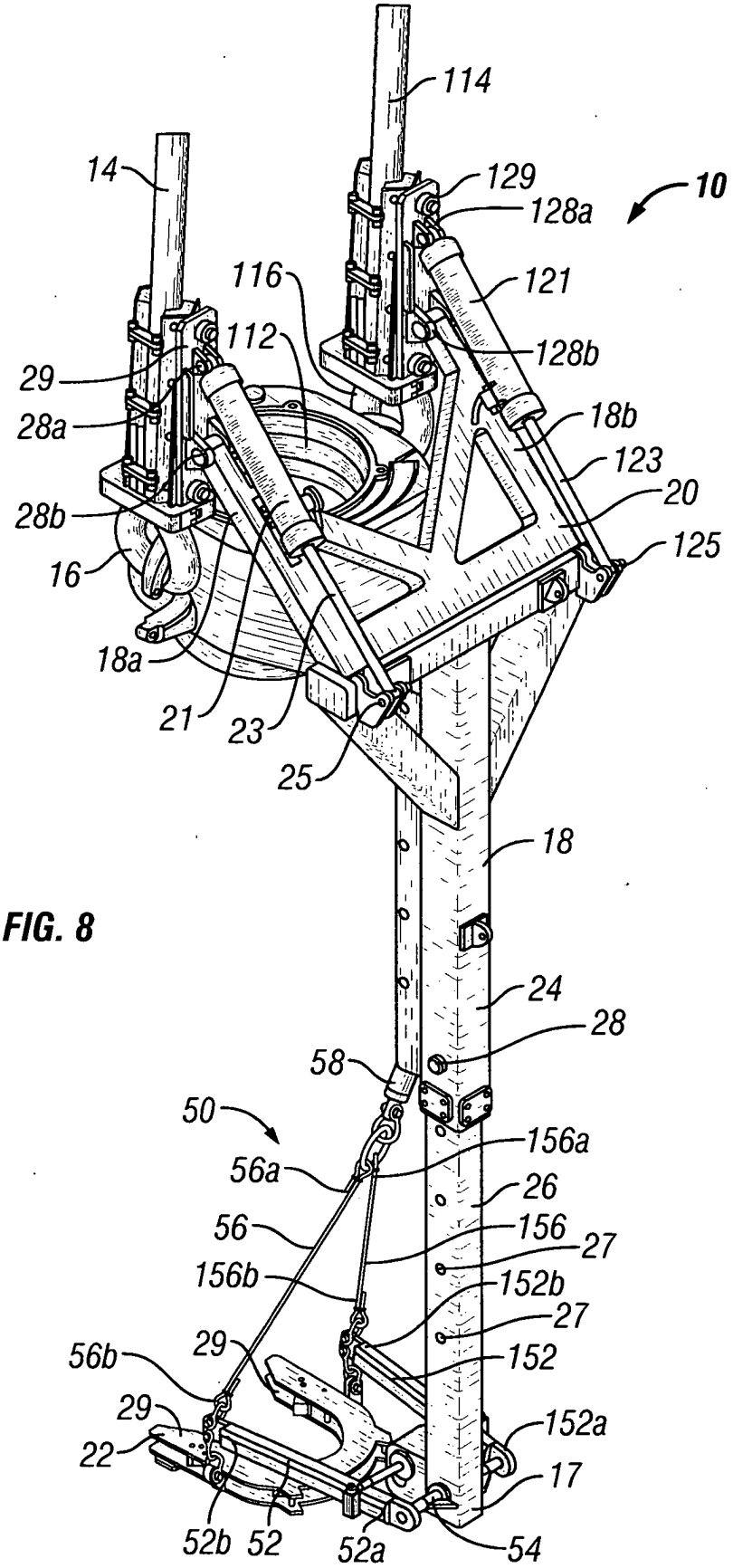



FIG. 7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14
129
10
128a
116
121
112
128b
29
18b
28a
123
20
28b
125
16
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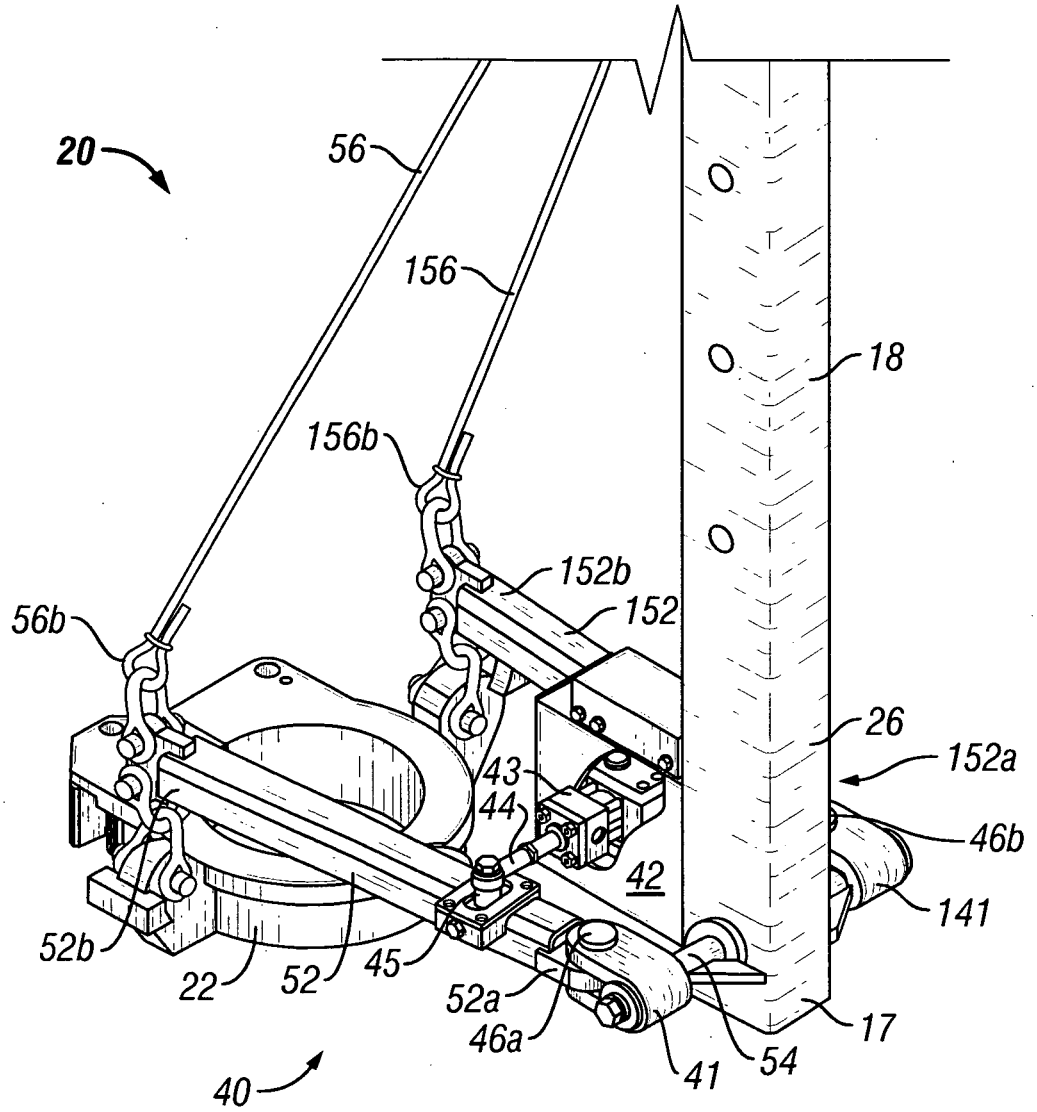
21
23
25
18
24
28
58
50
156a
56a
26
56
156
27
156b
152b
27
29
152
56b
29
152a
22
17
52b
52
52a
54

FIG. 8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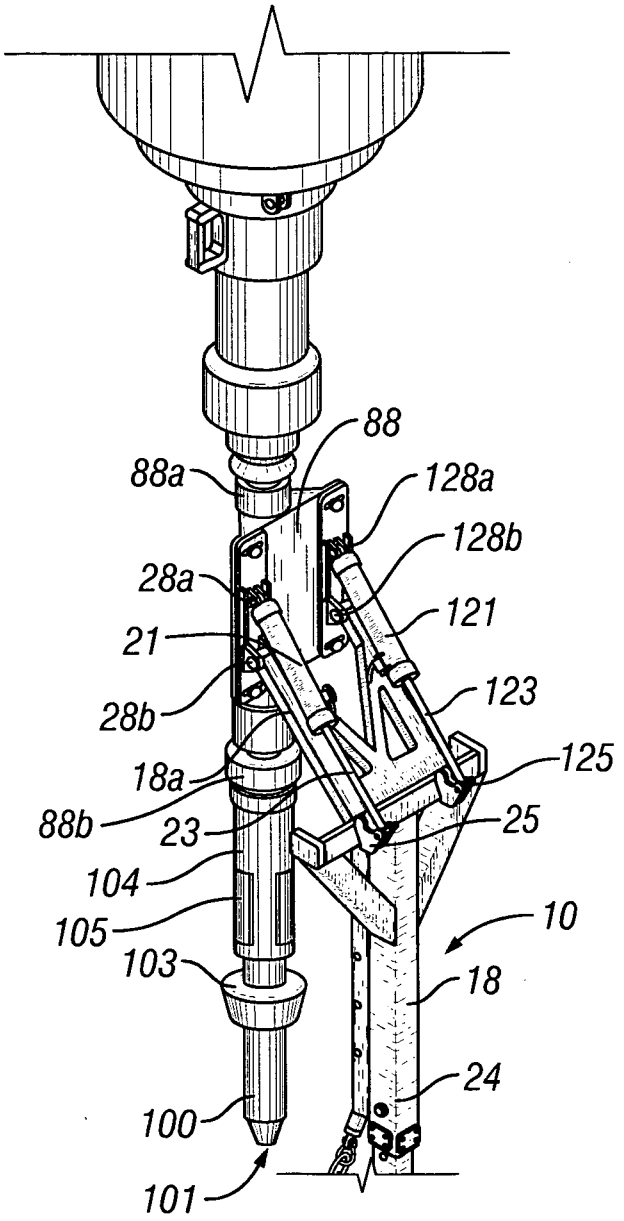
156
18
156b
152b
152
56b
26
152a
43
44
46b
42
141
52b
22
52
45
52a
46a
17
41
54
40

FIG. 9


88
88a
128a
128b
28a
121
21
123
28b
125
18a
88b
23
25
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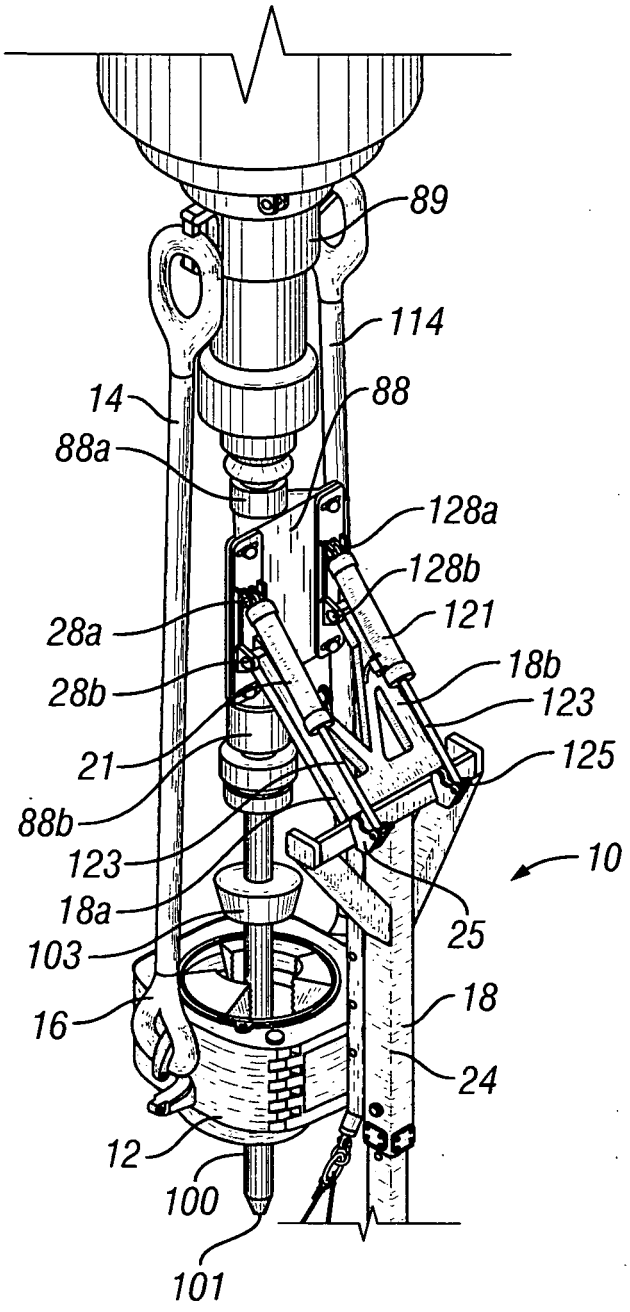
103
18
24
100
101

FIG. 10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14
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88a
128a
128b
121
28a
18b
28b
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21
88b
10
123
18a
25
103
18
16
24
12
100
101

FIG. 11

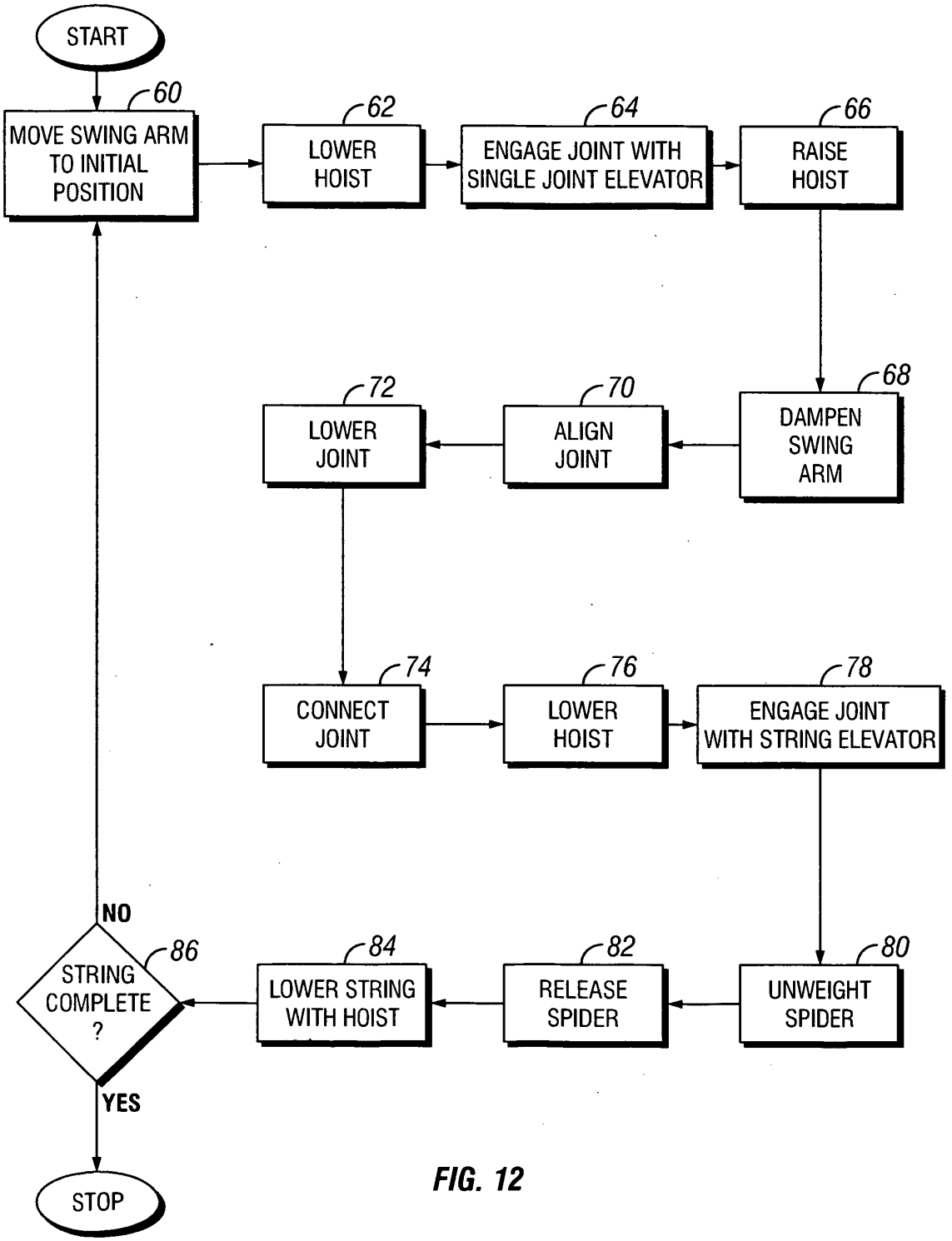
START
60
MOVE SWING ARM TO INITIAL POSITION
62
LOWER HOIST
64
ENGAGE JOINT WITH SINGLE JOINT ELEVATOR
66
RAISE HOIST
68
DAMPEN SWING ARM
70
ALIGN JOINT
72
LOWER JOINT
74
CONNECT JOINT
76
LOWER HOIST
78
ENGAGE JOINT WITH STRING ELEVATOR
80
UNWEIGHT SPIDER
82
RELEASE SPIDER
84
LOWER STRING WITH HOIST
86
STRING COMPLETE ?
NO
YES
STOP

*FIG. 12*

## REFERENCES CITED IN THE DESCRIPTION

*This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.*

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