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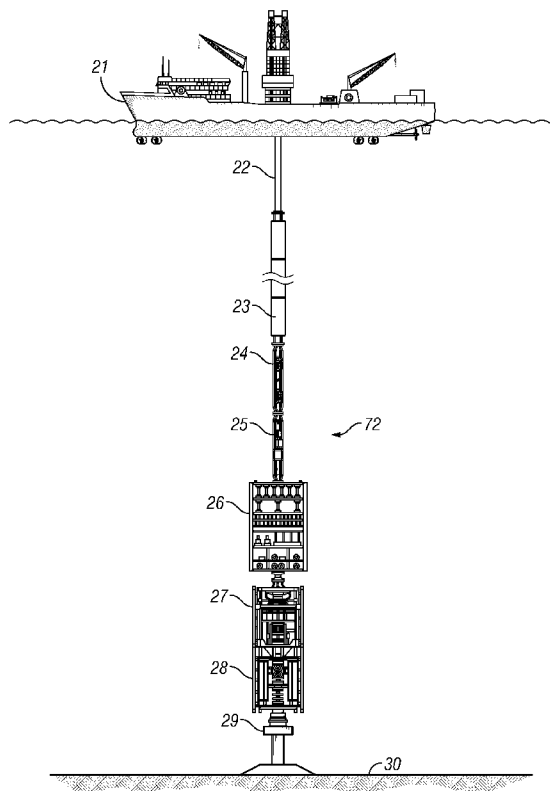


FIG. 1

(57) Abstract: An apparatus, system and process for deployment of subsea drilling equipment through a moon pool of a drilling vessel is disclosed. The drilling equipment may include a subsea mudlift pump (MLP) that is configured to be deployed below the surface of the ocean and is adapted for conducting dual gradient drilling (DGD) operations. In the apparatus and process, the MLP may be suspended temporarily aboard the vessel by a holding mechanism. The MLP may be combined first with a lower marine riser package (LMRP) prior to suspension of the MLP and/or MLP/LMRP aboard the drilling vessel. An equipment combination, comprising at least a MLP and a LMRP, may be with a BOP, the mating occurring at a position below the surface of the ocean. In one aspect, the BOP may be separately deployed into the ocean, and then subsequently mated subsea with the LMRP and/or a MLP/LMRP combined equipment package.



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PROCESS FOR SUBSEA DEPLOYMENT OF DRILLING EQUIPMENT

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application No. 61/858,348, (Chevron file number T-9559-P) filed on July 25, 2013 to Ma et al. entitled "Apparatus, System and Method for Deployment of Subsea Well Drilling Equipment".

FIELD OF THE INVENTION

[0002] The field of the invention is directed to apparatus, systems and methods for deployment of drilling equipment to the ocean floor.

BACKGROUND

[0003] In the drilling of subsea wells, it is common to use a drilling vessel to deploy large and heavy equipment to the floor of the ocean. Drilling vessels designed for this purpose have one or more openings in the bottom of the ship, which are commonly referred to as "moon pools". Such ships are outfitted with working hoists mounted above a moon pool designed to suspend and lower heavy equipment through the moon pool into the ocean.

[0004] In modern subsea drilling, a blowout preventer ("BOP") usually is located on or near the floor of the ocean. Above (and connected) to the BOP is a lower marine riser package, referred to as a LMRP. In conventional drilling operations, a BOP and LMRP may be deployed to a position near the ocean surface by lowering them through the moon pool.

[0005] A BOP designed for subsea operations may be as much as five stories high, and may weigh as much as about 800,000 pounds. The LMRP is the upper section of a two-section subsea BOP/LMRP stack consisting of a hydraulic connector, annular BOP, ball/flex joint, riser adapter, jumper hoses for the choke, kill, and auxiliary lines, and subsea control pods. In conventional drilling operations, it is common to deploy from a drilling vessel a BOP/LMRP in one connected unit.

[0006] With the advent new techniques for drilling, even more equipment is required to be positioned upon the ocean floor. For example, subsea mudlift drilling, sometimes called “dual gradient drilling,” is designed to employ a mudlift pump (“MLP”) in the subsea environment. U.S. Patent No. 6,102,673 to Mott et al (the “Mott patent”) reveals such a system. In **Figure 2A** of the Mott patent, a LMRP **44** is shown as proposed for sitting upon the top of BOP **46**. In a separate **Figure 2B**, a subsea mudlift pump **102** is integrated with a non-rotating subsea diverter **106**.

[0007] A single stack of a BOP, LMRP, MLP, SPU and SRD cannot be deployed into the ocean with conventional vessels or equipment, for several reasons. Most modern drilling vessels (or drillships, in some instances) have a limited height aboard the vessel between the deck (or equipment holding area) and the top of the hoist aboard. Thus, equipment that is to be mechanically linked for deployment from such a hoist has a height maximum dictated by the size of the vessel superstructure, and the geometry of the ship deck and moon pool. Conventional drilling vessels are believed to be unable to accommodate such a tall single stack of equipment for deployment. Furthermore, stacking of such massive pieces of equipment, such as an MLP that itself weighs as much as 450,000 pounds, combined with BOP and/or LMRP, cannot easily be accomplished without damage to the equipment or instability during stacking or deployment. A simple stack causes problems, due to gravitational forces upon the equipment aboard a vessel.

[0008] Another challenge in designing such a subsea deployment is that a single stack of a BOP, LMRP, MLP, SPU and SRD cannot easily be deployed as a unit from most conventional drilling vessels because the hook load limit of the hoist on the drillship vessel cannot easily accommodate the immense weight of so many structures stacked into a single deployable unit. Even a stack of only the BOP, LMRP and MLP would exceed both the height limits and the weight/load limits of most conventional drilling vessel hoists.

[0009] Deploying such devices separately, or in series, raises other issues or problems as well. The time required to lower equipment to the seabed is very costly. Rig time for modern drilling vessels may approach as much as one million dollars per day, and as such, each hour spent in deployment is very costly. Furthermore, making

connections between separate pieces of equipment only after they have been deployed deep into the ocean presents additional challenges and problems. Some connections are not suitable for being remotely made up at a position that is subsea, but instead, must be made manually by bolting or clamping aboard a vessel prior to deployment.

[0010] A significant challenge in the drilling of wells over water is to reduce time, effort and expense required in reliably deploying and properly connecting multiple pieces of large and heavy equipment into the water, and on the ocean floor, ready to conduct drilling operations. This invention is directed to improved techniques, apparatus, systems and methods for deployment of large and heavy drilling equipment to the ocean floor in a configuration that is prepared for drilling operations.

DEFINITIONS

[0011] In the description of the components herein, certain specific nomenclature is used, as further defined below.

[0012] MLP means a subsea mudlift pump.

[0013] LMRP means a lower marine riser package.

[0014] SPU means a solids processing unit.

[0015] SRD means a subsea rotating diverter.

[0016] MLP/LMRP means a subsea mudlift pump mechanically connected to a lower marine riser package.

[0017] SPU/MLP/LMRP means a solids processing unit mechanically connected to a subsea mudlift pump, with the subsea mudlift pump also being mechanically connected to a lower marine riser package.

[0018] SRD/SPU means a subsea rotating diverter mechanically connected to a solids processing unit.

[0019] SRD/SPU component means a device having at least the following in mechanical connection: a subsea rotating diverter mechanically connected to a solids processing unit.

[0020] BOP means a blowout preventer.

[0021] SRD/SPU/MLP/LMRP means a subsea rotating diverter mechanically connected to a solids processing unit, with the solids processing unit also being connected to a subsea mudlift pump that is mechanically connected to a lower marine riser package.

[0022] SRD/SPU/MLP/LMRP/BOP means a subsea rotating diverter mechanically connected to a solids processing unit, with the solids processing unit also being mechanically connected to a subsea mudlift pump that is mechanically connected to a lower marine riser package, in which the lower marine riser package further is connected to a blowout preventer.

[0023] “Inline” means generally equipment that is connected in series to form a string that is to become part of a riser string for subsea drilling operations.

[0024] “Combination” with reference to equipment means combined elements that are mechanically linked.

[0025] “Integrated” refers generally to equipment units that have been mechanically linked together.

SUMMARY

[0026] A process for connection and deployment of drilling equipment through a moon pool of a drilling vessel is disclosed. Broadly, a process is disclosed for suspending a first device, then suspending a second device below the first device, connecting the first and second device to form a connected pair, and then suspending the connected pair by holding the first device with a holding mechanism. Later, one or more devices may be connected, and then further connections may optionally be performed prior to deployment to the ocean.

[0027] In one embodiment, the process may comprise several steps, including: (a) suspending a MLP, the MLP having an upper side and a lower side having a first connection mechanism; (b) positioning a LMRP below the MLP, the LMRP having a lower side and an upper side having a second connection mechanism, the second connection mechanism of the LMRP being adapted for mating with the first connection mechanism of the MLP; (c) mating the first connection mechanism with the second connection mechanism to form an inline MLP/LMRP; and (d) suspending the inline MLP/LMRP by a holding mechanism that is fixed to the drilling vessel, the holding mechanism being reversibly attached to the MLP, the inline MLP/LMRP being suspended above the moon pool of the drilling vessel.

[0028] In other aspects of the invention, the process may further comprise the steps of: (e) providing an SPU with a top flange and a bottom flange; (f) connecting the bottom flange of the SPU to the upper side of the MLP to form an inline SPU/MLP/LMRP; and (g) suspending the inline SPU/MLP/LMRP in position for deployment through the moon pool.

[0029] In another aspect of the invention, the process may include the steps of: (e) providing an SPU with a top flange and a bottom flange; (f) providing an SRD with a bottom flange; and (g) connecting the bottom flange of the SRD with the top flange of the SPU to form a SRD/SPU component that comprises at least both an SRD and SPU.

[0030] In another aspect of the invention, the process may include the steps of: (h) connecting the bottom flange of the SRD/SPU to the inline MLP/LMRP to form an inline SRD/SPU/MLP/LMRP; and (i) suspending the inline SRD/SPU/MLP/LMRP upon the drilling vessel in position for deployment through the moon pool.

[0031] In yet another aspect of the invention, the process may include the steps of: (j) positioning a BOP adjacent the floor of the ocean; (k) lowering the inline SRD/SPU/MLP/LMRP to a position above the BOP; and (l) mating the lower side of the LMRP of the inline SRD/SPU/MLP/LMRP with the BOP to form an inline SRD/SPU/MLP/LMRP/BOP.

[0032] In other embodiments, there is disclosed a method, technique or process for deploying drilling equipment through a moon pool of a drilling vessel into the ocean, the process including: (a) suspending a BOP above the moon pool; (b) lowering the BOP through the moon pool into the ocean; (c) subsequently or simultaneously with step (b), suspending a MLP, the MLP having an upper side and a lower side with a first connection mechanism; (d) positioning a LMRP below the MLP, the LMRP having a lower side and an upper side having a second connection mechanism, the second connection mechanism of the LMRP being adapted for mating with the first connection mechanism of the MLP; (e) mating the first connection mechanism with the second connection mechanism to form an equipment combination comprising at least a MLP and a LMRP; and (f) suspending the equipment combination comprising at least a MLP and a LMRP aboard the drilling vessel by engaging the MLP with a holding mechanism that is fixed to the drilling vessel above or adjacent to the moon pool.

[0033] In yet another aspect of the invention, it may be possible to perform the steps of: (g) providing an SPU with a top flange and a bottom flange; (h) providing a SRD with a bottom flange; (i) connecting the bottom flange of the SRD to the top flange of the SPU to form an integrated inline SRD/SPU; and (j) connecting the: (i) bottom flange of the SRD/SPU to the equipment combination comprising at least a MLP and a LMRP to (ii) form an inline SRD/SPU/MLP/LMRP; and (k) suspending the inline SRD/SPU/MLP/LMRP in position for deployment through the moon pool.

[0034] The process may further include: (l) lowering the inline SRD/SPU/MLP/LMRP through the moon pool into the ocean. In other applications, the invention may be practiced by employing the step of: (m) mating the lower side of the LMRP of the inline SRD/SPU/MLP/LMRP with the BOP to form a SRD/SPU/MLP/LMRP/BOP. In some applications, the process may further comprise the step of: (n) activating an H4 subsea connection to secure the BOP to the inline SRD/SPU/MLP/LMRP.

[0035] In other applications, there may be employed a process for deploying drilling equipment through a moon pool of a drilling vessel into the ocean, the process comprising: (a) suspending a BOP above the moon pool; (b) lowering the BOP through the moon pool into the ocean; (c) suspending a MLP, the MLP having an

upper side and a lower side with a first connection mechanism; (d) positioning a LMRP below the MLP, the LMRP having a lower side and an upper side having a second connection mechanism, the second connection mechanism of the LMRP being adapted for mating with the first connection mechanism of the MLP; (e) mating the first connection mechanism with the second connection mechanism to form an equipment combination comprising at least a MLP and a LMRP; (f) suspending the equipment combination comprising at least a MLP and a LMRP aboard the drilling vessel by engaging the MLP with a holding mechanism that is fixed to the drilling vessel above or adjacent to the moon pool; (g) providing an SPU; (h) providing a SRD; forming an inline SRD/SPU/MLP/LMRP combination; (j) suspending the inline SRD/SPU/MLP/LMRP combination in position for deployment through the moon pool; (k) lowering the inline

SRD/SPU/MLP/LMRP through the moon pool into the ocean; and (l) mating the lower side of the LMRP of the inline SRD/SPU/MLP/LMRP with the BOP to form in the ocean a SRD/SPU/MLP/LMRP/BOP.

[0036] In other aspects of the invention, it is feasible to deploy a process that further comprises suspending an equipment combination comprising at least a MLP and a LMRP aboard the drilling vessel by engaging the MLP with a holding mechanism that is fixed to a carriage upon the drilling vessel, wherein the carriage is mounted upon rails, the carriage being adapted for movement along the rails to multiple predetermined positions above the moon pool of the drilling vessel.

BRIEF DESCRIPTION OF THE FIGURES

[0037] The Figures illustrate various aspects of the invention:

Figure 1 illustrates an overall schematic of subsea drilling from a drilling vessel showing a subsea riser extending downwards to an installed integrated inline SRD/SPU/MLP/LMRP/BOP positioned in stacked configuration upon the ocean floor;

Figure 2 shows a BOP;

Figure 3 illustrates a LMRP;

Figure 4 illustrates the flex joint of the LMRP removed from the LMRP to enable viewing of the flex joint;

Figure 5 shows a MLP designed for subsea mudlift drilling applications;

Figure 6 illustrates a SPU;

Figure 7 shows a SRD;

Figure 8 illustrates a riser pipe joint configured for connection of the subsea riser to the SRD;

Figure 9 illustrates an integrated inline MLP/LMRP connected by the flex joint of the LMRP;

Figure 10 shows an integrated inline SRD/SPU/MLP/LMRP connected to a riser pipe joint for deployment into the ocean;

Figure 11 illustrates an integrated inline SRD/SPU/MLP/LMRP being deployed into the ocean from a drilling vessel to a position near a BOP positioned adjacent the ocean floor;

Figure 12 reveals an installed integrated inline SRD/SPU/MLP/LMRP/BOP;

Figures 13-36 show, in one embodiment of the invention, a sequence of events that may occur to deploy the equipment in a manner to form the installed integrated inline SRD/SPU/MLP/LMRP/BOP of **Figure 12**;

Figure 13 shows a BOP being held in position upon a carriage on a drilling vessel with a MLP positioned in a storage location upon the vessel;

Figure 14 illustrates a drill pipe deployed near the top of the BOP, near the aft section of the moon pool, for connection to the BOP;

Figure 15 shows a connected BOP being lifted by the drill pipe upwards; while a carriage is suspended below the BOP;

Figure 16 illustrates the BOP being lowered upon the carriage positioned near the forward portion of the moon pool, while the MLP is being engaged by a transport cable for re-positioning;

Figure 17 shows the release of the BOP by the drill pipe, allowing the BOP to rest upon the carriage in the forward portion of the moon pool, while the MLP is being deployed upwards;

Figure 18 shows the BOP being re-engaged in the forward portion of the moon pool, while the MLP is re-positioned;

Figure 19 reveals the BOP being suspended by the drill pipe so that the carriage may be deployed out from under the BOP, while the MLP is repositioned;

Figure 20 illustrates the BOP being lowered through the moon pool of the drilling vessel;

Figure 21 shows a subsequent step whereby the LMRP is resting upon the vessel and the MLP is deployed to a position near the top of the LMRP to enable connection of the MLP to the LMRP flex joint;

Figure 22 reveals a connected integrated inline MLP/LMRP being raised;

Figure 23 illustrates lateral movement of the integrated inline MLP/LMRP;

Figure 24 shows the integrated inline MLP/LMRP being suspended by a connection mechanism from a carriage on board the vessel attaching to the MLP, allowing the LMRP to remain suspended in air by the flex joint attached to the MLP;

Figure 25 reveals the sequence of steps that are conducted in the upper deck of the vessel to position equipment for connection, including the movement of the SPU on a carriage;

Figure 26 reveals a lift of the SPU from its carriage for downward deployment through the upper deck of the vessel;

Figure 27 shows the SPU having been delivered to a position above an integrated inline MLP/LMRP (not shown), with an SRD being deployed laterally upon the upper deck of the vessel;

Figure 28 reveals the SRD being lowered upon the SPU for connection to the SPU;

Figure 29 shows an integrated SRD/SPU being lowered through the upper deck of the vessel for temporary storage;

Figure 30 shows lateral movement of a riser pipe joint on the upper deck of the vessel;

Figure 31 reveals the suspension of the riser pipe joint to a position above the integrated SRD/SPU to enable connection of the riser pipe joint to the top portion of the SRD;

Figure 32 shows the connected string of riser pipe joint, SRD, and SPU being lifted as a single unit;

Figure 33 illustrates the lowering of the connected string of **Figure 32** to mate with the integrated MLP/LMRP being held upon the carriage;

Figure 34 shows the integrated inline SRD/SPU/MLP/LMRP being raised from the carriage;

Figure 35 illustrates the integrated inline SRD/SPU/MLP/LMRP being lowered from the vessel through the moon pool into the ocean; and

Figure 36 shows an integrated inline SRD/SPU/MLP/LMRP being lowered down from a drilling vessel into the ocean to mate with a BOP near the ocean floor, to form an installed integrated inline SRD/SPU/MLP/LMRP/BOP upon the ocean floor as shown in **Figure 1** and/or **Figure 12**.

DETAILED DESCRIPTION

[0038] For purposes of this disclosure, “dual gradient drilling” or “DGD” refers to a drilling technique employing a seawater-filled return line in a portion of the riser. DGD is a drilling technique designed to address the problem of excess downhole pressures in a wellbore. That is, the significant difference between the pressure of the hydrostatic head of drilling mud in a riser and the pressure of the formation at points adjacent to the mudline presents a challenge. This pressure differential may cause operational difficulties that prevent drilling a well to its target depth using conventional riser return drilling methods. Dual gradient drilling employs a riser filled with seawater, which limits the pressure imbalance. To employ DGD techniques, there is a need to create an interface between the drilling mud in the wellbore (or wellhead) and the seawater in the riser. This interface may be a fluid-fluid interface, located generally above the wellhead in the riser, or may be implemented by employment of a mechanical device such as a subsea rotating diverter (“SRD”) to provide positive isolation of the two fluids.

[0039] One efficient configuration for conducting dual gradient drilling offshore presents an inline configuration with respect to the subsea riser. In that configuration, the MLP rests on the top of the BOP/LMRP stack. To deploy such a system it has been necessary to devise a system for deploying a MLP with the BOP and LMRP and other attached equipment through the moon pool of a drilling vessel to the well head on the floor of the ocean. However, the combined stack of these three components is very tall and extremely heavy. Such a height makes it extremely difficult, if not impossible, to work a full stack of MLP, BOP, and LMRP using hoists upon most

drilling vessels, due to height restrictions. Additionally, the immense weight of such a stack most likely would exceed the hook weight maximum of the hoists/lifting devices presently available on most drilling vessels.

[0040] In the practice of the invention, a deployment procedure and process has been developed to enable the equipment to be secured, connected, and deployed to the wellhead subsea in an efficient manner, without exceeding the weight or height restrictions of the drilling vessel.

[0041] A multiple trip deployment procedure may be employed in which the BOP is lowered to the seabed through the moon pool opening. Then, a combination stack of MLP/LMRP (with other equipment optionally added) may be deployed to the seabed. In some instances, the BOP may be deployed through a first moon pool opening (or from a first drilling assembly), and the combination stack of MLP/LMRP then may then be deployed in another trip to the seabed.

[0042] The BOP typically is deployed by drill pipes, using a threaded pipe connection into the top of the BOP. A hydraulic connector at the bottom of the LMRP may be used to latch or mate the LMRP with the BOP stack once the combination stack of LMRP is placed upon the BOP in the subsea environment.

[0043] In the practice of the invention, using a multiple trip deployment procedure, the MLP may be placed on top of the LMRP aboard the vessel. In conventional operations, for example, it is known to stack a LMRP directly upon a BOP on board a ship before deployment of the combination.

[0044] However, it is believed to be not advisable to securely rest the MLP upon the LMRP while on board the vessel. Other methods have been developed in the practice of the invention, as further described herein.

[0045] It is not advisable, when deploying a MLP on most drilling vessels, to place the MLP on top of the LMRP in a conventional manner, due to the tremendous weight of the MLP (i.e. about 450,000 lbs). This is the case, in part, because the flex joint between the MLP and LMRP would result in the MLP leaning over due to the immense weight, which could cause damage to personnel or equipment.

[0046] Thus, in the practice of the invention, a lifting hoist may be purposely designed and permanently installed above the storage station for handling these two components (MLP and LMRP). This hoist may be used to lift the MLP precisely over the LMRP. While the MLP is suspended, connection may be made between the two components. Then, a crane/hoist may lift the combination stack and move it to a moon pool cart or carriage. The MLP may be placed upon the cart or carriage in such a way that the total weight of this combination stack is supported by the carriage, in which the carriage connects to the MLP, with the LMRP being hung from below the MLP, the MLP being secured to the LMRP by the flex joint. Thus, the LMRP may be suspended with its flex joint connected to the lower margin of the MLP located above, with only the MLP being mechanically supported on the vessel. This design may assist in avoiding the stability problem of the MLP being unable to be directly stacked or rested upon the LMRP while on board the vessel.

[0047] Additionally, it may be useful to employ two or more carts or carriages, one to support the BOP, and another cart for managing and suspending the MLP/LMRP. Or, carriages may be reconfigured to support one or the other, in the course of the operations. Furthermore, additional equipment may be attached on top of the MLP, which may include a SPU and a SRD. It is feasible to provide an integrated design of common riser flanges to enable engagement of SPU and SRD and a riser pipe joint in an inline configuration, as further discussed herein.

[0048] In one aspect of the invention an inline configuration may be achieved on the seabed of the following equipment, from bottom (sea floor) to top: BOP, LMRP, MLP, SPU, SRD, and riser pipe joints extending above these pieces of equipment, the riser extending upwards to the drilling vessel.

[0049] In one application of the invention, a subsea rotating device or rotating control device ("SRD") may be deployed to divert drilling fluids to establish a dual gradient drilling environment. The subsea rotating device (SRD) that may be employed in the system of the invention may be in some respects analogous to a drilling rotating head. It may be the uppermost piece of equipment in the DGD drilling system. It is typically deployed above the mudlift pump (MLP), but its precise placement depends upon the configuration of the well, and the application. The SRD serves to separate

the roughly 8.6 pounds per gallon fluid in the riser from the higher weight density mud in the well, in cases for which dual gradient drilling is to be employed. The SRD assists to prevent gas from entering the riser, and provides a slight pressure on the well (typically less than 50 psi) needed to feed the MLP. By diverting mud returns from the well above the BOP, sizing the cuttings, and pumping to the surface using a specially configured vessel, a dual gradient drilling ("DGD") system may remove a major constraint to drilling at current depths. Such SRD devices are manufactured by various companies in the oil and gas drilling industry, such as Weatherford International and others.

[0050] A solids processing apparatus ("SPU") may be connected to the upper surface of the MLP. The SPU, in one embodiment, provides a central cavity, the central cavity being positioned inline with the riser and SRD and adapted for receiving drilled solids into its central cavity. The SPU is configured for reducing the particle size of the drilled solids to form processed solids. The solids processing apparatus, in one embodiment of the invention, includes a pressure rating at least as great as the pressure rating of the drilling riser. In one embodiment of the invention, a SPU similar to that disclosed in US Patent Publication No. 20120080186 A1 to Larry Reed may be employed, although other configurations could be deployed as well.

[0051] Mudlift pumps (MLP) for dual gradient drilling are disclosed, for example, in U.S. Patent No. 6,102,673 (Mott et al.) and U.S. Patent No. 6,325,159 (Peterman et al.). These references disclose positive displacement pumps powered by a fluid drive (such as seawater).

[0052] It should be noted that the invention disclosed herein may be employed with dual gradient drilling, but the invention is not necessarily limited to use in dual gradient drilling. The deployment process and techniques may be applied to other heavy and bulky equipment that is to be linked and suspended through a moon pool of a drillship to form a stack of equipment upon the floor of a body of water, or on the floor of the ocean.

[0053] As used in this specification, the term "inline" or "in-line" refers generally to the positioning of a component within a drill string as a component of the drill string and in

line with a subsea riser, as opposed to a position detached (or only remotely connected) to the drill string.

[0054] Referring to **Figure 1**, an inline SRD/SPU/MLP/LMRP/BOP **72** is shown installed upon the sea floor **30**, below and connected to a drilling vessel **21**. Riser **22** extends through moon pool **49** (not seen in **Figure 1**) into the ocean below the drilling vessel **21**, and provides a riser pipe joint **23** that is connected to SRD **24**. Below and connected to the SRD **24** is SPU **25**, that is mated to MLP **26**. Connected to MLP **26** is LMRP **27**, resting upon and fluidly connected to BOP **28**. BOP **28** rests upon well head **29** at a position that is adjacent to sea floor **30**.

[0055] To build inline SRD/SPU/MLP/LMRP/BOP **72** upon the sea floor **30**, many various techniques may be employed, including those described and claimed herein, and other techniques within the spirit and scope of those disclosed herein.

[0056] **Figure 2** reveals a BOP **28**, similar to many that are commercially available in the subsea drilling industry. BOP **28** comprises an upper side **31** and a lower side **32** and a well head connector **53**. **Figure 3** shows LMRP **27** having an upper side **37** and a lower side **38**. A connection mechanism **36** extends from the upper side **37**, and a connector **46** extends from the lower side of the LMRP **27**. The connector **46** may be of the type that is known in the industry as a hydraulic H4 connector that is adapted for making a connection in a subsea environment, such as, for example, those known in the industry manufactured and distributed by General Electric Hydril of Houston, Texas. **Figure 4** shows in greater detail the connection mechanism **36**, which in this particular embodiment is a flex joint type of connector that has been removed from LMRP **27** and shown separately for illustrative purposes.

[0057] **Figure 5** illustrates MLP **26**, having an upper side **43** and a lower side **44**. **Figure 6** shows more detail of SPU **25** having top flange **39** and bottom flange **40**, each of which is adapted for making secure and robust connections inline and in fluid communication with riser **22** (shown in **Figure 1**). **Figure 7** reveals SRD **24**, having top flange **41** and bottom flange **42**. Riser pipe joint **23** is shown in **Figure 8**. **Figure 9** illustrates an integrated inline MLP/LMRP **70**, in which connection mechanism **35** of the MLP **26** has been mated with connection mechanism **36** of LMRP **27** near the lower side **44** of the MLP **26**. Top side **43** of the MLP **26** is seen near the top of

Figure 9. LMRP 27 comprises connector 46, shown near the lower portion of **Figure 9.**

[0058]**Figure 10** illustrates an integrated inline SRD/SPU/MLP/LMRP 71, as further discussed herein, and comprising: riser pipe joint 23, SRD 24, SPU 25, MLP 26, and LMRP 27 connected in one continuous string of hardware. Connector 46 is positioned near the lower portion of LMRP 27, and is configured for mating with BOP 28 (see **Figure 1**). Other subsea configurations of equipment needed to conduct dual gradient drilling are possible, and such other configurations may be contemplated by the spirit and breadth of this disclosure. **Figure 11** shows the deployment from drilling vessel 21 of the integrated inline SRD/SPU/MLP/LMRP 71 as disclosed in **Figure 10**, nearing a position to mate with BOP 28 positioned upon well head 29 adjacent sea floor 30, and as further described herein. Components as described with reference to **Figure 10** are seen as well in **Figure 11**. **Figure 12** shows integrated inline SRD/SPU/MLP/LMRP 71 after having been mated with BOP 28 to form inline SRD/SPU/MLP/LMRP/BOP 72, in position for drilling in connection with dual gradient drilling (DGD) operations.

[0059]Various steps may be taken to generate upon the ocean floor form inline SRD/SPU/MLP/LMRP/BOP 72. This disclosure illustrates certain techniques that have been discovered as useful and workable for conducting such deployment from drilling vessel 21. However, other means of forming inline SRD/SPU/MLP/LMRP/BOP 72 may be evident from review of the disclosure and techniques described herein, and are within the scope of this invention.

[0060]In one embodiment, a BOP may be deployed first into the ocean. For example, with reference to **Figure 13**, BOP 28 may be held aboard vessel 21 by a holding mechanism 59 upon carriage 52 running on rails 50, 51. MLP 26 may be seen in **Figure 13** in a holding area. **Figure 14** illustrates a drill pipe 54 extending down from the aft portion of vessel 21 above BOP 28 and also above moon pool 49 (moon pool 49 is below **Figure 14** and is not seen in **Figure 14**).

[0061]**Figure 15** shows a point later in time in which the BOP 28 has been lifted by drill pipe 54, facilitating movement of BOP 28. Also, carriage 52 has moved to a position beneath the BOP 28.

[0062] In **Figure 16**, one can see the BOP **28** rested upon carriage **52** to a forward position above moon pool **49**. In **Figure 17**, drill pipe **58** extends to connect to BOP **28**. Then, in **Figures 18-20** BOP is deployed with drill pipe **58** to through moon pool **49** to the ocean.

[0063] **Figures 21-24** shows one embodiment in which MLP **26** is first mated with LMRP **27** and then suspended in position above moon pool **49**. First, conveyance line(s) **56** move the MLP **26** from its position of storage to a position above LMRP **27**. Then, while held in position, MLP **26** may be manually secured by connection mechanism **36** to LMRP **27**. Connection mechanism **36** may comprise a flex joint, as one example, although other means of connection could be employed. One feature of this sequence of steps is that the LMRP **27** is not made to support the full weight of the MLP **26** while on board the ship, which could cause failure of the flex joint and/or instability of components of great weight and bulk. **Figure 23** shows a connected and integrated inline MLP/LMRP **70** being moved laterally aboard the ship by conveyance line(s) **56**. **Figure 24** shows a resting position of the integrated inline MLP/LMRP **70** being held by holding mechanism **59**. In this configuration, the MLP **26** is being held and supported by holding mechanism **59** connected to carriage **52**, such that LMRP **27** and its flex joint (connection mechanism **36**) are not supporting the massive weight of the MLP **26**. Instead, the LMRP **27** is suspended by connection mechanism **36** to the MLP **26**. MLP **26** is being held in position. Rails **50, 51** and carriage **52** support the massive weight of both the MLP **26** and the LMRP **27** in this manner.

[0064] Once the integrated inline MLP/LMRP **70** is suspended, there are several options. Numerous methods may be devised for securing the remaining components (riser pipe joint **23**, SRD **24**, SPU **25**) in position and in fluid connection with the riser. For purposes of this disclosure, examples are provided, but the invention herein is not limited to only those examples illustrated herein.

[0065] In one example, it would be possible to make up flanged connections of riser pipe joint **23**, SRD **24**, SPU **25** at a position aboard drilling vessel **21** and above carriage **52**, i.e. above the suspended integrated inline MLP/LMRP **70**. This could occur, in one embodiment, on and/or through an upper deck of drilling vessel **21**.

Figures 26-35 show one example of how such a connection could be accomplished in an efficient manner.

[0066] **Figure 25** shows a holding mechanism **61** mounted upon and through deck **60**. The holding mechanism **61**, in one embodiment, could be mounted on the vessel **21** at a position well above the suspended integrated inline MLP/LMRP **70** shown in **Figure 26**. SPU **25** may be conveyed upon traveling cart **62** to a position adjacent holding mechanism **61**, and raised by lift **66** to a vertical position for downward entry into holding mechanism **61**. Then, SPU **25** may be suspended in holding mechanism **61** for that SRD **24** may likewise be raised from its traveling cart **63** (**Figure 27**) by lift **61** and applied to holding mechanism **61** as shown in **Figures 27-28**. The SRD **24** may be bolted/flanged upon SPU **25**, and the assembly lowered for temporary suspension in holding mechanism **61**, as shown in **Figures 29-30**. In a similar manner, riser pipe joint **23** may be raised from traveling cart **64** by lift **66** and flanged to the top of the SRD **24**, thus extending the string. **Figure 31** illustrates how this procedure may be employed to form a string of riser joint/SRD/SPU that is temporarily suspended in holding mechanism **61**. Or alternatively, once the string is flanged and ready, the riser joint/SRD/SPU **74** may be lowered through holding mechanism **61**, below the deck **60**, and applied to the upper side **43** of the MLP **26** as shown in **Figure 33**. Then, flange connections may be made to connect the riser joint/SRD/SPU **74** to the integrated inline MLP/LMRP **70**, thereby forming an integrated inline SRD/SPU/MLP/LMRP **71** that extends from a position below rails **50**, **51** above moon pool **49** all the way upwards through deck and through holding mechanism **61**.

[0067] Once the integrated inline SRD/SPU/MLP/LMRP **71** is fully connected and ready for deployment, it may be hoisted/lifted (after disconnect of holding mechanism **59**) and deployed through the moon pool **49** of vessel **21** into the waters of the ocean, as seen in **Figure 36**. Once delivered to a position near the seabed, the integrated inline SRD/SPU/MLP/LMRP **71** may be mated with a BOP **28** that has been positioned to receive and latch upon integrated inline SRD/SPU/MLP/LMRP **71**, thereby forming upon the sea floor **30** a fully assembled installed inline SRD/SPU/MLP/LMRP/BOP **72**.

[0068] In its broad application, the invention may include a process for connection and deployment of drilling equipment through a moon pool of a drilling vessel. A process is disclosed for suspending a first device, then suspending a second device below the first device, connecting the first and second device to form a connected pair, and then suspending the connected pair by holding the first device with a holding mechanism. Later, one or more devices may be connected, and then further connections may optionally be performed prior to deployment to the ocean. As one application, a subsea production manifold could be employed as the first device, in which the manifold is subsequently connected subsea for collecting production from one or more subsea wells and then sending the produced hydrocarbons to another location, such as an FPSO vessel. Thus, the process could be used to allow the stacking of a manifold subsea, in which stacking (with adverse gravitational forces upon the equipment) is not required upon the vessel prior to deployment of the connected equipment into the ocean.

[0069] Other examples and embodiments of the invention are contemplated by this disclosure, even if not set forth expressly herein, and the invention is not intended to be limited to only those specific examples and embodiments and techniques shown expressly herein, but also contemplates other similar techniques and processes within the general spirit and scope of the overall disclosure herein.

CLAIMS

We claim:

1. A process for deployment of drilling equipment through a moon pool of a drilling vessel, the process comprising:
 - (a) suspending a MLP, the MLP having an upper side and a lower side having a first connection mechanism;
 - (b) positioning a LMRP below the MLP, the LMRP having a lower side and an upper side having a second connection mechanism, the second connection mechanism of the LMRP being adapted for mating with the first connection mechanism of the MLP;
 - (c) mating the first connection mechanism with the second connection mechanism to form an inline MLP/LMRP; and
 - (d) suspending the inline MLP/LMRP by a holding mechanism that is fixed to the drilling vessel, the holding mechanism being reversibly attached to the MLP, the inline MLP/LMRP being suspended above the moon pool of the drilling vessel.
2. The process of claim 1 further comprising the steps of:
 - (e) providing an SPU with a top flange and a bottom flange;
 - (f) connecting the bottom flange of the SPU to the upper side of the MLP to form an inline SPU/MLP/LMRP; and
 - (g) suspending the inline SPU/MLP/LMRP in position for deployment through the moon pool.
3. The process of claim 1 further comprising the steps of:
 - (e) providing an SPU with a top flange and a bottom flange;
 - (f) providing an SRD with a bottom flange; and
 - (g) connecting the bottom flange of the SRD with the top flange of the SPU to form a SRD/SPU component that comprises at least both an SRD and SPU.
4. The process of claim 3, further comprising the steps of:

- (h) connecting the bottom flange of the SRD/SPU to the inline MLP/LMRP to form an inline SRD/SPU/MLP/LMRP; and
- (i) suspending the inline SRD/SPU/MLP/LMRP upon the drilling vessel in position for deployment through the moon pool.

5. The process of claim 4 further comprising the step of:

- (j) positioning a BOP adjacent the floor of the ocean;
- (k) lowering the inline SRD/SPU/MLP/LMRP to a position above the BOP; and
- (l) mating the lower side of the LMRP of the inline SRD/SPU/MLP/LMRP with the BOP to form an inline SRD/SPU/MLP/LMRP/BOP.

6. A process for deploying drilling equipment through a moon pool of a drilling vessel into the ocean, the process comprising:

- (a) suspending a BOP above the moon pool;
- (b) lowering the BOP through the moon pool into the ocean;
- (c) subsequently or simultaneously with step (b), suspending a MLP, the MLP having an upper side and a lower side with a first connection mechanism;
- (d) positioning a LMRP below the MLP, the LMRP having a lower side and an upper side having a second connection mechanism, the second connection mechanism of the LMRP being adapted for mating with the first connection mechanism of the MLP;
- (e) mating the first connection mechanism with the second connection mechanism to form an equipment combination comprising at least a MLP and a LMRP; and
- (f) suspending the equipment combination comprising at least a MLP and a LMRP aboard the drilling vessel by engaging the MLP with a holding mechanism that is fixed to the drilling vessel above or adjacent to the moon pool.

7. The process of claim 6 further comprising the steps of:
 - (g) providing an SPU with a top flange and a bottom flange;
 - (h) providing a SRD with a bottom flange;
 - (i) connecting the bottom flange of the SRD to the top flange of the SPU to form an integrated inline SRD/SPU; and
 - (j) connecting the:
 - (k) bottom flange of the SRD/SPU to the equipment combination comprising at least a MLP and a LMRP to
 - (l) form an inline SRD/SPU/MLP/LMRP; and
 - (m) suspending the inline SRD/SPU/MLP/LMRP in position for deployment through the moon pool.
8. The process of claim 7 further comprising the step of:
 - (l) lowering the inline SRD/SPU/MLP/LMRP through the moon pool into the ocean.
9. The process of claim 8 further comprising the step of:
 - (m) mating the lower side of the LMRP of the inline SRD/SPU/MLP/LMRP with the BOP to form a SRD/SPU/MLP/LMRP/BOP.
10. The process of claim 8 further comprising the step of:
 - (n) activating an H4 subsea connection to secure the BOP to the inline SRD/SPU/MLP/LMRP.
11. A process for deploying drilling equipment through a moon pool of a drilling vessel into the ocean, the process comprising:
 - (g) suspending a BOP above the moon pool;
 - (h) lowering the BOP through the moon pool into the ocean;
 - (i) suspending a MLP, the MLP having an upper side and a lower side with a first connection mechanism;
 - (j) positioning a LMRP below the MLP, the LMRP having a lower side and an upper side having a second connection mechanism, the second connection

mechanism of the LMRP being adapted for mating with the first connection mechanism of the MLP;

(k) mating the first connection mechanism with the second connection mechanism to form an equipment combination comprising at least a MLP and a LMRP;

(l) suspending the equipment combination comprising at least a MLP and a LMRP aboard the drilling vessel by engaging the MLP with a holding mechanism that is fixed to the drilling vessel above or adjacent to the moon pool;

(m) providing an SPU;

(n) providing a SRD;

(o) forming an inline SRD/SPU/MLP/LMRP combination; and

(p) suspending the inline SRD/SPU/MLP/LMRP combination in position for deployment through the moon pool;

(q) lowering the inline SRD/SPU/MLP/LMRP through the moon pool into the ocean; and

(r) mating the lower side of the LMRP of the inline SRD/SPU/MLP/LMRP with the BOP to form in the ocean a SRD/SPU/MLP/LMRP/BOP.

12. The process of claim 11 wherein step (f) further comprises suspending the equipment combination comprising at least a MLP and a LMRP aboard the drilling vessel by engaging the MLP with a holding mechanism that is fixed to a carriage upon the drilling vessel, wherein the carriage is mounted upon rails, the carriage being adapted for movement along the rails to multiple predetermined positions above the moon pool of the drilling vessel.

13. A process for deployment of drilling equipment through a moon pool of a drilling vessel, the process comprising:

suspending a first device above a moon pool;

suspending a second device below the first device;

connecting the first device to the second device to form a connected pair; and

suspending the connected pair with a holding mechanism attached to the first device.

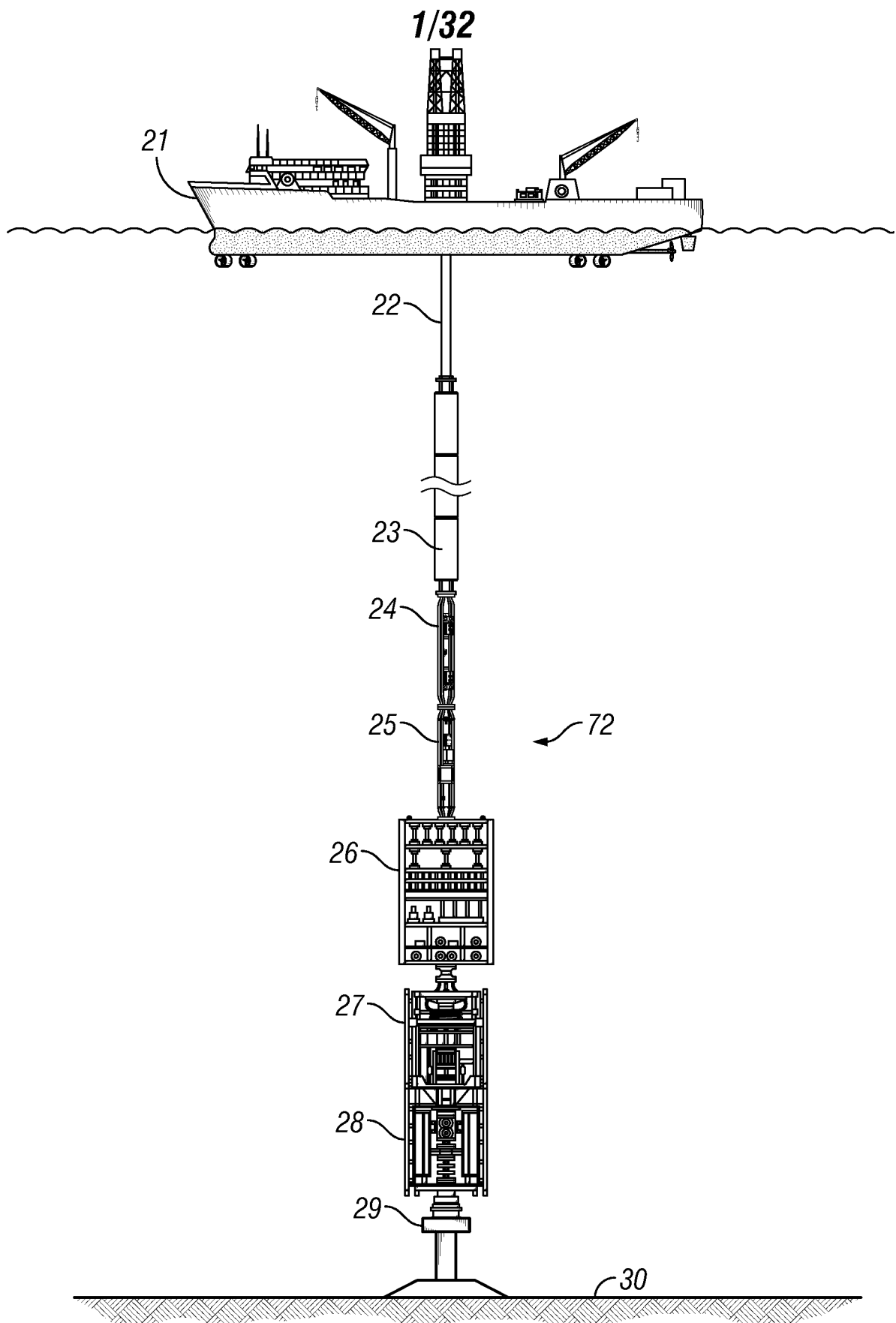


FIG. 1

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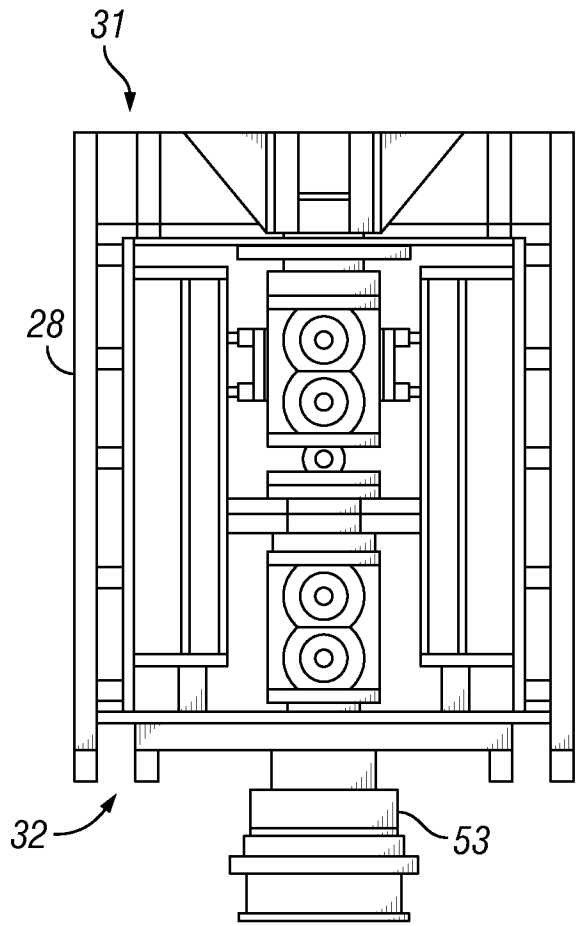


FIG. 2

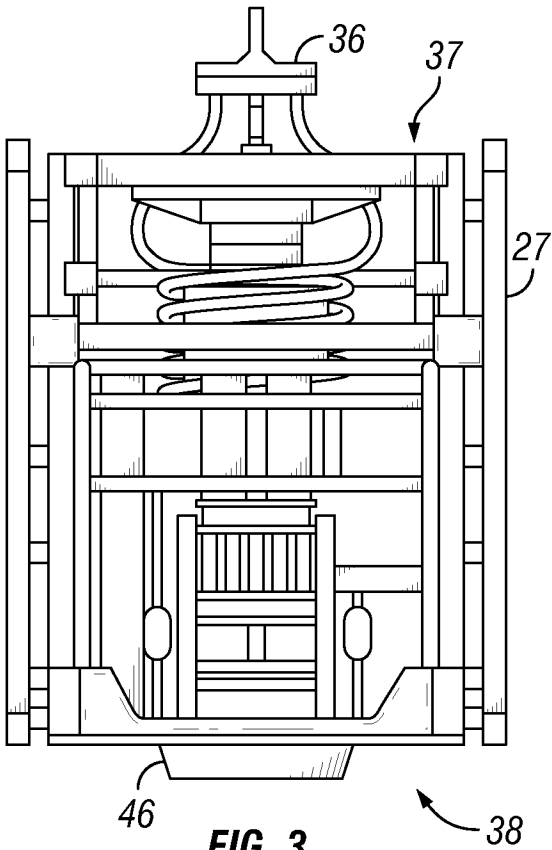


FIG. 3

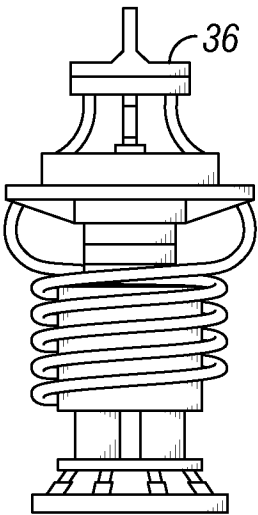


FIG. 4

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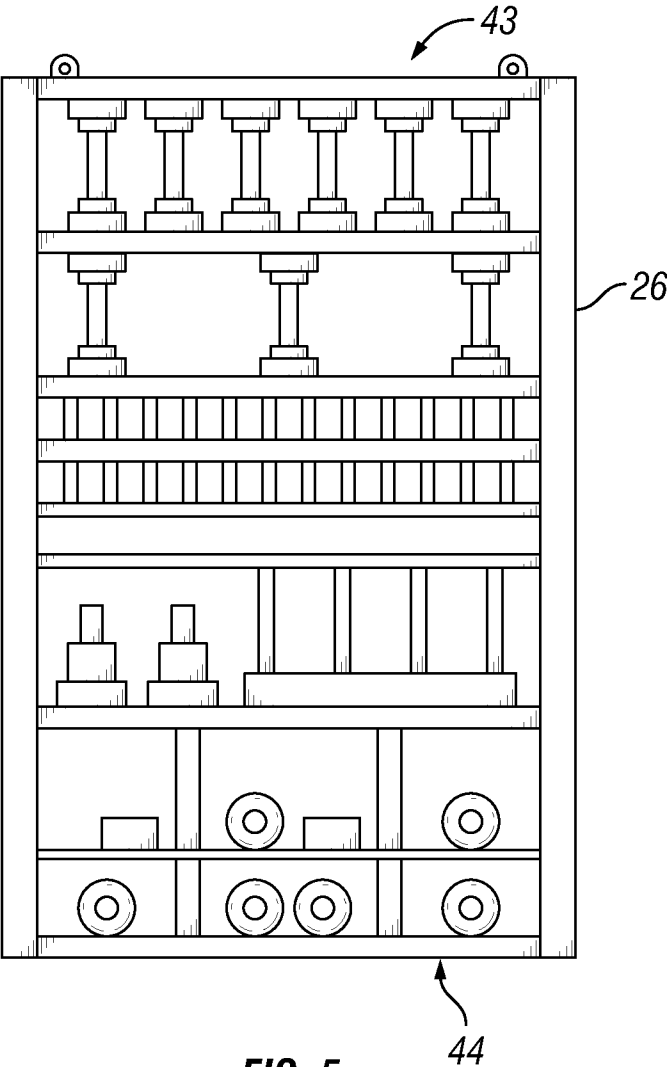


FIG. 5

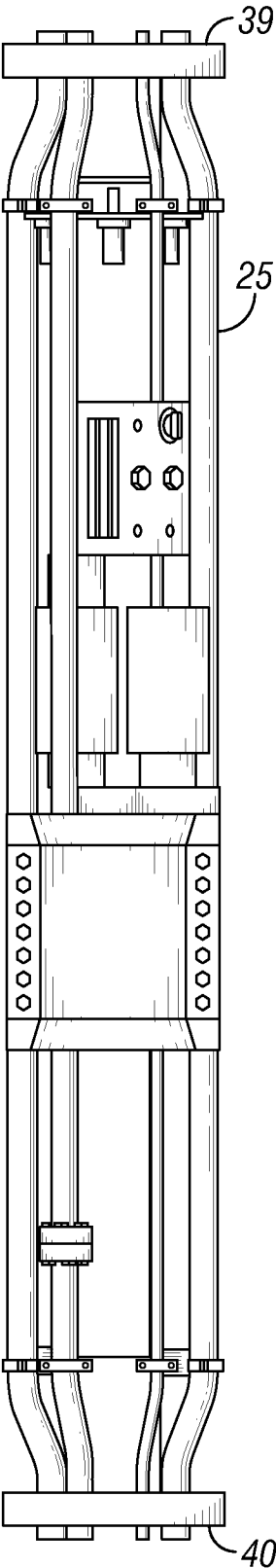


FIG. 6

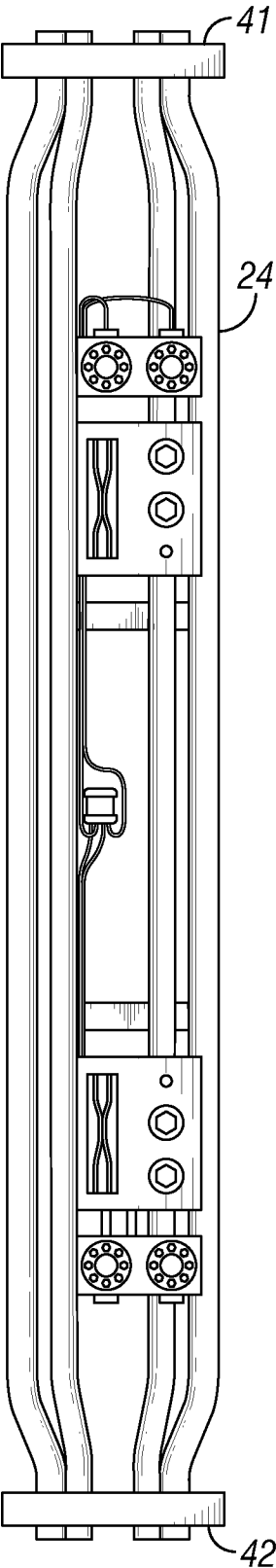


FIG. 7

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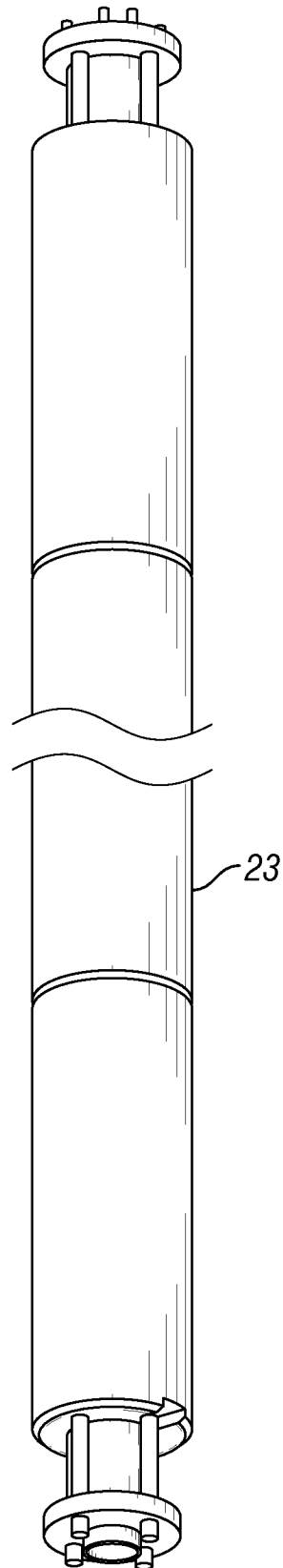


FIG. 8

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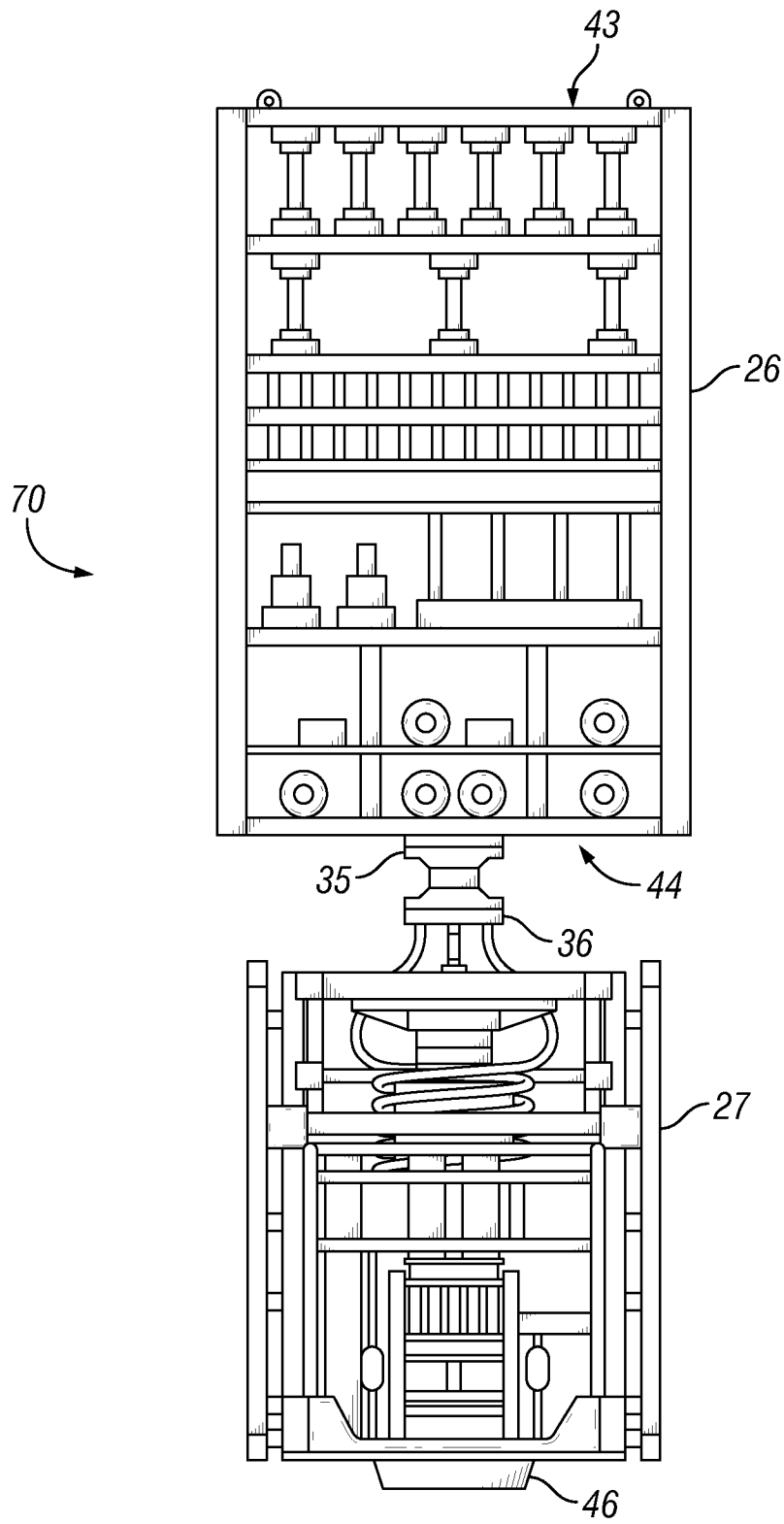


FIG. 9

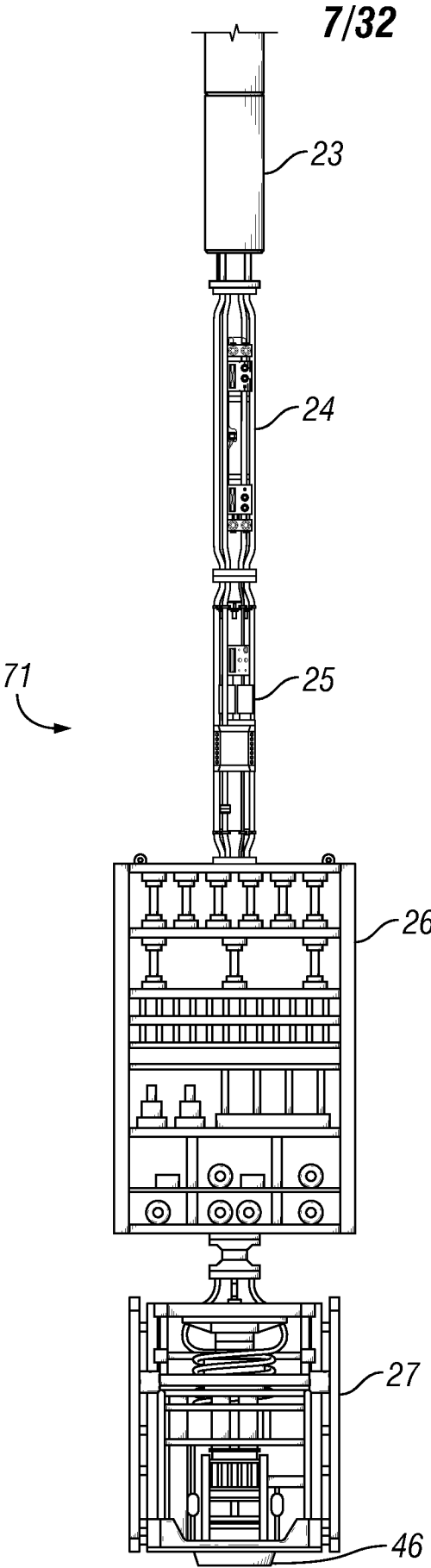
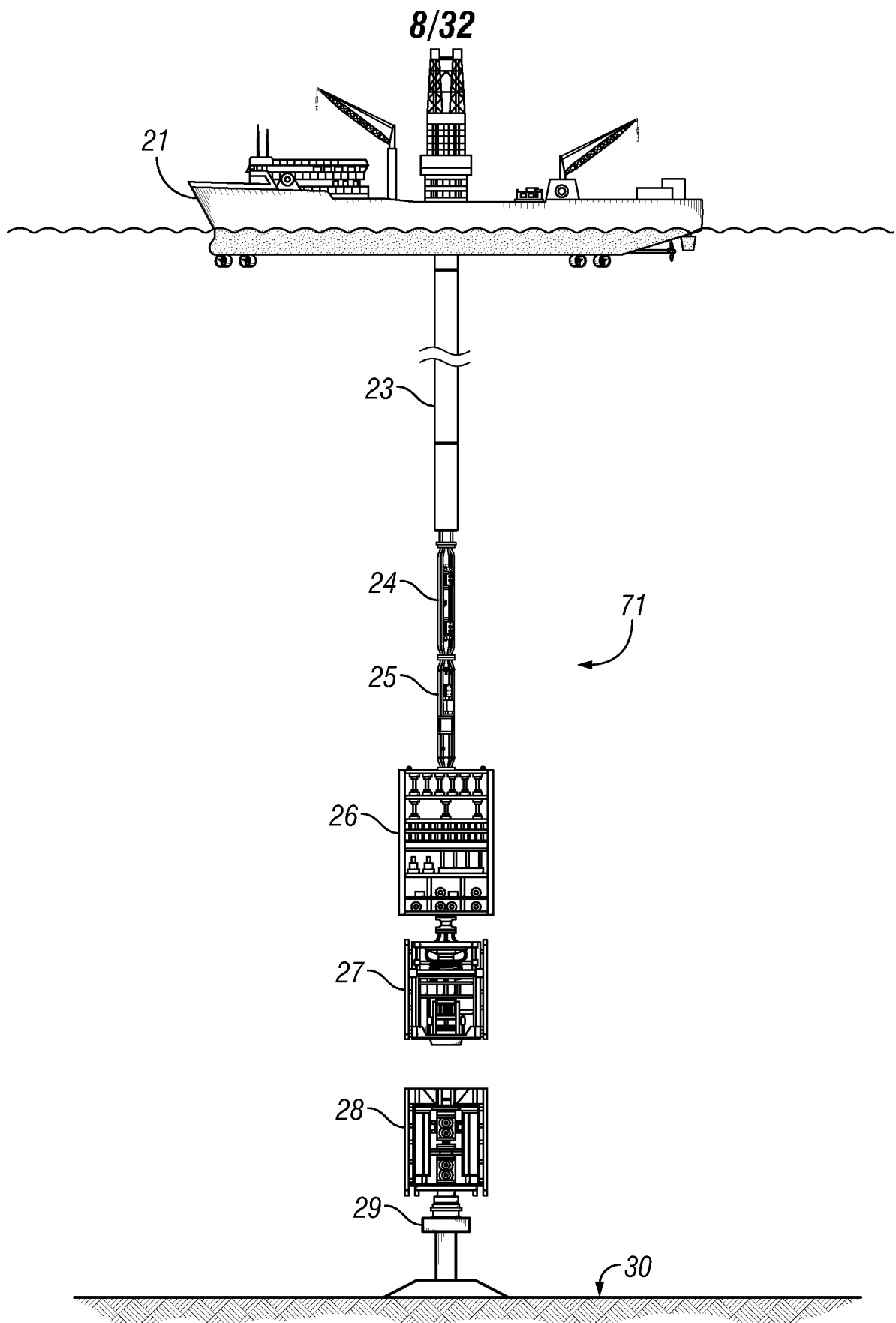


FIG. 10

**FIG. 11**

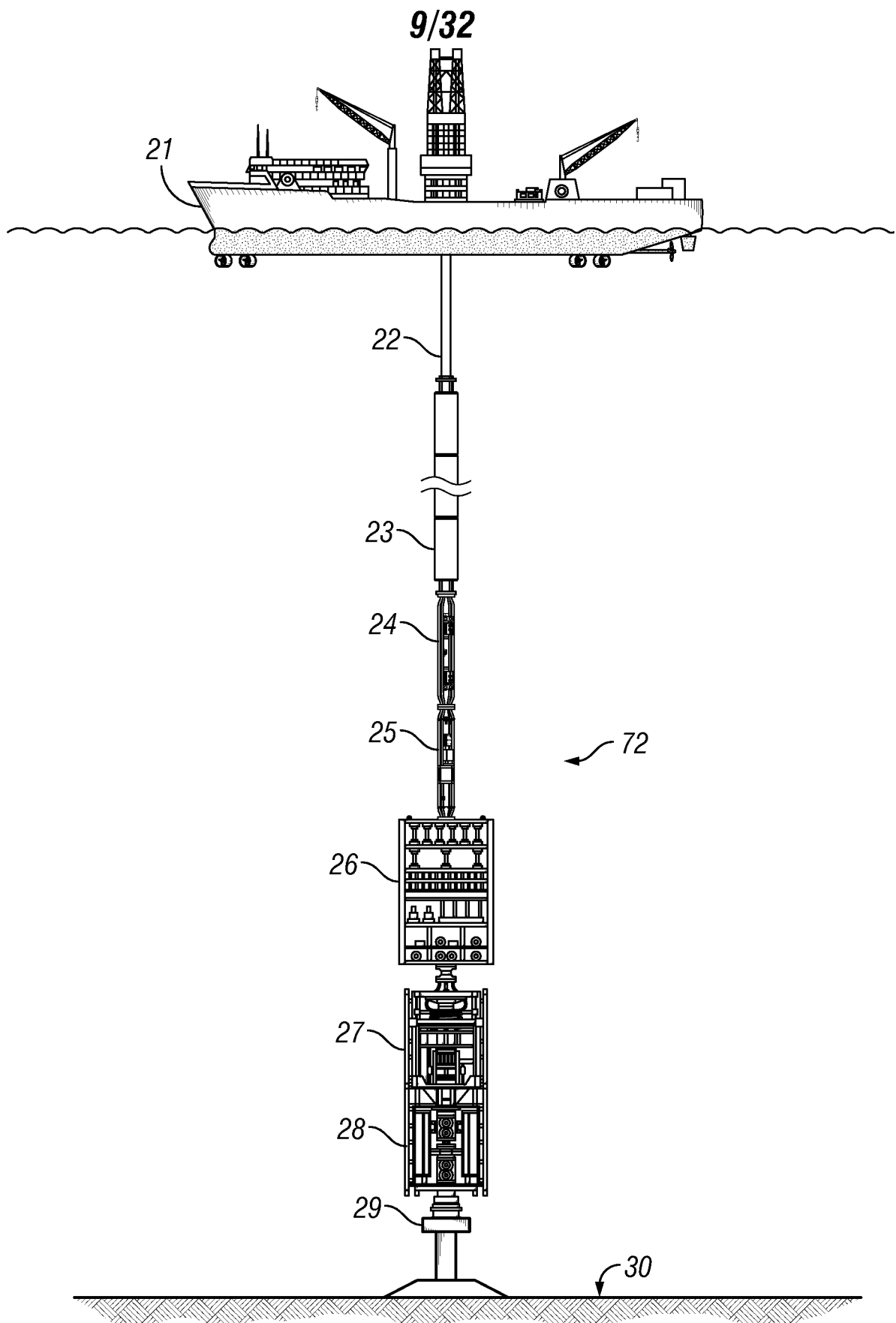


FIG. 12

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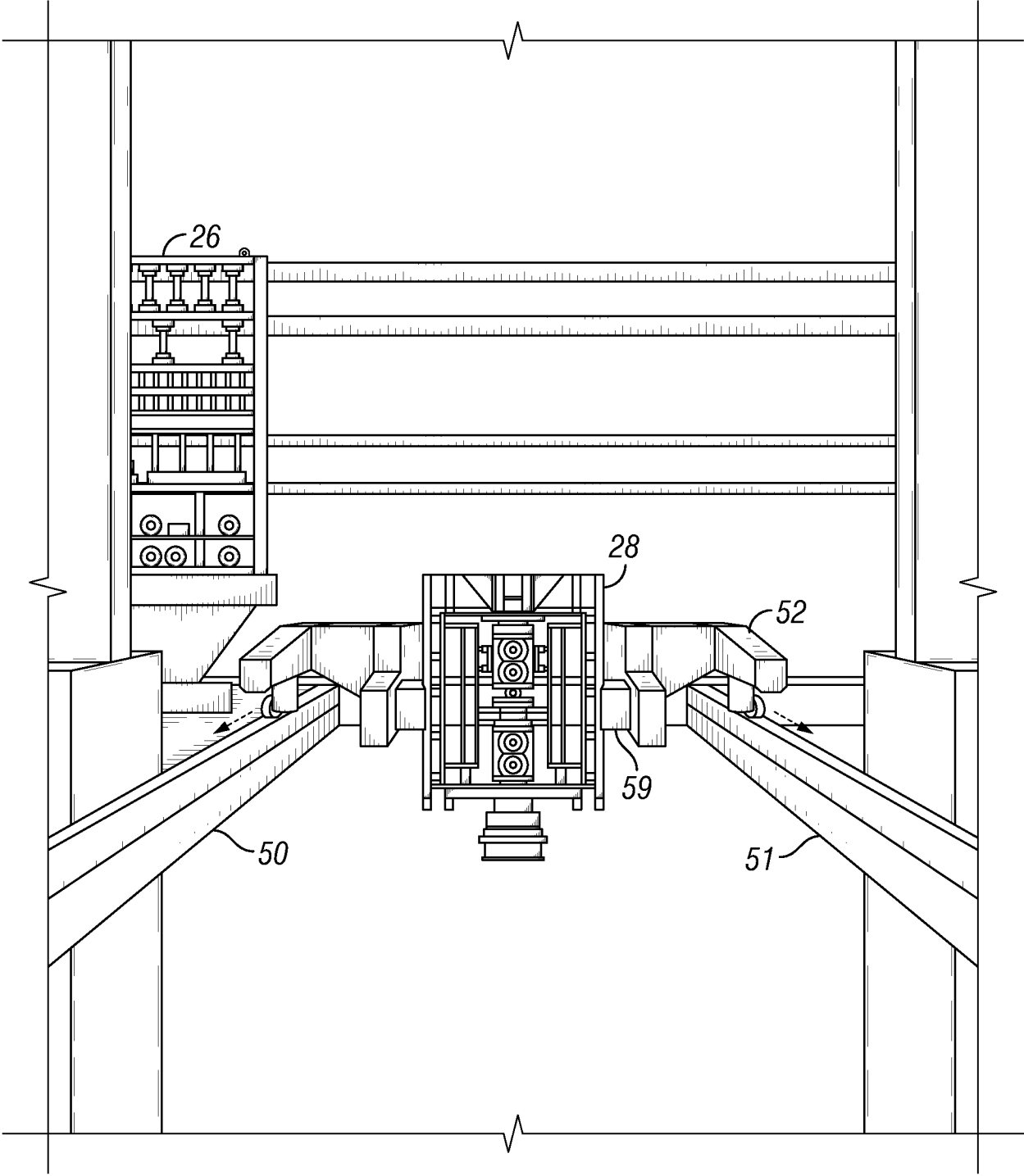


FIG. 13

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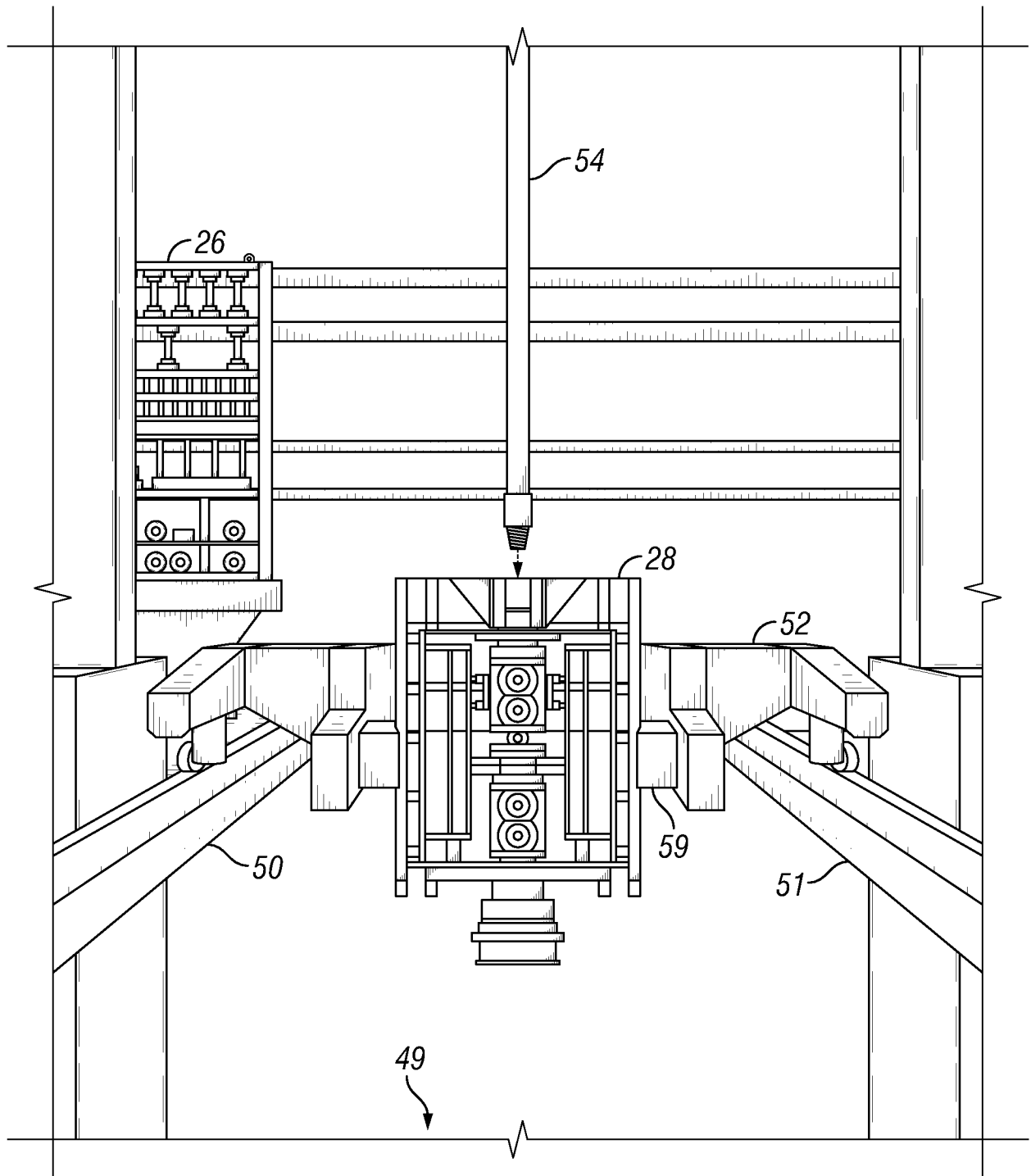


FIG. 14

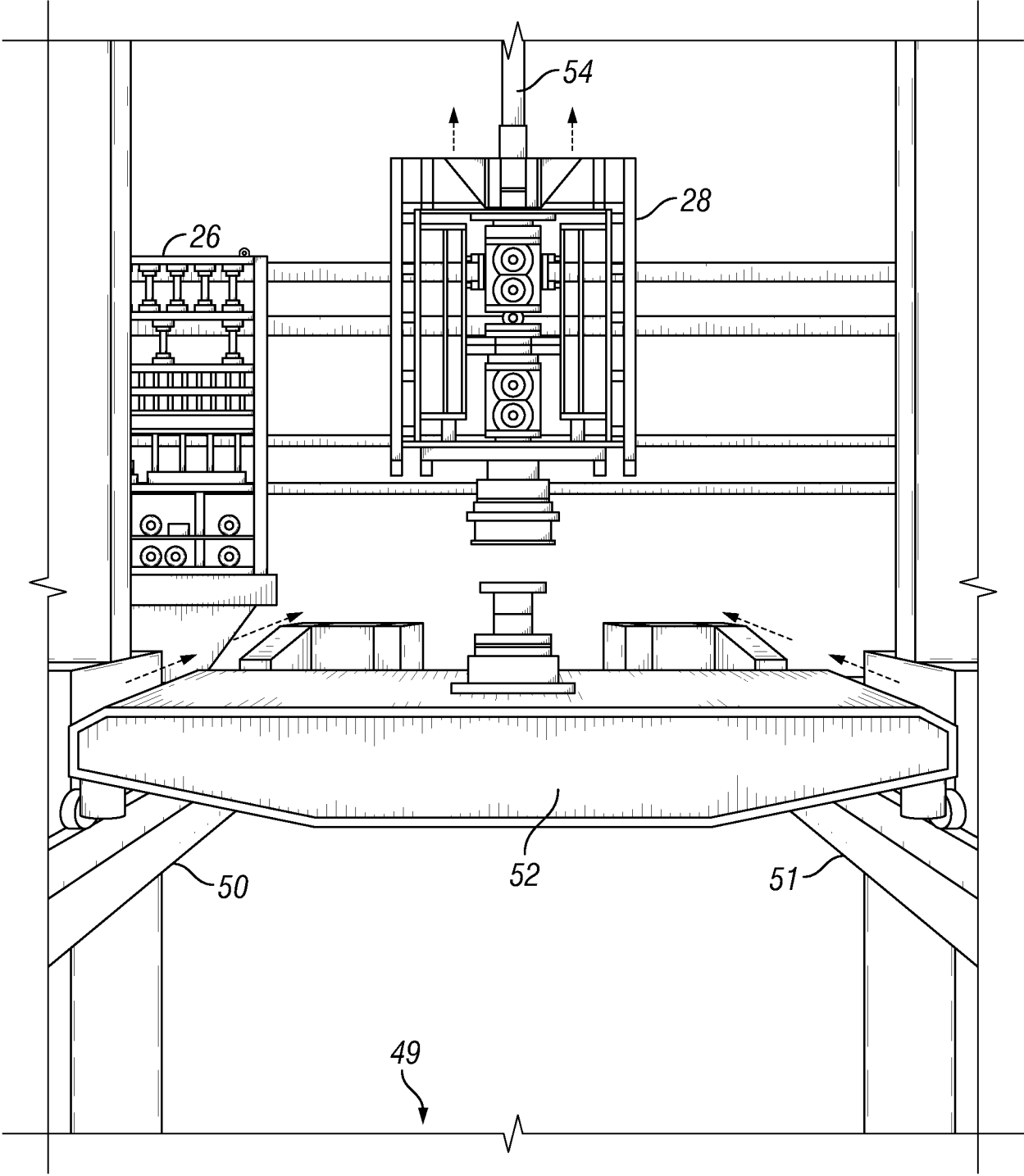


FIG. 15

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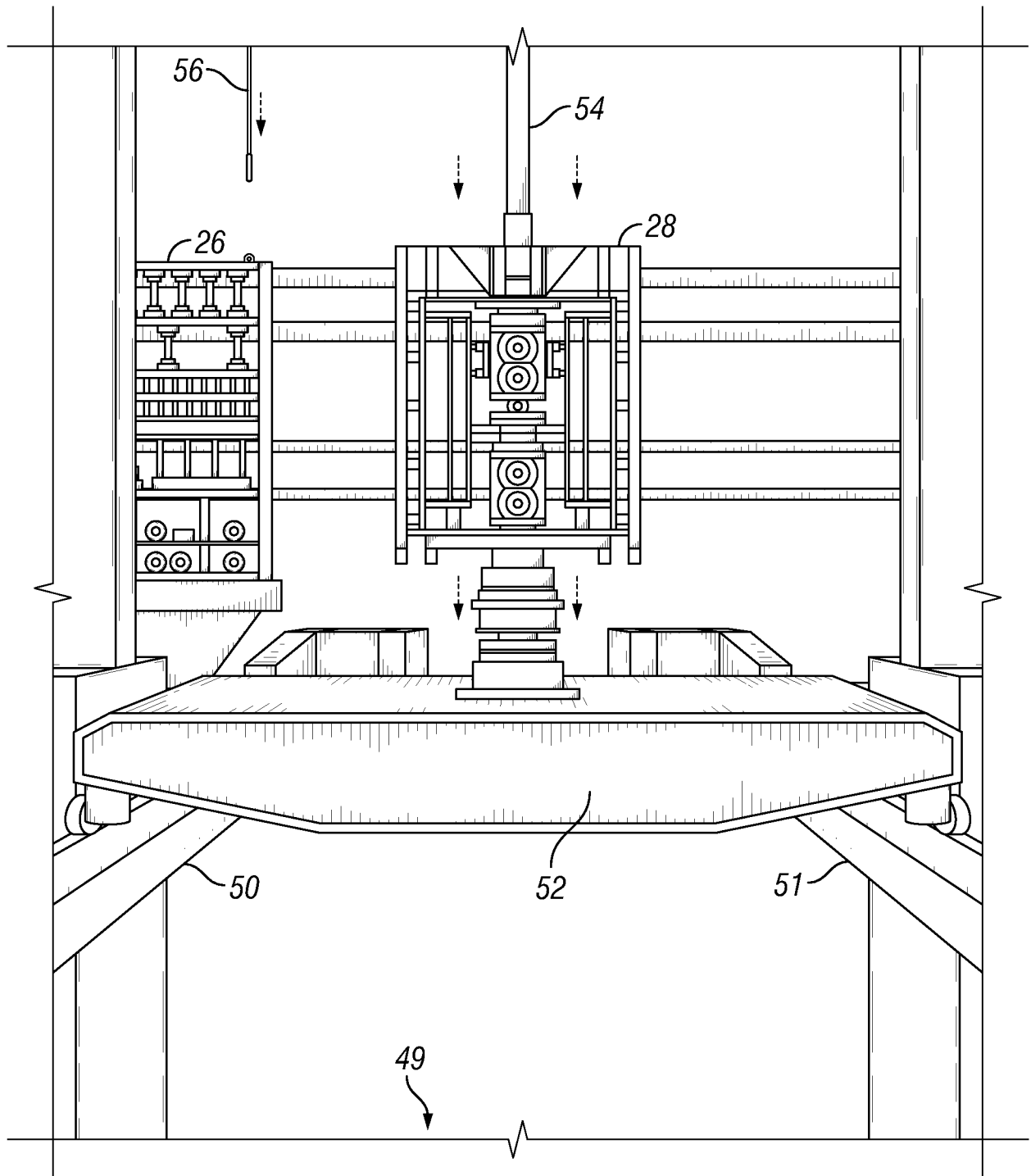


FIG. 16

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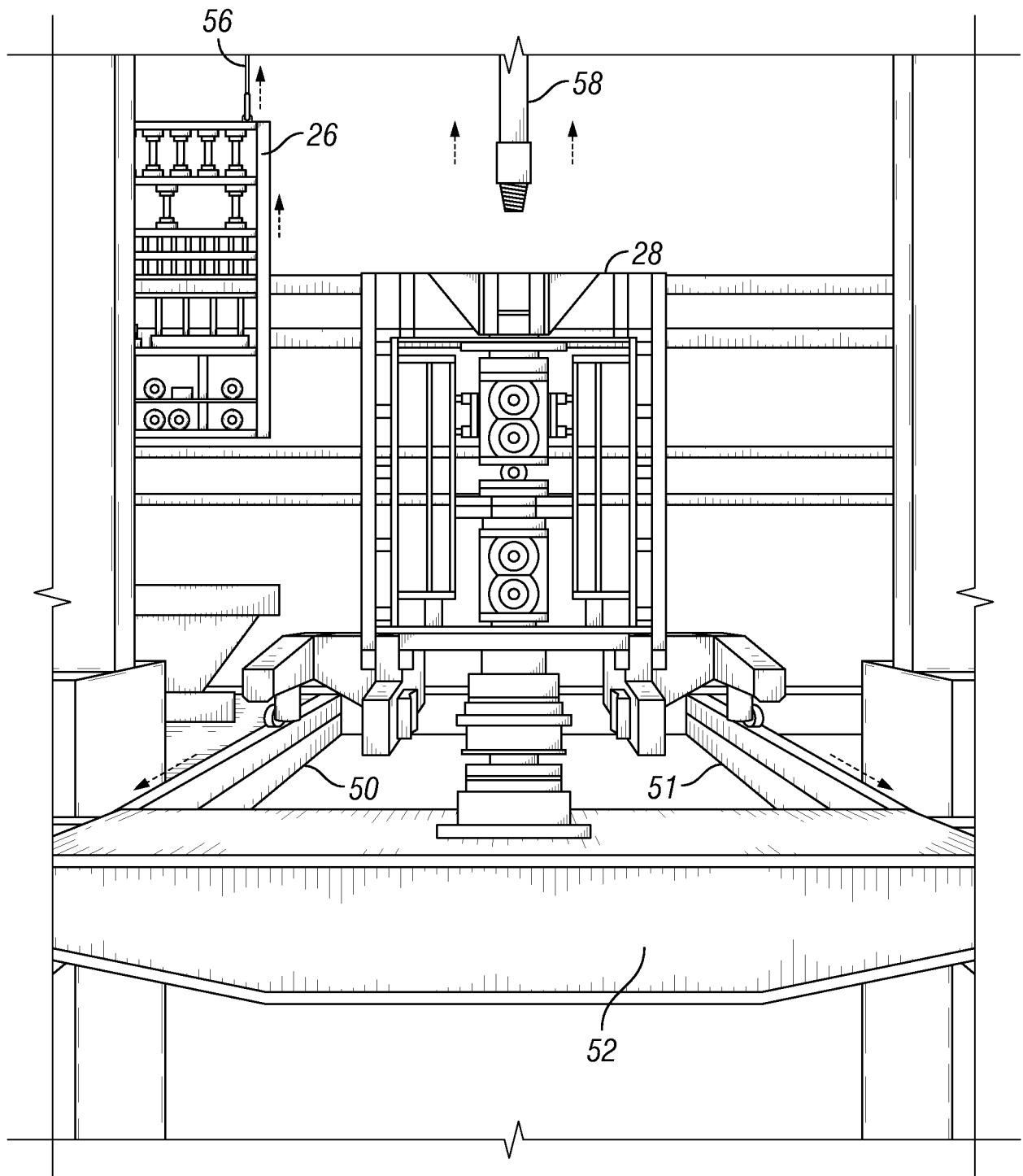


FIG. 17

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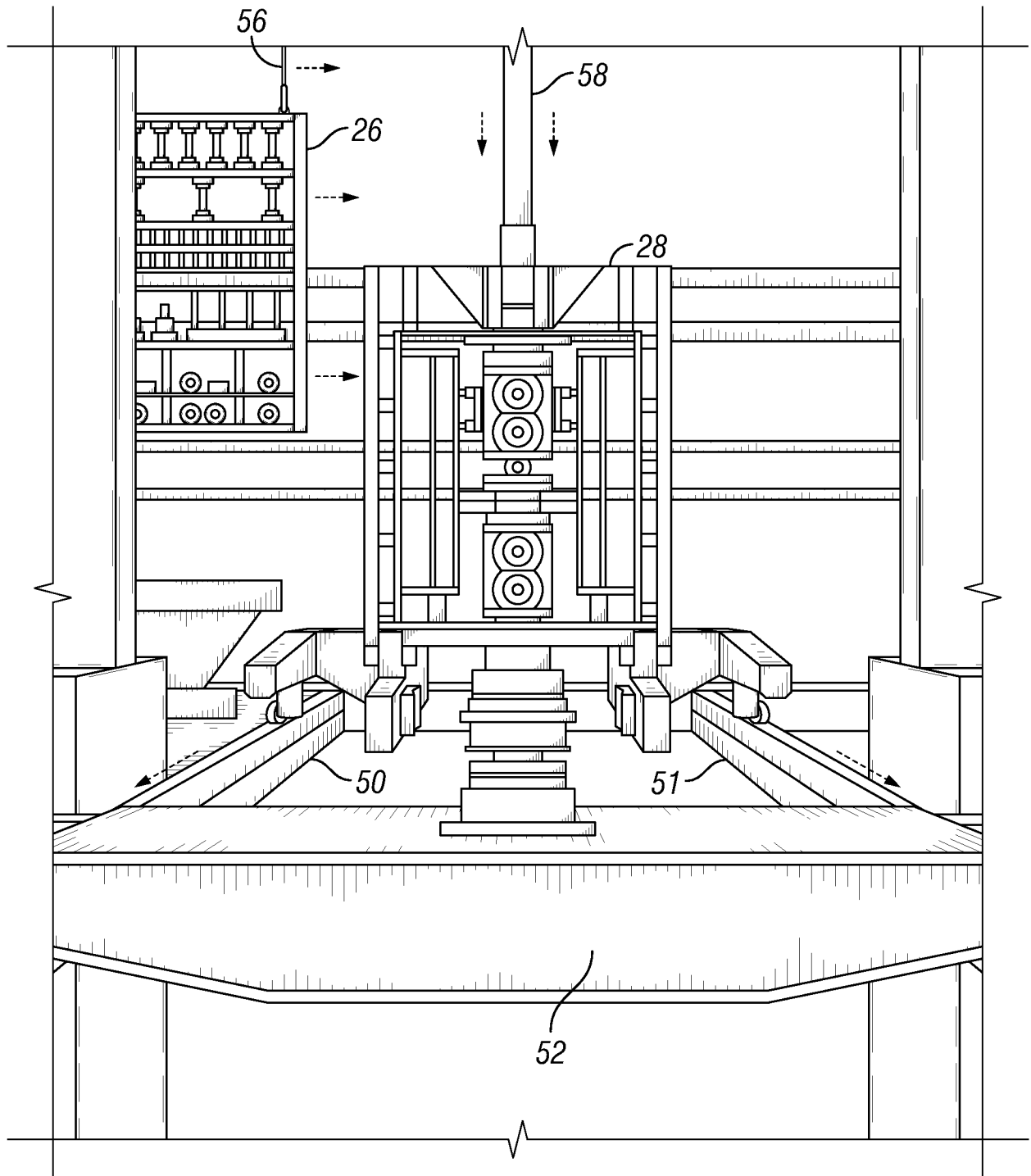


FIG. 18

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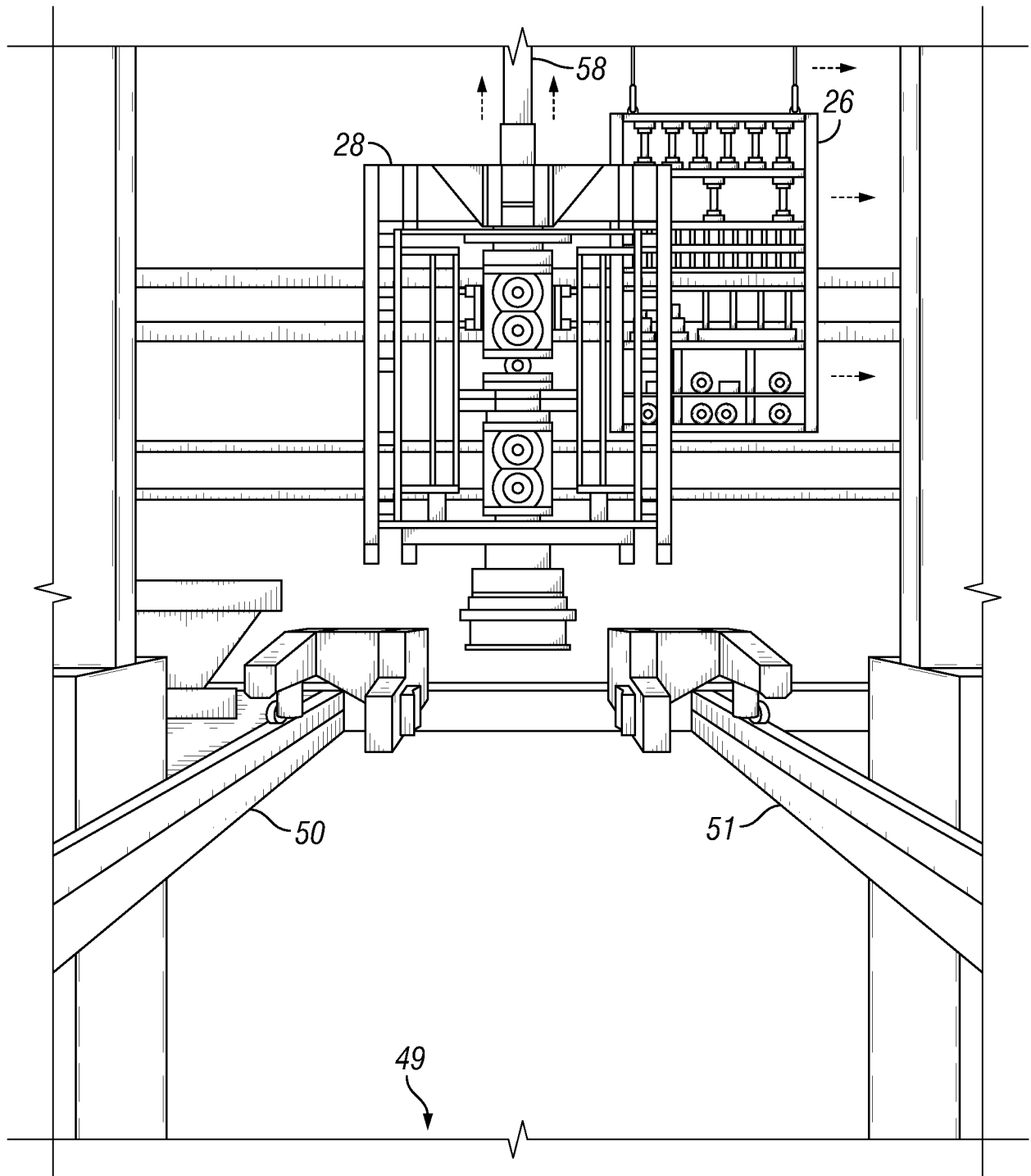


FIG. 19

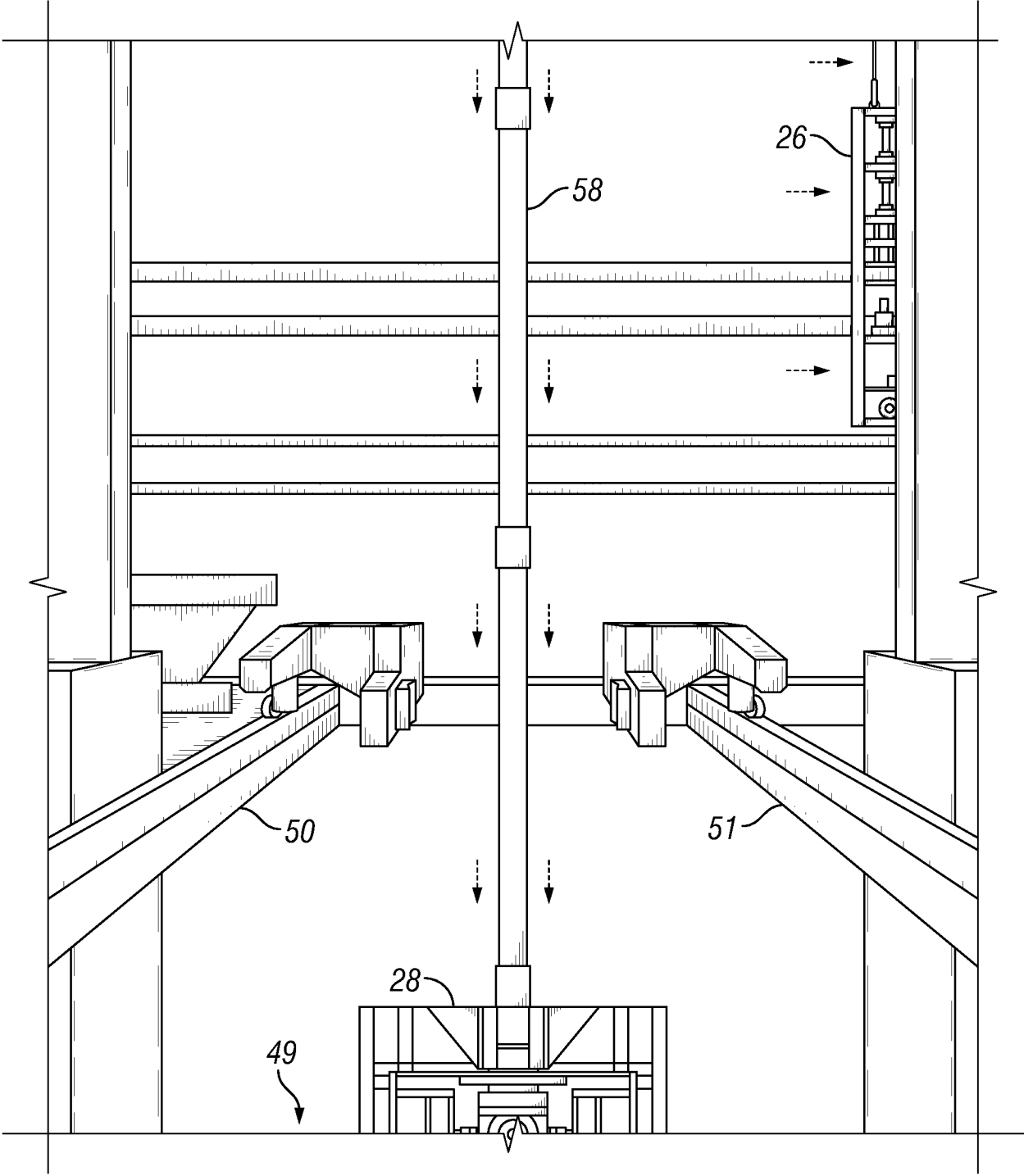


FIG. 20

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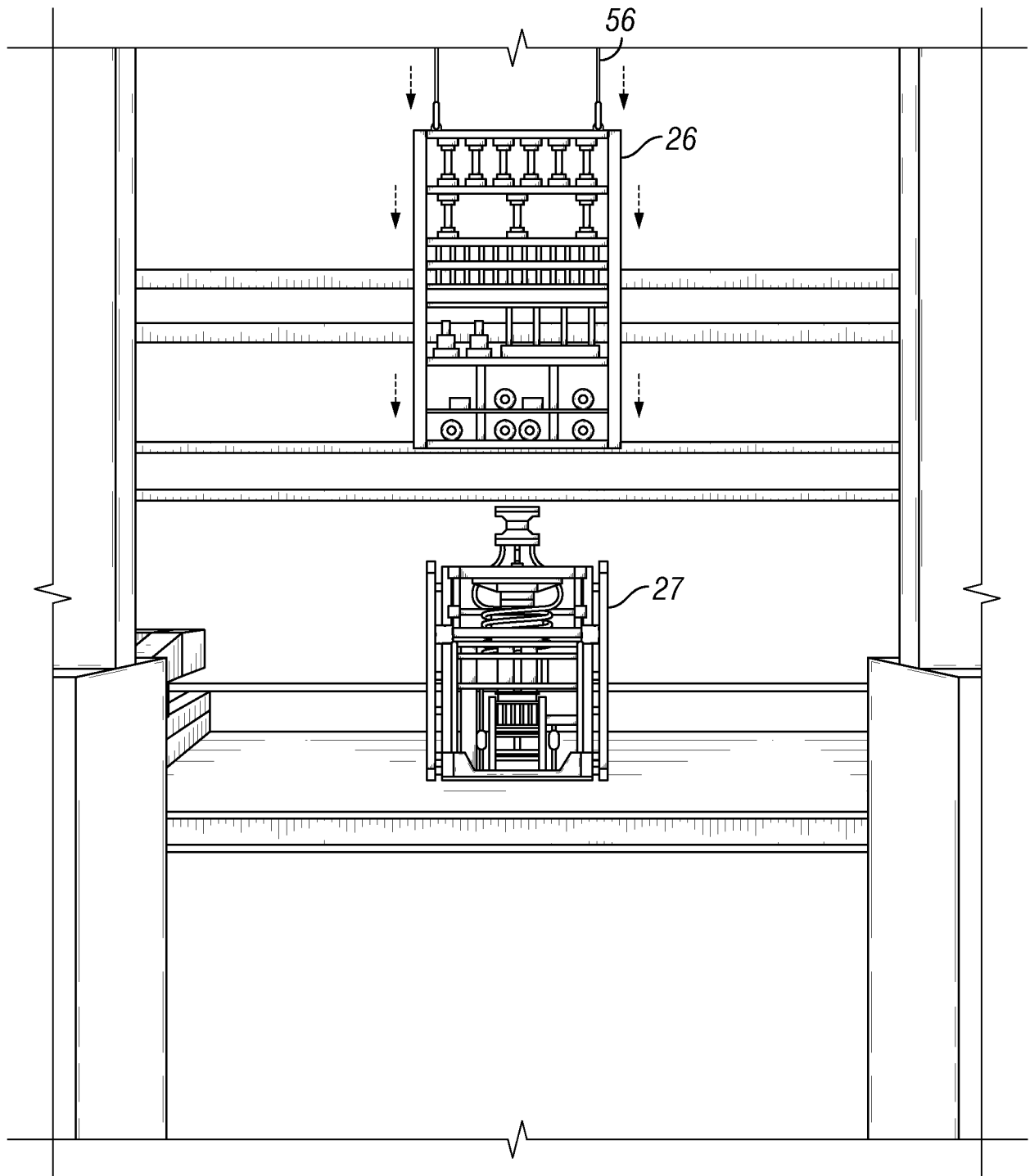


FIG. 21

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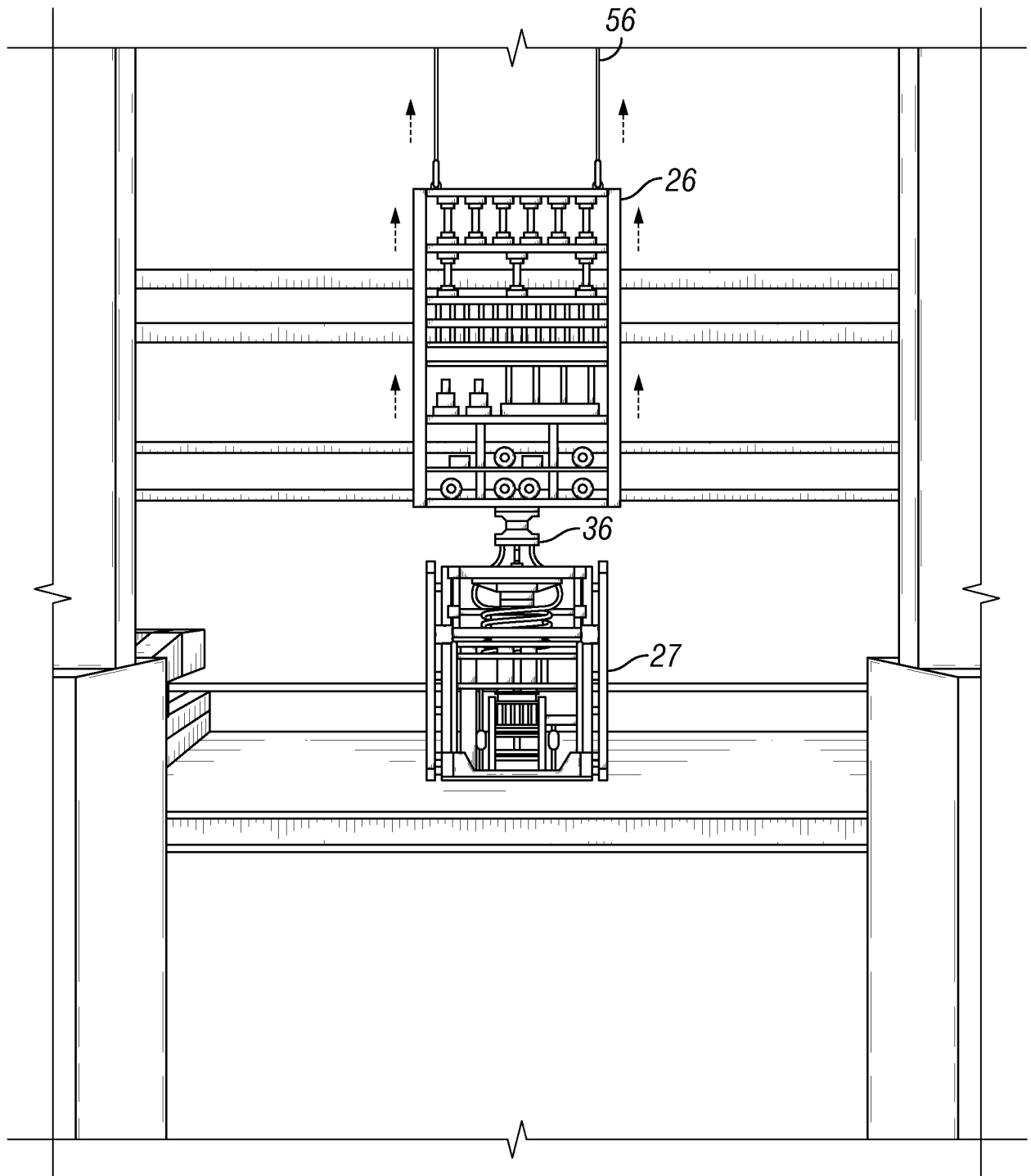


FIG. 22

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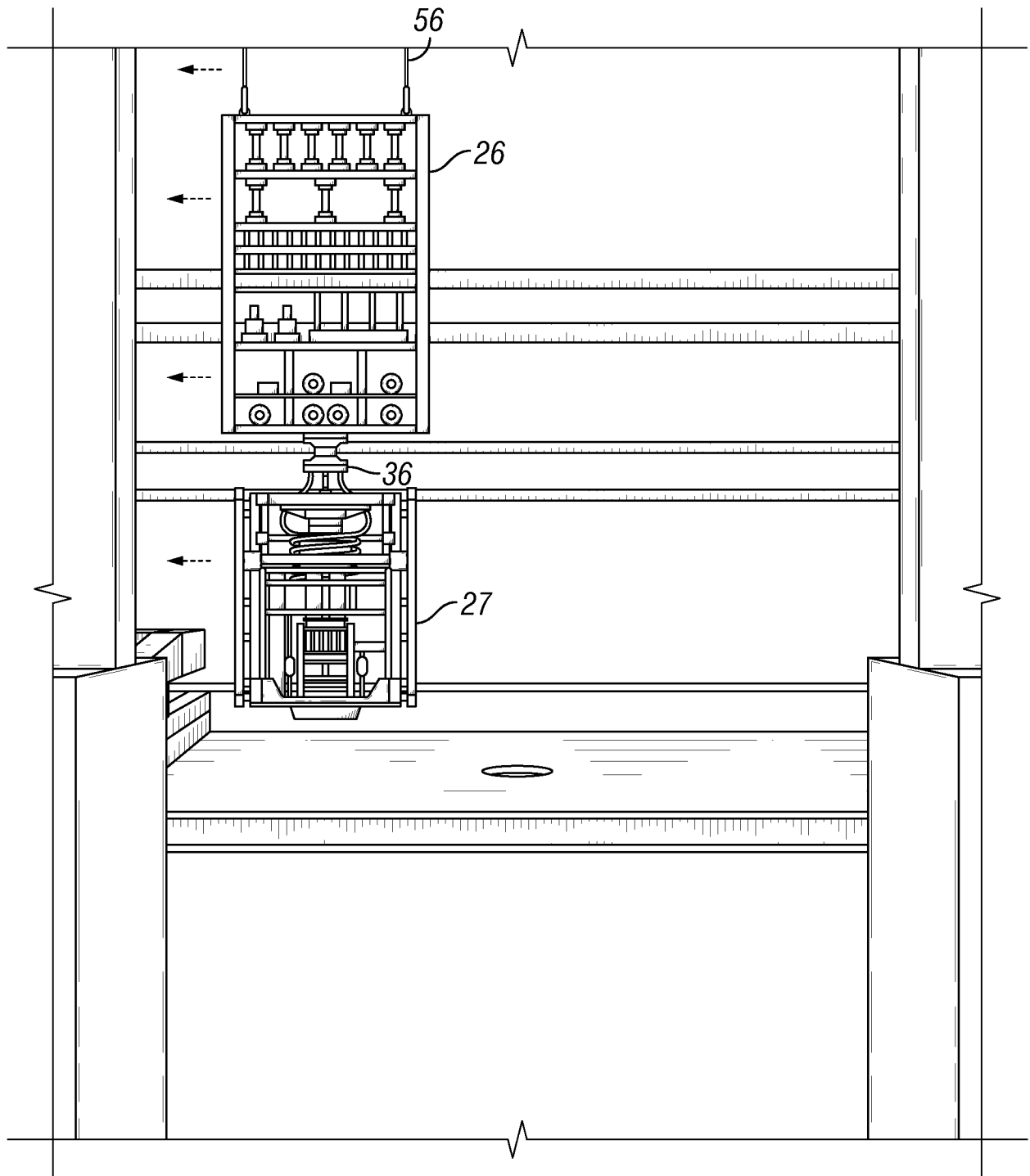


FIG. 23

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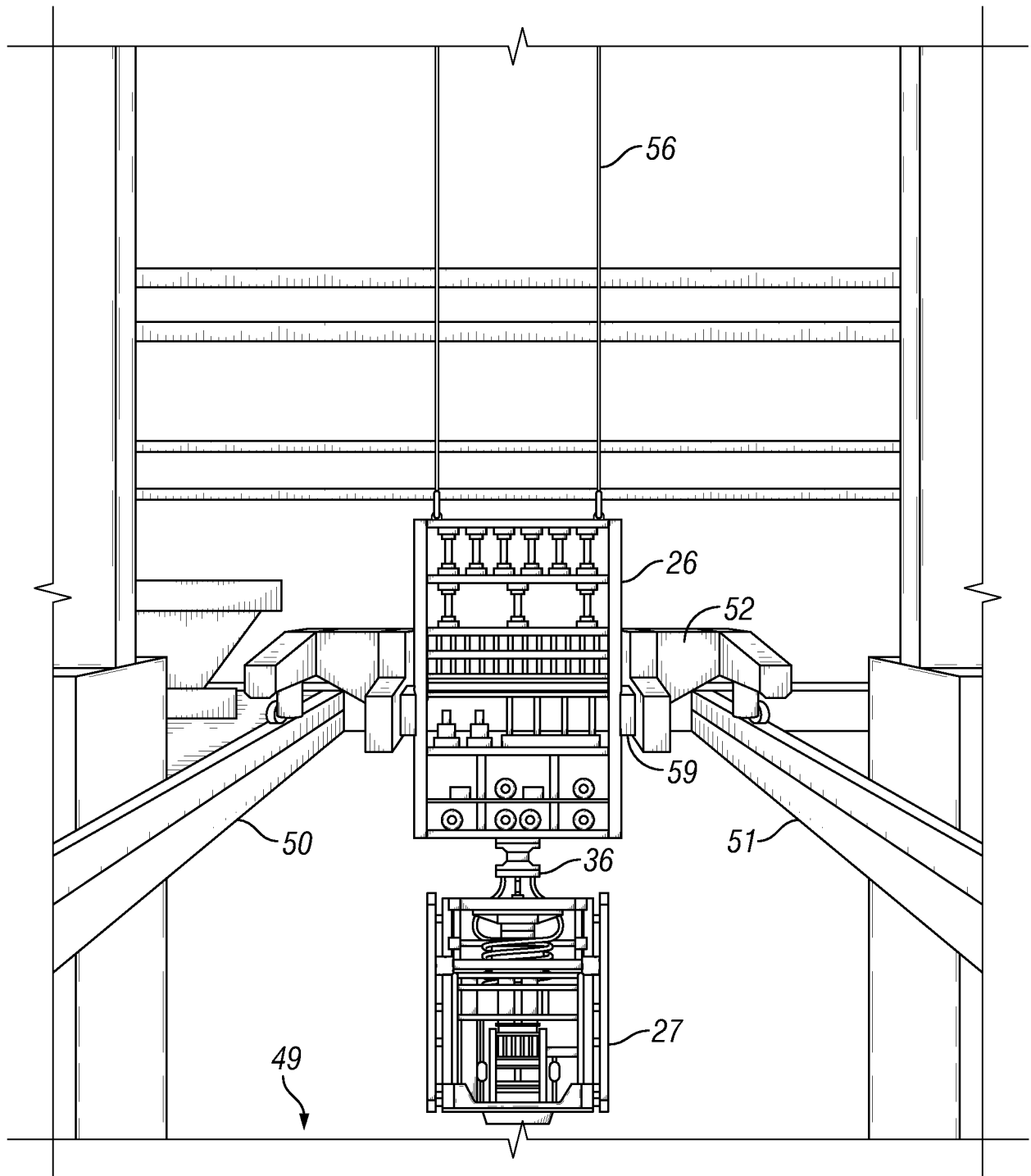
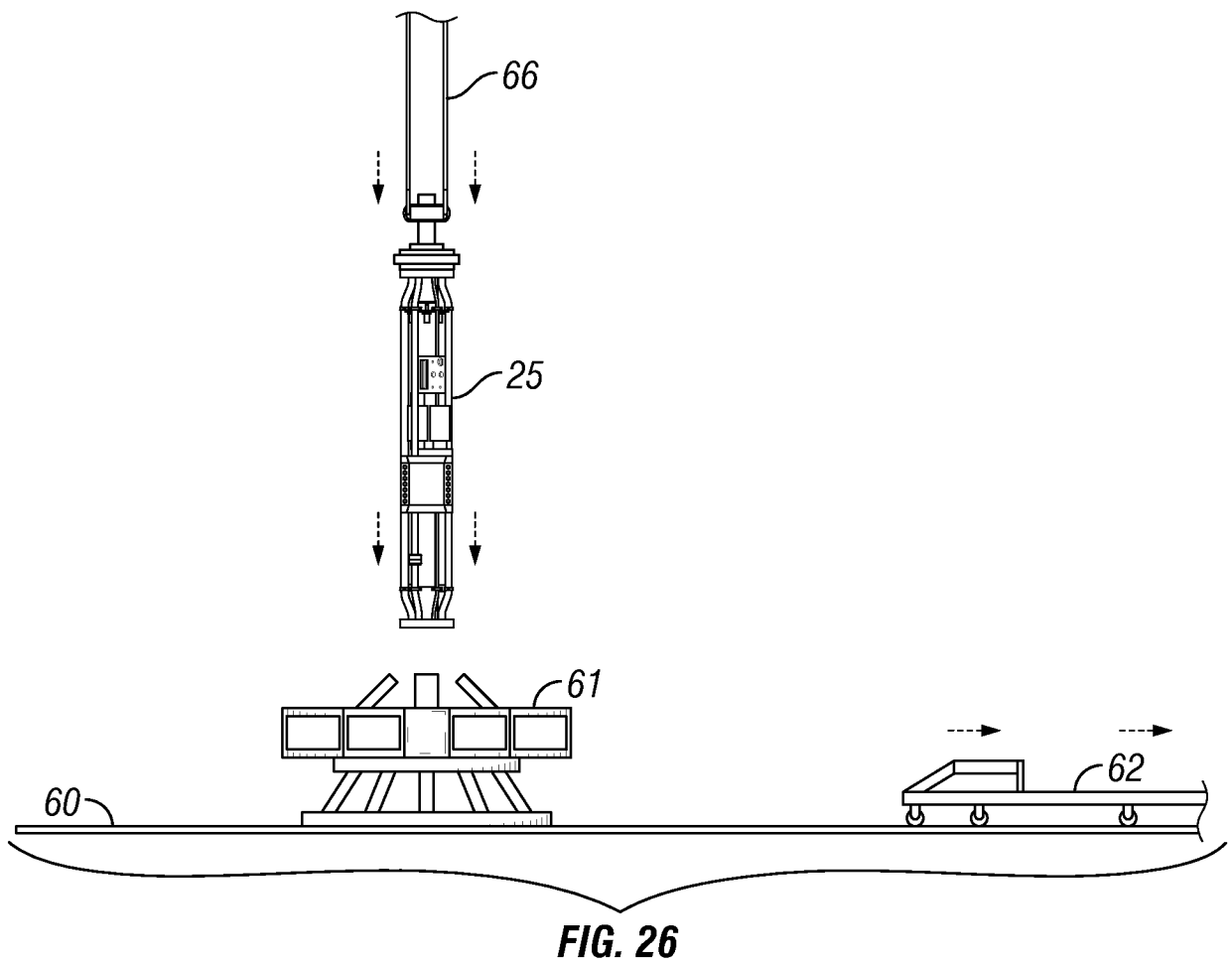
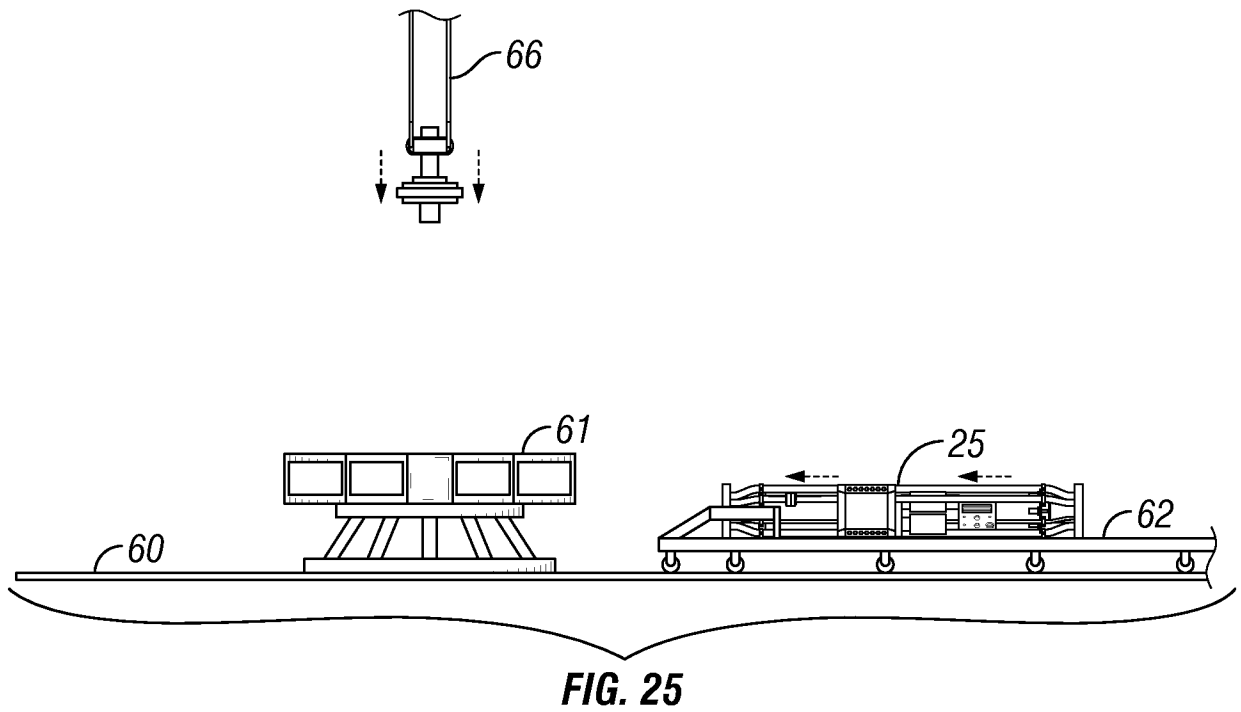


FIG. 24

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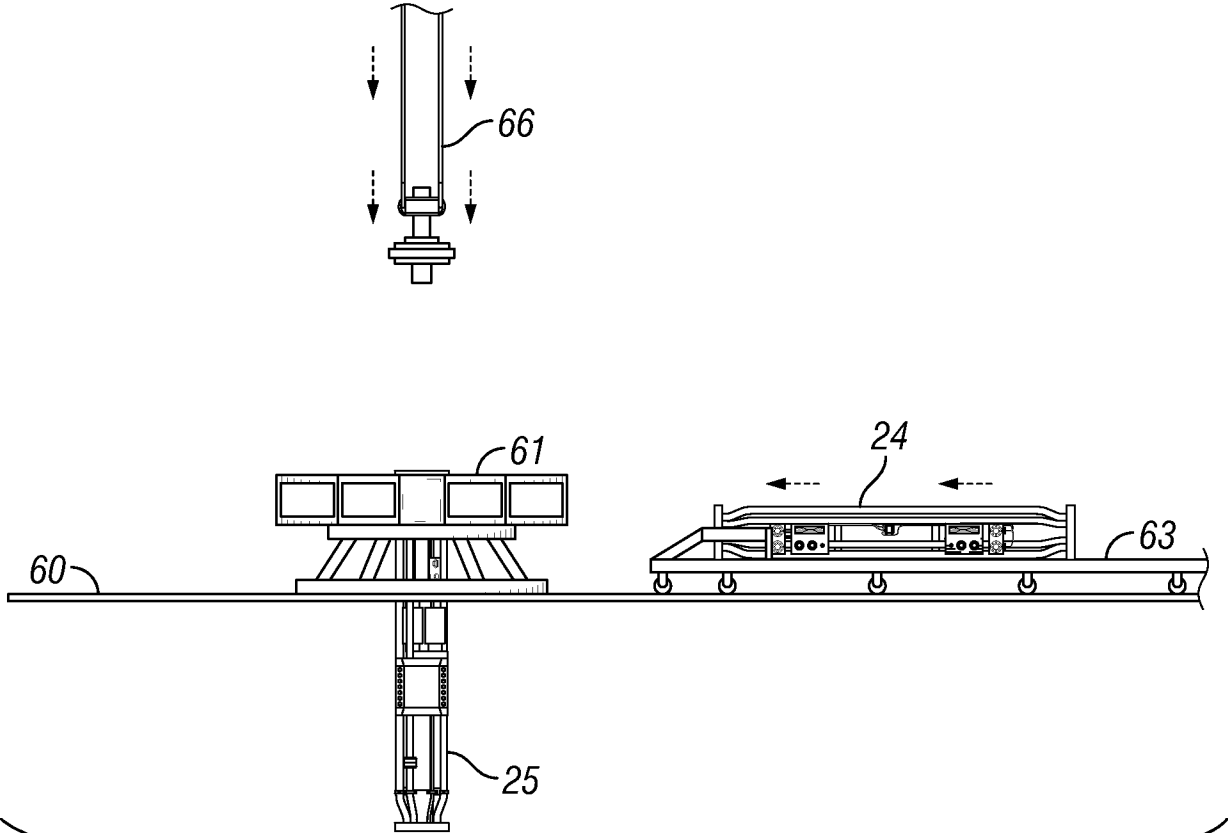


FIG. 27

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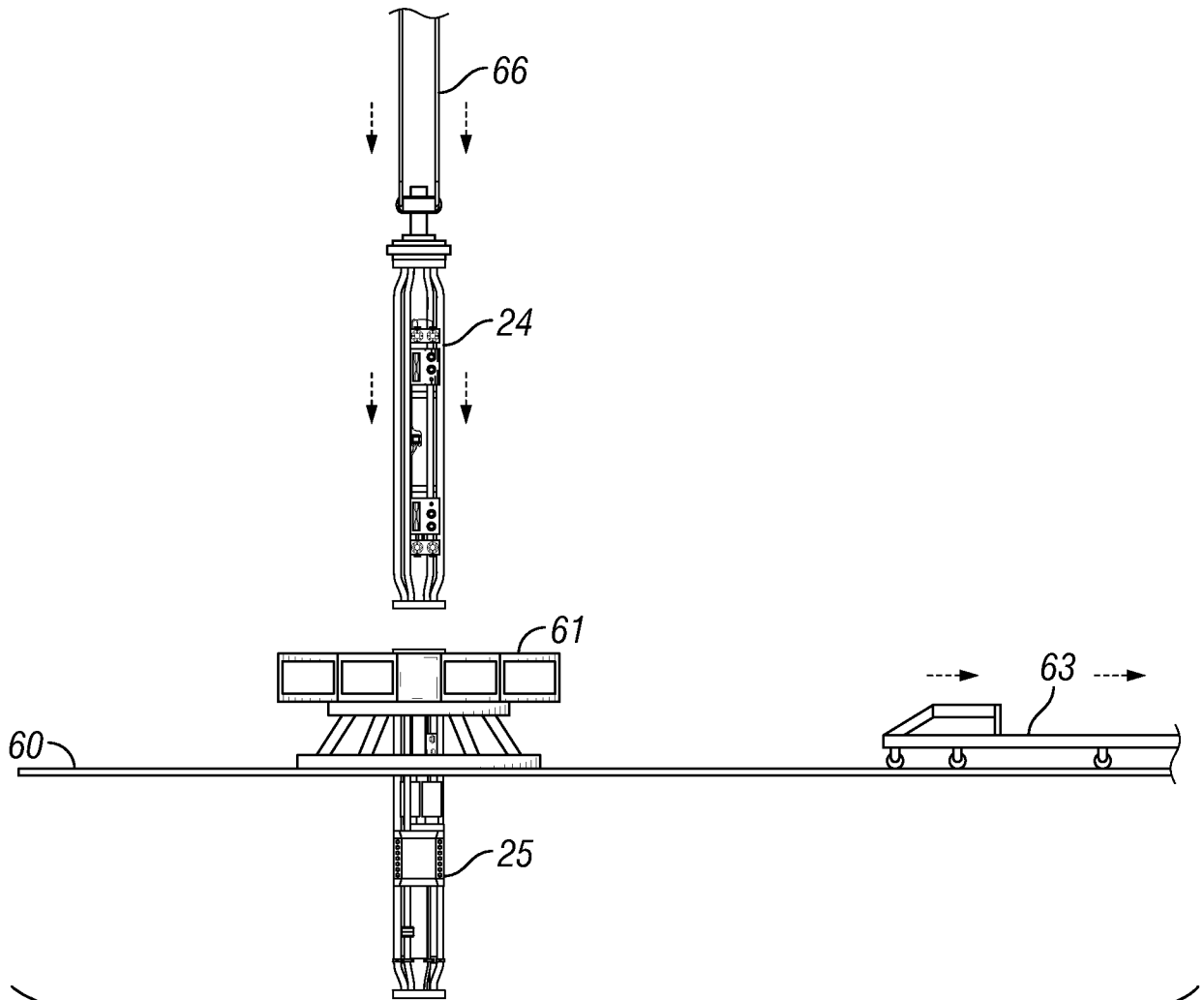
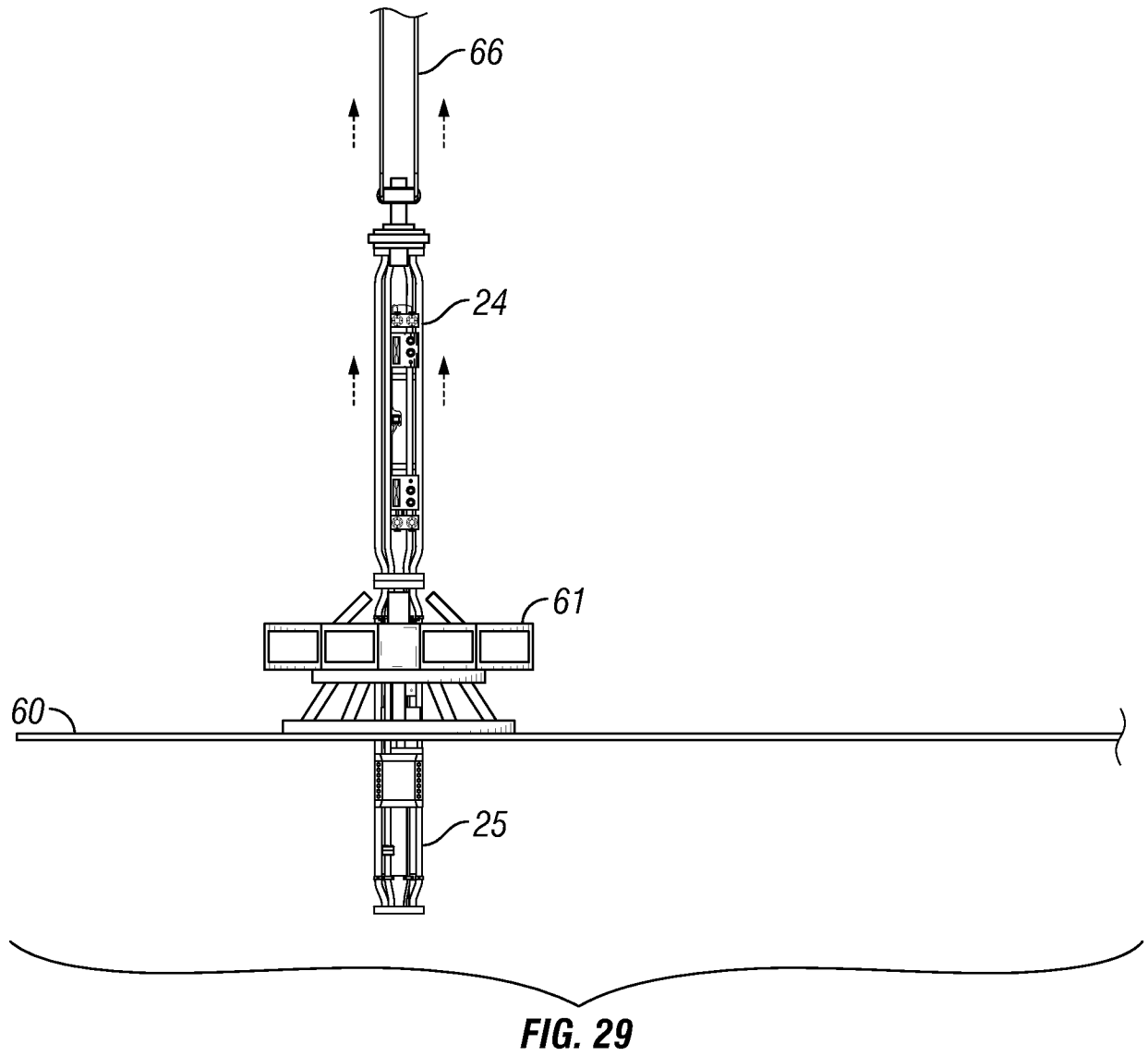


FIG. 28

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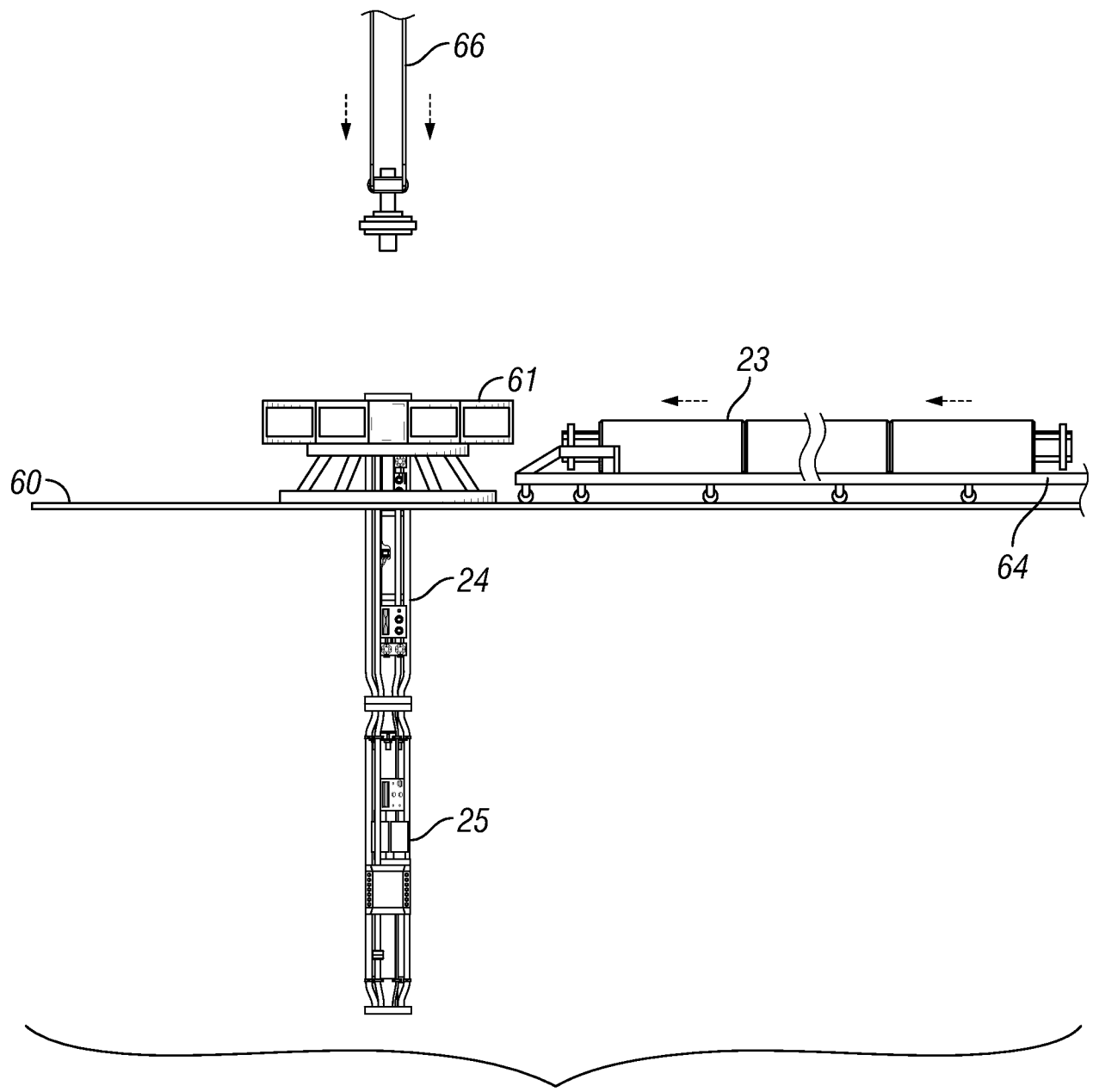


FIG. 30

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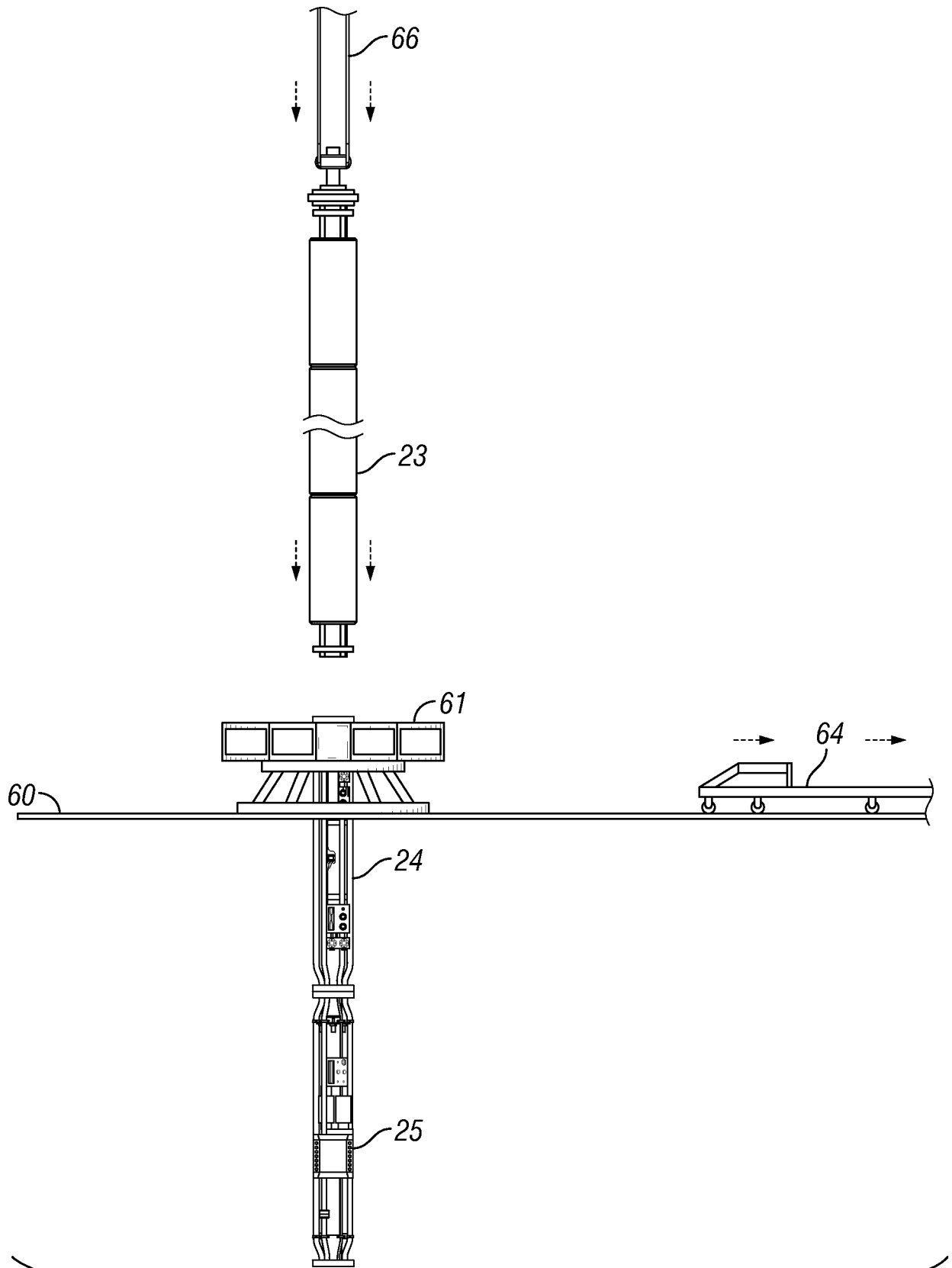
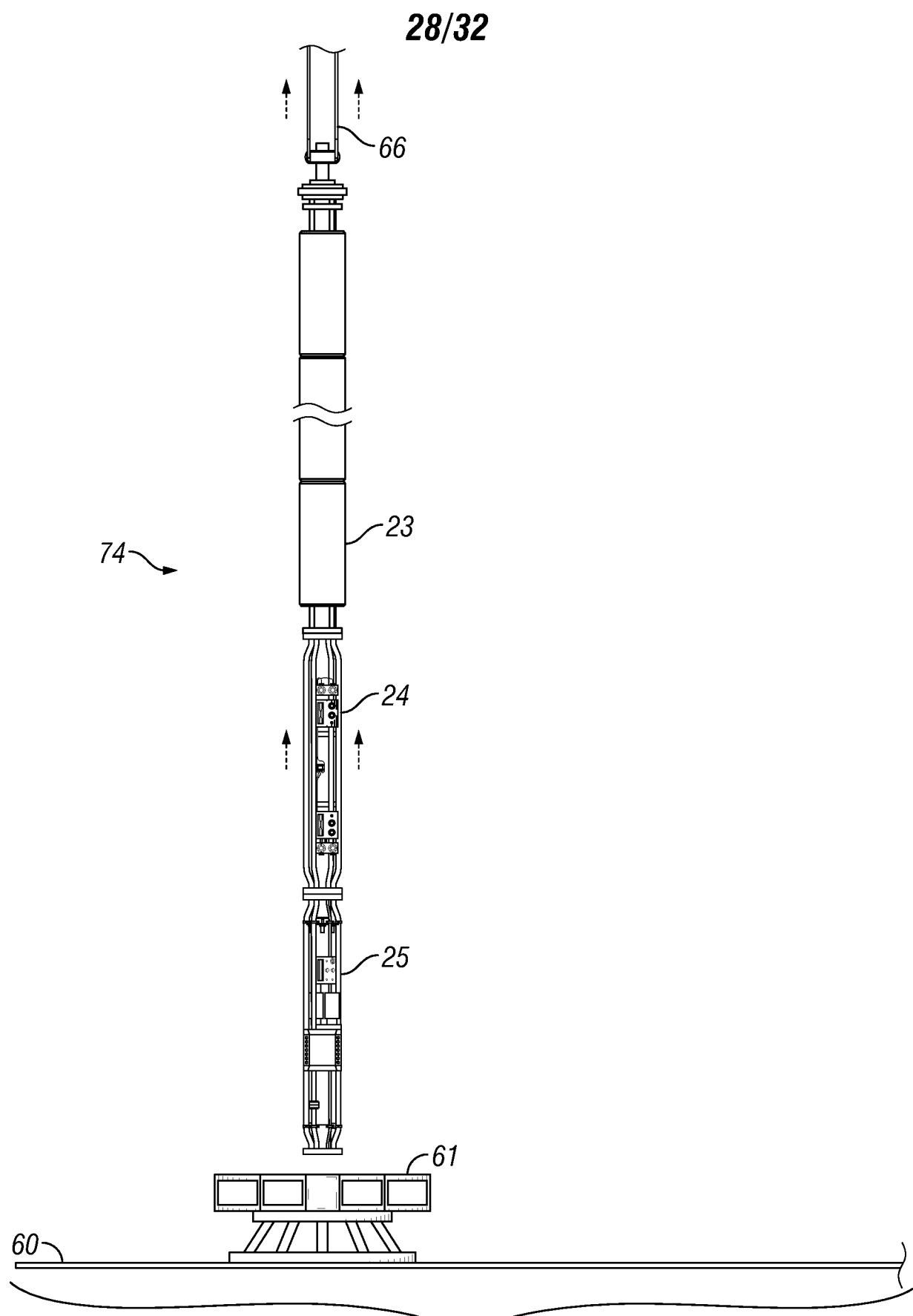


FIG. 31



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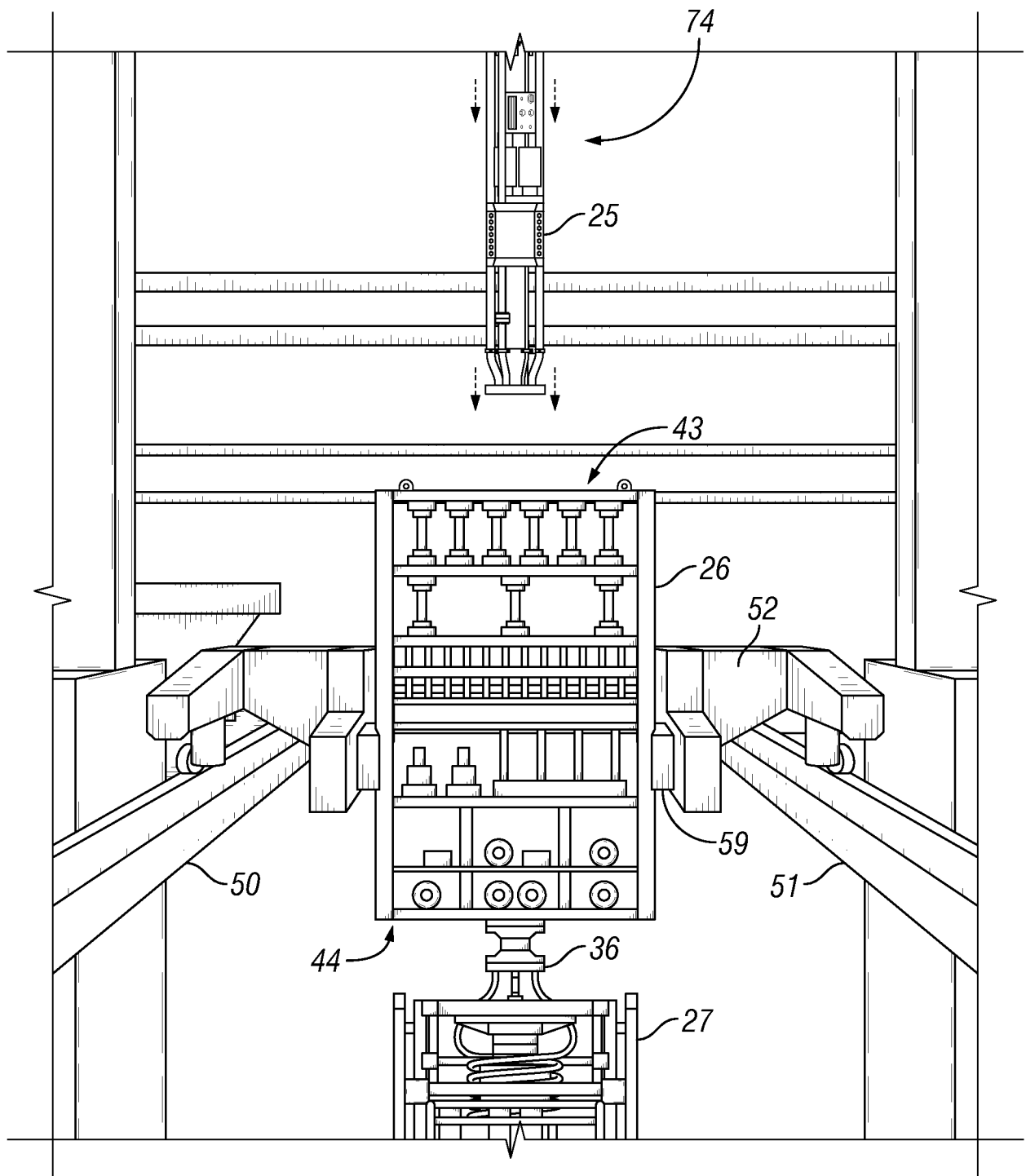


FIG. 33

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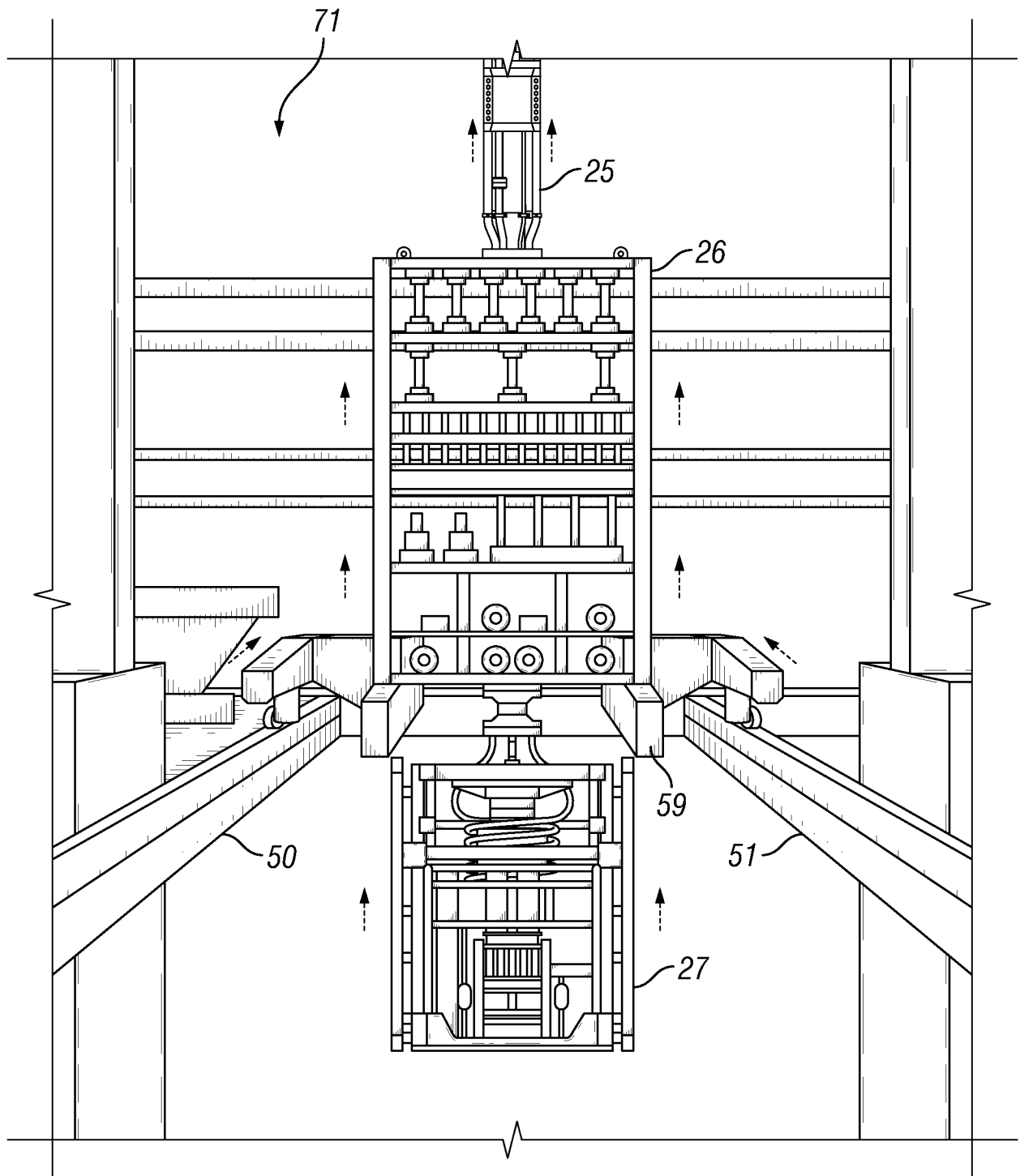


FIG. 34

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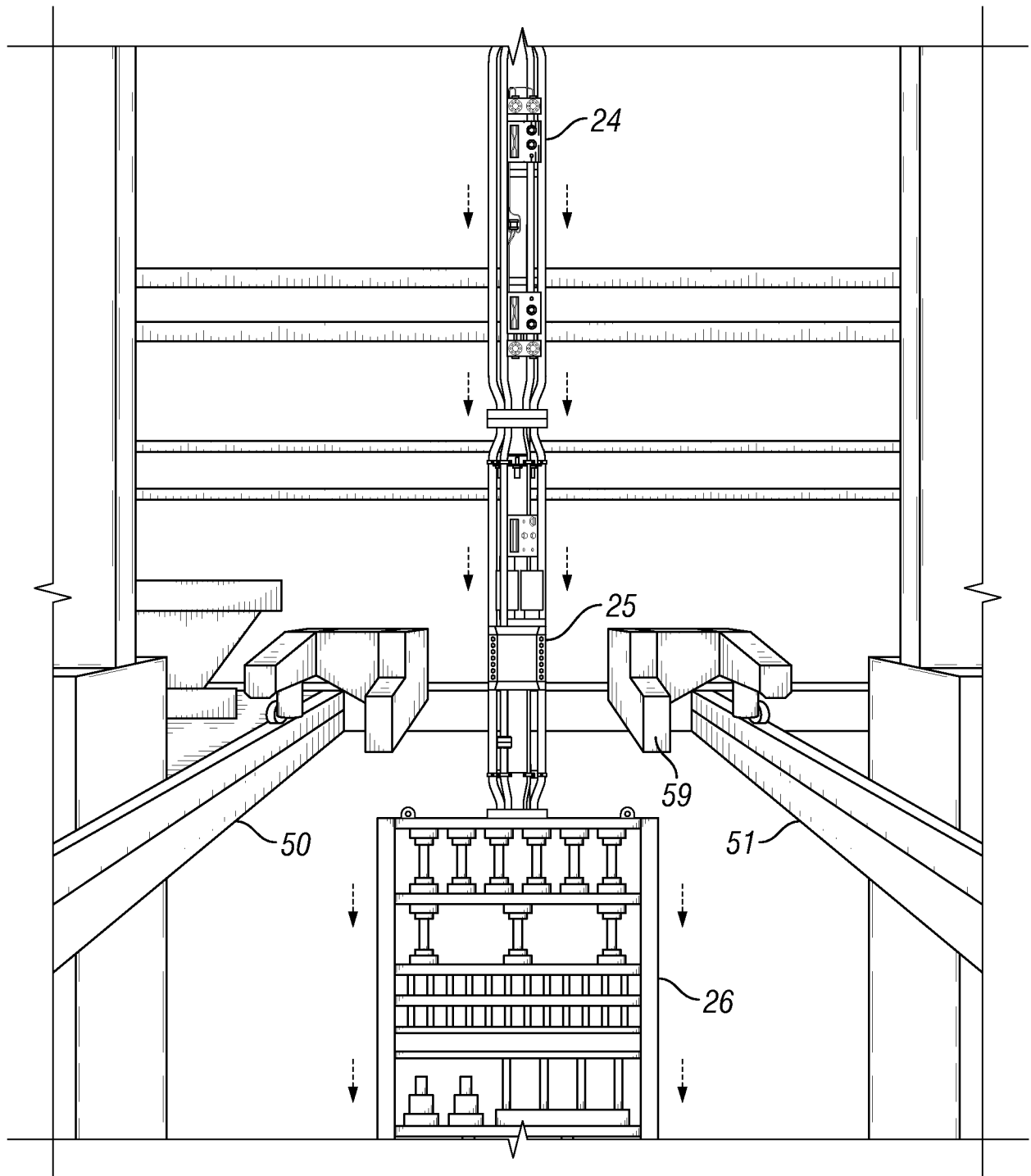


FIG. 35

