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(54) **ARRANGEMENT FOR SELF-ELEVATING DRILLING RIG**

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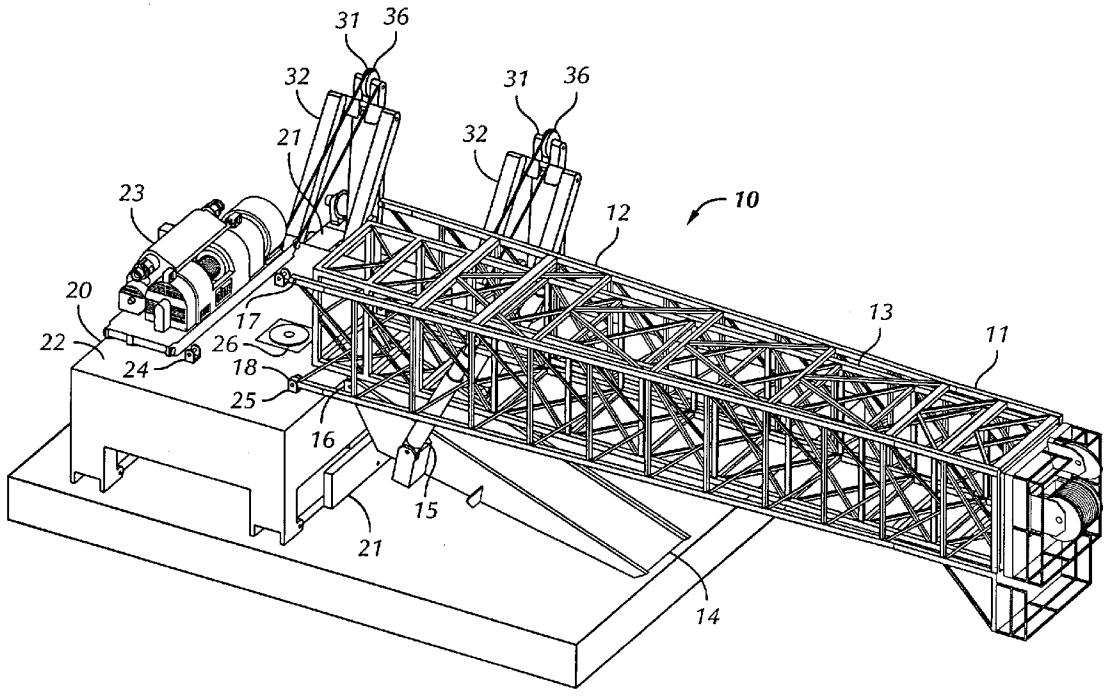
(52) **U.S. Cl.** **52/116**

(57) **ABSTRACT**

The present invention is directed to an arrangement for a drilling rig and a process for erecting, disassembling, and laterally moving the drilling rig. In particular, the present invention is directed to an arrangement which permits moving the drilling rig to a closely spaced nearby well following the completion of one or more previous adjacent wells without disassembling the entire structure. Further, the present invention is directed to an arrangement that facilitates the rapid erection and later disassembly of a drilling rig.



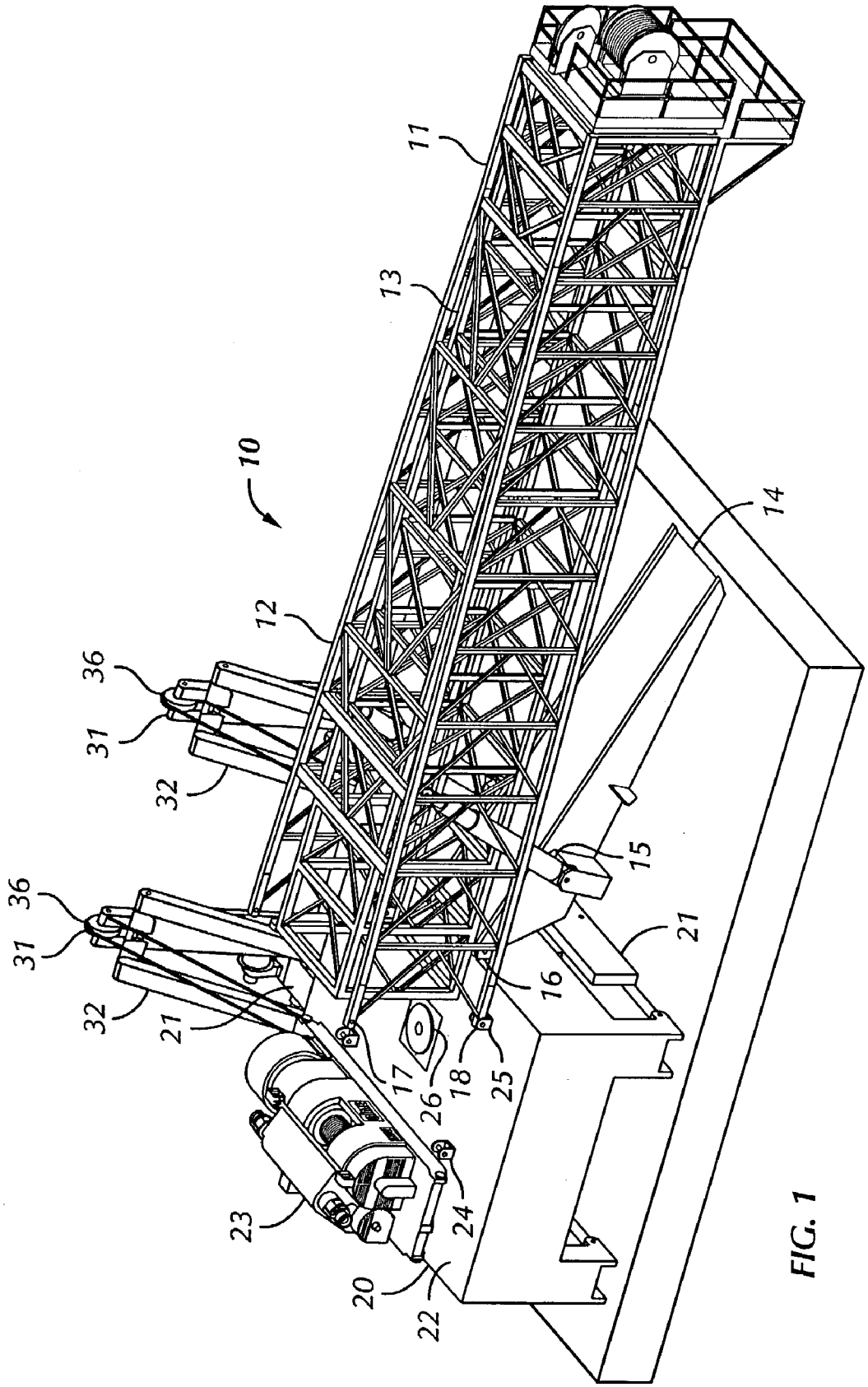


FIG. 1

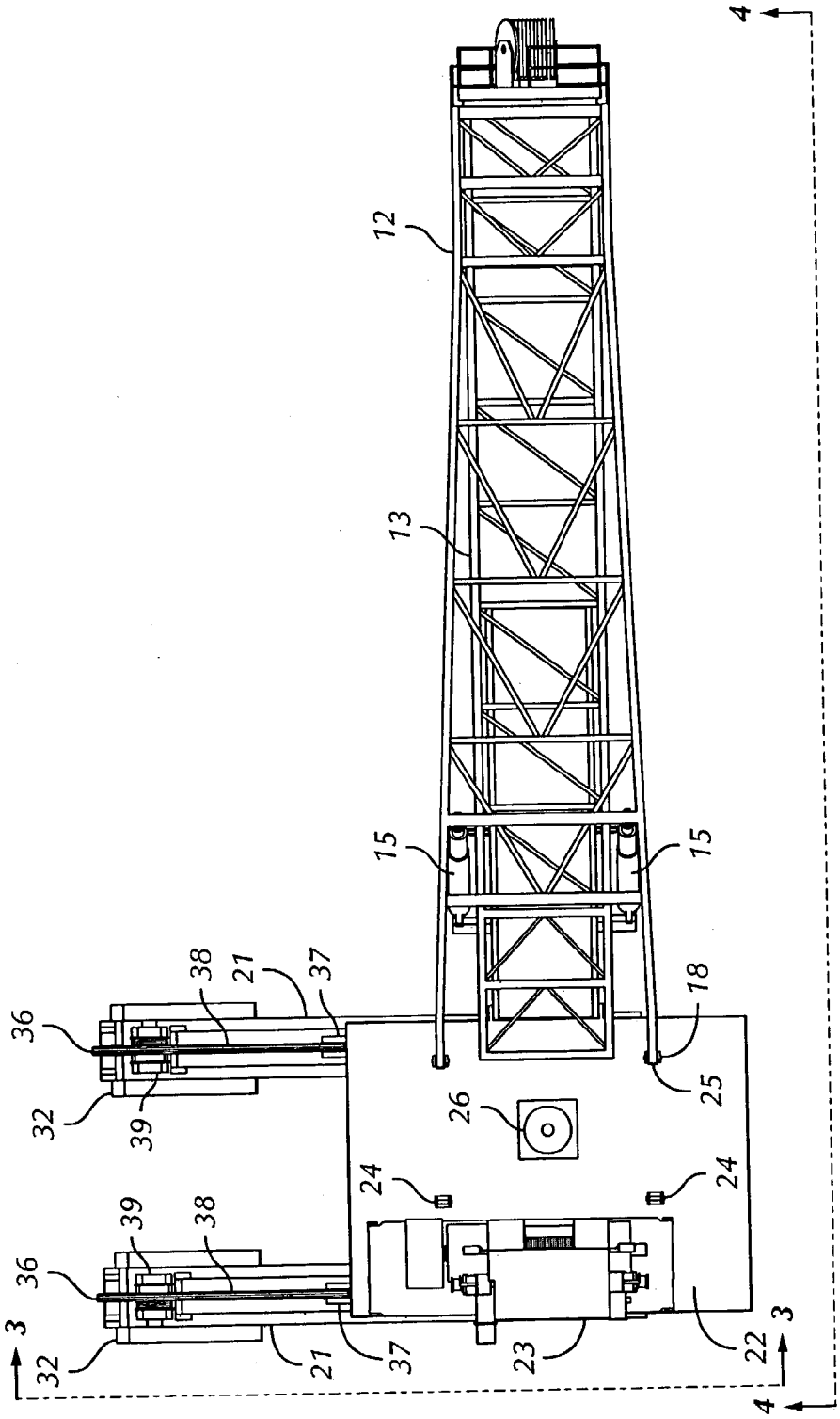

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FIG. 2

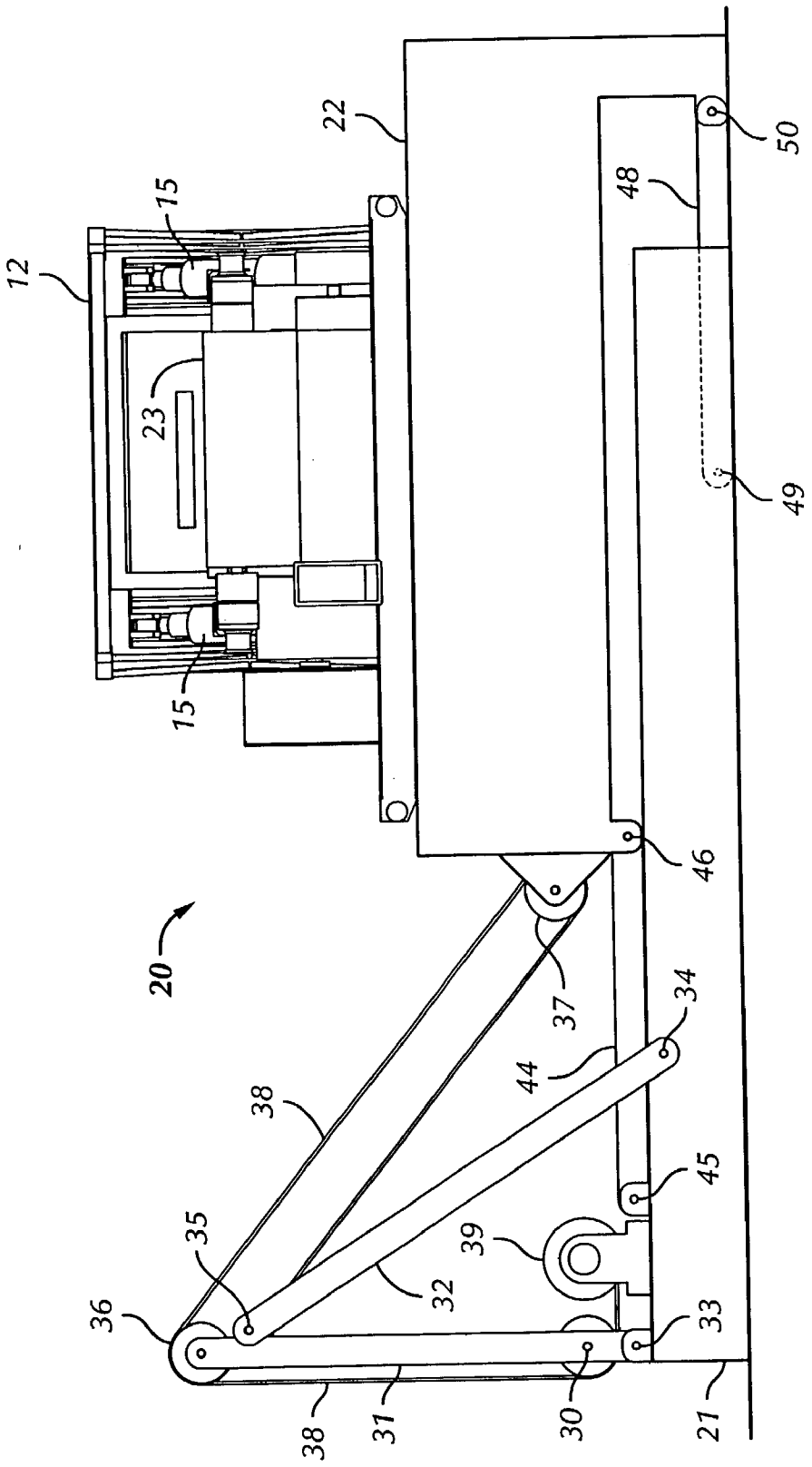


FIG. 3

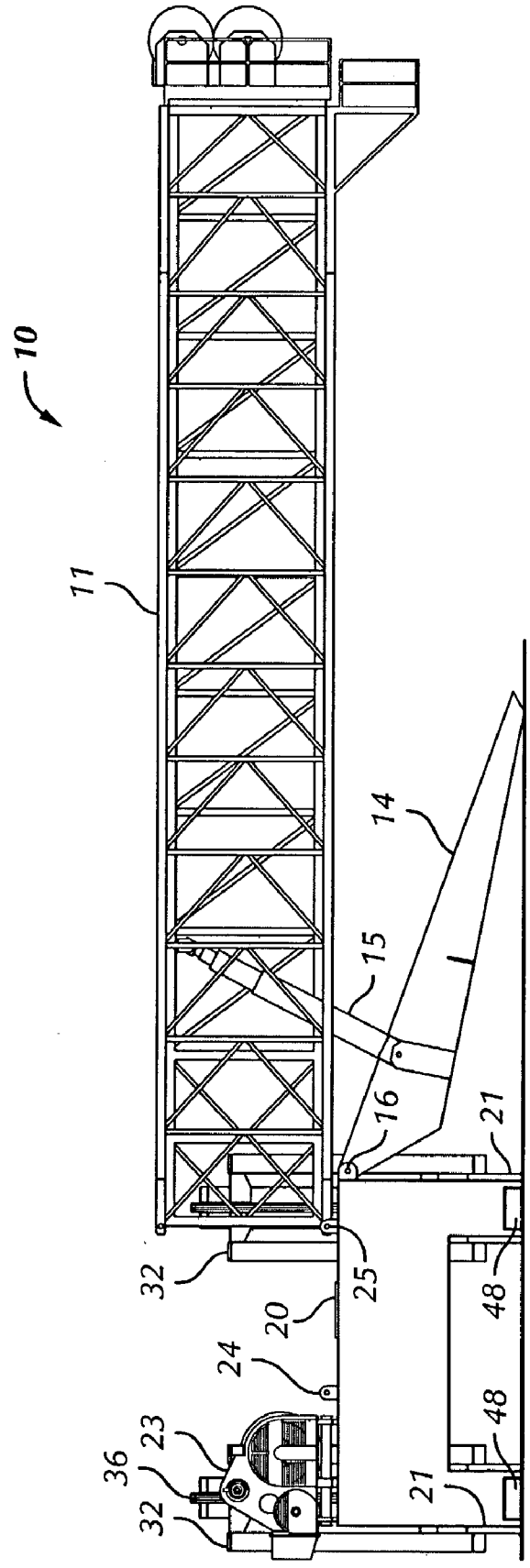


FIG. 4

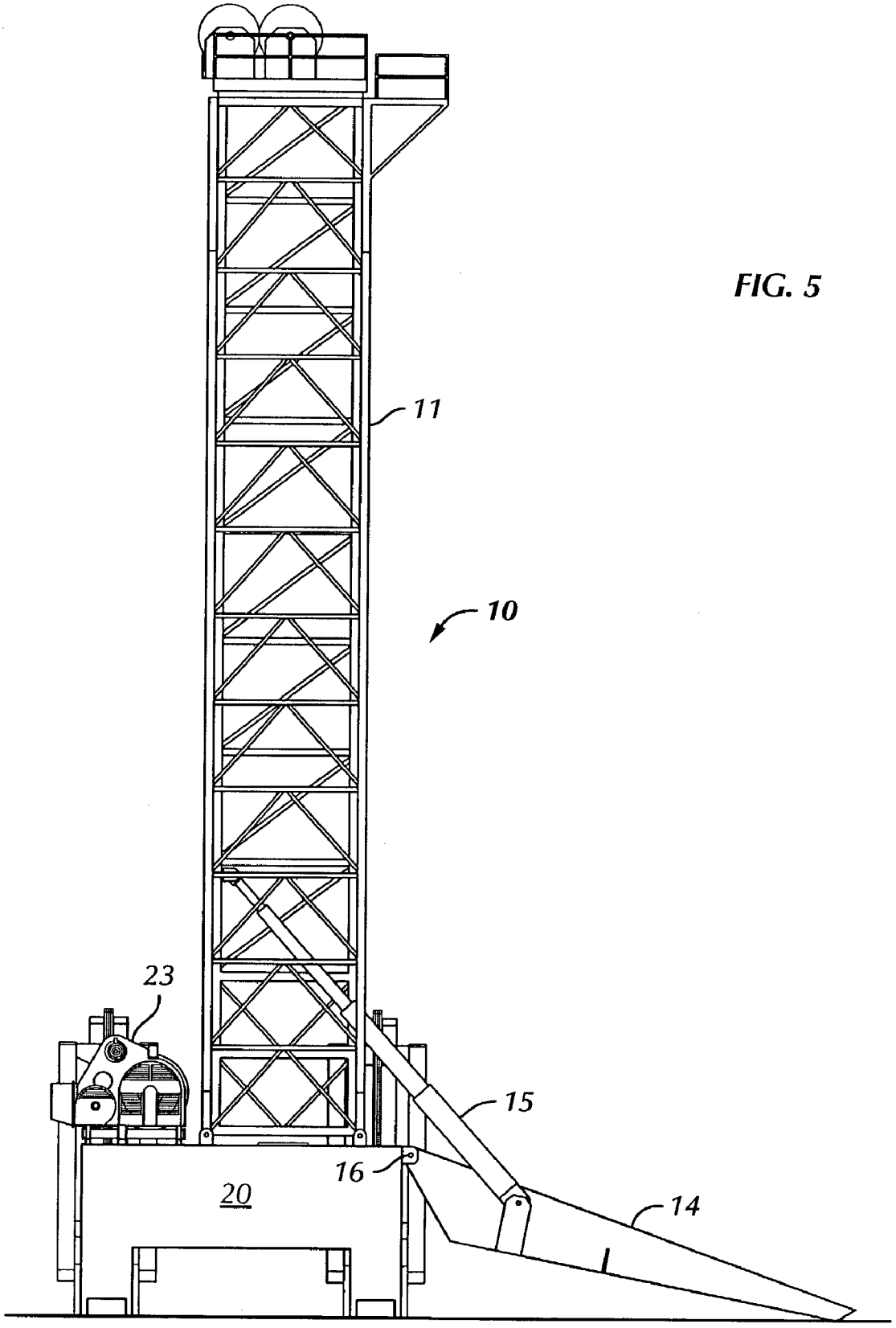
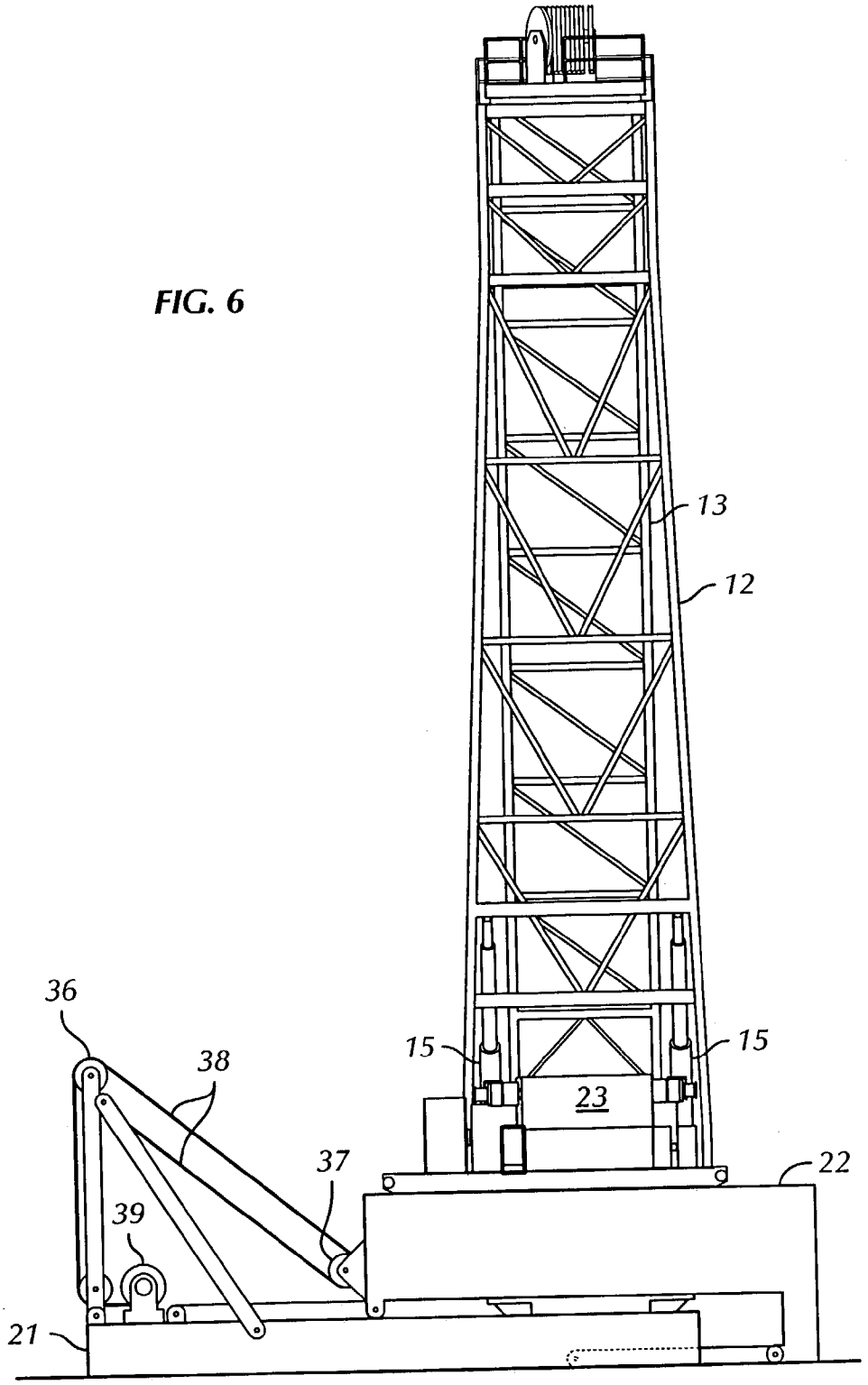


FIG. 5

FIG. 6



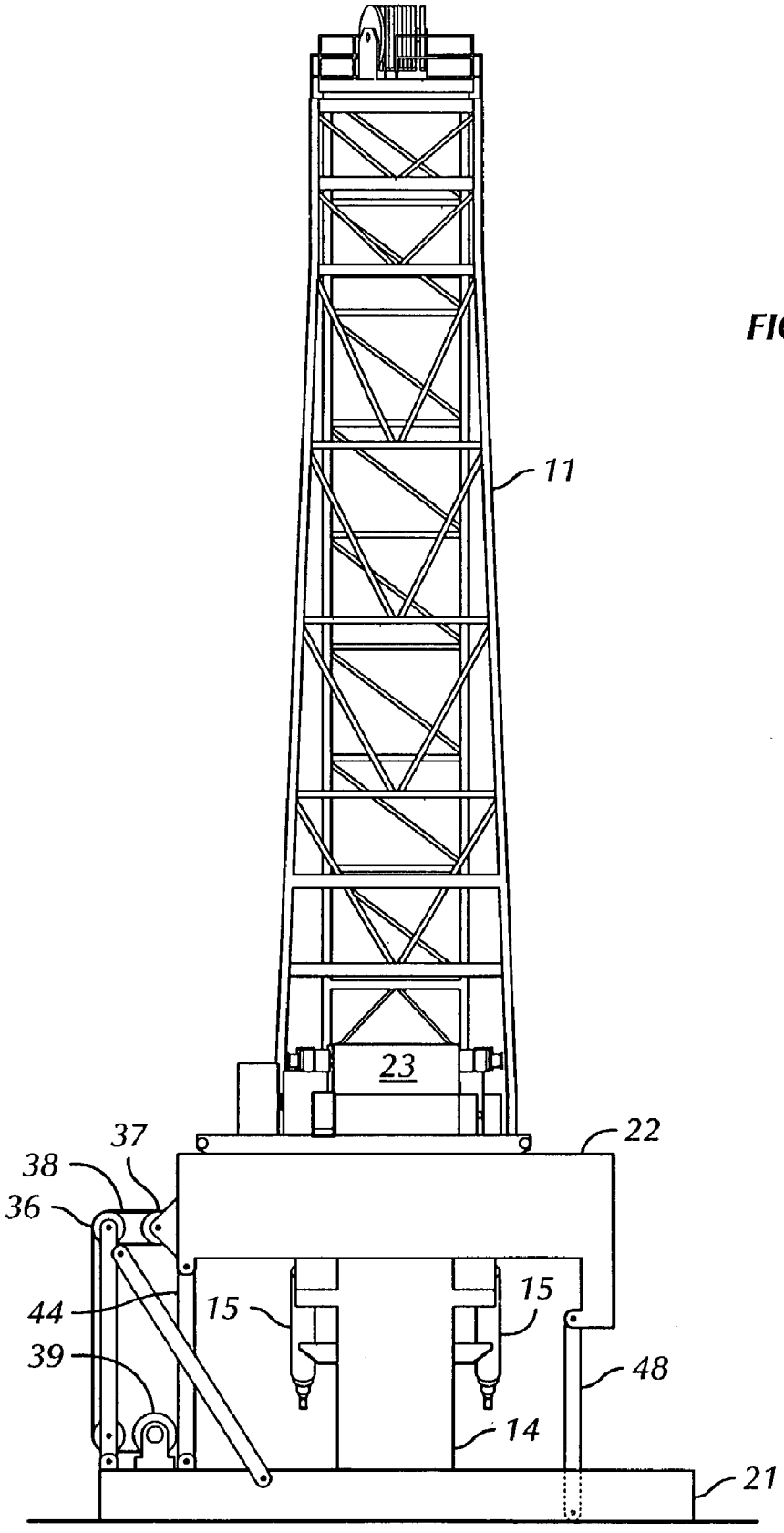


FIG. 7

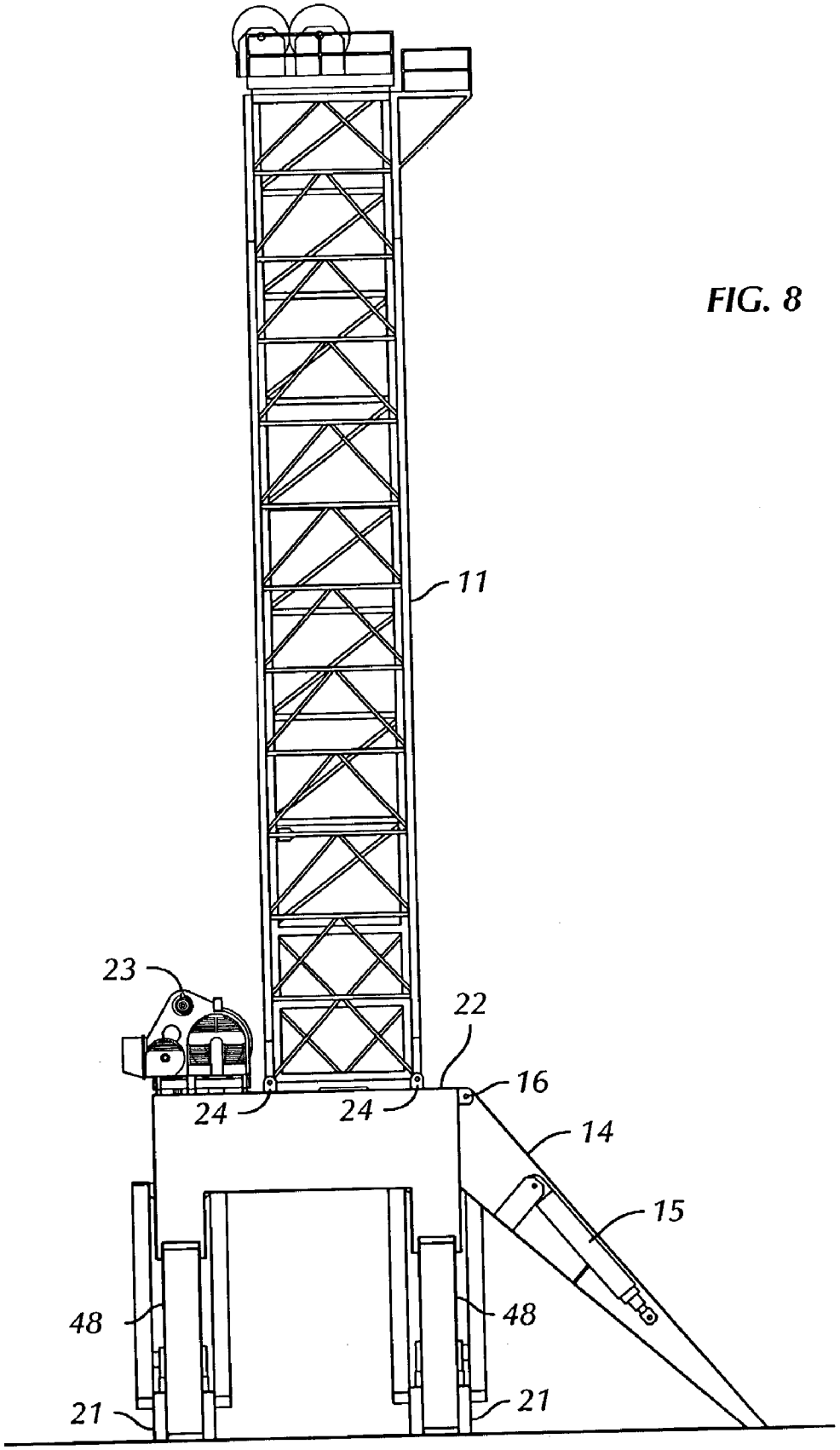


FIG. 8

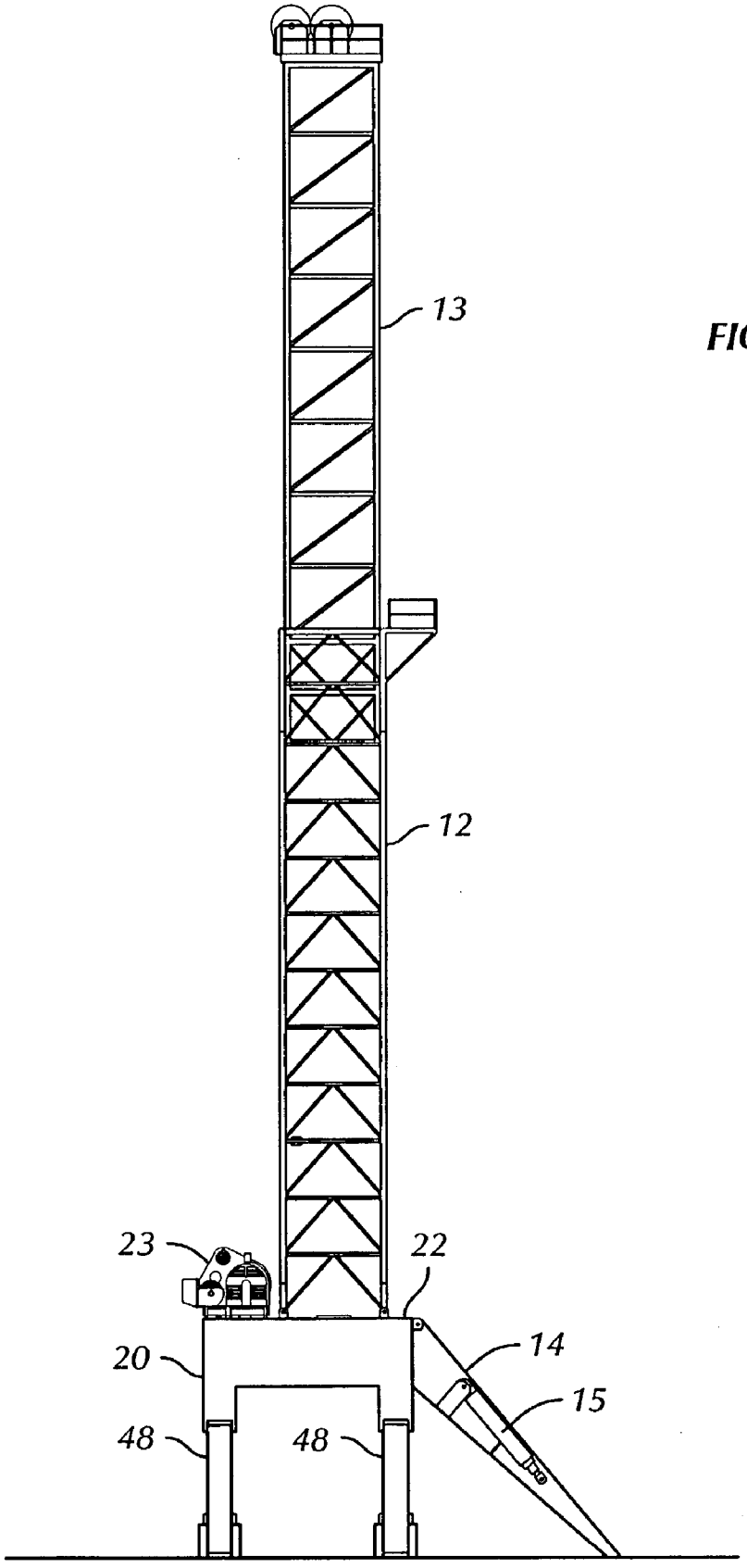


FIG. 9

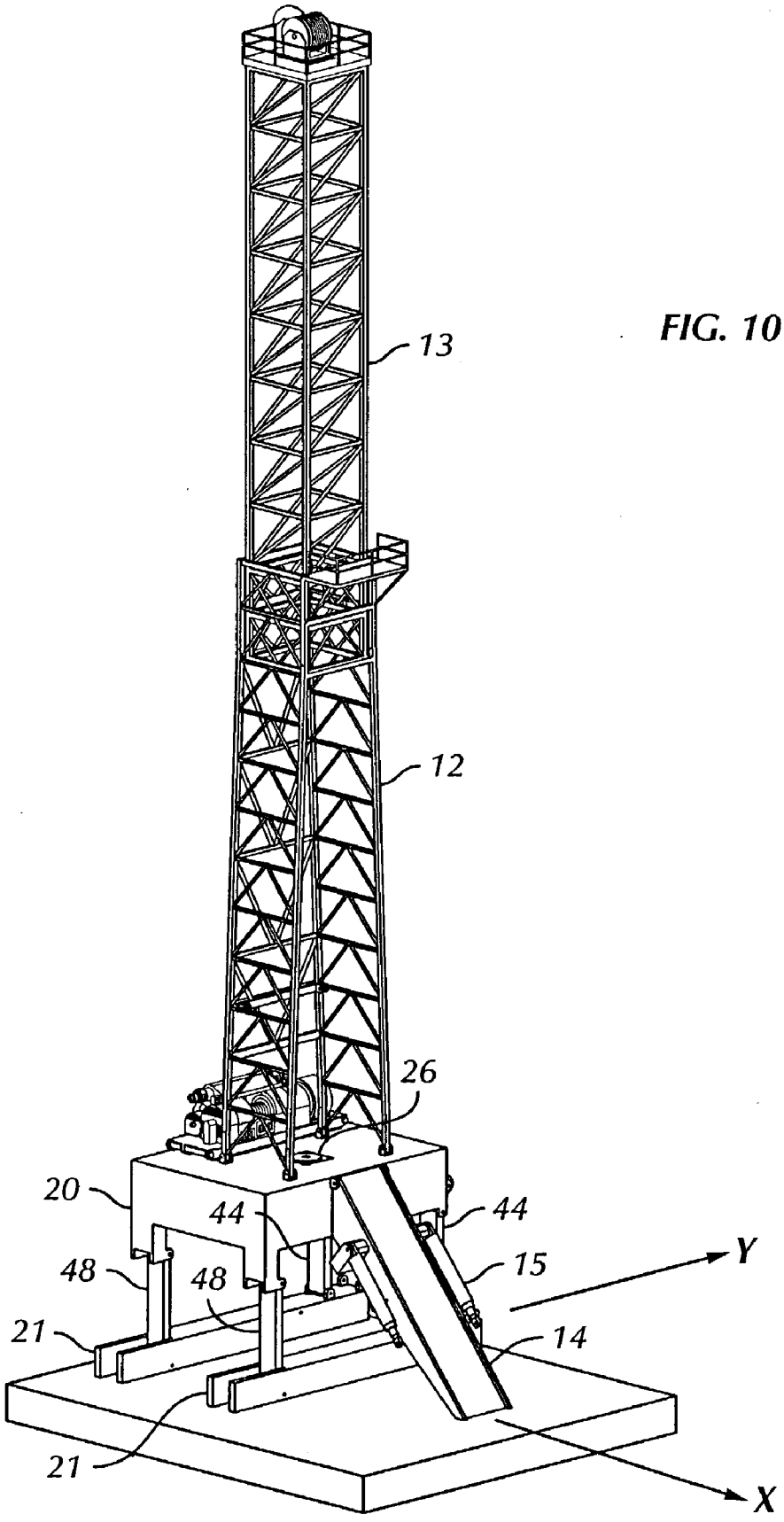


FIG. 10

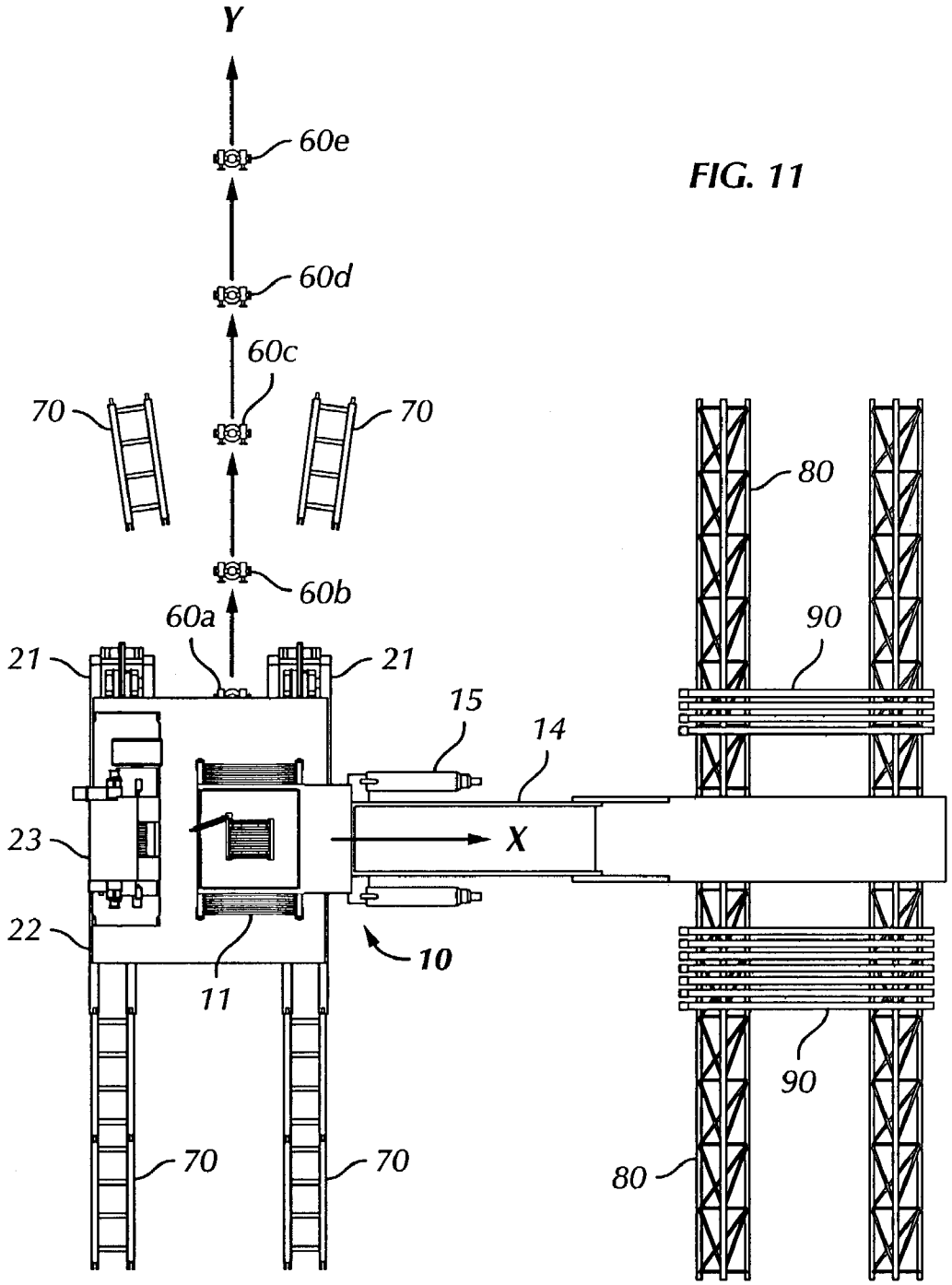
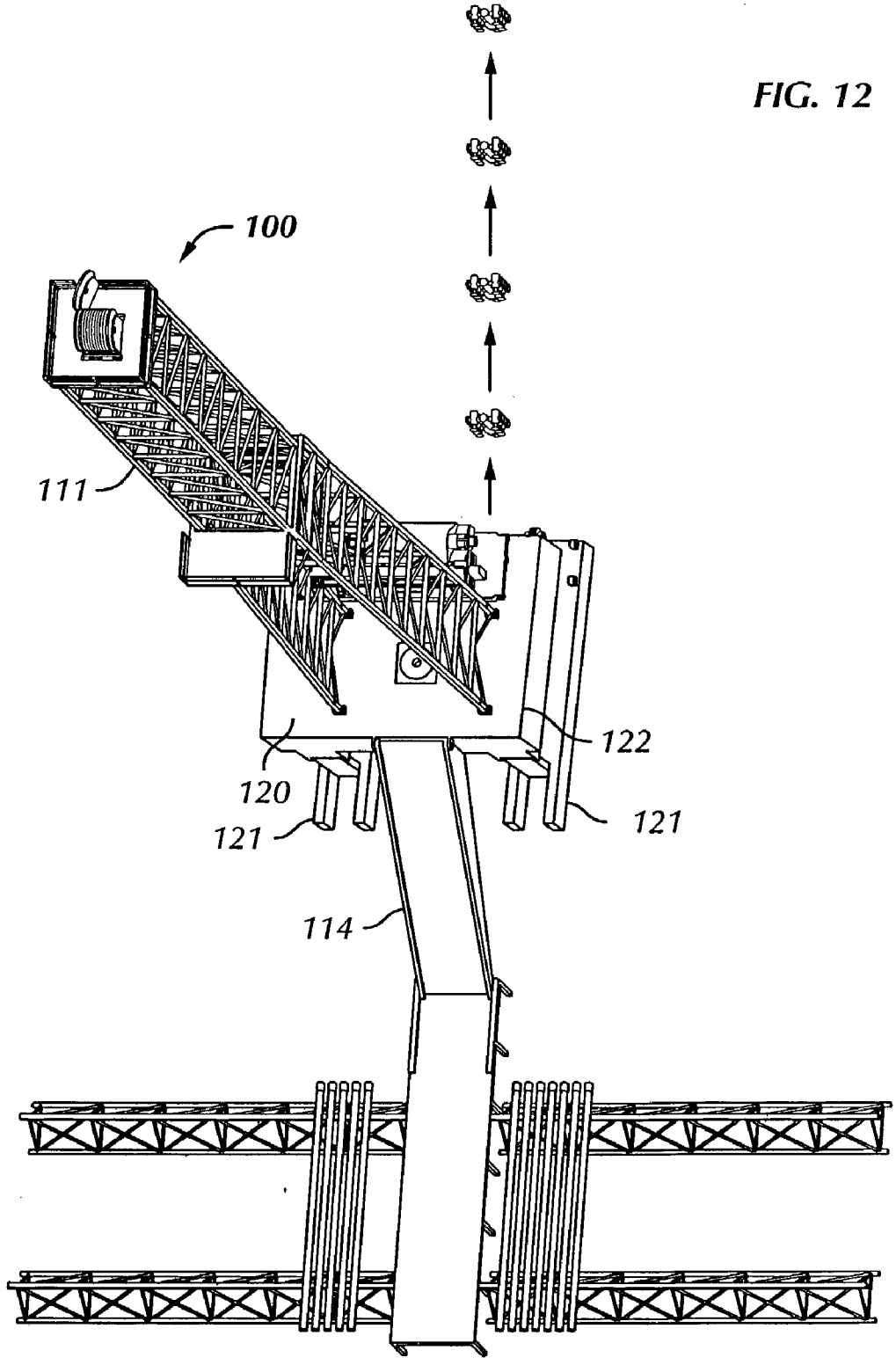


FIG. 11

FIG. 12



ARRANGEMENT FOR SELF-ELEVATING DRILLING RIG

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to pending U.S. Patent Application Serial No. 60/364,274 (Attorney Docket Number HRLT-P003V), filed Mar. 13, 2002 by inventor Shelby Frink and entitled "Arrangement for Self-Elevating Drilling Rig."

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention is directed to an arrangement for a drilling rig and a process for erecting, disassembling, and laterally moving the drilling rig. In particular, the present invention is directed to an arrangement which permits moving the drilling rig to a closely spaced nearby well following the completion of one or more previous adjacent wells without disassembling the entire structure.

[0004] 2. Description of the Related Art

[0005] A significant number of patents have been issued for means of erecting drilling rig masts and their associated elevated drill floors. Several of these patents are briefly described.

[0006] Lovell U.S. Pat. No. 2,887,191 treats a means for erecting a mast from a horizontal position. This patent discloses a combination of a) a telescoping hydraulic cylinder with its base pivot mounted slidably on a fixed base ramp and with its rod end slidably mounted on the mast, b) an auxiliary hydraulic cylinder for moving the base pivot, and c) an auxiliary hydraulic cylinder for moving the rod end pivot. The pivot points are moved to improve the mechanical advantage of the telescoping cylinder and to shorten its required length.

[0007] Woolslayer et al. U.S. Pat. No. 3,228,151 discloses a self-erecting rig floor and mast combination wherein either the drawworks or a telescoping hydraulic cylinder is used to raise the rig floor by pivoting and the drawworks is used to raise the mast in the same plane as for raising the rig floor. The mast is pivoted and supported from the parallel base beams by coaxial pins transverse to and mounted slightly above the base beams. The rig floor pivots are parallel to the mast pivots.

[0008] Woolslayer et al. U.S. Pat. No. 3,271,915 shows another self-erecting rig floor and mast combination which is elevated by use of the drawworks. The mast is pivoted up first by rotating it about coaxial pins mounted transversely on the parallel base trusses until it abuts the gin pole. The rig floor is then rotated up about pins parallel to the mast pins.

[0009] Wales U.S. Pat. No. 3,739,853 reveals means of partially disconnecting and rotating portions of the constituent beams of the substructure for the rig floor out of interference with the wellhead whenever the substructure is to be dragged away from the wellhead after completion of drilling.

[0010] Branham U.S. Pat. No. 3,747,695 discloses a system having parallel base beams and with a first support pedestal pair swung up about horizontal coaxial pins mounted on and perpendicular to the base beams. Sheave means usable for lifting the mast are supported either directly on the first pedestal pair or on gin poles mounted on the first pedestal pair. The mast is coaxially pinned to the base beams by pins with their axes parallel to the first pedestal pins. The drawworks, which is mounted on an adjacent base structure at the same, first end of the base beams as the first pedestal pair, is used to elevate the mast. Following this, a second pedestal pair carrying a portion of the rig floor is installed horizontally at the second end of the base beams and then rotated upwardly about coaxial pins parallel to the pins for the first pedestal pair so that the second pedestal is adjacent the mast. A second portion of the rig floor carrying the catworks and the rotary table is then mounted on top of the first and second pairs of pedestals to complete the installation.

[0011] Eddy et al. U.S. Pat. No. 3,922,825 describes a rig which has the horizontal mast preattached to the rig floor. Erection begins by using the trailer mounted-drawworks to elevate the floor that is pivoted upwardly about pins transverse to the parallel substructure beams. The drawworks is then used to pivot the mast upwardly about coaxial pins parallel to the pins for the floor linkage. One or more similar brace members having pinned ends and a sliding connection with the chord on the lower side of the mast are used to brace the mast during and after erection.

[0012] Reeve, Jr. et al. U.S. Pat. No. 3,942,593 uses a truck-mounted drawworks on a base mat in conjunction with a rig floor that is elevated vertically using extensible legs. Following elevation of the rig floor, the mast is brought in horizontally on the side where the drawworks will be located, skidded up a ramp from the level of the mat to the level of the deck and attached to pivot pins there. One or more telescoping hydraulic cylinders are then used to erect the mast that is then fully pinned to the deck on all four legs. Following this, the truck-mounted drawworks is driven into place.

[0013] Patterson U.S. Pat. No. 4,221,088 discloses a system wherein the mast is pinned to the parallel substructure beams by transverse pins and then elevated first along with one section of the rig floor. The mast raising is done with any available winching source. Following the mast erection, the main section of the floor with the drawworks and rotary is elevated using the drawworks. All the pivot pins are parallel.

[0014] Gallon U.S. Pat. No. 4,375,241 indicates an arrangement wherein the mast is initially pivotably connected to the rig floor and then erected using the drawworks. Following that, the rig floor is raised vertically by rack and pinion drives operating on vertical corner posts for the rig floor. Finally, diagonal braces are used to structurally reinforce the elevated rig floor for withstanding both horizontal and vertical loads.

[0015] McGovney et al. U.S. Pat. No. 4,569,168 describes a rig floor that has an articulated knee joint pattern symmetric about a central plane transverse to the substructure base beams. The knees are initially collapsed so that the rig floor is lying on the substructure beams. After the mast is attached to the rig floor and elevated, a cable-operated system is used to partially straighten the knees so that the rig floor is elevated. The knees operate in the planes of the substructure beams, and the mast is pivoted in the vertical midplane between the substructure beams.

[0016] Woolslayer et al. U.S. Pat. No. 4,587,778 shows a system that initiates erection with the rig floor lying on the parallel substructure base beams. Two counter rotating columns for each base beam are pinned horizontally at their bottom ends to the base beams. The pin axes are perpendicular to the base beam axes. The columns are then rotated to vertical positions using auxiliary winches to cause them to pivot. Next the auxiliary winches are used to vertically lift the rig floor above the base beams. Finally the horizontal mast is raised from the ground to the top of two opposed columns, pinned to the column tops by pins parallel to the column base pins, and then finally rotated to vertical by the drawworks. The mast rotates in the vertical midplane between the two base beams.

[0017] Reed U.S. Pat. No. 5,921,336 discloses a system of four walking jack devices swivelable about vertical axes that can be installed on the underside of a rig substructure. Each of the jack devices is reciprocable both horizontally and vertically and the set of jacks is positioned so that they can support the integrated rig and mast structures in a stable manner. In order to travel in a given direction, the jack devices are first lifted above the ground so that the rig is resting only on the base beams. At that point the jacks are all pointed in the direction of travel and the foot of each jack is moved horizontally so that all are at the first extreme of their horizontal travel. The jack devices are then lowered to support the rig and horizontally shifted so that they are each at the second extreme of their horizontal travel. The feet are then lifted so that the base beams support the rig while the jack devices are shifted horizontally back to their first extreme of their horizontal travel. This process is repeated until the rig has assumed its desired new location. At that point the jack devices can then be realigned with the base beams and positioned so that the rig is supported on the base beams alone or jointly by the beams and the jacks.

[0018] It can be understood from the descriptions above that Reeve, Jr. et al. U.S. Pat. No. 3,942,593, Gallon U.S. Pat. No. 4,375,241, and Woolslayer et al. U.S. Pat. No. 4,587,778 all disclose systems wherein the rig floors are jacked or lifted vertically in order to bring them to their final installed positions. All of these systems, except the mat type foundation described by Reeve, Jr., have horizontally-positioned masts, either before or after lowering, that are parallel to the base beams of the substructure. In general, these erected rigs would have to be moved by skidding or other appropriate means in a direction parallel to their base beams. The rig systems in this first group would all have problems if used for closely spaced linear arrays of wells. Reeve, Jr. would be unable to work with wells on a close spacing because of foundation or pipe ramp interference with the initial well or wells. The other rig systems in this first group would be able to drill no more than two or three closely spaced wells positioned in the midplane between the base beams before interferences would necessitate rig disassembly for relocation. Mast laydown would have to be over the line of wells unless the rig is moved away from the wells an appreciable distance.

[0019] Woolslayer et al. U.S. Pat. No. 3,228,151, Woolslayer et al. U.S. Pat. No. 3,271,915, Branham U.S. Pat. No. 3,747,695, Eddy et al. U.S. Pat. No. 3,922,825, and Patterson U.S. Pat. No. 4,221,088 describe rig floor assemblies that are rotated upwardly to their installed positions by using either linkages pinned to the base beams and the rig floor or, in the case of Branham, substructural elements which are rotated into upright positions after pinning to the base beams. The Dreco "Slingshot" rig also uses a similar arrangement to the systems mentioned in this group of patents. McGovney et al. U.S. Pat. No. 4,569,168 uses symmetric knee-type linkages with ends pinned at the base beams and at the rig floor in order to elevate the rig floor. All of the rig structural systems in this group of patents have horizontally-positioned masts, either before raising or after lowering, parallel to the base beams of the substructure. The ability of the rigs in this second group to drill closely spaced linear arrays of wells is limited in the same manner as those in the first group of rig systems.

[0020] Another difficulty with most of the rig systems discussed above is the need to use the drawworks extensively in the rig erection. This need leads to a requirement of drawworks availability and the necessity to rig and then unrig special lines for the required lifting operation. The modular construction of Wales U.S. Pat. No. 3,739,853 is arranged differently than that of the rig patents discussed previously. Yet partial disassembly of this rig structure is necessary in order to move the substantially intact rig laterally away from the wellhead of a completed well. Furthermore, the substructure module spacing is typically not compatible with a closely spaced linear array of wells.

[0021] The walking mechanism of Reed U.S. Pat. No. 5,921,336 could be applied to most typical self erecting rigs so that they could be readily moved, but in order to move away from a wellhead, it is necessary to partially dismantle the rig to avoid interference with the wellhead. Alternatively the rig can be first moved transversely to the base beams and then moved parallel to the base beams. However, combining two such maneuvers requires additional time and effort beyond that needed for a simple linear move.

[0022] The mast elevating means and method of Lovell U.S. Pat. No. 2,887,191 is overly complex and is less reliable than the use of a single telescoping cylinder for mast elevation. The foundation for the lifting cylinder is located on a stationary portion of the rig substructure that typically would not be suitable for a pipe ramp.

[0023] A strong need exists for a drilling rig which can be transported readily to a new location and there erected and later dismantled in a minimal amount of time. Additionally, a need exists for a rig that can be used to drill multiple wells in a closely spaced linear array without rig disassembly and reassembly being required so that interference with existing wellheads during the rig move can be avoided. Further, a need exists for a rig construction that is compatible with a variety of means of rig moving, such as skidding, the use of walking substructure devices, or the use of wheeled moving devices. A particular need also exists for a drilling rig that does not require that its mast be lowered to a horizontal position over a line of existing wellheads as a rig disassembly step when the final well in a linear array has been drilled.

SUMMARY OF THE INVENTION

[0024] The present invention relates in general to a drilling rig and a method for using the drilling rig in making bore holes for conducting petroleum exploration and development. In particular, the present invention relates to a process for erecting a modular rig in an efficient manner and for

facilitating the set up of the rig for drilling multiple wells in a closely spaced linear pattern from the same well site.

[0025] One aspect of the present invention is a drilling rig comprising: (a) a plurality of parallel foundation beams; (b) an elevatable platform adapted for erection above the foundation beams; (c) a rig floor forming a top of the elevatable platform, wherein the rig floor has (i) a drawworks attached to the rig floor on a first side of the rig floor, (ii) a pair of coaxial mast pivot pin mounts attached to the rig floor on a second side of the rig floor opposite the first side of the rig floor; (iii) a rotary table positioned between the drawworks and the mast pivot pin mounts; and (iv) a pair of coaxial mast connection pin mounts attached to the rig floor between the drawworks and the rotary table; and (d) a mast having a rectangular cross-section, a lower mast end and an upper mast end, the lower mast end pivotably attached on a first side to the mast pivot pin mounts such that the mast is pivotable in a vertical plane perpendicular to the foundation beams, the lower mast end further secured on a second side to the mast connection pins whenever the mast is in a vertical position.

[0026] Another aspect of the present invention is A drilling rig comprising: (a) a plurality of parallel foundation beams; (b) an elevatable platform adapted for erection above the foundation beams; (c) a rig floor forming a top of the elevatable platform, wherein the rig floor has (i) a drawworks attached to the rig floor on a first side of the rig floor, (ii) a pair of coaxial mast pivot pin mounts attached to the rig floor on a second side of the rig floor opposite the first side of the rig floor, (iii) a rotary table positioned between the drawworks and the mast pivot pin mounts, and (iv) a pair of coaxial mast connection pin mounts attached to the rig floor between the drawworks and the rotary table; (d) a pipe ramp attached to the platform proximal to the second side of the rig floor; (e) one or more hydraulic cylinders symmetrically mounted on opposed sides of the pipe ramp; and (f) a mast having a lower mast end pivotably attached on a first side to the mast pivot pin mounts such that the mast is pivotable in a vertical plane perpendicular to the foundation beams, the lower mast end further secured on a second side to the mast connection pins whenever the mast is in a vertical position.

[0027] The foregoing has outlined rather broadly several aspects of the present invention in order that the detailed description of the invention that follows may be better understood. Additional features and advantages of the invention will be described hereinafter which form the subject of the claims of the invention. It should be appreciated by those skilled in the art that the conception and the specific embodiment disclosed might be readily utilized as a basis for modifying or redesigning the structures for carrying out the same purposes as the invention. It should be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

[0029] **FIG. 1** shows an oblique view of the drilling rig of the present invention in its laid down arrangement prior to the initiation of erection;

[0030] **FIG. 2** shows the same structure as in **FIG. 1**, but in a plan view of the unerected drilling rig;

[0031] **FIG. 3** shows a profile view of the unerected rig floor taken along line **3-3** of **FIG. 2**, wherein the gin pole arrangement for elevating the rig floor is shown;

[0032] **FIG. 4** is a profile view of the rig taken along line **4-4** of **FIG. 2**;

[0033] **FIG. 5** is a profile view corresponding to **FIG. 4** and illustrating the raised mast of the rig in its vertical, unextended position;

[0034] **FIG. 6** is a profile view corresponding to **FIG. 3** and illustrating the raised mast of the rig in its vertical, unextended position prior to the elevation of the rig floor;

[0035] **FIG. 7** is a profile view corresponding to **FIG. 6** and showing the rig after the rig floor has been elevated;

[0036] **FIG. 8** is a profile view corresponding to **FIG. 5** and showing the rig after the rig floor has been elevated;

[0037] **FIG. 9** corresponds to **FIG. 8**, but shows the rig after the mast is fully extended to its operational height;

[0038] **FIG. 10** is an oblique view corresponding to **FIG. 1**, but showing the rig ready for drilling but without the peripheral equipment of the rig;

[0039] **FIG. 11** is a plan view of the rig on a multiple well location showing skid frames in position for a rig move in the direction of a linear array of closely spaced wells and illustrating the direction in which the mast is laid down; and

[0040] **FIG. 12** is an oblique view of a conventional rig showing the differences in alignment between it and the rig of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0041] The present invention relates in general to a drilling rig and a method for using the drilling rig in making bore holes for conducting petroleum exploration and development. In particular, the present invention relates to a process for erecting a modular rig in an efficient manner and for facilitating the set up of the rig for drilling multiple wells in a closely spaced linear pattern from the same well site.

[0042] The rig substructure is supported on a pair of spaced apart mirror-image foundation beams and the rig floor is stowed for travel lying on the foundation beams. The rig floor is attached to the foundation beams by mirror-image four-bar linkages each of which is moveable in the same vertical plane as its foundation beam. The rig floor is rotated from its stowed position to its elevated working position by means of one or more auxiliary winches and gin poles that cause the deck to pivot upwardly. The telescoping mast is attached to the rig floor on its vee door side by coaxial pins so that it may be rotated to its upright position about those pins. The mast may be either one piece or telescoping. The axis of the mast rotation is parallel to the foundation beams.

[0043] The horizontal mast is pinned to the rig floor, in its telescoped position, and then erected vertically prior to

elevating the rig floor. The erection of the mast is performed by using one or two telescoping hydraulic cylinders with their bases pivotably mounted on the pipe ramp with the pivot axes parallel to the foundation beams. For mast erection, the lower side of the pipe ramp is laid flush upon the ground and the side adjacent the rig floor is pin connected to the edge of the rig floor. This arrangement permits rig erection to proceed without special reaving of temporary lines to the drawworks. Additionally, the rig may readily be moved in the direction parallel to its foundation beams by skidding, attached substructure walking devices, or attached wheeled movers, such means being well known in the drilling art. All of these means of moving the rig may be used without substructure disassembly or interference with preexisting wellheads.

[0044] Referring now to the drawings, it is pointed out that like reference characters designate like or similar parts throughout the drawings. The Figures, or drawings, are not intended to be to scale. For example, purely for the sake of greater clarity in the drawings, component sizes and spacing are not dimensioned as they actually exist in the assembled embodiment.

[0045] In FIGS. **1-4**, the rig **10** of the present invention is seen after the constituent components have been assembled into place preparatory for erection so that drilling can commence. The rig is located on a preleveled site in order to minimize structural stresses and to avoid alignment problems. The sequence of rig erection procedures, which are herein described, are reversed in order to disassemble the rig.

[0046] The mast assembly **11** of rig **10** is of a conventional telescoping space truss construction with an upper mast section **13** positioned within lower mast section **12** and axially reciprocable between a first, retracted position and a second, extended position. The mast is shown in its horizontal, unextended position in which it is first connected to the rig. Selectably operable latching means (not shown) are provided to hold the upper and lower mast sections at either or both of the retracted or extended positions. The transverse cross sections of the upper mast section is rectangular, and the upper section of the lower mast section is also. Guideways are provided on both the upper and lower sections in order to ease relative motion of the sections and to transfer bending moments induced by wind or other loadings. On the lower side of lower mast section **12** close to the rig floor **22**, the cross bracings between the chords of the truss are removed in order to form a passage for drillpipe and casing to be raised or lowered from the pipe rack **90**, shown in **FIG. 11**, so that it may be stood or suspended within the mast and/or stood back vertically at the finger boards of the mast. This access opening in the lower portion of the lower mast section is termed a vee-door and is shown in **FIG. 10**.

[0047] Accessories for the mast include the crown and traveling blocks and any guides required for the traveling block, the finger boards, ladders and work platforms, mud hoses, air tuggers, and other items typically required for rig operation. On the upper side of the horizontal mast **11**, the extreme ends of the rig floor end of the upper truss chords of the lower mast section **12** are each provided with upper chord pad eyes **17** suitable for attaching the erected mast to the rig floor **22** at pin mounts **24**. On the lower side of the horizontal mast **11**, the extreme ends of the lower truss chords of the lower mast section **12** are each provided with lower chord pad eyes **18** by which the mast is pinned to the rig floor **22** at pin mounts **25**. The pins for lower chord pad eyes **18** are horizontal and coaxial and have their axis mutually parallel to the mast side of the rig floor and the foundation beams **21**, as seen in **FIGS. 2 and 3**.

[0048] Located immediately below the horizontal mast is pipe ramp **14**. Pipe ramp **14** seen from the side has a triangular prismatic shape with a reinforced upper face having lateral rims so that pipe **90** can be dragged up or slid down the ramp between the pipe rack **80** and the rig floor **22**. The bottom surface of pipe ramp **14** is configured to uniformly bear on the ground surface when the ramp is attached to the lowered rig floor **22** by horizontal pin connections **16** which are adjacent to the upper surface of the rig floor and the side beam of the rig floor on the mast side. The pin connections **16** have a common horizontal axis parallel to the mast side of the rig floor **22**. The side of the pipe ramp **14** adjacent to the rig floor **22** is cut back on its lower side by the maximum angle of inclination that the bottom face of the ramp will have when the rig floor **22** is elevated to its highest position, so the ramp can rotate upwardly without interference with the side of the rig floor.

[0049] One or two telescopic hydraulic mast elevating cylinders **15** are attached to the vertical sides of pipe ramp **14** by horizontal pin mounts that are parallel to the pipe rack pin connections **16** to the rig floor **22**. If two cylinders **15** are used, then they are identical and are symmetrically mounted about the vertical midplane of pipe ramp **14**. Rests are provided to hold the cylinders **15** parallel to the lower pipe ramp surface in a stowed position when they are not in use. As seen in **FIG. 8**, when the cylinders **15** are used to elevate or lower the mast **11**, they reach through the vee door and have their rod ends pinned to the upper side of mast **11** by horizontal coaxial pins parallel to the pin axes of the lower chord pad eyes **18**.

[0050] Rig base assembly **20** includes: a) spaced apart parallel foundation beams **21** resting on the ground, b) rectangular horizontal rig floor **22** which mounts most of the rig hardware, including the mast, and c) the erectable/collapsible supporting structure of the rig floor. The supporting structure consists of two mirror image four bar linkages, wherein the static link for each linkage is a foundation beam **21** which is cojoined by pinning to the similar, parallel first pivoting link arms **44** and second pivoting link arms **48** at their respective first ends. The opposed second ends of arms **44** and **48** are cojoined by pinning to the rig base **20**. The axes of the linkage pins are horizontal and perpendicular to the foundation beams **21**. Foundation beams **21** are longer than the rig floor **22** and are sized and spaced apart sufficiently to provide a stable foundation for the rig **10**. The axes of foundation beams **21** are parallel to the pipe ramp pin connection **16** to rig floor **22**. A conventional drawworks **23** is mounted aligned with the centerline of the horizontal mast, but on the opposite side of the rig floor from the mast that has its rotational axis parallel to the pipe ramp pin connection **16** to the rig floor **22**. The axis of rotation of the drawworks is parallel to the foundation beams **21**.

[0051] Pin mounts **24** for connecting the mast upper chord pad eyes **17** to rig floor **22** are mounted with their axes coaxial and parallel to the pipe ramp pin connection **16** to the

rig floor **22**, but on the drawworks side of the rig floor. Pin mounts **24** are spaced to engage the mast upper chord pad eyes so the mast can be rotationally fixed to the rig floor in a stable manner for erection. Pin mounts **25** for connecting the mast lower chord pad eyes **18** to rig floor **22** are mounted with their axes coaxial and parallel to the pipe ramp pin connection **16** to the rig floor **22**, but on the mast side of the rig floor. Pin mounts **25** are spaced to engage the mast lower chord pad eyes and are joined to those eyes by pin connections. Centrally located between pin mounts **24** and **25** within an opening in rig floor **22** is a conventional rotary table **26** for rotating the drillpipe.

[**0052**] A gin pole system, shown in **FIGS. 3, 6**, and **7**, is used both for elevating and stabilizing the rig floor **22**. One gin pole is located at the end of and in the vertical plane containing its foundation beam for each of the foundation beams **21** in a mirror image pattern about the vertical plane for symmetry of the rig substructure. Each gin pole system consists of a vertical sheave support **31** and an inclined knee **32** respectively attached to the foundation beam **21** by the bottom pin **33** and the bottom pin **34**. The sheave support **31** and knee **32** are interconnected by the top pin **35**. Turning sheaves **30** are mounted on the bottom of vertical sheave supports **31** to permit turning the floor lifting line **38** to vertical.

[**0053**] Upper floor lift sheaves **36** each have two independently rotatable sheaves respectively mounted at the upper ends of vertical sheave supports **31**. Lower floor lift sheaves **37** are respectively mounted on the gin pole side of rig floor **22** beneath the floor near its side beams and respectively aligned with upper floor lift sheaves **36**. A wire rope floor lifting line **38**, for each gin pole system, is anchored to the rig floor structure **22** and then reeved around the first rotatable sheave of the upper floor lift sheave **36**, then sheave **37**, then back around the second rotatable sheave of the lower floor lift sheave **36**, and then to independently operable auxiliary winch **39** which is mounted on foundation beam **21**.

[**0054**] Two parallel, equilength pivoting link arms **44** and **48** are mounted to foundation beam **21** by lower pivot point **45** and lower pivot point **49**, respectively. Pivoting link arms **44** and **48** are also mounted to rig floor **22** by upper pivot point **46** and upper pivot point **50**, respectively. First pivoting link arm **44** is mounted near the top side of foundation beam **21**, while second pivoting link arm **48** is positioned near the bottom side of foundation beam **21**. Upper pivot points **46** and **50** are located near opposed corners on the mast side of the rig floor **22**. All of the rotational axes of the pivoting link arms **44** and **48** are horizontal and perpendicular to axis of the pipe ramp pin connection **16** to the rig floor **22**. Mirror image arrangements of the pivoting link arms **44** and **48** exists for the two foundation beams **21**, as well as pivot points **45**, **46**, **49**, and **50**. The linkage arms **44**, **48**, the foundation beams **21**, and the side beams of the rig floor **22** form two identical, mirror-image four-bar linkages which may be caused to rotate by means of the winches **39** so that rig floor **22** can be raised. When the rig floor **22** has been raised, the pivoting arms are sufficient in length to provide an unhindered clearance for movement of the rig over a linear array of well heads **60***a,b,c,d,e* as shown in **FIG. 11**.

[**0055**] **FIG. 11** shows a plan view of a well site which has a multiwell linear array **60***a,b,c,d,e*. This well pattern is established sequentially one well head at a time from an initial position at well head **60***a*, which is located under the rotary table **26** of the rig **10** when it is in its initial position. The linear well pattern is parallel to the foundation beams **21** of the rig base assembly **20**. The direction of movement of the rigs, as well as the direction of the foundation beams, is indicated as Y in **FIGS. 10 and 11**. The well-to-well separation is determined by service access needs and the requirement for not accidentally intersecting well bores. Two skidways **70** are formed by multiple base frames or trusses which are located in a parallel pattern on the ground underneath foundation beams **21** of rig base assembly **20**. Rig **10** can be skidded in either direction along the length of skidways **70** in order to access any of the wells **60***a,b,c,d,e* in the linear array. Because skidways **70** may be constructed of multiple identical segments, the skidway can be extended readily in either direction by relaying the segments in a hand-over-hand fashion. In **FIG. 11**, it is seen that the racks **80** have been established parallel to and laterally offset from foundation beams **21** of rig base assembly **20**. Stored tubular goods (drillpipe and casing) are arrayed on the pipe rack **80** for easy access by the rig **10** across pipe ramp **14**. The mast **11** of rig **10** is shown laid down horizontally on the pipe rack **80**, as would be done for certain service purposes. The direction of mast pivoting and the direction of the pipe ramp are indicated as X in **FIGS. 10 and 11**.

[**0056**] **FIG. 12** shows a conventional self-erecting rig **100**, such as the Dreco "Slingshot" design. Rig **100** consists of telescoping mast **111**, pipe ramp **114**, and rig base assembly **120**, all constructed similar to the equivalent components for rig **10** of the present invention. One significant difference between conventional rig **100** and rig **10** is that conventional foundation beams **121** are parallel to horizontally positioned mast **111** of rig **100**, rather than the foundation beams **21** of the present invention that are perpendicular to the rig **10** horizontally positioned mast. Another important difference between rig **10** and conventional rig **110** is that the drawworks is used for upending mast **111** of the conventional rig and, typically, for rig floor raising.

[**0057**] Operation of the Invention

[**0058**] The procedure for erection of rig **10** of the present invention is described in the figures and the following material. Initially referring to FIGS. **1** to **4**, rig base assembly **20** is set upon a preleveled location and then pipe ramp **14** and the lower chord pad eyes **18** of the lower end of lower mast section **12** of telescoped mast **11** are mounted thereto by, respectively, pipe ramp pin connection **16** and pin mounts **25**. The rod ends of mast elevating cylinders **15** are pinned to the upper side of lower mast section **12**. At that point, application of hydraulic fluid from an independent source to the piston end of telescoping hydraulic mast elevating cylinders **15** will cause the mast to rotate about horizontal pin mounts **25** towards vertical. When mast **11** is vertical, as shown in **FIGS. 5 and 6**, then the connection can be made between upper chord pad eyes **17** of the lower mast section **12** and pin mounts **24** on the rig floor so that the mast is structurally stabilized. At that point, the rod ends of mast elevating cylinders **15** are disconnected from the upper mast section **12** and the cylinders collapsed and stowed on the sides of pipe ramp **14** as shown in **FIG. 8**. The lifting and downward reactions on pin mounts on rig floor **22** induced during erection of the mast **11** are sufficient low that rig base

assembly **20** is not destabilized. Most of the large lifting reaction acts downwardly on pipe ramp **14** during erection or lowering of mast **11**.

[**0059**] After the mast **11** has been placed vertically and fixed onto the rig floor, the gin pole systems shown in **FIGS. 3, 6**, and **7** are rigged. When independently powered winches **39** reel inwardly in unison, rig floor **22** is raised until it abuts the inclined knee **32** of the gin pole systems, where the rig floor assembly can be latched to the inclined sheave supports. First pivoting link arms **44** and second pivoting link arms **48** serve as columns to support rig floor **22** at its working level. The gin pole assemblies provide lateral stability and support to the erected rig floor **22**.

[**0060**] The next step in erecting rig **10** is to fully elevate the mast **11** by telescoping upper mast section **13** upwardly within lower mast section **12**. This is done by using the drawworks to pull upwardly on the lower end of upper mast section **13** using lines reeved to the top of lower mast section **12** in a method in very common use in the oilfield. **FIGS. 8, 9**, and **10** show the fully erected drilling rig **10**. The remaining tasks for preparing to drill involve hooking up the mud system, setting the pipe racks, and the like, all of which are done in a conventional manner.

[**0061**] **FIG. 11** shows the rig **10** mounted on skidways **70** so that it could be shifted along the axis of the skidways in order to access any of the linear well array **60***a,b,c,d,e*. The shifting can be done by winching or hydraulic cylinders. Alternatively, a walking mechanism such as that shown by Reed U.S. Pat. No. 5,921,336 or a wheeled moving unit of the type commonly used in the oilfield could be used to move the rig linearly in the direction of the well array. This movement can be done with the rig **10** fully erected, even though mast **11** is shown laid down on the pipe rack **80** in **FIG. 11**. This ability to move rig **10** in an unlimited manner along the direction of its foundation beams **21** results from the complete openness between the ground, the rig floor **22**, and the foundation beams **21**. Neither rig structure nor hardware intrude into that open area and hence cannot interfere with existing wellheads. Further, when the mast is laid down, it is never suspended or laid down over the linear array of wellheads.

[**0062**] In the case of rig **100**, the rig can be skidded readily only parallel to its foundation beams **121**. For this reason, its mast **11** will always be laid down over a linear array of wells unless it is skidded off a substantial distance, which is a definite operational and safety liability.

[**0063**] Advantages of the Invention

[**0064**] A very significant advantage of the present invention results from its use of auxiliary power sources, rather than the drawworks, to elevate the mast and rig floor. This use of auxiliary power permits rigging of the drawworks to proceed in parallel with the erection of the mast and the raising of the rig floor of the rig.

[**0065**] A second major advantage is the ability of the mast to be laid down away from the line of wells when the rig is used for a linear array of wells at a location. This speeds up rig tear down and is much safer than having the mast above existing wellheads.

[**0066**] A third major advantage is the high adaptability of the rig to different means of moving the rig about a location. A walking mechanism such as the mechanism shown in Reed U.S. Pat. No. 5,921,336, skidding, or a wheeled mover can readily be used to move the completely intact rig from well to well. This results in significant time and cost savings.

[**0067**] Although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A drilling rig comprising:

(a) a plurality of parallel foundation beams;

(b) an elevatable platform adapted for erection above the foundation beams;

(c) a rig floor forming a top of the elevatable platform, wherein the rig floor has

(i) a drawworks attached to the rig floor on a first side of the rig floor,

(ii) a pair of coaxial mast pivot pin mounts attached to the rig floor on a second side of the rig floor opposite the first side of the rig floor;

(iii) a rotary table positioned between the drawworks and the mast pivot pin mounts; and

(iv) a pair of coaxial mast connection pin mounts attached to the rig floor between the drawworks and the rotary table; and

(d) a mast having a rectangular cross-section, a lower mast end and an upper mast end, the lower mast end pivotably attached on a first side to the mast pivot pin mounts such that the mast is pivotable in a vertical plane perpendicular to the foundation beams, the lower mast end further secured on a second side to the mast connection pins whenever the mast is in a vertical position.

2. The drilling rig of claim 1, wherein the foundation beams are longer than the platform.

3. The drilling rig of claim 1, wherein the platform is supported by the foundation beams.

4. The drilling rig of claim 1, wherein the elevatable platform is supported on each foundation beam by an erectable four-bar linkage that lies in a vertical plane containing the supporting foundation beam.

5. The drilling rig of claim 1, wherein whenever the platform is elevated the platform has a clearance space between the foundation beams and the rig floor sufficient to pass over a pre-existing well head.

6. The drilling rig of claim 1, wherein the platform is elevated using an auxiliary winch and a plurality of gin pole assemblies.

8. The drilling rig of claim 6, wherein the auxiliary winch and the gin pole assemblies are attached to the foundation beams.

9. The drilling rig of claim, wherein the gin pole assemblies provide lateral stability to the elevated platform.

10. The drilling rig of claim 1, wherein the axis of rotation of the drawworks is parallel to the foundation beams.

11. The drilling rig of claim 1, wherein the mast is a telescoping mast.

12. The drilling rig of claim 11, wherein the mast is made in two sections comprising a lower section containing the lower mast end and an upper section containing the upper mast end, such that the upper section of the mast is telescopable within the lower section of the mast.

13. The drilling rig of claim 11, wherein the telescoping mast is extended using the drawworks.

14. The drilling rig of claim 1, further comprising a pipe ramp attached to the platform proximal to the second side of the rig floor.

15. The drilling rig of claim 14, wherein the pipe ramp is perpendicular to the foundation beams.

16. The drilling rig of claim 14, wherein the pipe ramp supports the mast whenever the mast is in a horizontal position.

17. The drilling rig of claim 14, wherein the pipe ramp has a triangular prismatic shape.

18. The drilling rig of claim 14, wherein the pipe ramp has a reinforced upper face with lateral rims and a lower face that serves as a foundation to support the loadings associated with raising and lowering the mast.

19. The drilling rig of claim 14, wherein the mast has a lower section containing the lower mast end and an upper section containing the upper mast end.

20. The drilling rig of claim 19, wherein the lower section of the mast has a vee door adjacent the pipe ramp.

21. The drilling rig of claim 14, further comprising one or more extensible hydraulic cylinders, the hydraulic cylinder pivotably attached to the pipe ramp on a cylinder bottom end.

22. The drilling rig of claim 21, wherein the extensible hydraulic cylinders pivot the mast between an up position and a down position.

23. The drilling rig of claim 19, further comprising a pair of hydraulic cylinders symmetrically mounted on opposed sides of the lower section of (the mast at a top cylinder end of each hydraulic cylinder and symmetrically mounted on opposed sides of the ramp at a bottom cylinder end of each hydraulic cylinder.

24. A drilling rig comprising:

(a) a plurality of parallel foundation beams;

(b) an elevatable platform adapted for erection above the foundation beams;

(c) a rig floor forming a top of the elevatable platform, wherein the rig floor has

(i) a drawworks attached to the rig floor on a first side of the rig floor,

(ii) a pair of coaxial mast pivot pin mounts attached to the rig floor on a second side of the rig floor opposite the first side of the rig floor,

(iii) a rotary table positioned between the drawworks and the mast pivot pin mounts, and

(iv) a pair of coaxial mast connection pin mounts attached to the rig floor between the drawworks and the rotary table;

(d) a pipe ramp attached to the platform proximal to the second side of the rig floor;

(e) one or more hydraulic cylinders symmetrically mounted on opposed sides of the pipe ramp; and

(f) a mast having a lower mast end pivotably attached on a first side to the mast pivot pin mounts such that the mast is pivotable in a vertical plane perpendicular to the foundation beams, the lower mast end further secured on a second side to the mast connection pins whenever the mast is in a vertical position.

25. A method for erecting a drilling rig, the method comprising the steps of:

(a) placing an elevatable platform attached to a plurality of parallel foundation beams on an area of ground, the platform comprising:

(i) a rig floor forming a top of the elevatable platform,

(ii) a drawworks attached to a first side of the rig floor,

(iii) a pair of coaxial mast pivot pin mounts attached to the rig floor on an opposed second side of the rig floor,

(iv) a rotary table positioned between the drawworks and the mast pivot pin mounts,

(v) a pair of coaxial mast connection pin mounts attached to the rig floor between the drawworks and the rotary table, and

(vi) a telescopic mast having a lower mast section and an upper mast section, the lower section having a vee door and four pad eyes, each pad eye positioned at a lower corner of a rectangle formed by the lower mast section;

(b) mounting a pipe ramp to the platform proximal to a second side of the rig floor, the pipe ramp having a cylinder end of a hydraulic cylinder attached to a side of the pipe ramp;

(c) attaching a first pair of pad eyes, located on a bottom end of the lower section of the mast on opposed sides of the vee door, to the pivot pins such that the mast is pivotable in a vertical plane perpendicular to the foundation beams;

(d) attaching a rod end of the hydraulic cylinder to an upper side of the lower section of the mast;

(e) extending the hydraulic cylinder to pivot the mast about the pivot pin mounts to a vertical position;

(f) connecting a second pair of pad eyes, located on a bottom end of the lower section of the mast opposite the first pair of pad eyes, to the pair of mast connection pin mounts to stabilize the mast preparatory to drilling;

(g) disconnecting the hydraulic cylinder from the mast;

(h) rigging a gin pole system to the platform, the gin pole system being attached to the foundation beams;

(i) elevating the platform using the gin pole system; and

(j) telescopically elevate the mast using the drawworks.

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