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(71) Applicant *(for all designated States except US)*: **ITREC B.V.** [NL/NL]; 2, Admiraal Trompstraat, NL-3115 HH Schiedam (NL).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **ROODENBURG, Joop** [NL/NL]; 7, St. Eustatiusstraat, NL-2612 HA Delft (NL). **WIJNING, Diederick Bernardus** [NL/NL]; 32, Gustav Vasaborg, NL-3124 TH Schiedam (NL). **QUINLAN, Eric William** [CA/NL]; 28, Fabriplein, NL-3117 MD Schiedam (NL).

(74) Agent: **HOLLANDER, M.W.**; P.O. Box 3241, NL-2280 GE Rijswijk (NL).

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(54) **Title**: LAND BASED EARTH BORING SYSTEM

(57) **Abstract**: The invention relates to a land based transportable earth boring system adaptable for transportation between different drilling pads, the system comprising at least a first and a second relocatable and transportable drilling tower unit, each adapted for movement from one drilling location to another drilling location on said drilling pad and for transport from one drilling pad to another drilling pad. The system further comprising a transportable shared mud unit for providing the drilling tower units with drilling mud, and/or a transportable shared power unit for providing the drilling tower units with power, and/or a transportable shared control unit for controlling the drilling process performed at each tower. The invention furthermore comprises a method for drilling, in particular shale gas drilling, using a land based transportable earth boring system comprising at least a first and a second independently relocatable and transportable drilling tower unit, and: a transportable shared mud unit for providing the drilling tower units with drilling mud, and/or a transportable shared power unit for providing the drilling tower units with power, and/or a transportable shared control unit for controlling the drilling process performed at each tower.

LAND BASED EARTH BORING SYSTEM

Field of the invention

The present invention relates to land based transportable earth boring equipment and techniques for producing fluids and/or gasses from a subterranean formation. More particularly, this invention relates to improved techniques for drilling multiple wells in a pad to recover gas from a shale formation.

Background of the invention

Shale gas has become an increasingly important source of natural gas over the past decade. Shale gas is typically recovered from shale formations. Because shale ordinarily has insufficient permeability to allow a significant fluid or gas flow to a well bore, multiple wells have to be drilled into the shale to obtain the gas.

To reduce the impact of drilling multiple wells on the landscape, the wells are drilled from isolated pads. In each pad typically 25 to 50 wells are drilled. The wells are drilled in a vertical direction until the shale layer is reached. In the shale layer, the wells are drilled in a lateral direction, e.a. over distances up to 3000 meter, to create a maximum borehole surface area in contact with the shale. By drilling in lateral directions away from the drilling pad, an area much larger than the pad is exploited.

After the wells are drilled, the shale is subjected to hydraulic fracturing (fracking) to create extensive artificial fractures around the well bores and thus release the gas from the shale.

To make shale gas a commercial viable source of energy, the many wells necessary for obtaining the gas have to be drilled in a minimum of time.

A general object of the present invention is to provide new and improved earth boring system and methods which combine technological advances in the areas of automation techniques, drilling operations, and transportation.

Another object of the present invention is to provide new and improved earth boring system and methods for relocating a transportable earth boring system on a pad from one drilling location to another drilling location.

Furthermore, a need exists for an earth boring system that has less impact on the ground cover or foliage when being transported. A need also exists for less impact on the ground when the earth boring system is set up and in use.

Summary of the invention

The present invention provides a land based transportable earth boring system comprising at least a first and a second transportable and relocatable drilling tower unit, each adapted for movement or displacement on a drilling pad from one drilling location to another drilling location on said drilling pad. The drilling tower units are furthermore adaptable for transportation from one drilling pad to another drilling pad.

The earth boring system furthermore comprises a transportable shared mud unit for providing the drilling tower units with drilling mud and/or a transportable shared power unit for providing the drilling tower units with power and/or a transportable shared control unit for controlling the drilling process of each tower. In a preferred embodiment according to the invention all three shared units are present in the system, so that they can be arranged on a drilling pad in combination with multiple drilling tower units on said pad.

By sharing the one or more mud, power, and/or control units by multiple drilling units, the overall footprint of the earth boring system is reduced compared to an earth boring system comprising separate drilling tower units each provided with their own drilling mud unit, power unit and control unit. The transport of the drilling tower units between drilling pads is facilitated since less equipment has to be transported compared to the transport of two fully equipped drilling tower units and corresponding mud, power, and control units. Furthermore, less personnel is needed for running a large shared system than for running two separate units of half the capacity.

By providing two or more transportable and relocatable drilling tower units in combination with shared units for providing mud and/or power to the drilling tower units and/or for controlling the drilling, parallel drilling of wells on a single pad is possible with relatively compact drilling tower units. The time needed for drilling multiple wells is reduced due to the parallel drilling activities as well as due to the compact tower units being easier to transport from one drilling location to another drilling location on the pad.

By providing the shared units the transportable and relocatable drilling tower units can be compact, and can thus be moved more easily. The shared units are set up on the drilling pad, e.g. centrally on the pad, and are not moved each time a drilling tower unit is moved to one location on said pad, which saves time and effort. Preferably, the shared units are set up at a central location on the drilling pad and are not moved until all the wells have been completed.

In a further embodiment the shared units are moved prior to all wells being drilled, but only after multiple wells have been drilled, for example at least five wells with each drilling tower unit. The shared units are thus only moved between a limited number of locations, the number of locations being significantly less than the number of wells drilled by each drilling tower unit.

Thus, with an earth boring system according to the invention the overall time needed for completing the drilling of the wells in a pad is reduced. Since the time for completing the wells is reduced, exploitation of the wells can start earlier.

In an embodiment, a shared control unit preferably houses a master computer, communication equipment, video monitors, for controlling the drilling processes in the drilling tower units. In a preferred embodiment, the control unit houses multiple drilling process control rooms for each controlling the drilling process of a drilling tower unit. Thus, each drilling tower unit can be operated by its own drilling operator or drilling crew from the control unit. The controls for the different drilling towers are now located in a shared control unit. Preferably the controls for the different drilling tower units are located close to each other, preferably in a single room, such that one person may control the drilling process and/or the mud handling and/or the power supply of multiple drilling towers. Thus, less personnel is needed for controlling the overall drilling process. In a further embodiment, the control unit may also comprise living quarters for personnel.

A mud, power, and/or control unit shared by the drilling tower units is typically larger than a corresponding single unit for servicing a single drilling tower unit in the prior art. However, the shared unit is more compact than the total of units of multiple drilling tower units in the prior art. Thus the over all footprint of the earth boring system according to the invention is small compared to the overall footprint of prior art systems in which multiple drilling rigs are used, each with its own mud supply, power supply, control, etc..

Furthermore, for example a known standard drilling unit is provided with a main power supply unit and a back up power supply unit for safety reasons. When the power supply is shared by two drilling tower units, the two main power supplies are combined into a single large main power supply. A single back up unit may be sufficient, such that the drilling tower units can share a normal sized back up power supply unit in stead of two combined back up power supply units. Thus, the overall footprint is reduced.

Furthermore, for example when providing each drilling tower unit with its own mud handling system, each mud handling system is preferably provided with a back up system. When the mud unit is shared by multiple towers a single back up system may be sufficient.
Thus, the footprint and the production cost of a shared unit can be reduced compared to the footprint and production costs for multiple units each for use with a single drilling tower unit only.

Preferably, shared units are provided for providing power or mud to either two or three or four, etc. drilling tower units of the system and for controlling either two or three or four, etc, drilling tower units. Thus, because the shared unit is designed for connection to a specific number of units, the shared unit can be provided with a minimal footprint.

It is observed that in an alternative embodiment, the earth boring system comprises three or more independently transportable and relocatable drilling tower units. The number of drilling tower units is chosen depending on the number of wells to be drilled on a pad, the lay-out of the wells on the pad, and/or the time within which said wells need to be completed. The shared units are preferably adapted for connection to the specific number of drilling tower units used.

The invention furthermore provides a method for drilling, in particular shale gas drilling, using a land based transportable earth boring system, the system comprising at least a first and a second independently relocatable and transportable drilling tower unit. The system further comprises one or more of the following;
- a transportable shared mud unit for providing the drilling tower units with drilling mud,
- a transportable shared power unit for providing the drilling tower units with power,
- a transportable shared control unit for controlling the drilling process performed at each tower. In a preferred method another embodiment of an earth boring system according to the invention is used.

With the method according to the invention, first the drilling tower units and the one or more shared units of the earth boring system are transported to a drilling pad. Subsequently, drilling tower units and the one or more shared units of the earth boring system are installed on the drilling pad, and the drilling tower units are located above a well drilling location on the pad. The drilling tower units are connected with the shared units. When the units are installed and connected, the drilling tower units each start drilling boreholes. When a drilling tower unit has completed a well, the respective drilling tower unit is disconnected from the shared units and is moved to a next drilling location on the drilling pad.

It is observed that although the different drilling tower units may drill wells close to each other, the geological features of each well may differ such that the time required for completing the wells is different for each drilling tower. Thus one or some drilling tower units may be in the process of relocating, while one or some other drilling tower units are drilling a well. Each shared unit is adapted for functioning when one or some drilling tower units are connected to it and when all drilling tower units are connected to it. For example, drilling mud may be provided to a first drilling tower unit, while a second drilling tower unit is being relocated and a third drilling tower unit is removing the drill string from the drilled well.
With a further method according to the invention a drilling tower unit can be provided with drilling mud from the shared mud unit and/or power from a shared power unit while moving at least one other drilling tower unit, which drilling unit is disconnected from the shared mud unit and/or power unit, from a first drilling location to another drilling location.

When a drilling tower unit, after its relocation, is positioned above another drilling location on the pad, it may be reconnected with the respective one or more shared units, and start drilling.
Thus, the drilling tower units are moved from one drilling location to another drilling location until all the wells of the drilling pad are completed.
When all wells have been completed, the drilling tower units are disconnected from the one or more shared units. The drilling tower units and the shared units of the earth boring system are subsequently adapted for transport, for example transformed into containerized units, to another drilling pad, and the earth boring system is transported to another drilling pad, e.g. by truck.

It is observed that in a further embodiment of an earth boring system according to the invention, the shared units are adapted to allowfor adding and/or removing drilling tower units during the process of drilling the wells in the pad. For example, in the beginning five drilling tower units may be provided for drilling on a single pad, or two adjacent pads. When most wells have been completed, the number of drilling tower units is gradually reduced and the last number of wells is drilled with just one or two drilling tower units.

In a further method according to the invention, the shared units of the earth boring system are relocatable units, adapted for movement on a drilling pad from a first location to a second location, e.g. are supported on a skid. The shared units can be disconnected from the drilling tower units e.g. when for example multiple wells, preferably five or more, have been completed by each drilling tower unit. The shared units are subsequently moved from a first location on the drilling pad to a second location on the drilling pad, after which they are reconnected to the drilling tower units.

In a further embodiment, the shared power unit is adapted for providing power to drilling tower units and/or shared units on multiple adjacent pads. Preferably, this shared power unit is located inbetween adjacent pads. Thus, the footprint of the earth boring system on the drilling pads is reduced.

In a further embodiment, the transportable and relocatable earth boring system comprises three or more transportable and relocatable drilling tower units for each drilling a well, which tower units share the mud handling unit and/or power unit and/or control unit.
In an alternative embodiment, the earth boring system comprises drilling tower units that each comprise their own mud unit, and share the single power unit and the single control unit. Thus, the power is generated and the drilling process is controlled from a central area where the shared units are placed, which allows for a small footprint of the drilling tower units and facilitates moving the drilling tower units on the drilling pad from one drilling location to another drilling location.
Furthermore, it is envisaged that the shared control unit is generally located at a greater distance from the drilling tower units than control units that are integrated with a drilling tower unit. This provides more safety for personnel working in the shared control unit in case something goes wrong, at a drilling tower unit.

In an alternative embodiment, the earth boring system comprises drilling tower units that each comprise their own power unit, and share the mud unit and the control unit. Thus, the mud is handled in and the drilling process is controlled from a central area, which allows for a small footprint of the drilling tower units and thus facilitates moving the drilling tower units on the drilling pad from one drilling location to another drilling location. Also, the overall footprint of the earth boring system is smaller than the overall footprint of the same number of drilling units each provided with their own drilling mud unit and their own control unit.

In an alternative embodiment, the earth boring system comprises drilling tower units that each comprise their own control unit, and share the mud unit and the power unit. Thus, the power is generated from and the mud is handled in a central area, which allows for a small footprint of the drilling tower units and thus facilitates moving the drilling tower units on the drilling pad from one drilling location to another drilling location. Also, the overall footprint of the earth boring system is smaller than the overall footprint of the same number of drilling units each provided with their own mud unit and their own power unit.

In a further embodiment, the earth boring system comprises multiple drilling tower units on multiple pads. In a further embodiment, the earth boring system is provided with a single, shared control unit that is adapted for controlling transportable and relocatable drilling tower units on multiple drilling pads.

In a preferred embodiment, the earth boring system comprises at least two shared units, for example a shared mud handling unit and a shared power unit, the power unit providing power to the other shared unit and to the relocatable drilling tower units.

In a further preferred embodiment, the earth boring system comprises at least three shared units, for example a shared mud handling unit, a shared power unit and a shared control unit. The three units mentioned are suitable for being located at a distance from the drilling tower units. Adapting them to be shared by multiple drilling tower units allows for an overall footprint of the earth drilling system that is significantly smaller than the overall footprint of the same number of drilling tower units provided with their own mud unit, power unit and control unit.

Preferably, multiple shared units are located close to each other, such that control personnel and maintenance personnel have easy access to them, and do not need to travel from one location on the drilling pad to another location on the drilling pad.

In addition to, or in stead of, the shared units mentioned above, a transportable and relocatable earth boring system according to the invention may comprises other shared units, for example a shared water unit, a shared cement unit, etc.

In a further embodiment, the earth boring system according to the invention further comprises a shared Bottom Hole Assembly preparation unit, for composing the BHA's for the different drilling tower units. The shared unit can also be sued for stack and maintenance of the BHA's. The BHA's are transported between the BHA preparation unit and the drilling tower units by truck or alternatively by a dedicated transport device comprising for example guide transport cars.

In a further embodiment according to the invention, the shared units of the earth boring system are adapted for, from a single location on the drilling pad, providing the transportable and relocatable drilling tower units at different locations along the periphery of said drilling pad with drilling mud and/or power and/or controlling the drilling tower units. With such an embodiment, the shared units are locate on a central area of the drilling pad, while the drilling tower units are drilling outside said central area, up to and along the periphery of the drilling pad. By locating the share units in the central area of the pad the average distance between the shared units and the drilling tower units is kept to a minimum.

In a further embodiment, the earth boring system is provided with a shared control unit that is adapted for obtaining information about the drilling process from one drilling tower unit, and for using this information for controlling the drilling process in one or more other drilling tower units. For example, when a first drilling tower unit encounters an especially hard layer during the drilling process, the parameters of the drilling process are subsequently adapted to optimally drill the especially hard layer. The information can subsequently be used by the control system to adapt the parameters of the drilling process in other drilling tower units in anticipation of the drill coming into contact with the especially hard layer.

In a preferred embodiment, the shared units, more in particular the manifold system and/or grid and/or control system, comprise flexible cables, flexible conduits, flexible pipes, etc, such that the shared units can stay connected to the drilling tower units when the latter are moved from one drilling location on the pad to another drilling location on the pad. Thus , the drilling towers do not need to be disconnected and reconnected prior to and afterwards moving the. This saves time.
The manifold system and/or the grid for example comprise flexible pipes, flexible hoses or flexible tubes, such that the grid for example can be rolled out when the drilling unit is moved away from the shared units and rolled in when the drilling tower unit is moved towards the shared control units. In contrast with a fully rigid system, these flexible elements allow for movement of the drilling tower unit over at least a certain distance, for example from a drilling location to the directly adjacent drilling location, without disconnecting the drilling tower unit from the shared units. Also flexible cables for connecting electronic devices and cables for providing electric power allow for a connection between a shared unit and drilling towers which does not need to be disconnected and reconnected when the drilling tower is moved. A surplus flexible cable may for example be provided on a winch and reeled in or fed out when the drilling tower unit is moved. Also, a drag chain may be provided for providing cables or tubes along a linear track.

A control unit is preferably adapted for controlling the main aspects of the drilling process, for example managing the drilling speed and drilling angle. In a further embodiment, in addition to personnel controlling the drilling process from the shared control unit additional personnel is present at the drilling tower unit for controlling particular aspects of the drilling

process. Preferably, the additional personnel are monitored from the shared control unit and is in contact with the personnel in the control unit.
In a preferred embodiment, the drilling unit towers are highly automated and for example the feeding of the tubulars into the drilling tower is also controlled from the control unit.

It is observed that in a preferred method according to the invention, the multiple drilling tower units start at drilling locations not directly adjacent to each other and/or move along drilling locations in a direction away from the other drilling tower units. Thus, the movement of the units is not hindered by the other units, The chance of one drilling tower unit blocking movement of the other drilling tower unit because the completion of the well takes more time is minimized.

It is observed that in the context of this text a shared unit should be understood as a single unit adapted for connection with multiple drilling tower units at the same time. Thus, when the system is provided with a shared mud unit, this mud unit provides all drilling tower units with drilling mud. A (shared) back up system may be provided.

It is observed that in the context of this text “relocate” relates to movement of units between different locations on a pad, for example drilling locations, while “transport” relates to movement of an earth boring system between different pads.

Both the boring system and the method according to the invention are especially suitable for drilling multiple boreholes in a limited surface area, for example when drilling multiple holes for obtaining the last oil from an almost depleted oil field. It is observed that the earth boring system and the method according to the invention are especially suitable for exploitation of shale gas fields in which a pad is to be provided with multiple wells.

It is observed that a drilling mud unit, a power unit and a control unit are essential components for a drilling unit. Thus, when an earth boring system according to the invention is not provided with a shared mud unit and/or a shared power unit and/or a shared control unit, each drilling tower unit is provided with its own mud unit and/or power unit and/or control unit respectively. Furthermore, an earth drilling system according to the invention comprises at least one shared mud unit, or one shared power unit or one shared control unit, and is preferably provided with two or even three out of this three mentioned shared units.

It is observed that a well is completed after the full drilling process is finished, i.e. the well is drilled and cemented and/or casing is provided such that the well is ready for exploitation and/or for fracking, etc.

It is observed that a shared unit may comprise multiple modular components, for example, a shared mud unit may be composed from multiple mud handling modules.

In a further embodiment, the earth boring system according to the invention comprises a shared power unit that is adapted to receive energy generated in a first drilling tower unit, e.g. by braking of an electrical winch when lowering drillstring or casing, and feeding that energy via the shared power unit to another drilling tower unit of the system. In prior art drilling units the energy generated by for example an electric winch is transferred into heat and is not used in the drilling process. The recovered energy may also be transferred to the one or more shared units to their operation, e.g. drive pumps, fans, etc.. Thus, with this embodiment of an earth boring system according to the invention, the drilling of the wells is more energy efficient and costs can be reduced.

According to the invention, the drilling tower units are relocatable, i.e. can be moved on a pad from a first drilling location to another drilling location. Thus, it is possible to displace the drilling tower unit, and any parts of the system that may be rigidly connected to the drilling tower unit, between locations on the pad between locations without the need to disassemble the drilling tower unit. During displacement of the drilling tower unit, the drilling tower is preferably kept in the operational position, in which the drilling tower extends in a vertical direction.
The drilling tower units are also transportable, i.e. can be conveyed from one drilling pad to another drilling pad. The drilling tower units can be disassembled and or transfigured, e.g. partly collapsed, to facilitate transportation between drilling pads. For example, the drilling tower unit can be provided with a tiltable and/or removable drilling tower.

In a preferred embodiment the transportable earth boring system is a containerized earth boring system. In such a system, the drilling tower units and/or one or more of the other units, preferably the drilling tower units and the shared units, can be transformed from a working configuration into a compact transport configuration, of one or more transport units that preferably have the dimensions of an ISO freight container. A compact transport configuration further facilitates transport by road, train or ship.

In an embodiment, the drilling tower units are each provided with a skid frame for sliding over skid beams. The drilling tower unit can be displaced with respect to the skid beams by sliding over them. The force required to make these sliding movements may be provided by one or more hydraulic actuators which push or pull the drilling tower unit over skid beams. Thus, the drilling tower units can be moved from one drilling location to another drilling location and relative to a shared mud unit, shared power unit, and shared control unit.

In an alternative embodiment the drilling tower unit is provided with wheels or caterpillar tracks for moving the drilling tower unit. In a further embodiment, the drilling tower unit is provided with propulsion means, for example a drive, for driving the wheels or caterpillar tracks.

In an alternative embodiment, the drilling tower unit comprises a displacement system to displace the drilling rig with respect to the ground surface in a substantially horizontal direction, wherein use is made of movable feet. Such a displacement system is for example provided with two or more displacement devices to displace the drilling tower unit, wherein each displacement device comprises a displacement foot extendable and retractable in a substantially vertical direction between an extended position, in which the displacement foot is arranged on the support surface, and a retracted position, in which the displacement foot is free from the support surface.
The displacement foot may comprises a lift actuator to move the displacement foot between the retracted position and the extended position. In an embodiment, the lift actuators of the two or more displacement devices together are capable to provide sufficient lifting force to lift the complete drilling tower unit, and the one or more displacement actuators of the two or more displacement devices are capable to provide sufficient force to move the complete drilling tower unit in the substantially horizontal direction. In such embodiment no further lifting or displacement means are required to lift and displace the drilling tower unit over the support surface.

In an embodiment, the drilling tower unit comprises a tilt adjustment device, capable of adjusting an orientation of a displacement device, such as a foot or wheel, to a non-horizontal ground surface and or to local elevations or depressions in the ground surface supporting the displacement devices. The ground surface on which the drilling tower unit is supported may not be completely flat. A tilt adjustment device may be arranged to adapt the orientation of the displacement device, for example foot, wheel or caterpillar track. This tilt adjustment device may be a passive device which automatically adjusts the orientation of the displacement device to the orientation of the support surface or an active device, which is actively controlled to adjust the position of the displacement device to the orientation of the support surface.

In a preferred embodiment, the drilling tower units are constructed in a way essentially similar to the drilling tower disclosed in patent publication US 7 255 180, which is incorporated herein by reference.

In a preferred embodiment, the earth boring system comprises a tubular handling apparatus for each drilling tower unit that is constructed in a way essentially similar to the tubular handling apparatus disclosed in patent publication US 7 255 180, which is incorporated herein by reference.

The invention furthermore provides a method for drilling. The invention envisages in particular the use of the system for shale gas drilling, using a land based transportable earth boring system according to claim 12. With a further method according to the invention, the time and effort for completing multiple wells in a pad is reduced.

The invention will now be described in more detail with reference to examples and the drawings. In the drawings:
FIG. 1 is a schematic overhead view of an earth boring system according to the present invention;
FIG. 2 is a schematic overhead view of an alternative earth boring system according to the present invention; and
FIG. 3 shows an example of a independently transportable and relocatable drilling tower unit 2 in working configuration.

In figure 1 a schematic overhead view of an exemplary land based transportable earth boring system 1 according to the present invention is shown. The earth boring system is set up on a pad 4 of which two rows 5, 6 of multiple drilling locations 7 are shown. A well is to be bored at each location. Preferably, as is known from the art, drilling is performed with directional drilling equipment.

The land based transportable earth boring system is adaptable for transportation between remote drilling pads, i.e. the units of the system can be adapted to facilitate transport thereof, e.g. by road. In a preferred embodiment the transportable earth boring system is a containerized earth boring system.

In this embodiment the drilling tower units and/or one or more of the other units, preferably the drilling tower units and all the shared units, are containerized units, i.e. they can be transformed from a working configuration into a compact transport configuration. In the transport configuration a unit or member of a unit preferably has the size of an ISO freight container, preferably a 40 feet container, to facilitate transport by train or truck. Advantageously, the base of the drilling unit, or members forming the base, is/are designed to be transportable as an ISO freight container and has ISO freight container corner fittings. In a preferred embodiment, the earth boring system comprises a tubular handling apparatus for each drilling tower unit that is constructed in a way essentially similar to the tubular handling apparatus disclosed in patent publication US 7 255 180, which is incorporated herein by reference.

The land based earth boring system 1 shown here comprises a first independently transportable and relocatable drilling tower 2 and a second independently transportable and relocatable drilling tower 3. In the embodiment shown, the two tower units 2,3 share a mud unit 8 for providing the drilling tower units with drilling mud, a power unit 9 for providing the drilling tower units with power, and a control unit 10 for controlling the drilling process of each tower.

The drilling tower 2,3 units are relocatable, i.e. can be moved on a pad common from a first drilling location to another drilling location. In the embodiment shown, the drilling tower units are provided with a base embodied as a skid frame for sliding over skid beams 16. Thus, the drilling tower units can be independently moved from one drilling location 7 to another drilling location on the pad and relative to the shared mud unit, the shared power unit, and the shared control unit which preferably remain at a stationary position on the pad during the drilling of all wells. The drilling towers are also transportable, i.e. can be moved from one drilling pad to another drilling pad, e.g. by trucks.

Each drilling tower unit 2,3 comprises a rigid frame support and a mast for supporting for example a B.O.P., a top drive drilling system, etc. The drilling unit further comprises a base structure, for example a tractor-trailer or skid frame, for moving the drilling unit from one drilling location on the pad to another drilling location on the pad. The base structure and the frame may be integrated.

The drilling tower units may also each comprise one or more winches, preferably electrically operated, for raising and lowering drilling tubulars, for example drill pipes and/or casing, and/or equipment into and out off the drilling well.

The transportable shared mud unit is equipped for providing the drilling tower units with drilling mud. The shared mud unit comprises mud handling devices for mixing and controlling the mud flow to the drilling tower units. The shared mud unit 8 comprises a pipeline manifold system 11 connecting the shared mud unit with the drilling tower units 2,3 for providing the drilling tower units with drilling mud when required in the drilling process. The drilling mud unit may further house boilers, water tanks, pump room, and a one or more mud tanks, etc..

The shared mud unit is connected with the drilling tower units via a manifold system 11 comprising pipes or conduits, for example a pipe string, extending between each tower and the shared mud unit. The pipes can be disconnected and reconnected for adapting the layout of the pipe string when the drilling tower unit is moved over the pad and relative to the shared mud unit.
The shared mud unit comprises a manifold system for distributing the mud over the pipe strings, and thus for distributing the mud over the drilling tower units. The mud unit, and the distribution of the drilling mud, is preferably controlled from the shared control unit.

The transportable shared power unit 9 is equipped for providing the drilling tower units with power. The shared power unit 9 for example comprises one or more diesel generators for generating electrical power, and an adaptable grid 12 for connecting the shared power unit with equipment of the drilling tower units 2,3 to provide the drilling tower units with power. The grid can be adapted, for example by adding more electrical cables and or hydraulic hoses, for reconnecting a drilling unit when it is moved over the pad and relative to the shared power unit.

In a further embodiment, the earth boring system comprises a shared power unit that is adapted to receive energy that has been generated in a first drilling tower, e.g. by braking of an electrical winch thereof when lowering drillstring or casing, and feeding that energy to another drilling tower unit. Thus, the drilling of the boreholes is more energy efficient and costs can be reduced.

The shared power unit can be an electric power unit or a hydraulic power unit. In a further embodiment, the shared power unit comprises a first shared power unit for providing hydraulic power to each of the drilling tower units and a second shared power unit for providing electric power to each of the drilling tower units. Thus, the multiple drilling tower units can be provided with hydraulic as well as electric power by the shared power unit.

In an alternative embodiment, each drilling tower unit is provided with its own hydraulic power unit, while electric power is provided by a shared power unit, which shared power unit preferably is adapted for recovering electric energy from one drilling tower unit and providing the energy to another drilling tower unit and/or to another shared unit such as the shared mud unit, e.g. to drive mud pumps.

The transportable shared control unit 10 is equipped for controlling the drilling process performed at each tower, preferably controlling and/or operating the drilling equipment of the drilling tower unit. The shared control unit 10 comprises a control system 13 connecting the shared control unit with equipment of the drilling tower units 2,3 for controlling the drilling operations of the drilling tower units. The control unit in the embodiment shown is furthermore connected to the shared power unit for power, and to the shared mud unit for controlling the distribution of the drilling mud over the drilling tower units.

In the embodiment shown in figure 1, the drilling tower units are placed on a pair of skid beams, extending on opposite sides of a row of drilling locations, for movement of the drilling tower unit over the pad from one drilling location to another drilling location in said row. The tower units are moved along the skid beams by a push pull device. The time needed for moving a tower unit from one drilling location to the next is a small percentage of the time spent drilling a well. Furthermore, the time needed for completing a well will differ for each tower/drilling location. Thus, in practice the tower units do not need to be moved at the same moment from one drilling location to the next, and the device for movement of the tower units, in this case the push-pull device, can be used for both tower units.

In an embodiment, the shared units of the earth boring system are relocatable units also. The shared units are then adapted for movement on a drilling pad from a first location to a second location, e.g. are supported on a skid or skid beams. Thus, the position of the shared units on the pad can be adapted to keep the distance between the shared units and the drilling units minimal. For example, after the drilling tower units have completed the wells of a first section of the pad, and are ready to start drilling in a second section, the shared units are moved from a position in the first section, to a position in the second section.

In a further embodiment, the earth boring system according to the invention further comprises a shared drilling tubulars stacking unit, for stacking e.g. drilling pipes, tubulars, casing, etc.. The tubulars stacking unit is provided with a pipe transfer device for delivering pipes from the shared stack to the drilling tower units.

The pipe transfer device preferably comprises trucks for transporting the pipes from the stacking unit to the pipe feeders. In a preferred embodiment, the drilling tubulars are provided at the stacking unit in magazines holding a predetermined amount of tubulars, for example 25 drilling pipes.

In the embodiment shown in figure 1 the drilling pipes are provided from a shared drilling tubular stacking unit, not shown, to pipe feeders 14, 15 of the first drilling tower unit and the second drilling tower unit.
By sharing a drilling tubular stacking unit, the percentage of extra tubulars kept on stock for, for example, replacing damaged tubulars can be reduced. For example, when providing each drilling unit with its own stack, a safety margin of 10% of the individual stacked supply is provided. With a shared stack a safety margin of 5% of the shared stacked supply may be sufficient. The overall number of drilling tubulars can be reduced because in practice not all drilling tubulars are needed at all drilling tower units at the same moment.

In a preferred embodiment, the pipe transfer device is also adapted for transporting the tubulars from one drilling tower unit to another drilling tower unit. For example when at one tower the drilling string is removed, the drilling pipes are transported to a drilling tower unit wherein the drilling of the well is still in process.

Figure 2 shows a further embodiment 21 of an earth boring system according to the invention, wherein a shared mud unit 28, a shared power unit 29 and a shared control unit 30 are located at the centre of a drilling pad 24. In the particular embodiment shown two essentially T-shaped connection grids 31,32 , comprising wires and pipes of the manifold system, the grid and the control system, are provided for connecting the three shared units with a first drilling tower unit 22 and a second drilling tower unit 23. In the embodiment shown, the connection grids 31,32 each extend along at least a significant part of a row of drilling locations (not individually indicated in the drawing). The connection grids are furthermore provided with branches 33 for connecting a drilling tower unit on a drilling location to the connection grid, and thus to the shared units. By providing a connection grid that extends along a number of drilling locations, the grid does not need to be adapted each time a drilling tower unit is moved from one drilling location to another drilling location. When all drilling locations along a connection grid are completed, the connection grid is adapted such that it for example extends along the adjacent row of drilling locations.

It is observed that a shared mud system and a hydraulic power unit are connected to the drilling tower units via a manifold system and a grid respectively, comprising pipes for

transporting the mud and hydraulic fluid. The manifold system and the grid may further comprise cables connecting electronic equipment for monitoring and managing the mud and power to the respective shared units.
A shared control unit and an electric power unit are connected to the drilling tower units via a grid and a control system, the grid and the control system typically comprising cables for transporting electric energy and/or cables for connecting electronic equipment for monitoring and managing the power and for carrying out the control.

It is furthermore observed that the manifold system, the grid and the control system can be adapted for disconnection from a drilling tower unit when it is moved from one drilling location to another drilling location on the pad. For example, the manifold system may comprise steel pipes which are used for laying a pipeline to the new location of the drilling unit. Also, the cable connection between the shared unit and the drilling tower unit may be adapted, i.e. lengthened or shortened, when a drilling tower unit is moved.

It is observed that in figure 1 each drilling tower unit is moved over a dedicated track. In an alternative embodiment, multiple drilling tower units may share one dedicated track.

Figure 3 shows an example of a independently transportable and relocatable drilling tower unit 2 in working configuration.

The drilling tower unit 2 has a mast 40 and a base structure 45 supporting the unit on the ground.

The mast 40 is preferably composed of multiple interconnected mast members, preferably each dimensioned and embodied to allow transportation (e.g. on a lorry, train, or ship) as an ISO standard shipping container.

The mast 40 is preferably disassembled only when transporting the tower 2 from one pad to another, remote drilling pad and kept in assembled and preferably in vertically erected position on the base structure when transporting or displacing the tower unit 2 from one drilling location to another (preferably neighbouring) drilling location on the same drilling pad that is to be provided with multiple wells 7a.

The base structure may also be composed of one or more base members that are preferably each dimensioned and embodied to allow transportation (e.g. on a lorry, train, or ship) as an ISO standard shipping container.

The base structure may be embodied to allow for skidding of the base structure over parallel rails 16 that have been installed on the drilling pad, or with wheels that roll over said rails as a train.

In another embodiment the base structure may be embodied with multiple support feet, e.g. four feet. For example the feet may each be operable in a manner such that the entire unit 2 is displaceable from one location to the next, e.g. each foot having a crawler track.

The mast can be equiped with a rotary top drive 46 as is preferred for drilling operations.

The unit 2 preferably allows to receive a BOP 47, preferably at a position below a drill floor 48 at an elevated position in the unit 2.

The figure 3 also illustrates the provision of a loader device 50 adapted to load drilling tubulars 51, e.g. drill pipe joints, into the tower 2 from a tubulars storage 52 adjacent the unit 2.

In an alternative embodiment, the drilling tower unit comprises a displacement system to displace the drilling tower unit with respect to a support surface in a substantially horizontal direction, wherein use is made of movable feet. Such a displacement system is for example provided with two or more displacement devices to displace the drilling tower unit, wherein each displacement device comprises a displacement foot extendable and retractable in a substantially vertical direction between an extended position, in which the displacement foot is arranged on the support surface, and a retracted position, in which the displacement foot is free from the support surface.
The displacement foot may comprises a lift actuator to move the displacement foot between the retracted position and the extended position. In an embodiment, the lift actuators of the two or more displacement devices together are capable to provide sufficient lifting force to lift the complete drilling tower unit, and the one or more displacement actuators of the two or more displacement devices are capable to provide sufficient force to move the complete drilling tower unit in the substantially horizontal direction. In such embodiment no further lifting or displacement means are required to lift and displace the drilling tower unit over the support surface.
In a further embodiment, the displacement foot comprises a lower part and an upper part, wherein said lower part is configured to be placed on the support surface, and wherein said upper part is connected to the drilling tower unit. Said lower part is movable with respect to

the upper part in at least one substantially horizontal direction, and said displacement foot comprises one or more displacement actuators to move the lower part and the upper part with respect to each other in the at least one substantially horizontal direction. When the displacement foot is in the extended position, the drilling tower unit can be displaced by relative movement in the horizontal direction of the upper part with respect to the lower part. This movement can be relatively small. In the retracted position, the displacement foot is no longer arranged on the support surface and the lower part and the upper part can be brought back in their initial relative position without movement of the drilling tower unit with respect to the support surface. By repeating these horizontal relative movements of the upper part and lower part in the extended and retracted position of the displacement feet, the drilling tower unit can be moved step wise over the support surface.
Other devices may be provided to cooperate with the two or more displacement devices to displace the drilling tower unit. In practice, three or four displacement devices may be provided to support and displace the drilling tower unit.

A drilling tower unit provided with displacement feet, as described above, for movement of the drilling tower unit, can be moved in a substantially horizontal direction for example by using a method comprising the steps of:
a) lifting the drilling tower unit by vertically extending the displacement feet to a position such that the drilling tower unit is only supported by the displacement feet of the displacement devices,
b) moving from an initial relative position between the upper parts and the lower parts the upper parts of the displacement feet in the substantially horizontally direction with respect to the lower parts to move the drilling tower unit over a substantially horizontal distance,
c) lowering the drilling tower unit by vertically retracting the displacement feet until the displacement feet are free from the support surface, and
d) moving the lower parts relative to the upper parts of the displacement feet back to the initial relative position, and
e) repeating steps a) to d) until the drilling tower unit has been moved over a desired horizontal distance.

C L A I M S

1. Land based transportable earth boring system adaptable for transportation between different drilling pads, the system comprising at least a first and a second relocatable and transportable drilling tower unit, each adapted for movement on a drilling pad from one drilling location to another drilling location on said drilling pad and for transport from one drilling pad to another drilling pad, said system further comprising one or more of the following:
- a transportable shared mud unit for providing the drilling tower units with drilling mud, the shared mud unit comprising a pipeline manifold system connecting the shared mud unit with the drilling tower units for providing the one or more drilling tower units with drilling mud;
- a transportable shared power unit for providing the drilling tower units with power, the shared power unit comprising a grid connecting the shared power unit with equipment of each drilling tower, for providing the one or more drilling tower units with power;
- a transportable shared control unit for controlling the drilling process performed at each tower, the shared control unit comprising a control system connecting the shared control unit with equipment of each drilling tower, for controlling the drilling process of each tower.

2. Earth boring system according to claim 1, wherein the tower units are each mounted on skids or a skid frame for moving each drilling tower relative to the shared mud unit and/or shared power unit and/or shared control unit by sliding them over the pad from a first drilling location to a second drilling location.

3. Earth boring system according to one or more of the preceding claims, wherein the system further comprises:
a shared drilling tubulars stacking unit, which unit is provided with a pipe transfer device for delivering pipes from a shared stack to the drilling tower units.

4. Earth boring system according to one or more of the preceding claims, wherein the system comprises a shared power unit, which shared power unit comprises:
a first shared power unit for providing hydraulic power to each of the drilling tower units and a second shared power unit for providing electric power to each of the drilling tower units.

5. Earth boring system according to one or more of the preceding claims, wherein the system comprises a shared power unit, which shared power unit is adapted to receive energy generated in a first drilling tower, e.g. by braking of an electrical winch when lowering

drillstring or casing, and feeding that energy via the shared power unit to another drilling tower unit.

6. Earth boring system according to one or more of the preceding claims, wherein the one or more shared units of the earth boring system are adapted for, from a location on the drilling pad, providing the transportable and relocatable drilling tower units at different locations along the periphery of said drilling pad with drilling mud and/or power and/or controlling the drilling tower units.

7. Earth boring system according to one or more of the preceding claims, wherein the one or more shared units of the earth boring system are relocatable units, adapted for movement on a drilling pad from a first location to a second location, e.g. are supported on a skid.

8. Earth boring system according to one or more of the preceding claims, wherein the transportable and relocatable earth boring system comprises three or more transportable and relocatable drilling tower units for each drilling a drilling well, said tower units sharing the mud handling unit, and/or the power unit and/or the control unit.

9. Earth boring system according to one or more of the preceding claims, wherein the transportable earth boring system is a containerized earth boring system.

10. Earth boring system according to one or more of the preceding claims, wherein the system comprises a shared power unit, which shared power unit is adapted for providing power to transportable and relocatable drilling tower units on multiple drilling pads.

11. Earth boring system according to one or more of the preceding claims, wherein the system comprises a shared control unit which shared control unit is adapted for controlling transportable and relocatable drilling tower units on multiple drilling pads.

12. Method for drilling, for example shale gas drilling, using a land based transportable earth boring system, the system comprising at least a first and a second independently relocatable and transportable drilling tower unit, the system further comprising one or more of the following:

- a transportable shared mud unit for providing the drilling tower units with drilling mud,
- a transportable shared power unit for providing the drilling tower units with power,
- a transportable shared control unit for controlling the drilling process performed at each tower,

the method comprising the steps;

- Transporting the drilling tower units and the one or more shared units of the earth boring system to a drilling pad,
- installing the drilling tower units and the shared units of the earth boring system on the drilling pad and locating each of the the drilling tower units above a well drilling location on the pad,
- connecting the drilling tower units with the shared units and drilling a well with each of the drilling tower units,
- when a drilling tower unit has completed a well, disconnecting the respective drilling tower unit from the shared units if necessary for moving the drilling tower, and moving the drilling tower unit to a next drilling location on the drilling pad,
- if the drilling tower unit was disconnected prior to moving it, reconnecting the drilling tower unit with the shared units and drilling a well,
- repeating the last two steps until all wells of the drilling pad are completed,
- disconnecting the drilling tower units from the shared units, and adapting the drilling tower units and the shared units of the earth boring system for transport to another drilling pad,
- transporting the earth boring system to another drilling pad.

13. Method according to claim 12, the method further comprising the step:
- providing a drilling tower unit on a pad with drilling mud from the shared mud unit and/or power from a shared power unit while moving at least one other drilling tower unit from a first drilling location to another drilling location on said drilling pad.

14. Method according to claim 12 or 13, the method further comprising the steps of:
- generating power with a first drilling tower unit, e.g. by braking of an electrical winch when lowering drillstring or casing, and feeding that energy via the shared power unit to another drilling tower unit.

15. Method according to one or more of the claims 12-14, wherein the one or more shared units of the earth boring system are relocatable units, adapted for movement on a drilling pad from a first location to a second location, e.g. supported on skidbeams, the method further comprising the steps:
- when multiple wells, preferably five or more, have been completed by each drilling tower unit and if necessary for moving the shared units, disconnecting the shared units from the drilling tower units
- moving the one or more shared units from a first location on the drilling pad to a second location on the drilling pad,

- if the one or more shared units was/were disconnected prior to moving, reconnecting the one or more shared units to the drilling tower units.

16. Method according to one or more of the claims 12-15, using an earth boring system according to one or more of the claims 1-11.

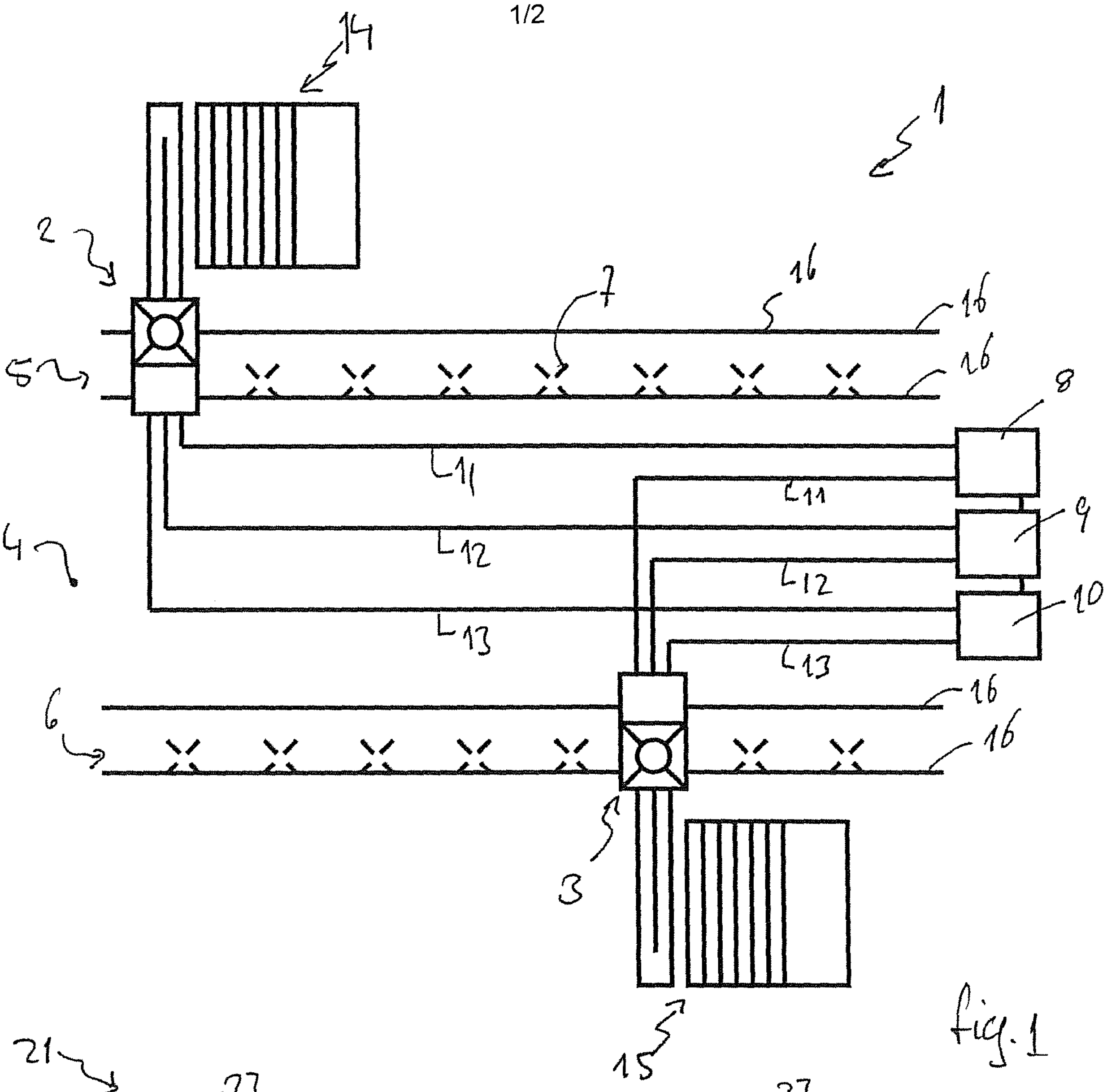
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fig.1

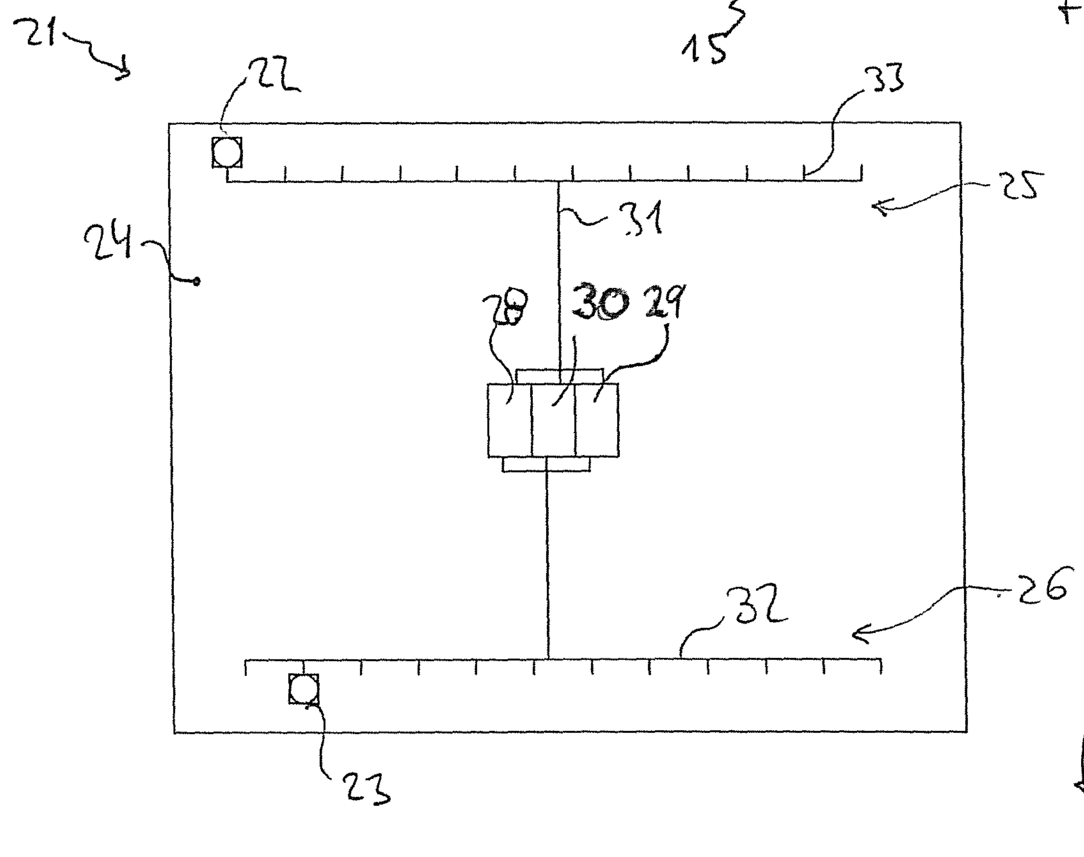
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fig.2

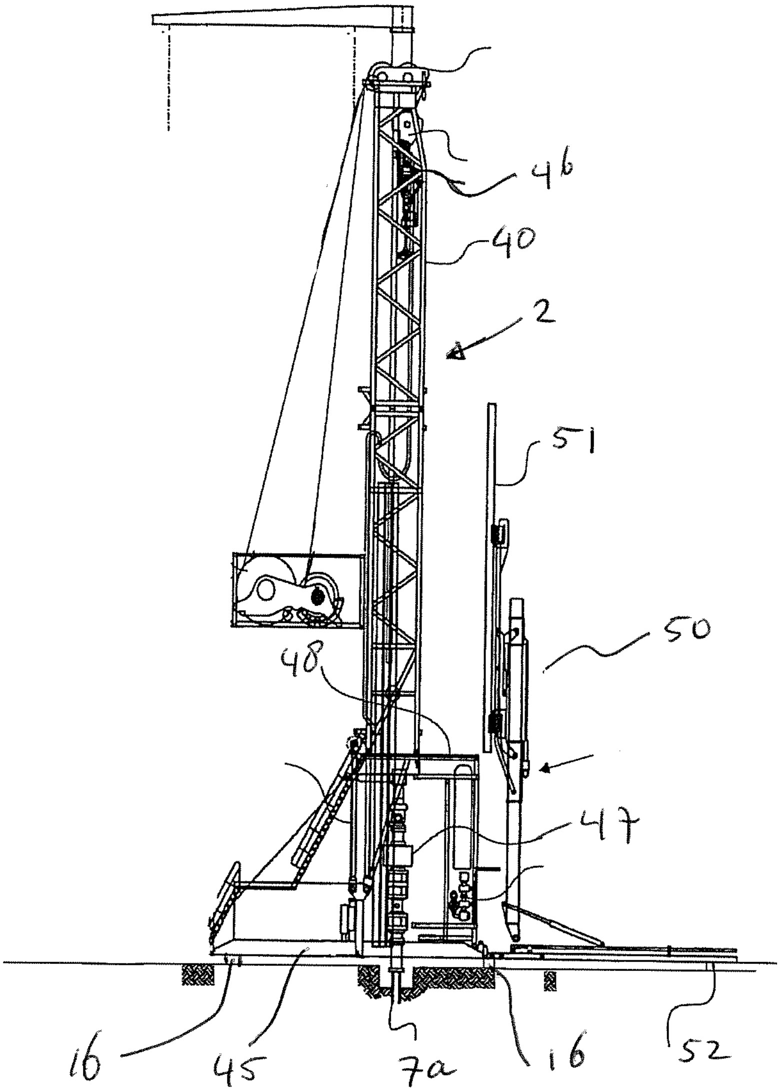

FIGURE 3