PIPE HANDLING UNIT

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APPL. NO.: 12/436,960

FILED: May 7, 2009

Related U.S. Application Data
Provisional application No. 61/051,280, filed on May 7, 2008.

ABSTRACT
A pipe handling unit particularly adaptable for use in association with slant wells includes a pipe manipulation mechanism mounted to a mobile pipe storage rack, which when sited adjacent to a drilling rig or service rig can transport pipe sections to or from the rig mast regardless of the angular orientation of the rig mast. The pipe manipulation mechanism includes a boom rotatably mounted to the storage rack, with two or more swivel arms mounted to the mast, with pipe grapple means connected to the outboard end of the swivel arms may be swivelled outward, about axes parallel to the boom, to a position in which the grapple means can grasp a pipe section held in the rig mast. The swivel arms may then be swivelled in the opposite rotation to rotate the pipe away from the mast. The boom and swivel arms are then manipulated in coordinated fashion to deposit the pipe section in the storage rack.
PIPE HANDLING UNIT

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit, pursuant to 35 U.S.C. 119(e), of U.S. Provisional Application No. 61/051, 280, filed on May 7, 2008, and said provisional application is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates to apparatus for handling pipe used in well drilling and servicing operations, particularly in association with inclined or “slant” wells.

BACKGROUND OF THE INVENTION

[0003] Oil and gas wells are typically drilled by rotating a drill bit mounted to the bottom of a “drill string” made up of sections of pipe (also referred to as “joints” or “tubulars”) joined together by means of threaded connections at the ends of each pipe section. After a well has been drilled, the drill string is removed and typically a string of tubular casing sections is installed to line the wellbore, and then a string of production tubing is inserted into the well to carry oil and gas from a subsurface formation up to ground surface. The term “tripping” is commonly used to describe the procedure of adding a tubular to the drill string or production string (“tripping in”) or removing a tubular from the string (“tripping out”). Well drilling and well servicing involve both tripping in and tripping out, for various purposes well known in the field. During tripping operations, tubulars removed from a drill string or production string must be transported to a pipe storage rack of some sort, and/or from the storage rack to the wellbore for connection to the string already in the wellbore.

[0004] There are many known types of apparatus suited for carrying out these pipe-handling tasks in association with vertical or near-vertical wells. However, pipe handling is more complicated for tripping operations relating to slant wells, in which the drill string or production string may enter the wellbore at up to 45 degrees or more from vertical.

[0005] U.S. Pat. No. 4,951,759 (Richardson) illustrates some of the challenges associated with tripping pipe oil a slant well, including safety issues associated with the handling of heavy joints of pipe. In accordance with conventional methods, handling tubulars usually requires a person to work on an elevated platform in the mast of the drilling rig or service rig, and to connect a winch line to each tubular as it is tripped out of the well so that it can be moved to a vertical suspended position and then swung away from the mast and into a storage rack. Richardson addresses these requirements with a mast-mounted device that can grasp a tubular while inclined parallel to the mast, and then rotate it away from the mast and deposit it on a horizontal storage rack. The mast-mounted pipe-handling device of Richardson must be either installed on a purpose-built rig where the device is accommodated into the design, or retrofitted to an existing rig, which would entail extensive and expensive modifications.

[0006] Accordingly, there remains a need for improved pipe handling apparatus, particularly for use in drilling and servicing slant wells. More particularly, there is a need for such improved apparatus that is readily usable with conventional drilling rigs and service rigs, without need for significant or any modification to the rigs. The present invention is directed to these needs.

SUMMARY OF THE INVENTION

[0007] In general terms, the apparatus of the present invention is a pipe handling unit comprising a pipe manipulation mechanism mounted to a mobile pipe storage rack, which can be parked adjacent to a drilling rig or service rig and which can pick up tubulars from the rig mast and position them in selected positions in a horizontal storage rack. The pipe manipulation mechanism provides for variable and selective pipe travel paths between the rig mast and the storage rack, such that precise positioning relative to the rig is not critical, thus providing greater flexibility in field-positioning of the pipe handling unit to avoid interference with wellhead equipment, flow lines, shacks, and other wellsite appurtenances. The pipe handling unit does not require an elevated work platform, and thus eliminates safety risks associated with such platforms.

[0008] The pipe manipulation mechanism incorporates grapple means for grasping a section of pipe, with actuation means whereby the mechanism can transport a section of pipe from a vertical or inclined rig mast to the pipe storage rack (i.e., tripping out), or from the storage rack to the rig (i.e., tripping in). The mobile storage rack preferably will accommodate storage of pipe sections in a horizontal or near-horizontal position, with vertical “finger racks” to facilitate pipe placement in desired locations within the rack. Racking the pipes horizontally rather than vertically eliminates the need to guy the rig mast in many situations, thus leading to much faster rig-up and rig-down times. However, horizontal pipe storage is not essential to the invention; the apparatus could also be adapted for use with non-horizontal pipe storage racks.

[0009] The mobile storage rack preferably has adjustable downriggers or stabilizing legs which may be extended to bear on the ground surface and carry up to the full weight of the unit as necessary to level and stabilize the storage rack and thus facilitate accurate positioning of pipe within the rack. Downriggers may be of any suitable type, such as those commonly used in association with mobile cranes. Although the present invention does not require the use of downriggers of any particular type (or at all), preferred embodiments comprise a downrigger stabilizer system incorporating means for laterally shifting or slewing the pipe manipulation mechanism relative to the rig mast and wellhead after the unit has been parked, thus minimizing or eliminating the need for comparatively precise positioning of the pipe handling unit relative to the rig.

[0010] The pipe handling unit preferably includes a self-contained hydraulic power unit to actuate the pipe manipulation mechanism so as to manipulate pipe joints with optimal speed and efficiency to achieve pipe-handling cycle times that are at least as fast as those achieved using conventional methods and equipment. In alternative embodiments, however, power for actuating the pipe manipulation mechanism may be provided from a suitable auxiliary power unit, which may be but is not limited to a hydraulic power unit.

[0011] The pipe handling unit of the present invention is readily adaptable to automated control and operation, using known technologies such as but not limited to microprocessors and programmable logic controllers (PLCs), which are well known in the art. Automated operation is particularly
advantageous for embodiments having vertical finger racks, as a computerized control system can readily determine and store in memory the positions of individual pipes within the storage rack and actuate the pipe manipulation mechanism to retrieve pipes from the storage rack in an automatic mode, thereby facilitating pipe handling without the pipes needing to be manually handled or manipulated.

Control of the pipe handling unit may be from a simple control panel that could be remotely mounted near the rig operator’s control panel. The control system may include a set-up mode and an operational mode, with control of the unit being handled primarily by a PLC or other suitable programmable device to enable semi- or fully-automated tripping operations, depending on the desired level of operational integration with the rig.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described with reference to the accompanying figures, in which numerical references denote like parts, and in which:

FIG. 1 is an isometric view of a pipe handling unit in accordance with the present invention, shown parked alongside a conventional service rig.

FIG. 2 is a rear view of a pipe handling unit positioned beside a service rig as shown in FIG. 1.

FIG. 3A is a side view illustrating the pipe handling unit of FIGS. 1 and 2, shown alongside a service rig with its mast in the vertical position.

FIG. 3B is a side view illustrating the pipe handling unit of FIGS. 1 and 2, shown alongside a service rig with its mast in an inclined position.

FIG. 4 is a partial plan of the pipe handling unit as in FIG. 3A, showing various possible positions of the unit’s pipe manipulation mechanism as it transports a pipe section to or from the service rig mast.

FIG. 5A is a side view of the pipe handling unit, showing various possible positions of the pipe manipulation mechanism as it moves a pipe section to or from the unit’s pipe storage rack.

FIG. 5B is a side view illustrating mechanisms for actuating the pipe manipulation mechanism in accordance with one embodiment of the invention.

FIG. 6 is a partial rear view of the pipe handling unit showing representative positions of the pipe manipulation mechanism as it places or retrieves a pipe section in or out of the pipe storage rack.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In preferred embodiments as illustrated in the Figures, the pipe handling unit 100 of the present invention comprises a pipe manipulation mechanism (generally indicated by reference numeral 50) mounted to a mobile pipe storage rack which may be positioned as required adjacent to a drilling rig or service rig 1 having a mast 2. Rig 1 does not form part of the broadest embodiments of the present invention. In the illustrated embodiments, the mobile storage rack is provided in the form of a trailer 10 adapted to be transported and maneuvered as required by a suitable tractor unit (not shown). In alternative embodiments, mobile pipe storage rack may be a self-propelled unit with its own motor and drive train. Trailer 10 is preferably provided with front downrigger stabilizer legs 11 and rear downrigger stabilizer legs 12 which may be deployed to lift trailer 10 off of its tires 13, whereupon stabilizer extension slides (not shown) may be used to position trailer 10 as appropriate adjacent to service rig 1 and then trailer 10 is leveled.

Trailer 10 has a flat deck 10A which serves as a pipe storage area or storage rack 60. In preferred embodiments, one or more sets of vertical dividers or “finger racks” 14 extend upward from deck 10A, preferably with one set of finger racks 14F near the front end of trailer 10 and a second set of finger racks 14R near the rear end of trailer 10 as shown in FIG. 1, to facilitate orderly storage of pipe sections 15 as they are tripped out of the well and stored pending their return to the well (“tripping in”) in accordance with typical well-servicing operations. The space between adjacent finger racks will be sized to receive a single pipe section, and finger racks 14 preferably will be adjustable to accommodate different pipe diameters. Preferably, the space between adjacent finger racks will be in the range of 1.5 to 1.8 times the pipe diameter, or less. To minimize weight trailer 10 will typically be designed only to carry racked pipe sections 15 while trailer 10 is supported in a stationary position on stabilizer legs 11 and 12. However, alternative embodiments may be designed for highway transport of racked pipe sections 15.

FIG. 1 shows pipe handling unit 100 positioned adjacent to a service rig 1 which has been configured to service a slant well having a wellhead 3 protruding from the ground (conceptually indicated by reference character G). In a typical application, service rig 1 uses a travelling block 5, which is longitudinally movable along mast 2, to lift a string of jointed pipe 4 (e.g., production string) out of the well using an elevator (not shown) of well-known type. When the elevator and travelling block 5 are not supporting the weight of pipe string 4, the weight is carried by slips 7 associated with wellhead 3 (in accordance with well-known technologies). In FIG. 1, a pipe section 15 has been disconnected from pipe string 4, and is being grasped by grapple means 30 associated with pipe manipulation mechanism 50, with pipe string 4 being supported by slips 7.

In preferred embodiments, pipe handling unit 100 incorporates an engine-driven hydraulic power unit (conceptually indicated by reference numeral 32) mounted to trailer 10, to provide pressurized hydraulic fluid for actuation of pipe manipulation mechanism 50. Preferred embodiments also incorporate a control system for pipe manipulation mechanism 50, also mounted on trailer 10 as conceptually indicated by reference numeral 33. However, alternative power means and control systems, including non-trailer-mounted and remotely-operated alternatives, may be used without departing from the concept and scope of the present invention.

FIG. 2 illustrates service pipe handling unit 100 positioned adjacent to rig 1 as in FIG. 1, but viewed from the rear. In the embodiment shown in FIG. 2, pipe manipulation mechanism 50 comprises a main boom 19 which is rotatably mounted to trailer 10 as described in greater detail below. Main boom 19 will typically be mounted to the rear end of trailer 10, and preferably offset from the trailer’s longitudinal centerline as shown in FIG. 2, for optimal accessibility to an adjacent rig 1. A boom extension 21 is slidable or telescoping mounted to main boom 19 for increased access to upper regions of mast 2 of rig 1.

As best appreciated with reference to FIGS. 2, 5, and 6, pipe manipulation mechanism 50 further includes an inner swivel arm 23 having an inner end 23A and an outer end 23B, with inner arm 23 being mounted along its inner end 23A to
boom extension 21 so as to be swivelable about a first swivel axis X-1 parallel to main boom 19. An inner arm actuator 24 is provided for swivelling inner arm 23 about first swivel axis X-1 as necessary. Pipe manipulation mechanism 50 further comprises an outer swivel arm 25 having an inner end 25B and an outer end 25C, with outer swivel arm 25 being mounted along its inner end 25B to outer end 25B of inner swivel arm 23 so as to be swivelable about a second swivel axis X-2 parallel to first swivel axis X-1 (and, therefore, parallel to main boom 19). An outer swivel arm actuator 26 is provided for swivelling outer swivel arm 25 about second swivel axis X-2 as necessary.

[0028] As indicated in the Figures, inner swivel arm 23 and outer swivel arm 25 may be of substantial width in the direction parallel to axes X-1 and X-2, and in preferred embodiments may be provided in the form of trussed frames as shown. However, this is only one of many possible configurations for inner swivel arm 23 and outer swivel arm 25, and the present invention is not limited to any particular form or structure for these components.

[0029] As perhaps best seen in FIGS. 3A, 3B, and 5A, an elongate axial slide member 28 is mounted to outer swivel arm 25 along outer end 25C thereof, so as to be selectively movable along and relative to outer swivel arm 25 in a direction parallel to second swivel axis X-2 (and, therefore, parallel to main boom 19), to facilitate even greater access to upper regions of mast 2 of rig 1. This functionality can be appreciated from FIGS. 3A and 3B, in which slide member 28 is in its lowermost axial position relative to outer swivel arm 25, and from FIG. 5A in which slide member 28 is in its uppermost axial position relative to outer swivel arm 25. Provided near each end of slide member 28 are grapples of any type suitable for grasping a section of pipe, whether from mast 2 or from pipe storage rack 60. An additional function of slide member 28 is to position grapples 30 so that they do not interfere with finger racks 14 when pipe manipulation mechanism 50 is depositing a pipe section 15 into storage rack 60.

[0030] As shown in FIG. 5A, main boom 19 is rotatably mounted to trailer 10 such that it can be rotated from a lowered position in which it is substantially parallel to deck 10A of trailer 10, to a fully-raised position (which typically but not necessarily will be the vertical position shown in FIG. 3A), with the ability to stop at any intermediate position between these extremes so as to be substantially parallel to mast 2 of a drilling rig or service rig with which pipe handling unit 100 is being used. In the preferred but non-limiting embodiment shown in FIG. 5B, this functionality is enabled by a providing a lower boom member 19L of which is mounted to trailer 10 so as to be rotatable about a first horizontal axis X-3 transverse to the longitudinal axis of trailer 10, and mounting the lower end 19L of main boom 17 to the upper end 19U of lower boom member 19 so as to be rotatable about a second horizontal axis X-4 parallel to first horizontal axis X-3. The rotational position of lower boom member 19 relative to trailer 10 is controlled by a lower boom actuator 18 (shown in FIG. 5B in the exemplary form of a hydraulic cylinder), and the rotational position of main boom 17 is controlled by an upper boom actuator 20 (shown in FIG. 5B in the exemplary form of a hydraulic cylinder with an associated mechanical linkage 22). Persons skilled in the art of the invention will appreciate that various other mechanisms may be devised to effect the desired functionality of main boom 17, with or without a lower boom member 19, and using hydraulic cylinders or other known types of actuators, without departing from the scope of the present invention.

[0031] Field operation of a pipe handling unit 100 in accordance with the present invention may be readily understood having regard to the Figures and the foregoing description. With trailer 10 positioned substantially parallel to a drilling rig or service rig 1 (as the case may be), with mast 2 of rig 1 being angularly oriented as required (i.e., vertical or inclined), main boom 17 is rotated upward until it is substantially parallel to the axis of mast 2. Inner and outer swivel arm actuators 24 and 26 may then be operated as required to rotate slide member 28 to a position allowing grapples 30 to engage and grasp a pipe section 15 disposed within mast 2 (after removal from a drill string or production string), in conjunction with any appropriate adjustment of the axial position of slide member 28 relative to outer swivel arm 25. This process can then be reversed to rotate pipe section 15 out of mast 2 (as may be particularly well understood with reference to FIGS. 4 and 5A), for deposition into storage rack 60 as shown in FIG. 6 (again, adjusting the axial position of slide member 28 as appropriate for optimal positioning of pipe section 15 in storage rack 60).

[0032] It will be appreciated from FIG. 4 in particular that boom extension 21 can start moving downward along main boom 17 and as soon as pipe section 15 has begun rotating out of and away from mast 2. This feature reduces pipe-handling cycle time compared to prior art pipe-handling equipment which due to structural constraints requires the pipe to be rotated fully out of the mast before rotation to a lower position can begin.

[0033] The foregoing describes the tripping-out procedure; for tripping-in operations, the process is simply reversed. During tripping-in operations, slide member 28 may be actuated to facilitate “stopping” each added pipe section 15 into the upper end of pipe string 4 for thread makeup, thus minimizing or eliminating the need to use the rig’s travelling block and elevator, and reducing the tripping-in cycle time as a result.

[0034] FIG. 6 further illustrates how pipe sections 15 may be deposited on storage rack 60, guided by finger racks 14 which facilitate orderly arrangement of pipe sections 15 and optimal pipe storage capacity. Grapples 30 are preferably adapted to release and pick up pipe sections from storage rack 60 one at a time without colliding with other pipe sections already in the rack. In order to do this most efficiently, pipe sections 15 can be laid down in and retrieved from horizontal layers, laying the pipe sections down from right to left (as viewed in FIG. 6) and picking them up from left to right. In order to move pipe sections 15 in and out of the fingers of finger rack 14, pipe manipulation mechanism 50 must lift and lower the pipe sections 15 in a vertical movement. However, this movement can be readily achieved by coordinated operation of inner swivel arm actuator 24 and outer swivel arm actuator 26, preferably in association with a programmed control mechanism, to manipulate inner swivel arm 23 and outer swivel arm 25 so as to produce the required vertical movement of slide member 28 and, in turn, a pipe section 15 held in grapples 30.

[0035] In preferred embodiments, the various actuators required to operate pipe manipulation mechanism 50 are hydraulically actuated and hydraulically controlled by use of suitable valves, which are in turn controlled by one or more PLCs or other programmable controllers or computers, based on control algorithms using control inputs from one or more
sensors (not shown) of known types and applicability. Such sensors may include, but are not limited to, linear and rotational absolute position transducers, hydraulic fluid pressure transducers, proximity sensors, and other position-sensing technologies.

Preferred embodiments of pipe manipulation mechanism 50 may further comprise graspable extension means (not shown) for facilitating alignment of grapple 30 with pipe section 15 disposed within the mast of a drilling rig or service rig. Such graspable extension means would be adapted to selectively extend one or both grapples (in concert, independently, or differentially) in a radial direction relative to slide member 28, so as to bring grapple 30 into optimal alignment with pipe section 15, even though the axis of slide member 28 might not be precisely parallel to the axis of the well (and pipe section 15). Accordingly, the apparatus can be adapted such that if grapples 30 are not optimally aligned with pipe section 15, the first grapple 30 to contact pipe sections 15 will not push it out of position, or if the pipe is constrained, it will not pull on outer swivel arm 25. Preferably, the control system of the apparatus will be programmed such that the first grapple contacting the pipe will sense, the contact and stop, allowing (and triggering) the other grapple to move into contact with pipe. Once both grapples 30 are in contact with the pipe, the gripping pressure applied by both grapples may be increased to an appropriate level before lifting the pipe. Persons of ordinary skill in the art will readily appreciate that the above-described functionality of the graspable extension means can be provided in a variety of ways using well-known technologies, such as (but not limited to) limit switches, linear potentiometer detection of position coupled with pressure or force transducer-generated inputs to PLC, or microprocessor-based automated control systems.

While preferred embodiments have been shown and described herein, modifications thereof can be made by one skilled in the art without departing from the scope and teaching of the present invention, including modifications which may use equivalent structures or materials hereafter conceived or developed.

The described and illustrated embodiments are exemplary only and are not limiting. For example, the illustrated embodiment of pipe manipulation mechanism 50 features two swivel arms (inner swivel arm 23 and outer swivel arm 25) in 24 and 26. However, it will be readily appreciated by persons skilled in the art that alternative embodiments may include three or more swivel arms and corresponding actuators without departing from the concept and scope of the present invention.

It is to be especially understood that the substitution of a variant of a claimed element or feature, without any substantial resultant change in the working of the invention, will not constitute a departure from the scope of the invention. It is to also be fully appreciated that the different teachings of the embodiments described and discussed herein may be employed separately or in any suitable combination to produce desired results.

In this patent document, any form of the word “comprise” is to be understood in its non-limiting sense to mean that any item following such word is included, but items not specifically mentioned are not excluded. A reference to an element by the indefinite article “a” does not exclude the possibility that more than one of the element is present, unless the context clearly requires that there be one and only one such element. Any use of any form of the terms “connect”, “engage”, “couple”, “attach”, or any other term describing an interaction between elements is not meant to limit the interaction to direct interaction between the subject elements, and may also include indirect interaction between the elements such as through secondary or intermediary structure. Relational terms such as “parallel”, “perpendicular”, “coincident”, “intersecting”, and “equidistant” are not intended to denote or require absolute mathematical or geometrical precision. Accordingly, such terms are to be understood as denoting or requiring substantial precision (e.g., “substantially parallel”) unless the context clearly requires otherwise.

What is claimed is:

1. A pipe handling apparatus comprising:
   (a) a mobile pipe storage rack having a longitudinal axis;
   (b) a boom having an upper end and a lower end, said lower end being mounted to the pipe storage rack such that the boom is rotatable, in a substantially vertical plane parallel to the longitudinal axis of the storage rack, between a lowered position and a raised position;
   (c) a first swivel arm having an inner end and an outer end, said inner end of the first swivel arm being mounted to the boom such that the first swivel arm is swivelable relative to the boom about a first swivel axis parallel to the boom;
   (d) a second swivel arm having an inner end and an outer end, said inner end of the second swivel arm being mounted to the outer end of the first swivel arm such that the second swivel arm is swivelable relative to the first swivel arm about a second swivel axis parallel to the boom;
   (e) an elongate slide member mounted in association with the outer end of the second swivel arm so as to be slidable relative to the second swivel arm along an axis parallel to the boom; and
   (f) grapple means associated with the slide member and adapted for gripping engagement of a length of pipe.

2. The pipe handling apparatus of claim 1 wherein the boom comprises a boom extension mounted to the boom so as to be selectively moveable in a direction parallel to the boom, and wherein the first swivel arm is swivelably connected to the boom extension.

3. The pipe handling apparatus of claim 1 wherein the boom comprises a lower boom member rotatably mounted to the pipe storage rack and a main boom member rotatably mounted to the lower boom member.

4. The pipe handling apparatus of claim 3 wherein the boom further comprises a boom extension mounted to the main boom so as to be selectively moveable in a direction parallel to the main boom, and wherein the first swivel arm is swivelably connected to the boom extension.

5. The pipe handling apparatus of claim 1 wherein the grapple means comprises grapple extension means whereby the position of the grapple means may be selectively adjusted in a radial direction relative to the slide member.

6. The pipe handling apparatus of claim 5 wherein the grapple means comprises two or more grapples, and wherein the grapple extension means is adapted for selectively adjusting the radial position of at least one of the grapples.

7. The pipe handling apparatus of claim 1, further comprising a control system for controlling the operation of the pipe handling apparatus.

8. The pipe handling apparatus of claim 7 wherein the control system comprises programmable control means.
9. The pipe handling apparatus of claim 8 wherein the programmable control means comprises a microprocessor.

10. The pipe handling apparatus of claim 8 wherein the programmable control means comprises a programmable logic controller.

11. The pipe handling apparatus of claim 7 wherein the control system is adapted for semi-automatic operation of the pipe handling apparatus.

12. The pipe handling apparatus of claim 7 wherein the control system is adapted for fully automatic operation of the pipe handling apparatus.

13. The pipe handling apparatus of claim 8, further comprising one or more sensors selected from the group consisting of linear absolute position transducers, rotational absolute position transducers, hydraulic fluid pressure transducers, and proximity sensors.

14. The pipe handling apparatus of claim 13 wherein the control system actuates the pipe handling apparatus in response to control inputs received from the one or more sensors.

15. The pipe handling apparatus of claim 7 wherein the control system is mounted in association with the mobile pipe storage rack.

16. The pipe handling apparatus of claim 1 wherein the mobile storage rack comprises a trailer.

17. The pipe handling apparatus of claim 1 wherein the mobile storage rack comprises at least one adjustable stabilizer leg, for adjusting the elevation of the mobile storage rack.

18. The pipe handling apparatus of claim 17, further comprising stabilizer extension means, for adjusting the lateral position of the mobile storage rack.

19. The pipe handling apparatus of claim 1 wherein the mobile storage rack comprises at least one set of spaced vertical dividers, with the space between adjacent dividers being selected to receive a pipe section of selected diameter.

20. The pipe handling apparatus of claim 19, wherein the mobile storage rack comprises first and second sets of vertical dividers positioned toward the front end and rear end, respectively, of the mobile storage rack.

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