United States Patent [19]

Swoboda, Jr. et al.

[11] **3,874,518**

[45] **Apr. 1, 1975**

[54] **RACKING ARM FOR PIPE SECTIONS, DRILL COLLARS, RISER PIPE, AND THE LIKE USED IN WELL DRILLING OPERATIONS**

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[22] Filed: **Jan. 17, 1974**

[21] Appl. No.: **434,186**

Related U.S. Application Data

[62] Division of Ser. No. 377,321, July 9, 1973, Pat. No. 3,840,128.

[52] **U.S. Cl.** ..... **214/1 P**

[51] **Int. Cl.** **B65g 47/08**

[58] **Field of Search** ..... 212/54, 55, 56, 57, 52; 214/2.5, 3, 3.1, 1 P, 141, 1 BC, 1 BD, 147 R, 147 T, 763; 294/74, 85

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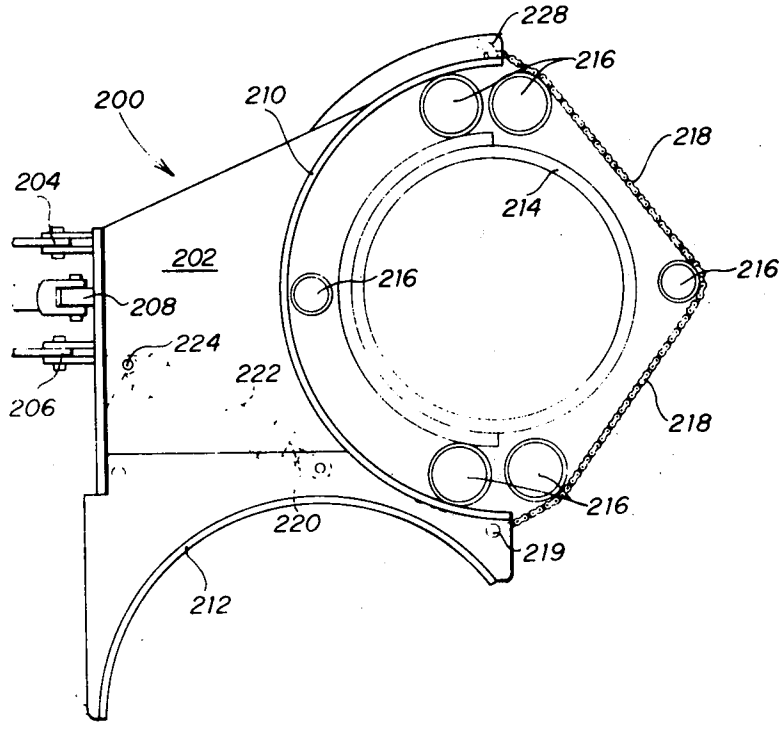
Primary Examiner—Frank E. Werner

Attorney, Agent, or Firm—Richards, Harris & Medlock

[57] **ABSTRACT**

The specification discloses a racking arm having a telescoping boom with a supported end and a free cantilevered end. A pipe gripping head is secured to the cantilevered end of the boom for clamping about elongated members such as pipe sections, drill collars, riser pipes or the like. The supported end of the boom is mounted for pivotal movement about a vertical axis and a motor is provided to selectively rotate the boom about the vertical axis. Hydraulic cylinders are provided to selectively raise and lower the free cantilevered end of the boom. Hydraulic cylinders also are provided to extend and retract the boom to selectively vary the length thereof. In operation, the boom is disposed on a drilling rig with the supported end spaced above the working platform of the drilling rig and the vertical axis spaced away from the well bore axis. The boom may then be employed to move elongated pipe members from various storage positions to the well bore or other areas and vice-versa. The pipe gripper head is normally automatically maintained horizontal during vertical movement of the boom. A first embodiment of the pipe gripper head clamps pipe sections, drill collars and the like for lateral movement while allowing the pipe sections and drill collars to slide vertically along their axes. In a second embodiment of the gripper head, riser pipe having an irregular cross-section may be tightly gripped by the gripper head.

3 Claims, 14 Drawing Figures



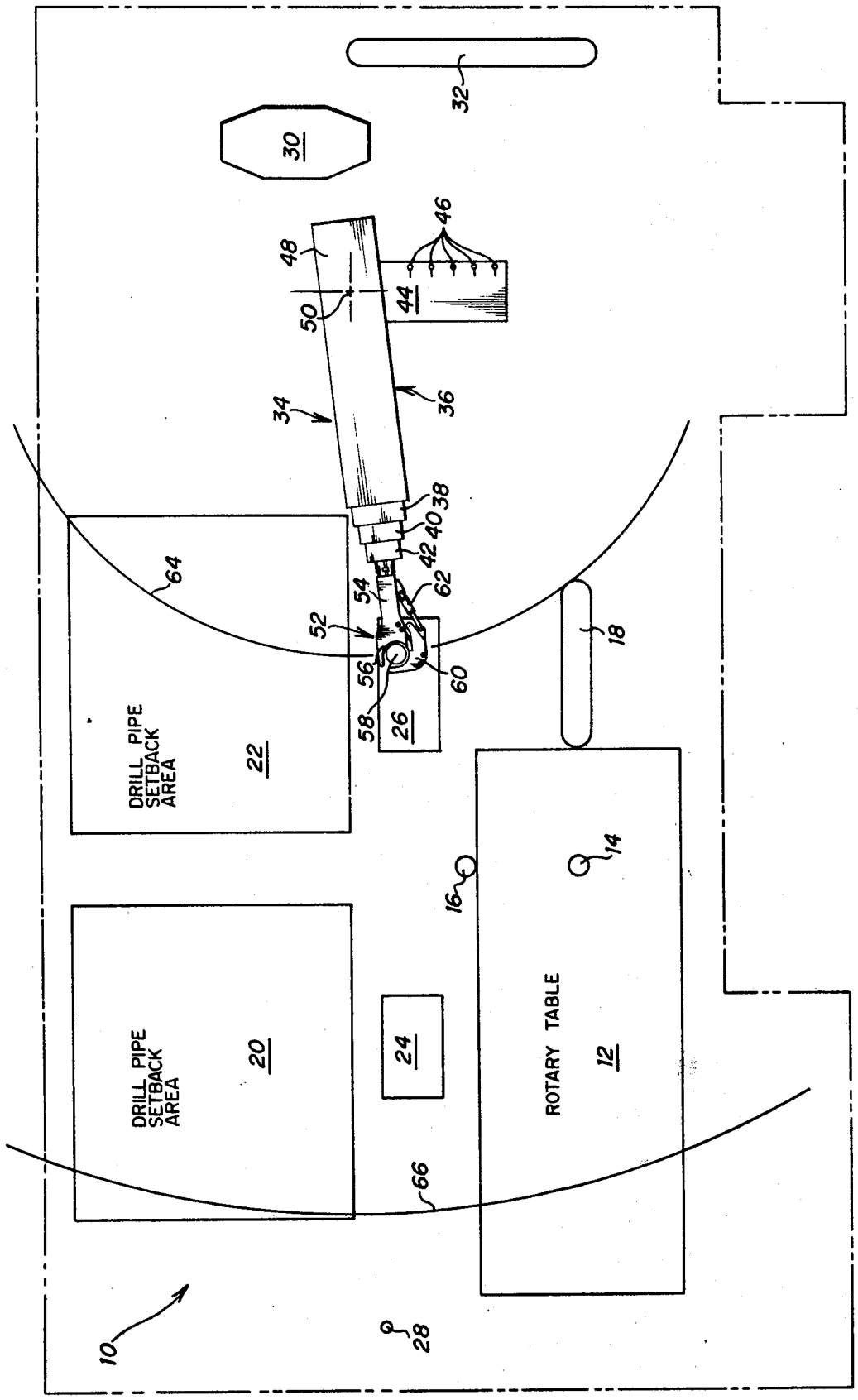

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18
DRILL PIPE SETBACK AREA
22
16
14
ROTARY TABLE
12
DRILL PIPE SETBACK AREA
20
24
66
10
28

FIG. 1

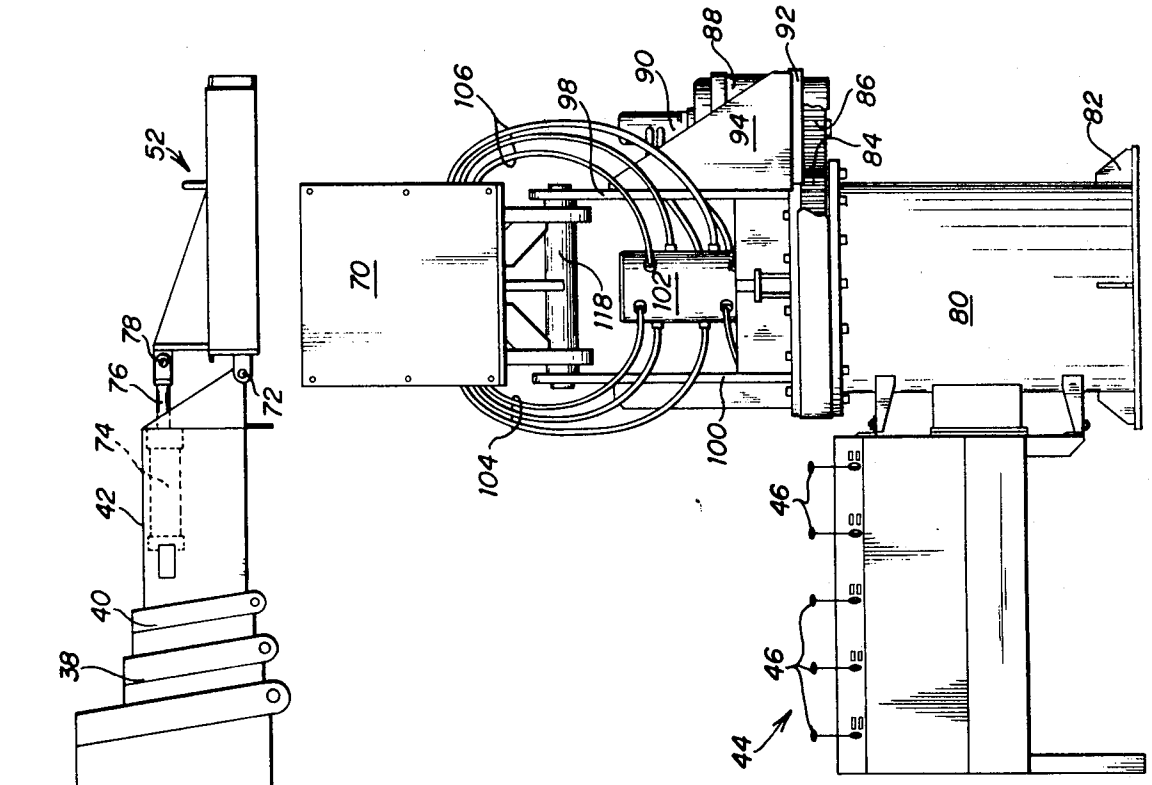
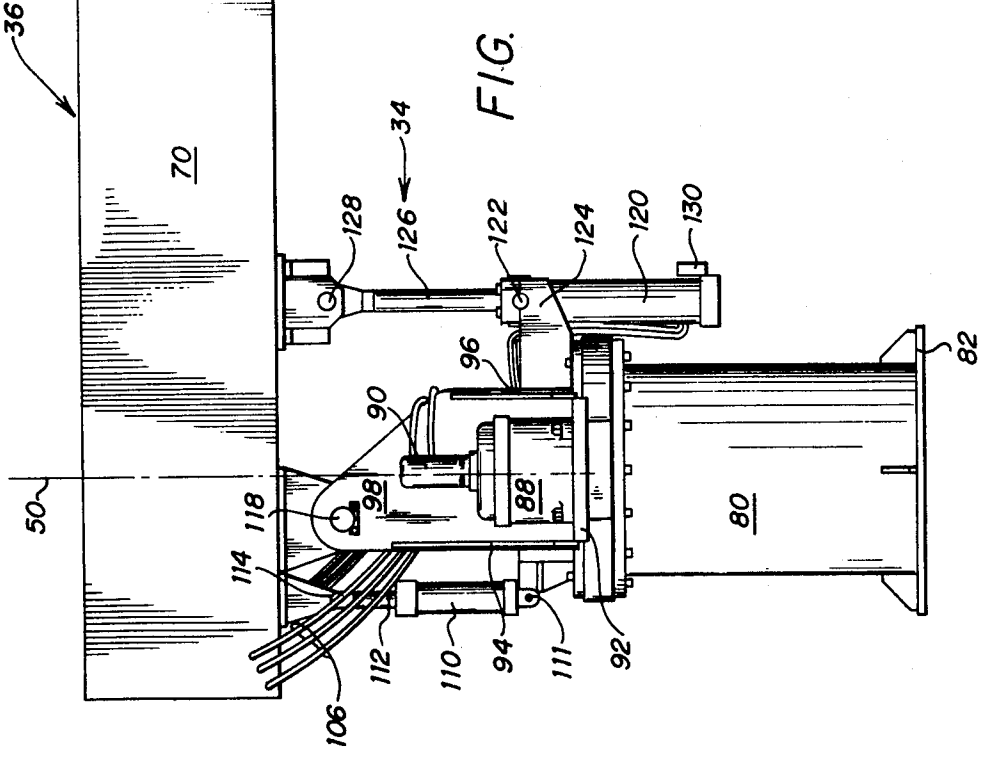

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100
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FIG. 2

FIG. 3


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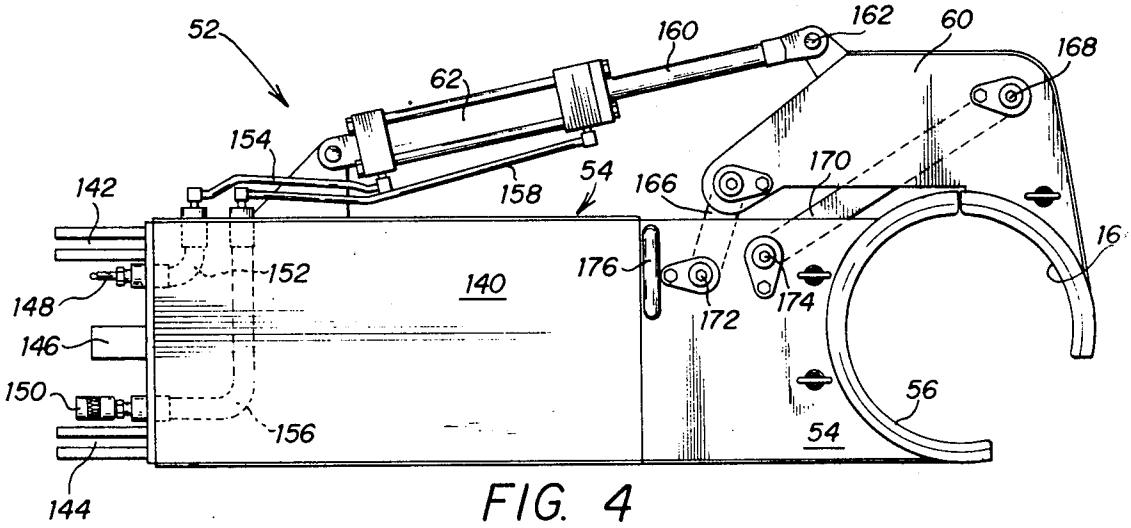


FIG. 4

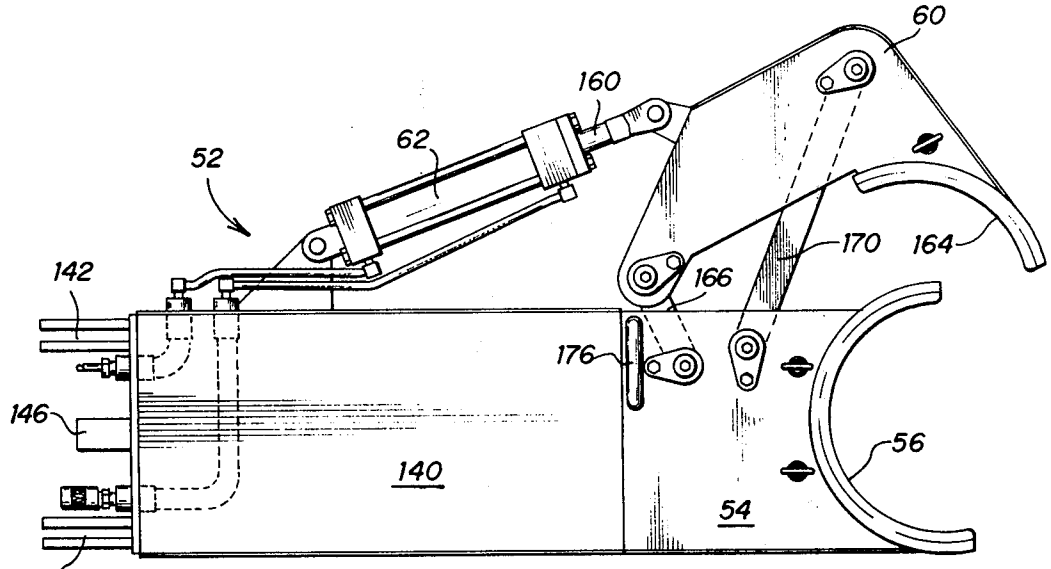


FIG. 5

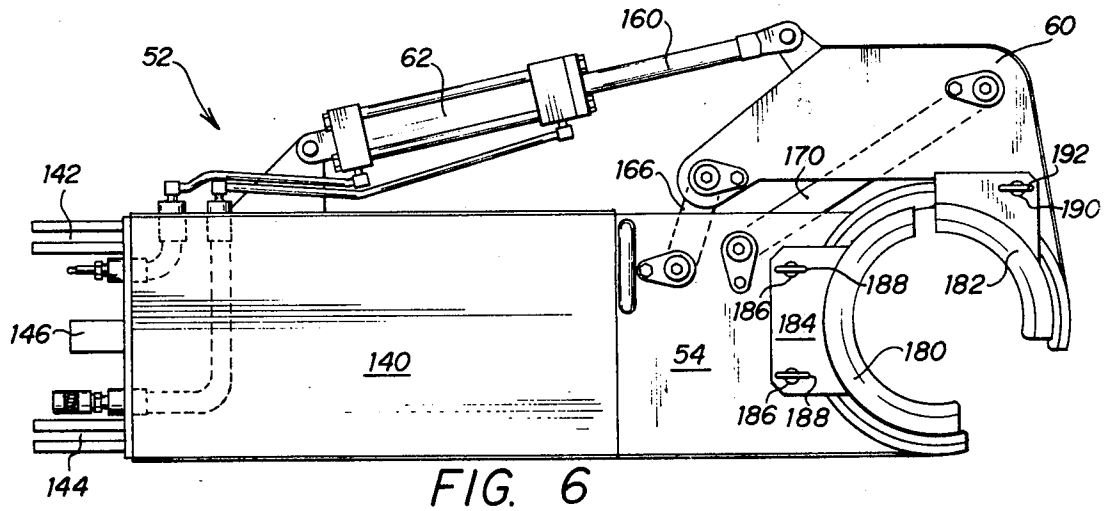


FIG. 6

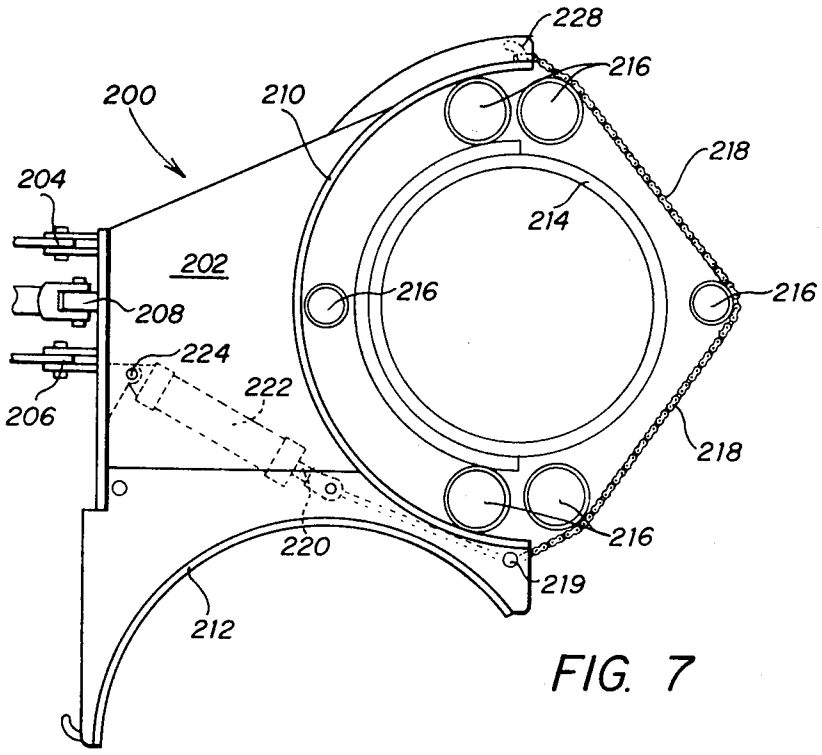

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FIG. 7

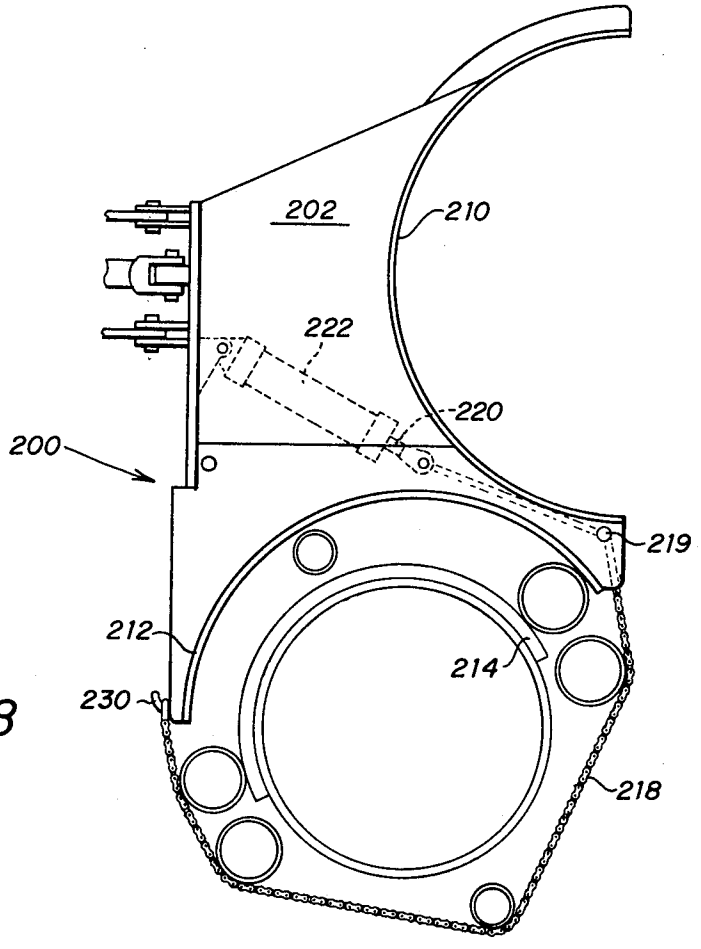

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FIG. 8

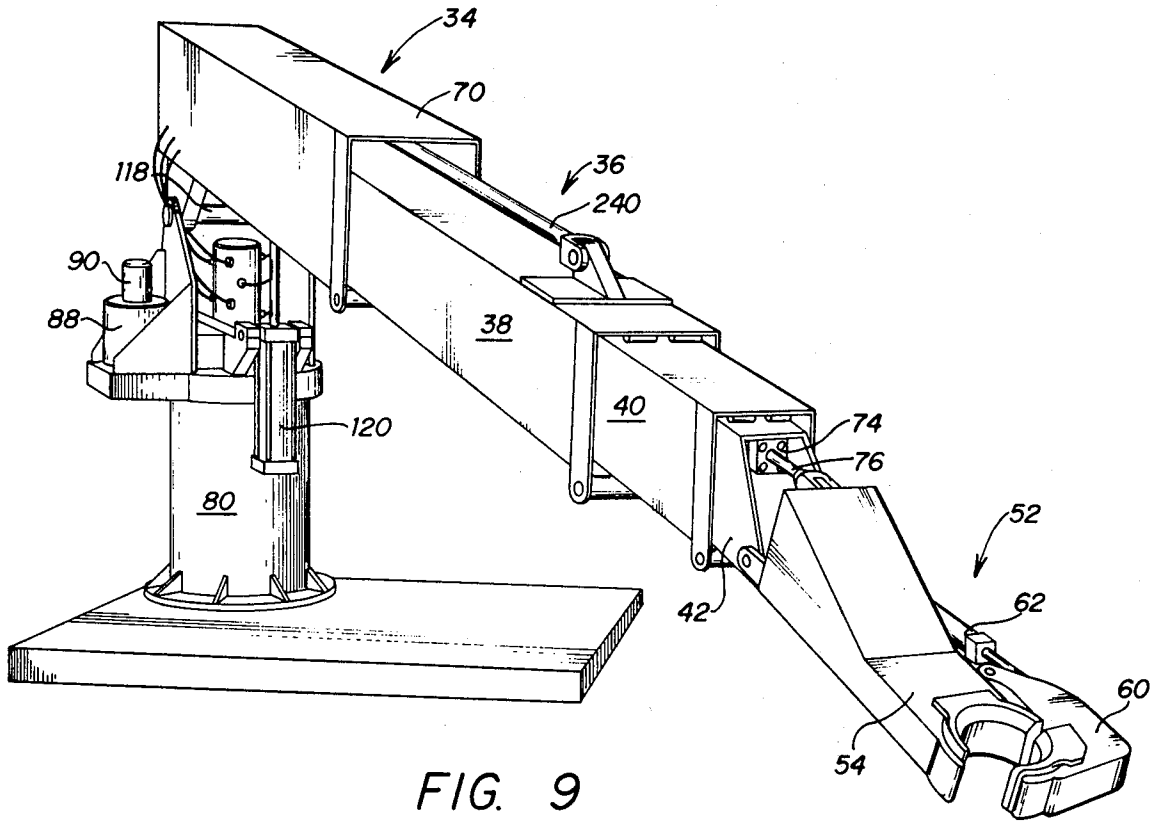

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120
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FIG. 9

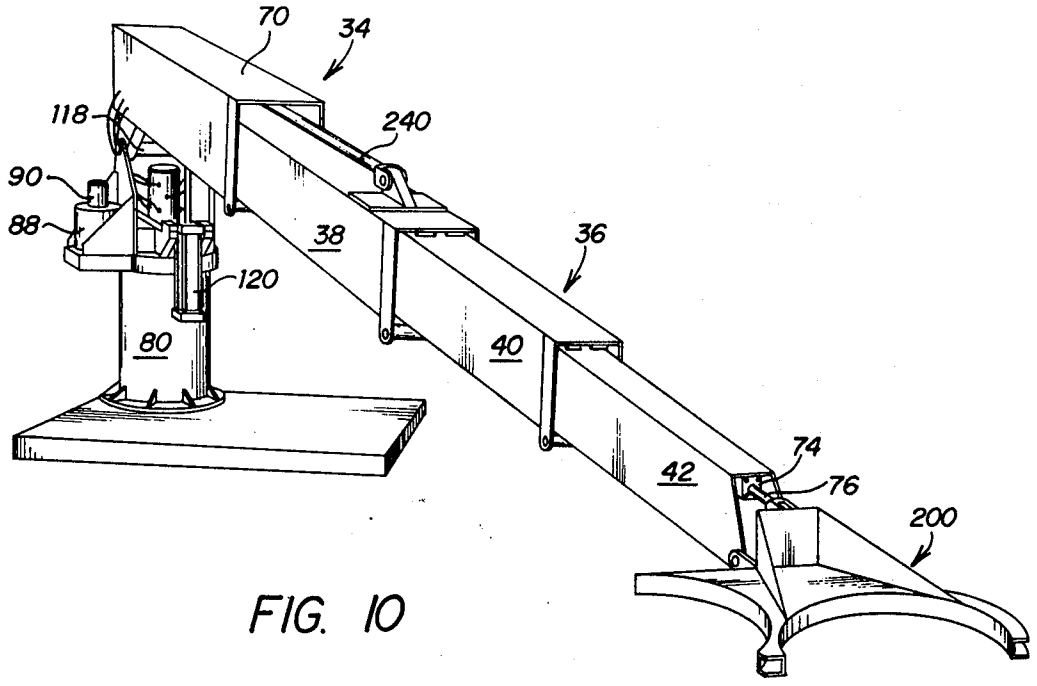

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FIG. 10

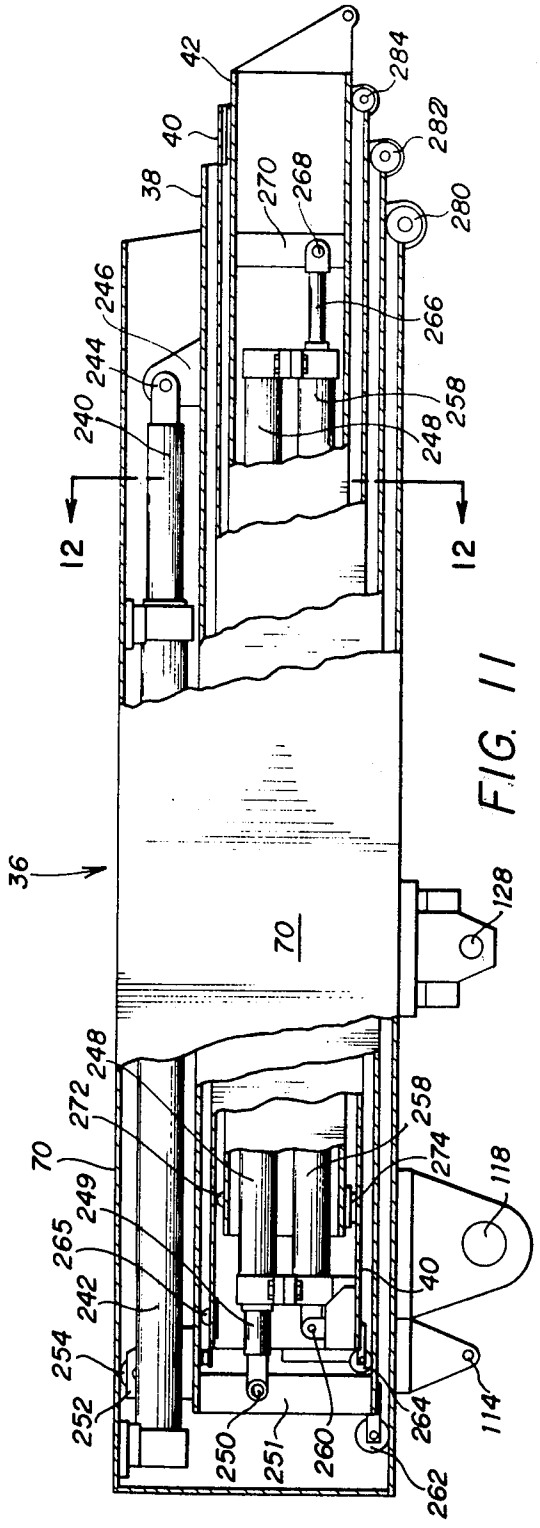


FIG. 11

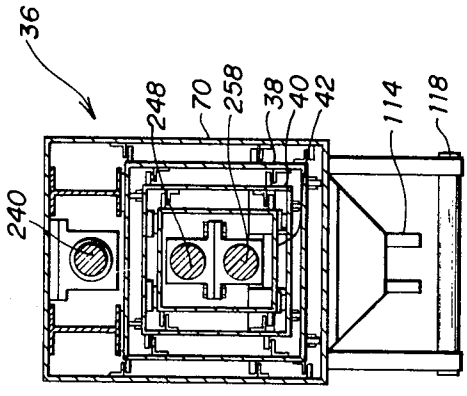


FIG. 12

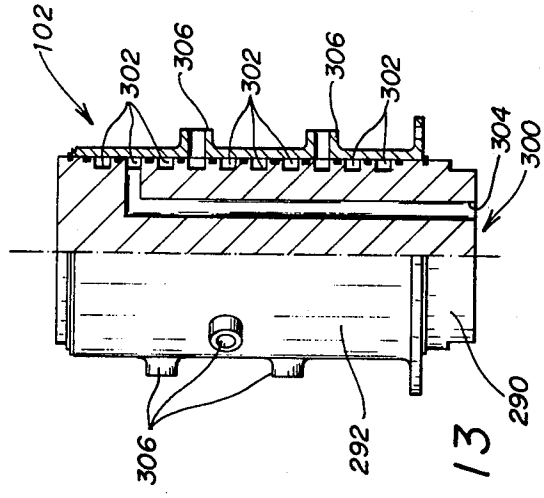


FIG. 13

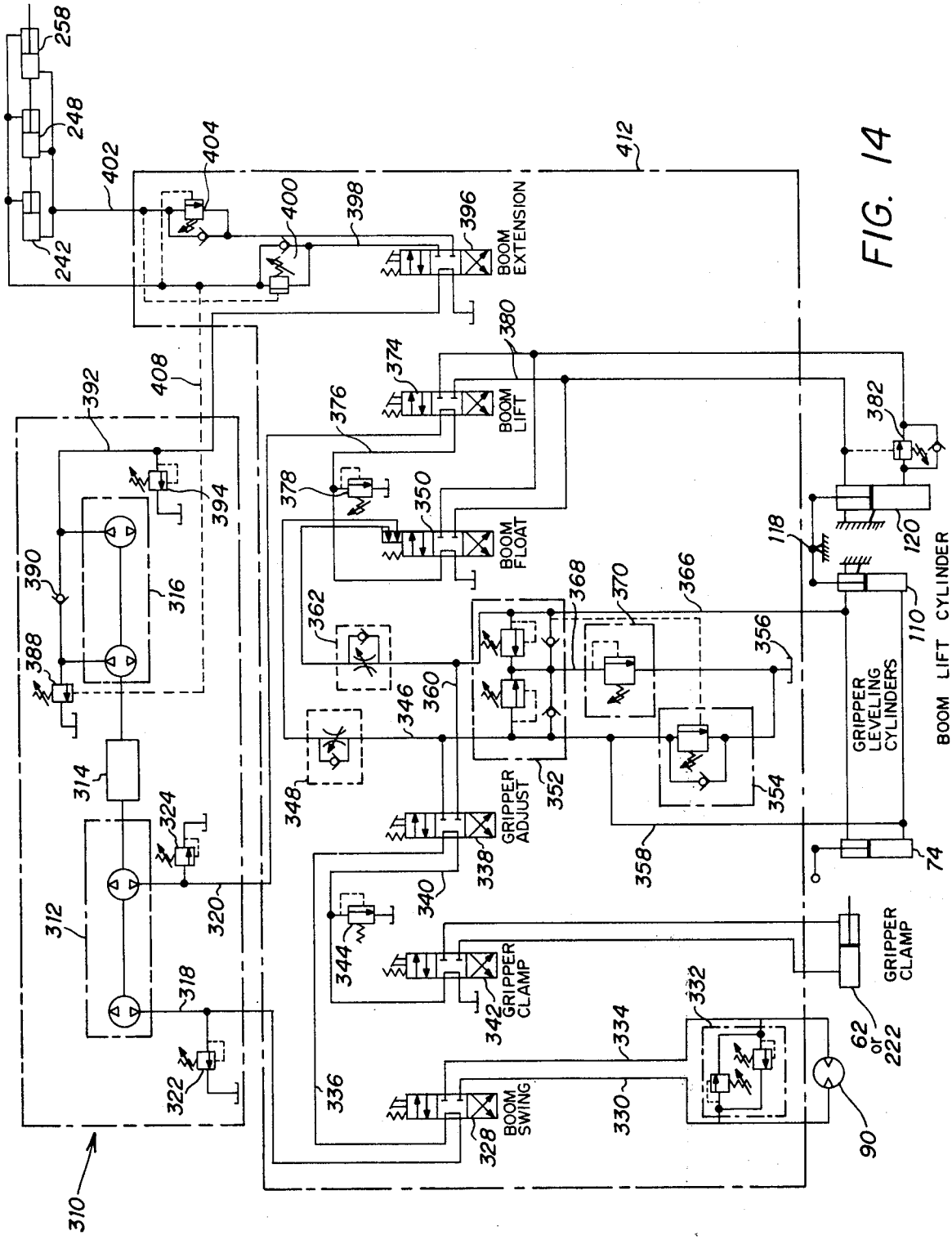

BOOM EXTENSION
BOOM LIFT
BOOM FLOAT
GRIPPER ADJUST
GRIPPER CLAMP
BOOM SWING
GRIPPER CLAMP
GRIPPER LEVELING CYLINDERS
BOOM LIFT CYLINDER
62 or 222
90
74
110
118
120
258
248
242
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FIG. 14

RACKING ARM FOR PIPE SECTIONS, DRILL COLLARS, RISER PIPE, AND THE LIKE USED IN WELL DRILLING OPERATIONS

This application is a division of application Ser. No. 377,321, filed July 9, 1973, now U.S. Pat. No. 3,840,128.

FIELD OF THE INVENTION

This invention relates to well drilling operations, and more particularly relates to a device for assisting in the handling of vertical sections of pipes, drill collars, riser pipes and the like in a well drilling rig.

THE PRIOR ART

As is well known, it is necessary during the drilling of oil wells to transport elongated pipe members in a vertical position to and from various locations on the oil drilling rig. For example, additional sections of drill pipe must be periodically moved from a setback area to the well hole as the well is extended further into the ground, or when a drill bit needs replacement, the drill pipe sections must be removed and temporarily stored in the setback area. Moreover, during drilling operations, drill collars must be removed from a setback area and transported to the drilling area. In addition, when drilling is being done on an offshore platform, riser pipes having an irregular cross-sectional area must be moved to the blowout preventers from a racking area.

Generally, such elongated pipe members as pipe sections, drill collars or riser pipes are lifted in a generally vertical position by means of a traveling block on a derrick hoist. When such pipe members are being transported in a vertical position, the lower end of the pipe members tend to sway. Not only does such swaying movement of the pipe members tend to present a safety problem to the drilling rig and personnel, but such movement of the pipe members may make it difficult to guide the pipe members to the desired location which may comprise a relatively small opening. The problem of swaying of pipe members is particularly critical when the drilling is being performed from a floating offshore vessel which is subject to severe pitching and rolling due to high winds and waves.

Heretofore, it has been known to manually attempt to restrain such pipe members from swaying during transport. Manhandling the pipe has not been particularly successful due to the large mass and unpredictable movement of the pipe members, and in some instances the attempt to manually restrain the pipe members has presented safety problems to personnel. A number of mechanical systems have thus been heretofore developed in an attempt to restrain the swaying of vertical pipe and to guide the pipe to the desired location in an oil drilling rig. As an example, U.S. Pat. Nos. 2,828,024, 2,829,783 and 3,467,262 disclose extendable pipe engaging members which may be operated to position a suspended pipe over a well borehole. However, such prior devices are limited to movement in a single horizontal plane and are provided only with extremely limited pivotal movement about a vertical axis, and are thus not practical for use in a well drilling environment to move a variety of different types and sizes of pipe members to a plurality of locations. In addition, such prior art devices have been subject to overload damage in case of sudden vertical or lateral movement of the pipe member. Previously developed systems have also not heretofore enabled the selective guiding of riser pipes, due to the various irregular shapes and configurations of the riser pipes.

SUMMARY OF THE INVENTION

In accordance with the present invention, a racker arm is provided which substantially reduces or eliminates many of the problems heretofore experienced in prior systems. The present racker arm includes an extendable boom which may be moved to any desired extent about a vertical axis and which may be selectively raised and lowered to operate in a variety of different horizontal planes. The system includes a first gripper head which may loosely clamp about pipe sections or drill collars and a second gripper head which may be tightly clamped about riser pipe having an irregular cross-section. The gripper head is automatically maintained at all times in a predetermined horizontal position regardless of the vertical position of the boom. The present system includes overload protection so that the boom is not damaged when the torque applied to the boom is exceeded by movement of the pipe member. The extendable boom first extends the larger and strongest boom sections and first retracts the smaller and weaker boom sections in order to maintain optimum stability of the boom in all stages of extension and retraction.

In accordance with a more specific aspect of the present invention, a racking arm is provided for guiding elongated members such as pipe sections, drill collars and riser pipe used in the rotary drilling of earth formations. The racking arm includes a telescoping boom having a supported end and a free cantilevered end. A pipe gripper is secured to the cantilevered end of the boom for clamping about elongated pipe members. Structure mounts the supported end of the boom for pivotal movement about a vertical axis and a motor is provided to selectively rotate the boom about the vertical axis. Structure is secured to the supported end of the boom for selectively raising and lowering the free cantilevered end. Structure is provided for extending and retracting the boom to selectively vary the length thereof. The boom may be disposed on a drilling rig with the supported end spaced above the working platform of the drilling rig and the vertical axis spaced away from the well bore axes. The racking arm may be employed to move elongated pipe members from various storage positions to the wellbore or other areas and vice-versa.

In accordance with another aspect of the invention, a racker arm system guides elongated pipe members used in well drilling operations and includes a pedestal for being rigidly mounted on a drilling platform. An extendable boom is pivotally mounted at one end portion on the pedestal and includes a free cantilevered end. A pipe gripper is mounted on the cantilevered end in order to encircle pipe members. Structure is provided to selectively pivot the boom about a vertical axes relative to the pedestal. Structure is provided to selectively raise and lower the cantilevered end. Structure is provided for selectively extending and retracting the boom wherein pipe members may be encircled by the gripper and guided by the boom to desired locations.

In accordance with another aspect of the invention, a racker arm assembly includes an extendable boom having a supported end pivotal about a vertical axis and having a free end movable upwardly and downwardly.

A pipe gripper is located on the free end of the boom. The boom includes an outer housing having a plurality of telescoping sections relatively movable from the housing to extend and retract the boom. Structure is provided to control the movement of the telescoping sections such that the outer sections are first outwardly extended prior to the outward extension of the innermost sections.

In accordance with another aspect of the invention, a racker arm assembly is provided to grip and guide riser pipe having an irregular cross-section. An extendable boom is movable to and from a plurality of locations in the region of a well drilling platform. A gripper head is mounted on the end of the boom and includes a cutout portion for receiving an inner peripheral portion of the riser pipe. A flexible chain is attached at one end to the gripper head and has a free end. The chain is of sufficient length to be wrapped around an outer peripheral portion of the riser pipe. Structure is provided to attach the free end of the chain to the gripper head so that the riser pipe is securely gripped for movement in a vertical position to the desired locations in the region of a well drilling platform.

In accordance with yet another aspect of the invention, a racker arm system is provided to guide elongated pipe members. The system includes an extendable boom having a free end movable to a plurality of locations in the region of the drilling platform. A pipe gripper is mounted on the free end of the boom and includes a gripper base having a semi-circular cutout portion for receiving a first peripheral portion of a vertical pipe. A movable gripper jaw is mounted on a side of the base and includes a curved portion for receiving a second peripheral portion of the pipe. At least two linear lengths pivotally interconnect the base and the jaw so that the jaw may be moved to and from the base in a generally linear path. A pressurized cylinder is connected between the base and the jaw for selectively moving the jaw to and from the base.

DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and for other objects and advantages thereof, reference is now made to the following description taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a top view of a typical installation of the present racker arm on an offshore drilling platform;

FIG. **2** is a side view of the present racker arm;

FIG. **3** is a rear view of the racker arm shown in FIG. **2**;

FIG. **4** is a top view of the pipe section gripper head in the closed position;

FIG. **5** is a top view of the gripper head shown in FIG. **4** in the opened position;

FIG. **6** is a top view of the gripper head shown in FIG. **4** with inserts added to enable gripping of smaller diameter pipes;

FIG. **7** is a top view of the riser pipe gripper head of the invention with a riser pipe gripped in a first position;

FIG. **8** is a top view of the riser pipe gripper head shown in FIG. **7** with a riser pipe clamped in a second alternate position;

FIG. **9** is a perspective view of the present racker arm in a partially extended position including the gripper head shown in FIG. **4**;

FIG. **10** is a perspective view of the racker arm in a fully extended position including the gripper head shown in FIG. **7**;

FIG. **11** is a sectional view, partially broken away, of the boom of the present invention;

FIG. **12** is a sectional view taken generally along section lines **12—12** in FIG. **11**;

FIG. **13** is a side view, partially sectioned, of the swivel assembly of the present racker arm; and

FIG. **14** is a schematic drawing of the hydraulic control circuitry for operation of the boom.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1**, a top view of a typical installation of the present invention is illustrated on an offshore drilling platform designated generally by the numeral **10**. The platform includes a conventional rotary table **12** having a well bore **14**, with a mousehole **16** and a rathole **18** located adjacent the table **12**. A pair of drill pipe setback areas **20** and **22** are positioned opposite the rotary table **12**, with a pair of drill collar setback areas **24** and **26** being positioned between the areas **20** and **22** and the table **12**. The platform includes a deadman anchor **28**, a derrick leg bedplate **30** and a stand pipe manifold **32**.

The racker arm of the invention is illustrated generally by the numeral **34** and is positioned between the rotary table **12** and the derrick leg bedplate **30**. The racker arm **34** includes an extendable boom **36** including an outer housing and three extendable boom sections **38, 40** and **42**. A control console **44** includes five manually operable levers **46** to enable control and operation of the racker arm. The boom **36** includes a supported end **48** which is pivotal about a vertical axis **50**. The vertical axis **50** is spaced away from borehole **14** and is positioned to enable access by the boom **36** to the various setback areas on the platform, while also enabling access to the well bore **14**, the mousehole **16** and the rathole **18**.

A pipe gripper head **52** is mounted on the free cantilevered end of the boom **36** and includes a gripper base **54** having a cutout portion **56** for receiving a portion of the periphery of pipe section **58**. The gripper head **52** also includes a movable gripper jaw **60** which is pivoted relative to the base **54** and is movable relative thereto by operation of a hydraulic cylinder **62**. As will be subsequently described in greater detail, the gripper head assembly **52** clamps about a pipe section or a drill collar in order to guide the pipe members to the desired location, while allowing movement of the pipe members along their vertical axes. An alternate gripper head may be utilized with the boom to enable rigid gripping of riser pipe for transportation to the blowout preventers.

The boom **36** in the illustrated position is pivotal about the vertical axis **50** to scribe a minimum arm radius illustrated by the arc **64**. When the boom is extended to the maximum extent by selective operation of the levers **46**, the racker arm **34** may be operated about a maximum arm radius illustrated by the arc **66**. It will thus be apparent that the racker arm **34** may be operated substantially over the entire area of the well bore and the setback areas of the platform.

FIGS. **2** and **3** illustrate side elevational views of the racker arm **34**, and like numbers will be utilized in the various drawings for like and corresponding parts. The

boom 36 comprises an outer housing 70 which receives the three telescoping boom sections 38, 40 and 42. The gripper head 52 is pivotally connected at pivot 72 to the lower end of the housing 42. A hydraulic cylinder 74 is mounted within the outer end of the housing 42 and includes an extendable rod 76 which is pivotally connected at pivot 78 to the upper portion of the gripper head 52. As will be later described, cylinder 74 is operated by the hydraulic control circuit to maintain the gripper head 52 in a selected position (usually horizontal) regardless of the attitude of the boom 36. In this manner, pipe members may be grasped at high or low positions without causing binding of the pipe members within the gripper head 52.

The boom 36 is mounted at the supported end upon a pedestal 80 which includes a base 82 which may be rigidly bolted to the floor of the well drilling platform. The opposite end of boom 36 comprises free cantilevered end which may be selectively moved in any direction. A hydraulic power unit assembly, not shown, is connected to the pedestal 80 in order to supply pressurized fluid thereto. The upper portion of the pedestal 80 supports a gear 84, best shown in FIG. 3, which meshes with a gear 86 driven through a gear box 88 by a hydraulic drive motor 90. The gear box 88 and motor 90 are mounted on a platform 92 supported by two spaced apart flanges 94 and 96 connected to a side brace 98. A second side brace 100 is spaced apart from brace 98 and both braces 98 and 100 are connected to a pivot platform above gears 84 and 86. Operation of motor 90 causes rotation of gear 86 to thereby pivot the upper assembly relative to the fixed pedestal 80.

As best shown in FIG. 3, a ten-way hydraulic swivel assembly 102 is mounted between the side braces 98 and 100 and serves to communicate hydraulic pressure applied from the pedestal 80 to the various hydraulic motors and cylinders of the racker arm. For example, pressurized hydraulic fluid is applied through hydraulic cables 104 and 106 from the swivel assembly 102 to the boom 36 in order to operate the hydraulic cylinders which control the extension and retraction of the boom. This pressurized fluid also controls the operation of the hydraulic cylinders 74 in order to control the attitude of the gripper head 52. A more detailed description of the ten-way hydraulic swivel assembly 102 will be described with respect to FIG. 13.

As shown in FIG. 2, a hydraulic cylinder 110 is pivotally connected at a pivot 111 to the pivot platform located above the pedestal 80. The cylinder rod 112 of the cylinder 110 is pivotally connected at 114 to the underside of the boom housing 70. Housing 70 is pivotally supported between the side braces 98 and 100 by a pivot pin 118. Cylinder 110 is slaved with cylinder 74 in order to maintain the gripping head 52 in a selected position. Cylinder 110 senses the attitude of the boom 36 and varies the volume of oil in cylinder 74 in order to maintain the gripper head 52 level at all times.

A cylinder 120 is pivotally mounted at pivot 122 in base member 124. The rod 126 of the cylinder 120 extends upwardly to a pivotal connection 128 with the underside of the boom housing 70. Hydraulic fluid for operation of the cylinder 120 is applied from the swivel assembly 102 via hydraulic lines. A counter balance 130 is provided on the lower portion of cylinder 120 to provide a counter balance to the system in case of failure of one of the hydraulic lines. Cylinder 120 is utilized to raise and lower the boom 36 in a manner to be described in detail with respect to the hydraulic circuitry shown in FIG. 14.

The console 44 includes five levers 46 as previously noted to enable operator control of the system. While the illustrated embodiment shows a hydraulic valve control system, it will be understood that an electrical control system could alternatively be utilized. In the preferred embodiment, the first lever moves the boom up and down, the second lever moves the boom in and out, the third lever pivots the boom left or right, the fourth lever opens and closes the gripper head and the fifth lever moves the gripper head up or down as desired. Each of the levers 46 comprises a conventional hydraulic control lever system which controls the application of pressurized fluid to the various cylinders and motors of the system shown in FIGS. 2 and 3.

FIGS. 4-6 illustrate in greater detail the construction and operation of the pipe section and drill collar gripper head assembly 52. As previously noted, the gripper head 52 comprises an integral unit which may be selectively pinned or unpinned to the cantilevered free end of the boom 36. In this manner, different types of gripper heads may be easily connected to the system for use with different applications.

Referring to FIG. 4, the assembly comprises the gripper base 54 including a rear portion 140 having a generally triangular cross-section as shown in FIG. 2. At the rear of the rear portion 140, a pair of lugs 142 and 144 are provided to enable pinning of the assembly to the end of housing 42 at the pivot point 72 (FIG. 2). At the top center of the rear portion 140 is a lug 146 to enable pinning of the assembly to the rod 76 at the pivot point 78 as shown in FIG. 2. Quick disconnect couplings 148 and 150 enable disconnection of the hydraulic lines of the assembly. The quick disconnect 148 connects hydraulic lines 152 and 154 to the lower portion of the cylinder 62, while the quick disconnect 150 connects the hydraulic lines 156 and 158 to the upper portion of the hydraulic cylinder 62. As previously noted, hydraulic pressure is applied to lines 154 and 158 via the ten-way hydraulic swivel assembly 102 shown in FIG. 3.

The rod 160 of cylinder 62 is pivotally connected at 162 to the gripper jaw 60. The gripper jaw 60 includes a curved cutout portion 164 for clamping about a portion of the periphery of a vertically extending pipe section or drill collar. The jaw 60 is pivotally connected to a rigid linkage 166 and is pivotally connected at a spaced apart pivot point 168 to a second rigid linkage 170. Linkage 166 is shorter than linkage 170. Linkage 166 is connected at pivot 172 to the gripper base 54 and linkage 170 is connected at pivot 174 to the base 54. A lifting eye 176 is connected to the base 54 to assist in manual installation of the gripper head. As previously noted, the base 54 includes a semi-circular cutout portion 56 for clamping against one-half of the periphery of a pipe section or drill collar.

FIG. 5 illustrates an important aspect of the gripper head 52 in that the gripper jaw 60 moves away from the gripper base 54 in a generally linear manner. This enables the gripper head 52 to clamp about a pipe section with much less required space than if the cutout sections 56 and 164 were directly hinged together. The present gripper assembly may thus be used to clamp and unclamp pipe sections or drill collars in a minimum space. The generally linear action is provided by the fact that the short linkage 166 tends to move the jaw

inwardly, while the linkage **170** moves the jaw **60** outwardly away from contact with the base **54.** The cylinder **62** is operated to retract the rod **160** in order to open the gripper jaw as illustrated in FIG. **5.**

FIG. **6** illustrates the connection of clamp inserts **180** and **182** to the gripper head in order to enable the assembly to clamp pipe sections or drill collars of smaller diameters. The insert **180** includes a base **184** with a pair of spaced apart apertures **186.** Retainer pins **188** rigidly connected to the base **54** extend through the apertures in order to securely fasten the insert to the base **54.** Insert **182** includes an aperture **190** which receives a retainer pin **192** in order to affix insert **182** to the jaw **60.** It will be understood that a variety of different sizes of insert sets may be utilized to enable the present device to guide a wide range of pipe member sizes.

An important aspect of the present racker arm is the ability to clamp riser pipe having an irregular cross-section. The riser pipe gripper head **200** is illustrated in FIGS. **7** and **8** and includes a rigid base **202** having a pair of spaced apart lugs **204** and **206** operable to be pivotally pinned to the free cantilevered end of the boom **36** in the same manner as the gripper head **52.** A central lug **208** is also adapted to be pivotally pinned to the rod **76** of the cylinder **74** as previously described. Operation of the rod **76** enables pivotal movement of the gripper assembly **200** about the lugs **204** and **206** in order to vary the attitude of the gripper assembly. The base **202** includes a pair of semi-circular cutout portions **210** and **212.** Riser pipe may be gripped in either of the cutout portions **210** or **212,** depending upon the position of the riser pipe when clamped and depending upon the desired arc of movement of the riser pipe.

FIG. **7** illustrates a riser pipe assembly **214** clamped in the cutout portion **210.** Riser pipe assembly **214** includes a plurality of pipes **216** which provide the riser pipe assembly with an irregular cross-section. In use of the present gripper assembly, the riser pipe is positioned within the cutout portion **210** and a flexible rigid chain **218** is wrapped around the outer periphery of the riser pipe in order to ragidly clamp the riser pipe within the gripper head assembly **200.** Chain **218** may comprise any suitable flexible linkage such as a chain, cable or the like. Chain **218** is connected to an end of a cylinder rod **220** and passes around a roller **219.** Operation of the cylinder **222** causes the chain **218** to be tightened about the riser pipe. Cylinder **222** is connected by a pivot **224** to the base **202.** The free end of the chain **218** is hooked about a hook **228** after being wrapped around a riser pipe. In operation, the riser pipe assembly **214** is positioned within the cutout portion **210.** The free end of the chain **218** is then wrapped around the riser pipe assembly and is hooked on the hook **228.** The cylinder **222** is then energized in order to tighten the chain **218** around the riser pipe assembly to securely clamp the riser pipe to the gripper head **200.**

FIG. **8** illustrates the use of the present gripping head to grip the riser pipe assembly **214** in the cutout portion **212.** In this mode of operation of the gripping head **200,** the chain **218** is passed around the roller **219** and around the outer periphery of the riser pipe assembly **214** and is hooked upon a hook **230** extending from the base **202.** The cylinder **222** is energized in order to tighten the chain **218** about the riser pipe assembly **214.** The irregular cross-sectional shape of the riser pipe assembly may be accommodated due to the flexible nature of the chain or cable **218.**

FIGS. **9** and **10** are perspective views of the racker arm **34** and illustrate the operation of the extendable boom **36.** Like numbers are utilized for like and corresponding parts in this drawing previously described. As previously mentioned, operation of the hydraulic motor **90** operates through the gear train **88** to rotate the upper housing relative to the pedestal **80.** In this manner, the extendable boom **36** may be rotated any amount about a vertical axis. Further, upon energization of the hydraulic cylinder **120,** the boom housing **70** and consequently the entire extendable boom may be selectively moved up and down to enable the pipe member to be gripped at any desired height. By operation of the cylinder **74,** the cylinder rod **76** may move the gripper head **52** up or down. Normally during operation, the gripper head **52** will be automatically maintained in a horizontal position by operation of the hydraulic control system which will be subsequently described. Operation of the cylinder **62** enables the gripper jaw **60** to open and close against the gripper base **54** as previously described.

Each of the telescoping boom sections **38, 40** and **42** include a corresponding hydraulic cylinder which enables selective individual operation of each boom section. For example, section **38** includes a cylinder rod **240** which may be selectively extended or retracted in order to move the section **38** into and out from the housing **70.** Similarly, sections **40** and **42** include separate hydraulic cylinders which enables relative movement of the sections to one another. As shown in FIGS. **9** and **10,** the housing **70** has the largest cross-sectional area and receives each of the sections **38, 40** and **42** in a telescoping manner. Similarly, section **38** has a larger cross-sectional area than do the innermost sections **40** and **42.** Likewise, section **40** has a larger cross-sectional area than the innermost section **42.**

An important aspect of the present invention is that the outermost sections are first extended prior to any extension of the innermost sections. Similarly, during retraction, the innermost sections are first retracted prior to any retraction of the outermost sections. Thus, the boom is provided with the optimum stability and strength at any point of extension or retraction. For example, FIG. **9** illustrates a mid-point in the extension of the boom **36.** In this position, section **38** is fully extended from the housing **70** and section **40** is just beginning to be outwardly extended from section **38.** Section **42** is not extended whatsoever from section **40.** In operation, section **40** will be fully extended from section **38** before any extension is provided to the innermost section **42.**

FIG. **10** illustrates the boom **36** in a fully extended position utilizing the gripper head **200** for riser pipe clamping. To retract the boom, the innermost section **42** is first retracted within the section **40.** Thereafter, section **40** and section **42** are retracted within the outermost section **38,** and then section **38** is retracted within the housing **70.** In this manner, the larger and therefore stronger outermost sections are utilized to bear the load when at all possible. This construction and operation differs from prior extendable booms utilizing cables wherein all sections are extended and retracted simultaneously.

FIG. **11** is a sectional view, partially broken away, of the boom **36** illustrating the interconnection of the sec-

tions 38, 40 and 42 of the housing 70. A first hydraulic cylinder 242 is rigidly connected to the top of the housing 70 and includes the cylinder rod 240 which is pivotally connected at 244 to a lug 246 attached to the top of the section 38. Section 38 includes a second hydraulic cylinder 248 having a rod 249 connected by a clevis pin 250 to the rear wall of section 38. Clevis pin 250 is mounted on a spacer 251 mounted across the back of section 38. A bracket 252 is connected to the top rear of the section 38 and includes a roller 254 which rolls against the underside of the housing 70.

Cylinder 248 is rigidly interconnected with a third cylinder 258 which is rigidly connected by a pin 260 to a bracket rigidly connected to the rear of the section 40. A roller 262 is connected to the lower rear of the section 38 to roll against the bottom of housing 70, and a roller 264 is connected to the rear of section 40 in order to roll along the bottom of section 38. A roller 265 is attached to section 40 for rolling along section 38.

A cylinder rod 266 extends from cylinder 258 and is connected by a clevis pin 268 with a bracket 270 rigidly mounted within the innermost section 42. Section 42 includes rollers 272 and 274 mounted on a rear thereof to roll within section 40. Housing 70 includes, at the lower front end thereof, a support roller 280. Support rollers 282 and 284 are respectively mounted on the front portions of sections 38 and 40.

Operation of the extendable boom 36 will be apparent in FIG. 11. When the boom is in the retracted position, hydraulic fluid is first applied to cylinder 242 and rod 240 causes the section 38 to be fully extended. Pressure is then applied to cylinder 248 and the rod 249 causes the section 40 to be fully extended from section 38. Pressurized fluid is then applied to cylinder 258 which causes the rod 266 to fully extend the innermost section 42. Upon retraction, the operation is reversed with the innermost section 42 being first retracted within section 40 as previously noted. The roller pins provided by the present invention provide smooth operation of the telescoping action of the boom at all times.

FIG. 12 is a sectional view of the boom 36 taken along section lines 12—12. FIG. 12 illustrates that cylinder 242 and cylinder rod 240 are mounted in the interior top of housing 70. As may be seen, guide rollers are connected between the housing 70 and the section 38 in order to provide smooth trouble-free operation of the boom. As shown in FIG. 12, cylinders 248 and 258 extend through the middle of the innermost section 42 and serve to operate both sections 40 and 42 as previously described.

FIG. 13 illustrates the ten-way hydraulic flexible assembly 102 previously shown in FIG. 3. The swivel assembly 102 includes a central housing 290 which is fixedly attached to the top of the pedestal 80 (FIG. 3). The assembly 102 further includes an outer housing 292 which is attached to the pivotal base above the pedestal 80 which rotates relative to the pedestal 80. Ten circular ports 300 are formed in the bottom of the housing 290 and extend upwardly through the length thereof. Each of the ports communicates with one of ten circular grooves 302 for about the periphery of the housing 290. For example, port 304 communicates with the bottom of the housing 290 and extends upwardly into contact with the second circular groove around the top of the housing 290.

Ten ports 306 are formed through the walls of the outer housing 292. Each of the ports 306 communicates with a different one of the grooves 302. Hoses are attached to the ports 306 and are directed to the extendable boom 36 and to the various cylinders and motors of the system. Housing 290 remains stationary, while outer housing 292 rotates during pivoting of the boom 36.

FIG. 14 is a diagram of the hydraulic control system for the racker arm. This system controls the operation of the cylinder 62 which opens and closes the gripper assembly, controls cylinders 74 and 110 which maintain the gripper assembly in a horizontal position, controls the cylinder 120 which raises and lowers the free cantilevered end of the boom, and controls cylinders 242, 248 and 258 which controls the extension and retraction of the boom. The power unit 310 of the hydraulic system includes a hydraulic pump 312 which is operated by a 60-H.P. electrical motor 314. Motor 314 also operates a second hydraulic pump 316. Pressurized fluid is applied from pump 312 via pump lines 318 and 320. Relief valves 322 and 324 relieve the pump lines at 1200 psi and 1600 psi, respectively. Pump line 318 is directed to a four-way control valve 328 which controls the swing of the boom about the vertical axis. Line 330 connects the valve 328 with the hydraulic motor 90 which operates the gears 84 and 86 in the manner shown in FIG. 3 in order to pivot the boom. A dual relief valve 332 is connected across the motor 90 in order to provide relief protection to the motor at 1000 psi.

The output of the motor 90 is applied through line 334 to valve 328. Line 336 is directed from the valve 328 to a fourway control valve 338 which operates to control the desired angular orientation of the gripper assembly. When the valve 338 is in the illustrated position, pressurized fluid is provided through line 340 to a four-way control valve 342 which operates to open or close the gripper jaw of the gripper assembly. The valve 342 thus controls the flow of pressurized fluid to the cylinder 62 connected on the gripper head shown in FIGS. 4 and 5. A low pressure relief valve 344 is connected to the input line to the 342 valve to relieve the valve at 600 psi. One output of valve 338 is applied through line 346 and through a needle valve 348 to a piloted control valve 350, termed the boom float valve. Line 346 is also applied to a dual relief valve 352 which provides crossover pressure relief 1000 psi. The output of valve 352 is applied to a counter balance valve 354 and to a reservoir 356 and is also applied via line 358 to cylinder 74. Cylinder 74 is slaved with cylinder 110.

The second output from valve 338 is applied via line 360 and through a needle valve 362 to the boom float control valve 350. Line 360 is also connected through the dual relief valve 352 and via line 366 to the cylinder 110 (FIG. 2). An output line 368 from the valve 352 is applied to a 200 psi relief valve 370.

The output line 320 from the pump 312 is applied to the boom lift four-way control valve 374. In the illustrated position, the valve 374 applies the fluid via line 376 to the boom float control valve 350. An 800 psi relief valve 378 is connected to line 376. The output of the control valve 374 is applied via lines 380 both to the boom float control valve 350 and to the boom lift cylinder 120. A counterbalance valve 382 set at 2500 psi is connected in series with lines 380.

The output from pump **316** is applied to an overcenter valve **388** and through a check valve **390** to line **392.** A highpressure relief valve **394** is set at 2000 psi and is connected to line **392.** Line **392** is directed to a boom extension four-way control valve **396.** Valve **396** controls the flow of fluid through line **398** through a counter balance **400** to the cylinders **242, 248** and **258** connected in series, as illustrated. The output of cylinders **242, 248** and **258** is applied through line **402** and through a 2500 psi counterbalance valve **404** to the boom extension control valve **396.** A pilot line **408** interconnects line **398** with the overcenter valve **388.**

The power unit **310** will generally be mounted in a separate unit, not shown in FIGS. **1–13,** which is conventionally connected to pedestal **80** to supply pressurized fluid thereto. The hydraulic circuitry located within the dotted line **412** is located within the control console **44** shown in FIG. **3.** The remainder of the motors and cylinders are located on the boom as previously described.

In operation of the hydraulic circuitry shown in FIG. **14,** selected ones of the manual control levers **46** shown in FIG. **3** will be operated in order to manually control the position of the control valves **328, 342, 338,** 374 and **396.** When it is desired to pivot the boom about the vertical axis, control valve **328** is operated in order to cause operation of the hydraulic motor **90.** The motor **90** rotates gear **86** which operates against gear **84** in order to pivot the boom relative to the fixed pedestal **80** as previously described.

When it is desired to open or close the gripper head, valve **342** is operated in order to selectively move the gripper clamp cylinder **62** as shown in FIGS. **4** and **5.** In the case of the gripper head shown in FIGS. **7** and **8,** operation of the valve **342** controls the operation of the cylinder **222** in order to tighten or loosen the flexible chain **218.**

As previously noted, cylinder **74** and **110** interact to maintain the gripper assembly in a desired position throughout all vertical movement of the free cantilevered end of the boom **36.** Cylinders **74** and **110** are thus slaved, so that the volume of hydraulic fluid in cylinder **110** is changed when the boom is moved up or down. The change of hydraulic fluid in cylinder **110** thus causes a corresponding opposite change in the volume of hydraulic fluid in cylinder **74,** in order to change the angle of the gripper head with respect to the boom in order to maintain the desired preset angle of the gripper head. The preset angle of the gripper head is adjusted by operation of control valve **338.**

The relief valve **370** maintains a minimum of 200 psi in the lines of the low pressure side of the cylinders. Valve **370** thus insures that air is kept out of the system due to the maintenance of 200 psi and thus compensates for the difference in area between cylinders **74** and **110.** The counterbalance valve **354** is important in providing overload release in case the boom is overloaded faster than cylinder **110** can compensate for. Upon overload, fluid is dumped into reservoir **356.**

An important aspect of the invention is that the boom **36** automatically floats vertically up and down with the riser pipe when the riser gripper head is engaged with the riser pipe. This floating action is provided by the boom float control valve **350.** Thus, the boom **36** may float with vertical movements of the riser pipe during movement from one location to another without harm to the boom. This floating operation is not required when the pipe section or drill collar gripping head is being utilized, as the pipe section or drill collar are not tightly gripped, but are allowed to move vertically with respect to the gripping head. Thus, when pipe sections or drill collars are gripped, the pipe sections or drill collars are able to move vertically along their axes and the gripper head is maintained in a predetermined angle to prevent binding up.

To explain the floating boom action, assume an upward force is exerted on boom **36.** As the pressure begins to build up due to lifting on the cylinder **74,** the hydraulic fluid supplied through line **346** is applied through the boom float control valve **350** and the cylinder **120** is allowed to raise the boom **36** to compensate for the overload in pressure. If an excessive downward load is applied to the boom, the cylinder **74** picks up the load and pressurized fluid is applied through line **366** to the boom float valve **350** and the cylinder **120** pulls the boom downwardly in order to automatically compensate for the overload.

When it is desired to lift or lower the cantilevered free end of the boom **36** to initially clamp onto a pipe member, the valve **374** is actuated by the respective manual lever and pressurized fluid is applied to the boom lift cylinder **120** in order to selectively raise or lower the boom about the pivot point **118** as previously described. Lifting of the boom **36** will cause pressurized fluid to be transferred from cylinder **110** to cylinder **74** in order to maintain the desired position of the gripper head relative to the horizontal.

When it is desired to extend or retract the boom **36,** the boom extension valve **396** is selectively operated and pressurized fluid is applied from the pump **316** to the cylinders **242, 248** and **258.** Due to the serial connection of the cylinders, the outermost sections are initially extended prior to the extension of the innermost section, as previously noted, in order to maintain the maximum strength of the boom at all times.

While the present invention has been primarily disclosed with respect to a manual control console, it should be understood that automatic or preprogrammed controls could be provided to the present racker arm. As an example, a limit switch system could be provided so that the boom automatically swings to and from the well bore, rathole or mousehole and predetermined setback areas. Alternatively, a properly programmed digital computer could be utilized in order to operate the boom according to preprogrammed instructions.

Whereas the present invention has been described with respect to specific embodiments thereof, it will be understood that various changes and modifications will be suggested to one skilled in the art, and it is intended to encompass such changes and modifications as fall within the scope of the appended claims.

What is claimed is:

1. In a racker arm assembly for gripping and guiding riser pipe having an irregular cross-section wherein an extendable boom is movable to and from a plurality of locations in the region of a well drilling platform, the combination comprising:

a gripper head mounted on the end of said boom and having a circular cutout portion for receiving an inner peripheral portion of the riser pipe,

a hydraulic cylinder mounted on said gripper head,

a flexible elongated member attached at one end to said hydraulic cylinder and having a free end, said

member being of sufficient length to be wrapped about an outer peripheral portion of the riser pipe,

means for attaching said free end of said flexible member to said gripper head, and

means for activating said hydraulic cylinder to cause the riser pipe to be securely gripped by said gripper head such that the riser pipe may be moved in a vertical position to desired locations in the region of the well drilling platform.

2. In a racker arm assembly for gripping and guiding riser pipe having an irregular cross-section wherein an extendable boom is movable to and from a plurality of locations in the region of a well drilling platform, the combination comprising:

a gripper head mounted on the end of said boom and having a first cutout portion for receiving an inner peripheral portion of the riser pipe,

a second cutout portion formed in said gripper head for receiving a peripheral portion of a riser pipe,

a flexible elongated member attached at one end between said first and second cutout portions and having a free end, said member being of sufficient length to be wrapped about an outer peripheral portion of the riser pipe when the riser pipe is disposed in either of said first and second cutout portions, and

means for attaching said free end of said flexible member to said gripper head so that the riser pipe is securely gripped by said gripper head to be moved in a vertical position to desired locations in the region of the well drilling platform.

3. The combination of claim **2** and further comprising:

a hydraulic cylinder attached to an end of said flexible member for tightening said member about the riser pipe.

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