United States Patent

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[54] **APPARATUS FOR MOVING DRILL PIPE INTO AND OUT OF AN OIL WELL DERRICK**
9 Claims, 8 Drawing Figs.

[52] **U.S. Cl.** ..... **214/2.5,** 175/85, 214/1 BD, 214/147 R
[51] **Int. Cl.** **E21b 19/14**
[50] **Field of Search** ..... 214/1 P, 1 B, 1 BS, 147, 147 G, 2.5, 3, 3.1, 1 CM; 175/85

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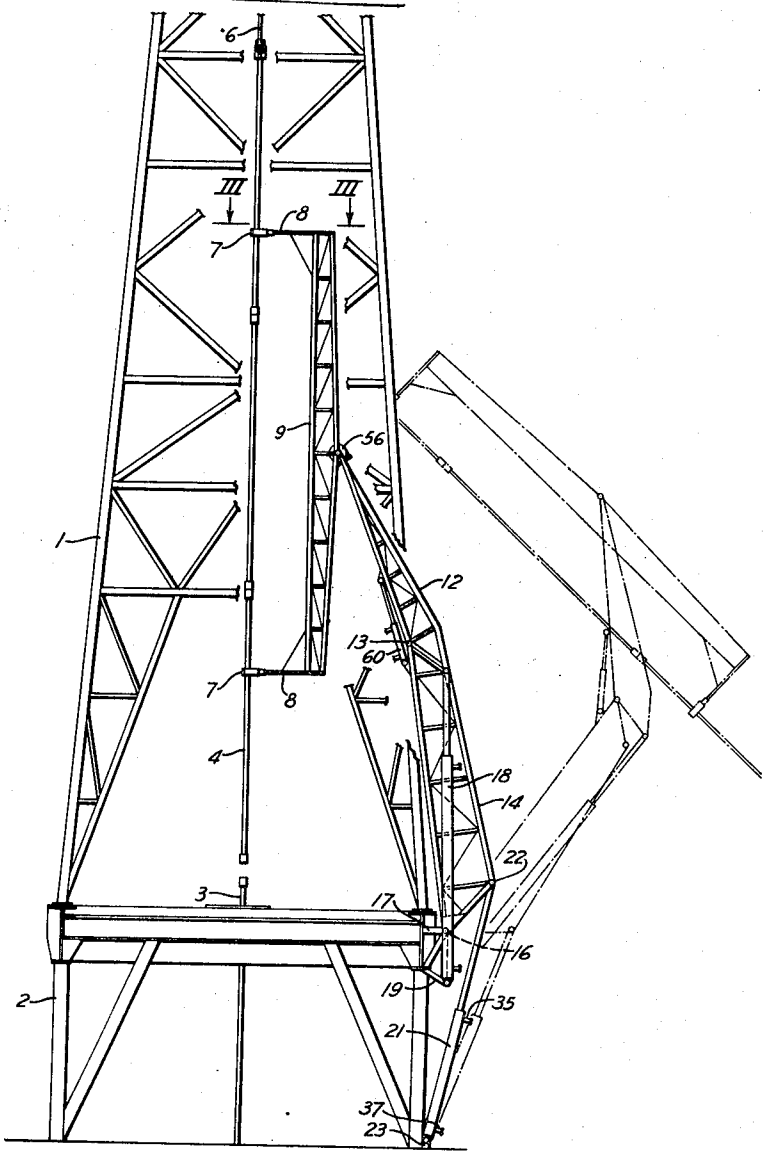
ABSTRACT: A boom has an inner end pivotally supported in front of the bottom of an oil well drilling derrick to enable the boom to be swung in a vertical plane toward and away from the derrick. A boom extension is hinged to the outer end of the boom on a horizontal axis and extends upwardly from the boom when the latter is in its raised position. Means are provided for swinging the outer end of the boom extension relative to the boom in a direction toward the center of the derrick while the boom is being lowered and away from the center while the boom is being raised. Pivotal means, pivotally connected to the outer end of the boom extension on a horizontal axis, supports clamping means for gripping drill pipe. The pivotal means is positioned to allow the gripped drill pipe to swing across the boom and boom extension as the boom is raised or lowered, whereby drill pipe suspended from the elevators can be moved back and forth between upright position in the derrick and forwardly extending position near its bottom.



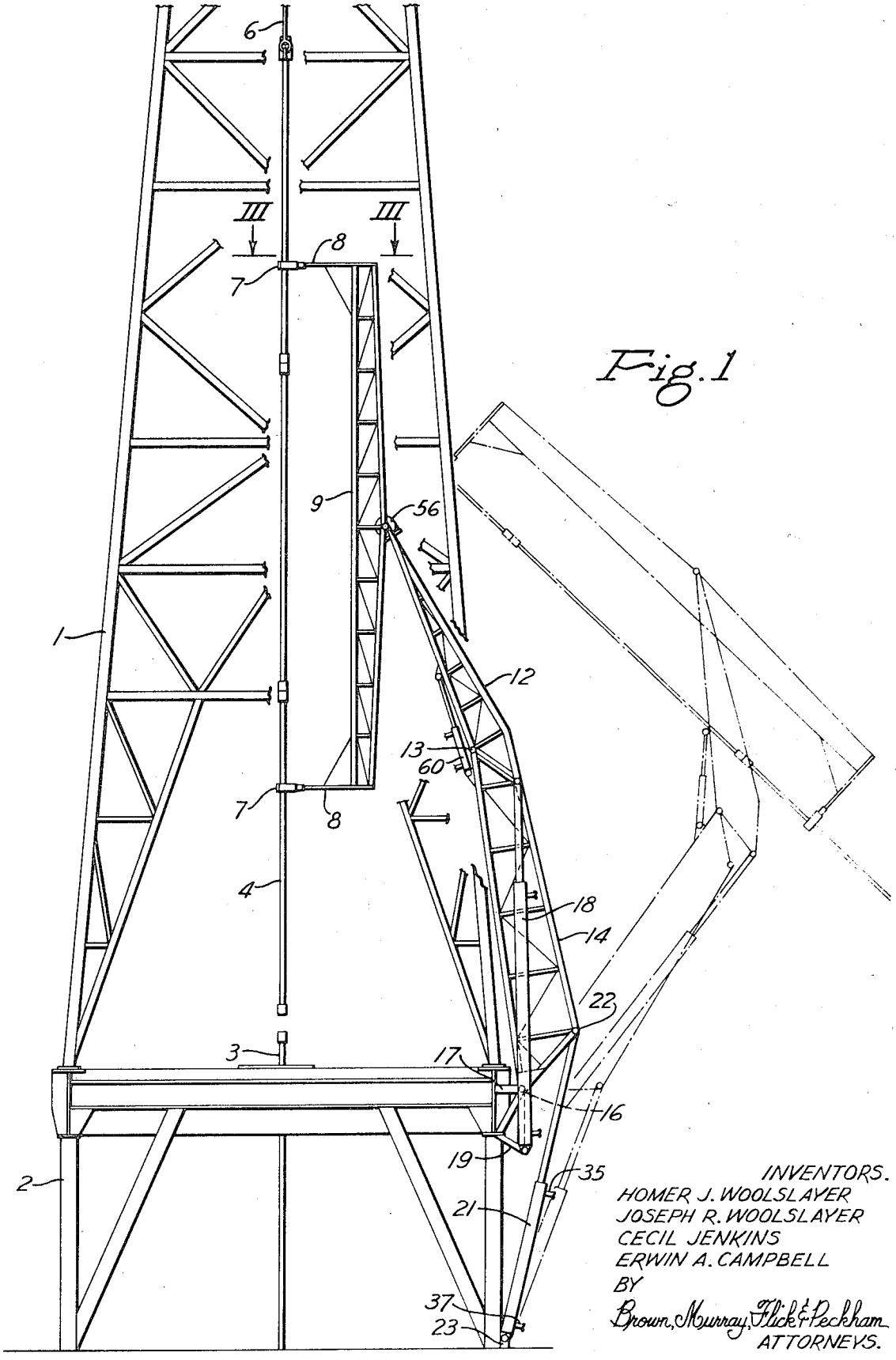


Fig. 1

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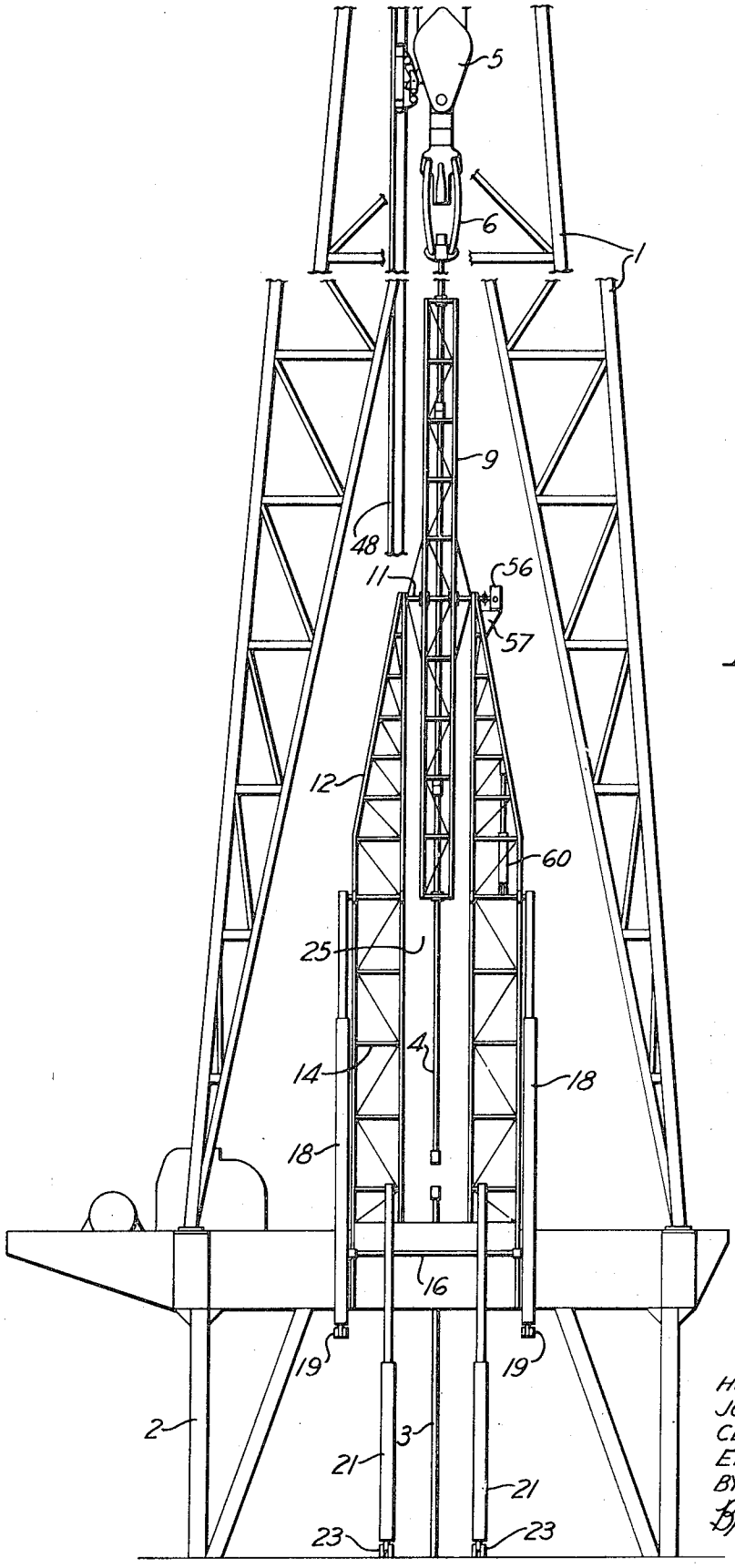

Fig. 2

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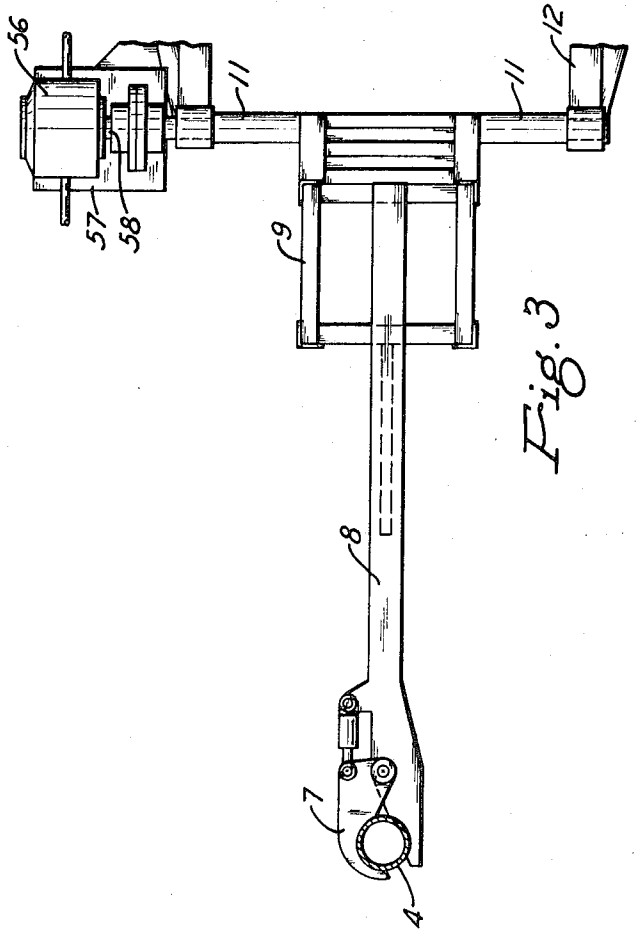

Fig. 3

Fig. 4

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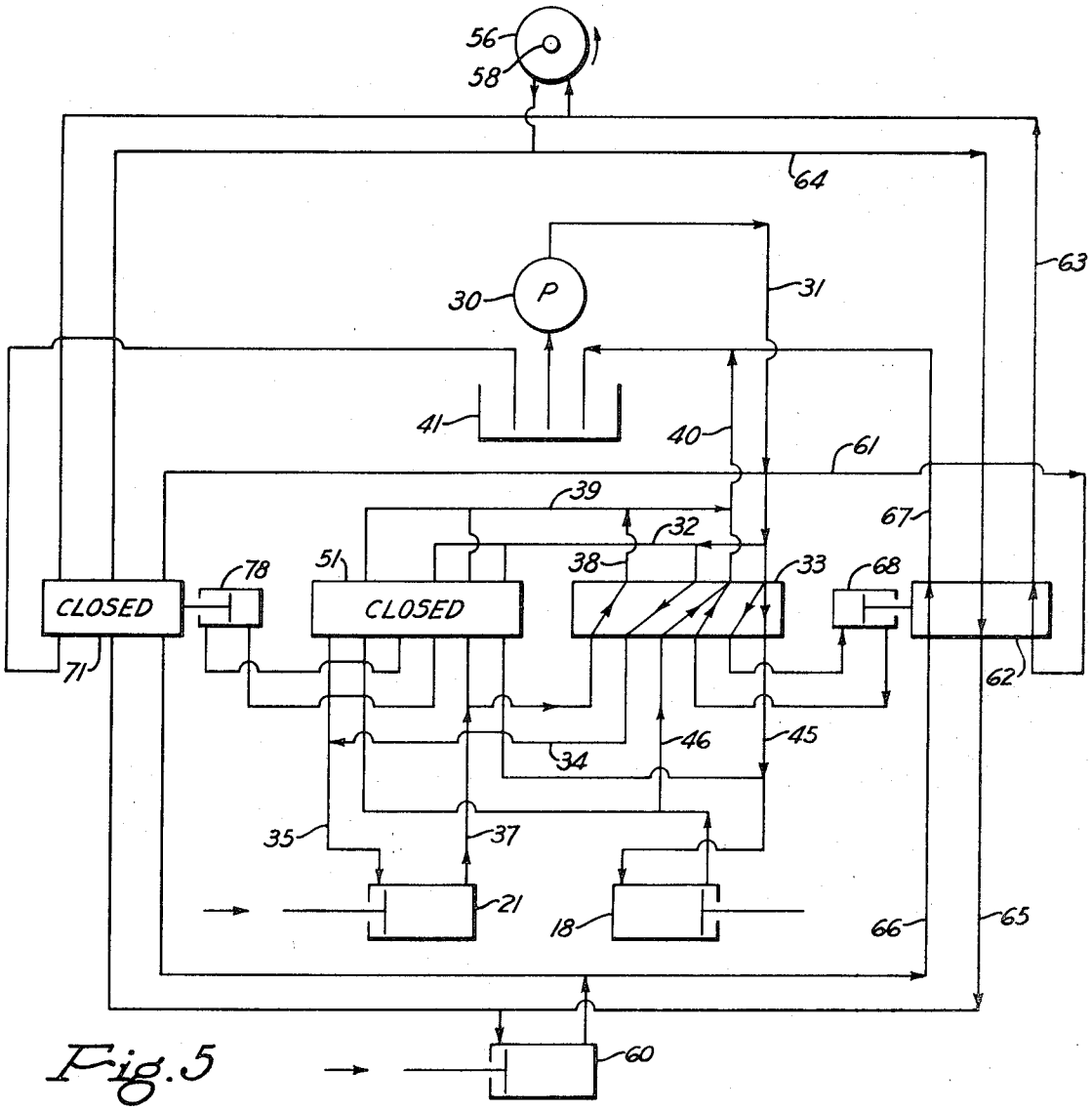
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Fig. 5

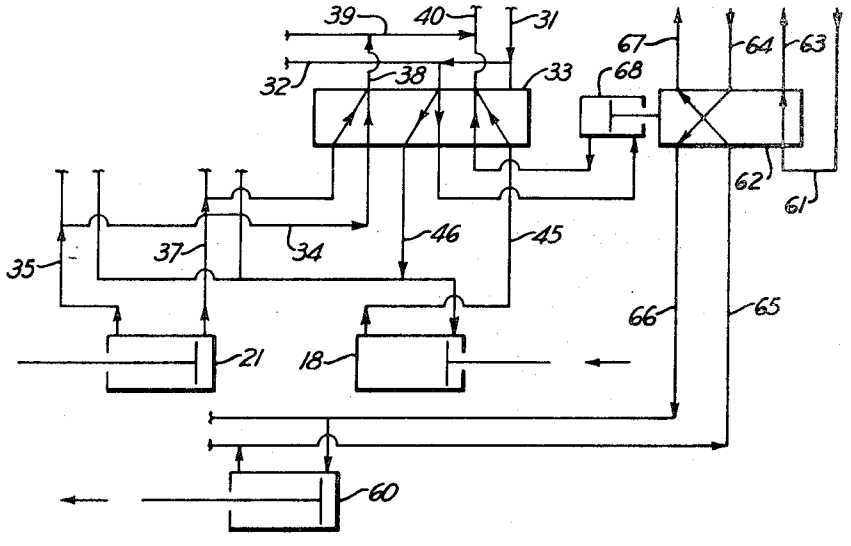
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Fig. 6

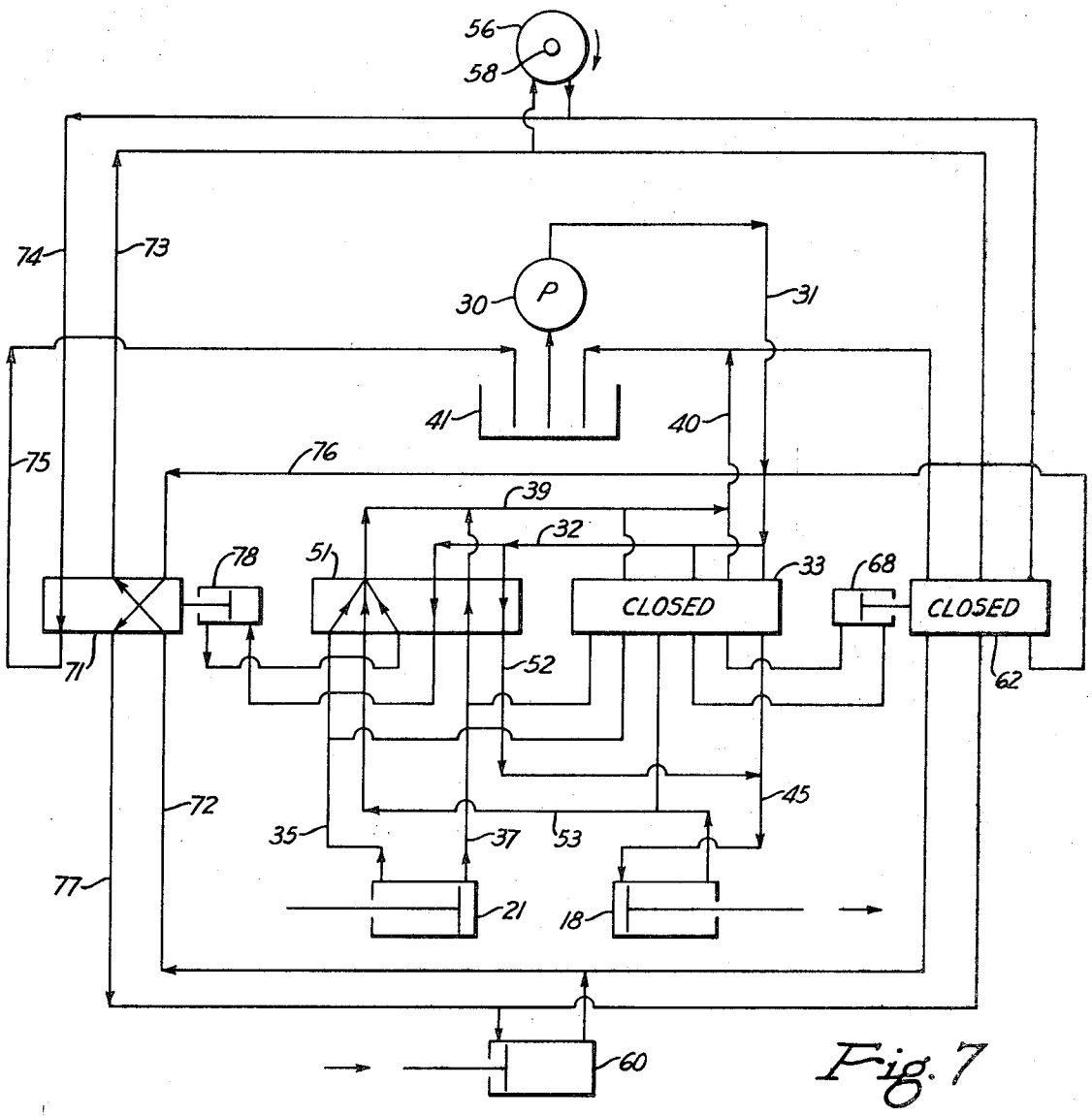
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Fig. 7

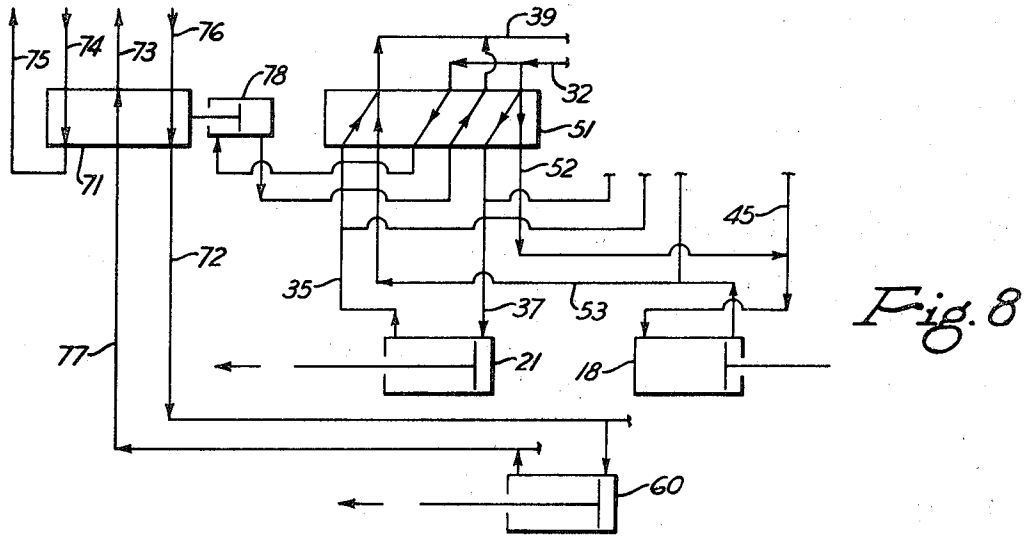
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Fig. 8

APPARATUS FOR MOVING DRILL PIPE INTO AND OUT OF AN OIL WELL DERRICK

During the drilling of an oil well it is necessary to move drill pipe into a derrick periodically and suspend it from the elevators so that successive stands of pipe can be connected together to form the drill string. When the string is pulled from the well, the stands have to be disconnected from one another and racked. Sometimes the racking is done inside the derrick itself and at other times the pipe is carried out of the derrick and racked in horizontal position beside it. The latter system has certain advantages and is especially desirable when drilling is being done from a barge or the like floating on a body of water, because it relieves the derrick from inertial forces induced by wave action and aggravated by the great weight of the racked pipe if it is standing up in the derrick. Various ways of racking pipe horizontally outside a derrick have been proposed, but they involve complicated apparatus and are slow in operation.

It is among the objects of this invention to provide apparatus for moving drill pipe back and forth between a reclining position beside a derrick and a position in which the pipe is suspended from elevators inside the derrick, and to accomplish this rapidly and with as little apparatus and manual effort as possible.

The preferred embodiment of the invention is illustrated in the accompanying drawings, in which

FIG. 1 is a fragmentary side view of an oil well derrick showing our pipe-handling apparatus in its upper position;

FIG. 2 is a front view as seen from the right-hand side of FIG. 1;

FIG. 3 is an enlarged fragmentary plan view of the pipe-handling apparatus, taken on the line III—III of FIG. 1;

FIG. 4 is a simplified side view of the derrick showing the pipe-handling apparatus in its lowest position; and

FIGS. 5 to 8 are diagrams of the hydraulic circuits used with the pipe-handling apparatus, showing the positions of the valves and pistons at different stages in the operation of the apparatus.

Referring to FIGS. 1 to 3 of the drawings, an oil well derrick 1 is shown mounted on a substructure 2, from which a string of drill pipe 3 extends down into a well. The upper end of the string, formed by a stand 4 of three pipes, is suspended from the traveling block 5 by any suitable detachable means 6, herein called elevators. The pipe stand is shown disconnected from the rest of the string below it and gripped at two vertically spaced points by clamping means which may be hydraulically operated jaws 7. These jaws are at the free ends of arms 8, the outer end portions of which are secured to the upper and lower ends of pivotal means, preferably a tall structural steel strongback 9. Although the jaws hold the pipe, they do not necessarily grip it so tightly as to prevent it from rotating while controlled by the strongback.

Projecting laterally from the central portion of the strongback is a pair of trunnions 11, the ends of which are journaled in the upper end of a boom extension 12. The derrick side of the lower end of the extension is pivotally connected or hinged at 13 to the derrick side of the upper end of an upright boom 14. The hinge axis is parallel to the axis of the trunnions. The lower end of the boom is pivotally mounted, likewise on a horizontal axis 16, on brackets 17 projecting forward from the front of the upper part of the substructure. While the boom is in its raised position, the boom extension 12 is held in its most extended position by a pair of laterally spaced vertical links 18 pivotally connected to the lower end of the extension in front of its connection to the boom. The lower ends of the links are pivotally supported by brackets 19 projecting from the front of the substructure below the brackets that support the boom. These links are formed from fully extended hydraulic rams that are maintained fully extended by hydraulic pressure while the boom is being swung down to its lower position. Swinging of the boom forward and down is accomplished by a second pair of rams 21, the upper ends of which are pivotally connected at 22 to the lower part of the front of the boom. These rams extend downwardly and are pivotally supported by brackets 23 at the bottom of the substructure.

After the strongback has been clamped onto the pipe stand in the derrick as shown in FIG. 1, fluid pressure is supplied to the upper ends of the cylinders of the boom rams 21 to shorten those rams and thereby swing the boom outwardly and down as indicated in dotted lines. Since the link rams 18 remain fully extended during this period, due to fluid pressure in the lower ends of their cylinders, they force the boom extension to swing relative to the boom in a direction toward the centerline of the derrick. In other words, as the boom in FIG. 1 swings in a clockwise direction the upper end of the boom extension swings in a counterclockwise direction. At the same time, the upper end of the boom extension is moving forward away from the derrick and down and thereby pulls the strongback forward. While this is occurring, the elevators are lowered just fast enough to keep the upper end of the pipe stand moving down along the centerline of the derrick. Due to the pipe stand being supported by the elevators, the lower end of the stand must swing forward out of the derrick. Since this means that the lower end of the drill pipe must pass the boom, the boom and its extension are bifurcated to provide them with a long longitudinal slot 25 through which the strongback and the pipe can swing forward. By the time the boom reaches its lowest position extending forward from the substructure as shown in FIG. 4, the boom extension is folded back over the boom as indicated in dotted lines in that figure and the strongback and pipe stand are nearly horizontal. The upper or inner end of the stand, however, is still attached to the elevators.

The next step is to disconnect the reclining pipe stand from the elevators so that the pipe can be moved forward and down into a pipe rack. This is done by supplying hydraulic pressure to the outer ends of link rams 18, which are now nearly horizontal, so that those rams are shortened to thereby cause the upper end of the boom extension to be swung forward and down into line with the boom as shown in full lines in FIG. 4. During this motion of the boom extension the former upper end of the strongback swings down through the extension slot and sets the pipe stand down horizontally on a suitable support or rack 27. The clamps are then disconnected from the pipe so that the boom can be swung upward again in order to grip the next stand suspended from the elevators and lower it to the pipe rack. This cycle is repeated until all of the drill pipe has been racked in horizontal position in front of the substructure.

In order to run the pipe back into the hole, the procedure just outlined is reversed. That is, the boom and its extension are placed in their lowest position with the strongback horizontal over the pipe rack so that the clamps can be attached to a stand of pipe therein. Then the link rams are extended to cause the boom extension to swing upwardly and rearwardly toward the derrick to the dotted-line positions in FIG. 4 in order to lift the inner end of the pipe stand up to a point where the lowered elevators can be attached to it. After this connection has been made, the elevators are raised at a controlled rate while the boom is swung upwardly by its rams 21. As the boom rises, the extended link rams, which now serve only as links, cause the boom extension to swing forward relative to the boom. The combined movement of the boom, boom extension and rising elevators will cause the lower end of the strongback to swing inwardly through the boom extension toward the centerline of the derrick until the pipe stand is in its vertical position hanging straight down from the elevators.

The hydraulic circuit for raising and lowering the boom 14 and for folding and unfolding the boom extension 12 is shown in FIGS. 5 to 8. In FIG. 5 the circuit is shown just as the boom starts to swing down from its upper position. At this time each ram 21 is fully extended as shown in FIG. 1, but hydraulic pressure is delivered to the upper or rod end of its cylinder by means of a pump 30 to start to shorten the ram. The flow is through lines 31 and 32, a three-position valve 33, and lines 34 and 35 to the ram cylinder. The head end of the cylinder is connected by a line 37, valve 33 and lines 38, 39 and 40 with a tank 41.

Rams 18 also are fully extended at this time, and they continue to be extended and to serve as links of fixed length while

the boom is being swung down to its lower position. Fluid pressure is maintained in the head end of each cylinder of these rams by means of the pump through line 31, valve 33, and a line 45. The rod end of the cylinder is connected with the tank through a line 46, valve 33, and line 40. As the boom is lowered, extended ram links 18 cause the boom extension 12 to fold as previously explained until it reaches the dotted-line position shown in FIG. 4. At this time valve 33 is shifted to the position shown in FIG. 6, where it will be seen that both ends of the cylinder of ram 21 now are connected with the tank, the rod end of the cylinder being connected to the tank by means of lines 35 and 34, the valve 33, and lines 38, 39, and 40.

Shifting of the valve reverses the ram 18 by delivering pressure fluid to its rod end through lines 31 and 32, valve 33, and line 46. The opposite end of the cylinder is connected by line 45 and the valve to line 40 leading back to the tank. This shortening of rams 18 swings the boom extension outwardly away from the derrick and down to its lowest position, shown in full lines in FIG. 4.

While the boom is being swung down from its upright position, the attitude or angle of the strongback relative to the ground is controlled by the traveling block and elevators in the derrick. The traveling block runs along a vertical track 48 (FIG. 2) in the derrick so that the block cannot swing away from the centerline of the derrick. When the traveling block and the boom reach their lower positions and the stand of pipe carried by the strongback is disconnected from the elevators, the attitude of the strongback during the rest of its travel down to the pipe rack 27 can be controlled by a tag line if desired. A way of controlling it automatically will be explained presently.

When a stand of drill pipe is to be lifted by the strongback from the rack and swung over for connection to the lowered elevators so that the pipe can be raised in the derrick, valve 33 is shifted to its third position to close it as indicated in FIG. 7, and a previously closed three-position valve 51 is opened. Lines 35 and 37 continue to connect ram 21 with the tank through this valve and line 39. On the other hand, the pump is connected through lines 31 and 32, valve 51, and lines 52 and 45 with the head end of ram cylinder 18, which thereby extends the ram, causing the boom extension to swing upwardly and toward the derrick to the dotted-line position shown in FIG. 4. The rod end of the same cylinder is connected at this time to a line 53, valve 51, and line 39 leading to the tank.

After the inner end of the pipe supported by the strongback has been connected to the lowered elevators, valve 51 is shifted to connect the pump through lines 32 and 37 with the head end of ram 21, as shown in FIG. 8. The ram then starts to extend in order to raise the boom. Ram 18 remains extended so that as the boom rises, the boom extension 12 is swung relative to the boom in a direction away from the elevators. Of course, during this movement the traveling block is being raised to lift the upper end of the drill pipe at the proper rate as its lower end swings inwardly toward the derrick.

It will be realized, of course, that while the pipe is being racked the strongback is carried upwardly each time without any pipe. Conversely, while pipe is being lifted from the rack and delivered to the derrick, the strongback makes each downward trip without any pipe. Since the travels of the strongback without pipe mean that at those times the traveling block cannot be used to control the attitude of the strongback, some other way of controlling it must be used. One way is with a tag line. However, it is preferred to do it automatically by means of a hydraulically operated actuator 56. This actuator is mounted on a bracket 57 secured to one side of the top of boom extension 12. The actuator includes a circular housing in which there is a vane (not shown) that is secured to a shaft 58 connected to the end of the adjoining trunnion 11 of the strongback. By delivering fluid pressure to the housing at one side or the other of the vane, the shaft and trunnion can be rotated in either direction. By controlling the delivery of fluid to the actuator, the strongback can be maintained at the correct angle to the ground as it is raised and lowered while it is not carrying drill pipe.

As viewed in FIG. 1, it will be seen that as the boom is lowered the strongback rotates in a counterclockwise direction. It continues to rotate in this same direction from the dotted line to the full line position in FIG. 4. When the boom is raised, the strongback is rotated in the opposite direction. It rotates relative to the boom extension considerably more degrees in FIG. 4 than it does in traveling between its dotted line and vertical positions. For example, the rotation in FIG. 4 may be about 138° while the rest of the rotation is about 67°.

The hydraulic circuit for controlling the actuator likewise is shown in FIGS. 5 to 8 as it uses the same pump. This circuit includes a metering ram 60 that is pivotally connected to the derrick side of the boom and boom extension and extends across hinge 13. It is extended and shortened by the folding and unfolding of the boom extension. In FIG. 1 this ram has been fully extended by the boom extension. At the beginning of the downward trip of the strongback the hydraulic circuit is as shown in FIG. 5. The pump 30 pumps fluid through lines 31 and 61, a three-position valve 62 and a line 63 to one side of the actuator. The exhaust from the other side of the actuator leaves through line 64, valve 62 and a line 65 connected to the rod end of the metering ram. Since shortening of the ram is controlled by the folding boom extension, the ram meters the fluid from the actuator to regulate turning of the actuator. The head end of the ram is connected at this time with tank 41 by means of line 66, valve 62, and a line 67.

When the boom reaches its lower position, valve 62 is shifted by its pilot 68 when valve 33 is shifted to its FIG. 6 position, so that although the connection between the pump and the actuator remains the same, exhaust fluid from the actuator now flows from line 64 to line 66 and into the head end of the metering ram cylinder. The opposite end of the cylinder is connected by line 65, valve 62, and line 67 with the tank. Consequently, it is now the larger volume end of the cylinder that meters the flow from the actuator as the ram is extended by the unfolding boom extension, and the actuator is thereby allowed to rotate a greater number of degrees than before in order to turn the strongback relative to the boom extension from the dotted-line position in FIG. 4 to its full line horizontal position.

At the time the strongback starts to lift a stand of pipe from rack 27, valve 33 is closed which causes pilot 68 to close valve 62, and a previously closed valve 71 is opened to connect the head end of metering ram 60 with actuator 56 through lines 72 and 73, as shown in FIG. 7. Folding of the boom extension causes the ram to force fluid into the actuator to turn it the required amount in a clockwise direction. The exhaust from the actuator returns to the tank through line 74, valve 71, and line 75. During this cycle the rod end of the metering cylinder is maintained full of fluid by the pump 30 through lines 31 and 76, valve 71, and line 77.

After the strongback has been lifted to the dotted line position shown in FIG. 4, valve 71 is shifted by its pilot 78 to the position shown in FIG. 8, when valve 51 is shifted. Raising of the boom causes its extension 12 to start to unfold and that extends the metering ram, which forces fluid from its rod end through line 77, valve 71 and line 73 to the actuator to continue its rotation. Exhaust from the actuator remains connected with the tank along the same route as before, but now it is the head end of the ram cylinder that is kept filled with fluid by means of the pump and line 72.

It will be seen that the metering ram meters fluid flowing from the actuator while the strongback is being lowered, and meters fluid flowing to the actuator while the strongback is being raised.

According to the provisions of the patent statutes, we have explained the principle of our invention and have illustrated and described what we now consider to represent its best embodiment. HOwever, we desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

We claim:

1. The combination with an oil well drilling derrick provided with elevators for drill pipe and with means for raising and lowering the elevators in the derrick, of pipe-handling apparatus for moving drill pipe suspended from said elevators back and forth between upright position in the derrick and a forwardly extending reclining position near its bottom, said apparatus comprising a boom having inner and outer ends, means pivotally supporting the inner end of the boom on a horizontal axis at the front of the bottom of the derrick to enable the boom to be swung in a vertical plane toward and away from the derrick, means for swinging the boom in said plane to raise and lower it, a boom extension hinged to the outer end of the boom on an axis parallel to said horizontal axis, said extension extending upwardly from the boom when the boom is in its raised position, means for swinging the outer end of the boom extension relative to the boom in a direction toward the elevators while the boom is being lowered and away from the elevators while the boom is being raised, clamping means for gripping drill pipe, and pivotal means supporting said clamping means and pivotally connected to the outer end of the boom extension on an axis parallel to said horizontal axis, said pivotal means being positioned to allow drill pipe gripped by said clamping means to swing across the boom and boom extension as the boom is raised or lowered.

2. The combination recited in claim 1, including means for swinging said boom extension away from the derrick while the boom is in its lower position to move said pivotal means farther away from the derrick and down to a lower level.

3. The combination recited in claim 2, including a fluid pressure-actuated device for controlling the angle of said pivotal means relative to the ground as the boom is being raised and lowered, and a fluid pressure system connected with said device for actuating it in opposite directions, said system including a hydraulic ram pivotally connected at its ends to the boom and boom extension for actuation thereby, the ram having a fluid pressure cylinder with a head end and a rod end, a pump, means for connecting the pump with the rod end of the ram cylinder and for connecting the head end of that cylinder with the inlet of said device while said boom extension is being swung from its lowest position toward the derrick, means for connecting the pump with the head end of the ram cylinder and for connecting the rod end of that cylinder with the inlet of said device while the boom is being raised, means for connecting the pump with the inlet of said device and for connecting the outlet of said device with the rod end of the ram cylinder while the boom is being lowered, and means for connecting the outlet of said device with the head end of the ram cylinder when said boom extension is being swung away from the derrick while the boom is in its lower position.

4. The combination recited in claim 1, in which said extension swinging means include a hydraulic ram pivotally connected at one end to the boom extension, and means pivotally supporting the opposite end of the ram below said horizontal axis, the ram being fully extended while the boom is being raised and lowered, and said apparatus includes means for shortening said ram while the boom is in its lower position to swing said extension away from the derrick to move said pivotal means farther away from the derrick and down to a lower level.

5. The combination recited in claim 1, including means for swinging said boom extension away from the derrick while the boom is in its lower position to move said pivotal means further away from the derrick and down to a lower level, and means for controlling the angle of said pivotal means relative to the ground as the boom is being raised and lowered and as the boom extension is swung toward and away from the derrick while the boom is in its lower position.

6. The combination recited in claim 1, including means for controlling the angle of said pivotal means relative to the ground as the boom is being raised and lowered.

7. The combination recited in claim 6, in which said angle-controlling means includes a fluid pressure-actuated device carried by the boom extension, and a fluid pressure system connected with said device for actuating it, said system including means controlled by the positions of the boom and boom extension relative to each other for metering flow of fluid in the system.

8. The combination recited in claim 7, in which said fluid-metering means include a hydraulic ram pivotally connected at its ends to the boom and boom extension for actuation thereby, and conduits connecting the ram into said system.

9. The combination recited in claim 1, in which said pivotal means is a strongback pivotally connected at its central portion to said boom extension, and said clamping means are spaced lengthwise of the strongback and project from one side of it, and said apparatus includes a fluid pressure-actuated device carried by the boom extension and operatively connected with the strongback, and means for supplying fluid under pressure to said device to control the angle of the strongback relative to the ground as the boom is raised and lowered.

* * * * *