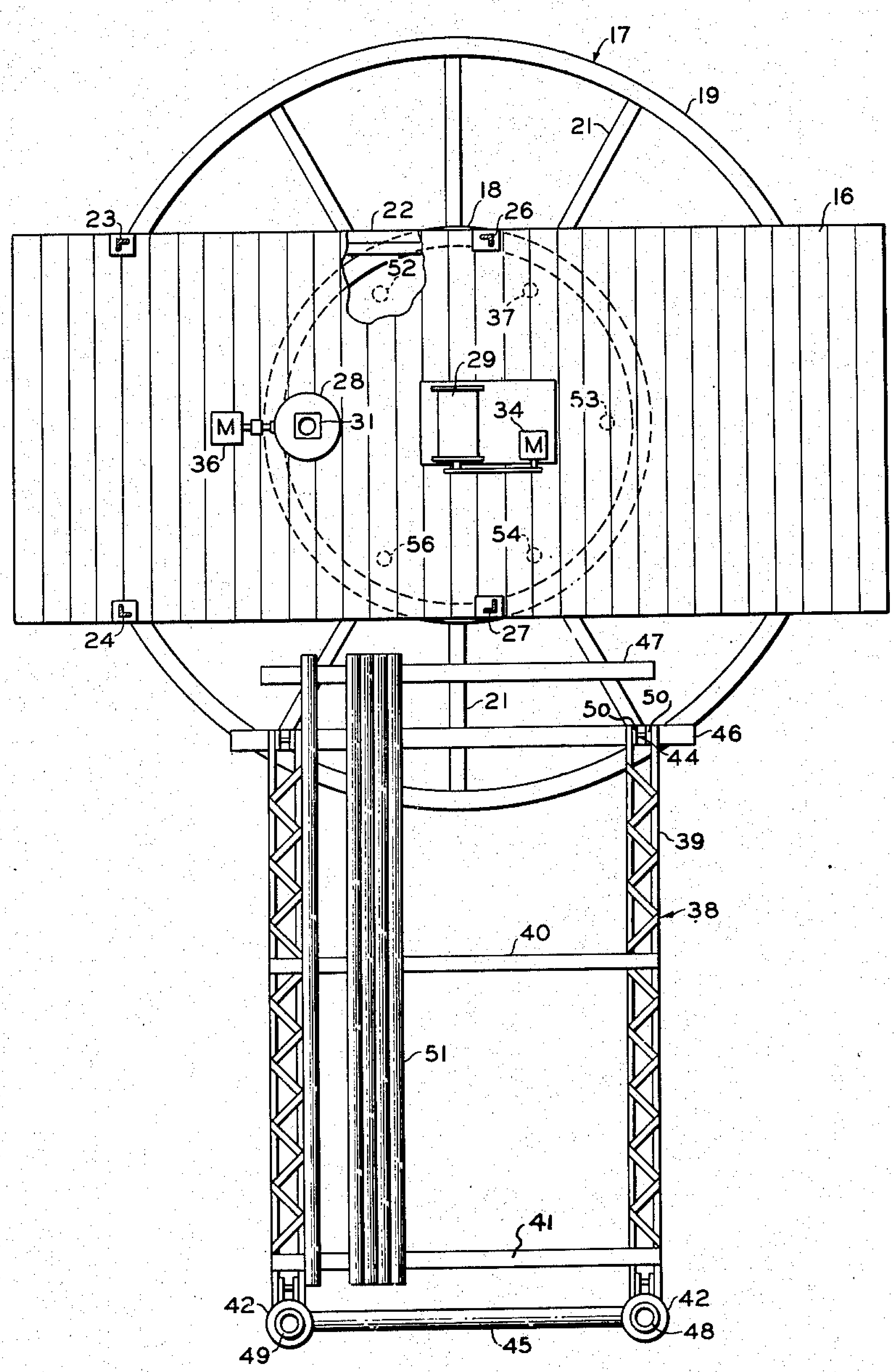

FIG. 1

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Feb. 17, 1953 **T. S. GRAHAM** **2,628,818**

WELL DRILLING RIG

Filed May 16, 1949 5 Sheets-Sheet 2

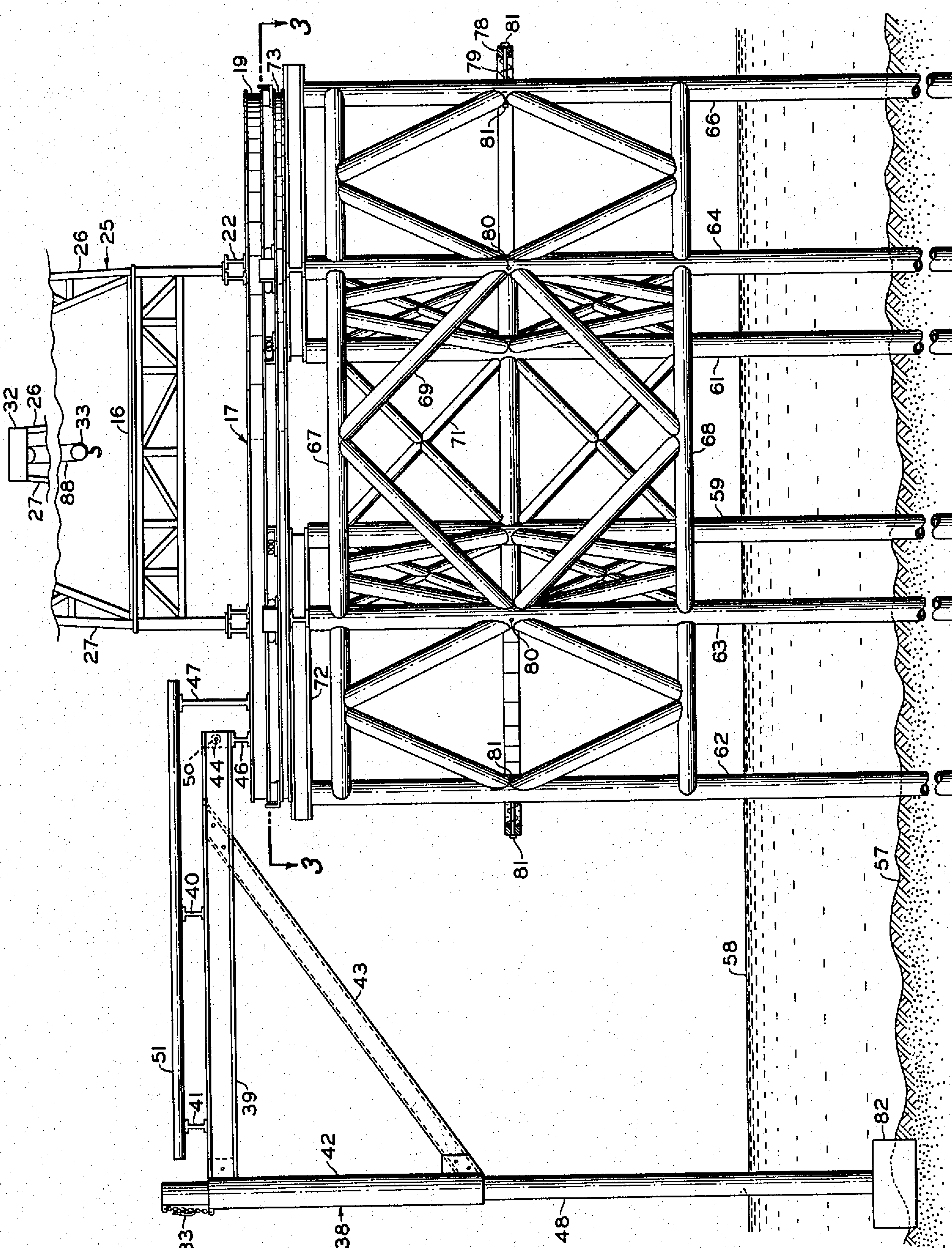

FIG. 2

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WELL DRILLING RIG

Filed May 16, 1949 5 Sheets-Sheet 3

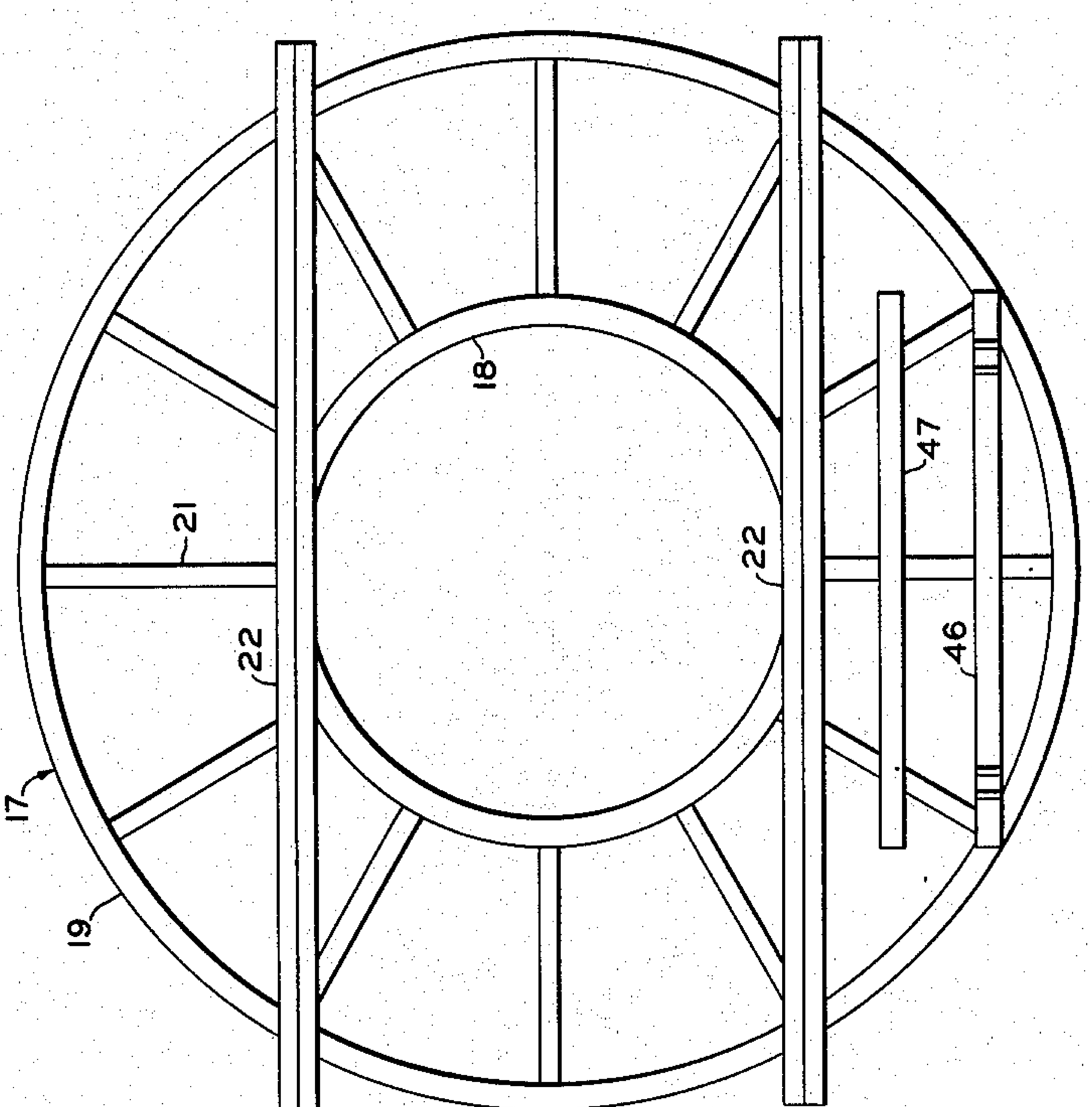

FIG. 4

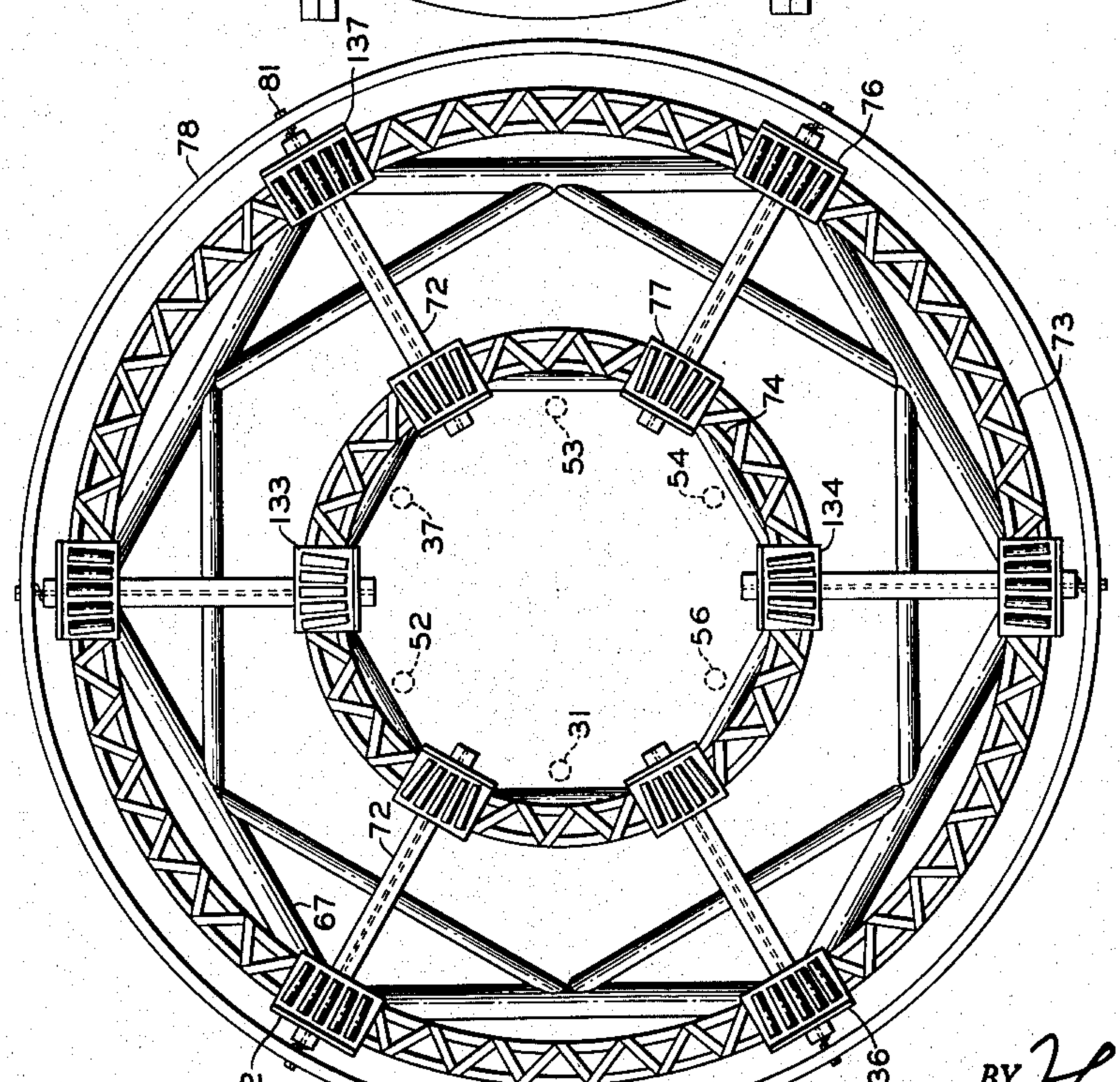

FIG. 3

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WELL DRILLING RIG

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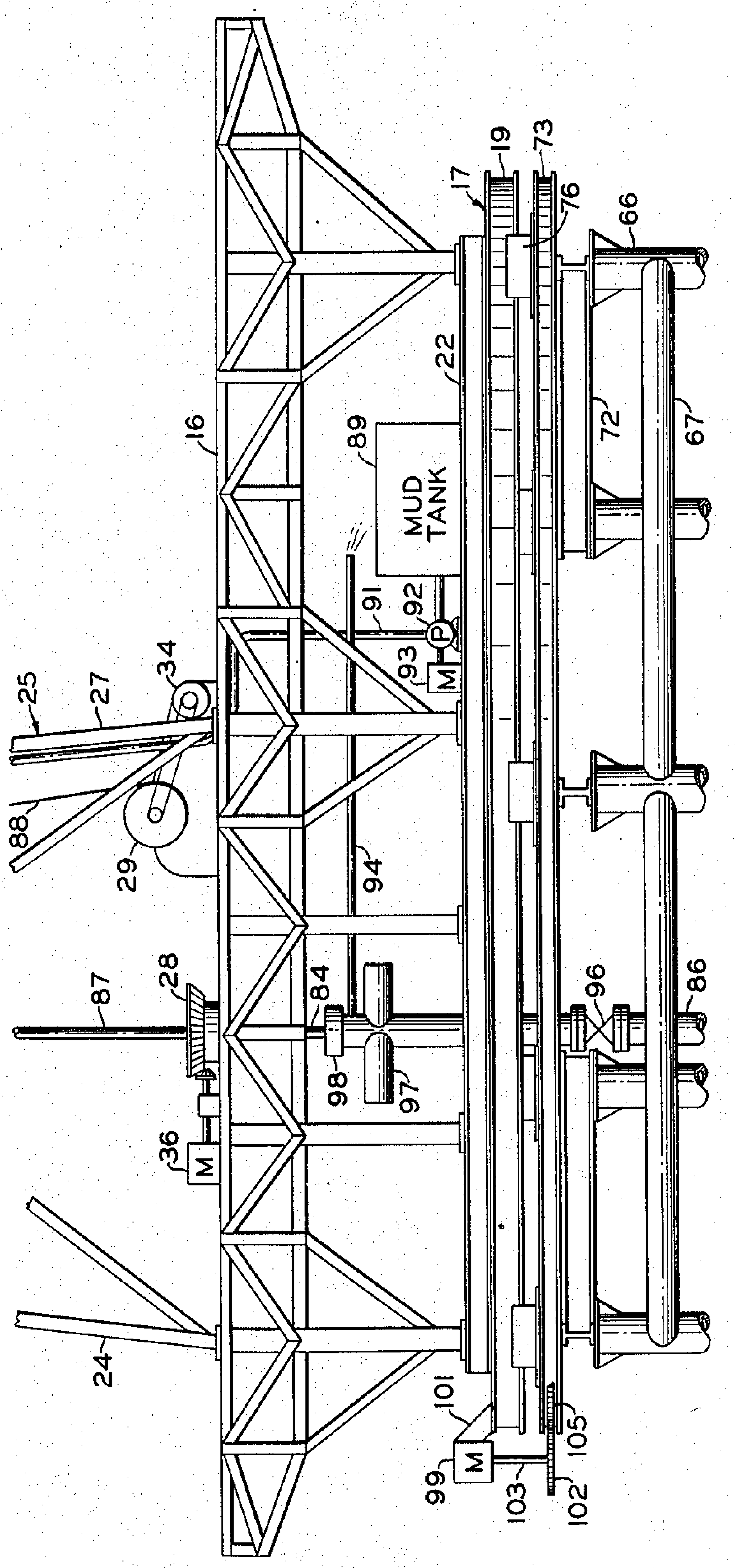

FIG. 5

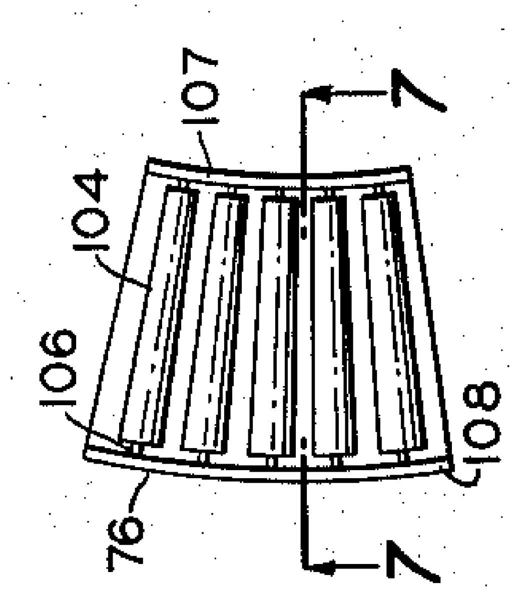

FIG. 6

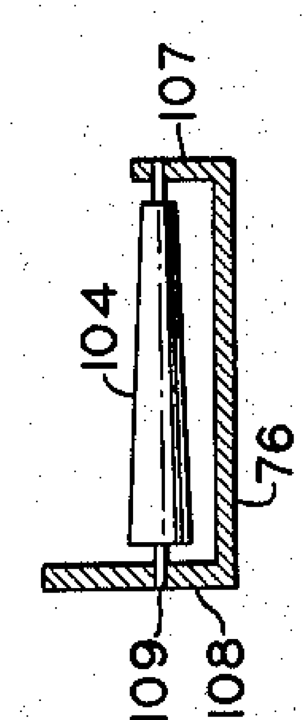

FIG. 7

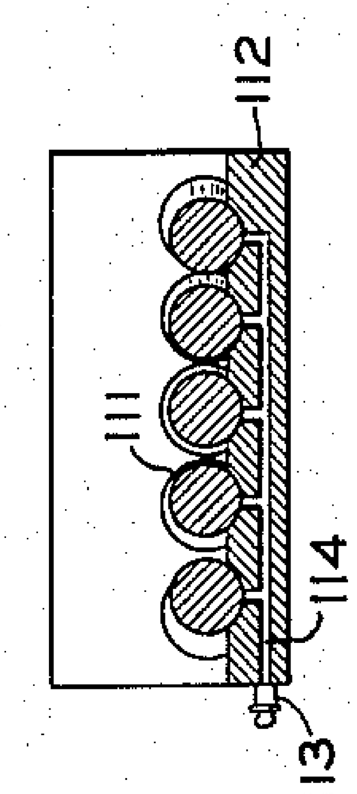

FIG. 8

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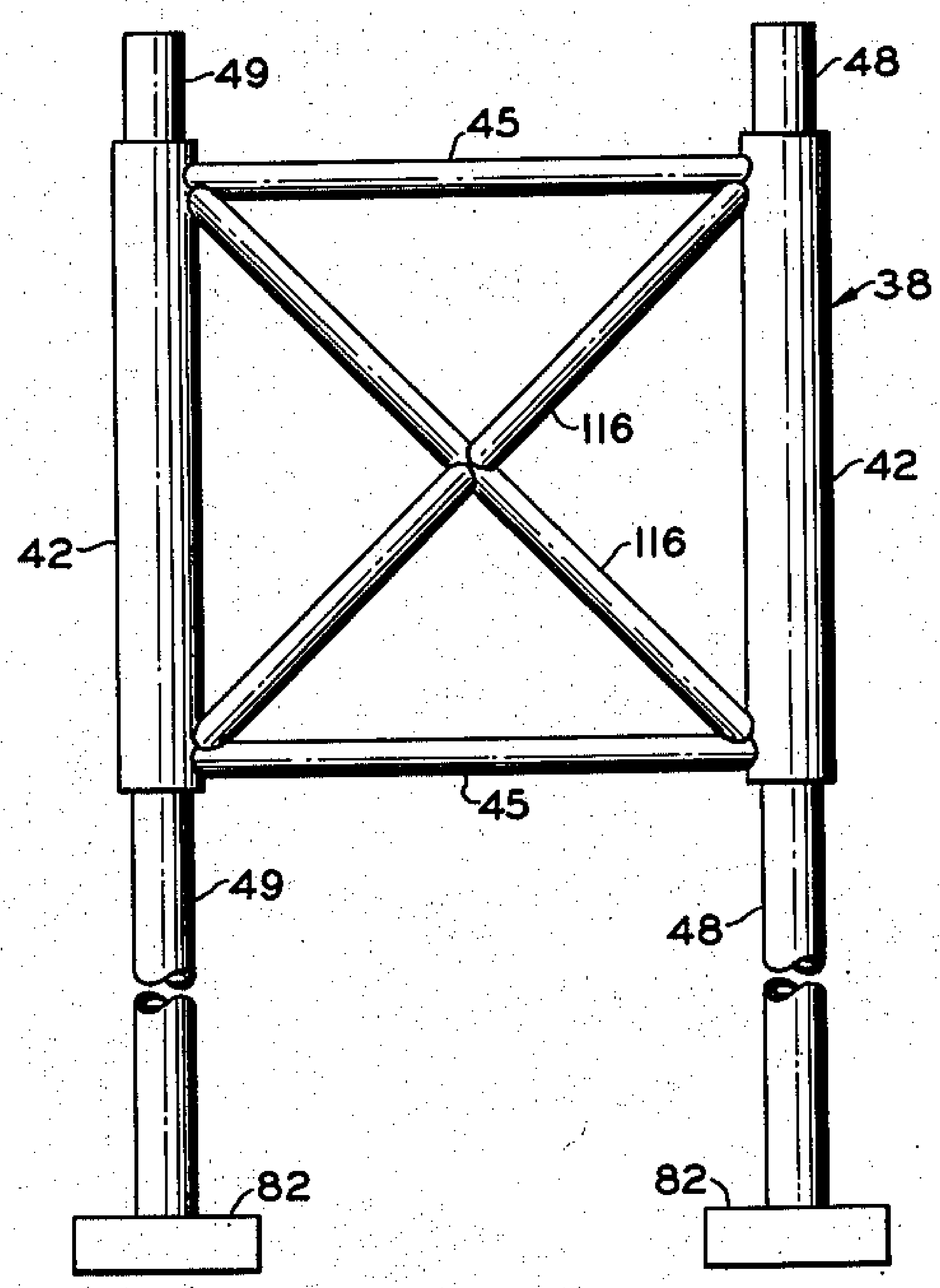

FIG. 9

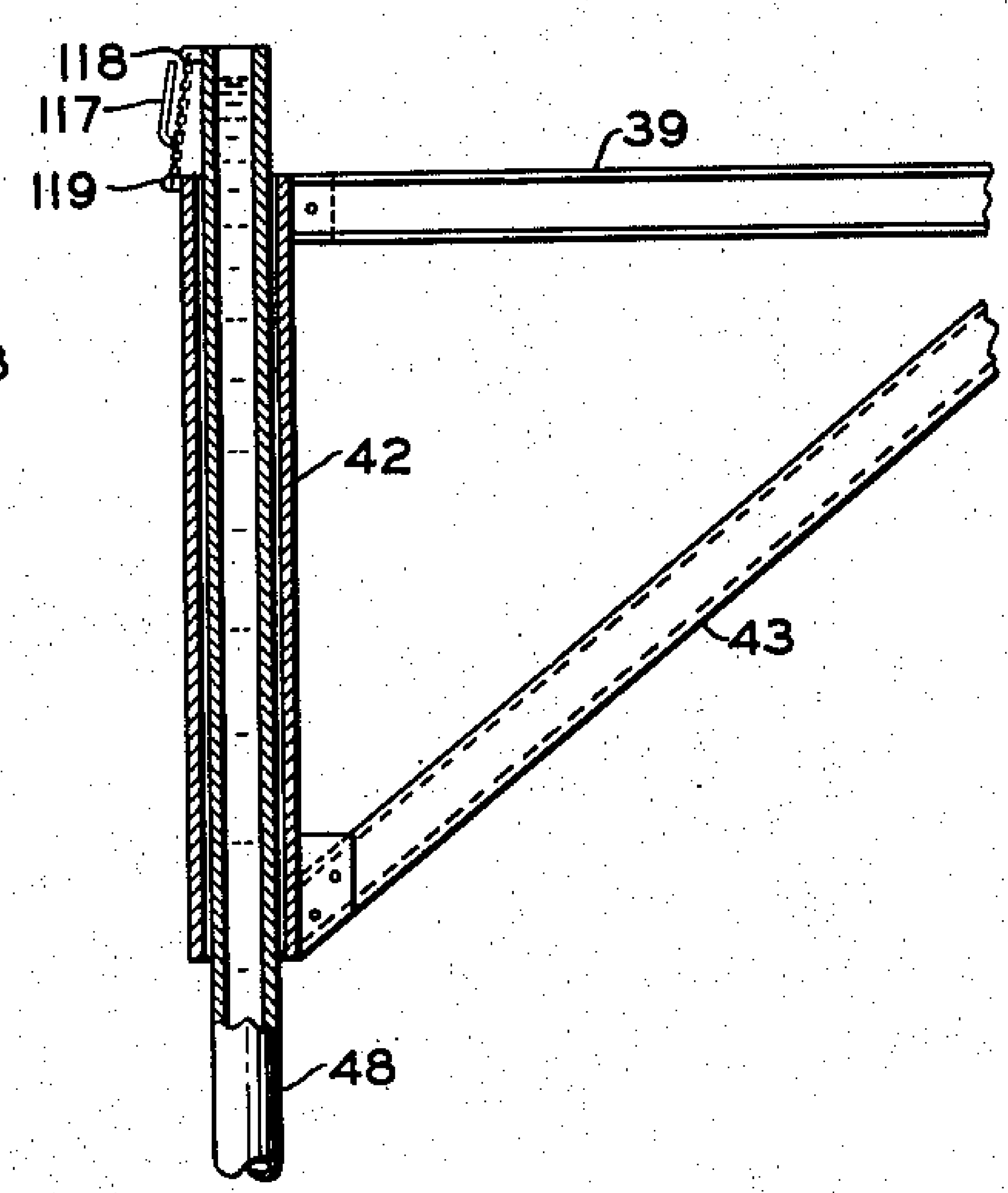

FIG. 10

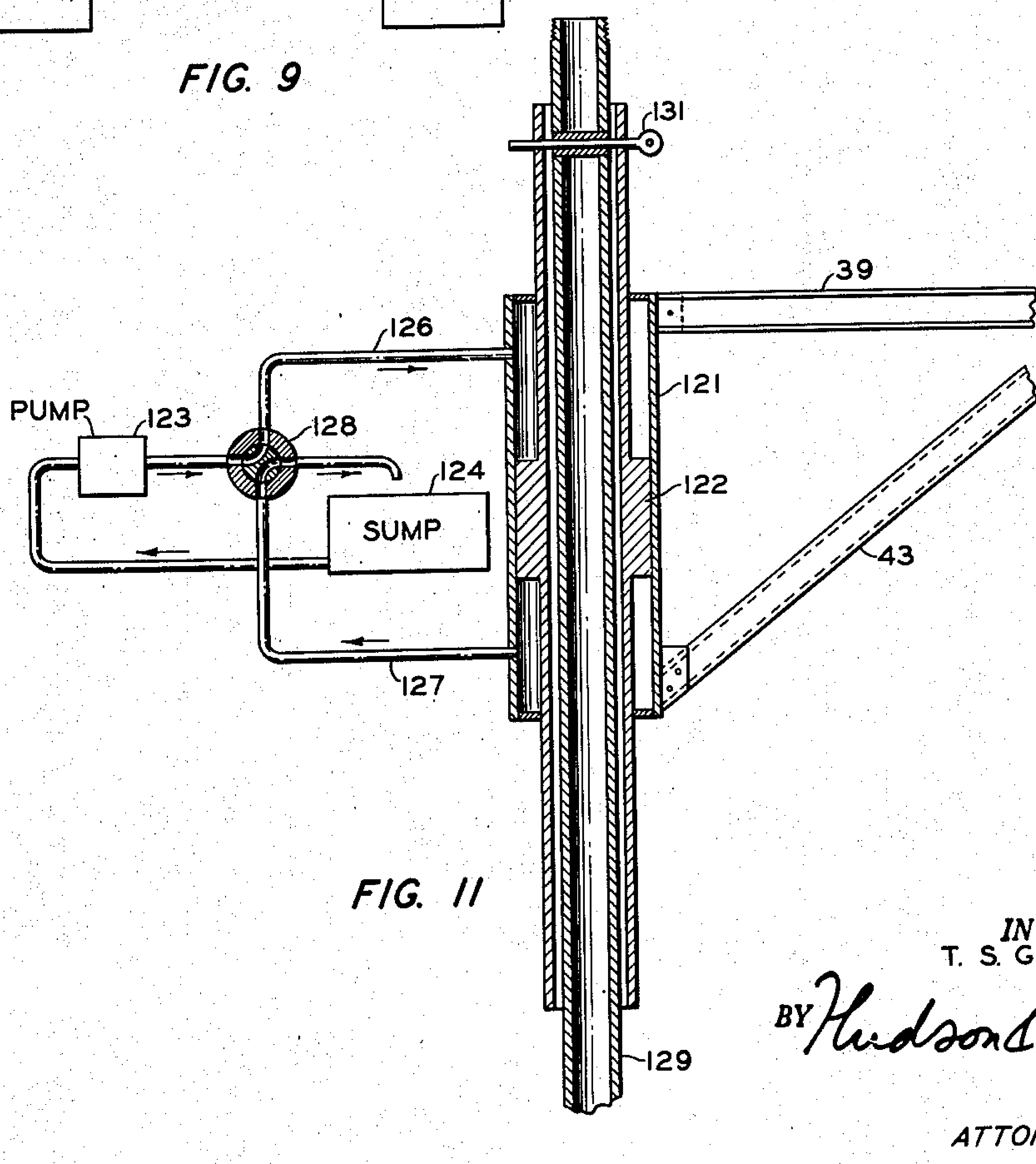

FIG. 11

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UNITED STATES PATENT OFFICE

2,628,818

WELL DRILLING RIG

Tom S. Graham, Alvin, Tex., assignor to Phillips Petroleum Company, a corporation of Delaware

Application May 16, 1949, Serial No. 93,514

9 Claims. (Cl. 255—2)

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This invention relates to well drilling rigs. In one specific aspect it relates to well drilling rigs having improved types of foundations. In another specific aspect it relates to well drilling rigs which may be rotated into a plurality of positions to drill a plurality of wells. In another specific aspect it relates to well drilling rigs particularly adapted for use in marine locations, especially in the open sea along the continental shelf.

Geological formations containing valuable deposits such as oil and/or gas may exist under the surface of bodies of water. These formations are being exploited by drilling wells down to the same. The drilling rigs used in such marine locations are subject to the destructive forces of nature, especially wave action. In non-marine locations as well as in marine locations, especially when the foundation required is expensive or difficult to install because of the nature of the ground and/or water covering the location, it is especially desirable to be able to drill more than one well so that the expense of the foundation can be divided between several wells. These wells of course can be deflected sufficiently below the surface of the ground to be properly spaced by the time the producing formation is penetrated.

Numerous designs proposed in the prior art have proved to be impractical because of the cost of under water construction or destruction by wave action especially during storms.

One object of the present invention is to provide an improved type of well drilling rig.

Another object is to provide a suitable rotatable well drilling rig capable of drilling a plurality of spaced wells when positioned in a plurality of positions during rotation.

Another object is to provide a well drilling rig which may be erected in the marine location without connecting the supporting members together under water.

Another object is to provide a marine foundation for a drilling rig in which vibration and wear and tear by wave action is minimized.

Another object is to provide a foundation for a marine location which may be removed whenever the location is to be abandoned without disconnection of parts under water except for pulling out, or breaking off short a few simple vertical piles, which can be done with a tug boat, or the like.

Numerous other objects and advantages will be apparent to those skilled in the art upon reading the accompanying specification, claims and drawings.

Figure 1 is a plan view of a well drilling rig embodying the present invention with parts broken away to show details of construction.

Figure 2 is an elevational view of the structure shown in Figure 1 illustrating its use in a marine

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location, parts shown being broken away, or in cross section, to show details of construction.

Figure 3 is a plan view of the foundation shown in Figure 2 which is generally below the line 3—3 of Figure 2 looking in the direction indicated with the location of future wells indicated by dotted line circles.

Figure 4 is a plan view of the frame for supporting a derrick (not shown) which is rotatably mounted on the top of the structure shown in Figure 3.

Figure 5 is an enlarged fragmentary elevational view of the upper portion of Figure 2 taken at right angles thereto showing the same well drilling rig of the preceding figures in the operation of drilling a well.

Figure 6 is a plan view of a modified form of a bearing for use in place of the bearing shown in Figure 3.

Figure 7 is a cross sectional view of the bearings shown in Figure 6 taken along the lines 7—7 of said figure looking in the direction indicated.

Figure 8 is a cross sectional view of a third form of the bearing.

Figure 9 is an elevational view of the major parts of the pipe rack supporting structure shown in Figure 2 but taken at right angles from said figure.

Figure 10 is a cross sectional view of a portion of the pipe rack of Figure 2 showing details of construction.

Figure 11 is a view similar to Figure 10 showing details of construction of a modified form of pipe rack.

In Figure 1 a platform **16** is mounted on a frame generally designated as **17**. Frame **17** is preferably formed from inner and outer concentric annular members **18** and **19** respectively secured together by radial members **21**. Platform **16** is preferably secured to frame **17** by longitudinal girders **22**. Girders **22** support the legs **23**, **24**, **26** and **27** of a four-legged derrick generally designated as **25**, which derrick has a centrally located rotary table **28** and a draw works **29** both mounted on derrick platform **16**., if the rotary method of drilling is employed. When other drilling methods are employed rotary table **28** is not present and there is merely a centrally located opening in floor **16** over the proposed well **31**.

As shown in Figure 2 derrick legs **27** and **26** are capped by a crown block housing **32** having removably secured thereto in the conventional manner a conventional crown block centrally located over well **31** so that traveling block **33** can raise and lower well drilling equipment from well **31** by centrally disposed vertical forces, thereby creating forces of reaction acting equally on derrick legs **23**, **24**, **26** and **27**, and preferably said reaction forces will comprise mainly a simple force of compression axial of each leg.

Traveling block 33 is operated by a cable from draw works 29 in the customary manner.

Suitable driving means comprising motors 34 and 36 are provided for draw works 29 and rotary table 28 respectively.

In many instances it is desirable to service the well drilling rig from a tender (not shown) which tender often is a LST (landing ship for military tanks) anchored near the rig with its bow preferably in the direction of prevailing winds and said ship being in the lee of said well drilling rig. Said ship may generate power to drive the motors 34, 36 and 93 of the drilling rig and transmit the same to the rig, and mud pumps similar to 92, mud tanks similar to 89 and other structure (not shown) may be provided on the ship which may act also as a rack for pipe. Motor 93 as shown in Figure 5 drives a conventional mud pump 92, pumping well-drilling mud from tank 89 into pipe 91 from which it proceeds by the usual flexible pipe (not shown) into the drill pipe 87, 84, down to the bottom of the well and out holes in the well-drilling bit (not shown) from which the mud returns to surface through casing 86 and flow line 94 back into mud tank 89.

When such a ship (not shown) is used it is convenient to rotate frame 17 into a position for drilling the first well 31 so that the ship may be in the lee of the rig and most convenient for transferring pipe thereto. By the time well 31 is finished, the prevailing winds may seasonally shift so that a second well such as 37 then becomes more convenient to work with and then may be drilled. However, anyone of the six wells 31, 37, 52, 53, 54 and 56 shown, and wells intermediate thereto, may be drilled regardless of the direction of the prevailing winds by suitably anchoring the ship (not shown). Generally some means of arranging the ship so it will not be on the windward side of the rig can be devised, as it is undesirable to have a ship anchored to windward, where it could break loose from its anchors in a storm and be driven against the rig.

While a ship can be employed as a pipe rack I prefer to use a movable pipe rack generally designated as 38. Pipe rack 38 comprises a framework composed of members 39, 40, 41, 42 and 43 secured together and pivoted to frame 17 by pivots 44 run through holes of greater diameter than pivots 44 in lugs 50 on beam 46 secured to members 19 and 21. The hole in lug 50 of greater diameter than pivot 44 is shown in dotted lines around 44 in Figure 2. Pivot 44 obviously may be provided with retaining means on each end, such as a nut thereon (not shown). As shown in Figure 9 vertical members 42 are secured together by horizontal members 45 and cross bracing members 116. An auxiliary pipe supporting beam 47 may also be secured to members 21 to extend the effective length of the pipe rack 38 to handle longer pipe 51. Pipe rack 38 has vertical legs 48 and 49 which will be described with reference to Figure 2.

Well drilling pipe and/or casing 51 may be stored on rack 38 as desired.

While in theory a great number of wells may be drilled by rotating frame 17, in practice it is best to drill not more than six wells 31, 37, 52, 53, 54 and 56 so that during the drilling the legs 23, 24, 26 and 27 of the derrick will each be above, or substantially above, a supporting pile, as will be explained later.

In Figure 2 the structure shown has been erected by driving twelve piles into the ground 57 which may or may not be covered by water 58. The twelve piles are driven into the ground in the form of concentric hexagons, in Figure 2 piles 59 and 61 being in the inner hexagon and piles 62, 63, 64 and 66 being in the outer hexagon. Two piles in the inner hexagon are hidden behind piles 59 and 61 and two are hidden behind piles 63 and 64. Two of the piles in the outer hexagon are also hidden behind 63 and 64.

While not necessary to some aspects of the invention, nevertheless it is preferable in exposed locations, to secure the upper portion of said piles together by cross bracing members 67 and 68 at a plurality of levels. Sway bracing members 69 and 71 may be provided to strengthen the foundation.

It is realized that such bracing is old in engineering structures generally, but the following features are believed to be novel, namely, that all of said framework is at an elevation greater than the minimum low tide level of water 58 so that all of said bracing members 67, 68, 69 and 71 can be erected on and removed from piles 61, 62 etc. in situ without under water operations. Fastening parts together under water is both expensive and unsatisfactory, and generally requires the employment of divers. Divers are especially skilled workers having a very high wage rate and generally can only work in the calmest of weather. Preferably all of said framework is at an elevation greater than mean high tide by a distance greater than one-half the average wave height in order to minimize vibration of said drilling rig by waves passing through the foundation. By wave height is meant the vertical distance between the crest and trough of a wave. The average wave height is the average throughout the year at that location.

It is realized of course that during storms waves are going to pass through the framework and perhaps above members 67, and a generally open construction of members 68, 69 and 71 will minimize the effect of the waves. Nevertheless each member 68, 69 and 71 that is submerged in the wave receives a force from the wave which tends to destroy the structure especially after endless repetition. By having brace 68 above the usual wave height, a constant beating of waves on the structure is avoided and the structure is therefore in better shape to resist occasional storms.

The piles 59 to 66 are preferably capped with radial I beams 72 which in turn may be framed with prefabricated girders 73 and 74 as shown in Figure 3. A bearing 76, or 77, is secured to the prefabricated girders 73 and 74 secured to the radial I beams 72 above the top of each pile and these bearings may be anti-friction bearings having rollers which will be described later with reference to Figures 6 to 8.

If desired a fender 78 may be provided extending around the entire structure to receive and absorb a limited amount of shock from a contacting ship by means of springs 79. Fender 78 is preferably resilient and will bend and return to shape upon release of the bending force. Bolts 81 are screwed into holes in the fender 78 at points opposite piles such as 62 and 66, and bolts 81 are also movably mounted in holes 80 in the pile.

Figure 4 shows frame 17 in more detail than was possible in Figure 1. Circular tracks 18 and 19 of the frame are adapted to be supported for rotation on the tops of the outer and inner bearings 76 and 77 respectively.

As shown in Figure 2 pipe platform 38 consists of vertical members 42 and horizontal members 39 secured together by brace members 43. The inner end of the platform 38 is supported on I beam 46 and the outer end 42 is slidably mounted on leg 48. Leg 48 is provided with a suitable foot 82.

A suitable positioning means 83 may be provided for positioning pipe 42 on pipe 48 as will be explained below.

Platform 38 may be removed, preferably by picking the same up with a derrick on a ship (not shown) and moving it from one position to another whenever derrick platform 17 is rotated.

In Figure 5 further details of the well drilling operations are shown. While reciprocating drilling, advancing-motor drilling, and other methods of well drilling may be employed, it is generally preferred to employ the rotary well drilling system in which a string of drill pipes 84 is lowered into a well casing 86 and is rotated by a rotary table 28 through a kelly 87. The drill string is lowered by cable 88 and the traveling block 33 is actuated by reeling cable 88 on and off of draw works 29. Drill string 84 has a cutting bit (not shown) on its lower end and well drilling mud from tank 89 is pumped through pipe 91 by pump 92 driven by motor 93 down through kelly 87 and pipe 84 out the drill bit and up the annular space between pipe 84 and casing 86 and then returned to mud tank 89 through pipe 94. Well casing 86 may be provided with a master gate valve 96, blowout preventor 97, and drilling stuffing box 98. As each well 31, 52, etc. is completed, it is arranged with conventional flow lines (not shown) below member 73 so as to be out of the way of the rotating upper parts on platform 17.

Platform 17 may be rotated by various means such as one or more motors 99 mounted on brackets 101 on platform 17 and engaging member 73 with a driving wheel 102 driven by a shaft 103 of motor 99. In practice, wheel 102 is a gear wheel of small diameter as shown and engages a rack or cog track 105 secured to member 73. If desired reducing gearing may be employed between motor 99 and gear 102. If desired rack 105 can be mounted inside of 74 and the motor drive 99 can be secured to the inside of ring member 18 instead of member 19 as shown.

Details of the bearings such as 76 are shown in Figures 6, 7 and 8. In Figures 6 and 7 the bearings comprise conical rollers 104 having shafts 106 journaled in raised sides 107 and 108 of bearing block 76 in any friction-bearing (not shown) or ordinary shaft bearings 109 as shown in Figure 7. Side 108 is higher than side 107 and than bearing roller 104 so that these high sides of the bearing will engage I beam ring member 19 of the platform 17 and center the same.

In Figure 8 rollers 111 rest on bed 112 which is provided with anti-friction means comprising grease pumped in through fitting 113 and passage 114.

As shown in Figure 9 the pipe platform 38 formed of vertical members 42 secured together by horizontal members 45 may also be provided with cross bracing members 116.

In Figure 10 it will be seen that member 42 is slidable on leg 48 and may be positioned thereon by positioning means 83 of Figure 2 comprising an adjustable length chain and adjusting clamp 117, connecting lug 118 on member 48 with lug 119 on member 42. The adjustable positioning is obtained by bringing up a ship, such as an LST (not shown), with a derrick (not shown), which picks up 42 by means of bar 45 and adjusts the same, whereupon a sailor may adjust clamp 117 and thereby tighten chain 118 so that upon disengagement of the derrick the member 42 has been fastened in an adjusted position.

In Figure 11 members 43 and 39 are connected with a vertical tubular member 121 which replaces member 42. Member 121 contains piston 122 which may be positioned at any point in cylinder 121 and pump 123 pumps liquid from tank 124 through pipes 126 or 127 depending on the position of four-way valve 128. A leg 129 which replaces leg 48 is secured to piston 122 by means of pin 131 passing through the piston and the leg as shown. Leg 129 and piston 122 are secured together by pin 131 so there is no relative movement between these parts, as the relative movement is entirely between piston 122 and cylinder 121. Pump 123 will pump piston 122 from one end of cylinder 121 to the other, the direction of movement depending on the setting of valve 128.

Operation

Six piles are driven in the form of a hexagon and then six more piles are driven in the form of a hexagon concentric with the first hexagon. The portion of the piles 61 to 64 etc. above the minimum low tide level are then fastened together by welding or bolting on members 67, 69, 71, 72 and the like. Each pile has a bearing such as 76 or 77 directly above the pile.

Rotatably mounted on bearings 76, 77 etc. is a platform 17 having a derrick generally designated as 25 mounted thereon. It will be noted in Figures 1 and 3 that as the derrick is positioned over each one of wells 31, 52, 37, 53, 54 and 56 that each of legs 23, 24, 26 and 27 of the derrick will be above a bearing and the bearing will be directly above a pile. For example, in drilling well 31, leg 23 of Figure 1 will be above bearing 132 of Figure 3, and similarly leg 26 will be above bearing 133, leg 27 above bearing 134, and leg 24 above bearing 136. The same situation occurs in drilling the other five wells, in each instance each leg of the derrick is above a bearing. Furthermore the far end of platform 16 is above bearing 137 and 76, so that platform 16 as a whole is supported on six of the bearings directly over piles. Furthermore platform 17 with rings 18 and 19 is always supported by all 12 bearings.

While I have shown a preferred embodiment of the invention for purposes of illustration, the invention is not limited thereto but is of a scope commensurate with the appended claims.

Having described my invention, I claim:

1. A well drilling rig comprising in combination a foundation secured to the earth, first bearing means disposed in two concentric horizontal circles secured to said foundation, a frame comprising a well drilling derrick having four legs and a derrick floor, a rotary table mounted on said derrick floor, and second bearing means secured to said frame and disposed to engage said first bearing means to rotatably support said frame and derrick on said foundation, each of said derrick legs being always disposed above said second bearing means, two of said legs being always disposed above the outer and two above the inner of said concentric circles, and said rotary table always being disposed with its central vertical axis inside of said inner concentric circle.

2. The combination of claim 1 in which the

derrick is square in horizontal cross-sectional area.

3. The combination of claim 1 in which the derrick has a crown block, and the crown block and rotary table are mounted in the center of the derrick.

4. The combination of claim 1 in which the derrick is square in horizontal cross-sectional area and has a crown block, and the crown block and rotary table are mounted in the center of the derrick.

5. The combination of claim 1 in which the foundation comprises a plurality of piles driven into the earth and disposed in said two concentric circles, and the first bearing means comprises bearings secured to the top of a plurality of said piles.

6. The combination of claim 5 in which there are six piles in the inner circle and six piles in the outer circle disposed in the form of two concentric regular hexagons, and the frame is rotatable to position said derrick in six positions to drill six wells with each leg of said derrick disposed in each position adjacent the vertical axis of a pile to thereby reduce the forces tending to warp said frame during the drilling of said wells.

7. A well drilling rig comprising in combination a foundation secured to the earth, first bearing means disposed in two concentric horizontal circles secured to said foundation, a frame comprising a well drilling derrick having four legs and a derrick floor, and second bearing means secured to said frame and disposed to engage said first bearing means to rotatably support said frame and derrick on said foundation, each of said derrick legs being always disposed above said second bearing means, and two of said legs being always disposed above the outer and two above the inner of said concentric circles.

8. The combination of claim 7 in which the foundation comprises a plurality of piles driven into the earth and disposed in said two concentric circles, and the first bearing means comprises bearings secured to the top of a plurality of said piles.

9. The combination of claim 7 in which there are six piles in the inner circle and six piles in the outer circle disposed in the form of two concentric regular hexagons, and the frame is rotatable to position said derrick in six positions to drill six wells with each leg of said derrick disposed in each position adjacent the vertical axis of a pile to thereby reduce the forces tending to warp said frame during the drilling of said wells.

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