

Dec. 12, 1961

R. F. BAUER ET AL

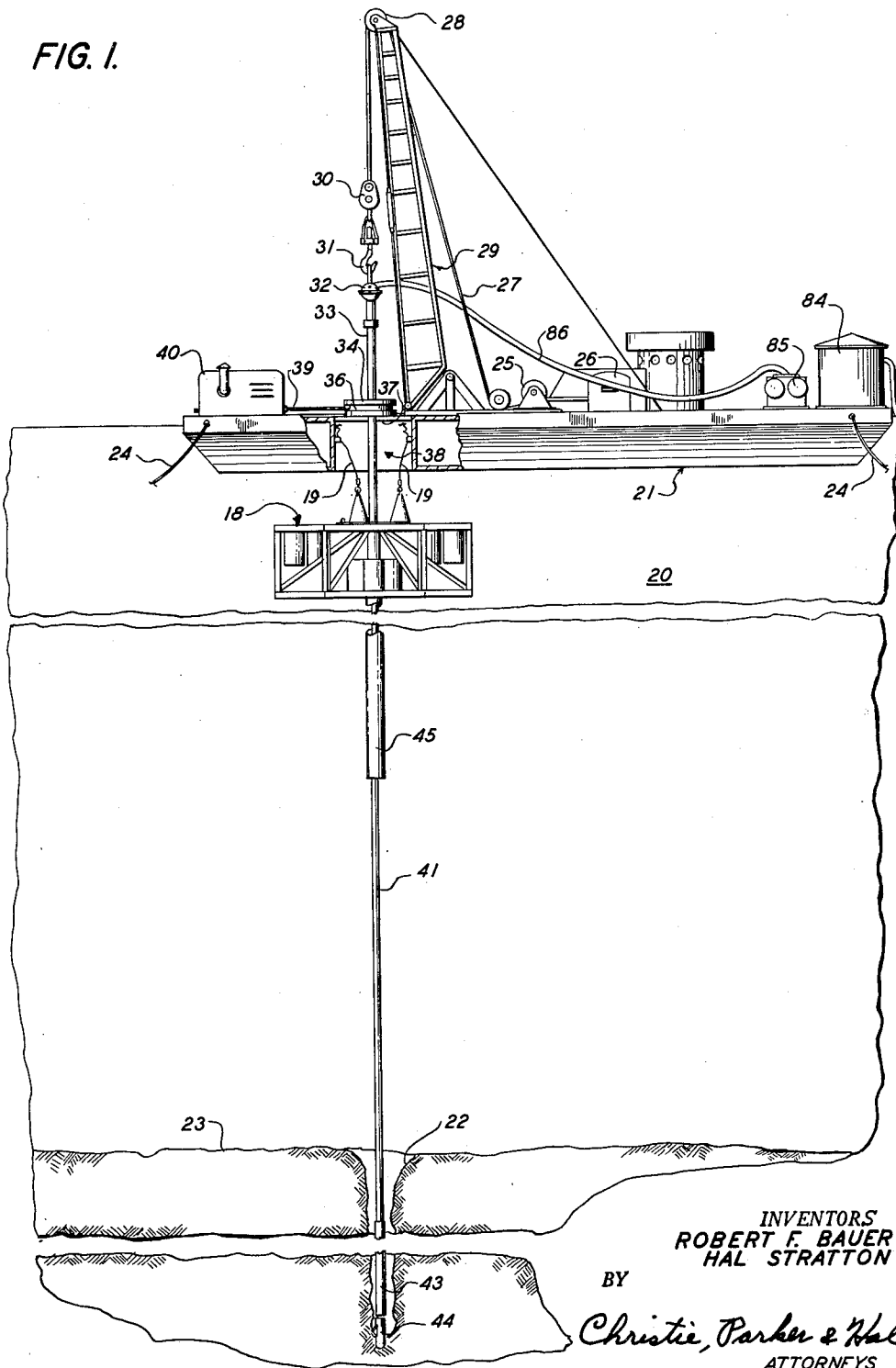
3,012,610

DRILLING

Filed July 26, 1956

9 Sheets-Sheet 1

FIG. 1.



INVENTORS
ROBERT F. BAUER
HAL STRATTON

BY

Christie, Parker & Hale
ATTORNEYS

Dec. 12, 1961

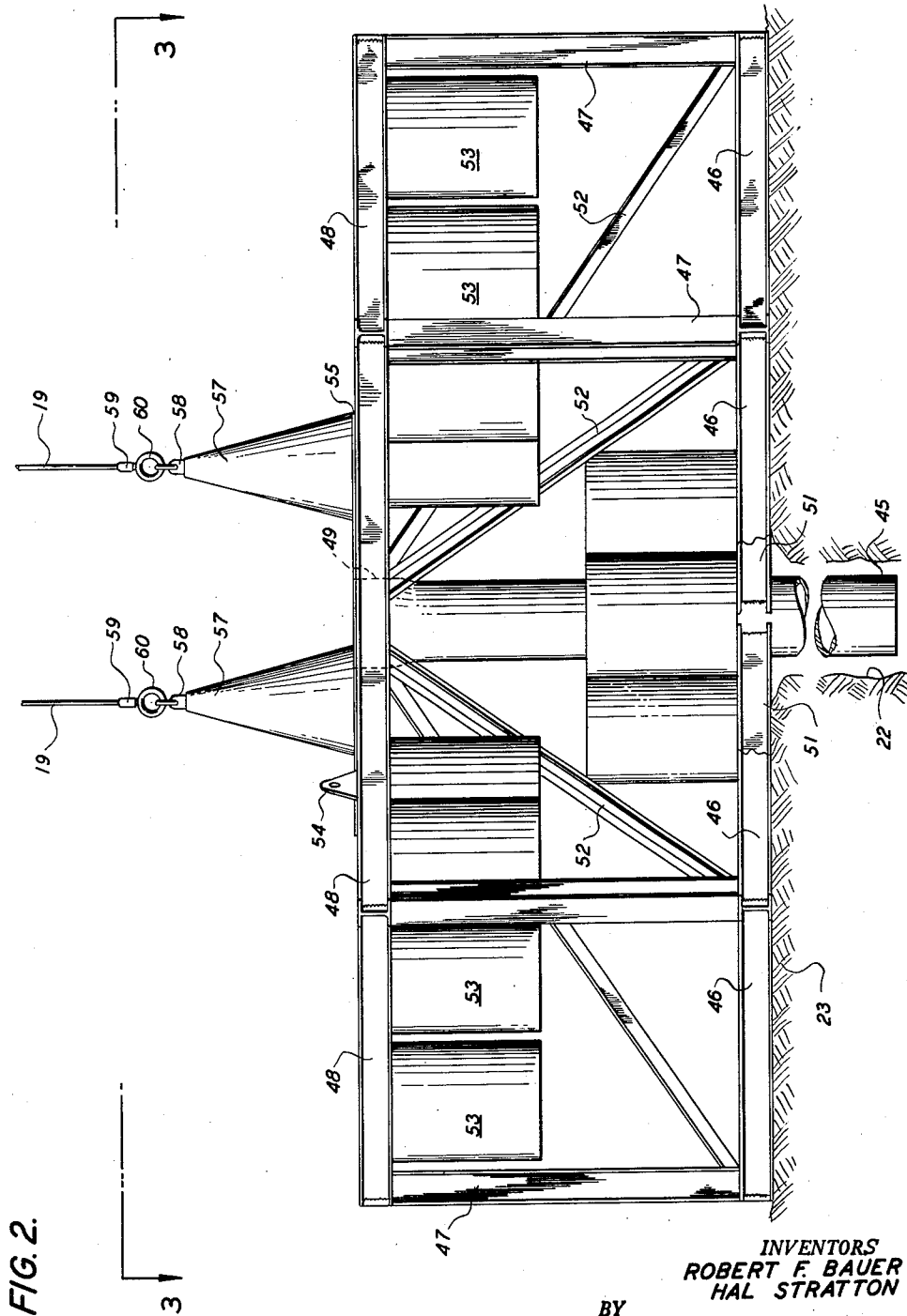
R. F. BAUER ET AL

3,012,610

DRILLING

Filed July 26, 1956

9 Sheets-Sheet 2



INVENTORS
ROBERT F. BAUER
HAL STRATTON

BY

Christie, Parker & Hale
ATTORNEYS

Dec. 12, 1961

R. F. BAUER ET AL
DRILLING

3,012,610

Filed July 26, 1956

9 Sheets-Sheet 3

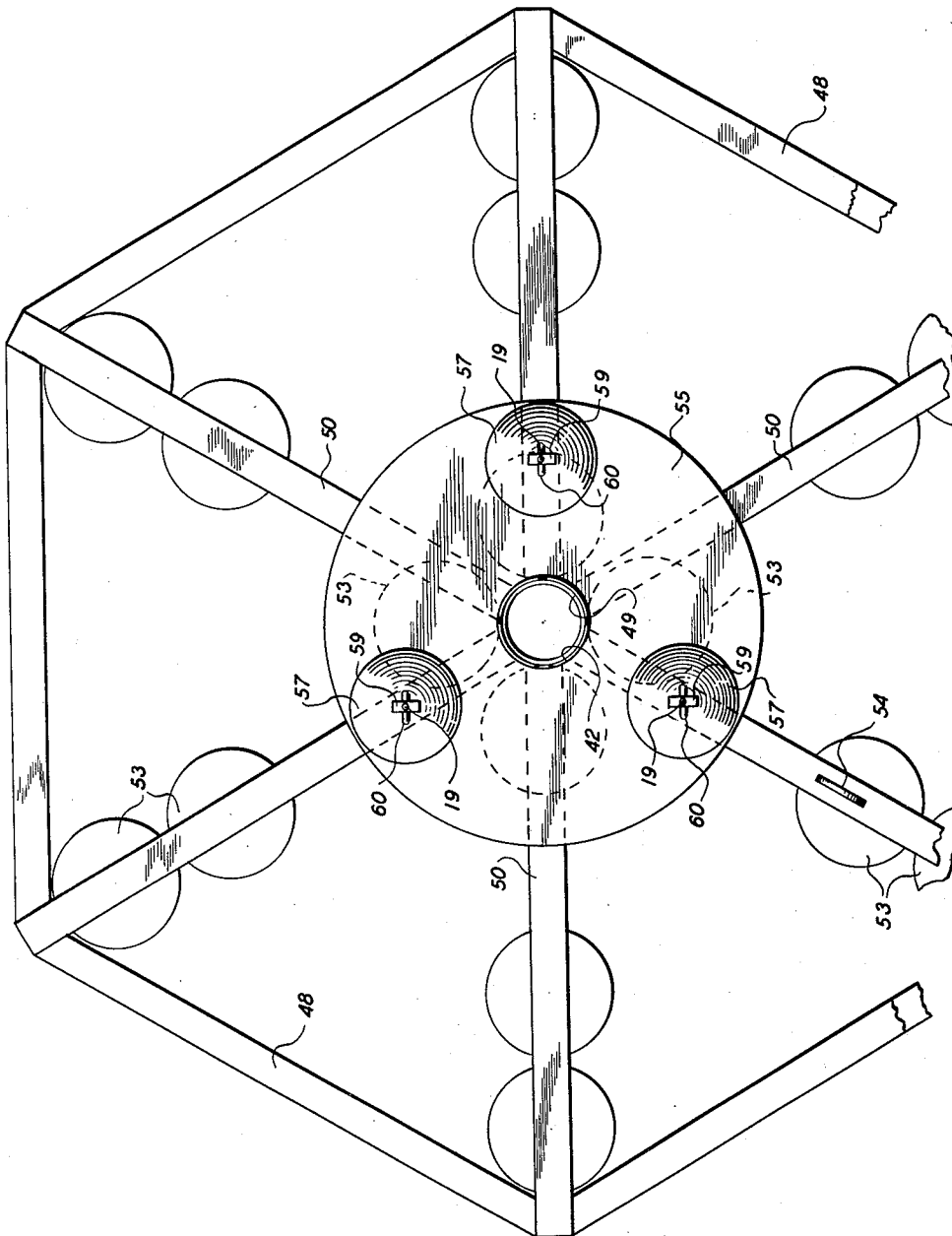


FIG. 3.

INVENTORS
ROBERT F. BAUER
HAL STRATTON

BY

Christie, Parker & Hale
ATTORNEYS

Dec. 12, 1961

R. F. BAUER ET AL

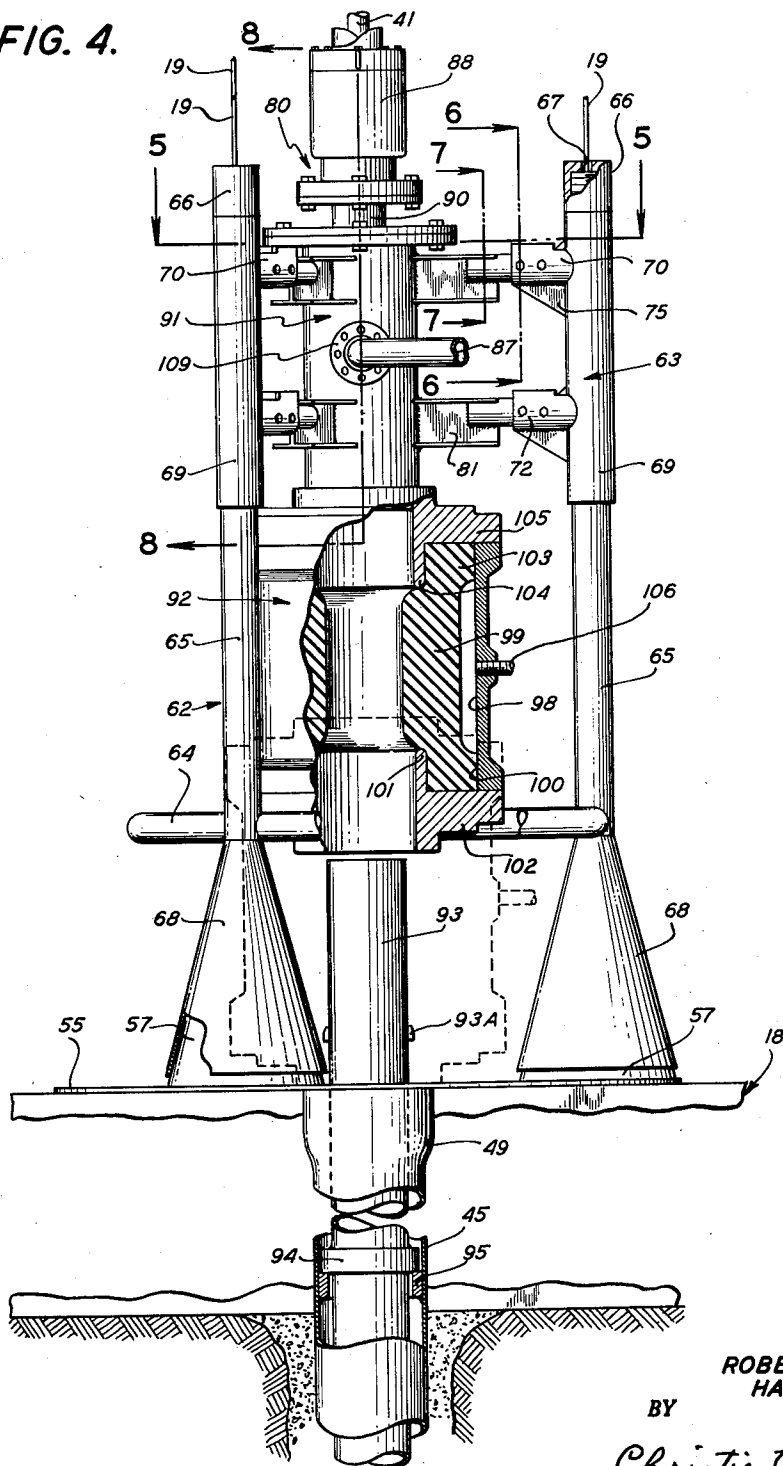
3,012,610

DRILLING

Filed July 26, 1956

9 Sheets-Sheet 4

FIG. 4.



INVENTORS
ROBERT F. BAUER
HAL STRATTON

BY

Christie, Parker & Hale
ATTORNEYS

Dec. 12, 1961

R. F. BAUER ET AL
DRILLING

3,012,610

Filed July 26, 1956

9 Sheets-Sheet 5

FIG. 5.

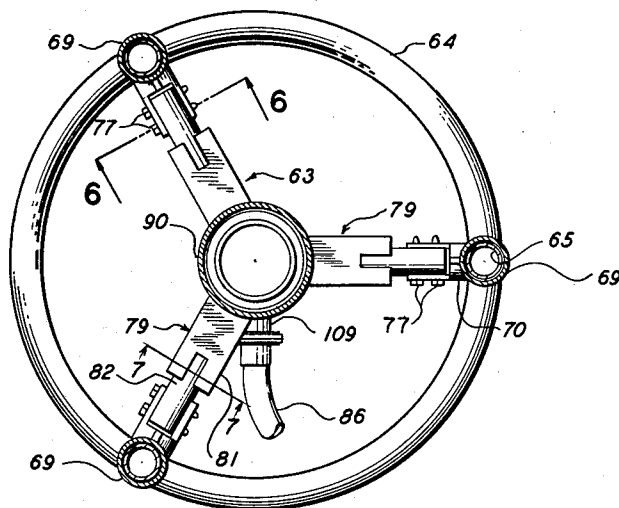


FIG. 6.

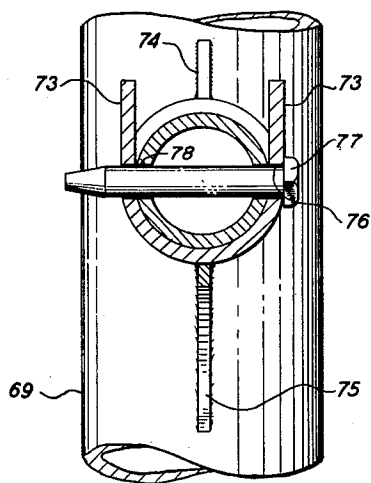
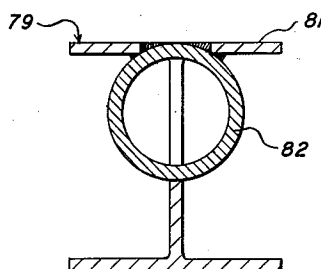


FIG. 7.



INVENTORS
ROBERT F. BAUER
HAL STRATTON
BY

Christie, Parker & Hale
ATTORNEYS

Dec. 12, 1961

R. F. BAUER ET AL

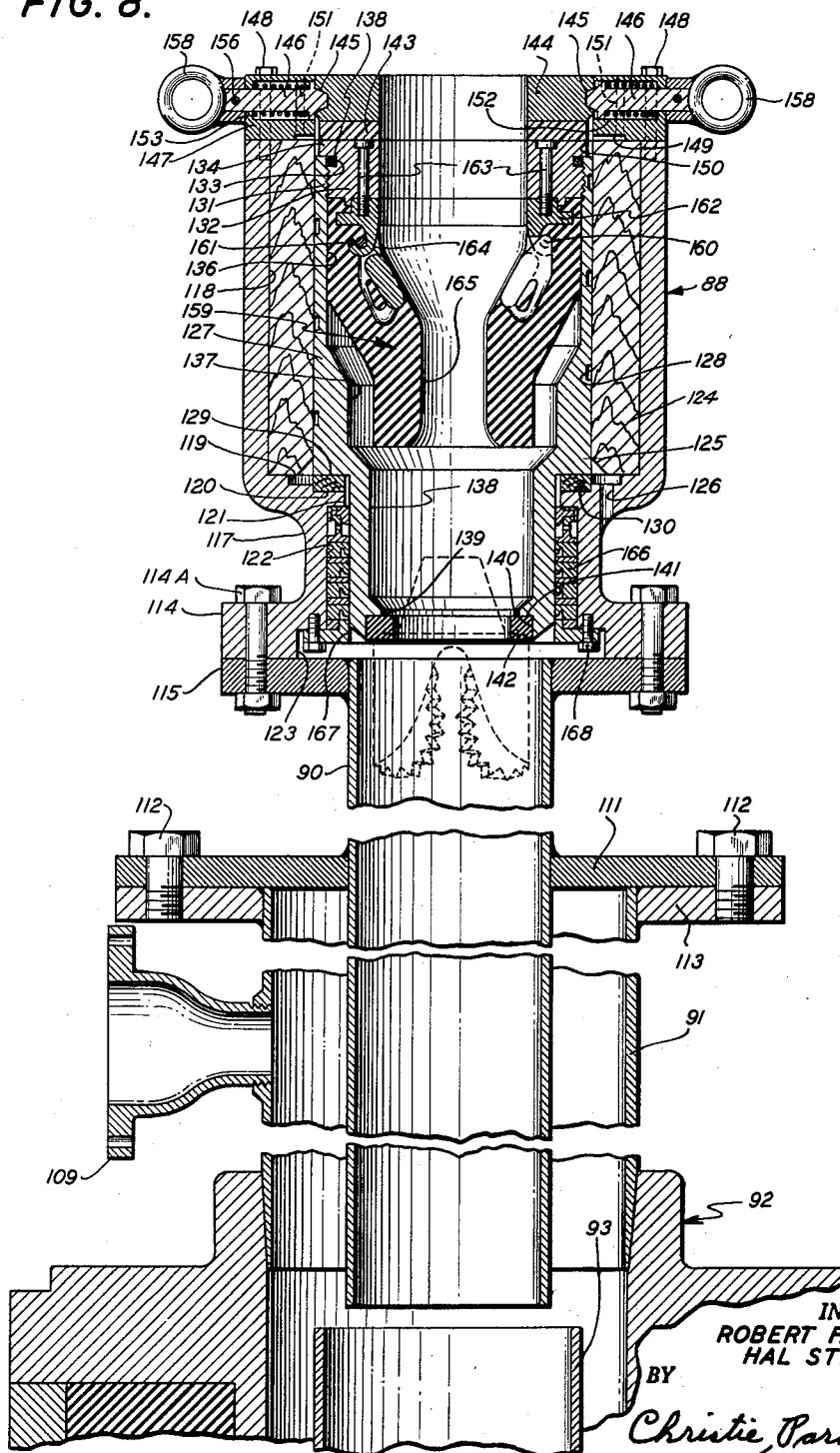
3,012,610

DRILLING

Filed July 26, 1956

9 Sheets-Sheet 6

FIG. 8.



Dec. 12, 1961

R. F. BAUER ET AL

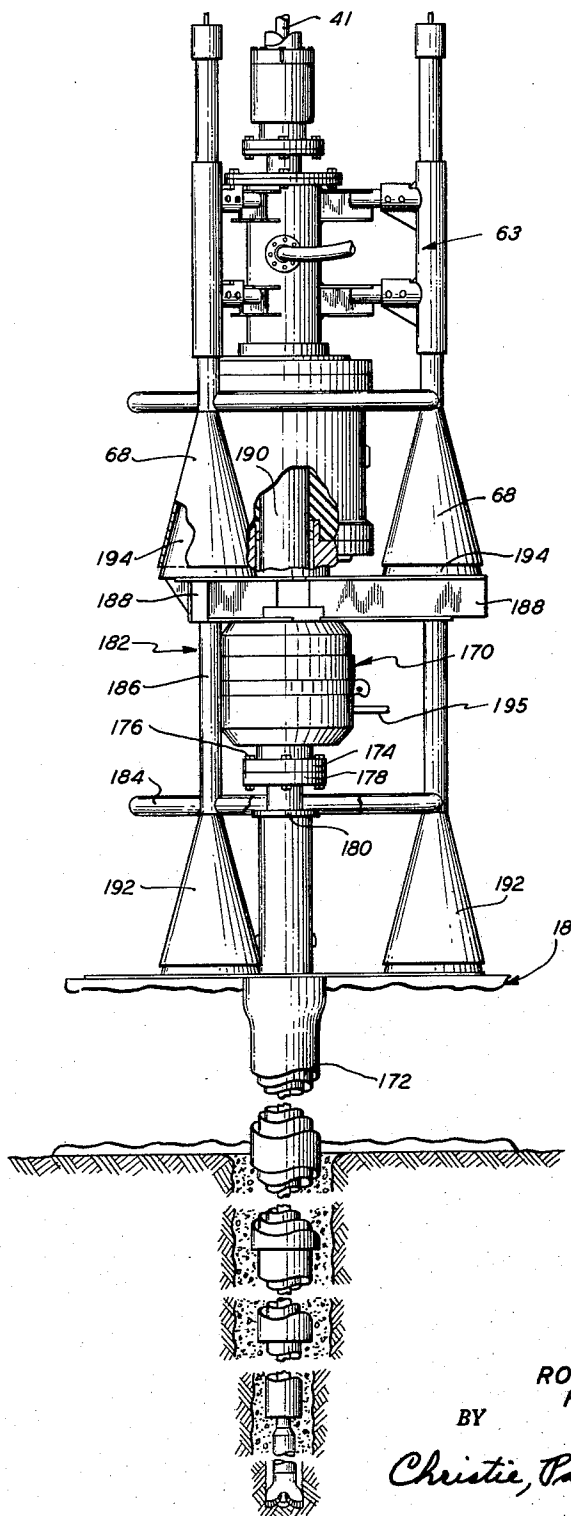
3,012,610

DRILLING

Filed July 26, 1956

9 Sheets-Sheet 7

FIG. 9.



**INVENTORS
ROBERT F. BAUER
HAL STRATTON**

BY

Christie, Parker & Hale
ATTORNEYS

Dec. 12, 1961

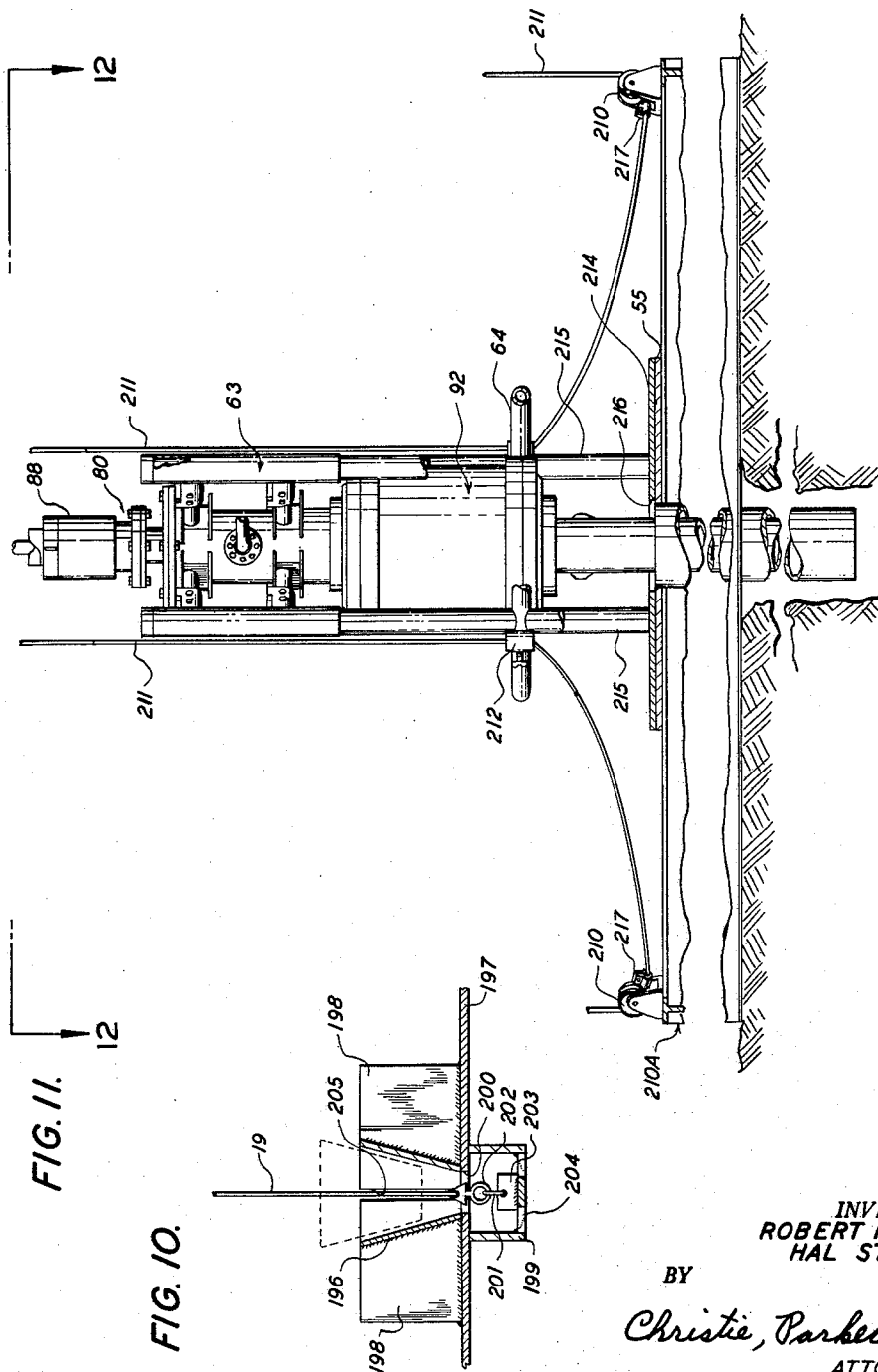
R. F. BAUER ET AL

3,012,610

DRILLING

Filed July 26, 1956

9 Sheets-Sheet 8



INVENTORS
ROBERT F. BAUER
HAL STRATTON

BY

Christie, Parker & Hale
ATTORNEYS

Dec. 12, 1961

R. F. BAUER ET AL

3,012,610

DRILLING

Filed July 26, 1956

9 Sheets-Sheet 9

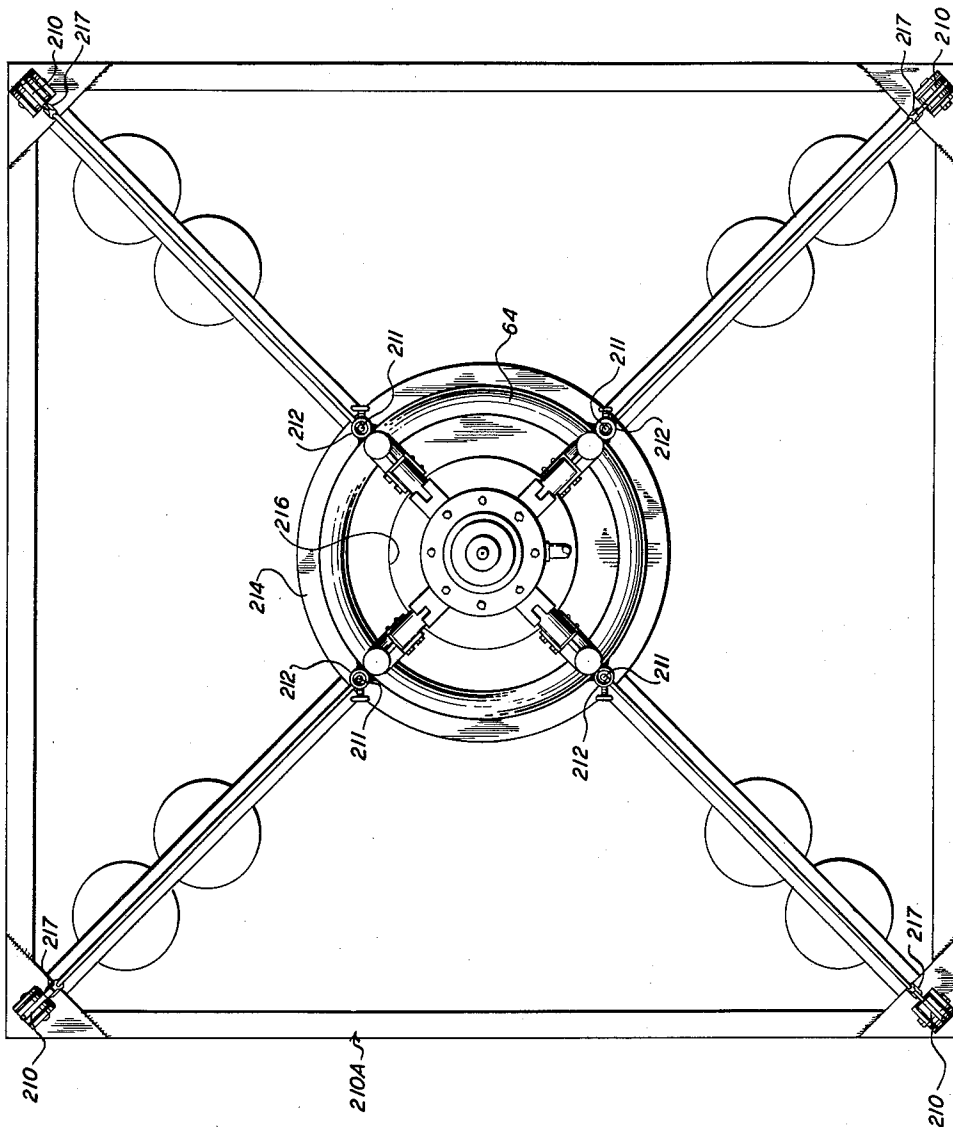


FIG. 12.

INVENTORS
ROBERT F. BAUER
HAL STRATTON

BY

Christie, Parker & Hale
ATTORNEYS

1

3,012,610 DRILLING

Robert F. Bauer, Whittier, and Hal Stratton, La Habra, Calif., assignors to Shell Oil Company and Continental Oil Company, both of Los Angeles, Calif., corporations of Delaware, The Superior Oil Company and Union Oil Company of California, both of Los Angeles, Calif., corporations of California

Filed July 26, 1956, Ser. No. 600,248
10 Claims. (Cl. 166—66.5)

This invention relates to apparatus for drilling and working on underwater wells.

The apparatus of the invention may be used in connection with wells under any kind of water, whether marine or fresh, but for simplification of explanation of the invention, the apparatus is described as being used in an ocean.

At the present time, underwater or off-shore well drilling is usually accomplished from stationary structures rigidly anchored to the underwater formation. These structures provide static bases for the drilling equipment and are satisfactory for relatively shallow water, for example, depths of fifty feet or less. However, for deeper water, say depths of several hundred feet, stationary structures are not always economically practical. Furthermore, the structures are sometimes permanent installations which may become navigation hazards.

This invention overcomes the disadvantages of stationary bases for off-shore drilling by providing apparatus for drilling and working on wells from a floating vessel which can readily be moved from one location to another, and which can be used in water of practically unlimited depth.

The principal difficulty in drilling or working on an underwater well from a floating vessel is in guiding drilling and other equipment such as tubing, casing, etc., to the well from the surface of the water. The movement of a floating vessel due to wind, current and wave action, which is almost invariably present, makes it difficult to relocate the well once equipment is removed from it.

Co-pending application Serial No. 468,214, filed November 12, 1954, now U.S. Patent No. 2,808,229 issued October 1, 1951 describes in detail apparatus and methods for drilling underwater wells from a floating vessel to overcome the disadvantage of static structures. In that co-pending application there is described apparatus for guiding equipment from a floating vessel to an underwater well. The present invention provides improved apparatus for guiding equipment to an underwater well, the equipment being adapted either to fit around or into the well.

Briefly, the apparatus of this invention includes an elongated guide member anchored at its lower end adjacent a well bore in an underwater formation and extending upwardly toward the water surface. A guide assembly is adapted to move up and down on the guide member between an upper position and a lower position. An equipment bracket on the guide assembly is adapted to slide up and down with respect to the guide assembly and guide equipment to the well bore. Means are provided for indexing the guide assembly in its lower position with respect to the well bore to bring the equipment into alignment with the well bore, and means are provided for lowering the equipment bracket and equipment when the guide assembly is properly indexed in its lower position so that the equipment bracket may be lowered toward the well and the equipment properly positioned either around or within the well.

In a preferred form, the invention includes a well head base adapted to rest on the ocean floor, and has an upright opening which is aligned with the well bore. A plurality

2

of the guide members are anchored at their lower ends to the well head base at spaced locations. The guide assembly rests on the base in its lower position so that the base serves as a foundation and support for equipment as it is lowered into the well, or after the equipment is attached at the upper end of the well.

The advantage of the apparatus of this invention is that by having the equipment bracket movable up and down with respect to the guide assembly, the equipment bracket can be held in a raised position while the guide assembly is accurately located in its lower position which automatically brings the equipment carried by the equipment bracket into alignment with the well bore. Thus the equipment is accurately located above the well bore before it is lowered to the same level as the upper end of the well bore, thereby avoiding battering or "hanging up" the lower end of the equipment at the upper end of the well bore. For example, "hanging up" of a drill bit without preliminary alignment could easily occur since the diameter of the well bore is usually only a few inches larger than the outside diameter of the bit being lowered toward the well from a distance as much as several hundred feet. The difficulty is compounded because of the up and down motion imparted to the drill bit due to the wave action on the floating vessel. "Hanging up" of the drill bit under such conditions could easily cause expensive damage and perhaps loss of a well since the drill bit would have behind it the weight of the drill collars and a substantial length of drill pipe. However, this invention avoids this trouble because the weight of the guide assembly is negligible compared to that of the drill collars and drill pipe, and the guide assembly is indexed into its lower position without battering the well head base with damaging forces.

The invention will be more fully understood from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic fragmentary elevation of the well head base being lowered to an ocean floor from a floating vessel;

FIG. 2 is an enlarged elevational view of part of the apparatus of FIG. 1, showing in detail the well head base after it is landed on the ocean floor;

FIG. 3 is a plan view of the well head base taken on line 3—3 of FIG. 2;

FIG. 4 is a fragmentary elevation of the well head base showing the guide assembly and equipment bracket with some typical equipment being lowered toward the well head;

FIG. 5 is a plan view taken on line 5—5 of FIG. 4; FIG. 6 is a sectional view taken on line 6—6 of FIG. 5; FIG. 7 is a sectional view taken on line 7—7 of FIG. 5; FIG. 8 is a vertical section taken on line 8—8 of FIG. 4; FIG. 9 is a fragmentary elevation of the well head base showing installation of a blow-out preventer to permit the well to be closed off;

FIG. 10 is a fragmentary sectional elevation of an alternate arrangement for indexing the guide assembly on the well head base;

FIG. 11 is a fragmentary elevation, partially broken away, of an alternate embodiment of the invention for guiding equipment to the well; and

FIG. 12 is a plan view taken on line 12—12 of FIG. 11.

Referring to the drawings, FIG. 1 shows a well head base 18 supported by guide lines 19, and being lowered by the guide lines in a body of water 20 from a floating barge 21 toward a well 22 being drilled from the barge in an underwater formation 23. The upper ends of the guide lines may be controlled by suitable means, such as winches (not shown). The barge is anchored over the well by a plurality of suitable anchor lines 24 extending

in opposite directions from the barge and connected to anchors (not shown).

A draw works 25 and a power unit 26, which may be of conventional type, are mounted on the barge to operate the hoisting cable 27 carried over a crown block 28 located at the upper end of a collapsible drilling rig 29. The travelling end of the hoisting cable carries a travelling block 30 and a hook 31 which supports a swivel joint 32. A Kelly joint 33 extends downwardly from the swivel through a Kelly bushing 34 in the center of a rotary table 3 mounted on a gimble in a manner similar to that described in U.S. Patent 2,606,003. The rotary table is supported on a platform 37 directly over a cellar 38 which may be located in the center of the barge as illustrated. Power is supplied to the rotary table through a shaft 39 turned by a rotary table power unit 40.

A string of drill pipe 41 is connected to the lower end of the kelly and extends down through the cellar, a central opening 42 in the well head base (see FIG. 3), the water and into the well. A drill collar 43 and an under reamer drill bit 44 are attached to the lower end of the drill pipe for boring the well to a diameter slightly larger than the outside diameter of a conductor pipe 45 which is welded at its upper end to the well head base in the central opening of the well head base, and which projects downwardly from the well head base.

As shown in FIG. 2, once the well is drilled to a sufficient depth to receive the conductor pipe, the well head base is lowered from the barge by means of guide lines so that the conductor pipe slides down around the drill pipe and into the well, the bottom of the well head base resting on the earth formation around the upper end of the well. If desired, the conductor pipe may be firmly anchored in the well by pumping cement (not shown) down the drill pipe. The under reamer may be retracted and the drill pipe, drill collar and drill bit removed from the well bore, or drilling may be continued without removing the drill bit from the well until some later period of the drilling operation.

As shown most clearly in FIGS. 2 and 3, the well head base is a relatively flat and wide structure which is hexagonal in shape, as viewed in plan. The periphery of the bottom of the well head base is made up of six sections 46 of I-beams of equal length welded together end to end to form a hexagon. A separate vertical brace 47 is welded to the junctions of the ends of each of the I-beam sections 46 and connects the bottom of the well head base to the top of the well head base, which is also formed of six sections 48 of I-beams welded together end to end to form a hexagon identical in size and shape to the bottom of the well head base.

The upper end 49 of the conductor pipe 45 is flared to a slightly enlarged diameter and is flush with the upper surface of the well head base. The conductor pipe extends below the bottom of the well head base for any suitable length, say ten to fifty feet. An upper set of horizontal and radially extending braces 50 extends from the joints to the ends of the peripheral sections of the top of the well head base to terminate at the outside diameter of the upper end of the conductor pipe to which they are welded. A lower set of horizontal radially extending braces 51 are similarly welded to the joints of the ends of the peripheral sections of the bottom of the well head base and are welded at their inner ends to the conductor pipe in the plane of the bottom of the well head base. A set of six diagonal braces 52 extending upwardly and inwardly from the joints of the ends of the peripheral sections of the bottom of the well head base are welded at their lower ends to the base bottom and at their upper ends to the enlarged portion of the conductor pipe.

A plurality of separate water tight compartments 53 are attached to the interior of the well head base so that it may be floated and towed to any desired location. A pad-eye 54 welded to one of the radial sections in the top

of the well head base provides a convenient means for attaching a tow line (not shown).

An annular circular plate 55, is disposed around the central opening 42 in the well head base. The plate 55 is welded to the top surfaces of the radially extending braces in the top of the well head base. Three cones 57 spaced at 120° on a common circumference are welded to the top surface of the circular plate. A separate pad-eye 58 is welded to the upper end of each cone, and the lower end of a separate guide line 19 is connected to each pad-eye with a swivel 59 and a shackle 60.

A drilling operation as illustrated in FIG. 1 is commenced with the well head base as follows:

The well head base is towed to the desired location, and the drilling barge is firmly anchored. The guide lines are connected to the cones, and the tow line is disconnected from the well head base. The buoyant compartments in the well head base are then flooded either by puncturing the wall of the compartments or by opening valves (not shown).

The upper ends of the guide lines being controlled from the drilling barge, the well head base is allowed to sink and swing under the cellar in the barge, where it is held by the guide lines at a shallow depth below the cellar. The drill bit, drill collar and drill pipe are then made up on the barge and lowered through the conductor pipe in the well head base. The drilling operation then proceeds as described above until a sufficient depth is reached to permit the conductor pipe to be lowered into the well and allow the bottom of the well head base to rest on the ocean floor. The drill bit may then be either removed immediately or drilling may proceed to such a depth that it is necessary to replace the bit or provide for return circulation of drilling mud to support the walls of the well bore. At this point it is necessary to have apparatus which will permit equipment to be guided accurately to the well bore. Such apparatus is shown in FIGS. 4 and 8.

Referring to FIG. 4, a guide assembly 62 is adapted to slide up and down the guide lines and carry with it an equipment bracket 63 adapted to slide up and down with respect to the guide assembly. The guide assembly includes a horizontal circular hoop brace 64 at its lower end which is made up of three equal segments welded at each end to the lower ends of three hollow vertical guide posts 65. A respective guide line passes through each guide post. The upper end of each guide post is threaded and a separate guide post cap 66 having an outside diameter slightly greater than the diameter of the guide post is screwed on to the upper end of each guide post. Each guide post cap has a central opening 67 to accommodate a respective guide line. A separate hollow guide assembly cone 68 is welded to the lower end of each guide post and adapted to nest on a respective well head base cone so that the guide assembly is centered above the central opening in the well head base when the guide assembly is lowered to rest on it.

The equipment bracket is attached to three vertical hollow sleeves 69, each sleeve having an inside diameter to make a sliding fit over a respective guide post. The outside diameter of each sleeve is substantially the same as the outside diameter of each guide post cap, which limits the upward travel of the equipment bracket on the guide assembly. A separate, horizontal upper arm 70 is welded at its outer end to each guide post and extends inwardly for a relatively short distance toward the center of the guide assembly. A separate, horizontal lower arm 72 is similarly attached to each guide sleeve below its respective upper arm.

The details of construction of the inner end of each of the upper and lower arms is shown most clearly in FIG. 6. Each arm is a short section of pipe having its inner end split longitudinally for a relatively short distance at the uppermost portion of the arm and having a circumferential split at the outer end of the longitudinal split extending one quarter way around the arm on each side

5

of the longitudinal split. The upper quarter of the inner end of each pipe on each side of the longitudinal split is bent upwardly to form a vertical wall 73. A separate small gusset 74 is welded to the outer end of the uppermost portion of each arm and the innermost portion of a respective guide sleeve. A separate larger gusset 75 extending along the entire length of each arm is welded to the bottom of each arm and the inner portion of the respective guide sleeve.

A pair of laterally spaced horizontal bores 76 through the inner end of each arm receive bolts 77 disposed in matching bores 78 in the outer end of a respective, radially extending equipment arm 79 which in turn is attached at its inner end to drilling mud return circulation equipment 80 which is to be guided to the well. Each equipment arm includes a short section 81 of I-beam welded at its inner end to the return circulation equipment. A separate short section of pipe 82 is welded to the outer end of each section 81, as shown in FIG. 7, and rests in a respective equipment bracket arm, to which it is secured by bolts 77.

With the return circulation equipment properly sealed to the well as described below, a closed circuit is provided for circulating drilling mud from a mud pit 84 on the barge, through a pump 85, a drilling mud hose 86, the swivel 32, down the center of the Kelly joint and drill pipe, out the end of the drill bit, up the annulus between the drill pipe and the well bore, and back to the drilling barge through a drilling mud return line 87 connected to the return circulation equipment.

Referring to FIG. 4, the return circulation drilling equipment includes a drill pipe seal housing 88 at its upper end which makes a rotary seal with the drill pipe extending through the center of the drill pipe seal housing. The lower end of the drill pipe housing is connected to the upper end of a hollow spool 90 which extends coaxially into a drill mud conduit 91. The spool is connected intermediate its ends to the upper end of the drilling mud conduit as described below. The drilling mud conduit is connected at its lower end to the upper end of a well casing seal housing 92 adapted to slip down over and seal to the upper end of a first casing 93 which projects from the well bore above the top of the well head base for a suitable distance, say two or three feet. A pair of equally spaced, diametrically opposed and vertical ears 93A, tapered inwardly and upwardly at their upper ends, are welded to the outside of the first casing two or three feet below the upper end of the first casing to provide means by which a "J-slot" tool (not shown) may be releasably coupled to the upper end of the first casing to lower it to the position shown in FIG. 4.

The first casing is positioned coaxially within the conductor pipe and extends for a considerable distance, say fifty to three hundred feet, into the well. Preferably the first casing is considerably longer than the conductor pipe and is cemented in the well to provide a firm anchoring to the underwater formation. An outer landing ring 94 welded to the upper portion of the first casing rests on the upper edge of an inner landing ring 95 welded to the inside of the conductor pipe. The first casing may be placed in the position shown by any one of several suitable procedures. For example, it may be "stripped" down over the drill pipe during the initial drilling of the well, using the above-mentioned "J-slot" tool to support the casing during the lowering operation.

The well casing seal housing 92 has an upright cylindrical wall 98. The lower end of an annular flexible well casing seal 99 is friction fitted into an upwardly opening annular channel 100 formed in the lower end of the well casing seal housing between the housing wall and an upwardly extending ring 101 on an annular bottom closure 102 for the housing. The upper end of the well casing seal is friction fitted into a downwardly opening annular channel 103 formed in the upper end of the

6

well conduit seal housing between the housing wall and a downwardly extending ring 104 on an annular upper closure 105 for the housing. A sealing nipple 106 is threadably engaged in the wall of the well casing seal housing so that hydraulic pressure may be applied by means of a hydraulic line (not shown) to the well casing seal when it is lowered around the upper end of the well casing. This also provides positive gripping means by which the return circulation equipment is held down on the well conduit during drilling operations.

As shown in FIG. 8, the lower end of the drilling mud conduit 91 is welded into the upper end of the well conduit seal housing. One end of a drilling mud return nipple 109 is threaded through the drilling mud conduit wall. The outer end of the nipple is connected to the flexible drilling mud return line 87 which extends to the mud pit in the barge.

The spool 90 serves as an aligning conduit for the drill bit and is coaxially disposed within the mud conduit so that its lower end terminates just above the upper end of the first casing 93 when the well casing seal housing is in the dotted line position shown in FIG. 4. An outwardly extending flange 111 attached to the intermediate portion of the spool is secured by bolts 112 to a matching outwardly extending flange 113 on the upper end of the mud conduit. The inside diameter of the spool is smaller than the inside diameter of the well conduit and therefore serves to guide a drill bit (shown in phantom lines in FIG. 8) into the well conduit and avoid "catching" of the bit on the upper end of the first casing 93 as the bit is lowered into drilling position.

The drill pipe seal housing 88 has an outwardly turned flange 114 at its lower end secured by bolts 114A to an outwardly turned flange 115 at the upper end of the spool. The external diameter of the drill pipe seal housing is less than that of the well casing seal housing and is reduced at 117 just above flange 114. The drill pipe seal housing has a relatively large first internal bore 118 which extends from the upper end of the housing down almost to the portion of the housing which is of reduced external diameter. The bore is then stepped down to a smaller second bore 119 for a short distance, then is stepped down to a third bore 120 for a short distance, then is stepped down to a fourth bore 121 for a short distance, then is stepped up to a fifth bore 122 slightly less than that of the third bore to extend to a point near the lower end of the housing 88, and is then stepped up to a larger sixth bore 123 which extends to the lower end of the housing 88.

A sleeve bearing 124 which may be lignum vitae, for example, is disposed within the large bore at the upper end of the housing 88, the lower end of the bearing resting on the shoulder formed at the end of the first bore and its upper end being flush with the upper end of the housing 88. The inner diameter of the sleeve bearing is less than that of the second bore. The inner edge of the lower end of the sleeve bearing is beveled at 125 to permit water to flow up through a lubricating inlet port 126 provided in the horizontal section of the housing 88 wall above the reduced external diameter of the housing. A metal insert 127 having an external diameter at its upper end slightly less than the internal diameter of the sleeve bearing is rotatably disposed within the sleeve bearing so that the upper end of the insert is below that of the bearing. An external spiral groove 128 in the insert wall permits water to be circulated by convection and friction up from the lubricating inlet port to keep the insert cool and lubricated during rotation.

The external diameter of the insert is stepped down to a reduced diameter at the same location where the first bore of the housing 88 is stepped down to a reduced diameter to form an external shoulder 129 on the insert which rests on a thrust ring bearing 130 carried in the shoulder formed between the third and the fourth bores of the housing 88. The upper end of the insert is inter-

nally threaded at 131 to receive a threaded bushing 132 which has an annular external groove 133 near its upper end and an outwardly turned flange 134 which rests on the upper edge of the insert. An O ring 135 in the annular groove effects a fluid tight seal between the bushing and the insert.

The insert has a relatively large internal first bore 136 at its upper end which tapers to a reduced second bore 137 near its intermediate portion, then tapers again to a reduced third bore 138 in its lower portion, tapers again to a reduced fourth bore 139 and then steps out to an increased fifth bore 140 to provide a lifting shoulder 141 on which there is disposed a cushion ring 142 which may be made of heavy rubber.

An upper thrust ring bearing 143, which may be made of micarta (a phenolic plastic), is disposed on the upper end of the bushing and supports a retaining ring 144 provided with a pair of diametrically opposed slots 145 in its periphery, each slot being adapted to receive a longitudinally movable locking pin 146. A fastening ring 147 is disposed on top of the upper ends of the sleeve bearing and the body wall and is rigidly attached to the body wall by bolts 148. The inner periphery of the underside of the fastening ring has a groove 149 which communicates with an annulus 150 formed between the upper thrust ring bearing the upper end of the bushing, the fastening ring and the sleeve bearing. A plurality of vertical lubricating outlet ports 151 in the fastening ring connect with the groove 149 and permit the lubricating water to flow from the interior of the body.

A pair of horizontal bores 152 through the fastening ring house the locking pins. The bores are of reduced diameter at their outer ends to form a shoulder 153. A compression spring 154 is coaxially disposed around each locking pin and bears against a flange 155 attached to the inner end of each locking pin and bears against the shoulder of the locking pin bores. The outer ends of the locking pins extend out beyond the fastening ring and each has a traverse pin 156 which holds a stop collar 157 around the outer end of each locking pin. A ring handle 158 is welded to the outer end of each stop collar to facilitate the operation of each locking pin.

An annular flexible drill pipe seal 159 is coaxially disposed within the insert and is supported at its upper end by a plurality of metal "eyes" 160 molded into the seal and held by corresponding hooks 161 formed integrally on a seal ring 162 secured to the underside of the bushing by bolts 163. The drill pipe seal has a relatively large first bore 164 at its upper end and tapers to a reduced second bore 165 at its lower end, and is sufficiently flexible to be expandable to a large enough diameter to permit the passage of drill pipe and drill collars. However, under ordinary drilling operations, the seal clamps tightly around the drill pipe or drill pipe joints so as to rotate with the pipe and effect a fluid-tight rotating seal.

An insert seal 166 is disposed in the annular space formed between the lower end of the insert 127 and the fifth internal bore 12 of the body. The insert seal is held up in position by means of an insert seal retaining ring 167 secured by bolts 168 to the shoulder formed between the fifth and sixth internal bores of the body.

The return circulation equipment, equipment bracket, and guide assembly are raised and lowered with the drill pipe by causing the drill bit to engage the cushion ring 142 in the drill pipe seal housing.

If desired, the drill bit may be removed from the circulating equipment on the barge without removing the bit from the drill pipe by pulling out the locking pins to permit the bit and insert 127 to be removed from the interior of the drill pipe seal housing.

The operation of the apparatus for guiding equipment to the well is as follows:

Each of the guide lines are held taut from the floating barge so that as the guide assembly is lowered on the guide lines, each guide assembly cone slips over a respec-

tive well head base cone even though the barge may be set over from directly above the well due to wind and current action. With the return circulation equipment shown in FIGS. 4 and 8, the guide assembly is lowered by lowering the drill pipe from the barge, the drill bit supporting the equipment by engaging the cushion ring 142 in the drill pipe seal housing. The weight of the guide assembly causes it to move down ahead of the equipment bracket as shown in FIG. 4.

Due to the relatively small diameter of the upper ends of each of the well head base cones and the relatively larger dimensions of the lower position of the guide assembly cones, there is considerable tolerance permitted in getting the guide assembly into proper position. Once the guide assembly cones are started on the well head base, the guide assembly is accurately centered over the well as the cones nest snugly together. This insures that the well casing seal housing is located directly over the upper end of the first casing. Since the guide assembly moves down ahead of the equipment bracket and equipment, there is no danger of the full weight of the equipment battering the well head base because the travel of the bracket on the guide assembly is made long enough to accommodate any vertical motion which may be imparted to the barge due to wave action during the drilling operation.

Lowering of the drill pipe is continuing from the barge to permit the return circulation equipment and equipment bracket to slide down the guide posts so that the well casing seal housing slips over the upper end of the first casing as shown in dotted lines in FIG. 4. Hydraulic pressure is then applied to the well casing seal through the nipple 106, and the return circulation equipment is thus rigidly anchored to the upper end of the first casing. Lowering of the drill pipe is continued so that the drill bit enters the first casing and finally reaches the bottom of the well. Circulation is then started with the mud pump, and the rotary table is operated to turn the drill pipe to resume drilling operations.

The drill pipe may be removed and replaced in the well bore as described by simply raising the drill pipe until the drill bit engages the cushion ring within the drill pipe seal housing. The hydraulic pressure is then released from the well casing seal, and the drill pipe is used to lift the return circulation equipment from the well head base and return it with the guide assembly up the guide lines to the barge.

As the drilling proceeds to greater depths, the possibility increases of encountering high pressure formations which might cause a "blow-out," that is, the forcing of the drilling mud from the well. To guard against this possibility the invention provides apparatus for installing a blow-out preventer on the well head which can be used to seal off the well and prevent a blow-out with the drill pipe either in or out of the well.

FIG. 9 shows the installation of a blow-out preventer 170 at the upper end of the well. As shown in FIG. 9, the well has been drilled to a sufficient depth to warrant the installation of a second casing 172 which extends down through the first casing and which is located in the well and cemented to the formation in a manner similarly described for the first casing. The lower end of the blow-out preventer has an outwardly turned flange 174 connected by bolts 176 to a first outwardly turned flange 178 on the upper end of the second casing. A second flange 180 on the second casing just below the first flange is adapted to land on the upper end of the first casing.

The blow-out preventer is supported within a blow-out preventer assembly 182 which includes a horizontal circular hoop brace 184 at its lower end which is made up of three equal segments welded at each end to the lower ends of three separate, equally spaced, vertical and hollow posts 186, through each of which passes a respective guide line. Each post 186 is welded at its upper end to the outer end of a separate, horizontal, radially

and inwardly extending I-beam 188 welded at its inner end to the upper end of the blow-out preventer and to the lower end of a conduit 190 attached to the upper end of the blow-out preventer. A separate lower hollow cone 192 is attached to the lower end of each post 186 so the blow-out preventer assembly may slide up and down the guide post lines and nest on the well head base cones. A separate, upper cone 194 is welded to the outer end of each of the I-beams 188. The upper set of cones are adapted to receive the guide assembly cones so that the guide assembly may be raised and lowered with respect to the blow-out preventer and well conduit 190 exactly as described for the upper end of the first casing 93.

The blow-out preventer may be of a conventional type, for example, a Hydrill type "MSP-200" which is operated through a line 195 which extends to the barge.

Ordinarily, the well is kept under control by the use of a drilling mud of sufficient weight, and the blow-out preventer is left open during drilling operations so the drill pipe can be removed and replaced in the well bore as described previously. In the event that a dangerous pressure is encountered while the drill pipe is in the well, the blow-out preventer can be closed around the drill pipe and prevent a blow-out. If the drill pipe is out of the well, the blow-out preventer can also be closed completely to seal the well.

Although the apparatus of FIGS. 1 through 9 shows the use of upright cones for aligning the guide assembly and blow-out preventer assembly at the well head base, some or all of the cones may be inverted as shown in FIG. 10. A hollow inverted truncated cone 196 is welded to the top of the well head base 197. The cone is reinforced by a pair of diametrically opposed vertical and radially extending stiffener plates 198 welded to the outside of the cone and to the top of the well head base. A pocket 199 is welded to the underside of the well head base which has an opening 200 directly over the pocket and under the central vertical axis of the cone. The lower end of one of the guide lines 19 is secured by a shackle 201 and a swivel 202 to a pad-eye 203 welded on a spider 204 in the bottom of the pocket. The open space provided by the spider in the bottom of the pocket permits the easy removal of any detritus which might tend to accumulate in the cone 196. A vertical slot 205 in the cone permits the guide line to be carried to one side of the well head base and lie along the top of the well head base and the ocean floor. This is sometimes an advantage when the guide line is not needed and it is desirable to reduce the tendency of the guide line to foul with equipment or other guide lines. The slot permits an inverted cone (shown only in phantom line) on the guide assembly or other apparatus to nest in the slotted cone although the guide line is carried to one side and is out of use.

FIGS. 11 and 12 show an alternate embodiment of the invention for aligning the equipment guide assembly over the well. The apparatus shown in FIGS. 11 and 12 is similar to that shown in FIG. 4, the principal difference being that the guide cones of the apparatus of FIG. 4 are omitted, and replaced by a separate vertical pulley or sheave 210 mounted at each corner on the top of a well head base 210A which is square-shaped in plan view. See FIG. 12. Each sheave lies in a vertical plane which passes through the center of the opening in the well head base. A separate guide line 211 passes down the outside of each sheave, through the sheave, up the inside of each sheave, and is attached by clamps 212 to the hoop base 64 on the bottom of the guide assembly. A horizontal circular guide assembly plate 214 of the same size as the well head base circular plate is attached to the lower ends of leg 215 attached to the bottom of the guide assembly. The guide assembly plate has a central opening 216 which matches a central opening in the well head base plate. A separate stop clamp 217 on each guide line between the inside edge of a respective sheave and the point where its respective guide line is clamped to the hoop brace limits

the travel of its respective guide line in a direction which pulls the guide assembly down on the well head base. Each stop clamp is spaced from the guide assembly so that when each stop clamp is pulled tight against its respective sheave, the guide assembly circular plate is pulled snugly down on the well head base and centered on it.

The operation of the apparatus of FIGS. 11 and 12 is relatively simple. To move the equipment down toward the well head base, the outer portion of each guide line is pulled upwardly until the respective stop clamp on each guide line is pulled firmly against its respective sheave. This insures positive alignment of the equipment guide assembly over the well. The equipment bracket and well equipment are then lowered to the well by the drill pipe as previously described. The equipment bracket and guide assembly are raised from the well head base by releasing the well casing seal and lifting the drill pipe as described previously.

The apparatus of FIGS. 11 and 12 has the advantage of providing means for exerting a strong lateral pull on the equipment guide assembly, which is sometimes helpful if the floating barge is excessively set over from the well due to wind and current, a condition which is aggravated in deeper water.

We claim:

1. Apparatus for guiding equipment to a well bore in an earth formation underlying a body of water, the apparatus comprising an upwardly extending, elongated laterally flexible guide member, means for supporting the guide member in a generally upright position, means securing the guide member at its lower end to the formation adjacent the well bore, a guide assembly, means connecting the guide assembly to the guide member so the guide assembly is movable between an upper and a lower position on the guide member, an equipment bracket, means connecting the equipment bracket to be slidable up and down on the guide assembly and restrain the equipment bracket from lateral movement with respect to the guide assembly, means connecting the equipment to the equipment bracket so the equipment is a fixed distance from the guide member when the guide assembly is in the said lower position, first aligning means on the guide assembly, second aligning means anchored to the formation adjacent the well bore to mate with the first aligning means when the guide assembly is in its lowest position and thereby bring the equipment into alignment with the well bore, and means for lowering the equipment bracket to slide down on the guide assembly toward the well bore while the equipment is so aligned.

2. Apparatus for guiding equipment to a well bore in an earth formation underlying a body of water, the apparatus comprising a well head base adapted to rest on the bottom of the body of water, the base having an upright opening extending through it and aligned with the well bore, an upwardly extending, elongated laterally flexible guide member, means for supporting the guide member in a generally upright position, means securing the guide member at its lower end to the well head base adjacent the well bore, a guide assembly, means connecting the guide assembly to the guide member so the guide assembly is movable between an upper and a lower position on the guide member, an equipment bracket, means connecting the equipment bracket to be slidable up and down on the guide assembly and restrain the equipment bracket from lateral movement with respect to the guide assembly, means connecting the equipment to the equipment bracket so the equipment is a fixed distance from the guide member when the guide assembly is in the said lower position, first aligning means on the guide assembly, second aligning means mounted on the well head base adjacent the well bore to mate with the first aligning means when the guide assembly is in its lower position and thereby bring the equipment into alignment with the well bore,

and means for lowering the equipment bracket to slide down on the guide assembly toward the well bore while the equipment is so aligned.

3. Apparatus for guiding equipment to a well bore in an earth formation underlying a body of water, the apparatus comprising a well head base adapted to rest on the bottom of the body of water, the base having an upright opening extending through it and aligned with the well bore, an upwardly extending, elongated laterally flexible guide member, means for supporting the guide member at its lower end to the well head base adjacent the well bore, a guide assembly, means connecting the guide assembly to the guide member so the guide assembly is movable between an upper and a lower position on the guide member, a guide cone on the base, a guide cone on the guide assembly, one of the cones being open at its base and mounted with its base portion nearest the other cone, the other cone being mounted with its apex portion nearest the cone with the open base so the cones nest when the guide assembly is in its lower position, an equipment bracket, means connecting the equipment bracket to be slidable up and down on the guide assembly and restrain the equipment bracket from lateral movement with respect to the guide assembly, means connecting the equipment to the equipment bracket so the equipment is a fixed distance from the guide member when the guide assembly is in the said lower position, and means for lowering the equipment bracket to slide down on the guide assembly toward the well bore while the guide assembly is in the said lower position.

4. Apparatus for guiding equipment to a well bore in an earth formation underlying a body of water, the apparatus comprising a well head base adapted to rest on the bottom of the body of water, the base having an upright opening extending through it and aligned with the well bore, an upwardly extending, elongated laterally flexible guide member, means for supporting the guide member in a generally upright position, means securing the guide member at its lower end to the well head base adjacent the well bore, a guide assembly, means connecting the guide assembly to the guide member so the guide assembly is movable between an upper and a lower position on the guide member, a first set of cones on the base, a second set of cones on the guide assembly, at least one of the cones being open at its base, each open base cone on one set being mounted to receive the apex portion of a respective cone in the other set so the cones of one set nest with the cones of the other set when the guide assembly is in its lower position, an equipment bracket, means connecting the equipment bracket to be slidable up and down on the guide assembly and restrain the equipment bracket from lateral movement with respect to the guide assembly, means connecting the equipment to the equipment bracket so the equipment is a fixed distance from the guide member when the guide assembly is in the said lower position, and means for lowering the equipment bracket to slide down on the guide assembly toward the well bore while the guide assembly is in the said lower position.

5. Apparatus for guiding equipment to a well bore in an earth formation underlying a body of water, the apparatus comprising a well head base adapted to rest on the bottom of the body of water, the base having an upright opening extending through it and aligned with the well bore, floodable buoyant compartments attached to the base to permit the base to be floated to a desired location and sunk at that location, an upwardly extending, elongated laterally flexible guide member, means for supporting the guide member in a generally upright position, means securing the guide member at its lower end to the well head base adjacent the well bore, a guide assembly, means connecting the guide assembly to the guide member so the guide assembly is movable between an upper and a lower position on the guide member, an equipment

bracket, means connecting the equipment bracket to be slidable up and down on the guide assembly and restrain the equipment bracket from lateral movement with respect to the guide assembly, means connecting the equipment to the equipment bracket so the equipment is a fixed distance from the guide member when the guide assembly is in the said lower position, first aligning means on the guide assembly, second aligning means anchored to the formation adjacent the well bore to mate with the first aligning means when the guide assembly is in its lower position and thereby bring the equipment into alignment with the well bore, and means for lowering the equipment bracket to slide down on the guide assembly toward the well bore while the equipment is so aligned.

6. Apparatus for guiding equipment to a well bore in an earth formation underlying a body of water, the apparatus comprising a well head base adapted to rest on the bottom of the body of water, the base having an upright opening extending through it and aligned with the well bore, a sheave connected to the base, an upwardly extending guide line disposed to move in the sheave, means for supporting the guide line in a generally upright position, means securing the guide line at its lower end to the well head base adjacent the well bore, a guide assembly, means connecting the guide assembly to the guide line so the guide assembly is movable between an upper and a lower position on the guide line, an equipment bracket, means connecting the equipment bracket to be slidable up and down on the guide assembly and restrain the equipment bracket from lateral movement with respect to the guide assembly, means connecting the equipment to the equipment bracket so the equipment is a fixed distance from the guide line when the guide assembly is in the said lower position, a stop on the guide line to limit its travel in the direction to carry the guide assembly toward the lower position, and means for lowering the equipment bracket to slide down on the guide assembly toward the well bore while the guide assembly is in its lower position.

7. Apparatus for guiding equipment to a well bore in an earth formation underlying a body of water, the apparatus comprising a well head base adapted to rest on the bottom of the body of water, the base having an upright opening extending through it and aligned with the well bore, an upwardly extending, elongated laterally flexible guide member, means for supporting the guide member in a generally upright position, means securing the guide member at its lower end to the formation adjacent the well bore, a guide assembly, means connecting the guide assembly to the guide member so the guide assembly is movable between an upper and a lower position on the guide member, an equipment bracket, a removable arm on the bracket and connecting it to be slidable up and down on the guide assembly and restrain the equipment bracket from lateral movement with respect to the guide assembly, means connecting the equipment to the equipment bracket so the equipment is a fixed distance from the guide member when the guide assembly is in the said lower position, first aligning means on the guide assembly, second aligning means anchored to the formation adjacent the well bore to mate with the first aligning means when the guide assembly is in its lower position and thereby bring the equipment into alignment with the well bore, and means for lowering the equipment bracket to slide down on the guide assembly toward the well bore while the equipment is so aligned.

8. Apparatus for guiding equipment to a well bore in an earth formation underlying a body of water, the apparatus comprising a well head base adapted to rest on the bottom of the body of water, the base having an upright opening extending through it and aligned with the well bore, an upwardly extending, elongated laterally flexible guide member, means for supporting the guide member in a generally upright position, means securing the guide member at its lower end to the well head base adjacent the well bore, a blow-out preventer guide as-

sembly, means connecting the blow-out preventer guide assembly to the guide member so the blow-out preventer guide assembly is movable between an upper and a lower position on the guide member, a blow-out preventer attached to the blow-out preventer guide assembly, a casing attached to the blow-out preventer to extend down from the preventer into the well, an equipment guide assembly, means connecting the guide assembly to the guide member so the guide assembly is movable between an upper and a lower position on the guide member and rests on the blow-out preventer guide assembly when in the lower position, an equipment bracket, means connecting the equipment bracket to be slidable up and down on the equipment guide assembly and restrain the equipment bracket from lateral movement with respect to the guide assembly, means connecting the equipment to the equipment bracket so the equipment is a fixed distance from the guide member when the equipment guide assembly is in the said lower position, first aligning means on the equipment guide assembly, second aligning means on the blow-out preventer guide assembly to mate with the first aligning means when the blow-out preventer guide assembly and the equipment guide assembly are each in their respective lower positions and thereby bring the equipment into alignment with the well bore, and means for lowering the equipment bracket to slide down on the equipment guide assembly toward the well bore while the equipment is so aligned.

9. Apparatus for guiding equipment to a well bore in an earth formation underlying a body of water, the apparatus comprising a well head base adapted to rest on the bottom of the body of water, the base having an upright opening extending through it and aligned with the well bore, an upwardly extending, elongated laterally flexible guide member, means for supporting the guide member in a generally upright position, means securing the guide member at its lower end to the well head base adjacent the well bore, a guide cone on the base, a blow-out preventer guide assembly, means connecting the blow-out preventer guide assembly to the guide member so the blow-out preventer guide assembly is movable between an upper and a lower position on the guide member and rests on the base when in the lower position, a blow-out preventer attached to the blow-out preventer guide assembly, a casing attached to the blow-out preventer to extend down from the preventer into the well, a first guide cone on the blow-out preventer guide assembly, a second guide cone on the blow-out preventer guide assembly, an equipment guide assembly, means connecting the equipment guide assembly to the guide member so the equipment guide assembly is movable between an upper and a lower position on the guide member, a guide cone on the equipment guide assembly, an equipment bracket, means connecting the bracket to the guide assembly to be slidable with respect to it and restrained from lateral movement with respect to it, means for connecting the equipment to the equipment bracket so the equipment is

a fixed distance from the guide member when the guide assembly is in the said lower position, some of the said cones having open bases, each open base cone being disposed to receive the apex of a respective one of the other cones so the first guide cone on the blow-out preventer guide assembly nests with the cone on the base when the preventer assembly is lowered to rest on the base and so the guide cone on the equipment guide assembly nests with the second cone on the blow-out preventer guide assembly when the equipment guide assembly is in its lower position, and means for lowering the equipment bracket toward the well bore when the blow-out preventer guide assembly and the equipment guide assembly are in their respective lower positions.

10. Apparatus for guiding equipment to a well bore in an earth formation underlying a body of water, the apparatus comprising a well head base adapted to rest on the bottom of the body of water, the base having an upright opening extending through it and aligned with the well bore, an inverted frusto-conical member attached to the base, the frusto-conical member having an upright slot, an elongated guide member attached at its lower end within the frusto-conical member, means for disposing the guide member to extend upwardly and also lie substantially horizontally and extend through the said slot, a guide assembly, means connecting the guide assembly to the guide member so the guide assembly is movable between an upper and a lower position on the guide member, an equipment bracket, means connecting the equipment bracket to be slidable up and down on the guide assembly and restrain the equipment bracket from lateral movement with respect to the guide assembly, means connecting the equipment to the equipment bracket so the equipment is a fixed distance from the guide member when the guide assembly is in the said lower position, first aligning means on the guide assembly, second aligning means anchored to the formation adjacent the well bore to mate with the first aligning means when the guide assembly is in its lower position and thereby bring the equipment into alignment with the well bore, and means for lowering the equipment bracket to slide down on the guide assembly toward the well bore while the equipment is so aligned.

References Cited in the file of this patent

UNITED STATES PATENTS

962,019	Flood et al.	June 21, 1910
1,645,989	Hansen	Oct. 18, 1927
1,691,787	Hansen	Nov. 13, 1928
1,732,887	Hansen	Oct. 18, 1929
1,766,628	Hansen	June 24, 1930
2,187,871	Voorhees	Jan. 23, 1940
2,399,656	Armstrong	May 7, 1946
2,676,787	Johnson	Apr. 27, 1954
2,783,027	Gilbert	Feb. 26, 1957
2,808,229	Bauer et al.	Oct. 1, 1957
2,808,230	McNeil et al.	Oct. 1, 1957

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,012,610

Decem^r 12, 1961

Robert F. Bauer et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 11, for "3" read -- 36 --; column 7, line 22, for "atached" read -- attached --; column 10, line 46, for "lowest" read -- lower --.

Signed and sealed this 8th day of May 1962.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

DAVID L. LADD

Commissioner of Patents