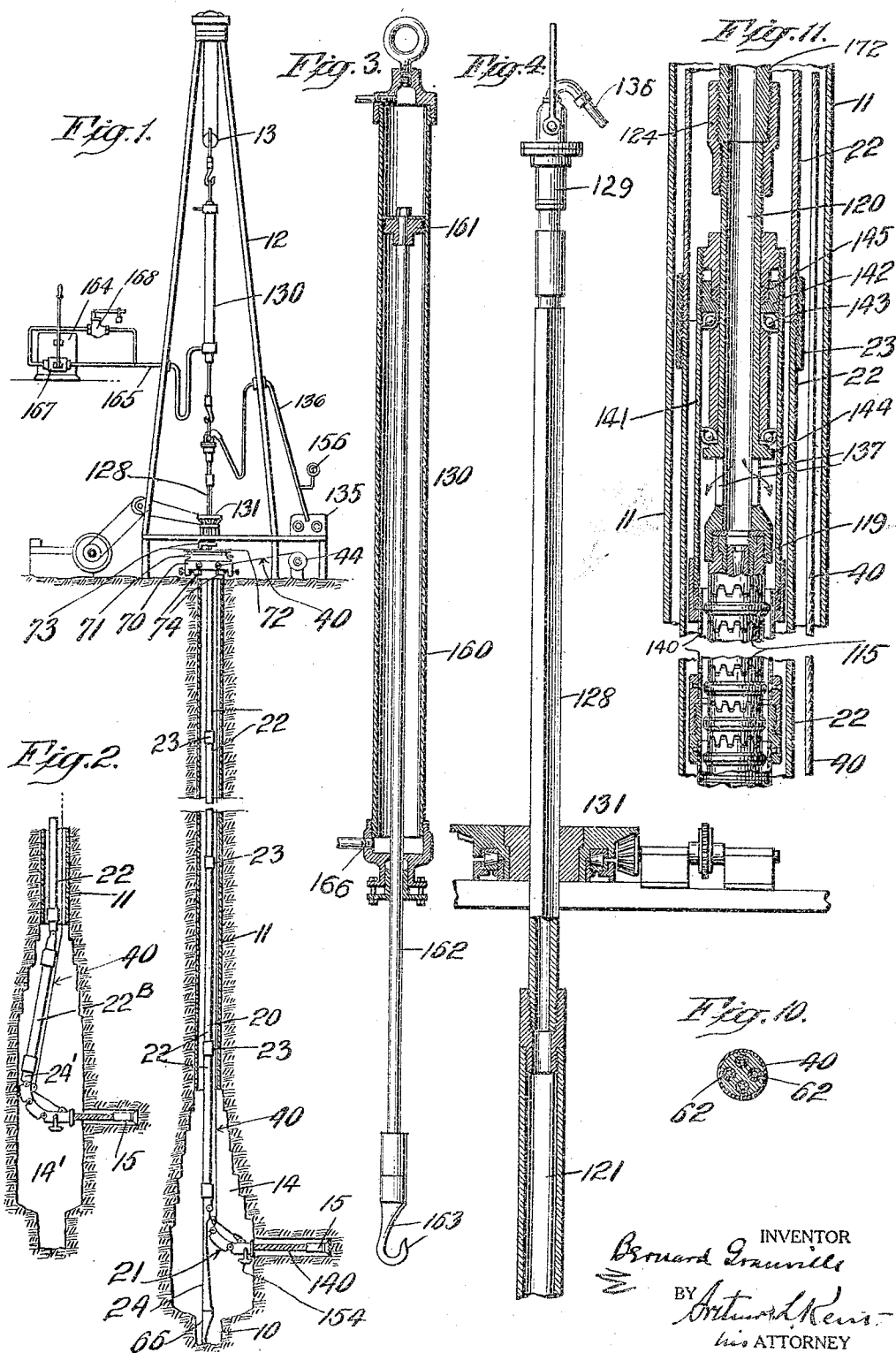


APPARATUS FOR DRILLING

Original Filed July 21, 1923 6 Sheets-Sheet 1



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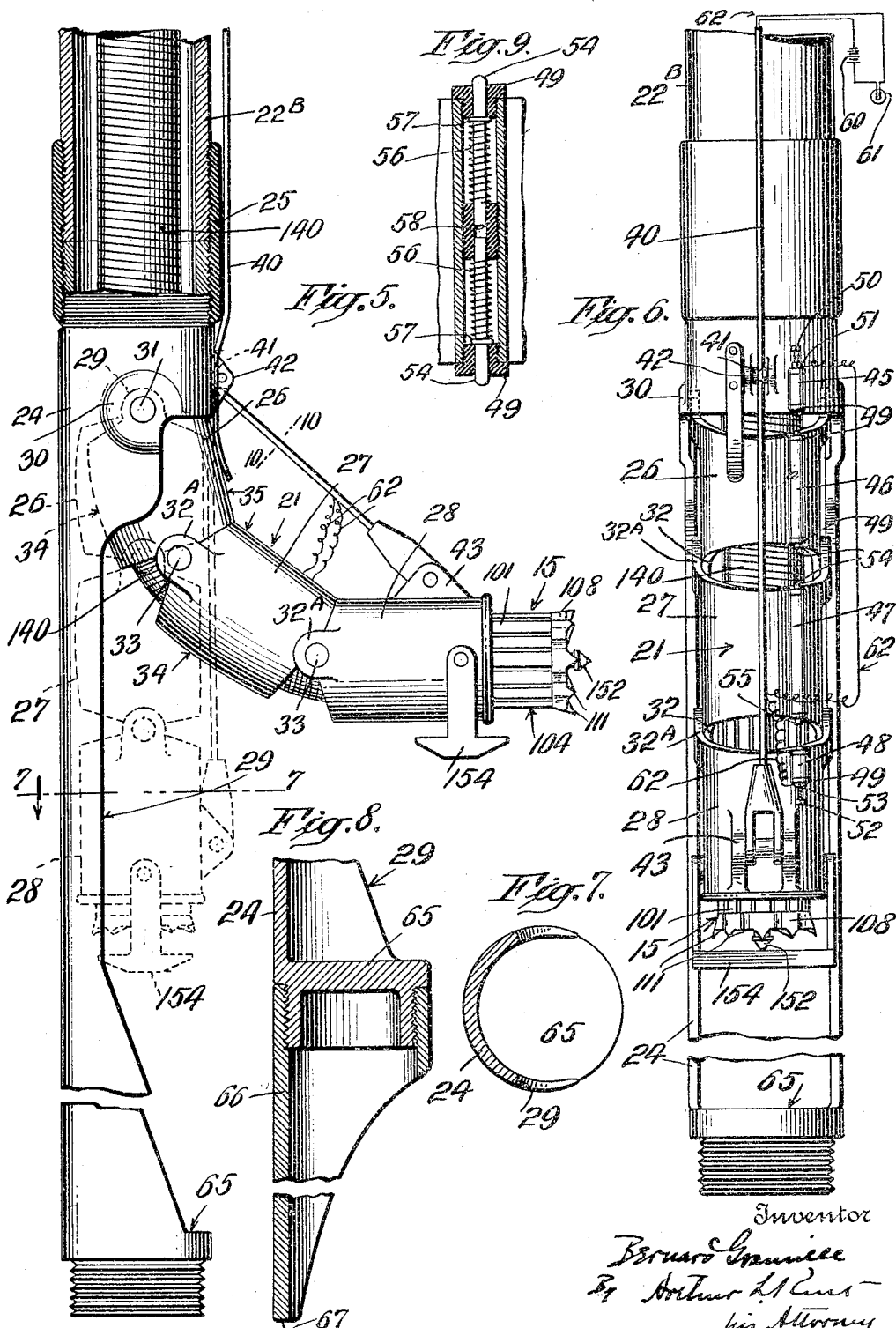
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R. GRANVILLE

1,865,853

APPARATUS FOR DRILLING

Original Filed July 21, 1923 6 Sheets-Sheet 2



Inventor
 Bernard Granville
 By Arthur H. Kent
 his Attorney

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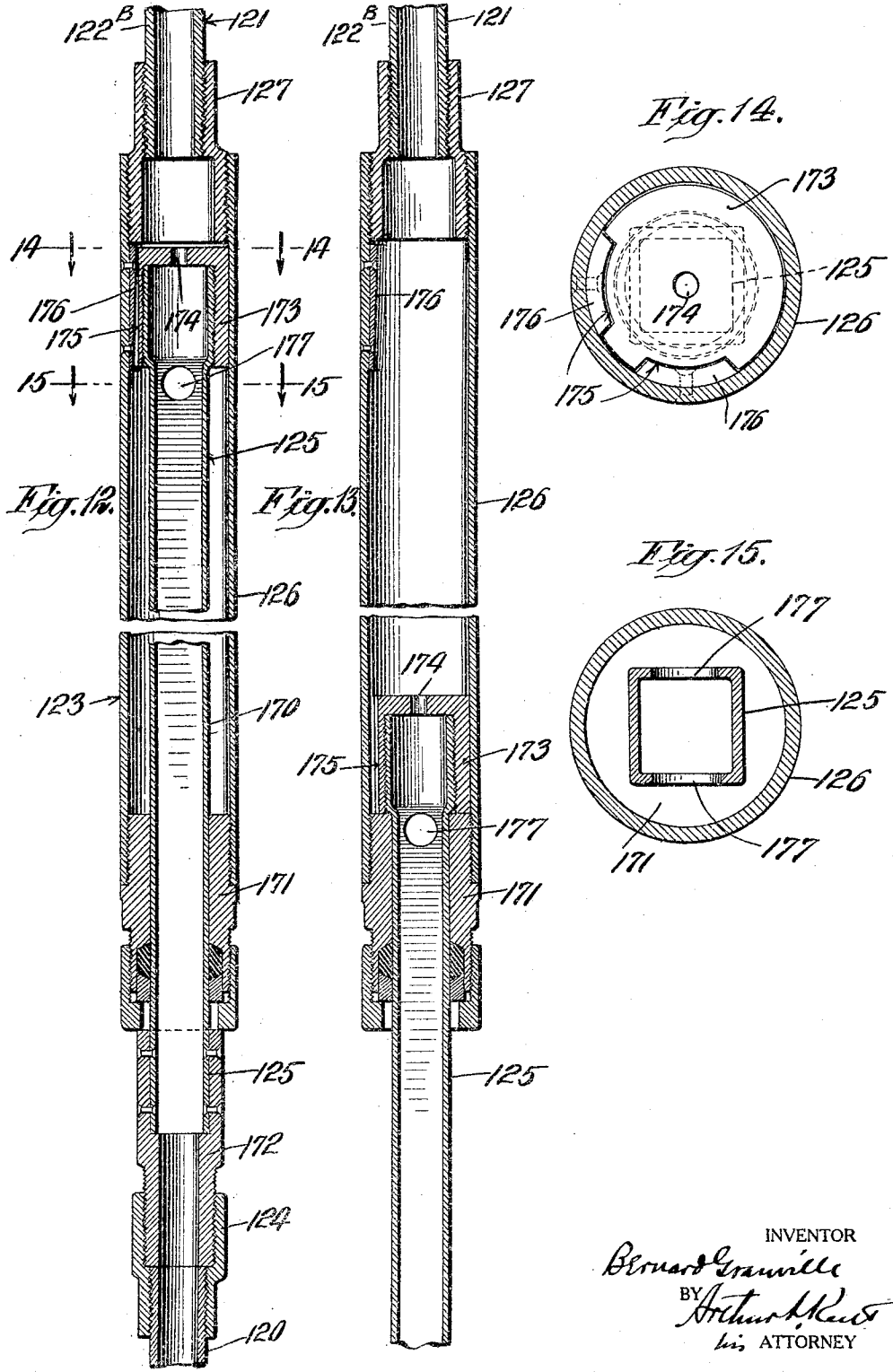
July 5, 1932.

R. GRANVILLE

1,865,853

APPARATUS FOR DRILLING

Original Filed July 21, 1923 6 Sheets-Sheet 3



INVENTOR
Bernard Granville
BY Arthur H. Kees
his ATTORNEY

19

July 5, 1932.

R. GRANVILLE

1,865,853

APPARATUS FOR DRILLING

Original Filed July 21, 1923 6 Sheets-Sheet 4

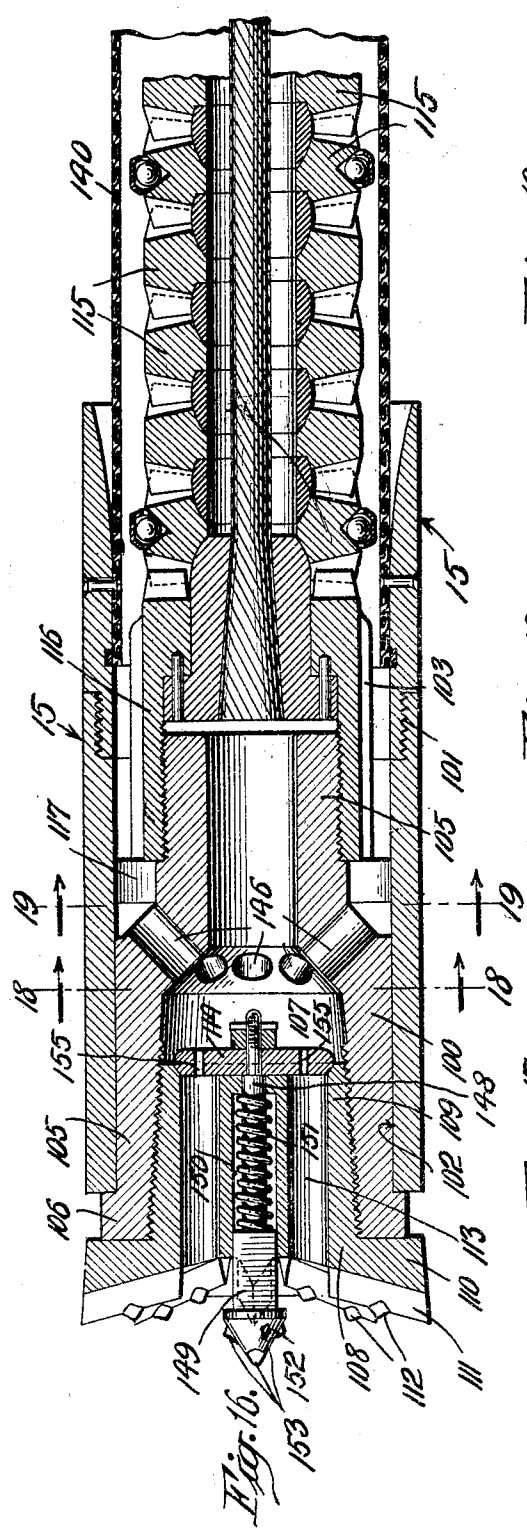


Fig. 19.

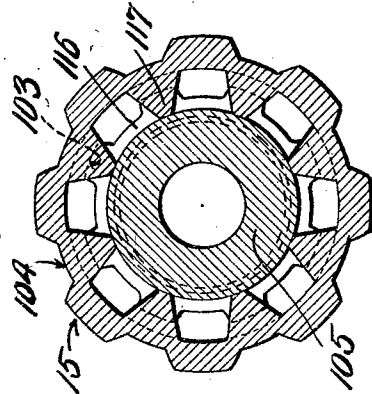


Fig. 18.

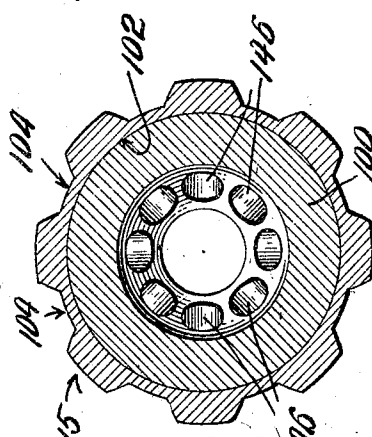
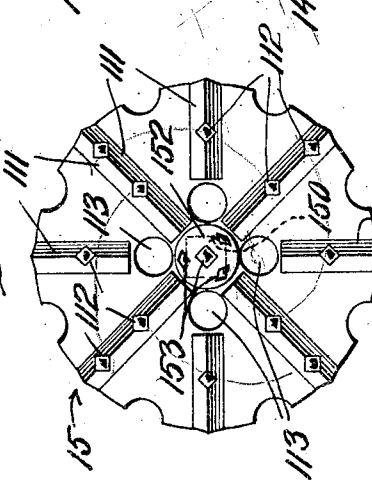


Fig. 17.



Inventor
Bernard Granville
By Arthur H. Kuntz
his Attorney

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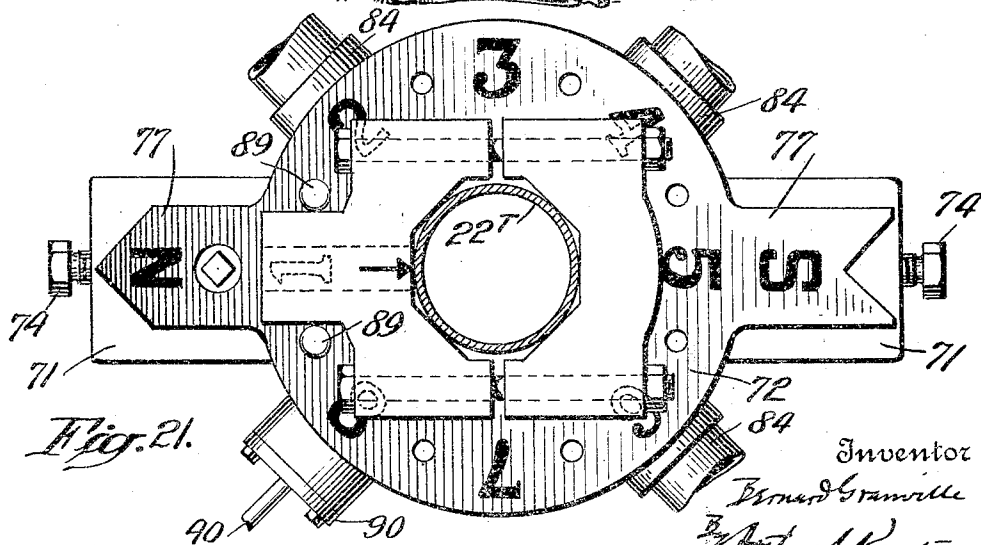
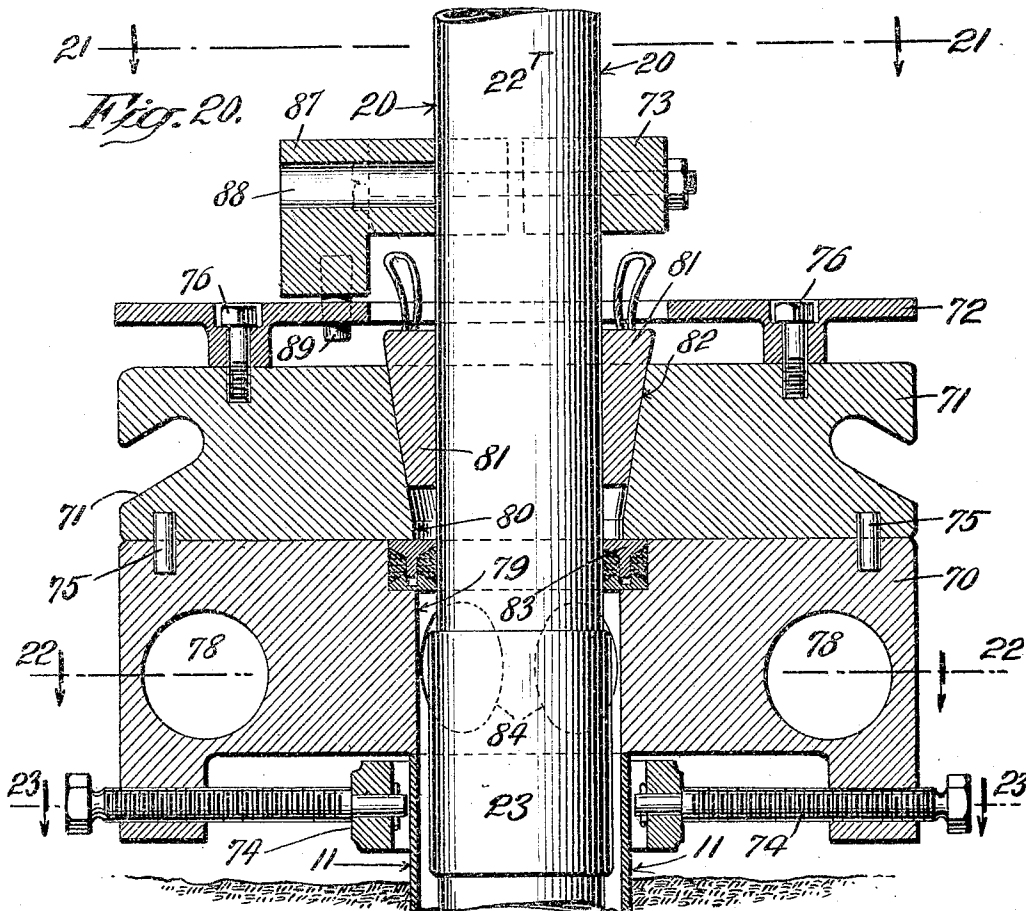
July 5, 1932.

R. GRANVILLE

1,865,853

APPARATUS FOR DRILLING

Original Filed July 21, 1923 6 Sheets-Sheet 5



Inventor
Bernard Granville
By Arthur H. Kears-
his Attorney

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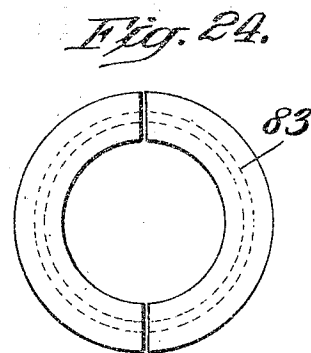
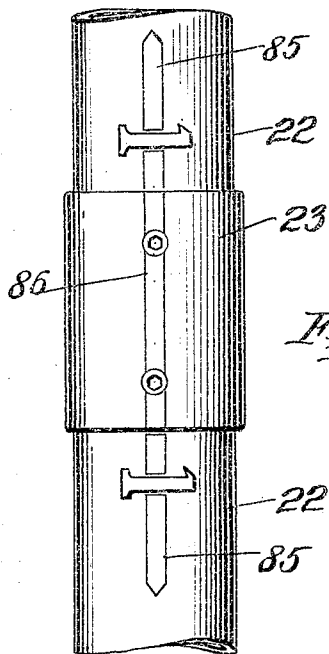
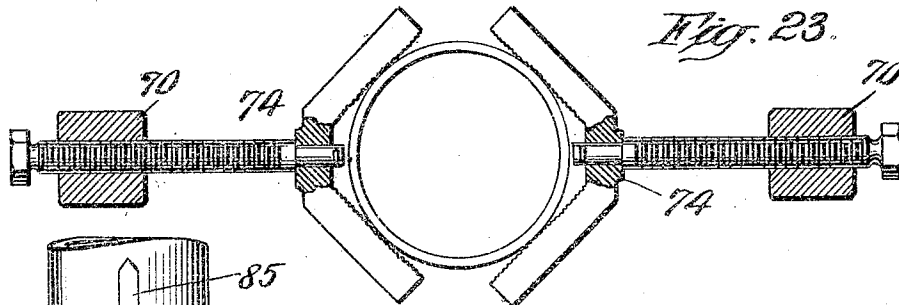
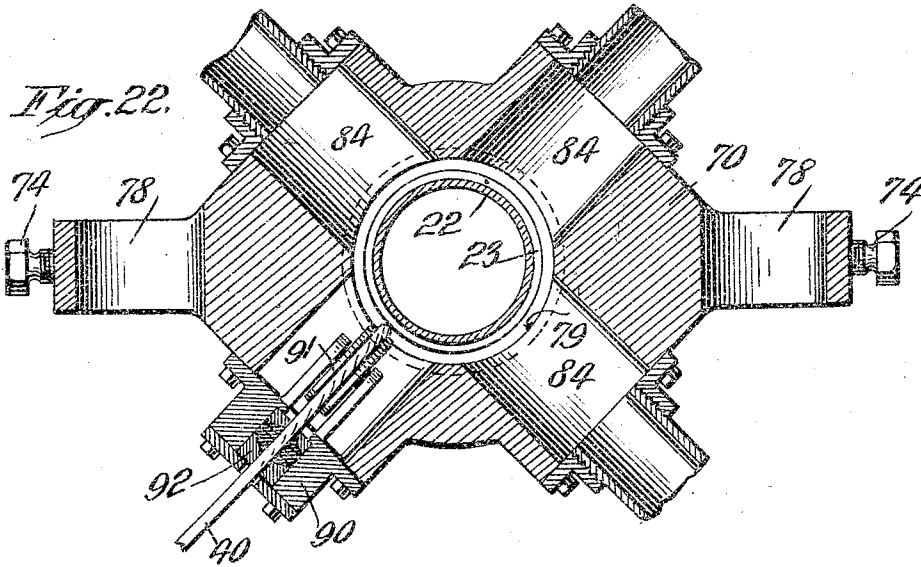
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R. GRANVILLE

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Inventor
Edward Granville
By Arthur H. Kent
his Attorney

Patented July 5, 1932

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UNITED STATES PATENT OFFICE

BERNARD GRANVILLE, OF NEW YORK, N. Y., ASSIGNOR TO GRANVILLE HOLDING CORPORATION, A CORPORATION OF NEW YORK

APPARATUS FOR DRILLING

Application filed July 21, 1923, Serial No. 652,905. Renewed September 28, 1931.

This invention relates to apparatus for drilling. The principal object of the invention is to drill a hole at an angle to a hole already drilled, and more specifically to drill a lateral hole in a substantially horizontal direction from any point of a deep vertical hole or well.

Apparatus embodying the invention includes means for positioning a drill for boring a lateral hole from a cavity in a well, means for rotating the drill and for forcing it forward, and means for controlling its forward movement. In an approved form of the apparatus the drill positioning means includes a rigid sectional pipe which is lowered into a well within the well casing and has at its lower end a flexible elbow which hangs in line with the rigid pipe during the lowering, and may be turned out of line with the pipe by means operable at the top of the well. The means for operating the drill include a hollow drill rod, which is lowered within the rigid pipe, and a connection between this drill rod and the drill, which is flexible so that it may pass through the elbow of the rigid pipe, and is arranged to transfer rotation of the drill rod to the drill and to conduct water pumped into the drill rod to the drill so as to apply to the drill a hydraulic pressure to force it forward. The means for controlling the forward movement of the drill may include a hydraulic lift from which the drill rod is suspended, and a flight in the drill rod.

Other features of the invention are hereinafter described in connection with a detailed description of a practical drilling apparatus embodying the invention. Such apparatus is illustrated in the accompanying drawings, in which:—

Fig. 1 is a diagrammatic side elevation of the entire apparatus, showing it in the operation of boring a lateral hole from a point near the bottom of a well;

Fig. 2 is a fragmentary side elevation of the lower part of the apparatus showing a modification of the drill positioning means;

Fig. 3 is an axial section of the hydraulic lift from which the swivel holding the grief stem is suspended;

Fig. 4 is an elevation partly in axial section showing the water swivel and grief stem from which the drill rod is suspended, and the rotary head;

Fig. 5 is a side elevation, partly in axial section, of the lower part of the apparatus showing, in full lines, the elbow in operative position, and in dotted lines, the elbow in inoperative position;

Fig. 6 is a front elevation of the parts shown in Fig. 5 with the elbow in inoperative position;

Fig. 7 is a transverse section on the line 7—7 of Fig. 5;

Fig. 8 is an axial section of the foot of the drill positioning means;

Fig. 9 is an enlarged axial section of the circuit closer on one of the elbow sections;

Fig. 10 is an enlarged transverse section of the cable taken on the line 10—10 of Fig. 5;

Fig. 11 is an axial section of a part of the apparatus above that shown in Fig. 5, showing the swivel connection between the drill rod and the flexible pipe, and part of the flexible shaft;

Fig. 12 is an axial section, on a larger scale, of the flight which connects the lower end of the drill rod with the swivel shown in Fig. 11;

Fig. 13 is a similar view of the flight showing the parts of it in a different position;

Fig. 14 is an enlarged transverse section on the line 14—14 of Fig. 12;

Fig. 15 is a similar transverse section on the line 15—15 of Fig. 12;

Fig. 16 is an enlarged axial section of the drill and the parts immediately connected with it;

Fig. 17 is a front end view of the drill;

Fig. 18 is a transverse section on the line 18—18 of Fig. 16;

Fig. 19 is a transverse section on the line 19—19 of Fig. 16;

Fig. 20 is an axial section of the blow-out head at the top of the well casing and the parts connected with it;

Fig. 21 is a top view of the parts shown in Fig. 20 showing the outer pipe sectioned on the line 21—21 of Fig. 20;

Fig. 22 is a transverse section on the line 22—22 of Fig. 20;

Fig. 23 is a transverse section on the line 23—23 of Fig. 20;

Fig. 24 is a top view of the packing ring in the blow-out head; and

Fig. 25 is a fragmentary side elevation showing one of the couplings in the outer pipe.

The apparatus illustrated is adapted for boring a lateral hole from a point near the bottom of a deep well such as an oil well. Such a well 10 with the customary lining 11 extending nearly to its bottom is illustrated in Figs. 1 and 2. At the top of the well is a derrick 12 for use in lowering drilling and other apparatus into the well. The derrick 12 is provided with the usual draw-out works comprising a traveling block 13 operated by a power driven hoist not shown in the drawings.

In drilling laterally from the bottom of a well with my apparatus, an enlarged cavity 14 is first formed at the bottom of the well 10 below the lower end of its lining 11. This cavity may be formed by firing a charge of explosive at the bottom of the well. It is, however, more desirable to form it by means of an underreamer.

After the cavity 14 has been formed, the underreamer is withdrawn from the well 10, and a drill 15 is lowered into the well with its axis vertical, swung into a horizontal position in the cavity 14, and forced out through the wall of the cavity as indicated in Fig. 1.

The apparatus illustrated includes a rotary drill 15, means for positioning this drill so that it may bore a lateral hole from the well 10 at any desired depth below the surface of the ground, at a predetermined angle to the vertical, and in any predetermined lateral direction, that is, at any desired angle to the meridian; means for operating the drill, that is, in the specific apparatus shown, means for rotating it; means for urging the drill forward; and means for controlling the forward movement of the drill.

The drill positioning means

The means for positioning the drill 15, so that it may bore a lateral hole at a predetermined distance below the ground level and at a predetermined angle to the vertical comprises a rigid outer sectional pipe 20 having at its lower end a flexible elbow 21.

The pipe 20 consists of pipe sections 22 secured together by couplings 23. As the pipe is lowered into the well from the ground, additional pipe sections are added to its upper end in the usual manner. The length of the pipe 20 determines the distance below the ground level at which the lateral hole will be bored. It will be understood, of course, that the cavity 14 must be formed at a desired

level before the pipe 20 is lowered into the well.

The flexible elbow 21, as best shown in Figs. 5 to 10, is hinged to a hollow spud 24 which is secured to the lowermost pipe section 22B by means of a coupling 25. The elbow 21 consists of a plurality of tubular sections 26, 27, 28 which are hinged together, so that they may either be extended longitudinally in spud 24 or swung up, through a lateral opening 29 in the spud, to form an elbow. While the hinging may be effected by securing the sections to a flexible hinge member, I prefer to use pivotal connections. Therefore, the upper elbow section 26 has, at its upper end, two diametrically opposite projections 29, which are secured to offset portions 30 near the top of the spud 24 by means of pivots 31; and each of the elbow sections 26, 27 has at its lower end two diametrically opposite downward projections 32, while each of the sections 27, 28 has at its upper end two diametrically opposite projections 32A which are offset outwardly from the section. The projections 32A overlap the projections 32, as best seen in Fig. 6, and the sections are hinged together by pivots 33 passing through these projections. The sections 26 and 27 are formed so that their outer sides 34 are curved, while their inner sides 35 are straight.

Means are provided for swinging the sections 26, 27, 28 from their normal vertical position shown in Fig. 6 and in dotted lines in Fig. 5 to the position shown in full lines in Fig. 5. Such means include a flexible cable 40 which passes around a pulley 41 on a projection 42 on the inner side of the spud 24 and has its lower end secured to a projection 43 at the inner side of the section 28. The cable 40 extends to the top of the well and is wound on a drum 44 (Fig. 1). When a pull is applied to it, the sections 26, 27, 28 are drawn up to form an elbow.

Adjustable stops are provided to arrest the movement of the elbow sections under the pull of the cable 40 when the axis of the outer section 28 is horizontal or at any desired predetermined angle to the axis of the well. With the stops is combined means for indicating at the top of the well, the instant at which the elbow sections have been drawn into the predetermined position. Adjustable stops and a part of the indicating means are mounted in longitudinal cylindrical ribs 45, 46, 47, 48 projecting from the front sides of the spud 24 and the sections 26, 27, 28 respectively. These ribs are hollow and their ends are closed by insulating plugs 49. An adjustable bolt 50 is screwed into a tapped hole in the plug at the upper end of the rib 45. The lower end of this bolt projects from the lower end of the rib 45 through a central hole in the plug at this end of the rib. The bolt may be retained in any longitudinal position in the rib by means of a lock nut 51. A similar ad-

justable bolt 52 with a similar lock nut 53 is mounted in the cylindrical rib 48 on the section 28. In each of the cylindrical ribs 46, 47 is mounted a pair of slidable plungers 54 whose outer ends project out through the plugs in the ends of these ribs. The plunger 54 in each of these ribs is normally thrust outward by compression springs 56, their outward movement under the effect of these springs being limited by collars 57. When the plungers in each of these ribs are in their normal position their inner ends 58 are out of contact with each other.

The adjustable bolts 50 and 52 are connected in an electrical circuit which includes a source of electro-motive force 60 and an indicator 61 both located at the top of the well and indicated diagrammatically in Fig. 6. The wires 62 forming this circuit extend from the adjustable bolts to the cable 40 and then extend within the cable to the top of the well.

When the elbow sections are swung upward by a pull applied to the cable 40 at the top of the well, the bolts 50 and 52 come into contact respectively with the upper plunger in the rib 46 and the lower plunger in the rib 47, while the lower plunger in the rib 46 comes into contact with the upper plunger in the rib 47. As the pull on the cable 40 continues, the plungers in the ribs 46 and 47 are thrust inwardly against the force of the springs 56 until the inner ends of each pair of plungers come into contact with each other. When this occurs the upward swinging of the elbow sections is arrested. It is apparent that by adjusting the longitudinal position of the bolts 50 and 52 in their respective ribs before the elbow sections are lowered into the well, the exact angle between the axis of the outer section 28 and that of the spud 24 may be predetermined.

Owing to the length of the cable 40, the cable is necessarily somewhat stretchable so that it is difficult to determine by the load on the cable just when the upward swinging of the elbow sections has been arrested by the stops. The electrical connections which have been described, however, indicate the exact moment when the elbow sections have reached the desired predetermined position. This is because the electric circuit containing the indicating means 61 is completed at the instant that the inner ends of the two pairs of plungers 54 come into contact with each other. As this final connection which completes the circuit is made within the cylindrical ribs 46, 47 from which the water with which the well is filled is excluded by the insulating plugs 49, the water in the well cannot cause a short circuit. As the result, the indicating means 61 is not operated until the moment that the elbow sections have been drawn into the desired predetermined position. This position may be that shown in Fig.

5, in which the axis of the section 28 is horizontal.

The indicating means which have been described have an additional function which is hereinafter described in connection with the drill 15.

The spud 24 serves to relieve the strain on the couplings of the pipe 20. It extends below the flexible elbow 21. The lower end of the spud 24 is threaded for the attachment of a foot 66 which consists of a short pipe section cut away so as to provide a supporting surface 67 directly under the side of the spud 24 opposite to the opening 29 in the spud. When it is desired to drill a lateral hole at some distance above the bottom of an existing well, one or more rigid pipe sections similar to the sections 22 may be inserted between the bottom of the spud 24 and the top of the foot 66.

In the use of the drill-positioning means which have just been described, the pipe 20 is lowered into the well until the supporting surface 67 of the foot 66 rests upon the bottom of the well or the bottom of the cavity 14. In this way the couplings 23 are relieved of excessive strain, as the weight of the pipe sections 22, as well as that of the elbow sections, is in large part supported from the bottom of the well. Owing to the positioning of the supporting surface 67 under the back wall of the spud 24, the compression strain on the spud does not cause a buckling of the spud.

After the outer pipe 20 has thus been placed in position in the well, the drill 15 is lowered through the pipe into the elbow section 28, and the elbow sections are then swung up to the position shown in Fig. 5. During the lateral drilling the back thrust on the elbow is in part resisted by the seating of the foot 66 at the bottom of the well, and therefore, does not cause a side strain on the pipe section 22B.

When the apparatus is used for drilling lateral holes at a comparatively short distance below the surface of the ground, the lower part of the spud 24 may be dispensed with, owing to the fact that in this case the weight of the apparatus does not place an excessive strain on the couplings 23 of the pipe 20.

When the lower part of the spud is not needed, the apparatus may be made to operate in a comparatively narrow cavity by use of the modified drill positioning means shown in Fig. 2. In this modification the spud 24 is replaced by a collar 24' and the lowermost pipe section 22B is hinged to the next pipe section 22 by means of pivots parallel to the pivots 31, 33 of the flexible elbow. This arrangement permits the pipe section 22 to be swung to one side in the cavity 14' when the elbow sections are drawn up, and thus permits use of the elbow in a narrow

cavity 14'. When this modification is used, the elbow 21 is pushed against one wall of the cavity 14' during the lateral drilling, so that the back thrust of the drilling does not cause a side strain on the lower part of the outer pipe 20.

The apparatus for predetermining the lateral direction, that is, the angle to the meridian at which the lateral hole is bored, is located at the top of the well 10. This apparatus, best shown in Figs. 20 to 24, includes a casing head 70, a spider 71, an index plate 72, and a clamp 73. The casing head 70 is mounted on the upper end of the casing 11 of the well 10 and secured to this casing by clamps 74. The spider 71 rests on the head 70 and is held against rotation with respect to the head by means of dowel pins 75. The index plate 72 is mounted on the upper surface of the spider 71 by means of bolts 76. The index plate may be formed to provide an arrow 77 as shown in Fig. 21. Before the head is firmly clamped to the casing 11 it is turned about the casing by means of bars passed through holes 78 until the arrow 77 points toward the north, preferably toward the north magnetic pole. It is then secured in position by tightening the clamps 74. After this apparatus has been thus placed in position, the sectional pipe 20 is lowered into the well through central openings 79, 80 in the head 70 and the spider 71 which register with the casing 11. It will be understood that the pipe is lowered in the ordinary manner by means of the draw-out works of the derrick 12 and that an additional pipe section is attached whenever the upper end of a pipe section has been lowered to the top of the spider 71. Wedges or slips 81 fitting in a tapered portion 82 of the hole 80 are provided to hold the sections already lowered, while each new section is attached. When the pipe 20 has been completely lowered, the spider 71 is raised from the casing head 70 and a packing 83 is inserted between them to prevent oil, gas or water rising in the casing 11 from flowing out of the top of the hole 79. Such oil, gas or water flows off through radial openings 84 in the head 70. After the packing has been inserted the spider 71 is replaced and the wedges 81 are inserted to hold the uppermost of the pipe sections 22T. The upper pipe section may then be detached from the travelling block 13 of the derrick 12.

Each of the pipe sections 22 has at its ends aligned marks 85 and each of the couplings 23 has a mark 86. As each new pipe section is attached during the lowering of the pipe 20, the marks 85 and 86 are placed in alignment, as shown in Fig. 25. It follows that after the pipe has been completely lowered, the mark 85 at the upper end of the uppermost pipe section 22T indicates the direction in which the front of the elbow 21 is turned.

After the pipe has been completely lowered

the clamp 73 is secured to the uppermost pipe section 22T above the plate 72. By reference to the uppermost mark 85 on the upper pipe section 22T or to the mark 86 on the coupling, this clamp is applied so that its extending end 87 is turned in the same direction as the front side of the elbow 21. The projecting end 87 of the clamp contains a radial hole 88 in which a crow-bar may be inserted for turning the pipe 20.

In order to turn the elbow in any desired direction after the pipe 20 has been lowered, the upper end of the pipe 20 may be secured to the travelling block 13 of draw out works of the derrick 12 and raised slightly by the hoist of derrick so that the wedges 81 can be removed. A crow-bar is then inserted in the hole 88 of the clamp 73 and the pipe 20 is turned until the projecting end 87 points in the desired direction. It is then retained in this direction by pins 89 inserted at opposite sides of it in the plate 72. The wedges 81 are then again inserted and the upper pipe section is released from the travelling block of the derrick and held in position firmly by the wedges.

The cable 40 which is used to draw the elbow 21 into operative position extends to the top of the well between the casing 11 and the pipe 20. It passes out of the casing head 70 through one of the radial holes 84. This hole is provided with a cap 90 on the inner side of which is secured a sheave 91 over which the cable passes. A stuffing box 92 in the cap 90 surrounds the cable 40 and prevents liquids or gases rising from the well from escaping through the radial hole through which the cable is drawn. From the stuffing box 92 the cable 40 passes to the drum 44 on which it may be wound and held firmly by mechanism not shown in the drawing.

The drill and the means for operating and feeding it

The drill 15 which is lowered through the pipe 20 into the lower or outer portion of the elbow 21 before the elbow is swung up into operative position, is shown in detail in Figs. 16 to 19. The drill 15 comprises an inner rotary portion 100, and an outer non-rotary bearing portion 101. The outer portion 101 has the form of a tube or hollow cylinder having on its inside a smooth bearing surface 102 and a grooved bearing surface 103, and having on its outside a fluted surface 104. Rotatably mounted against the bearing surface 102 of the cylinder 101 is the drill chuck 105. This chuck has at its outer end an external flange 106 which fits against the outer end of the cylinder 101 and has a fluted outer surface. The forward part of the chuck 105 contains a central tapering chamber 107 which is threaded for the insertion of the cutting head 108 of the drill. The cutting head 108 has at its rear end a

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tapered extension 109 which is screwed into the chuck 105 and at its outer end an external flange 110 which fits against the outer end of the flange 106 of the chuck. The diameter of the front end of the cutting head is slightly greater than the external diameter of the cylinder 101. The front face of the cutting head is provided with radial ridges 111 which can be set with diamonds 112.

The cutting head 108 is provided with a plurality of longitudinal passages 113 which extend from its front surface to its back surface and communicate at their rear ends with the chamber 107 in the chuck 105. A valve 114 controlling the flow of water through the passages 113 may be provided for a purpose hereinafter explained. This valve is, however, not essential to the operation of the drill and when it is provided it is arranged in such manner as to leave the passages 113 unobstructed during the drilling operation.

Means are provided for rotating the chuck 105 and cutting head 108. These means include a flexible shaft 115 secured by a gear coupling 116 to the rear end of the chuck 105. The outer surface of the gear coupling 116 bears against the grooved internal bearing surface 103 of the cylinder 101. The inner end of the gear coupling bears against an internal fluted flange 117 in the cylinder 101. This bearing cooperates with the bearing provided between the flange 106 and the outer end of the cylinder 101 to retain the chuck in fixed longitudinal position within the cylinder. The flexible shaft 115 illustrated in the drawings comprises a series of units having cooperating gear teeth and held together by a central flexible cable. As this flexible shaft forms the subject matter of my previous application filed July 28, 1922, Serial No. 578,107, it is not herein described in detail. The flexible shaft 115 has a length a little greater than that of the lateral hole to be drilled. The rear end of the shaft is secured by a coupling chuck 119 on the lower end of a hydraulic swivel rod 120, as shown in Fig. 11. The upper end of the swivel rod 120 is connected to the lower end of a hollow sectional drill rod 121 (Fig. 4) which extends within the pipe 20 to the top of the well. The upper end of the swivel rod 120 may be secured directly to the lowest section 122B of the drill rod 121, but for a reason hereinafter explained, I prefer to insert a flight 123, shown in Figs. 12 to 15, between the upper end of the swivel rod 120 and the lower end of the drill rod 121. When this is done, the upper end of the swivel rod 120 is secured by means of a coupling 124 to the lower end of the stem 125 of the flight 123, while the upper end of the cylinder 126 of the flight is secured by a coupling 127 to the lower end of the bottom section 122B of the drill rod 121. The upper end of the drill

rod 121 is secured to a hollow grief stem 128 which is suspended from the travelling block 13 of the derrick 12 through a water swivel 129 and a hydraulic lift 130 (see Figs. 1, 3, 4) which is hereinafter described. As shown in Fig. 4 the grief stem 128, which is square in cross-section, is rotated by a power driven rotary head 131 of usual construction. The rotation thus imparted to the grief stem 128 and the drill rod 121 is transferred to the swivel rod 120 by the flight 123, which is formed to prevent relative turning of its cylinder and stem, and thence through the flexible shaft 115 to the drill chuck 105.

The means for feeding the drill forward while it is in operation comprises apparatus for applying fluid pressure to the rear end of the drill. This apparatus includes a pump 135 adapted to force water into the upper end of the grief stem 128 through a pipe 136 and the water swivel 129 (Fig. 1). The water passes down through the drill rod 121, through the flight 123, and into the hollow hydraulic swivel rod 120. The water flows out of this rod through lateral openings 137 near its lower end, (Fig. 11) and from this point the water is conducted to the drill by means of a flexible tube 140. As shown in Fig. 11 the upper end of this tube is connected to a short rigid pipe 141 which surrounds the lower portion of the hollow hydraulic swivel rod 120 and is supported from this rod by means of a swivel member 142 which is rotatably mounted on the rod 120 and supported by thrust bearings 143 engaging an external flange 144 on the rod 120. Leakage of water from the upper end of the pipe 141 is prevented by a packing 145. It will be noted that the arrangement described permits rotation of the rod 120 without rotation of the pipe 141 or the flexible tube 140, and that it also forces water descending through the hollow swivel rod 120 to flow down through the flexible tube 140. As shown in Fig. 16, the lower end of the flexible tube 140 is secured to the inner end of the bearing cylinder 101 of the drill. It will be noted, that when the drill is being lowered in the pipe 20 the entire weight of the drill 15 and the flexible tube 140 and the flexible shaft 115 is supported by the hollow sectional drill rod 121.

The water which enters the rear end of the bearing cylinder 101 from the lower end of the flexible tube 140 passes forward between the fluted inner wall 103 of the cylinder 101 and the outer surface of the coupling piece 116 and enters the chamber 107 in the drill chuck 105 through inclined radial holes 146. The water is pumped in so fast that a substantial pressure is maintained in the chamber 107 notwithstanding the escape of water from the chamber through the passages 113, and in consequence the drill is urged forward by hydraulic pressure. At

the same time the water which flows out of the chamber through the passages 113 serves to wash away the detritus formed in drilling. This water passes back along the fluted outer surface 104 of the cylinder 101, rises to the top of the well in the space provided between the casing 11 and the pipe 20, and flows out through the radial openings 84 in the head 70.

As the drill 15 with the flexible shaft 115 and the flexible tube 140 are lowered into the pipe 20 after the pipe has been placed in position within the casing 11, it is desirable to provide means for indicating at the top of the well the instant at which the drill reaches the elbow 21. The electrical indicating means hereinbefore described in connection with the operation of the elbow may be used for this purpose. In order to make such use of these means, the elbow sections are swung into operative position before the drill is lowered into the pipe 20 and the upper end of the cable 40 is held by a frictional grip (for example by a frictional brake applied to the drum 44) with sufficient force to resist the downward pull caused by the weight of the elbow sections. The indicating lamp 61 then remains lighted. The drill and the apparatus for rotating it are then lowered into the pipe 20. As soon as the front end of the drill strikes the elbow section 26 in the course of its descent, the weight of the drill causes an extra strain on the cable 40 which is too great to be resisted by the frictional grip in which the cable is held. The elbow sections then sag down somewhat, breaking the electric circuit and extinguishing the lamp 61. As soon as the lamp goes out the lowering of the drill is stopped. The cable 40 is slackened to allow the elbow sections to hang down vertically and the drill is then lowered a measured distance so as to bring the face of the cutting head of the drill substantially at the front end of the elbow section 28. The elbow is again drawn into operative position, bringing the drill into position to start a lateral hole.

In the form of the apparatus illustrated, however, indicating means separate from the electric circuit are provided for indicating the instant at which the drill has been lowered to the elbow. By the use of separate indicating means for this purpose, the necessity of twice raising the elbow into operative position is avoided. The separate indicating means illustrated include the valve 114 located in the chamber 107 of the chuck 105 and means for operating this valve. The valve 114, as shown in Fig. 16, is mounted on a valve rod 148 on whose outer end is a square plunger 149 which is free to slide longitudinally in a square axial hole 150 in the cutting head 108. A compression spring 151 thrusts the plunger 149 outward and brings the valve 114 over the inner ends of

the passages 113. At the outer end of the plunger 149 is a pointed projection 152 in which diamonds 153 are fastened. In the normal position of the parts shown in Fig. 16, the foremost of the diamonds 153 is in advance of the front face of the cutting head 108. A stirrup 154, shown in Figs. 5 and 6, is provided to operate the plunger 149. This stirrup is pivotally secured to the outer end of the elbow section 28. When the elbow sections are depending in inoperative position this stirrup hangs across the outer end of the outer section 28 as shown in Fig. 6, and in dotted lines in Fig. 5. This, therefore is the position occupied by the stirrup while the drill is lowered into the pipe 20. While the drill is being lowered, hydraulic pressure is maintained in the chamber 107 by applying pressure to the upper end of each section of the hollow rod 121 as the sections are attached and lowered. Since the valve 114 is normally closed, a pressure may be maintained in the chamber 107 without pumping in any more water than escapes through small openings 155 provided in the valve. The water which passes through these openings accumulates in the well and partially balances the internal pressure within the drill chuck and the drill rod 121.

When the drill has reached the outer portion of the elbow in its descent the projection 152 on the plunger 149 strikes the stirrup 154, forcing the plunger inwardly and opening the valve 114. This permits water to pass out of the chamber 107 freely through the passages 113, causing a reduction of pressure in the drill rod 121 which can readily be detected by a pressure gauge 156, applied to the pipe 136. Consequently, the moment at which the drill reaches the outer end of the elbow is indicated at the top of the well. As soon as this occurs, the drill is hoisted a few inches, drawing the projection 152 out of contact with the stirrup 154 and permitting the valve 114 to close. The drill is held out of contact with the stirrup while the flexible elbow is swung up into operative position, so that as the elbow is swung up the stirrup swings down until it lies below the lower surface of the elbow section 28, as shown in Fig. 5, so that it does not interfere with forcing the drill out through the end of the elbow and against the wall of the cavity 14 in which the lateral hole is to be bored, the projection 152 on the plunger 149 strikes this wall, forcing the plunger inwardly and opening the valve 114. The valve is in this way held open during the drilling operation.

Means are provided for controlling the forward movement of the drill 15 in the drilling of a lateral hole. The means for this purpose illustrated in the drawings include the hydraulic lift 130 which connects the travelling block of the derrick and the grief stem 128 from which the drill rod 121 is suspended,

and the flight 123 which connects the drill rod 121 and the swivel rod 120 from which the flexible shaft 115 and the flexible tube 140 and the drill 15 are suspended.

5 The hydraulic lift 130 comprises a cylinder 160, the upper end of which is suspended from the travelling block 13 of the derrick. Within the cylinder is a plunger 161, and a plunger rod 162 extends through a packing
10 at the lower end of the cylinder. At the lower end of the plunger rod is a hook 163 to which is secured the upper end of the water swivel 129 to which is attached the grief stem 128. A force pump 164 is provided for forcing
15 water into the cylinder 160 below the plunger 161. A pipe 165 leads from the pump 164 to an opening 166 in the lower end of the cylinder. A manually operated three-way valve 167 provides means for connecting
20 the pipe 165 either with the discharge of the pump 164 or with an outlet. A safety valve 168 is connected to the pipe 165.

The extensible rotation-transmitting connecting device, or flight, 123, shown in Figs. 12 to 15, comprises a cylinder 126 and a stem 125. The stem 125 consists of a square pipe 170, which fits in a square hole in a plug 171
25 fixed in the lower end of the cylinder 126, and a nipple 172 secured to the lower end of the pipe 170. The hollow swivel rod 120 from which the drill is supported is secured to this nipple by means of a coupling 124. A plunger 173 is secured to the upper end of
30 the pipe 170. This plunger fits against the inner wall of the cylinder 126. It contains a small central opening 174 which permits water descending in the drill rod 121 to pass slowly through the flight into the rod 120 regardless of the position of the stem 125 in
35 the cylinder 126. The plunger 173 also contains two ports 175 which have the form of longitudinal tapering grooves in its side wall. As the stem 125 is moved to its highest position in the cylinder 126 these ports are gradually
40 closed by means of wedge-shaped longitudinal strips 176 secured to the inner side wall of the cylinder near its upper end. The water which passes down through the ports 175 when the stem is not at its highest point enters the space between the cylinder and
45 the square pipe 170 and thence flows into the stem through transverse ports 177 formed in the square pipe 170 just below the plunger 173. When the stem is in its lowest position
50 in the cylinder, as shown in Fig. 13, the part of the stem containing the ports 177 enters the hole in the plug 171 so that these ports are closed.

It is apparent from the above description
60 that, while a small flow of water through the flight is always permitted by the hole 174, a rapid flow of water through the ports 175 and 177 is permitted except when the stem is either in its uppermost or lowermost position
65 in the cylinder.

The use of the apparatus which has been described in controlling the forward movement of the drill 15 is as follows:—After the pump 135 has been placed in operation to
70 force water into the upper end of the drill rod 121, the three-way valve 167 is turned to permit the escape of water from the cylinder 160 of the hydraulic lift 130. This allows the piston 161 to descend, lowering the drill
75 rod 121 until the cylinder 126 of the flight 123 slides down over the stem 125 of the flight to the position shown in Fig. 12. The moment at which the lowering should be stopped by closing the three-way valve is indicated by a
80 rise of pressure on the gage 156 which is caused by the closing of the ports 175 of the flight. The drill rod 121 is then raised slightly by turning the three-way valve 167 so that the pump 164 forces water into the cylinder
85 160 of the hydraulic lift 130. As soon as the pressure indicated on the gage 156 drops, indicating that the ports 175 have been opened, the three-way valve is again closed. The hydraulic pressure applied to the back of the
90 drill 15 by the pump 135 forces the drill forward, and the drill draws with it the flexible shaft 115, the flexible tube 140, and the hydraulic swivel rod 120 to which they are attached. The stem 125 of the flight 123 is
95 therefore drawn down within the cylinder 126 of the flight. When the stem has descended far enough to close the ports 177 of the flight, the checking of the flow of water through the flight is apparent from a rise in
100 pressure on the gage 156. The three-way valve 167 is then turned to permit the escape of water from the hydraulic cylinder 160, allowing the drill rod 121 and the cylinder 126 of the flight to descend until it again slides
105 down over the stem 125 to the position shown in Fig. 12. The operation which has been described is then repeated. Obviously, the variations in hydraulic pressure may easily be detected by observing the action of the pump, but the gage is most desirably used.

By proper adjustment of the safety valve 168 the feeding of the drill may be made automatic. This is because the checking of the
110 flow of water through the flight when the stem of the flight has been drawn down far enough to cover the ports 177 causes an increased pull on the plunger 161 of the hydraulic lift. The safety valve 168 may be adjusted
115 so that it will remain closed under the pressure maintained in the hydraulic cylinder 160 by the pull on the plunger 161 during normal operation of the drill, that is, when the ports 177 are open and the drill is feeding normally, but will open under this increased pull.
120 The opening of the safety valve 168, permitting escape of water from the hydraulic cylinder 160, lowers the drill rod 121 and the cylinder 126 of the flight so that the ports 177 of the flight are uncovered. When this occurs the extra pull on the plunger 161 ceases
130

and the safety valve 168 automatically closes. It remains closed until the drill has been forced forward far enough to draw the stem 125 of the flight down sufficiently to close the ports 177 again. The safety valve then automatically opens again, lowering the drill rod further.

Such automatic feeding of the drill may be obtained by means of the hydraulic lift and safety valve without the use of the flight, provided that the weight of the parts supported by the hydraulic lift is not great and the safety valve is designed to operate on a slight change of pressure. I find it desirable, however, to use the flight except when a lateral hole is to be drilled at a comparatively short distance below the surface of the ground.

As the drilling proceeds the plunger 161 is periodically raised by turning the three-way valve 167 to admit water to the hydraulic cylinder 160, to raise the grief stem 128 for the insertion of an additional drill rod section just below the lower end of the grief stem. If the hydraulic lift is shorter than the grief stem the travelling block 13 of the derrick is raised by the draw-out works when a new drill rod section is inserted.

The apparatus which has been described provides a practical means for increasing the yield of oil wells by tapping oil bearing sand or rock located at one side of the well. It may be used also to render dry wells productive. It is useful also in connection with mining and tunneling, and for other purposes not connected with the production of oil.

It will be apparent to those skilled in the art that the form and arrangement of various parts of the apparatus described may be changed without changing their functions, and that mechanical equivalents may be substituted for some parts of the apparatus illustrated. I wish it clearly understood, therefore, that my invention is by no means limited to the particular form and arrangement of the parts of the apparatus described. Furthermore, certain features of this apparatus may under some circumstances advantageously be used without other parts of the apparatus, and some features, for example those connected with controlling the feed of the drill, may be used in connection with straight drilling. I wish it understood, therefore, that my invention includes all the novel features of apparatus shown regardless of the particular use to which they may be put.

What is claimed is:

1. Lateral drilling apparatus, comprising the combination with a rotary drill and flexible means for rotating said drill and forcing it forward, of means for placing said drill in a cavity in a well with its axis parallel to the axis of the well, and means operable

from the top of the well to turn said drill in said cavity so as to bring its axis at a predetermined angle to the axis of the well.

2. Lateral drilling apparatus, comprising the combination with a rotary drill and flexible means for rotating and feeding said drill, of means for positioning said drill in a cavity in a well, comprising a rigid pipe extending from the top of the well to the cavity, a flexible elbow secured to the lower end of said pipe and normally extending in line therewith, and means operable from the top of the well for flexing said elbow so as to bring the axis of its outer end at a predetermined angle to the axis of the well.

3. In lateral drilling apparatus, the combination of a rigid pipe, a drill-directing flexible elbow secured to the lower end of said pipe and consisting of a plurality of tubular sections hinged together so that they normally hang in line with said pipe, and means operable to draw said sections out of line with said pipe.

4. In lateral drilling apparatus, the combination of a rigid pipe, a drill-directing flexible elbow secured to the lower end of said pipe and consisting of a plurality of tubular sections hinged together on parallel transverse pivots so that they normally hang in line with said pipe, and means operable to draw said sections out of line with said pipe.

5. In lateral drilling apparatus, means for positioning a drill in a cavity in a well, comprising a rigid pipe extending from the top of the well to the cavity, a flexible elbow secured to the lower end of said pipe and consisting of a plurality of tubular sections hinged together so that they normally hang in line with said pipe, and a flexible tension member secured to the outer section and extending to the top of the well so that the sections may be swung out of line with the pipe by a pull applied to said member.

6. In lateral drilling apparatus, means for positioning a drill in a cavity in a well, comprising a rigid pipe extending from the top of the well to the cavity, a flexible elbow secured to the lower end of said pipe and consisting of a plurality of tubular sections hinged together so that they normally hang in line with said pipe, and a flexible tension member secured to the outer section and extending to the top of the well so that the sections may be swung out of line with the pipe by a pull applied to said member, the sections being formed so that their adjacent ends come into contact with each other to arrest such swinging when the axis of the outer section is at a predetermined angle to the axis of the pipe.

7. In lateral drilling apparatus, means for positioning a drill in a cavity in a well, comprising a rigid pipe extending from the top of the well to the cavity, a flexible elbow secured to the lower end of said pipe and con-

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 sisting of a plurality of tubular sections hinged together so that they normally hang in line with said pipe, a flexible tension member secured to the outer section and extending to the top of the well so that the sections may by swung out of line with the pipe by a pull applied to said member, the sections being formed so that their adjacent ends come into contact with each other to arrest such swinging when the axis of the outer section is at a predetermined angle to the axis of the pipe, and means for indicating at the top of the well the moment at which the adjacent ends of the sections come into engagement with each other.

8. In lateral drilling apparatus, means for positioning a drill in a cavity in a well, comprising a rigid pipe extending from the top of the well to the cavity, a flexible elbow secured to the lower end of said pipe and consisting of a plurality of tubular sections hinged together so that they normally hang in line with said pipe, a flexible tension member secured to the outer section and extending to the top of the well so that the sections may be swung out of line with the pipe by a pull applied to said member, and adjustable abutments on said sections to arrest such swinging when the axis of the outer section is at a desired angle to the axis of the pipe.

9. In lateral drilling apparatus, means for positioning a drill in a cavity in a well, comprising a rigid pipe extending from the top of the well to the cavity, a flexible elbow secured to the lower end of said pipe and consisting of a plurality of tubular sections hinged together so that they normally hang in line with said pipe, a flexible tension member secured to the outer section and extending to the top of the well so that the sections may be swung out of line with the pipe by a pull applied to said member, adjustable abutments on said sections to arrest such swinging when the axis of the outer section is at a desired angle to the axis of the pipe, and means for indicating at the top of the well the moment when said abutments come into contact with each other.

10. In lateral drilling apparatus, means for positioning a drill in a cavity in a well, comprising a rigid pipe extending from the top of the well to the cavity, a flexible elbow secured to the lower end of said pipe and consisting of a plurality of tubular sections hinged together so that they normally hang in line with said pipe, a flexible cable secured to the outer section and extending to the top of the well so that the sections may be swung out of line with the pipe by a pull applied to said cable, adjustable abutments on said sections to arrest such swinging when the axis of the outer section is at a desired angle to the axis of the pipe, and indicating means comprising an electric circuit including a source of electromotive force and an indicator lo-

cated at the top of the well, electric conductors extending within said flexible cable, and contact pieces mounted on one of said sections and arranged to come into contact with each other at the moment when said abutments arrest the swinging of the elbow.

11. In lateral drilling apparatus, means for positioning a drill in a cavity in a well, comprising a rigid pipe extending from the top of the well to the cavity, a flexible elbow secured to the lower end of said pipe and consisting of a plurality of tubular sections hinged together so that they normally hang in line with said pipe, a flexible tension member secured to the outer section and extending to the top of the well so that the sections may be swung out of line with the pipe by a pull applied to said member, indicating means comprising an electric circuit including a source of electromotive force and an indicator located at the top of the well, electric conductors extending downwardly in the well, contact pieces mounted on one of said sections and arranged to come into contact with each other at the moment that the swinging of the elbow is arrested by said abutments, and a casing surrounding portions of said contact pieces to exclude liquid from their contact surfaces so that liquid in the well cannot cause a short circuit between them.

12. In lateral drilling apparatus, drill positioning means comprising a rigid sectional pipe extending downwardly into a well, a hollow spud containing a lateral opening and secured to the lower end of said pipe, supporting means secured to the lower end of said spud and resting on the bottom of the well to support a part of the weight of said sectional pipe, a flexible elbow communicating with the lower end of the rigid pipe and normally depending within said spud, and means for swinging the said elbow outwardly through the opening in the spud so as to bring the axis of the outer end of the elbow at an angle to the axis of the rigid pipe.

13. In lateral drilling apparatus, drill positioning means comprising a blow-out head secured to the upper end of a well casing and containing radial openings, a rigid sectional pipe having its upper end secured in said blow-out head and extending down within the well casing to the bottom thereof, a flexible elbow secured to said rigid pipe section and consisting of a plurality of tubular sections hinged together, and a flexible cable secured to the outer section passing between said rigid sectional pipe and the well casing to the top of the well casing and passing out through one of the radial holes in the blow-out head.

14. In lateral drilling apparatus, drill positioning means comprising a blow-out head secured to the upper end of a well casing, a rigid pipe extending down within the well

casing to the bottom thereof, means for detachably securing said rigid pipe in said blow-out head, an elbow secured to the lower end of the rigid pipe, a clamp secured to the rigid pipe above the blow-out head, and means co-operating between the clamp and the blow-out head to prevent turning of the clamp from various different positions in which it may be set.

15. In lateral drilling apparatus, the combination of a rigid pipe terminating in an elbow, a flexible tube within said rigid pipe and passing through said elbow, a drill attached to the end of said flexible tube, means for operating said drill, a hollow rod within said rigid pipe and secured to the rear end of said flexible tube, and means for forcing fluid under pressure into the upper end of said hollow rod so that said fluid passes through the rod and the flexible tube and applies pressure to the drill to force it forward.

16. Apparatus for drilling a lateral hole from a well, comprising a rigid pipe extending into the well and terminating in an elbow, a hollow drill rod extending downwardly in the well within said rigid pipe, a flexible tube within said rigid pipe and passing through said elbow, a swivel connection between the lower end of the drill rod and the upper end of the flexible tube adapted to direct liquid from the rod into the tube and to permit rotation of the rod without rotation of the tube, a drill rotatably mounted at the outer end of the tube, and a flexible shaft within the flexible tube connecting said drill with the drill rod.

17. Apparatus for drilling a lateral hole from a deep well, comprising a rigid pipe extending into the well, a flexible elbow secured to the lower end of said pipe, a rotary drill, means for lowering said drill into said pipe, and means for indicating at the top of the well when said drill reaches said elbow.

18. Means for drilling a lateral hole from a deep well, comprising a rigid pipe extending into the well, a flexible elbow secured to the lower end of said pipe and adapted normally to hang in line with said pipe, means for swinging said elbow up out of line with said pipe, a stop pivoted at the outer end of said elbow so as to hang across its outer end when the elbow is in its normal position and to leave the outer end of the elbow unobstructed when the elbow is swung up, a drill having a longitudinal passage therethrough, a spring-actuated valve normally closing said passage, an actuating member for opening said valve projecting from the front surface of the drill, means for lowering said drill in said pipe, means for applying a fluid pressure to the rear end of the passage in the drill while it is being lowered, and means at the top of the well for indicating such pressure.

19. In drilling apparatus, the combination of a hollow power-driven rotating drill rod extending into a well, a rotary drill for cutting by rotary motion, connecting means between the lower end of the drill rod and the drill adapted to rotate the drill and to conduct liquid from the drill rod to the drill, a flight in said drill rod, means for obstructing the flow of water through the drill rod when the flight reaches its extreme position in one direction, and means controlled by the water pressure in the drill rod for indicating when the flight has reached such position.

20. In drilling apparatus, the combination of a hollow power-driven rotating drill rod extending into a well, a rotary drill for cutting by rotary motion, connecting means between the lower end of the drill and the drill rod adapted to rotate the drill and to conduct liquid from the drill rod to the drill, means for supplying liquid under pressure to said drill rod to apply fluid pressure to the drill to urge it constantly against the end of the drilled hole, a flight in said drill rod, and means for obstructing the flow of water through the drill rod when the flight reaches its extreme position in one direction.

21. In drilling apparatus, the combination of a hollow drill rod extending into a well, a drill, connecting means for suspending said drill from the lower end of said drill rod and rotating the drill and for conducting liquid from said rod to the drill, a flight in said drill rod, means for obstructing the flow of water through the drill rod when the flight is at its extreme position in each direction, and means controlled by the water pressure in the drill rod for indicating when the flight has reached such position.

22. Apparatus for drilling a lateral hole from a well, comprising a rigid pipe extending into the well and terminating in an elbow, a hollow drill rod extending downwardly in the well within said rigid pipe, a drill, a flexible connection between a lower end of the drill rod and the drill providing means for transferring rotation of the rod to the drill and means for directing water from the drill rod to the drill, a flight in the drill rod, and means for obstructing the flow of water through the drill rod when the flight is at its extreme position in each direction.

23. In drilling apparatus, the combination of a drill, a hydraulic lift, a hollow drill rod suspended from said lift and connected to the drill, means for forcing liquid into said hollow drill rod to apply pressure to the drill, and an escape valve connected to said hydraulic lift and arranged to open when the pull on said lift is greater than the pull thereon during normal operation of the drill.

24. In drilling apparatus, the combination of a drill, a hydraulic lift, a hollow drill rod suspended from said lift and connected to the

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drill, a flight in said drill rod, means for forcing liquid into said hollow rod to apply pressure to the drill, and an escape valve connected to said hydraulic lift and arranged
5 to open when the pull on said lift is greater than the pull thereon during normal operation of the drill.

25. In drilling apparatus, the combination of a drill, a hydraulic lift, a drill rod suspended from said lift and connected with said
10 drill, means for forcing water into said drill rod to apply fluid pressure to the drill, a pressure indicator on said forcing means, a flight in said drill rod, and means for obstructing
15 the flow of water through the drill rod when the flight is at its extreme position in either direction.

26. In drilling apparatus, the combination of a hollow drill rod, a hollow cylinder secured to the lower end of the drill rod, a hollow stem slidably mounted in said cylinder and containing a lateral port, means limiting the sliding movement of said stem in each direction, means for preventing turning of
25 said stem with respect to said cylinder, a plunger on said stem fitting within said cylinder and containing a port, means for closing the port in said plunger when the stem is at its extreme position in one direction, means
30 for closing the port of said stem when the stem is at its extreme position in the other direction, a drill, and a connection between said stem and said drill providing means for transferring rotation of the stem to the drill
35 and for conducting water from the stem to the drill.

27. In lateral drilling apparatus, the combination of a flexible elbow, means for positioning said elbow in a cavity in a well with
40 its axis in line with the axis of the well, and means operable from the top of the well for flexing said elbow so as to bring the axis of its outer end at a predetermined angle to the axis of the well, a flexible shaft extending
45 through said elbow, and a drill at the end of said shaft.

28. In lateral drilling apparatus, the combination of a hollow drill rod, a hollow swivel rod secured to the lower end of the drill rod
50 and containing a lateral outlet, a pipe surrounding said swivel rod and providing a bearing in which said rod may rotate, means surrounding said swivel rod to prevent liquid from flowing out of the upper end of said
55 pipe, a flexible tube having its upper end secured to the lower end of said pipe, a drill rotatably mounted in the lower end of said flexible tube, and a flexible shaft lying within said flexible tube and connecting the lower
60 end of the swivel rod with the drill.

In testimony whereof I have hereunto set my hand.

BERNARD GRANVILLE.