June 22, 1965 J. CAPERAN ETAL 3,190,374

SOIL DRILLING APPARATUS HAVING MEANS TO CHANGE THE DIRECTION OF THE DRILL

Filed Dec. 22, 1960 2 Sheets-Sheet 1

Fig. 1.

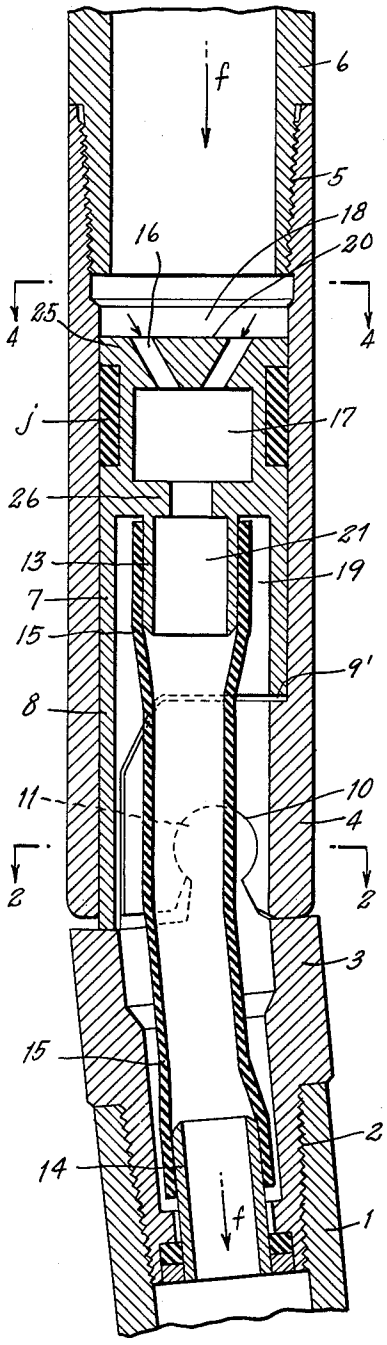


Fig. 4.

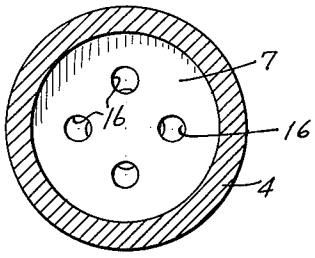


Fig. 3.

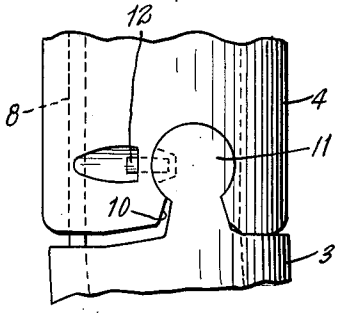
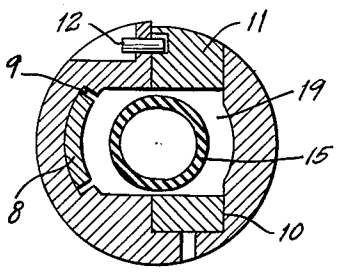


Fig. 2.



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SOIL DRILLING APPARATUS HAVING MEANS TO CHANGE THE DIRECTION OF THE DRILL

Filed Dec. 22, 1960 2 Sheets-Sheet 2

Fig. 5.

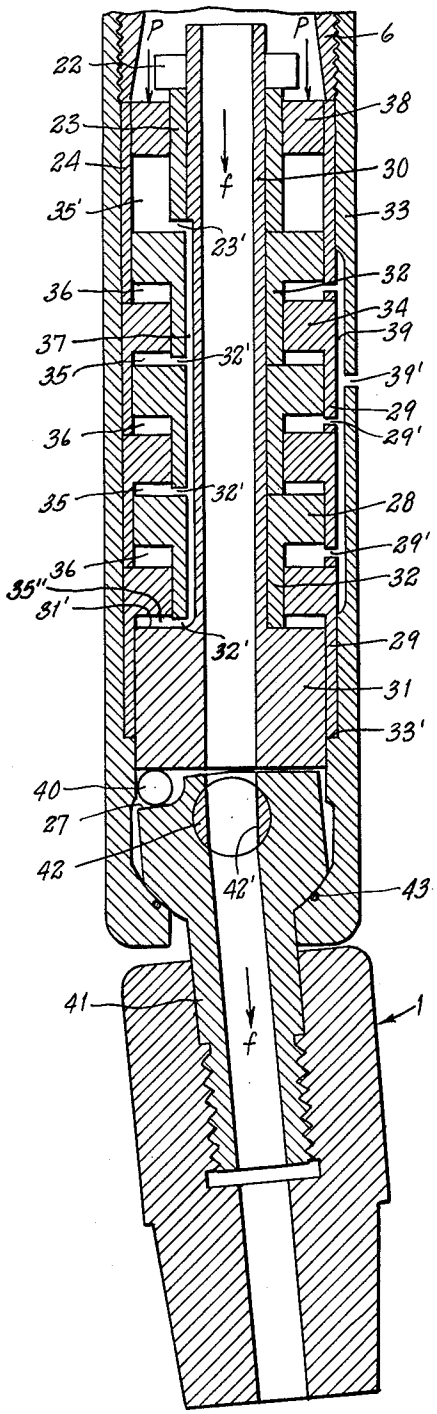
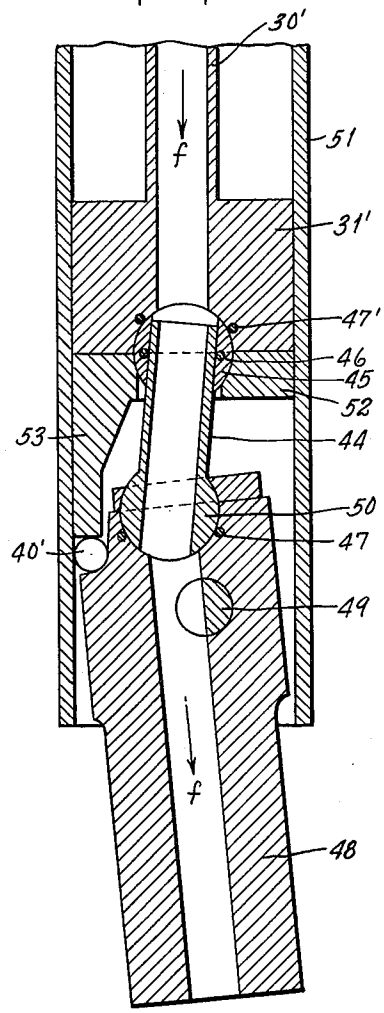


Fig. 6.



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3,190,374

SOIL DRILLING APPARATUS HAVING MEANS TO CHANGE THE DIRECTION OF THE DRILL

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7 Claims. (Cl. 175—74)

This invention relates to soil drilling apparatus and is particularly concerned with the type of apparatus employed in seeking for oil.

In the search for oil, the method by which the shaft is sunk into the earth depends upon the type of the terrain and the drilling conditions that will be encountered. Thus, such factors will determine the axis projection of the hole, both vertically and horizontally, that should be followed in reaching for the given objective. But however carefully these calculations are made, it is still difficult to determine in advance the actual profile the proposed shaft will take in reaching the objective. For example, in order to reach a certain objective it may be considered necessary to drill a non-vertical shaft which would be difficult to attain because of the terrain on which the drilling rig is to be mounted, as in the case of ocean shore, mountains, etc. It may also happen that in drilling a shaft diverging from the vertical plane of the objective, the forces of gravity will be superior to the deviating applied forces with the consequence that the objective may not be attained.

In its efforts to overcome the difficulties of following a predetermined profile for the shaft to be drilled, the art has proposed various methods of "controlled drilling" designed to control the path of the drilling tool as it progresses through the earth by creating periodically, accurately applied deviating forces on a control device capable of causing the drilling tool to gradually correct its course so as to maintain itself on the predetermined path. To this end, the art has proposed for example, the coupling of the drilling tool to an underground turbine whose stator is rigidly connected to perpendicularly operating pistons by a special fitting, known as an elbow bushing and composed of two threaded members fixed in converging relation so as to form an angle of from 1 to 3 degrees between them. This type of construction has been employed with some success, but its degree of deviation is not very large. In fact, the angle of such elbow bushing cannot be increased for the purpose of increasing the deviation forces, because of the difficulties that will then be encountered in raising or lowering the pistons in the shaft.

It is the primary object of the present invention to provide an improved device capable of satisfactorily producing substantially greater changes in the direction of the course of the drill through the earth than the devices heretofore known.

In accomplishing this object, the present invention provides a device for use in conjunction with an underground motor, such as a drilling turbine, or with any other drilling apparatus carried by a fixed joined assembly of pistons, and operable to maintain a fairly rectilinear piston operation in the straight parts of the hole being bored, but adapted to create substantial deviating forces to change the course of the drilling apparatus to the extent desired.

The device of the invention is mounted between the underground motor and the drilling string of the apparatus and essentially comprises a hollow bushing formed in two pivotally connected sections and operable by the pressure of the drilling fluid on a part thereof to control the inclination of the motor. In accordance with a preferred form of the invention, the upper section of the bushing is connected to the drill string of the apparatus

and is constructed to provide the axis of articulation for the lower section. The upper section further carries a piston having an extension or push member that is arranged on movement of such piston to cause the lower section of the bushing which is connected to the turbine, to assume an inclined position with relation to the upper section. The deviating force exerted by the push member on the lower section is the resultant of a difference of opposing pressures applied to upper and lower faces of the piston.

The device of the invention is constructed so that the aforesaid upper face of the piston is subjected to the pressure of the drilling fluid that is pumped down through the interior of the drill string, and in opposition to complementary pressures present in an annular space between the pistons and in a central chamber extending the height of the device. This difference between these two opposing sets of pressures, which is due to the loss of force of the drilling fluid as it passes through the device and the turbine and starts to rise again in the annular space around the turbine, creates a substantial axial force on the top of the piston in the device and which is applied through the push member thereof as an intermediary, on the lower section of the bushing so as to give the latter an inclination corresponding to such force.

It will become evident that the creation of the force for inclining the lower section of the bushing can only take place while the drilling fluid or sludge is circulating and the turbine is operating. When the sludge stops circulating, the turbine axis will take the direction most favorable to the operation of the drilling pistons and such as to enable them to progress with least resistance from the walls of the hole.

A reduction in the generated amount of differential pressure on one or the other part of the piston of the device hereof can be accomplished by the underground motor and/or by any other device, such as a nozzle, labyrinth, or hydraulic receptor, used either singly or in combination. In the event, the resultant axial force obtained by the variance of pressure on the two faces of such piston would be insufficient to actuate the lower section of the elbow to the desired inclination, one can in accordance with the invention, employ a plurality of such pistons disposed in series and connected with one another. In such a construction, each of the pistons in the series is subjected to the resultant force created by the action of the varying pressures of the drilling fluid on its upper and lower faces, and the resulting combined axial thrusts of such pistons would provide sufficient force to accomplish the desired inclination of the lower section of the elbow.

The orientation of the drilling apparatus at the bottom of the hole has effect on the surface, in accordance with known procedures, in the angle of rotation of the drill table which may be disposed at a given angle corresponding to the torsion angle of piston operation, or corrected directly after the extent and position of the deviation of such apparatus has become known.

Embodiments of the device of this invention are shown by way of example in the accompanying drawings, in which

FIG. 1 is a vertical sectional view of a single pistoned device embodying the invention;

FIG. 2 is a horizontal sectional view taken along the line II—II of FIG. 1;

FIG. 3 is a detailed view of the pivotal connection between the two sections of the device;

FIG. 4 is a horizontal sectional view taken along the line IV—IV of FIG. 1;

FIG. 5 is a vertical sectional view of a device embodying the invention and provided with a series of connected pistons; and

FIG. 6 is a modified form of the device shown in FIG. 5.

Referring now more particularly to FIGS. 1 to 4 of the drawings, the reference numeral 1 indicates the upper part of a drilling turbine of known construction such as shown for example in U.S. Letters Patent 3,018,997 issued January 30, 1962. The turbine part 1 is connected by means of a screw thread 2 to the lower section 3 of the device of the invention which is termed an elbow bushing. The reference numeral 4 designates the upper section of the bushing which is connected at its upper end by means of a thread 5 to the lower end of the drill string constituted of an aligned series of drill pipes 6 of known construction. The drilling fluid circulates through the drill pipes 6 and the bushing sections 3, 4 and into the turbine in the direction of the arrows *f* in FIG. 1.

The upper bushing section 4 is tubularly-shaped and functions as a cylinder housing for a cylindrically-shaped piston 7 which is located in an intermediate portion of such section and which is limited in its downward movements in such section by an inwardly extending split circular shoulder 9' formed by an increase in the wall thickness of the lower end portion of the section. The wall of the lower end portion of the upper section is formed so that the ends of the split shoulder 9' connect with the upper ends of the side walls of an interior vertically disposed keyway 9 which extends downwardly from such shoulder to the lower end of the upper bushing section 4. Slidably mounted in the keyway 9 is a depending extension 8 of the piston 7. The extension 8 and keyway 9 prevent any rotative movement of the piston 7 and such extension is of sufficient length to project a substantial distance below the lower end of bushing section 4 when the piston 7 is seated on the shoulder 9'. The engagement of the piston 7 with the inner wall of bushing section 4 is made watertight by a suitable packing ring *j* provided in an annular recess at the upper end of piston 7.

The lower end of the extension 8 of piston 7 bears against the upper rim of the lower bushing section 3 which is also tubularly-shaped and which is pivotally connected to the upper bushing section 4 by a ball and socket joint formed to confine the pivotal movements of section 3 about a horizontal axis that is perpendicular to the axis of the upper section 4 and in substantial parallelism with a transverse line on extension 8 which in the construction shown may be a chord (note FIG. 2). The ball and socket joint between sections 3 and 4 is composed of two diametrically opposed sockets 10 provided in the lower end portions of section 4 and two upwardly projecting diametrically opposed, extensions 11 of the wall of section 3. The upper ends of the extensions 11 and the portions of the sockets 10 in which they are received are circularly-shaped and of a diameter greater than the width of the mouths of such sockets so that the lower section is supported in depending pivoted relation on the upper section 4 by such ball and socket joint 10, 11. This connection is locked by an adjustable pin 12 in FIGS. 2 and 3 threadedly carried by the upper section 4 and extending into a recess provided in the upper circular end of at least one of the extensions 11. It will be noted that the pin 12 is horizontally disposed at right angles to the pivotal axis of section 3 and the said recess is sufficiently enlarged so that the desired pivotal movements or articulation of section 3 are not interfered with.

Fitted in watertight relation in the lower end of the bore of the lower bushing section 3 is an inwardly and upwardly directed pipe section 14 forming a coupling connection for the lower end of a flexible hose 15 which extends upwardly through section 3, through the ball and socket joint 10, 11 and up into piston 7. The upper end of the hose 15 is coupled to a downwardly projecting tubular section 13 formed inside of piston 7 and communicating at its upper end with the fluid passageway in the drilling pipes 6. It will thus be seen that the piston 7 and the hose 15 serve as a portion of the sludge conduit, the latter conducting the drilling fluid past the ball and socket joint of sections 3, 4 and to the turbine 1.

It will be understood from the foregoing that the upper section 4 of the devices of this invention is fixed with relation to the drill pipes 6 so that its longitudinal axis is fixed with and forms an extension of the longitudinal axis of such drill pipes. Thus any elbow articulation which takes place in the device will be a movement of the lower section 3 about the fixed pivotal axis of the ball and socket joint 10, 11 under the force exerted on an upper end portion thereof offset from such axis by the extension 8 which functions as a push member. The pushing force applied to the extension or push member 8 is created by the piston from the forces in the drilling fluid delivered to the turbine by the drill pipes 6 and returning upwardly in the annular space around the drilling apparatus.

As is shown more clearly in FIGS. 1 and 2, the piston 7 is closed at its upper end by a transverse wall 25 whose upper face 20 is opposed to the flow of the drilling fluid from the pipes 6 and which forms the upper wall of a chamber 17 formed in the upper end portion of such piston. The bottom wall 26 of chamber 17 is provided with a discharge opening of less diameter than the interior diameter of the tubular section 13 which depends therefrom. The opening in wall 26 brings the chamber 17 into communication with the chamber 21 enclosed at its upper end by such tubular section 13 and defined by the hose 15. It will be noted in FIG. 1 that the exterior diameter of tubular section 13 is less than the interior diameter of the enclosing wall portion of piston 7 so that there is formed therebetween an annular chamber 19 which is closed at its upper end by the bottom wall 26 of chamber 17.

The upper wall 25 of chamber 17 is provided with a plurality of passages or nozzles 16 whose longitudinal axes coverage toward the center of chamber 17. Thus the drilling fluid discharged by the drill pipes 6 passes in the form of jets through the nozzles 16 and into chamber 17; the jet energy of the fluid streams discharged by the nozzles 16 being dissipated in chamber 17 which is constructed so that it is protected against the abrasive action of the fluid projected into such chamber.

It will be observed that in the space 18 above piston 7, the drilling fluid from the drill pipes 6 will be applying its full force against the upper face 20 of the piston 7. In opposition to this downward force on such upper face 20 are two smaller complementary forces. One of these complementary forces is the force remaining in the drilling fluid contained in the central chamber 21 inside the hose 15 after the energy of the jets through nozzles 16 has been dissipated in chamber 17, and such force is less than the force on the upper face 20 by the substantial amount of energy so dissipated. The second complementary force is the upward force exerted on the piston by the returning drilling fluid in the annular chamber 19 and which has been reduced by the amount of force consumed by the drilling turbine and the weight of the returning flow so that it is quite a bit less than the force of the fluid in the chamber 21 though still substantial enough to create an important axial force.

It will be understood from the foregoing that the resultant of the force applied on the upper face 20 of piston 7 and the combined complementary opposing forces in the chambers 19 and 21 on such piston, is utilized by the piston as a pushing force which is applied through the push member 8 thereof onto the lower section 3 to cause the latter to assume an angle of inclination relative to the upper section 4 corresponding to such resultant force. By varying the pressure in the drilling fluid, the resultant force and consequently the angle of inclination of the lower bushing section 3 can be correspondingly varied to maintain the drilling apparatus on the course which had been previously plotted therefor.

As has been previously indicated, the strength of the resultant force exerted on the lower bushing section can be increased by providing the device of the invention with a plurality of pistons comparable to piston 7 and connected in series so that they exert a combined push on the lower bushing section of the device. A construction provided with such a plurality of pistons is shown in FIG. 5 of the drawings, wherein the numeral 41 indicates the lower bushing section of the device illustrated, and the numeral 33 designates the upper section thereof, the lower section 41 being shown connected to the upper part 1' of a turbine of known construction, such as disclosed in the foresaid Patent 3,018,997. The two section 41 and 33 are pivotally connected by a shaft 42 extending through the upper end of section 41 at right angles to the central axis of section 33 and supported at its ends by the annular wall of the upper bushing section 33. The shaft 42 is provided with an opening 42' to permit the passage of the sludge destined to feed the turbine. A water-tight joint is provided between the bushing section 41 and 33 at 43. Instead of the previously described push member 8, changes in the inclination of the lower bushing section 41 are attained through a disk 40 seated in a recess 27 formed in the upper end of section 41 in offset relation to its pivotal axis so that force applied to such disk will cause a corresponding movement of section 41 about shaft 42. The push force is applied to disk 40 through the enlarged cylindrically-shaped bottom end 31 of a tubular member 30 centrally located in the upper section 33 and through which the drilling fluid passes on its way from the drilling pistons 6 to the turbine. Seated in stacked relation on the enlarged end 31 of member 30 and closely encircling such member are a plurality of annular pistons 32 provided at their upper ends with outwardly projecting annular flanges 28. Alternately arranged with the flanges 28 are a plurality of inwardly projecting flanges 34 provided on the upper ends of fixed tubular members 29 mounted in stacked relation on an internal annular shoulder 33' provided on the upper bushing section in the region of the bottom end 31 of member 30. The members 29 are secured in position against the shoulder 33' by a top tubular member 24 which is locked in position by the bottom end of the lower most drill pipe 6. The pistons 32 are secured in position on the member 30 by a tubular member 23 locked in position on member 30 by a collar 22.

It will be noted that in the aforesaid construction the fixed flanges 34 define annularly-shaped chambers of fixed dimensions within each of which a piston flange 28 forms a movable partition or wall dividing each of such fixed chambers into an upper annular chamber 35 and a lower annular chamber 36. Above the topmost flange 34, topmost piston flange 28 divides the annular space formed between such topmost flange 34 and a ring 38 into a lower annular chamber 36 and an upper annular chamber 35'. The annular spaces 35 and 35' are in communication with each other through a vertically disposed conduit 37 formed by the pistons 32 and a vertical slot provided in the outer surface of the tubular member 30, an aperture 23' in the lower end of the tubular member 23 and apertures 32' in the lower ends of the two uppermost annular pistons 32. The lowermost piston 32 is also provided with an aperture 32' to connect conduit 37 with an annular space 35''. The annular spaces 35, 35' and 35'' and conduit 37 are filled with oil so that any pressure on the ring 38 will be transmitted without substantial change to the upper surfaces of the piston flanges 28 and surface 31' of member 30. The ring 38 is a free ring mounted for slidable movement between the tubular members 23, 24 and subjected on its top surface to the pressure of the drilling fluid discharging from the drill pipes 6 and entering the central bore of the central tubular member 30. The free ring 38 therefore functions as a piston to transmit the pressure of the drill sludge to the oil in the chambers 35 and 35' which constitute the high pressure chambers of the device.

The chambers 36 are connected by orifices 29' provided in the fixed tubular members 29 with a vertically disposed conduit 39 formed by providing a vertical slot in the inner wall of the upper bushing section 33. The conduit 39 and consequently the chambers 36 are brought into communication with the annular space of the drill hole enclosing the section 33 by an orifice 39' provided in the wall of such section. As the pressure in the drilling fluid returning by way of the annular space of the drill hole is substantially lower than the pressure P applied on the ring 38, the chambers 36 constitute the lower pressure chambers of the device.

It will be understood from the foregoing, that in the operation of the device of FIG. 5, the pressure of the drilling sludge passing from the lower end of the drill pipes 6 and into the bore of the central tubular member 30 acts on the ring 38 in the direction of the pressure P indicated by the arrows in FIG. 5 and is transmitted by the oil in chambers 35' and 35 to the upper faces of the annular pistons 32. The lower faces of the flanges 28 of such pistons are subjected to the opposed reduced pressure of the drilling fluid returning up to the surface along the annular space formed between the drill hole and the drilling apparatus. The resultant of these two opposing forces on the annular pistons 32 is a downward thrust which is transmitted by such pistons to the enlarged bottom end portion 31 of the tubular member 30. The downward force so exerted on the portion 31 is transmitted through the disk 40 to the lower bushing section 41 which is caused to move about its axis 42 to an inclined position corresponding to the degree of force exerted thereon. As in the case of the embodiment shown in FIGS. 1 to 4 of the drawings, the inclination of the lower bushing section 41 may be varied by varying the pressure of the sludge delivered by the drill pipes 6.

The device illustrated in part in FIG. 6 of the drawings is similar to the construction shown in FIG. 5 except that the pivotal connection between the two bushing sections is accomplished by means of a tubular-type of coupling. This coupling includes a tubular member 44 having a circularly-shaped lower end 50 seated in a correspondingly shaped recess provided in the upper end of the lower bushing section 48 of the device. This connection is made watertight by a packing seal 47. The lower bushing section 48 is supported on the lower end of the upper bushing section 51 for pivotal movement about a horizontal axis offset from the longitudinal axis of such section 48, by a shaft 49 whose ends are mounted on the annular wall of such lower end of section 51 and which is formed to permit an unobstructed flow of the drilling fluid through the bore of section 48 to the turbine.

The upper terminal end of the tubular coupling member 44 is slidably connected in the central bore of a circular socket member 45 seated in a suitably shaped recess formed in the lower end of the enlarged bottom end 31' of the central tubular member 30' and in an annular push member 52 connected to such bottom end 31'. The connection between the upper end of member 44 and socket member 45 is made water-tight by a packing seal 46 and the connection between such socket member 45 and the bottom end 31' of the tubular member 30' is made watertight by a packing seal 47'.

The push member 52 is provided with a downwardly projecting extension 53 engaging with a disk 40' to transmit the downward thrust created by the annular pistons mounted on the tubular member 30' to the lower bushing section 48 in the manner described in connection with the construction of FIG. 5.

While preferred embodiments of the invention have been illustrated in the drawings and hereinabove described, it will be evident to those skilled in the art that modifications of such embodiments may be made with-

out departing from the spirit of the invention or the scope of the appended claims.

We claim:

1. A device for use in earth drilling apparatus, comprising an upper section providing a tubular piston housing for connection to a drill string in fixed relation thereto, a lower section for connection to a drilling unit including a motor, means movably joining the upper end of said lower section to the lower end of said upper section, means for conducting drilling fluid from said drill string through said upper section, past said joining means and through said lower section to said drilling unit, a plurality of pistons mounted in said upper section and connected in aligned relation for movement longitudinally of said upper section as a unit, means for simultaneously subjecting an upper transverse surface of each of said pistons to the forward thrust of the drilling fluid at the entry end of said upper section, including a free ring positioned in said upper section in spaced relation above the uppermost of said transverse upper surfaces and adapted to be engaged by the drilling fluid entering such section, and a substantially incompressible fluid filling the space between said ring and said uppermost transverse upper surface, whereby the thrust of the drilling fluid is applied to such surface through said ring and said incompressible fluid, means for simultaneously subjecting a lower transverse surface of each of said pistons to the force of the fluid returning from the drilling operation so that said pistons are activated by the resultant of such forces, movable means connected to said pistons and subjected to the combined push of the latter for movement thereof toward said joining means, said movable means being connected to said lower section and operable when advanced toward said joining means to pivot said lower section on said joining means.

2. A device for use in earth drilling apparatus, comprising an upper section providing a tubular piston housing for connection to a drill string in fixed relation thereto, a lower section for connection to a drilling unit including a motor, means movably joining the upper end of said lower section to the lower end of said upper section, means for conducting drilling fluid from said drill string through said upper section, past said joining means and through said lower section to said drilling unit, a plurality of pistons mounted in said upper section and connected in aligned relation for movement longitudinally of said upper section as a unit, said pistons being annularly-shaped, and including a central tubular member to which said pistons are connected, and means on said upper section forming an operating chamber for each of said pistons, means for simultaneously subjecting an upper transverse surface of each of said pistons to the forward thrust of the drilling fluid at the entry end of said upper section, means for simultaneously subjecting a lower transverse surface of each of said pistons to the force of the fluid returning from the drilling operation so that said pistons are activated by the resultant of such forces, movable means connected to said pistons and subjected to the combined push of the latter for movement thereof toward said joining means, said movable means being connected to said lower section and operable when advanced toward said joining means to pivot said lower section on said joining means.

3. A device such as defined in claim 2, in which one end of all of said chambers forms part of the means for applying the forward thrust of the drilling fluid to all of said transverse upper piston surfaces, and in which the other ends of said chambers form part of the means for applying the force of the fluid returning from the drilling operation.

4. A device for use in earth drilling apparatus, comprising an upper section providing a tubular piston housing for connection to a drill string in fixed relation thereto, a lower section for connection to a drilling unit including a motor, means movably joining the upper end of said lower section to the lower end of said upper section, means for conducting drilling fluid from said drill string through said upper section, past said joining means and through said lower section to said drilling unit, a plurality of pistons mounted in said upper section and connected in aligned relation for movement longitudinally of said upper section as a unit, means for simultaneously subjecting an upper transverse surface of each of said pistons to the forward thrust of the drilling fluid at the entry end of said upper section, means for simultaneously subjecting a lower transverse surface of each of said pistons to the force of the fluid returning from the drilling operation so that said pistons are activated by the resultant of such forces, movable means connected to said pistons and subjected to the combined push of the latter for movement thereof toward said joining means, said movable means being connected to said lower section and operable when advanced toward said joining means, to pivot said lower section on said joining means, said movable means comprising an elongated tubular member forming part of said drilling fluid conducting means, and on which said pistons are mounted, means fixedly connecting all of said pistons to said tubular member, and an actuating member operable by said tubular member and connected to said lower section.

5. Soil drilling apparatus comprising, a soil drilling turbine supported at the lower end of a drill string, an elongated tubular piston housing located above said turbine, means connecting said turbine for pivotal movement on the lower end of said housing, means for feeding drilling fluid under pressure to said turbine including means providing a closed passageway for such fluid through said housing, past said pivotal connecting means and into said turbine, the portion of the closed passageway contained in said housing being longitudinally movable in said housing, means exteriorly of said closed passageway means for supplying into said housing return drilling fluid under pressure substantially less than that of the drilling fluid in said passageway means, a plurality of pistons mounted in aligned relation on the portion of said closed passageway contained in said housing, said pistons being fixed to said passageway portion, whereby the latter and said pistons are moved as a unit under the applied forces of the drilling fluid, means for simultaneously subjecting an upper transverse surface of each of said pistons to the force of the drilling fluid fed to said turbine, each of said pistons having a lower surface in communication with said return fluid passageway means and subjected to the force of the lower pressure drilling fluid introduced into said housing by such passageway means, and movable means connected to the lower end of said aligned pistons and subjected to the combined push of the latter in the movement of said pistons toward said pivotal connecting means, and means operatively connecting said movable means to said turbine and enabling said movable means to pivot said turbine about the axis of said pivotal connecting means.

6. A device for use in earth drilling apparatus, comprising an upper section providing a tubular piston housing for connection to a drill string in fixed relation thereto, a lower section for connection to a drilling unit including a motor, means movably joining the upper end of said lower section to the lower end of said upper section, means for conducting drilling fluid from said drill string through said upper section, past said joining means and through said lower section to said drilling unit, said conducting means comprising an elongated rigid tubular member forming a portion of the passage for the drilling fluid and forming with said piston housing an elongated annular chamber, means slidably supporting said tubular member for longitudinal movement in said piston housing, means in said elongated annular chamber providing a longitudinally extending series of adjacent annular piston chambers around said tubular member, an annular piston located in each of said piston chambers and

fixed to said tubular member, means for simultaneously subjecting an upper transverse surface of each of said pistons to the forward thrust of the drilling fluid applied at the upper end of said elongated annular chamber, means bringing all of said piston chambers into communication with the exterior of said piston housing between the ends of said tubular member so as to simultaneously subject a lower transverse surface of each of said pistons to the force of the returning drilling fluid passing upwardly over the exterior of said piston housing, whereby said pistons and consequently said tubular member are moved by the resultant of such forces, and means connecting the lower end of said tubular member to said lower section and operable when said tubular member is moved downwardly in said piston housing to pivot said lower section on said joining means, said tubular member being of sufficient length to enable it to conduct drilling fluid continuously through said series of piston chambers throughout the range of movements thereof.

7. Soil drilling apparatus comprising, a soil drilling turbine supported at the lower end of a drill string, an elongated tubular piston housing located above said turbine, means connecting said turbine for pivotal movement on the lower end of said housing, means for feeding drilling fluid under pressure to said turbine including means providing a closed passageway for such fluid through said housing, past said pivotal connecting means and into sai dturbine, said conducting means comprising an elongated rigid tubular member forming a portion of the passage for the drilling fluid and forming with said piston housing an elongated annular chamber, means slidably supporting said tubular member for longitudinal movement in said piston housing, means in said elongated annular chamber providing a longitudinally extending series of adjacent annular piston chambers around said tubular member, an annular piston located in each of said piston chambers and fixed to said tubular member, means for simultaneously subjecting an upper transverse surface of each of said pistons to the forward thrust of the drilling fluid applied at the upper end of said elongated annular chamber, means bringing all of said piston chambers into communication with the exterior of said piston housing between the ends of said tubular member so as to simultaneously subject a lower transverse surface of each of said pistons to the force of the returning drilling fluid passing upwardly over the exterior of said piston housing, whereby said pistons and consequently said tubular member are moved by the resultant of such forces, and means connecting the lower end of said tubular member to said turbine and operable when said tubular member is moved downwardly in said piston housing to pivot said turbine about the axis of said pivotal connecting means, said tubular member being of sufficient length to enable it to conduct drilling fluid continuously through said series of piston chambers throughout the range of movements thereof.

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