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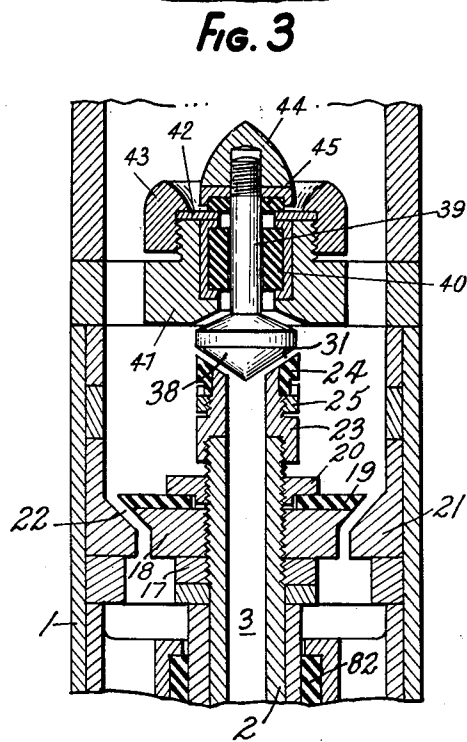
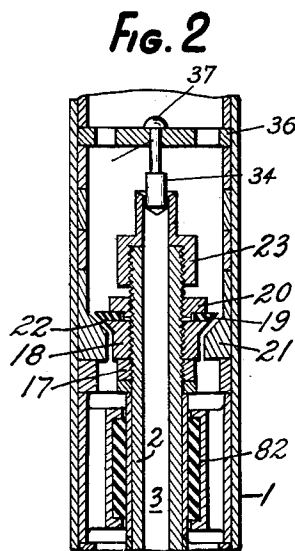
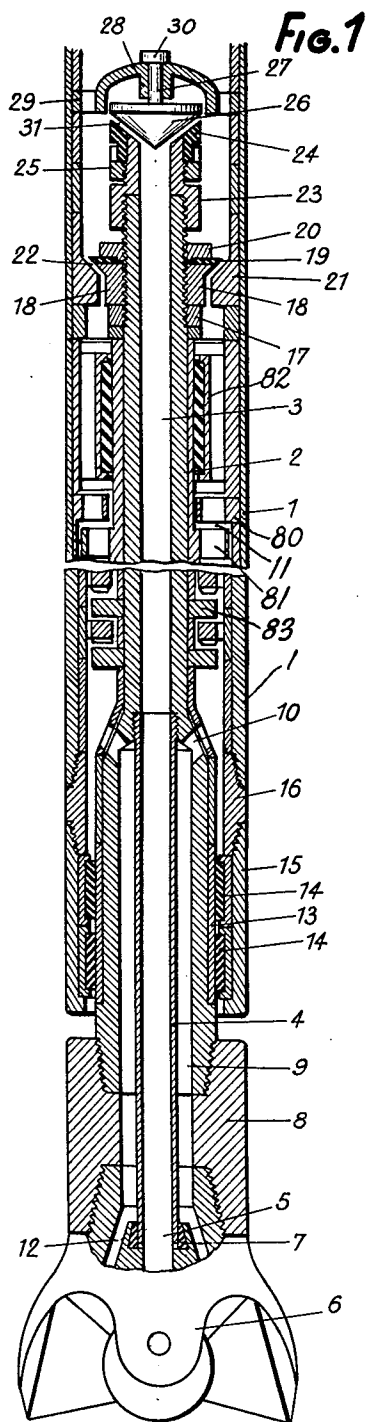
W. TIRASPOLSKY ET AL

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DRILLING TURBINE

Filed Nov. 18, 1957

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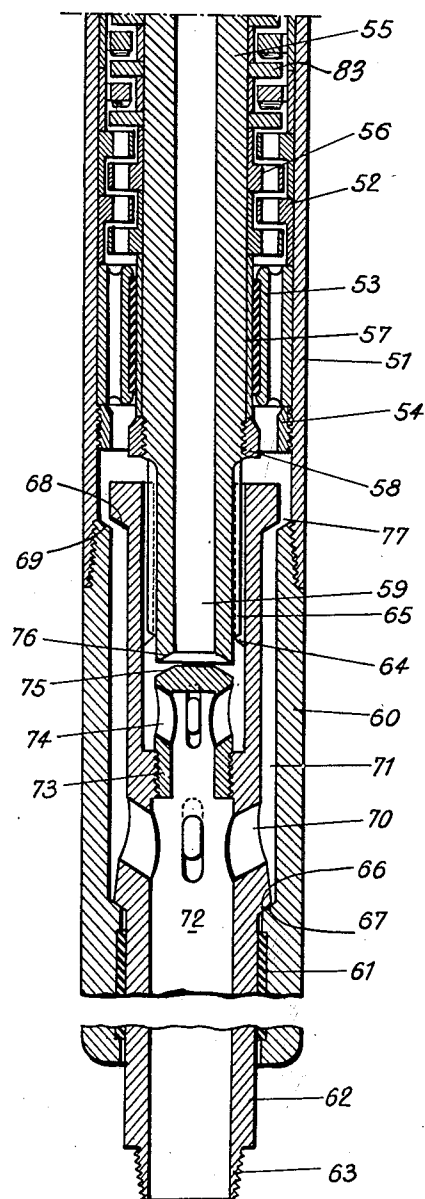
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DRILLING TURBINE

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FIG. 4



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DRILLING TURBINE

Wladimir Tiraspolsky, 69 Avenue Victor Cresson, Issy-les-Moulineaux, France, and Roger Francois Rouviere, Castor, Lot 24, Aureilhan, France

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The present invention relates generally to the art of drilling the ground and has particular reference to apparatus of the type used for example for drilling wells through soft or substantially unconsolidated soils.

For drilling some kinds of soils, it is only sufficient to provide at the end of any rod or pipe, for example a flexible pipe, one or several nozzles or a tool fitted with nozzles or equivalent ports and to inject through them water or another fluid under a suitable rate of flow and an appropriate forcing pressure for achieving or considerably hastening the disintegration of the soil and ensuring a forward motion of the apparatus. Such is the case for example of very soft or light soils or when effecting drilling at small depth, for example when drilling for geological or geophysical prospecting as are effected through superficial non-consolidated layers of the soil.

However the use of such hydraulic jet perforators have not been satisfactorily widespread because their practical use encounters difficulties due to the lack of homogeneous ground. Actually when encountering in the course of drilling a hard or compact layer of ground (for instance a stony or clayey layer) perforation or drilling by means of jets of liquid is no longer possible, whereupon the flexible pipe must be removed from the well being drilled and conventional drilling methods must be resorted to, that is to say, the drilling must be continued with the aid of a revolvable tool or a percussion tool, which cancels the advantages resulting from hydraulic jet perforation.

It has already been proposed to arrange in superimposed relation a drilling turbine and a hydraulic jet perforator. However the practical solutions that were proposed were not satisfactory because on the one hand turbines are not generally built for withstanding at their outlet end the large pressure drops that are necessitated by hydraulic jet perforating tools and on the other hand as the fluid must flow through the power parts of the turbine and the jet perforation nozzles, it undergoes a serious overall pressure drop of which only a fraction is used at each stage of the drilling operation. Finally the idle rotation of the turbine, when drilling a well by fluid jets, represents a considerable useless expenditure owing to the serious wear of moving parts.

An object of the invention is to remedy the aforesaid disadvantages of the prior art and to provide a new or improved drilling turbine utilizable selectively as a hydraulic jet perforator and adapted selectively to permit jet drilling or turbine drilling while ensuring total or partial deactivation or idling of one of said systems when the other one is used by an automatic control.

Viewed in one aspect, the invention is embodied in a new or improved turbo-drill utilizable as a hydraulic jet perforator and characterized by the fact that it comprises two separate circuits for the flow of the circulating fluid toward the lower end of the turbine which is fitted with a

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rotatable drilling tool and jet drilling nozzles, one circuit ensuring communication between the fluid inlet and the lower end of the turbine through the medium of the power parts of said turbine, while the other circuit provides a direct or substantially direct communication between said fluid inlet and said lower end, and means ensuring a selective flow of the main stream of fluid toward said lower end of the turbine through either the one or the other of said circuits.

Another object of the invention is to provide an improved drilling turbine as aforesaid comprising automatic operating control means permitting the circulating fluid to be circulated entirely or partly through a circuit undergoing a very small load drop and channelling said fluid to the turbine nozzles from which the fluid jets are projected for drilling the well without simultaneously driving the turbine shaft or alternatively, the fluid to be circulated through the power parts of the turbine, thereby imparting rotation to the shaft while the first-named circuit is closed.

Viewed in a more specific aspect, the invention is embodied in a particular constructional form wherein those members which selectively perform the flow of the main fluid current toward the lower end of the turbine through either the one or the other of the aforesaid circuits are so constructed that control of said members is caused by a relative axial displacement of the two parts of the turbine. The turbine shaft which is connected to the drilling tool may be mounted for example for being axially shiftable with respect to the stator parts of the turbine for ensuring said control. According to a constructional modification, the bit or bit holder is axially shiftable with respect to the shaft or stator parts of the turbine and may for example axially slide on said turbine shaft. Said relative axial shift of the two parts of the turbine may be caused for example by the weight applied to the tool.

A further object of the invention is to provide a drilling turbine as aforesaid wherein the members which selectively direct the main fluid current toward the lower end of the turbine are controlled by a variation of the feed pressure of the power fluid, which pressure variation may have a transient character, whereafter the feed pressure may resume its initial value or may be set to another value following activation of the control.

Viewed in a still more specific aspect, the invention is further embodied in a particularly advantageous constructional form wherein the aforesaid selectively operating members are constituted by valves, lift valves, gate valves or equivalent means so mounted as to ensure a selective closing of one of the circuits and the opening of the associated circuit. There may be provided for example in the turbine, a circuit involving a small load drop comprising a longitudinal bore extending through the turbine shaft, the circuit associated with the aforesaid circuit passing through the stator and rotor part stacks and imparting rotation to said shaft, the selective flow of the fluid through the one or the other circuits being controlled by valves, lift valves, gate valves or the like.

The turbine may include a sealing device adapted to prevent the fluid from leaking through the foot bearing of said turbine when the small load drop circuit is operative. Preferably this sealing device is so arranged as angularly to lock the turbine shaft with respect to the stator structure, which method of mounting is advan-

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tageous particularly when the power circuit of the turbine is only partly closed off as the fluid flows through the small load drop circuit. Such an arrangement is particularly advantageous for deep drilling work because it permits the tool to be slowly rotated from the ground surface when the drilling work is entirely or partly effected by means of liquid jets projected by nozzles.

With these and such other objects in view as will incidentally appear hereafter, the invention comprises the novel construction and combination of parts that will now be described with reference to the accompanying diagrammatic drawings exemplifying the same and forming a part of the present disclosure.

In the drawings:

FIGURE 1 is a partial sectional elevational view of a constructional form of the improved drilling turbine according to the invention, said turbine being utilizable selectively as a hydraulic jet perforator.

FIGURES 2 and 3 are sectional views of constructional modified details.

FIGURE 4 is a partial sectional elevational view of a constructional modification.

The drilling turbine which is partly represented in FIG. 1 includes a body 1 in which is mounted a shaft 2 provided with a longitudinal bore 3 extending through the entire length thereof constituting a fluid conduit. A tube 4 is screwed into the lower end of the shaft 2 and forms a continuation of the conduit defined by longitudinal bore 3. Said tube 4 communicates at its lower end with the inlet port 5 (provided in the bit 6) of nozzles (not shown) through which the fluid used for jet drilling is projected. A sealing gasket 7 is provided adjacent the port 5 for preventing any leakage of the fluid from the tube 4.

The drilling bit 6 is screwed upon a sleeve 8 which is itself screwed upon the lower end of the shaft 2, said lower end of the shaft and said sleeve 8 defining around the tube 4 an annular channel 9 which communicates at its upper end through ports 10 with a space 11 provided inside the body 1 and containing the stacks of stator and rotor parts 80, 81 respectively. The upper bearing of the turbine has been shown at 82. At its lower end the annular channel 9 communicates with ports 12 in the drilling bit. These ports are different from the inlet port 5 and have, generally speaking, a larger cross sectional area.

The foot bearing of the turbine comprises, in the present construction, a wear-taking ring 13 connected to the shaft 2 and rubber rings 14 carried by a sleeve 15 screwed upon a joint 16 which is in turn screwed upon the turbine body 1, thereby clamping the stack of stator parts 80.

The shaft 2 is threaded adjacent its upper end and first receives a nut 17 which clamps the stack of rotor parts 81 upon said shaft. The nut 17 is topped by a mushroom-shaped member 18 the upper face of which is provided with a rubber disc 19 clamped by a nut 20. The periphery of the rubber disc 19 may be applied (as visible in FIG. 1) against a companion fillet member 21 rigid with the turbine body 1 so as to provide adequate fluid tightness. Alternatively the periphery of the rubber disc 19 may be moved off said member 21 for defining an annular channel 22 providing communication between the power space 11 of the turbine and the intake of the circulating fluid.

The upper threaded end of the shaft 2 is also provided with a member 23 terminating in a hollow cone which receives a rubber or like ring 24 held by a nut 25. The ring 24 forms a seat for a tapering valve 26, the stem 27 of which is guided through a sleeve 28 rigid with a further member 29 interposed in the stator structure of the turbine. A collar or flange 30 limits the downward stroke of the valve 26. The gap or channel 31 selectively defined between the valve 26 and its seat constituted by the ring 24 provides communication between the longitudinal bore 3 in the shaft 2 and the intake of the circulating fluid.

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The members 21 and 26 carried by the turbine body constitute first valve members which cooperate in reverse directions with the second valve member parts 19 and 24 supported upon the shaft so that one of the aforesaid channels is open when the other one is closed. Such channels have such size that the loop drop of the fluid flowing through them is very small.

The turbine shaft is also equipped with axial thrust bearings 83 of the single acting type having a sufficient clearance for permitting the shaft to move while performing selective opening and closing of the channels 22 and 31.

The operation of this turbine utilizable as a hydraulic jet perforator is as follows:

As long as the liquid jets are sufficient for breaking up the soil, the weight exerted upon the bit 6 is kept under a given value represented by the total weight of the tool and rotor parts of the turbine and the corresponding hydraulic thrust. This produces a downward axial thrust which is operative upon said members and upon the shaft 2. Consequently the sealing disc 19 is applied against the member 21 since the channel 22 is closed. Conversely the sealing ring 24 is moved off the valve 26. The circulating fluid cannot flow through the stacks of power parts of the turbine and the entire fluid then flows through the channel 31, the bore 3 in the shaft 2 and the tube 4 before reaching the inlet ports 5 for the nozzles. The turbine shaft 2 and the bit 6 are thus held against rotation. The tool is merely shifted downwardly in proportion as the drilling work progresses.

If found desirable by the operator or where the soil being drilled is too hard for permitting drilling by jets of liquid to be performed, the turbine proper may be set into operation. For that purpose, the bit pressure upon the soil being drilled or dug is increased, whereupon the channel 22 is opened while the channel 31 is closed due to the relative axial movement which takes place between the shaft and bit, on the one hand, and the turbine body on which the weight of the string of rods exerts itself, on the other hand. Therefore the circulating fluid is prevented from flowing into the shaft bore 3 and the jet feed is interrupted. However the fluid flows through the power structure of the turbine so that the drilling work is continued by means of the rotary bit 6 in the usual manner. The fluid escapes through the channels 10, 9 and 12 without undergoing any appreciable load drop.

As soon as the hard portion or layer of the soil has been drilled, the reverse action of the valves controlled by the downward movement of the tool and shaft with respect to the turbine body stops the operation of the turbine while setting into operation the drilling nozzles again for hydraulic continuation of the work.

In FIGURE 1, the valve members, the stator and rotor blades and the axial bearing elements have been shown in a position of equilibrium between the operative positions, but it will be understood that such a position is only of transient character and that the parts occupy said position only when moving from an operative position to the other for selectively opening or closing one of the circuits of the turbine.

It is obviously necessary that the conduit (string of rods or flexible pipes) which feeds the turbine should have a sufficient resistance to torsional stresses for counter-balancing the power torque of said turbine.

In the constructional modification represented in FIG. 2, selective closure of the bore 3 in the shaft 2 is ensured by a cylindrical needle valve 34 whose shank 35 is engaged through a hole in a member 36 rigid with the turbine body. A head member 37 limits the downward motion of the needle valve 34. The member 36 acts as a guide for the shank 35 of the needle valve which is arranged for sliding and rotating with respect thereto. For performing the closure, the cylindrical needle valve 34 is engaged (as shown) into the bore 3 in the shaft 2.

In the constructional modification shown in FIG. 3,

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the valve 38 is guided by its stem 39 through a rubber or like bearing 40 supported by a member 41 rigid with the turbine body. The rubber bearing 40 is held in position by a washer 42 applied thereto by a suitably shaped nut 43. The valve stem 39 carries at its upper end a screwed ogee-shaped abutment 44 which limits its downward motion. Such as abutment bears against the washer through a rubber or like member 45 so as to constitute a thrust bearing. Consequently the valve may be rotated with respect to its guide when it is applied on the turbine shaft and said shaft is rotated.

Lubrication of the rubber bearing 40 is ensured by a flow of the fluid through the space between the bearing and the stem 39. Such fluid circulation is facilitated by the provision of the shaped nut 43 at the inlet end and channels or grooves 78 formed inside the ring that forms the bearing 40.

According to the constructional modification shown in FIG. 4, the turbine body 51 receives the stack of stator parts 52 (only a few elements of which are shown in the drawings) and the lower bearing 53. Tightening is provided by a nut 54. The turbine shaft 55 carries the stack of rotor parts 56 and the wear-taking ring 57 of the lower bearing. Tightening is performed by the nut 58. Through said shaft also extends over its full length a longitudinal bore 59 the upper end of which communicates with the inlet of the circulating fluid. The rotor part of the turbine is axially held with respect to the stator structure by an abutment of conventional type (not shown).

The lower end of the turbine body 51 is fitted with a sleeve 60 carrying adjacent its lower end a rubber or like bearing 61 through which may rotate a lower shaft 62 having a threaded tip portion 63 upon which is screwed the tool (not shown). The shaft 62 is provided adjacent its upper end with a fluted bore 64 which cooperates with splines 65 machined upon the lower end of the shaft 55. The two shafts 55 and 62 are thus connected for joint angular motion although the lower shaft 62 may be axially shifted with respect to the shaft 55. The shaft 62 has a slanting downwardly facing shoulder 66 which, in its lowermost position as shown in FIG. 4, rests upon the upwardly facing shoulder 67 on the sleeve 60, thereby cutting off the flow of the circulating fluid toward the lower bearing 61. Also in said position, an upper slanting downwardly facing shoulder 68 on said shaft cooperates with an upwardly facing end shoulder 69 on the sleeve 60 so as to restrict the outward fluid passage for the power part of the turbine. Ports 70 provide a communication between the annular passage 71 defined between the shaft 62 and the sleeve 60 and a longitudinal bore 72 formed in said shaft 62.

There is, moreover, provided inside the lower shaft 62 an end member or spigot 73 provided with a central passage 79 and screwed into a threaded portion of the shaft. Said end member 73 has side ports 74 and adjacent its upper end a bevelled portion 75 capable of being applied against a complementary seat portion 76 provided at the lower end of the turbine shaft 55.

The operation of the turbine built according to the last-named constructional form is similar to the one described with respect to FIG. 1. As long as the drilling work is done by liquid jets, the bit does not touch the soil being drilled, and the weight of the tool and shaft 62 brings the parts into the position shown in FIG. 4. Therefore the fluid freely reaches the nozzles through the channel 59 and the passage defined between the seat portion 76 and the bevelled portion 75 which is sufficiently wide for preventing any appreciable load drop, the ports 74 and the bore 72. Conversely the flow of the fluid through the power structure of the turbine is considerably braked or hampered by the provision of the throttle 77 between the shoulders 68 and 69. Contact of the shoulder 66 against the shoulder 67 produces a frictional torque which prevents the turbine shaft from rotating.

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If the soil being drilled becomes too hard for permitting jet drilling to be performed or where the foreman in charge of supervision of the drilling deems it useful, he may press the bit against the bottom of the well. Under the effect of the weight of the turbine and string of rods, the seat portion 76 is then applied against the bevelled portion 75 while the oppositely located shoulders 66, 67 and 68, 69 are moved off each other. Consequently the end member or spigot 73 closes the channel 59 so that the fluid must flow through the turbine blades before reaching the drilling nozzles. However, the fluid then freely flows from the power structure to the bore 72 through the annular passage 71 while irrigating the foot bearing 61. The turbine thus operates in the usual manner.

Minor constructional details may be varied without departing from the scope of the subjoined claims.

What is claimed is:

1. In a drilling turbine utilizable selectively as a hydraulic jet perforator and including a tubular turbine body, a shaft, bearing means supporting said shaft within said body for a rotatable and limited axial movement relative thereto, blade sets within said body for driving the shaft and operably responsive to flow of a circulating fluid through said sets, a tool fitted at the lower end of said shaft, the inlet of the fluid being adjacent the upper end of the turbine while its outlet is adjacent its lower end, a first fluid circuit defined by said body and shaft providing communication between said upper end and said lower end through the blade sets of the turbine, and a second fluid circuit including a bore defined within said shaft providing direct communication between said upper and lower ends of the turbine; the combination of first and third valve members fixed on the turbine body, and second and fourth valve members fixed upon said shaft, said first valve member being engageable with said second valve member as the shaft moves axially upwardly with respect to said body while said third and fourth valve members separate so as to open said first fluid circuit and to close said second fluid circuit, while said third valve member is engageable with said fourth valve member when the shaft moves axially downwardly with respect to the body and said first and second valve members separate so as to close the first fluid circuit and to open the second fluid circuit.

2. Fluid operated well drilling apparatus selectively usable as a hydraulic jet perforator or a hydraulic turbine comprising in combination, a tubular body having an upper and a lower end, means mounting a turbine shaft within said body for rotative and axial movement relative thereto, said shaft having a lower end extending from the lower end of said body, a tool mounted on said shaft lower end, turbine blade sets affixed to said shaft located within said body intermediate the body upper and lower ends, a conduit communicating with said body having an inlet communicating with the upper end of said body and having an outlet adjacent said tool, said body and shaft defining a turbine fluid flow path through said blade sets and valve means within the upper end of said body operatively responsive to the axial position of said shaft relative to said body selectively controlling the flow of fluid through said apparatus either through said turbine flow path or said conduit.

3. In a drilling turbine utilizable selectively as a hydraulic jet perforator or a turbine and including a tubular turbine body, a shaft, bearing means supporting said shaft within said body for rotatable and limited axial movement relative thereto, blade sets for rotating the shaft responsive to flow of a circulating fluid through said sets, a tool fitted at the lower end of said shaft, the inlet of the fluid being adjacent the upper end of the turbine while its outlet is adjacent its lower end, a first fluid circuit defined by said body and shaft providing communication between said upper end and said lower end through the blade sets of the turbine, and a second fluid circuit including a con-

duit providing direct communication between said upper and lower ends of the turbine; the combination of first valve members fixed to the turbine body, and second valve members fixed upon said shaft, said second valve members being operatively positionable with respect to said first valve members upon occurrence of relative axial motion of the shaft with respect to the turbine body for determining selective flow of the circulating fluid either through said first fluid circuit or through said second fluid circuit.

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