

May 16, 1961

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2,984,309

TURBODRILL

Filed Oct. 28, 1957

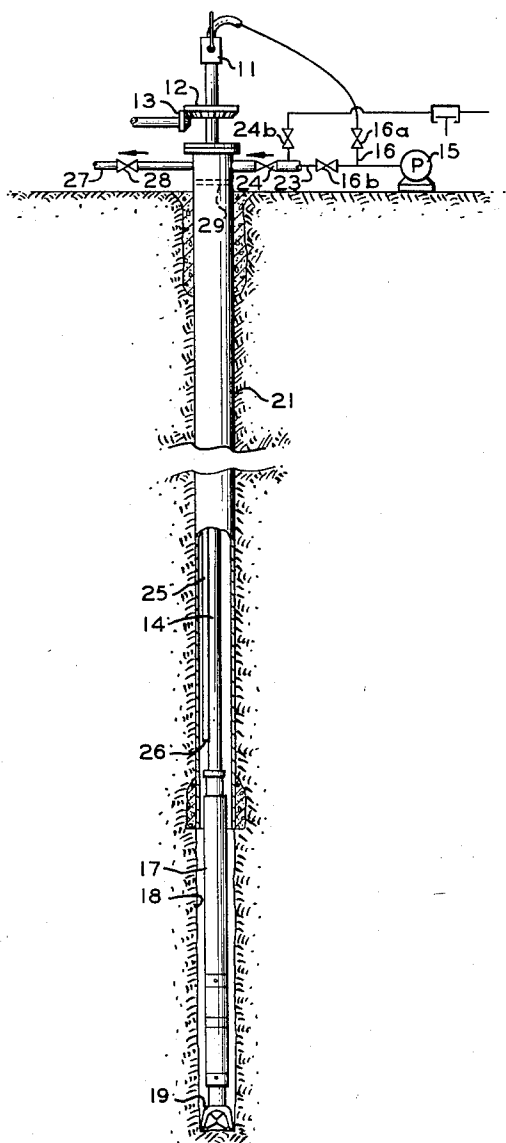


FIG. 1

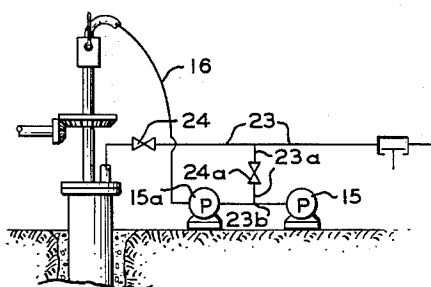


FIG. 3

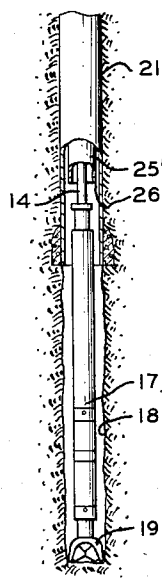


FIG. 2

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2,984,309

TURBODRILL

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Filed Oct. 28, 1957, Ser. No. 692,863

9 Claims. (Cl. 175—69)

This invention relates to method and apparatus for drilling with a turbodrill. In one specific aspect it relates to drilling wells wherein the mud is aerated after it leaves the exhaust of the turbine that comprises a portion of the turbodrill.

One technique for drilling wells, particularly oil wells, is to use a turbodrill which comprises a turbine that rotates the bit. The turbine derives its power from the hydraulic horsepower in the drilling fluid. Its use is especially advantageous in drilling deep holes (those more than 6 or 7 thousand feet deep) because the turbine is situated close to the bit at the bottom of the hole and thus eliminates power losses due to friction and torsion, such as are found in a rotary drill.

The drilling fluid, which includes water, solutions of clays such as bentonite, oil-water emulsions, and starch base solutions, creates a problem in deep holes because of the high head created at the bottom of the well by the column of fluid. This requires that high pressure pumps be furnished in order to assure that the fluid will return to the earth's surface. Obviously, when the fluid is used to drive a turbodrill, the exhaust pressure of the turbine will depend on the depth of the well. A high exhaust pressure for the turbine is undesirable because it requires a higher pressure of the drilling fluid that is delivered to the turbine inlet. This in turn increases operating costs by requiring pumps capable of delivering the higher pressure fluid. Hereinafter, when I employ the term "drilling fluid," I refer to a liquid or liquiform slurry, and do not include therein aeriform or gaseous materials, excepting such gases as are normally sorbed in such liquid or slurry in the course of the operations described.

This invention involves aerating the fluid mud exhausted from the turbodrill. Air would normally be used. However, compressed exhaust gases from the drilling rig can be used to reduce fire hazard, or methane may be used because it is approximately half the weight of air. Regardless of the type of gas used, the effect of aeration is to decrease the density of the column of fluid that is returning to the earth's surface. The advantages thus obtained are lower turbine exhaust pressures, hence lower pump pressures in the pumps that provide the turbine with pressurized drilling fluid. The lower exhaust pressure necessarily means a lower bottom hole pressure, which in turn means a faster drilling rate and a reduction in lost circulation. In addition, the invention includes a process of starting up which permits lower air pressures on startup, hence smaller compressors, by establishing a column of aerated fluid during starting.

It is one of the objects of this invention to provide a method and apparatus for improving the operation of a turbodrill by aerating the fluid during start-up and during operation. Other objects and advantages will be apparent from the following specifications and drawings.

In the drawings,

Figure 1 is a vertical cross-section of a well with the apparatus for practicing the invention during both start-up and operation.

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Figure 2 is a partial vertical cross-section showing another arrangement of the equipment in the well.

Figure 3 shows schematically a modified arrangement of the equipment at the earth's surface which can be used with either Figure 1 or Figure 2.

Referring now to Figure 1, 11 represents a swivel assembly from which is suspended a kelly 12 which after passing through a rotary table assembly 13 is connected to drill pipe 14. A pump 15 supplies drilling fluid through a line 16 with a valve 16a therein to the swivel and thence through the kelly to the drill pipe 14. The drill pipe is connected to the inlet of a turbine 17, the latter being disposed near the bottom of the well, preferably in the open hole 18, and connected to the bit 19. To avoid air binding, non-aerated drilling fluid is supplied to the turbine 17 which is designed for operating on a non-aerated fluid, although it is possible to use a Pelton wheel turbine with special nozzles to permit use of aerated fluid as the hydraulic fluid. The drill pipe 14 passes vertically downward through well casing 21 as does the gas or air supply line 23. The well casing 21 provides a return passage for drilling fluid mixed with air returning to the earth's surface. Valves 24 and 24b are disposed in the line 23 to control flow therethrough. The line 23 is connected to an air injection pipe 25 which terminates at some point 26 above the turbine, preferably in the casing 21. The aerated fluid outlet 27 is connected to well casing 21 at the top thereof. Valve 28 is disposed in the outlet 27 to control the aerated mud flow. Safety devices such as a blow out preventor 29 are disposed at the top of well casing 21.

Referring now to Figure 2, the apparatus is arranged as in Figure 1, except for those parts denoted by primed numbers, the latter carrying out substantially the same functions as their counterparts in Figure 1. Air is delivered to air injection point 26 through the concentrically arranged conduit 25'. Mud is delivered through drill pipe 14 which is concentrically arranged with the conduit 25'.

Referring now to Figure 3 an alternate arrangement of apparatus which permits a different startup technique is shown. The pump 15 delivers drilling fluid to a pump 15a which in turn further pressurizes the fluid and directs it into line 16. Connected between the pumps 15 and 15a is a branch airpipe 23a connected at its other end to the airpipe 23. A valve 24a is disposed in the pipe 23a.

If the system were started up by circulating drilling fluid to build a column thereof before the air is injected through the injection pipe 25, it is clear that the initial air pressure would be excessively high and much above operating pressure when aeration is first begun because of the hydrostatic pressure of the column of mud extending up to the earth's surface. During drilling, as when a string pipe is pulled to change a bit, drilling fluid is ordinarily pumped into a well to pressurize it and to thereby prevent portions of the wall from caving in and plugging the well. This, too, creates a column of fluid that would require high air pressures at startup. In any case, this pressure will fall to the operating pressure only after the column has been aerated. In order to eliminate having to provide a compressor capable of delivering air at such high initial pressure into a fluid-filled well, the use of certain of the apparatus of Figure 1 or Figure 3 is preferred in order to minimize the hydrostatic pressure of the column of returning fluid.

The operation of Figure 1 at startup will now be described. The purpose of this method is to inject mud and air into the air pipe and to thereby deliver aerated mud into the well. This technique lessens the chance of air binding the turbine. In essence, the procedure may be visualized by assuming a U-tube with fluid in

both legs; then aerated fluid under a pressure displaces the fluid in one leg; then by supplying gas (or air) alone and increasing the gas pressure, displacing the aerated fluid with gas (or air) by driving it down past the bottom of the U-tube, thereby displacing the leg of unadulterated fluid with the aerated fluid. In starting up, it is assumed that the hole is full of fluid and that all valves are closed. The valves 28, 24 and 16b are opened and pump 15 is started. This directs drilling fluid into the air injection pipe 25. The valve 24b is opened and compressed air is fed into the pipe 23 at a low rate. The volume of air admitted to line 23 is increased and the fluid volume is maintained constant. When aerated fluid comes out of line 27, valve 16b is closed and valve 16a is opened. Drilling can now begin.

Referring now to Figure 3, the purpose of this modification is to inject air into the mud being fed to the turbine thence into the well. Pumping is done in two stages and air is injected therebetween. This arrangement permits low head pressures at the compressor because the air pressure does not have to equal the pressure of the drilling fluid being fed to the turbine but only has to equal the interstage pressure of the fluid. At startup it is assumed that all valves are closed and the well is full of fluid. First, the valve 28 (see Fig. 1) is opened, then pumps 15 and 15a are started. Then valve 24a is opened thereby allowing air to flow through the branch line 23a into the stream of fluid at point 23b. Pumping in this manner is continued until aerated fluid appears at the outlet 27. Then valve 24a is closed and the valve 24 is opened and drilling is commenced.

The preceding two methods of starting up are useful when the well is full of mud. If there is no mud in the well, start up with a dry hole is best accomplished by first opening the valve 28, then starting the pump 15 as best seen in Figure 1. The valve 24 is then cracked so that low pressure air flows out of the pipe 25 at 26. After the mud level has reached 26 the valve 24 is slowly opened until the proper volume of air per unit of mud pumped is being furnished. Drilling can then commence.

It is obvious that if initial starting up is accomplished as just described, then the hydrostatic pressure created at point 26 by a column of aerated drilling fluid is no greater than the working pressure. It follows that air compressors of lower head pressure can be used.

In describing further operation of the system, Figure 1 will be referred to, although it is to be understood that Figure 2 is operated in much the same manner. In order that the following apply to Figure 2, it is only necessary to substitute primed numbers where appropriate.

Referring still to Figure 1, the operation of the system is continued as follows: the pump 15 pressurizes the drilling fluid and delivers it to line 16 which in turn conducts the fluid to the swivel 11, the drill pipe 14 and finally to the inlet of the turbine 17. The fluid then passes through the turbine and in doing so undergoes a pressure drop sufficient for the turbine to deliver the necessary power. The fluid is exhausted from the turbine into the open hole 18. The hydraulic horsepower derived from this pressure reduction drives the bit 19 and the exhaust fluid then picks up chips and cuttings and begins its passage back to the surface through the return fluid passage provided by well casing 21.

In order to decrease the density of the column of returning fluid, compressed air is continuously supplied through the supply line 23 and passes therethrough into injection pipe 25. At point 26, the bottom of injection pipe 25, the air enters the drilling fluid, thereby aerating it and lifting it up the well casing 21 to the outlet 27. The drilling fluid can thereafter be cleansed of chips, deaerated, and the process repeated, if desired.

The foregoing description of operation demonstrates that the turbodrill can be operated without using the rotary table 13 of Figure 1. However, rotary tables are

commonly found in drilling equipment and can serve a useful purpose in improving drilling with a turbodrill by declutching (the clutch is not shown) the rotary table to allow the drill pipe, turbine, and bit assembly to rotate slowly in the well. The advantage obtained in doing this is that filter cake formation in the open hole is curtailed and this operates to keep the entire well clear of obstructions caused by filter cake formation. The filter cake is formed by solids in the drilling mud building upon the well surface at porous rock formations and the like. When rotation is allowed, the concentrically arranged pipe of Figure 2 is preferred because then there is no danger of damaging the conduits by the whipping action that might occur along drill pipe 14.

It is not my intention to be bound by the apparatus shown, described, and claimed herein but to include as my invention all the changes and alterations thereto which would be apparent to those skilled in the art.

I claim as my invention:

1. In drilling a well with a turbo drill, said turbo drill comprising a turbine adapted to operate on drilling fluid and a drill bit driven by said turbine, the turbine and bit being disposed within the well; the method that comprises pumping drilling fluid through a confined passage to the inlet of the turbine; reducing the pressure of the fluid by passing it through the turbine and thereby driving said turbine; driving a bit with said turbine; passing the reduced pressure drilling fluid to a point adjacent the bit; injecting a gas into the reduced pressure drilling fluid; and passing the mixture of drilling fluid and gas to the surface, thereby to reduce the head of drilling fluid returned to the earth's surface and to therefore reduce the first pressure required for a given turbine horsepower.

2. Apparatus for drilling a well using a drilling fluid as the power fluid in a turbodrill that includes a turbine, comprising a pump for drilling fluid, a turbine having an inlet and exhaust, a first conduit disposed between the discharge of said pump and said turbine inlet, a drill bit connected to and driven by said turbine, means for delivering drilling fluid from said turbine exhaust to said bit, a second conduit for delivering a gas into the drilling fluid at a point above said bit to thereby form a mixture of drilling fluid and gas, and a means for receiving the mixture of drilling fluid and gas at the end of the well opposite the bit and removing said mixture to a point adjacent said pump.

3. A method of starting a well drilling operation wherein the well is initially full of unadulterated drilling fluid and wherein the turbine of a turbodrill is situated in the well and is normally operated by drilling fluid, the drilling fluid being removed from adjacent the turbine exhaust by aeration, comprising pumping drilling fluid to the inlet of the turbine, injecting air into the drilling fluid at a first point upstream of the turbine inlet thereby to aerate the drilling fluid pumped into the turbine, passing the aerated drilling fluid through the turbine and simultaneously allowing the turbine to idle by not performing any substantial cutting with a bit driven by said turbine, and continuing the said steps of pumping, injecting, and passing until the well is filled with the aerated drilling fluid to an air injection point, whereby the air pressure for injection at said air injection point in the well outside the turbine at start-up is not greater than the air pressure necessary during operation subsequent to starting.

4. A method of starting up a turbodrill in a well drilling operation comprising pumping drilling fluid to the turbine inlet; passing the drilling fluid through the turbine; continuing said pumping and passing until the well is partially filled with said fluid; starting to inject a gas at a low pressure into said fluid; and continuing to pump the drilling fluid thereby to raise the level of the drilling fluid while at the same time increasing the pressure of the gas injected until the well is full of drilling fluid.

5. A method of starting up a turbodrill in a well drill-

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ing operation that uses drilling fluid for the hydraulic fluid to power the turbine that is part thereof, comprising beginning to pump drilling fluid through a circuit that initially contains no drilling fluid, the circuit including in series a delivery line from a pump to the turbine, the turbine, the open hole, a portion of a return passage, and a first point between the exhaust of the turbodrill proper and the earth surface and the remainder of the return passage; starting to inject gas when the level of the drilling fluid reaches the said point; and increasing the pressure of the gas injected as the level of the drilling fluid rises in the remainder of the return passage.

6. Well drilling apparatus for aerating drilling fluid after expansion through a turbine comprising a well casing, an open hole beneath said casing, a turbine having an inlet and an outlet, a drill bit connected to said turbine and disposed in said open hole, a source of pressurized drilling fluid, a first conduit within said well casing connecting said turbine inlet to said source of pressurized drilling fluid, said turbine outlet being disposed so as to exhaust drilling fluid into the open hole, a source of pressurized gas, and a second conduit positioned in said casing with one end connected to said source of pressurized gas and the other end thereof disposed at the lower end of said casing.

7. Well drilling apparatus comprising in combination a well, a turbodrill disposed in said well adjacent the bottom thereof, a first conduit disposed in said well and connected between the turbine inlet of said turbodrill and a source of pressurized drilling fluid, and a second conduit disposed in said well and connected between a source of pres-

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surized gas and a point in said well down-stream of and external to the turbine exhaust of said turbodrill.

8. A method of drilling a well with a turbodrill that includes a turbine driving a drill bit comprising delivering drilling fluid at a first pressure to the turbine inlet of the turbodrill, passing the delivered drilling fluid through the turbine, and injecting a gas into the drilling fluid that has passed completely through and exhausted from the turbodrill.

9. A method of starting a well drilling operation using a turbodrill having the exhaust fluid removed by aeration, wherein the aeration pressure necessary when starting need not exceed that necessary for drilling and wherein said well is initially full of non-aerated drilling fluid which comprises delivering additional drilling fluid to said well, injecting gas into the additional drilling fluid, forming a mixture of said drilling fluid and gas, conducting said mixture to a point in a region between the exhaust of the turbodrill proper and the earth's surface thereby forming a gas-drilling fluid phase in said well and continuing said steps of delivering, injecting and conducting until at least a portion of the well is fluid with a mixture of said gas and drilling fluid.

References Cited in the file of this patent

UNITED STATES PATENTS

1,324,304	Carmichael	Dec. 9, 1919
1,390,025	Drake	Sept. 6, 1929
2,588,311	Wagner	Mar. 4, 1952
2,726,063	Ragland et al.	Dec. 6, 1955
2,828,107	Bobo	Mar. 25, 1958