

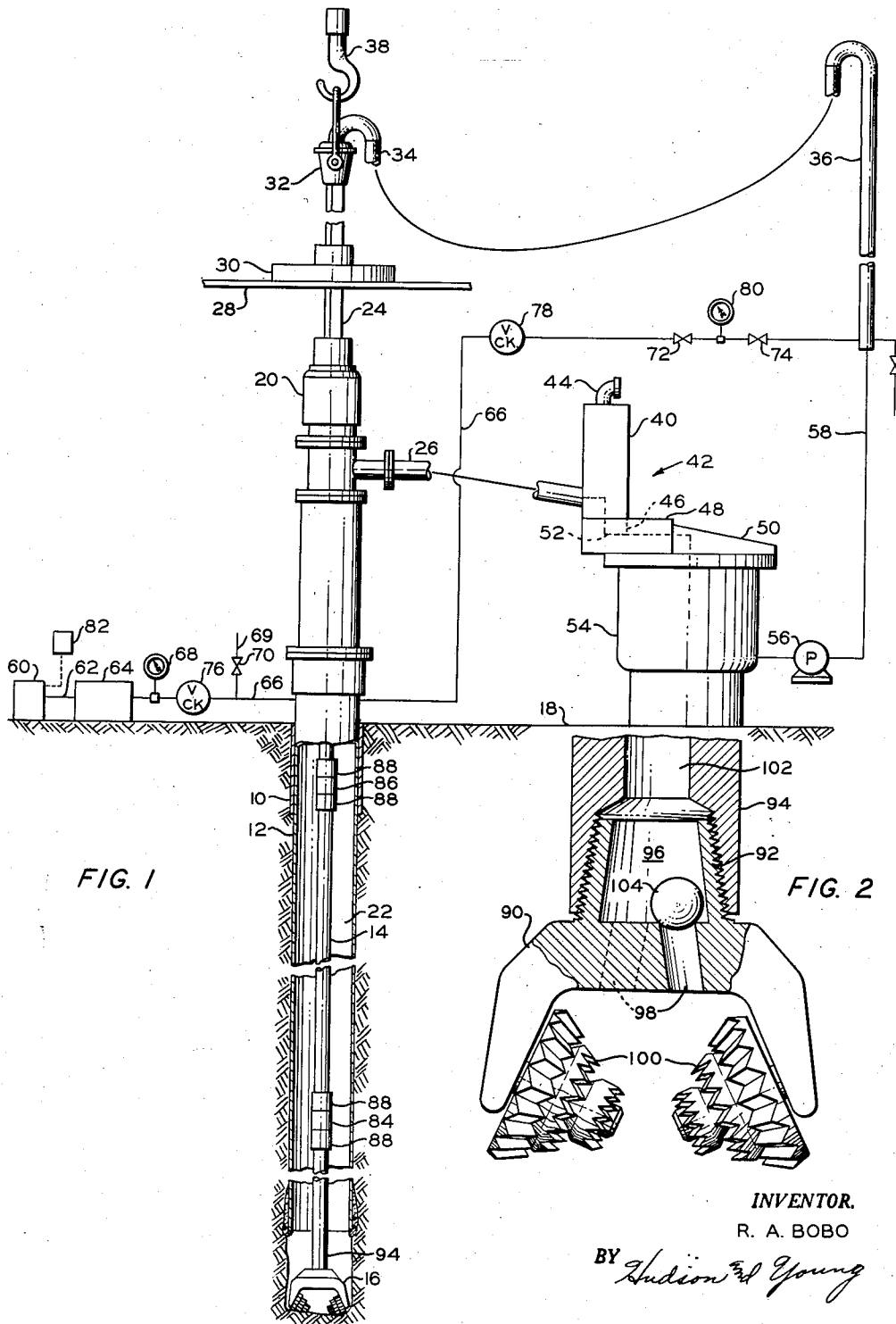
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R. A. BOBO

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MEANS AND METHOD OF DRILLING WITH AERATED DRILLING LIQUIDS

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INVENTOR.

R. A. BOBO

BY Hudson and Young

ATTORNEYS

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MEANS AND METHOD OF DRILLING WITH AERATED DRILLING LIQUIDS

Roy A. Bobo, Houston, Tex., assignor to Phillips Petroleum Company, a corporation of Delaware

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This invention relates to an improved rotary well drilling process and apparatus.

Of all its problems, the oil industry should be most acutely aware of the benefits to be derived from reducing drilling costs. Since the expenditure for drilling wells amounts to a sizable portion of each company's budget, improvements in drilling methods or drilling technique will result in substantial savings.

It has been found that using a light weight drilling fluid often increases the drilling rate and reduces the number of bits used, thus decreasing drilling costs. In some instances air or natural gas have been used as the circulating fluid but an air-lightened-liquid-circulating fluid has the following advantages over air or gas alone:

(1) Low pressure water zones can be penetrated. With air or gas alone, presence of moisture balls up the cuttings, causing bridging and locking of the pipe in the hole.

(2) Safer operations result since quick weight build-up can be obtained when needed by shutting off the air and circulating with mud.

(3) The mud phase makes it much easier to obtain a gas tight seal at the drilling head.

(4) The sleeve bearing effect of the liquid phase between the drill collars and the walls of the hole reduce the tendency toward crooked holes.

(5) Cuttings for sample purposes are larger and easier to catch since they remain with the liquid phase.

(6) The hole, being continually subjected and conditioned to mud, will stand up better. When air or gas has been used, sloughing often occurs when the hole is filled with mud. Sloughing also is likely with air drilling when small quantities of water are encountered.

Aerated mud has the following advantages over normal drilling methods:

(1) Faster drilling rates and increased bit life result.

(2) Good tests are obtained on all productive zones that are penetrated without resorting to expensive drill stem tests.

(3) Less horsepower is required for drilling.

(4) Wear and tear on equipment is considerably reduced.

The introduction of both air and mud into the drilling string requires separate equipment for each phase. That for the mud phase remains identical to that employed in conventional mud drilling. The air phase, in runs made thus far, was delivered by a conventional air compressor connected to the standpipe thru the equipment illustrated and described herein.

One of the problems which arises when utilizing an aerated drilling liquid, such as an aerated drilling mud, in rotary drilling is the "self-unloading" of the aerated liquid from the drill string when the upper end of the drill string is opened to add joints of pipe to the drill string. This step entails disconnecting the kelly from the upper end of the drill string as hole is made and attaching or adding another joint of pipe to the string by conven-

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tional threading and coupling means. As the upper end of the drill string is opened to the atmosphere the pressure in the aerated mud due to the compression of the air therein is expanded upwardly and overflows or unloads onto the floor of the drilling rig, which is obviously undesirable.

Another problem arises in connection with the use of aerated drilling mud in rotary drilling when it is desirable to change from a non-aerated drilling mud to an aerated drilling mud which is of considerably less density and of lower viscosity than the non-aerated mud. Rotary drilling bits are provided with conduits or passageways which permit flow of drilling fluid from the hollow drill string into the bore hole outside the bit and these conduits are conventionally adjusted in transverse cross sectional area so as to provide a suitable pressure drop across the drill bit for conventional drilling mud. When the change is made in the drilling process to an aerated drilling mud which has considerably lower density and viscosity, the pressure drop across the bit is greatly decreased and it is desirable to reduce the capacity of the flow passageway thru the bit without removing the bit from the hole or pulling the bit.

The principal object of the invention is to provide an improved method and means for rotary drilling of an earth bore hole or well. Another object is to provide a method and means for rotary well drilling utilizing an aerated drilling fluid such as an aerated drilling mud. Another object is to provide a method and means for preventing or minimizing overflow or "self-unloading" of an aerated drilling fluid from the upper end of the drill string when adding joints to the string. It is also an object of the invention to provide a method of changing the pressure drop across the drill bit when changing from a non-aerated drilling fluid to an aerated, less dense and less viscous fluid without pulling the bit. Other objects of the invention will become apparent from a consideration of the accompanying disclosure.

I have found that the incorporation of a check valve in the drill string just below the kelly permits the downward flow of the aerated drilling mud therethru and prevents upflow therethru when the upper end of the drill string is opened to the atmosphere. As hole is made and additional pipe joints are attached to the upper end of the drill string, the check valve progressively moves down the hole and is relocated or repositioned closer to the kelly when the string is pulled for any reason, such as for the replacement of the bit. In operation where the earth formation being penetrated is such that a drill bit is worn out very slowly and quite a number of joints are added to the string before pulling the bit, it is desirable to run another upwardly closing check valve several joints after running the first check valve so as to prevent unloading of some of the drilling fluid due to expansion of the gas in the hollow drill string between the first run check valve and the upper end of the string.

In some drilling operations it is desirable to drill to a given depth utilizing conventional drilling mud and then to shift to an aerated drilling fluid of considerably less density and viscosity. This is true, for example, when aerated mud is used to prevent lost circulation in a portion of the hole. Also, it is necessary to displace the aerated mud with non-aerated mud each time a new bit is run to provide the desired higher pressure obtained with non-aerated mud. I have found that it is feasible to insert a small body of relatively high density, such as a metal, plastic, or rubber ball, into the drilling mud at the upper end of the drill string when the same is open so that as the drilling mud is circulated thru the drill string the ball arrives at the drill bit and seats in one of the conduits passing thru the drill bit thereby shutting off flow thru this

conduit and increasing the pressure drop across the drill bit. This change in flow capacity renders the drill bit more suitable for drilling with the less dense aerated drilling mud.

The term "aerated drilling fluid" is to be understood to mean a drilling fluid which contains air or other gas in compressed condition so as to render the fluid substantially less dense. The term includes all of the conventional drilling fluids, such as oil, water, mud, etc., which have been aerated. However, the use of aerated drilling mud is preferred even though the invention is broadly applicable to aerated drilling fluids of great variation in density.

A more complete understanding of the invention may be had from a consideration of the drawing of which Figure 1 is a schematic elevational view, partly in section, showing a rotary drill string in an earth formation and an arrangement of equipment for rotary drilling with an aerated drilling fluid; and Figure 2 is a longitudinal cross section of a conventional rotary drill bit of the roller bearing rock bit two-cone type.

Referring to Figure 1, the equipment shown is associated with a well bore 10 into which is cemented a casing 12. A drill string 14 comprising a series of pipe joints is connected by threaded couplings in conventional manner. A bit 16 is threaded onto the lower end of the drill string. Attached to the casing above the earth level 18 is a drilling head 20 which may be of any suitable type, such as a conventional Shaffer drilling head. Drill string 14 forms an annular space 22 with the casing and the bore hole below the casing. This annular space is sealed off at the upper end by drilling head 20 which also forms a rotary seal with kelly 24 so as to prevent overflow of mud at the upper end thereof except thru outlet conduit 26 which connects with a section of the casing subjacent the drilling head.

Kelly 24 extends upwardly thru floor 28 of the drill rig and thru rotary drilling table 30. A circulating swivel 32 on the upper end of the kelly makes a connection with a flexible conduit or hose 34 for delivery of drilling fluid from standpipe 36, usually extending from the floor of the rig. Flexible conduit 34 is provided so as to allow freedom of movement of kelly 24 as the drilling progresses and joints are added to the drill string. The swivel is supported by hook 38 which, in turn, is supported from the crown block by conventional means (not shown).

Drilling mud flowing from the upper end of the casing thru line 26 passes into a first compartment 40 of a mud box 42 which is closed except for a vent line 44 and the mud seal outlet 46 at the bottom. A second compartment 48 is open at the top and discharges over shale shaker 50. Flow of mud as indicated by dotted line 52 is into mud tank 54.

Mud is circulated into standpipe 36 by means of mud pump 56 positioned in conduit 58 which connects directly with a lower section of mud tank 54 and with the lower end of standpipe 36.

The aeration apparatus or equipment comprises a conventional air compressor 60 which has an outlet line 62 leading into a surge tank 64. An air line 66 connects surge tank 64 with standpipe 36. Positioned in air line 66 is a metering device 68, a take-off line 69 containing a bleed valve 70, and a pair of shut off valves 72 and 74. Also included in the air line is a pair of check valves 76 and 78 for preventing back flow of fluid from standpipe 36 toward compressor 60. Check valve 78 is a rapid-acting check valve and functions to prevent flow of mud into the air line upstream thereof, while check valve 76 is of slower acting design and functions principally as a safety device which functions when valve 78 fails. A pressure recorder 80 indicates the pressure in line 66. A conventional compressor control means 82 controls the operation of the compressor as required in aerated drilling mud drilling operation.

Shown in the hollow drill string are a first check valve 84 and a second check valve 86 between couplings 88. Check valve 84 is inserted, preferably at the first or second joint in the drill string below kelly 24, when operating with aerated drilling mud. As hole is made and additional pipe joints are connected to the upper end of the drill string in conventional manner, check valve 84 correspondingly progresses down the bore hole and functions when uncoupling the kelly from the upper end of the drill string to prevent self-unloading of the aerated mud onto the drilling rig platform. As additional hole is made and after several pipe joints have been added above check valve 84, it is desirable, in the event that the drill bit is still functioning satisfactorily, to incorporate a second check valve 86 in the drill string when a joint of pipe is being added. Check valves 84 and 86 may be of the same or different construction and of any suitable construction which permits circulation of mud downwardly in the drill string but closes when the mud tends to flow upwardly, thereby shutting off the flow of fluid therethru. Plain flapper, vented flapper, and spring ball types of float or check valves are commercially available and function satisfactorily in the operation of the invention. While two check valves are shown more than two may be used to advantage when drilling a considerable depth with the same bit, the number depending on the amount of hole made.

Figure 2 shows a two-cone bit of conventional design comprising a body section 90 and a threaded shank section 92 which screws into the end of drill collar 94. A tri-cone bit may be utilized in lieu of the two-cone bit. The shank of the drill bit provides a fluid passageway 96 which leads to conduits 98 which, in turn, provide a fluid passageway to each of the cones 100 of the drill thereby permitting circulation of drilling fluid from conduit 102 in the drill string into the bore hole and the annulus between the drill string and the casing or bore hole. A ball 104 is shown in position over the mud conduit leading to one of the cones so as to shut off flow of drilling fluid thru this conduit. Ball 104 is introduced to the open end of the drill string when the kelly is removed for this purpose or for the purpose of adding a pipe joint; and the ball is circulated to the drill bit along with the drilling fluid where it is readily seated in one of the conduits extending thru the drill bit, as shown.

In operation with aerated drilling fluid, it is desirable to replace the aerated fluid by circulating non-aerated fluid to fill up the drill string and annulus surrounding same before pulling the string (for bit replacement, etc.); otherwise, the aerated mud in the hole will "unload" as pressure is released and expansion of the air in the fluid takes place. Then when the string is rerun aerated fluid is circulated to displace the non-aerated heavy fluid. In such operation the ball plug in the bit is not placed in the new bit (or replaced old bit in the event the bit is not changed) in order to facilitate the flow of fluid thru the bit until the heavy non-aerated fluid is displaced. At about this time a ball or similar plug is again inserted in the aerated drilling fluid at the upper end of the string and is circulated to the bit where it seats in one of the conduits therein so as to again adapt the flow to the lighter drilling fluid.

It is also feasible to circulate non-aerated drilling fluid down at least to the level of the uppermost check valve before opening the upper end of the drill string to the atmosphere to add pipe joints, thereby avoiding unloading of aerated fluid above the check valve.

Certain modifications of the invention will become apparent to those skilled in the art and the illustrative details disclosed are not to be construed as imposing unnecessary limitations on the invention.

I claim:

1. Drilling apparatus for use with drilling fluid containing compressed gas in gaseous phase comprising a

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hollow imperforate drill string; a bit on the bottom end of said string having at least one conduit therethru connected with said hollow drill string; a kelly on the upper end of said string; and a first upwardly-closing check valve in an upper section of said string a substantial distance below said kelly, and a second upwardly-closing check valve in an upper section of said string between said kelly and said first check valve said second valve being adapted to pass liquid downwardly thru the drill string from the upper end thereof and to close when said kelly is removed and gas in said fluid between said first and second check valves expands, and conduit means connecting the upper end of said kelly with a source of aerated liquid drilling fluid.

2. A process for drilling a well with a rotary drilling means comprising rotating a hollow drilling means having a kelly on the upper end and a cutting means on the lower end thereof in a bore hole so as to bore into an earth formation; circulating an aerated drilling liquid downwardly thru said drilling means from the upper end thereof thru said cutting means and upwardly thru an annulus between said drilling means and the wall of said bore hole; running a back flow prevention means in an upper section of said drilling means and, as hole is made, adding further sections of hollow drilling means intermediate said kelly and said back flow prevention device, whereby said back flow prevention device prevents back-flow of aerated fluid from the drilling means below; continuing drilling until replacement of said cutting means is desired; pulling said drilling means and replacing said cutting means; rerunning the said hollow drilling means and, as drilling means is rerun, inserting said back flow prevention means therein at a position in said drilling means closer to said kelly than it was just before pulling; and continuing the drilling.

3. The process of claim 2 wherein said drilling fluid comprises a drilling mud.

4. The process of claim 2 including the insertion of a second back flow prevention device in said drilling means at a point above first said back flow prevention device to avoid overflow of the aerated drilling fluid from the drilling means above first said back flow prevention device when said kelly is removed to insert an additional section of hollow drilling means.

5. The process of claim 4 wherein said fluid is a drilling mud.

6. In a process for drilling a well with a rotary drilling means comprising a hollow drilling means containing a terminal rotary cutting means having a plurality of passages therein for flow of drilling mud from the drilling means thru the cutting means, wherein, after a portion of the hole is drilled, a change from a non-aerated drilling mud to an aerated drilling mud of lower viscosity is made, the steps comprising inserting in the mud in said string a medium adapted to plug one of said passages and circulating same to the cutting means so as to plug one of said passages and thereby adapt the cutting means to

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more desirable flow conditions for said aerated mud and flowing said aerated mud thru the cutting means via at least one of said plurality of passages.

7. A process for drilling a well with a rotary drilling means comprising rotating a hollow drilling means having a kelly on the upper end and a cutting means on the lower end thereof in a bore hole so as to bore into an earth formation; circulating an aerated drilling liquid downwardly thru said drilling means from the upper end thereof thru said cutting means and upwardly thru an annulus between said drilling means and the wall of said bore hole; running a first back flow prevention means in an upper section of said drilling means and, as hole is made, adding sections of hollow drilling means to said drilling means intermediate said kelly and said first back flow prevention means, thus causing said first back flow prevention device to move a substantial distance down the hole; thereafter adding at least a second back flow prevention means in an upper section of said drilling means above said first back flow prevention means, whereby said second back flow prevention means prevents back-flow of aerated fluid from the sections of hollow drilling means between said first and second back flow prevention means because of expansion of gas in said aerated drilling liquid.

8. A well-drilling process comprising drilling a bore hole with rotary drilling means comprising a hollow drilling means containing a terminal rotary cutting means having a plurality of passages therein for flow of drilling mud from the drill string into the bore hole which comprises drilling in an earth formation with an aerated drilling mud and with one of said conduits closed until pulling of said cutting means is desired; thereafter circulating non-aerated drilling mud thru said drilling means and the annulus surrounding same so as to displace said aerated mud; pulling said drilling means and replacing said cutting means with a similar cutting means having all conduits therein open; rerunning said drilling means and circulating aerated drilling mud thru said drilling means and into the surrounding annulus and thus displacing the non-aerated mud; inserting in the mud in said drilling means a medium adapted to plug one of said passages; and circulating said aerated mud until said medium plugs one of said passages, while leaving at least one other of said passages open.

References Cited in the file of this patent

UNITED STATES PATENTS

50	1,681,502	Sheldon	Aug. 21, 1928
	1,867,832	Hill	July 19, 1932
	2,092,822	West	Sept. 14, 1937
	2,132,161	Hall	Oct. 4, 1938
	2,169,675	Bays	Aug. 15, 1939
55	2,238,895	Gage	Apr. 22, 1941
	2,595,715	Sloan	May 6, 1952