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METHOD OF REMOVING FORMATION FLUIDS FROM
A WELL BORE IN DRILLING OPERATIONS
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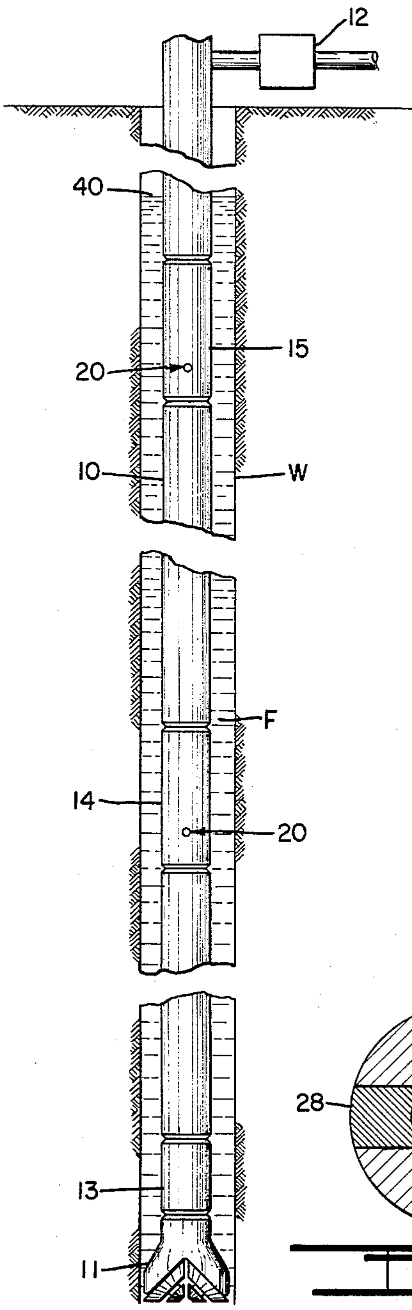

FIG. 1

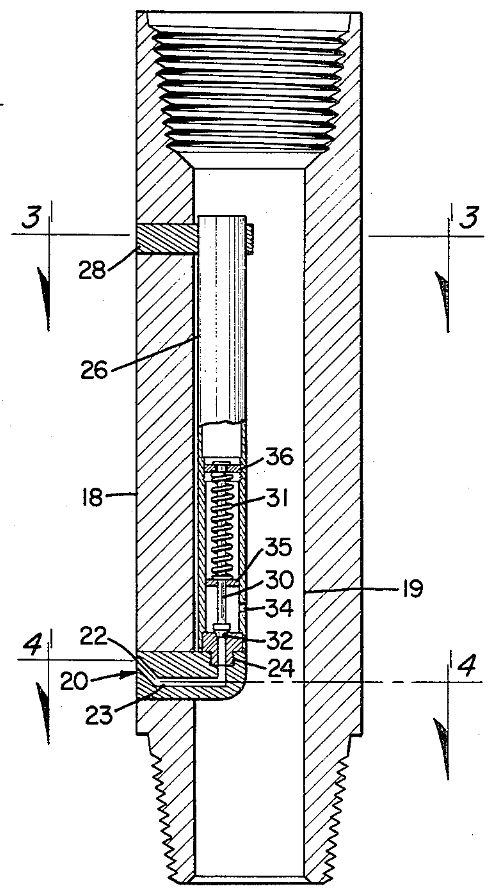

FIG. 2

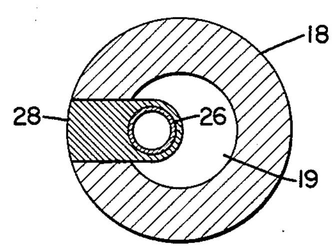

FIG. 3

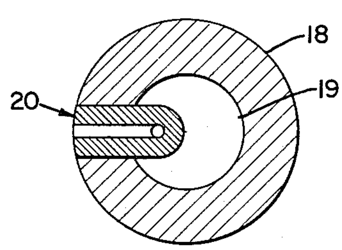

FIG. 4

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METHOD OF REMOVING FORMATION FLUIDS FROM A WELL BORE IN DRILLING OPERATIONS

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This invention relates to a new and useful method for the withdrawal of undesired formation fluids from a well bore annulus in air or gas drilling operations.

The drilling of wells with air or gas as a circulating medium has always been plagued by the occurrence of formation fluids, usually water, which interferes with the proper circulation of the compressed air or gas through the drill string. Some progress has been made in overcoming this problem primarily through the use of foaming agents which are added to the injected air in an effort to lift the water out of the hole. However, when air or gas circulation ceases during trips and while making connections, accummulation of formation fluids in the well bore becomes particularly pronounced. Accordingly, when circulation of air is attempted, it is often found that there is too much water in the hole and that artificial means such as a booster compresser is necessary to unload the hole before drilling operations can be resumed.

In producing wells, it is common practice to employ pressure-actuated valves, conventionally termed "differential stage lift valves," for the purpose of lifting or removing fluids from the well. Generally the valve is given a differential opening and closing pressure and by the injection of compressed air or gas either through the casing annulus or tubing the fluid build-up in the well can be withdrawn in stages, and here for a typical mode of flowing a producing well in this manner, reference is made to the patent to Boynton No. 2,307,016. Notwithstanding this, to the inventor's best knowledge and belief, no one has contemplated the use of differential-type valves of a type which may be incorporated in the drill string without restricting the passage of compressed air or gas therethrough and which would be effective in a unique way in cooperation with the circulating air or gas medium available to carry out differential lifting in stages of the formation fluids accumulating in the well bore. This eliminates the need for artificial aids, such as foaming agents or a special booster compresser, and considerably reduces the delay occasioned by the presence of the formation fluids in the well bore.

Accordingly, it is a principal and foremost object of the present invention to make provision for a novel and improved method of removing formation fluid accumulations in a well bore in air or gas drilling operations which eliminates the need for special attachments and equipment at the surface of the well, or foaming agents, while appreciably reducing rig time.

It is a further object of the present invention to make provision for a method and means for withdrawing undesired formation fluids from the well bore in air drilling operations which are easily conformable for use in wells of virtually any depth and pressure and where the available compressed air or gas pressure supply source may be effectively utilized for the removal of such fluids in a rapid and dependable manner.

It is an additional object of the present invention to provide for the unique disposition and arrangement of differential-type pressure actuated valves in an air or gas drilling string where, by selective pressure settings corresponding to the maximum pressure of the air or gas supply, water and other undesired fluid accumulations in

the well annulus can be easily and efficiently removed thereby reducing rig time and eliminating the need for booster compressors and other special equipment.

The above and other objects advantages and features of the present invention will become more readily understood from a considerable for the following details description of a preferred form and arrangement for practicing the method of the present invention, taken together with the accompanying drawings, in which:

FIGURE 1 is a somewhat schematic representation of the disposition and arrangement of a series of differential-type pressure actuated valves in an air drilling string and illustrating their manner of utilization in the removal of undesired fluids from a well bore;

FIGURE 2 is a sectional view in detail representing in more detail one typical form of pressure actuated valve which may be utilized in carrying out the method of the present invention;

FIGURE 3 is a sectional view taken about line 3—3 of FIGURE 2; and

FIGURE 4 is a sectional view taken about line 4—4 of FIGURE 2.

Referring in more detail to the drawings, there is shown by way of illustrative example in FIGURE 1 a rotary air-drilling string 10 and attached bit 11 positioned in a well bore W and having an air compressor designated at 12 for introducing either air or gas under pressure through the tubing string. Arranged at spaced intervals above the lower end of the drill string are a check valve 13 just above the drill bit and a pair of unloading sub assemblies 14 and 15, each having opposite threaded male and female end portions for interconnection in a conventional manner with the drill string.

It will become evident that any desired number of sub assemblies may be positioned in the drill string depending upon the depth of fluid in the well bore and thus one or more may be effectively utilized to carry out the objectives and intent of the present invention. It is emphasized further in this connection that the sub assemblies 14 and 15 as represented in the drawing merely represent one conventional way of carrying out differential stage lifting of undesired formation fluids, indicated at F in the drawing, from the well bore, with the provision that the sub assemblies will in no way restrict the passage of air or gas under pressure through the drill string in order to carry out the drilling operation.

A conventional differential stage lift valve is illustrated in FIGURES 2–4, representative of various types of valves which may be employed in carrying out the method of the present invention. For example, a Type C Intermittent and Continuous Flow Valve manufactured by Camco, Incorporated, of Houston, Texas can be utilized, and for a more detailed description and showing of this valve reference is made to the Camco catalog entitled "Complete Service—Gas Lift and Wire Lines," 1957. As stated previously, valves of this type are conventionally employed either for tubing or casing flow in completed wells and where the sole purpose of the operation is to increase production of the wall. As specifically adapted for use in a drill string, however, and as shown in FIGURE 2, each sub assembly comprises a valve mandrel 18 having a central fluid conducting passage 19. A port 20 is provided in the wall of the valve mandrel to serve as a means for selectively introducing high pressure air or gas from the passage 19 into the well bore annulus.

Each port includes an upwardly directed opening 22 communicating with a laterally extending cavity 23 with a threaded bore 24 positioned in the top wall of the cavity for connection of a pressure-actuated valve body 26 which controls opening and closing of the port; a bracket 28 retains the upper end of the valve body in place. As represented in FIGURE 2, the valve has a valve stem

30 which, under the urging of spring 31, is biased into normally closed relation with seat 32, thus normally restricting flow of air through the valve port. Here, orifices 34 are provided in the valve body which permit introduction of air under pressure from the drill string to act against the working area of piston 35 less the area of the seat 32, and the force exerted by the spring can be preset by adjustment of the threaded limit stop 36 to correspond with the maximum discharge pressure of the compresssed air source acting across the piston. However, upon opening, this opening pressure will act across the entire piston area including the valve seat. In any event, the pressure required to open the valve is greater than that acting across the effective area of the stem just before it closes, so that a definite "spread" or differential pressure is available to prevent premature closing of the valve.

As will be seen from FIGURE 1, intermediate positioning of one or more valves in spaced relation above the drill bit will provide for a means of selective introduction of air under pressure into the well bore annulus thereby to permit lifting of accumulations of formation fluid, such as, water and mud in the well bore annulus, in stages where otherwise introduction of air merely through the lower end of the drill string would require considerably greater pressures. Thus, for example, placement of the valves in the drill string will largely depend upon the maximum discharge air pressure available in relation to the pressure head of water or to other fluids accumulating in the well bore. The spread between opening and closing pressure will be established only to insure that sufficient amounts of air are passed through the open valve port to effectively lift that portion of the fluid above the valve out of the well. For instance, the spread between opening and closing pressure of each valve may be in the order of 10% so that where the opening pressure is set at 1,000 p.s.i., the closing pressure would be at 900 p.s.i. and the valve would remain open for all pressures above 900 p.s.i. In addition, in positioning a series of valves in the drill string, the valves should be so spaced and regulated in relation to one another as to remain open throughout successively decreasing pressure ranges for each lower valve. Accordingly, if the highest valve is set to close at 900 p.s.i., the next lower valve in succession may be set to open at pressures 900 p.s.i. or above and to close at 800 p.s.i.

To illustrate the above in practice, assuming that fluid has accumulated in a well to a depth of 5,000 feet, the upper valve 15 may be set to open at 1,000 p.s.i. and to close at 900 p.s.i. and would be located in relation to the fluid level 40 in the annulus to insure that the pressure head of fluid thereabove is no greater than the opening pressure of the valve.

As a rough approximation, one pound per square inch pressure would be effective to lift two feet of water and, assuming an available air pressure of 1,000 p.s.i. the uppermost valve would be spaced not more than 2,000 feet beneath the fluid level in the annulus.

The next lower valve 14 is correspondingly set to open at or above 900 p.s.i. and to close for example at 800 p.s.i. The spacing of the lower valve 14 beneath the valve 15 would be such that the pressure head of fluid remaining above the valve 14 after removal of the fluid accumulation above the valve 15 could be overcome by the lifting force of air pressure directed through the valve port so that for example it could be spaced 1,500 feet beneath the valve 15. Similarly, 1,500 feet would separate the valve 14 and lower end of the drill string and the pressure head of fluid remaining after withdrawing the fluid accumulation above the valve 14 could be lifted under the force of air pressure directed through the lower end of the drill string.

In air or gas drilling operation, as drilling proceeds, the depth of fluid encountered for example as drill sections are added can be accurately and very closely established.

Accordingly, depending upon the depth of fluid accumulation, an unloading sub assembly is spaced at each required interval above the lower end of the drill string. As explained previously, the uppermost valve is given an opening pressure corresponding to the maximum discharge pressure of the compressor and the closing pressure may be set for example at 900 p.s.i. The next lower valve would be similarly set and for example the opening pressure may be the same as that for the higher valve. However, it is most important that the closing pressure be lower than that of the highest valve in that the next lower valve will not effectively lift the water out of the hole until the first valve has completed its lifting cycle and reduced the pressure head of water from above the next lower valve. Accordingly, when the first valve has closed, the air under pressure will be introduced through the next lower valve to force the water above that valve out of the hole and to continue this action until a sufficient amount of air has been bled off through the valve to reduce its pressure to the closing pressure. Subsequently, air passing through the check valve at the lower end of the drill string will be of sufficient pressure to force the remaining fluid accumulation out of the hole, after which the air drilling operation may proceed. Through all of this, it will be noted that it is not necessary to suspend operation for addition or use of special equipment or agents and actually this operation proceeds very rapidly, thus saving considerable rig time and expense.

Broadly, therefore, the method of the present invention enables lifting of formation fluid accumulations in a unique manner from the annulus between the well bore W and rotating drill string through the simple expedient of positioning one or more pressure-actuated valves at selected intervals along the drill string where each valve is given a differential opening and closing pressure and is also arranged to close at a successively decreasing pressure. Fluid under pressure is introduced through the drill string to establish a pressure level at the highest valve corresponding to the opening pressure thereof, then upon reduction of the pressure level to the closing pressure of the valve, each next lower valve in succession will remain open at the closing pressure of the next higher valve and admit air under pressure for the purpose of lifting the formation fluid accumulated above each respective valve. Thereafter, the remaining fluid accumulation between the lowest valve and the bottom of the drill string is removed by the introduction of air under pressure through the check valve 13 at the lower end of the drill string. Again, it is emphasized that various different types of differential flow valves may be employed, the major requirements being that the valve will not restrict the free passage of air through the drill string and will effectively operate between differential opening and closing pressures in order to insure that sufficient quantities of air under pressure are introduced into the well bore to lift the fluid accumulations therefrom.

It will be evident from the foregoing that a novel and greatly improved method of lifting undesired fluid accumulations from a well bore in air drilling operations has been provided and that various modifications and changes may be made, particularly in the mode of carrying out the method of this invention, without departing from the scope of this invention as defined by the appended claims.

What is claimed is:

1. In combination with well drilling apparatus including a hollow drill string for driving a bit and in which the hollow of the drill string forms a first conduit for pressure fluid and the annulus between the well bore and the outer surface of the drill string forms a second conduit for removal of formation fluid, the improvement which comprises apparatus for sequentially lifting from the top successive portions of formation fluid in said

annulus, said apparatus including a plurality of differential pressure valves sequentially positioned inside said drill string from the top down for bleeding pressure from said first to said second conduit, each of said valves having different opening pressures and each valve having a closing pressure less than its opening pressure, each succeeding valve from the top valve down having an opening pressure less than the closing pressure of the valve immediately above it.

2. In combination with well drilling apparatus, a hollow drill string for driving a bit in which the hollow of the drill string forms a first conduit for pressure fluid during drilling and the annulus between the well bore and the outer surface of the drill string forms a second conduit for removal of formation fluid, said drill string including hollow subs joining pipe sections together, each sub having a differential pressure valve supported in its interior for bleeding pressure from said first to said second conduit, each of said valves having a different opening

pressure and having a closing pressure less than its opening pressure, said subs being arranged from the top of the drill string down so that each succeeding valve from the top valve down has an opening pressure less than the closing pressure of the valve immediately above it.

References Cited in the file of this patent

UNITED STATES PATENTS

2,385,316	Walton	Sept. 18, 1945
2,620,741	Garrett et al.	Dec. 9, 1952
2,691,383	Church	Oct. 12, 1954
2,797,700	McGowen	July 2, 1957
2,815,764	Bryan	Dec. 10, 1957
2,833,517	Bobo	May 6, 1958

OTHER REFERENCES

Murray, A. S. et al.: "Water Still Poses Tough Problem in Drilling With Air," Oil and Gas Journal, pp. 105–112, vol. 55, June 1957.