July 19, 1932. F. F. HILL 1,867,833

SUBCIRCULATION OIL WELL DRILLING APPARATUS WITH SUCTION PUMPING

Filed June 6, 1928

Fig. 1.

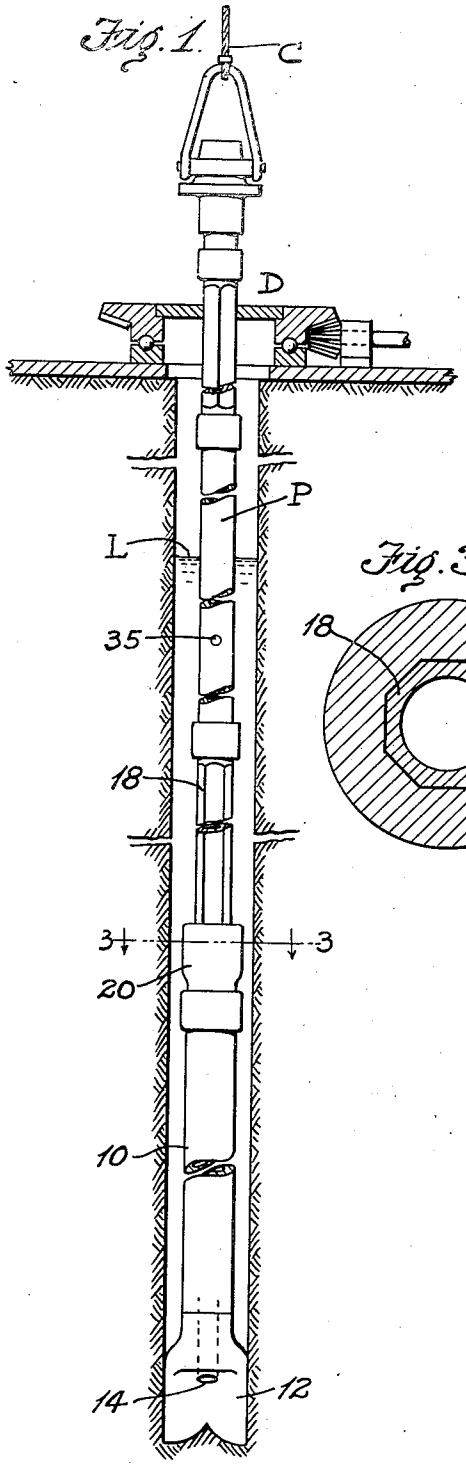
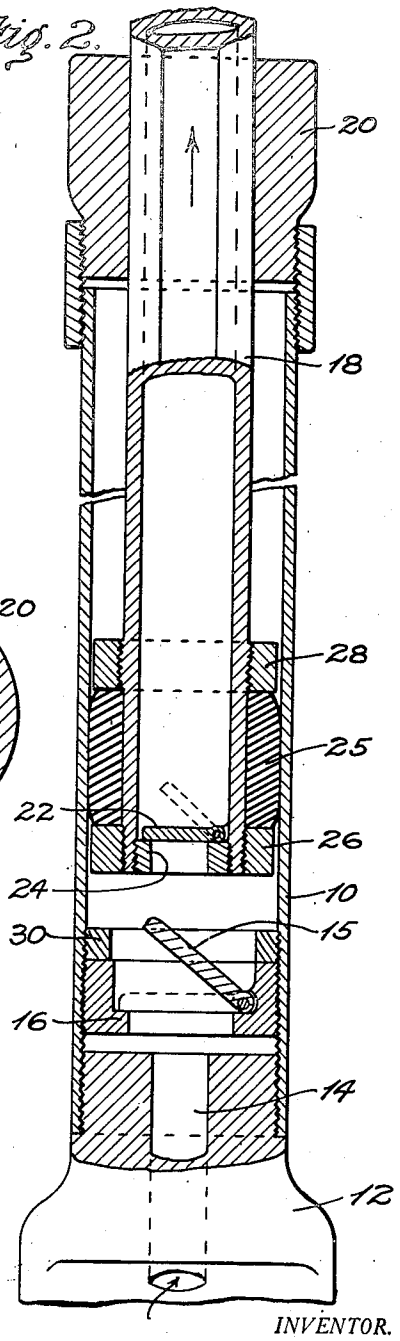


Fig. 3.

Fig. 2.



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Patented July 19, 1932 1,867,833

UNITED STATES PATENT OFFICE

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SUBCIRCULATION OIL WELL DRILLING APPARATUS WITH SUCTION PUMPING

Application filed June 6, 1928. Serial No. 283,282.

This invention relates to methods and apparatus for the drilling of deep wells, particularly oil wells, and while it is especially adapted to the sinking of wells through low pressure formations and to drilling operations conducted by the rotary method, it is not necessarily limited either to low pressure zones or to rotary procedures.

Rotary drilling consists usually in advancing a drill through earth strata by the rotation of a hollow stem to which the drill is affixed and in circulating a fluid in the form of a comparatively thin mud from the surface down through the drill stem and bit and up through the hole outside the stem for the purpose of removing the cuttings and keeping the drill bit cool. The hydrostatic head thus produced by this mud is necessarily great at the bottom of a deep hole, and in addition a pump pressure is employed to produce sufficient mud velocity to carry out the cuttings. These pressures being greater than the natural rock pressures, large quantities of mud are injected into porous formations, and clogging thereof by the mud commonly results. In some cases it is of course desirable to thoroughly mud the walls of the hole, for instance, when passing through water strata or gas zones or loose formations not productive of oil. Also mudding in high pressure formations usually offers no great objection because of the fact that the high pressures serve to expel the mud when the well is brought in. But in low pressure formations, such as depleted oil sands, the clogging condition continues to a large extent and thereby seriously retards the flow of oil into the well when production is finally established. This fact is clearly substantiated by results obtained in drilling known formations of low pressure under the old method just described and in then drilling in the same formation and in the same locality according to the present invention, the yield in the latter instance being much greater than in the former. Another objection to the use of circulating mud is that the mudding of a low pressure sand is frequently so effective as to entirely seal it off during the drilling, and a commercially productive stratum thereby has its productivity entirely destroyed.

Thus it is clear that if circulation with mud can be omitted and high head and pump pressures can be eliminated, the formation will not be affected as with the old methods and superior results in the way of increased production will be obtained.

The object of this invention therefore is to permit drilling of deep wells, particularly oil wells, through low pressure formations without employing circulating mud and without circulating a liquid column from the surface, whereby to avoid the clogging of the formations.

A further object is to provide a method for drilling through low pressure oil formations, which will require only small quantities of drilling liquid, and preferably only such liquid as is produced by the formations.

In attaining these objects, I have found that desirable results can be obtained, especially in rotary drilling, and especially when penetrating low pressure sands, by using only such liquid as the formation produces, by circulating such liquid locally in the vicinity of the bit, and by intermittently removing the cuttings. The local circulation, which I prefer to call "sub-circulation", serves to cool the bit and keep the hole clear around the bit, and also avoids clogging. The head pressure of the liquid used need not be maintained at a value materially greater than the rock pressure, the term "rock pressure" being that which is usually applied to indicate the natural pressure in the formation acting to supply liquid to the well. However, if the formations yield insufficient fluid, enough may be added to supply sub-circulation requirements. By the expression "head pressure not materially greater than rock pressure" is meant the pressure of a liquid head which is not sufficient to disturb the formation either by causing a clogging thereof or by forcing foreign fluids or bodies back into the stratum being penetrated.

This method of operation may be carried out so that the head pressure never exceeds the rock pressure, and since an effort is usually made to remove as little liquid as possible

when the cuttings are removed, this head pressure remains substantially constant and closely approximates the rock pressure. Pressure equilibrium is thereby maintained and I have elected to apply the term "equilibrium drilling" to drilling operations promoted under these conditions. Such pressure maintenance is highly desirable in that it largely insures the avoidance of caving when working in loose formations where caving is apt to result if the head pressure is allowed to fall materially below rock pressure. When caving is not a material factor, or is eliminated by progressive casing, the head of liquid is not so material and the only criterion is the maintenance of enough liquid to insure sub-circulation.

I have found that by maintaining the liquid head at approximately the natural rock pressure and by removing the cuttings from the vicinity of the bit frequently so as to assist in keeping the bit clear, drilling may be advanced at a satisfactory rate considering especially the off-setting advantage residing in the fact that the original porosity of the formation is maintained.

According to the preferred form of the present improvement an apparatus is used which includes a hollow drill stem comprising two telescopic parts connected in rotary driving relation and also connected to operate as a suction pump whereby the cuttings may be drawn up into the stem and movement of liquid past the bit may be accomplished to insure proper cooling and clearing. According to a preferred embodiment, a port may be provided at an elevated point in order that any surplus liquid drawn up into the stem may, after the cuttings have settled, be returned to the hole in order to maintain the liquid head substantially constant thereby maintaining the pressure upon the formation substantially the same as that naturally occurring in the formation.

Briefly stated, the invention therefore may be considered to reside in drilling a formation to deepen the hole, maintaining a relatively low liquid head therein, that is, a head much less than the depth of the hole, drawing the cuttings intermittently up into the hollow drill stem with movement of liquid past the drill, thereby clearing and cooling the latter, and continuing drilling following such removal of the cuttings. Specifically the invention includes such drilling in low pressure sands, and especially when drilling by the rotary method, the head being preferably maintained at the natural rock pressure. The invention also includes the step of returning excess liquid to the hole from the drill stem. It further includes the apparatus employed.

In the accompanying drawing wherein one embodiment of the invention is shown by way of illustration,

Fig. 1 is an elevation showing a circulator of the present invention in association with a drill and with a hollow rotary drill pipe extending into a well being drilled;

Fig. 2 is a vertical section through the circulating pump; and

Fig. 3 is a cross section taken on line 3—3 of Fig. 1.

A lower hollow drill stem section 10 has at its lower end a bit 12 of any suitable type provided with a water course 14 according to the usual practice, a flap or other suitable valve 15 being carried in said section on a mounting 16 above the drill 12, and an upper hollow section 18 of drill stem extending telescopically into the lower section 10. Said section 18 is polygonal in cross section and enters a correspondingly shaped nut 20 carried by the upper end of the section 10, this structure being provided both to permit telescopic action and for rotation of the drill 12, the section 18 being rotated through the medium of drill pipe P and a rotary drive D at the surface. Within the section 18 a second upwardly opening flap or other valve 22 is provided, this valve being carried on mounting 24 secured to stem 18. In order that these parts may act as a suction pump a packing 25 is disposed about the lower end of the section 18 between a collar 26 and another retainer 28, the collar 26 when in its lowermost position being adapted to rest upon an annular stop 30.

When a hole is being drilled a limited liquid level such as that indicated at L is established in the hole and the drilling takes place therein. When the cutting accumulate about the bit 12 and the latter begins to heat up, the rotation is temporarily suspended and the main stem section 18 is lifted by cable C, whereupon the collar 26 is withdrawn from its seat upon the stop 30, thus producing a suction between the valves 15 and 22, through the sealing effect of the packer 25, to cause the cuttings and liquid to be drawn through water course 14 into the lower drill stem section 10, the relative upward movement of section 18 being limited by engagement of the retainer 28 with the nut 20. This operation brings fresh liquid into contact with the point of the bit and cools the same and at the same time clears the bit. The main stem 18 is then allowed to descend, whereupon the valve 15 closes and the liquid and cuttings there above are forced past the valve 22 up into the interior of said section 18. This operation is repeated as often as is required to clear and cool the bit, and drilling is resumed when proper clearing and cooling have been produced.

With this style of operation a small quantity of liquid in the hole is sufficient to accomplish the desired results. In fact the head may be either quite small or relatively high, but in any event, if the formation liquid is

relied upon, the head will never be greater than the formation pressure, and all detrimental effects normally incident to higher head pressures will be avoided. Also this method and apparatus provide for withdrawal of the cuttings from the formation with sufficient dispatch. When the drill string is removed from the well either for the purpose of replacing the bit 12 or otherwise, the cuttings are dumped thereby clearing the interior of the drill stem, and if necessary further cleaning of the hole may be accomplished by bailing while the bit is withdrawn.

If the liquid head is so low that the amount of liquid accumulated in the stem by the pumping action would otherwise reduce the liquid head materially, a port 35 may be provided in the main stem section 18 at a point which will always be above the upper end of the section 10, even when the parts are fully telescoped, so that excess liquid rising above the settled cuttings will drain therefrom. Or the port 35 may be provided in all cases, in which event, if the liquid level stands in the well above the port the same level will stand in the stem section 18, liquid in this section draining therefrom when the string is withdrawn from the well. Usually due to the short distances drilled between removal of the drill, it is the experience of the inventor that the space necessary for the accumulation of detritus and liquid in the drill stem is small, perhaps amounting to only a couple of barrels. It will be seen that under the usual conditions this will not materially lower the head of liquid in the hole. Thus the maintenance of a substantially constant head may be maintained regardless of conditions.

The method of drilling herein disclosed, while being particularly applicable to rotary drilling, is not limited thereto, and while being especially designed for working in low pressure formations with employment of the liquid furnished thereby, the method may in some cases be used in drilling other formations, including those which produce no liquid whatever. In the latter instance liquid of sufficient quantity will be introduced into the hole, an advantage here being that by employing a small liquid head, only a small pressure will be released into a low pressure formation when the tool enters the same.

From the foregoing it will be clear that the method of drilling here presented serves quite efficiently to protect low pressure formations from the effects of high heads of drilling mud or other drilling liquid, the method at the same time being applicable to other formations, especially when drilled by the rotary method. Moreover, the method may be applied to core drilling, in which case a core drill will be employed as the bit 12.

It should be understood that this method may be combined with the conventional mud circulating method where known structures are being penetrated, mud circulation being employed when drilling the non-productive zones, and the present method being resorted to when productive zones, especially low pressure formations, are being approached.

It is to be understood that the disclosures herein contained are to be considered merely as illustrative of the generic invention and as no wise limiting since many variations within the spirit hereof may be made by those skilled in the art.

I claim.

1. In a structure for drilling a deep well, a hollow drill stem comprising two telescoping sections, a drill on the lower end of the lower section, said drill having a water course therethrough, a driving connection between the two sections extending throughout the range of their telescopic engagement, and an upwardly opening valve in each section.

2. A structure according to claim 1 wherein a liquid passage is provided through a wall of the upper stem section at a point which is above the upper end of the lower section when the sections are fully telescoped.

3. In a structure for deep well drilling, a hollow drill stem comprising two telescoping sections, a drill on the lower end of the lower section, said drill having a water course therethrough, a driving connection between the two sections, an upwardly opening valve in each section, a liquid passage being provided through the wall of the upper section at a point materially elevated above the upper end of the lower section when the sections are fully telescoped whereby cuttings may accumulate in the upper section below said passage without clogging the latter and whereby excess liquid accumulating above the cuttings may discharge through said passage.

4. In well drilling apparatus, a rotary drill, a suction pump connected with said drill and comprising a pair of telescoping members one extending above the other, said members having upwardly opening valves, a drill stem extending above said pump, and means to rotate said stem and drill, the upper telescopic member having a liquid discharge at an elevated point thus forming a trap in the lower portion of the said upper member to segregate cuttings from the drilling liquid.

Signed at Los Angeles, in the county of Los Angeles and State of California, this 31st day of May, A. D. 1928.

FRANK F. HILL.