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ROTARY WELL DRILLING APPARATUS

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Fig. 1.

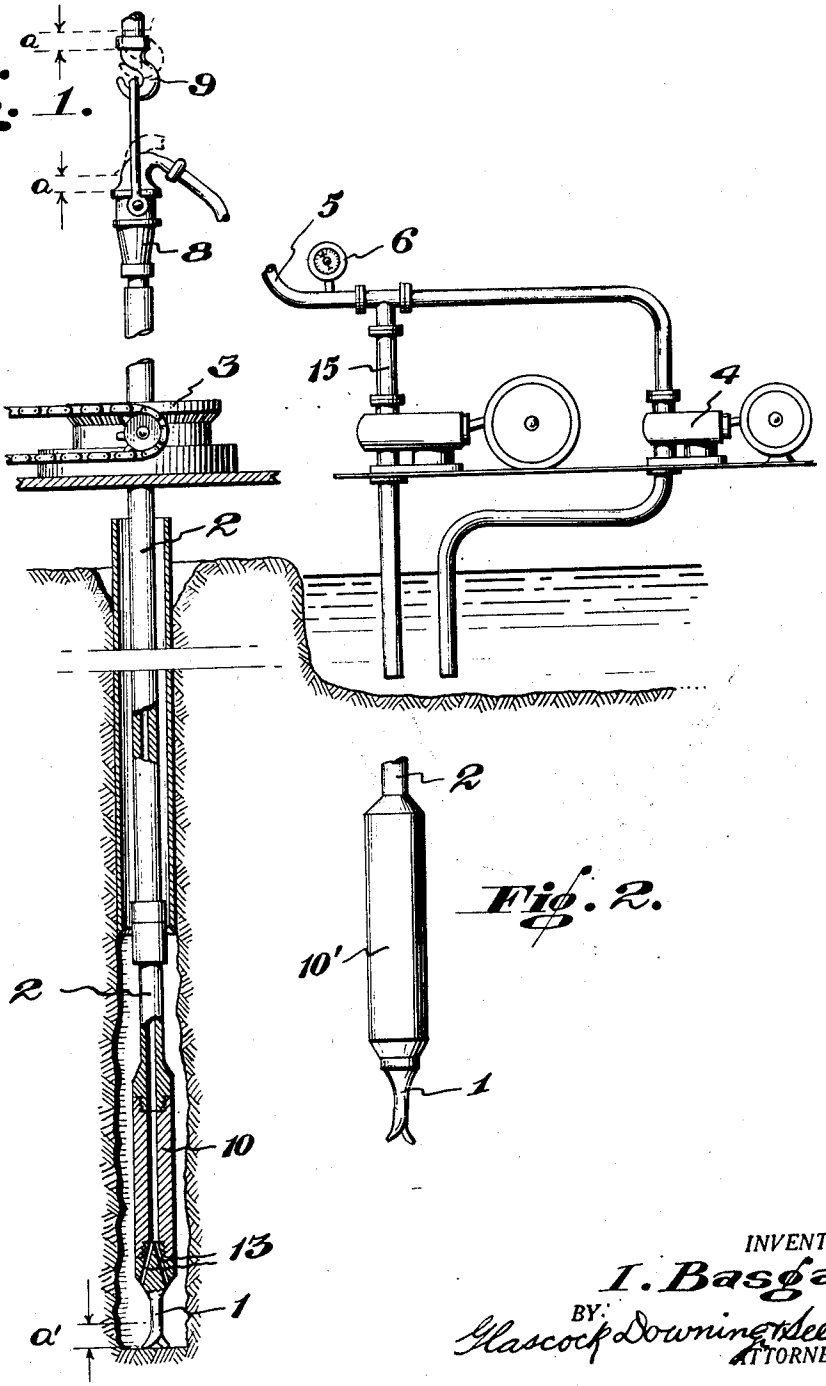


Fig. 2.

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ROTARY WELL DRILLING APPARATUS

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3 Claims. (Cl. 255—24)

The object of this invention, which I have achieved after very full practical and theoretical investigations, is the improvement of rotary drilling used for boring oil wells by changing the principle of this system both as to method of working and arrangement of string of tools, whereby an increased efficiency is obtained.

It is known that in the rotary system of drilling, the cutting tool, viz. the bit, advances by means of rotation, this being due to the weight applied by this string of tools on bottom. The movement of rotation is impressed upon the string of tools and hence on bit by a known couple applied at this surface. This string of tools is made up from the bottom upwards as follows: bit, drill-collar and drill pipe which connects string with surface machinery.

If, whilst bit is rotating a vibratory movement be impressed upon bit, such as to allow bit apart from the movement of rotation an oscillating movement vertically, resulting in an action of percussion, the efficiency of drilling operations will be increased appreciably.

The oscillating percussion motion is easy to produce on account of the general shape of string of tools, wherein the ratio between length thereof and cross section is very large. A body of this shape may have longitudinal vibrations easily impressed upon, this resulting in oscillatory increments at both ends of known frequency.

The invention is illustrated by way of example in the accompanying drawing, in which

Fig. 1 is a diagrammatic elevation partly in section of a boring plant operating in accordance with the process according to the invention and Fig. 2 is a vertical elevation of a modified detail.

Referring to the drawing, 1 is the drilling bit which is connected to the hollow drill rods 2 to which rotary motion is imparted in the usual manner by means of a rotary table 3, the drill rods being supported by a swivel head 8 of conventional construction suspended from a hook 9 forming part of a block and tackle system. Liquid for clearing the bore hole is supplied to the interior of the drill rods 2 through the swivel head 8 by means of a pipe 5 which is connected up at 15 to any suitable source of liquid under pressure, the liquid passing into the bore hole through passages 13 provided in the portion of the boring implement secured to the lower end of a drill collar 10.

For producing the pressure variations to set up the longitudinal vibrations, a pump 4 is provided which delivers to the pipe 5 and produces periodical surges in the pipe line 5, the resulting pressure variations being measured by means of a pressure gauge 6. These pressure variations periodically raise and lower the swivel head 8 together with the hook 9, the amount of movement a of the swivel head and the hook being the same as shown diagrammatically in Fig. 1. These rising and falling movements are impressed upon the rods 2 in the form of longitudinal vibrations and transmitted to the boring implement to which a corresponding rising and falling movement a' is imparted to produce the required impacts. In this manner a wave motion is set up in the liquid in the hollow boring rods which is propagated downwardly from the top, the said wave motion being superimposed on the wave motion of the string of tools proper, which latter, however, in theory and practice, are rapidly damped out, leaving only the forced vibrations produced by the surges in the pipe line 5, the frequency of which can be regulated at will. During the practical application, I have measured the effect of these vibrations at the upper end of string of tools, it being possible to record amplitude and frequency of oscillation. On the other hand I have found by calculation that work done by this oscillating percussion action of bit, when in contact with bottom of hole, is of utmost importance from the point of view of penetration of bit in various formations. Practical results have entirely confirmed the increase in efficiency of drilling carried out on these lines, that is to say by a joint effect of movement of rotation with a movement of percussion. By its action of percussion, bit weakens formations and thus rotary action shaves formation off easier and cleans bottom of hole more satisfactorily. The effect of the action of percussion increases, as the weight applied on string of tools at bottom is adjusted in such a fashion that drill pipe shall not be unduly stressed under torsion in their rotating movement, by too large a weight applied on bottom.

Thus, bit oscillating vertically, will easily maintain direction of gravity during penetration, this resulting in straight holes, over and above an increase of drilling efficiency.

It appears quite clearly that so far, rotary drilling has made use of a movement of rotation only and exclusively, for penetration, whereas by this invention drilling, viz. advancement of cutting tool, is insured and realized by both movements of rotation and percussion. In order to impress upon bit this movement of percussion during its rotation, either the liquid column inside the storing of tools may be made use of, as explained above, or by any other suitable mechanical device insuring the same results, viz. creating a movement of percussion in addition to rotation impressed on string of tools from surface.

In this string of tools, constituted as above mentioned, and as generally used today, the drill-collar has a definite weight per unit length, exceeding that of drill pipe proper and each size of drill pipe is provided with a drill-collar of same nominal size. The action of drill-collar,

as in use, may be described as follows: a rigid connection between bit and drill pipe giving a better driving action and also insuring a sufficient weight to produce the necessary pressure when bit comes in contact with formations.

In bore hole drilling apparatus, the string of tools comprises, in addition to the drill rods and the drill bit, a drill collar which provides a rigid connection between the drilling bit and the drill rods and produces a better driving action and acting as guiding means for the drill bit. This drill collar has a definite weight per unit length, exceeding that of the drilling rods, and each size of drilling rod is provided with a drill collar of the same nominal size. In accordance with the present invention, in addition to the weight acting on the bit due to the drill collar and the drilling bit itself and any connecting means for the bit, an additional concentrated weight is applied to the lower end of the string of tools, either by increasing the weight of the bit, drill collar or any other member situated at the lower end of the string or by providing an additional weight member at this point, for the purpose of countering the upwardly acting hydro-mechanical pressure acting in the opposite direction to the direction of penetration of the drill. This hydro-mechanical pressure, which acts unfavourably on the drilling rods and is the cause of a number of difficulties in drilling which frequently lead to heavy losses, is due to the upward flow of the mud discharged by the clearing fluid. The magnitude of the hydro-mechanical force acting in the negative direction, the direction of penetration of the drill being assumed to be positive, is appreciable and varies with the total weight of the string of tools, the rate of discharge and specific gravity of the mud and the cross-sectional area of the discharge passages holes for the clearing liquid in the boring implement. Thus, the weight to be added to the lower end of the string of tools is not a constant quantity but varies with the factors referred to, namely the weight of the string of tools, the rate of discharge of the mud and the cross-sectional area of the clearing liquid discharge passages. In Fig. 2, this additional weight is provided by employing a heavy drill collar 10 above the bit 1, which also gives a more regular rotary movement, the weight acting as energy storer and increasing the efficiency of the drilling and producing a bore hole of more regular formation, leading to important economies.

In order to exhibit the procedure of calculating this weight, the following simplified relation is given, which in its simplicity takes into account working conditions.

$$G=K_1.G_1+K$$

Where:

G=weight concentrated at lower end of string of tools, necessary to take up resultant of hydromechanical pressures in kilos.

G_1=total weight of string of tools in kilos.

K_1=a coefficient determined by density of mud fluid and density of material of drill pipe, values having been determined as follows:

K_1=0,15 for mud density varying from 1,1 to 1,3.

K_1=0,20 for mud density varying from 1,5 to 1,7.

K =a coefficient determined by cross sectional area of holes of bit and rate of discharge of mud fluid.

For all practical purposes K=50.

Value of coefficients K_1 and K may be expressed and have been calculated by me by detailed formulae, however, above given figures are sufficient for all practical purposes necessary in application of my invention.

Example.—In case of mud of 1,2 density and standard cross sectional area of bit holes, weight necessary to take up resultant hydromechanical pressures will be:

$$G(\text{kilos})=0,15G_1+50$$

Therefore, for a weight of string of tools of 50,000 kilos concentrated at lower end of said string, there must be a weight of about 7,550 kilos. This is the weight necessary to take up hydromechanical pressures, to which may be added also the drilling pressure, thus having latter also in proximity of bit. Therefore, if it be desired to drill under a pressure of say 2,450 kilos, total weight concentrated at lower end of string, according to above, will be about 10,000 kilos.

All such changes relating to above weight, as compared to present weight of bit, of drill-collar and any other element of lower end of string resulting in establishing the concentrated weight according to the principle of this invention, are included in this invention.

Weight necessary at bottom of completed well, as resulting from calculations included in this specification, need not but may be used from beginning of drilling operation.

The alterations brought about my invention in the design, especially with a view to weight, of all constituents of lower end of string of tools, as well as those of their succession, may be easily evidenced by comparing said elements with those included in present day works-practice.

This concentrated weight at lower end of string, according to above explained principles, may be carried out on any element at the lower end of said string by altering its design so as to satisfy weight requirements. In order to apply my invention, adequate bits and drill-collars will have to be manufactured and these will be either changed or interconnected in numbers of 2, 3 or more during drilling-operations, according to increase in weight of string.

The taking up of hydromechanical pressures over and above its use in my invention, may be successfully made use of when applied to straight rotary drilling.

The taking up of hydromechanical pressures is applicable and I have successfully tried same for all operations connected to drilling, such as: coring, fishing, setting casing, etc.

When setting casing the amortization of hydromechanical pressures insures a satisfactory concentric setting and cementing of string of casing and results therefore in a satisfactorily consolidated hole and a good water shut-off.

It is necessary to point out that my invention uses for the first time a weight, under the shape of a drill-collar or similar element, for operations such as coring, fishing and setting casing.

From the above, the advantages of the application of this invention, may be detailed as follows:

Increase of efficiency of drilling, straighter and better quality holes, with a resultant decrease in fishing possibilities, breakages of drill pipe, etc. satisfactory cementing and more efficient water shut-offs.

I claim:

1. In rotary bore hole drilling apparatus, the combination of a drill string comprising hollow drill rods and a drill bit having a conduit therein for establishing open communication between the bore hole and the interior of the drill rods, said drill rods and drill bit rigidly secured to one another, supporting means for the drill string, a pump and a supply conduit connected up thereto for supplying clearing liquid to the interior of the drill rods, with a second pump connected up to said supply conduit for producing pressure variations in the liquid column within the supply conduit and the drill string, so as to set up longitudinal vibrations in said liquid column and drill string.

2. In rotary bore hole drilling apparatus, the combination of a drill string comprising hollow drill rods and a drill bit having a conduit therein for establishing open communication between the bore hole and the interior of the drill rods, said drill rods and drill bit rigidly secured to one another, supporting means for the drill string and means for supplying clearing liquid to the interior of the drill rods, of a concentrated weight at the lower end of the drill string for countering the upwardly acting hydro-mechanical pressure acting in the opposite direction to the direction of penetration of the drill, said weight substantially equal to 0.15 times the weight of the drill string plus 50 kg.

3. In rotary bore hole drilling apparatus, the combination of a drill string comprising hollow drill rods and a drill bit having a conduit therein for establishing open communication between the bore hole and the interior of the drill rods, said drill rods and drill bit rigidly secured to one another, supporting means for the drill string and means for supplying clearing liquid to the interior of the drill rods, of a concentrated weight at the lower end of the drill string for neutralizing the negative hydro-mechanical pressure acting in the opposite direction to the direction of penetration of the drill, said weight substantially equal to 0.2 times the weight of the drill string plus 50 kg.

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