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HYDRAULIC VIBRATORY DRILLING TOOL.

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The present invention relates primarily to the art of drilling.

It has long been known to operate a drill either by rotation through a shaft or by reciprocation through a cable. Each of the types of apparatus just mentioned has its own advantages for certain conditions. For instance, in relatively soft strata, the rotary tool can be sunk more rapidly, and possesses also the important advantage that it minimizes the danger of caving. In hard structure, however, the cable tools are more satisfactory, and the fact that a well of any great depth is apt to strike hard strata accounts for the wide use of the cable drilling apparatus.

It is the principal object of the present invention to provide an apparatus combining the major advantages of both the rotary and cable types of drilling apparatus.

The apparatus according to the present invention is adapted to reciprocate the drill at the bottom of a hole by mechanism operated by fluid transmitted to said mechanism through a hollow pipe or shaft. Preferably the drill is rotated during the reciprocation so that it may be operated either as a rotary apparatus or as a reciprocating apparatus or as a combined rotary and reciprocating apparatus as may be desirable under the conditions encountered.

The novel features of the present invention are pointed out with particularity in the appended claims. The invention itself, however, together with further objects and advantages, will best be understood from the following description taken in connection with the accompanying drawing in which:

Figs. 1 and 1^a are a central longitudinal section of a drilling apparatus according to the present invention, Fig. 1^a being a continuation of the drill portion of the apparatus shown in Fig. 1;

Fig. 2 is a detail of the splined joint of the apparatus illustrated in Fig. 1, drawn to a larger scale;

Fig. 3 is a detail of the valve mechanism of the apparatus illustrated in Fig. 1, drawn to a larger scale;

Fig. 4 is a view of the valve mechanism illustrated in Fig. 3, the parts being, however in a different position;

Fig. 5 is a section of the apparatus taken on the line 5—5 of Fig. 2;

Fig. 6 is a section of the apparatus taken on the line 6—6 of Fig. 3 looking in the direction of the arrows;

Fig. 7 is a section of the apparatus taken on the line 7—7 of Fig. 3, looking in the direction of the arrows;

Fig. 8 is a view, somewhat diagrammatic in character, illustrating the apparatus according to the present invention as set up for operation.

The drill illustrated in the drawings is adapted more particularly for drilling deep oil wells. The drill bit 10 has a cutting face which is designed for cutting due both to the reciprocating motion imparted to the bit and to the rotary action imparted to the entire drilling apparatus. The upper end of the bit has a threaded shank by which it may have a threaded connection with a coupling or bushing 12 in the lower end of the drilling mechanism. Coupling 12 is threaded into the lower end of a pipe 14 forming a continuation of a barrel 16, parts 14 and 16 being connected by a head or hollow coupling 18 (Fig. 1). At its upper end the barrel 16 carries a second head or coupling 20 threaded thereto, coupling 20 supporting a pipe length 22 serving as a part of a splined joint between the barrel 16 and a rotatable pipe or hollow rotatable shaft 24, through which motive fluid is delivered to the apparatus. With this construction the barrel 16 may be reciprocated on shaft 24 and will rotate with the shaft 24. A head 26 threaded to the upper end of tube 22 fits closely to the shaft 24 and serves as a guide for the barrel 16 thereon. On its interior surface, tube 22 is provided with two ribs 28, 28 parallel to its axis and also parallel to that of the shaft 24, tube 22 and shaft 24 being coaxial. The ribs 28 on the inner surface of tube 22 overlap in the radial direction with ribs 30, 30 formed on the outer surface of a coupling member 32 threaded to the lower end of shaft 24. Ribs 30 are parallel to the ribs 28, the two pairs of ribs having finished contacting surfaces permitting relative reciprocation of tube 22 and coupling 32 but preventing relative rotation thereof after the ordinary manner of splined joints.

Threaded to coupling 32 is a tube 34 forming an extension of the shaft 24. Tube 34 extends through coupling 20, running some distance into the barrel 16. At its lower end, tube 34 carries a fixed hollow piston 36 between which and the inner surface of the barrel 16 are mounted a series of cup leathers 38, 38. The tube 34 and hollow piston 36 are adapted to deliver motive fluid entering the apparatus through hollow shaft 24 to a pressure chamber 40 within barrel 16 below the piston 36. Cup leathers 38 prevent leakage of motive fluid upward along the surface of barrel 16 from pressure chamber 40. Fluid pressure in chamber 40 forces the barrel forwardly or downwardly and when the pressure in chamber 40 is relieved a spring 39 acts to return the barrel 16 and connected parts to its original position. Breather holes 41, 41 are formed in the upper portions of barrel 16 and pipe 22 so that the reciprocation of the parts may not be hindered by trapped liquid.

Water under pressure is introduced into the pressure chamber 40 through the hollow shaft 24 and hollow piston 36. To build up a pressure in the chamber 40 the coupling 18 at the lower end of the barrel 16 is closed by means of a valve 46 and a pipe 42 having a valve 56 at its upper end. The variations in the pressure in the chamber 40 are caused by the operations of the valves 46 and 56 which alternately permit and check the escape of fluid from the chamber. The fluid which escapes from the chamber passes downwardly through the pipe 14 and flows out into the well being drilled through an opening 45 formed in the upper end of the drill bit 10.

Referring more particularly to the operation of the valve 46, it will be seen in Figs. 3 and 4 that valve 46 is made in the form of a hollow cylinder which is slidably mounted on the upper end of the pipe 42. The lower end of the valve 46 is conical to fit on a valve seat formed on the upper end of the coupling 18. The pipe 42 is smaller in diameter than the diameter of the opening in the coupling 18, so that a passage way 44 is provided between the coupling and pipe by which fluid may escape from the chamber 40 into the pipe 14 in flowing out through the opening 45 in the drill bit. The valve 46 is normally held open or raised from the seat on the coupling 18 by means of a compression spring 48 which is mounted between the upper end of the coupling and lugs 50 formed on the upper end of the valve.

The valve 56 is shown in closed position in Fig. 3 and in open position in Fig. 4. This valve is located within the pressure chamber and is normally opened and closed by inertia weights 52 and a spring 54. To accomplish this valve 56 is fixed to a cage

58 which fits over the outside of tube 42 and carries at its lower end a ring 60 (Fig. 3) whereby the valve 56 is guided on the tube 42 but is permitted to reciprocate thereon. The lower face of the valve 56 is grooved at 62 to receive the upper edge of the tube 42 and the top face of valve 46 is recessed at 64 to receive the lower edge of the ring 60, the grooves 62 and 64 serving to cushion the contact between the parts in the operation of the apparatus as hereinafter described. The weight 52 lies within the tube 14 and has a lesser outer diameter than that of the interior surface of the tube leaving an opening 53 running straight down from the outlet side of valve 46 to the lower end of weight 52. Moreover, weight 52 is hollow affording with pipe 42 a straight passage for fluid from the outlet side of valve 56 to the lower end of weight 52. Below weight 52 fluid from valves 46 and 56 has a practically unimpeded passage through the lower end of tube 14 to the discharge through bushing 12. It will be seen also that motive fluid discharged through bushing 12 and openings 45 is directed into the drill hole adjacent the cutting edge of drill 10, so that the spent motive fluid assists the drilling action.

From the foregoing, it is apparent that parts 10, 14, 18, 16, 20, 22, and 26 are firmly connected and are mounted by means of the splined joint including parts 22 and 32 to reciprocate with respect to the shaft 24 and piston 36. It is evident also that the parts 42 and 52 are resiliently mounted within the reciprocating structure just mentioned. Assuming now that the parts are in the position illustrated in Fig. 3 and that a motive fluid, preferably water, is being pumped down through shaft 24 and hollow piston 36 into the pressure chamber 40, spring 48 tends to keep valve 46 in the open position, but if the pressure head on the motive fluid is sufficient the drop across the valve 46, or in other words the rate of flow through this valve, produces pressure enough on the valve to force it to its seat. The full static pressure being then exerted on the top of the valve 46, it is held tightly closed. The tube 42 being closed by the valve 56, there is no outlet for the fluid from chamber 40, and the valve 46 and coupling 18 act as a piston the static pressure on which forces barrel 16 and connected parts rapidly downward producing a stroke of the drill 10 and compressing the spring 39. Owing to the resistance of spring 54, the weight 52 and tube 42 are not accelerated as rapidly as the barrel 16. Moreover, weight 52 is purposely made heavy and given a high inertia relatively to the barrel 16 and connected parts so that it will accelerate less rapidly. When the drill 10 strikes the bottom of the hole, the barrel 16 and connected parts are brought

to a sudden stop, but weight 52 is free to move under its own inertia and the pressure of the motive fluid against valve 56 and moves downwardly compressing the spring 54 until the ring 60 strikes the valve 46. The weight 52 and tube 42 however continue on downwardly, causing the valve 56 to be thrust away from the top of tube 42 as illustrated in Fig. 4. An outlet is thereby provided through tube 42 and weight 52 of sufficient size to permit the rapid escape of fluid from chamber 40 and consequently the rapid reduction of static pressure therein. Spring 48 thereupon opens valve 46. The spring 39 now returns barrel 16 to the position illustrated in Fig. 1. Soon after, spring 54 throws weight 52 and tube 42 upwardly again, the top of the tube 42 picking up valve 56 and closing the outlet from chamber 40 through the tube 42. The parts have now passed through a complete cycle, being in the position illustrated in Fig. 3 and, assuming that sufficient liquid is delivered through tube 24 to build up pressure in chamber 40 and flow through coupling 18 to a given point, the cycle just described repeats itself indefinitely. In fact, with well designed apparatus according to the present invention, the reciprocation of the barrel 16 and drill 10 is so rapid that it is properly described as vibratory.

As above stated, shaft 24 is rotatable. In the normal operation of the apparatus according to the present invention, the shaft 24 is rotated by power delivered thereto by any desired or usual means. In the arrangement illustrated in Fig. 8, a shaft 70 is driven by a belt (not shown) on pulley 72 keyed to shaft 70. Shaft 70 has a bevel pinion 74 thereon controlled by clutch 76, pinion 74 meshing with a bevel gear 78. Pipe or shaft 24 extends up through gear 78 and is driven thereby to rotate therewith through any known or desired means such as are commonly used for rotating a pipe string from a rotating gear. Shaft 24 is supported from above by a tackle (not shown) hooked to an eye 80. The eye 80 is fastened to a plate 82 threaded to a pipe 84. The lower end of pipe 84 is connected to the upper end of shaft 24 by a swivel joint. The inner member of said joint is not shown but the outer member thereof is in the form of a cap piece 86 threaded to the top of shaft 24. By means of the swivel joint just described and of which cap 86 forms a part, the pipe string or hollow shaft 24 is free to rotate with respect to pipe 84 although the weight of the string or shaft is supported from eye 80 through plate 82 and pipe 84. Water or other motive fluid for operating the mechanism for reciprocating drill bit 10 as above described is admitted to the apparatus through a flexible pipe 88 which connects with pipe 84 and

thence to shaft 24 through rigid pipe 90 threaded into a T 92 in pipe 84. The pump for supplying motive fluid under pressure to pipe 88 is not shown.

It is evident that a rotary movement in the shaft or tube 24 has no effect upon the operation of the parts as above described so that the tool 10 may be operated as a rotary drill, reciprocating drill, or combined rotary and reciprocating drill as desired. It is evident also that the reciprocation of drill 10 occurs only when the rate of feed and pressure of the motive fluid delivered through the shaft 24 exceeds a given minimum. The reciprocating action of the drill can thus be started or stopped at will by the drillers by increasing or decreasing the pressure of the motive fluid. The minimum pressure or rate of feed of the motive fluid at which reciprocation of the drill occurs depends in some measure upon the design of the valve mechanism for controlling the outlet of fluid from the pressure chamber 40. It has been found, moreover, that the efficiency of the apparatus is promoted by giving the fluid as straight a course as possible through the apparatus. The apparatus illustrated herein is designed to obtain the effect just mentioned.

While I have herein specifically described the present invention with relation to a particular apparatus, I do not limit myself by the detailed description herein. In particular, it is evident that the barrel part and fixed piston of the design illustrated herein may be replaced by a fixed barrel and movable piston.

Having thus described my invention, I claim—

1. A drilling mechanism comprising a member mounted for reciprocation, and means for reciprocating said member including a valve arranged to close automatically upon the flow through it reaching a given value, means whereby fluid may by-pass said valve to relieve the pressure thereon after movement of said member in one direction, means to open said valve, and means to move said member in the opposite direction.

2. A drilling apparatus comprising a barrel, a drill, means including a chamber whereby fluid pressure in said barrel reciprocates said drill, means forming two outlets from said chamber, a valve controlling one of said outlets, a spring for opening said valve but permitting it to close under fluid pressure, a weight resiliently supported from a reciprocating portion of the apparatus, and a second valve for controlling flow of fluid from said chamber through the other of said outlets and controlled by said weight.

3. A drilling apparatus comprising a hollow shaft, a piston head fixed to said shaft, a barrel mounted to reciprocate on said shaft, and two valves controlling the exit

of fluid from said barrel on one side of said piston head and operated automatically to cause reciprocation of the barrel.

4. A drilling apparatus comprising a hollow shaft, a barrel mounted for reciprocation on said shaft, and means whereby fluid delivered through said shaft may reciprocate said barrel, said means including a valve adapted to control the escape of fluid from said barrel and operated or not, depending upon the velocity of escape of said fluid.

5. A drilling apparatus comprising a pressure chamber, a drill and means whereby fluid pressure in said chamber reciprocates said drill, said means including a spring controlled valve and an inertia controlled valve.

6. A drilling apparatus comprising a reciprocating chamber, means for introducing fluid into said chamber to move it in a given direction, a starting valve operable by the action of the liquid in the chamber to cut off the outflow of fluid therefrom and to thereby initiate a stroke of said chamber, a drill operated by said chamber, a relief valve for reducing the pressure in said chamber to permit the chamber to make a return stroke, and means whereby said relief valve is opened at the end of a stroke of the chamber, said starting valve having means associated therewith whereby it is opened on release of pressure in said chamber.

7. A drilling mechanism comprising a pressure chamber, a drill and means whereby fluid pressure in said chamber reciprocates said drill, said means including a valve constructed and arranged to close automatically upon the flow through it reaching a given value, a second valve constructed and arranged to be held normally closed by pressure and to act as a by-pass to said valve, and mechanical means for opening said second valve.

8. A drilling apparatus, comprising a pressure chamber, a drill and means whereby pressure in said chamber reciprocates said drill, said means including a valve constructed and arranged to close automatically upon the flow through it reaching a given value, a second valve held normally closed by fluid pressure, and means including an inertia weight for mechanically opening said second valve.

9. A drilling mechanism comprising a member mounted for reciprocation, and means for reciprocating said member including a valve constructed and arranged to

close automatically upon the flow through it reaching a given value, a second valve normally held closed by fluid pressure, and mechanical means for opening said second valve including an inertia weight resiliently mounted on said member.

10. A drilling apparatus comprising a member mounted for reciprocation, and means for reciprocating said member including a valve constructed and arranged to close automatically upon the flow through it reaching a given value, a spring for opening said valve, a second valve arranged to by-pass said first valve, and means including an inertia weight for opening said second valve.

11. A drilling mechanism comprising a member mounted for reciprocation and means for reciprocating said member including a valve operated by the velocity of the fluid passing therethrough, a second valve arranged to by-pass said first valve and normally closed by the pressure of the liquid, and means including an inertia weight for opening said second valve.

12. A drilling apparatus comprising a member mounted for reciprocation, and means for reciprocating said member including a valve closed by the velocity of the fluid passing therethrough, a spring for opening said valve upon reduction of pressure thereon, a second valve arranged to by-pass said first valve and normally held closed by pressure, and means including a tubular inertia weight for opening said second valve, the said valve being arranged to admit water to the opening in said weight when open.

13. A drilling apparatus comprising a barrel mounted for reciprocation and having a pressure chamber therein, a valve for controlling escape of fluid from said chamber and closed upon the velocity of flow through it reaching a given value, a tube having a weight therein and resiliently mounted on said barrel so as to have movement relative thereto, said tube projecting into said chamber, a valve mounted on the end of said tube and adapted to close the same, said valve, tube and chamber being so constructed and arranged that movement of said tube relative to the barrel may open said valve to permit flow of liquid to said tube to relieve the pressure in said chamber, and a spring for opening said first mentioned valve.

In testimony whereof I affix my signature.

JAMES P. FISHER.