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HYDRAULIC EXPANSIBLE CHAMBER MOTOR WITH LONGITUDINALLY EXTENSIBLE CYLINDER

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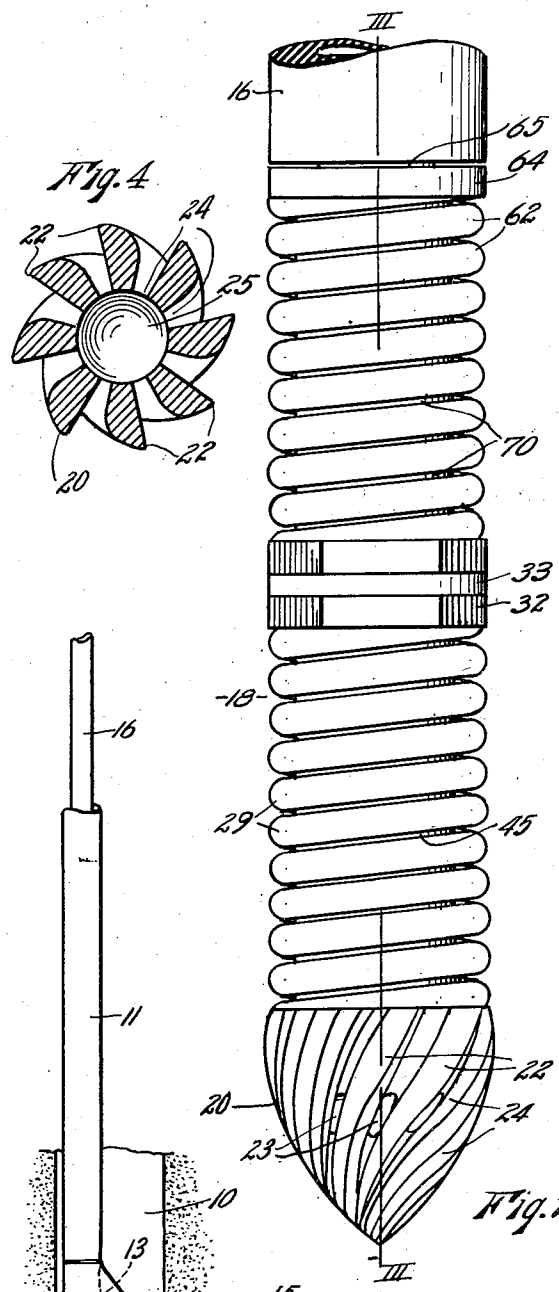


Fig. 1

Fig. 2

Fig. 4

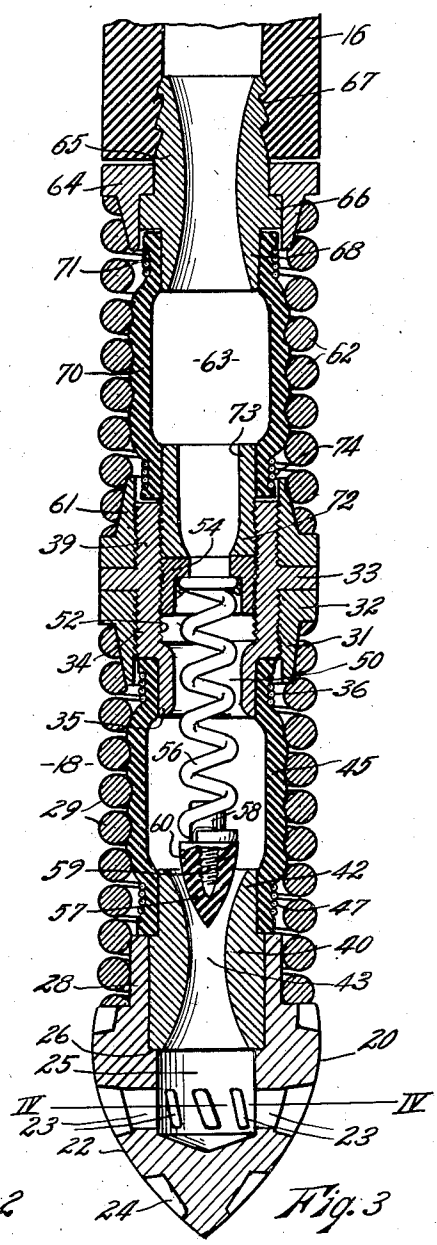


Fig. 3

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HYDRAULIC EXPANSIBLE CHAMBER MOTOR WITH LONGITUDINALLY EXTENSIBLE CYLINDER

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4 Claims. (Cl. 121—48)

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This invention relates to well drilling apparatus and more particularly to improvements in mechanisms for cutting drainage channels transversely to a main drill hole; being in part a continuation of co-pending application Serial No. 533,371, for a Hydraulic drilling device, filed April 29, 1944, now Patent No. 2,388,741, dated November 13, 1945.

In the development of a small, flexible, hydraulically operated drilling tool capable of being turned through a 90° angle near the bottom of a well bore and of being extended laterally for cutting drainage channels in fluid bearing strata; the improvements made have been of two basic types. Since the cutting head of the tool has a reciprocating action, it is evident that the rate of cutting may be increased (1) by increasing the number of impacts per second, and (2) by increasing the intensity of these impacts. An increase in the frequency of the head is obtained by decreasing the turbulence attendant to the passage of fluid through the engine and by increasing the frequency of the valve throw mechanism. An increase in the throw of the head is obtained by synchronizing the elements responsive to the valve frequency and designing them with similar frequencies or multiples thereof in order to set up a state of resonance.

The mechanical problems involved are better appreciated when it is realized that the engines now being tested have an outside diameter of one inch, operate under fluid pressures up to 800# per sq. inch, are laterally flexible sufficiently to be projected through a curved passageway having a five inch radius, and are capable of standing up under continuous operation. These conditions require very rugged construction and the elimination of small sliding parts in the moving elements since the latter have an uncanny habit of freezing as a result of tiny particles of abrasive material packing between them, particularly when the fluid stream projected against the face of the cut is recycled.

With these considerations in mind, the broad objectives of the current improvements in such a hydraulically operated drilling device are:

1. The provision of an improved method of mounting an exhaust port valve disc upon an adjustable tension valve throw spring to increase its frequency.

2. The provision of a Venturi shaped exhaust port and Venturi shaped chokes in the fluid flow line to reduce turbulence of the supply stream during passage through the engine.

3. The provision of a pointed rubber exhaust valve face capable of being driven hydrodynamically into the bell of the exhaust port to positively close the port when the axes of the port and the valve are not in alignment.

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4. The provision of an auxiliary expansion chamber located behind the engine proper, and having the same natural frequency, said chamber being actuated by the pulsations of the fluid supply column and setting up a state of resonance which increases the stroke of the cutting head.

5. The provision of an improved cutting head permitting the rapid flow of fluid through it and having spiraled cutting teeth so that rotation of the head during operation is not necessary in cutting a full hole, said head also being shaped to pass readily through a curved passageway.

Ancillary objectives such as easy assembly and adjustment of the various parts of the engine will be made clearer by the following description taken in conjunction with the accompanying drawings in which:

Figure 1 is a diagrammatic sketch illustrating the manner in which a hydraulic engine such as that embodied in this invention is extended laterally from a well bore.

Fig. 2 is an enlarged elevational view of the engine shown in Figure 1.

Fig. 3 is a longitudinal sectional view taken on line III—III of Figure 2 with parts shown in elevation.

Fig. 4 is a cross sectional view taken on line IV—IV of Figure 3.

Referring to the drawings, a string of tubing 11, Figure 1, is run into a well bore 10 until a footpiece 12 carried by the tubing lies opposite a fluid bearing stratum 15, an anchor 14 extending from the bottom of the footpiece 12 to the bottom of the well and maintaining it at the desired height. A curved passageway 13 within the footpiece 12 is aligned at its upper end with the center of the tubing 11, and at its lower end opens against the well wall so that the high-pressure hose 16 carrying the flexible drilling engine 18, floated down the inside of the tubing 11 after it and the well bore have been filled with water, is forced through the curved passageway 13, and thus projected at right angles to the well bore for cutting drainage lateral 19 into fluid bearing stratum 15.

The drilling engine 18 which is operated by a high-pressure fluid stream carried in hose 16, has a tempered, tool steel cutting head 20 of more or less conical form, the surface being grooved to form spiral cutting teeth 22 and fluid exhaust channels 24 so arranged that the edges of the

teeth 22 form a continuous circular cutting face the outside diameter of which is slightly greater than the diameter of the engine 18 and the hose 16 by which it is carried. A fluid decelerating chamber 25 lies inside the point of the head 20, Figure 3, and connects with the drainage grooves 23 to permit exhausting of the spent fluid from the engine into lateral 19. The upper end of the head 20 is reduced in size to form a shoulder 28 to which the lower end of the mainspring 29 of the water engine is fixed. The upper end of the coiled spring 29 is soldered to the outside of the threaded ring 31, having flange 32 by which it is screwed on the threaded extension 34 of the flanged nipple 33. A farther and smaller extension 35 of the nipple 33 projects downward inside coiled spring 29 and has secured to it by wire 36 the upper end of heavy rubber tube 45 fitting conformably with spring 29 and secured at its lower end by wire 47 to the extension 42 of the exhaust port 40 carried inside drill head 20 and seating on shoulder 26.

When the throat 43 of the Venturi shaped exhaust port 40 is closed by valve 60, the inside of rubber tube 45 is seen to comprise a closed, longitudinally extensible chamber which is laterally flexible within the limits of bending of the coiled mainspring 29, thereby permitting its extension through passageway 13, but normally maintaining it in alignment with its initial direction of travel. The exhaust port valve 60 consists of a resilient rubber cap 57 of conical form screwed onto the threaded extension 59 of the plug 58 carried by the lower end of the valve throw spring 56. The upper end of compression spring 56 passes freely through the inside 50 of extension 35 of flanged nipple 33 and is fixed to the inside of threaded ring 54 which screws inside of the couple 33 to vary the distance the valve 60 is normally held from the exhaust port 40, the hollow locking screw 72 serving to maintain it in the desired position.

The resonance chamber 63 which lies between the main working chamber of the engine 18 and the fluid supply hose 16 is identical with the working chamber in size and construction but has no valve in its exhaust port. It consists of a coiled spring 62 fixed at its lower end to the outside of threaded ring 61 secured on flanged nipple 33, and fixed at its upper end to flanged swivel 64 mounted on shoulder 66 of coupling 65, the upper end of which forms an extension 67 to which the fluid supply hose 16 is secured, and the lower end of which forms an extension 68 on which the upper end of rubber extension tube 70 is secured by wire 71; the lower end of tube 70 being secured by wire 74 to the upper extension 73 of lock screw 72.

In operation the engine described is far more dependable and operable over a wider fluid pressure range than any of the similar engines tested by reason of the exhaust valve arrangement. This valve is simultaneously responsive to two different dynamic principles. The first of these is that incorporated in the hydraulic ram and described in detail in said Patent No. 2,388,741. The valve 60 being normally spaced or timed so that its nose partially fills the throat of the exhaust port 43, acts to accelerate the high pressure fluid stream passing between it and the port 43 with a subsequent decrease in pressure which creates a hydrodynamic force acting to positively seat the valve 60 in the port against the tension exerted by the valve throw spring 56. With closing of the exhaust port, the fluid stream decelerates creating a shock wave, and subsequently the pressure in the line decreases to normal line pressure, whereupon the tension of the spring 56 pulls the valve 60 from port 43 to open it, thereby permitting acceleration of the fluid stream and repeating the cycle.

The pertinent distinction between the exhaust valve's operation at this time and later resides in the fact that movement of the drill head and longitudinal expansion of the engine chamber 46 is not essential to its operation. Hence, even if the drill head 20 be stuck, the valve continues to operate and a force of considerable magnitude set up through pulsation of the fluid supply stream is available to loosen it. With normal operation, however, the effect of closing the exhaust port 43 is to cause the accelerated fluid stream to exert its energy in extending the expansion chamber 46 against the tension of the mainspring 29 and thus drive the drill head 20 downward. Since the port 43 carries the valve 60 with it, this movement acts to increase the throw tension of spring 56, with the result that it throws quicker and farther from the exhaust port than would be the case were the position of the drill head 20 fixed. This increased opening of the port 43 acts in turn to permit more rapid emptying of expansion chamber 46 through the contraction tension of the encircling mainspring 29 placed under tension during its expansion and further acts to permit movement of a larger mass of fluid through the port in a given period, thereby increasing the hydrodynamic force originally available to close the valve 60 again.

From the standpoint of dependable and continuous operation, this valve arrangement is further advantageous in that fine adjustment of the tension of the valve throw spring 56 is not essential to its operation. This arises from the fact that if the valve 60 closes the port 43 initially (and it normally does so at fluid pressures below the normal operating range), the hydrostatic head acts to extend the expansion chamber 46 until the exhaust port 43 carried by it is pulled far enough away from the valve 60 to set it into operation. Since the hydrostatic head exerts a force of considerable magnitude, this makes the engine difficult to kill through a wide range of feeding pressures, too rapid feeding of the supply hose into the cut giving rise to a bucking action of the engine during which it throws itself clear of the cut instead of dying.

A further advantage of this rugged valve action lies in the fact that it will take off when the engine is twisted laterally. Even so, the engine would not function properly were it not for the resilient nature of the exhaust valve 60 and the fact that its tapered shape permits it seating in the belled throat of the exhaust port 43 even when not in alignment with the port. Many different types ranging from ball to needle valves were tried before the shape shown and made of vulcanized innertube rubber was developed. This valve and the use of a valve spring 56 having the same frequency as the mainspring 29 but a smaller amplitude, used in conjunction with an expansion chamber 46 having a similar fluid frequency are the essential elements in obtaining continuous operation of the engine.

Since a water engine operated by the elements shown and described, is capable of wide adaptation for use where space requirements prevent

the adaptation of more convventional types of hydraulic engines, what is claimed is:

1. In a hydraulic engine, a fluid pressure supply conduit, a coupling, a longitudinally extensible, tension contractable cylinder carried by and communicating with said conduit through said coupling, a head carried by said cylinder having an outlet port for said cylinder, a valve for said port inside of said cylinder, a valve throw spring fixed to said coupling and carrying said valve, said spring normally urging said valve to an open position with respect to said port, hydraulic means urging said valve to a closed position with respect to said port, said hydraulic means being stronger than said spring tension means when said cylinder is contracted, and said spring tension means being stronger than said hydraulic means when said cylinder is extended, whereby said valve closes said port when said cylinder is contracted and opens said port when said cylinder is extended thereby intermittenly varying the fluid pressure inside of said cylinder to cause reciprocation of said head.

2. In a hydraulic engine, a fluid pressure supply conduit, a coupling, a longitudinally extensible, tension contractable cylinder carried by and communicating with said conduit through said coupling, a head carried by said cylinder having an outlet port for said cylinder, a valve for said port inside of said cylinder, a valve throw spring having a smaller operating amplitude than the operating amplitude of said cylinder adjustably fixed to said coupling and carrying said valve, said spring normally urging said valve to an open position with respect to said port, hydraulic means urging said valve to a closed position with respect to said port, said hydraulic means being stronger than said spring tension means when said cylinder is contracted, and said spring tension means being stronger than said hydraulic means when said cylinder is extended, whereby said valve closes said port when said cylinder is contracted and opens said port when said cylinder is extended thereby intermittently varying the fluid pressure inside of said cylinder to cause reciprocation of said head.

3. In a hydraulic engine, a tension contractable cylinder, a traveling exhaust port, and exhaust valve hydraulically closing said port and tension means resisting its travel therewith, said port being belled and said valve being pointed and composed of a resilient material whereby said valve will close said port in response to hydraulic urging when not in direct alignment with said port.

4. In a hydraulic engine, a fluid pressure supply conduit, a coupling, a longitudinally extensible, tension contractable cylinder carried by and communicating with said conduit through said coupling, a head carried by said cylinder having an outlet port for said cylinder, a valve for said port inside of said cylinder, a valve throw spring having a frequency substantially that of said cylinder but smaller operating amplitude than the operating amplitude of said cylinder adjustably fixed to said coupling and carrying said valve, said spring normally urging said valve to an open position with respect to said port, hydraulic means urging said valve to a closed position with respect to said port, said hydraulic means being stronger than said spring tension means when said cylinder is contracted, and said spring tension means being stronger than said hydraulic means when said cylinder is extended, whereby said valve closes said port when said cylinder is contracted and opens said port when said cylinder is extended thereby intermittently varying the fluid pressure inside of said cylinder to cause reciprocation of said head.

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