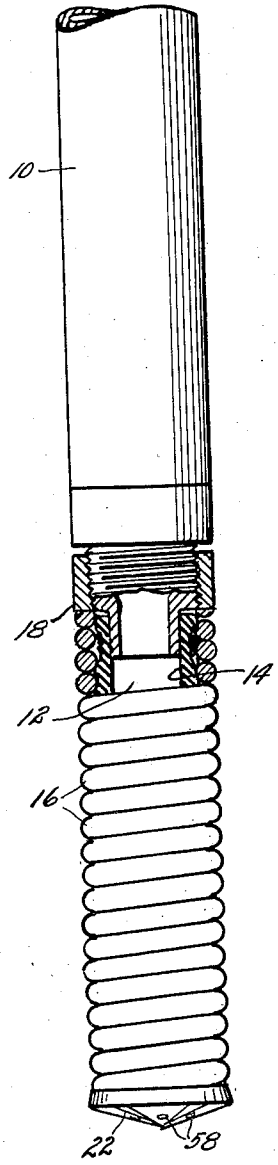
Nov. 13, 1945. R. R. HAYS 2,388,741

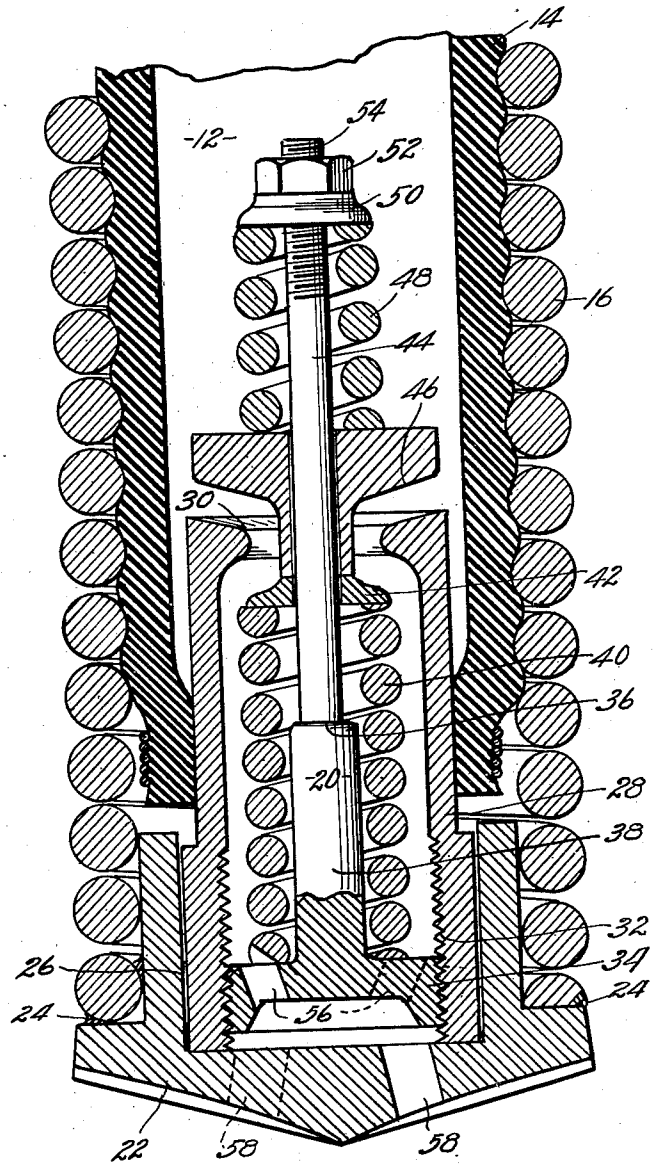
HYDRAULIC DRILLING DEVICE

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Fig. 2

Fig. 1





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HYDRAULIC DRILLING DEVICE

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Application April 29, 1944, Serial No. 533,371

5 Claims. (Cl. 255—4.4)

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 my co-pending application, Serial No. 486,446, for Well drilling apparatus, filed May 10, 1943.

The use of a high pressure fluid stream to cause rapid reciprocating movement of a drilling head carried by a fluid conduit shows that such movement may be produced by a variety of mechanisms which utilize different mechanical principles; and that the cutting efficiency of the head is critically dependent upon the principle utilized. These mechanisms fall into three groups; (1) water engines in which a high pressure fluid stream is alternately fed into an expansion chamber by synchronized inlet and exhaust valves. The principle used here parallels that incorporated in a conventional steam engine; (2) pressure regulators in which the exhaust port of the expansion chamber is blocked by a valve held in position by spring tension. When the hydrostatic head becomes greater than the spring tension the valve opens with a subsequent decrease in pressure. When an inlet valve is synchronized with the exhaust valve a recipricating action is set up. This principle is used in a wide variety of automatic feed systems, safety valves, flutter valves and the like. (3) Vibrating exhaust valves which periodically divert a rapidly moving fluid stream into an expansion or pressure chamber. This is the principle utilized by the hydraulic ram.

Because of their simplicity, the drilling heads using the same mechanical principle as that incorporated in the hydraulic ram have given the most satisfactory cutting action. In general, the frequency of movement of heads of this type is much higher and the amplitude of their stroke much smaller than that of heads using the other type mechanisms. Such rapid action is the reverse of that of the conventional hydraulic ram used to raise water. In the latter, the frequency is very low and the amplitude of the stroke very long.

The principle upon which the present ram operates is that a valve at the bottom of a column of fluid is tension or weight loaded sufficiently to open against the hydrostatic head. With opening of the valve, movement of the fluid column occurs. Since the valve partially blocks the port from which the fluid is exhausting, a hydrodynamic force is set up tending to close the valve. When this force becomes greater than the tension tending to maintain the valve open, the exhaust port is closed. With closing of the exhaust port a force is exerted by the fluid column which is the product of its mass times its momentum. In the case of the hydraulic ram, this force is utilized to fill a pressure chamber which in turn raises a smaller column of water. In the case of the present invention this force is utilized to extend a tension loaded expansion chamber such as that described in detail in my co-pending application, Serial No. 486,446.

Since the mass of the drilling head must of necessity be small, drilling efficiency will result only when it has a high velocity which because of its reciprocating action is expressed as frequency. Adaptation of the mechanical principle of the hydraulic ram to such a drilling head is thus seen to rest upon four prerequsites, namely: (1) To initiate high frequency vibration of a positively acting exhaust port. (2) To maintain this frequency of vibration constant. (3) To cause oscillation of the fluid supply stream in response to vibration of the exhaust valve to activate the drilling head, and (4) To set up resonance between the moving parts in order to increase the amplitude of movement of the drilling head.

The principal object of this invention is the provision of a hydraulic drilling device wherein is provided a structure to cause the momentum of a rapidly moving fluid column to produce high frequency movement of a drilling head in response to periodic movement of an exhaust valve which opens in response to spring tension greater than the hydrostatic head of the column, and closes in response to a hydrodynamic force greater than the tension of the spring.

Another object is the provision of means for inducing high frequency vibration in such an exhaust valve by the use of opposed springs having different spring constants used in conjunction with means for initially limiting the amplitude of the valve's vibration with respect to the exhaust port with which it operates.

Still another object is the provision of a fluid chamber, an exhaust valve of the character described, and a tension resisted fluid expansion chamber all of which have approximately the same natural frequency of vibration as a result of which resonance is set up with operation of the drill head, thereby increasing the amplitude of the movement of these elements.

Ancillary objectives such as minimum obstruction to the passage of the exhausted fluid from the expansion chamber, ease in the assembly and adjustment of the component parts, and simple,

rugged construction of the mechanism will be made clearer from a consideration of the following description taken in conjunction with the accompanying drawing in which:

Fig. 1 is an elevational view partly in section of a drill mechanism suited for using an exhaust valve device and embodying this invention.

Fig. 2 is an enlarged irregular sectional view of the exhaust valve assembly carried by the drill head of Fig. 1.

Referring to the drawing, a section of high pressure hose 10 carries an expansion chamber 12 on its extending end, said chamber consisting of a section of rubber tubing 14 contained within a coiled spring 16, the inner end of the tube 14 being fixed to the hose 10 by means of a coupling 18, to provide an expendable continuation of the fluid conduit contained by the latter; and the outer end of the tube 14 being fixed to an exhaust valve mechanism 20 carried by the drill head 22 which is solidly affixed in the extending end of the spring 16 by welding at 24 or by other means such as described in the co-pending application Serial No. 486,446.

The exhaust valve mechanism 20 seats in a suitable recessed section 26 of the drill head 22 and since it sits freely therein the head 22 and the spring 16 may be slipped over the valve mechanism 20 and the rubber tube 14 which greatly facilitates assembly and adjustment of the mechanism. The exhaust valve mechanism 20 consists of a short rigid tube 28, the upper end of which is formed to provide the exhaust port 30 and the lower end of which is threaded on the inside at 32 to adjustably carry the throw spring adjustment screw 34. The adjusting screw 34 is provided with an axially disposed stem 36 having a section 38 adjacent the screw of relative large diameter to serve as a pilot for throw spring 40 which rests against adjusting screw 34 and carries a push plate 42 slidably mounted on the reduced end portion 44 of the stem 36. Stem portion 44 extends through exhaust port 30 and slidably carries the exhaust valve 46. A recoil spring 48 resting on valve 46 is disposed about the reduced portion 44 of the stem and is secured against the valve by means of push plate 50 and nut 52 operatively mounted on the threaded end 54 of the stem. The tension of springs 40 and 48 may be varied by adjusting nut 52.

Since the hydrostatic head to be used is known, the tension required in the valve spring 40 to throw the valve 46 can be readily computed, and from this the strength of the spring required to open the valve 46 can be calculated by the use of Spring Constant, Frequency, and Amplitude formula found in engineering text books such as Elements of Mechanical Vibration by Freberg and Kemler. However, the strength of the spring 40 should be considerably greater than this figure. And the strength of the recoil spring 48 should be greater still, but the amplitude of its natural frequency should be considerably less than the amplitude of the natural frequency of the throw spring 40. It will be evident therefore, that with tightening of the adjustment nut 52 the tension on the springs 40 and 48 will be equalized, but that with downward movement of the valve 46 the tension exerted by the recoil spring 48 decreases much more rapidly than the tension exerted by the throw spring 40 increases, and that with upward movement of the valve 46, the reverse variation in tension occurs. In short, upward movement of the valve 46 is tension resisted more strongly than is downward movement.

If the screw adjustment 34 now be turned until the valve 46 slightly clears the exhaust port 30 it will be found that at a certain setting for any specific hydrostatic head, vibration of the valve 46 will be set up, during which the exhaust port 30 is completely closed by the valve 46 at the end of each periodic down beat. When such a valve is set up on an ordinary water line it will produce a loud chattering sound due to the rearward travel of shock waves arising with the instantaneous closing of exhaust port 30. When the valve is used with an expansion chamber 12 intermediate it and the fluid supply line 10 this action is noticeably altered, particularly when resonance is set up between the valve 46 and the expansion chamber spring 16. Although the creation of such resonance is easily demonstrable, no formulas are available for accurately estimating the number of coils required in the main spring 16 to set up such resonance. This results from the fact that the expansion chamber acts as a damper and this in turn acts to decrease the frequency of the exhaust valve 46. Moreover, the expansion chamber appears to have its own natural frequency which, due to the damping influence of the yieldable sidewalls of 14, is less than that of a column of water of equal length.

The most practical way to set such a system in resonance appears to be first of all to choose a satisfactory cutting frequency; for instance, 6 cycles/sec. The desired length of the expansion chamber at a given pressure to give it a natural frequency of 6 cycles/sec. can then be estimated. The same type of calculations are used in predetermining a similar frequency for the exhaust valve 46. The mainspring 16 is, however, made considerably over length to begin with. Inasmuch as the effective coils can be varied by gripping the spring tightly, this provides a simple method for varying its frequency and thus creating resonance in the system. Tension adjustments are then made on valve springs 40 and 48 to locate the most favorable frequencies. The number of coils of the mainspring 16 providing the most reliable resonance, with the frequency chosen is located and the spring cut to length.

During normal operation, a rapid flow of high pressure fluid is moving constantly from the supply hose 10 into the expansion chamber 12, and hence through the valve mechanism 16; passing through the exhaust port 30 it moves along the wall of the tube 28 to pass through the adjustment screw orifices 56, and hence out the exhaust orifices 58 in the drilling head 22. With closing of the valve 46 by reason of the hydrodynamic force created on the valve by this rapidly moving fluid stream being greater than the opposed tension of the valve throw spring 40, the inertia of the moving column of water acts to extend the expansion chamber 12 and to maintain the valve 46 closed until the mainspring 16 has been extended to a point at which its tension equals the force exerted by the fluid stream, this force being decidedly greater than the normal pressure exerted by the hydrostatic head of the fluid column. At the instant of arresting the movement of the fluid column by the mainspring 16, a reverse surge or shock wave occurs subsequent to which the pressure effective against the valve 46 decreases so that the tension of the valve throw spring 40 is now great enough to throw the valve and open the exhaust port 30. The ex-

panison chamber 12 now exhausts and contracts by reason of the kinetic energy stored in the mainspring 16 and subsequently movement of the fluid supply column is resumed.

The part which the recoil spring 48 plays in this operation is an important one. In order that the fluid column may accelerate as quickly as possible, the valve 46 should have a relatively long throw, but when it throws too far the pressure differential between the expansion chamber 12 and the exhausted fluid becomes so small that the fluid stream can no longer pick up the valve. The function of the recoil spring consequently is first to yield under the impact of the thrown valve 46 thereby permitting the port 30 to open wider than would be possible were simple stops used. Secondly, the recoil spring acts immediately afterwards to return the valve 46 to a position where the now accelerated exhaust stream can readily pick it up and thus close the exhaust port again.

Since the amount of fluid which can be exhausted through the port 30 for a given valve frequency will be proportional to the amplitude of the valve's movement, and since attainment of increased amplitude is dependent upon resonance between the periodic movement of the expansion chamber 12 and the valve 46; it is evident that only through the use of approximately the same natural frequencies for the mainspring 16, the expansion chamber formed by the rubber tube 14, and the exhaust valve 46 can such resonance be instigated and an effective hammering action of the drilling head 22 be obtained.

What I claim as new and desire to be secured by Letters Patent is:

1. In well drilling mechanism, for drilling lateral holes from well bore, a fluid pressure supply conduit, a tubular wall constituting a longitudinally expansible and transversely flexible chamber communicating with and secured to said conduit, a drill bit carried on the free end of said chamber, a valve seat and valve carried by the drill bit, said valve being responsive to the fluid flow between said valve and valve seat to move said valve to the closed position, and resilient means normally urging said valve to the open position whereby the pressure is intermittently varied to cause reciprocation of said drill bit.

2. In well drilling mechanism, for drilling lateral holes from well bore, a fluid pressure supply conduit, a tubular wall constituting a longitudinally expansible and transversely flexible chamber communicating with and secured to said conduit, a drill bit carried on the free end of said chamber, a valve seat and valve carried by the drill bit, said valve being responsive to the fluid flow between said valve and valve seat to move said valve to the closed position, resilient means normally urging said valve to the open position whereby the pressure is intermittently varied to cause reciprocation of said drill bit, and resilient means to limit the opening of said valve.

3. In well drilling mechanism, for drilling lateral holes from well bore, a fluid pressure supply conduit, a tubular wall constituting a longitudinally expansible and transversely flexible chamber communicating with and secured to said conduit, a drill bit carried on the free end of said chamber, a valve seat and valve carried by the drill bit, said valve being responsive to the fluid flow between said valve and valve seat to move said valve to the closed position, adjustably resilient means normally urging said valve to the open position whereby the pressure is intermittently varied to cause reciprocation of said drill bit, and adjustable resilient means to limit the opening of said valve.

4. In well drilling mechanism, for drilling lateral holes from well bore, a fluid pressure supply conduit, a tubular wall constituting a longitudinally expansible and transversely flexible chamber communicating with and secured to said conduit, a drill bit carried on the free end of said chamber, a valve seat and valve carried by the drill bit, said valve being responsive to the fluid flow between said valve and valve seat to move said valve to the closed position, resilient means normally urging said valve to the open position whereby the pressure is intermittently varied to cause reciprocation of said drill bit, and adjustable means whereby the length of stroke of said drill bit is varied.

5. In well drilling mechanism, for drilling lateral holes from well bore, a fluid pressure supply conduit, a tubular wall constituting a longitudinally expansible and transversely flexible chamber communicating with and secured to said conduit, a drill bit carried on the free end of said chamber, a valve seat and valve carried by the drill bit, said valve being responsive to the fluid flow between said valve and valve seat to move said valve to the closed position, resilient means normally urging said valve to the open position whereby the pressure is intermittently varied to cause reciprocation of said drill bit, and adjustable means to vary the frequency of said valve to conform with the natural frequency of the expansible chamber whereby they are brought into resonance.

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