

Sept. 9, 1958

E. A. MORI
HAMMER DRILL

2,851,251

Filed April 27, 1954

3 Sheets-Sheet 1

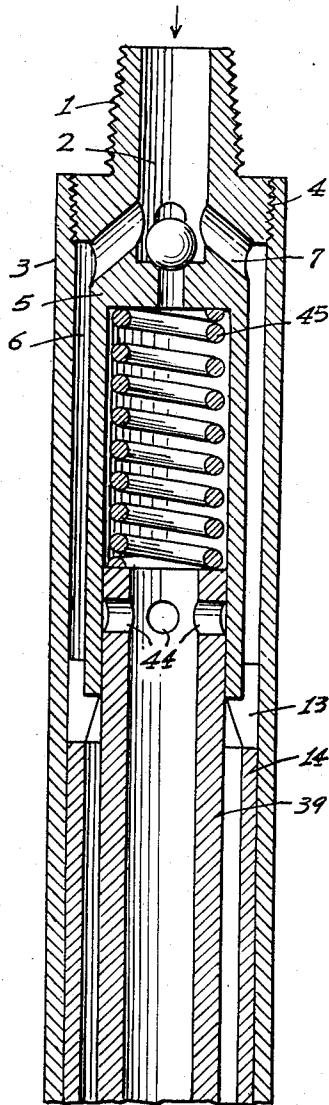


Fig. 1.

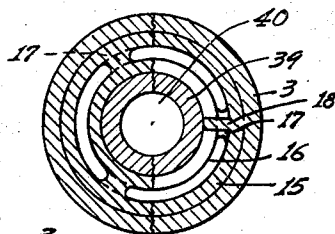
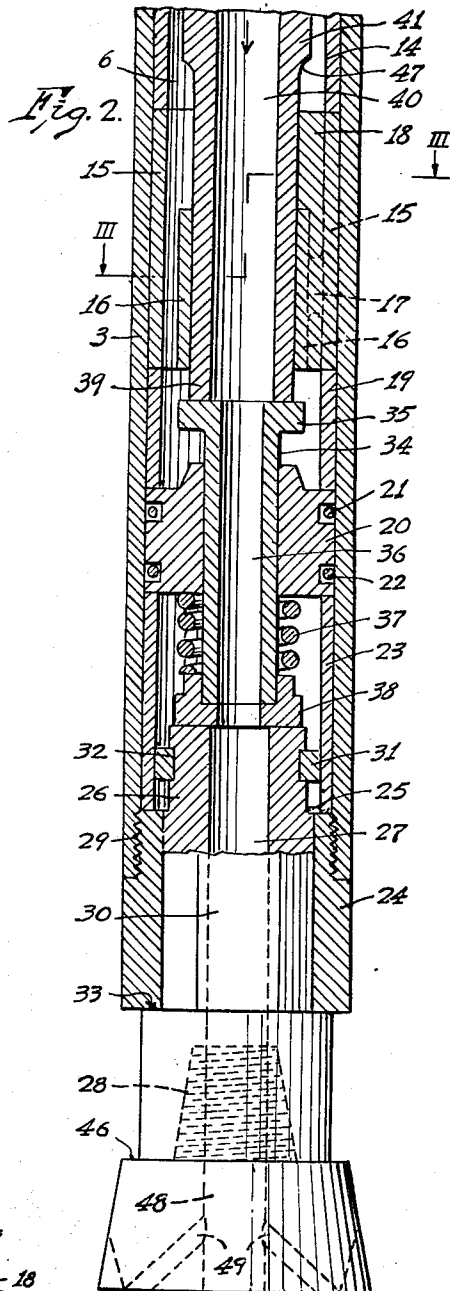


Fig. 3.



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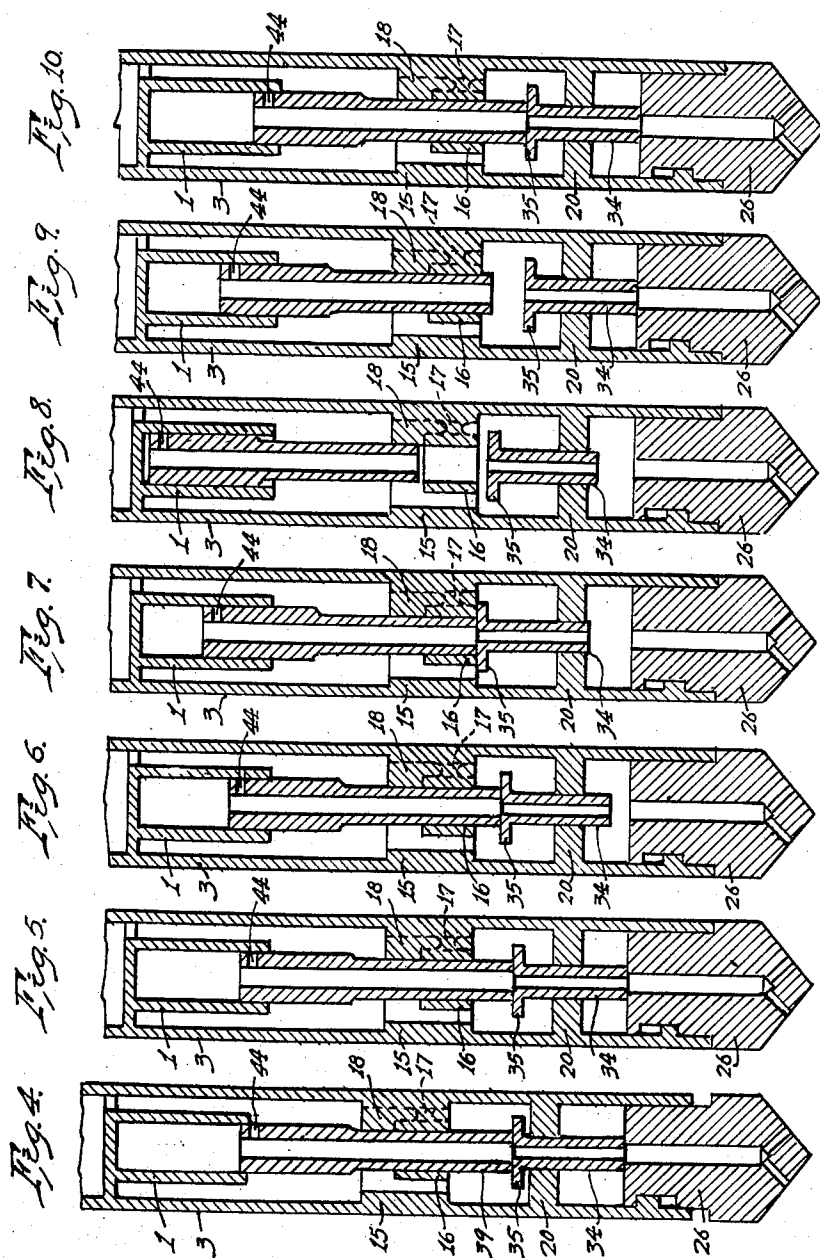
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3 Sheets-Sheet 2



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3 Sheets-Sheet 3

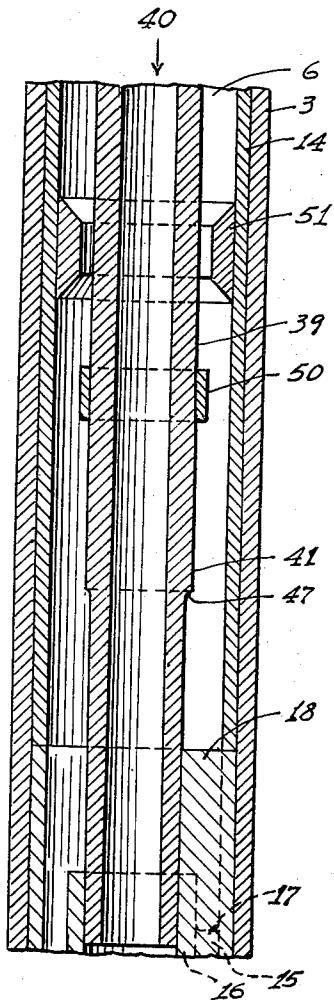


Fig. 11.

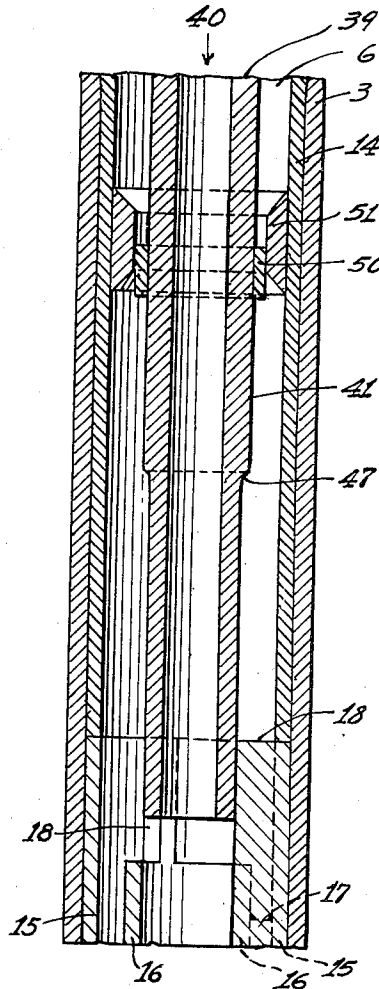


Fig. 12.

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2,851,251

HAMMER DRILL

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Application April 27, 1954, Serial No. 425,867

7 Claims. (Cl. 255—4.4)

This invention relates to well drills and more particularly to a deep-well drill combining the advantageous features of rotary and percussion drill mechanisms and particularly to an improvement in the hammer drill described in U. S. Patent No. 2,661,928, of Edward Topanelian, Jr., which issued December 8, 1953.

A hammer drill of the type described in the U. S. Patent No. 2,661,928 functions satisfactorily under normal operating conditions. However, in operating at great depths where a high back pressure on the drill is built up by the static head of fluid in the well, or where from other causes a high back pressure on the drill is built up, it has been found that the upper and lower rams sometimes separate before making a full upstroke, breaking the fluid seal between them and releasing the fluid pressure so that both upper and lower rams fall by gravity before being raised to their maximum elevation whereby the impact supplied by each is reduced, due to the shorter stroke.

Also, it has been found, that under some of the above-specified conditions the upper ram, on its down stroke, contacts and strikes the head of the lower ram before the lower ram is fully returned and seated on the bit stem. This action reduces the impact applied to the bit stem through the lower ram, and also causes hydraulic shock in the system.

The hammer drill of the present invention is characterized in that the fluid seal between the upper and lower rams is not broken prematurely, before each has completed its upstroke, so that a maximum impact is derived from the fall of each member.

The hammer drill of the present invention is also characterized in that the downward movement of each ram is controlled separately and independently of the other so that the lower ram falls, strikes the bit stem and is seated before the upper ram falls and strikes the head of the lower ram to deliver its impact to the bit stem through the lower ram.

My invention is illustrated in the drawings accompanying this specification and forming a part thereof and in which:

Fig. 1 is a longitudinal section taken through the upper portion of a preferred embodiment of my drill;

Fig. 2 is a longitudinal section taken through the lower portion of the drill of Fig. 1 showing the drill bit attached thereto;

Fig. 3 is a broken cross-section of the spider arrangement controlling elevation of the upper and lower rams taken on line III—III of Fig. 2;

Figs. 4 to 10, inclusive, are diagrammatic representations illustrating various phases during the operation of my drill.

Figs. 11 and 12 are longitudinal sectional views of a modified structure in accordance with the invention.

Reference is made to the drawings in which like numerals indicate the same element in the various views. In Figure 1, adapter 1 serves to connect the drill assembly with a drill pipe (not shown), the drill pipe having a

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central passage as is conventional for supplying drilling fluid.

Adapter 1 is provided with a central passage 2 for the purpose of supplying drilling fluid under pressure to the drill mechanism. Adapter 1 is screwed into drill housing 3 by threads 4 and a portion of the adapter of reduced diameter 5 extends into housing 3 with an annular clearance 6 between them. Openings 7 permit drilling fluid to pass from passage 2 into annular space 6. Adapter 1 at its outside lower end has fingers 13 welded to it. There are three or more such fingers which fit snugly within housing 3 and rest in turn on a liner 14. Liner 14 also fits snugly in housing 3. Below liner 14 is a spider arrangement as shown in Figure 2 and of which Figure 3 is a cross-sectional view, consisting of two concentric cylinders 15 and 16 separated and held concentric by three or more rigid arms 17. Arms 17 are sufficiently strong to withstand the repeated impact of lower ram 34 on its upstroke under the impetus of high fluid pressure. However, there is ample space between the arms to permit the free, unrestricted flow of drilling fluid between the inner and outer cylinders. The outer cylinder 15 fits snugly within housing 3 between liner 14 above and liner 19 below. The inner cylinder 16 fits slidably around the lower end of upper ram 39. Guiding ribs 18, of which there are three or more are extensions of arms 17 and extend above inner cylinder 16 to act as a guide for upper ram 39. When upper ram 39 is elevated beyond the upper end of and emerges from inner cylinder 16, the fluid seal is broken and the fluid pressure differential across upper ram 39 which caused its upward movement is released, allowing it to travel downward by its own weight, as soon as the velocity of its upward motion is expended. A liner 19 fitting snugly within casing 3 lies below the spider outlet cylinder 15.

Outer cylinder 15 fitting within casing 3 carries inner cylinder 16 rigidly attached thereto within its circumference by arms 17 so that the longitudinal position of cylinder 15 within casing 3, as determined by the length of liner 14 and liner 19, determines the location of inner cylinder 16 above head 35 of lower ram 34. The lower end of inner cylinder 16 acts as a stop which prevents further elevation of lower ram 34, and thus determines the longitudinal movement of lower ram 34 which is the valve element. The lower end of inner cylinder 16 then forms a temporary seal with head 35 of lower ram 34, thereby maintaining fluid pressure which continues to exert an upward force on and elevate upper ram 39. The length of inner cylinder 16 determines the height to which upper ram 39 is elevated by the fluid pressure after the elevation of lower ram 34 is stopped by contact with the lower end of inner cylinder 16, thereby breaking contact between and separating the two rams and continuing the elevation of the upper ram 39 above the head 35 of lower ram 34. The spider arrangement therefore controls the distance upper ram 39 and lower ram 34 travel, and assures a full elevation and stroke of both rams for each cycle of operation. The longitudinal position of inner cylinder 16 is therefore dictated by the length of stroke selected for lower ram 34, and the length of inner cylinder 16 is dictated by the length of stroke selected for upper ram 39.

Below liner 19 is a guide 20, which is sealed to the inside of housing 3 by O-rings 21 and 22, and which has a smaller inside diameter than that of inner cylinder 16. Guide 20 rests on liner 23. The lower end of housing 3 is threaded as at 29 for a bushing 24 which has a smaller internal diameter than housing 3, so that the various liners, etc., are firmly clamped between shoulder 25 of bushing 24 and the lower end of adapter 1, when bushing 24 is screwed up tightly into housing 3. Thus, bushing 24 holds in place liner 23, guide 20, liner 19, spider

15, with inner cylinder 16 attached thereto by rigid arms 17, ribs 18, liner 14, and fingers 13, the latter attached to the lower end of adapter 1.

Starting now at the lower end of Figure 2, there is shown a bit stem 26 which has a central passage 27 through which drilling fluid reaches the bit. A conventional drilling bit 46 may be screwed onto the bit stem 26 by means of threads 28. Drill bit 46 has a central passage 48 and is further provided with passages 49 connecting the central passage with the well bore to facilitate the removal of cuttings and chips therefrom by means of flushing action of the drilling fluid. The drill bit per se forms no part of my invention and any type of bit may be used. Bushing 24 is shaped hexagonally on its inner surface and the outer surface of bit stem 26 is also hexagonally shaped as at 30. Bit stem 26 fits slidably within bushing 24 upon matching the hexagonal surfaces so that torque may be transmitted from bushing 24 to bit stem 26 and bit 46. Instead of using hexagonal shape, the rotary driving engagement between bushing 24 and bit stem 26 may have square or other equivalent shape, such as splines and grooves. Accordingly, during drilling, the entire assembly may be rotated from the surface of the ground by means of the conventional drill pipe (not shown) and this will rotate the bit 46. Bit stem 26 fits slidably within bushing 24, the amount of longitudinal motion being limited by a split ring 31 mounted in a groove 32 in the upper end of the bit stem. When bit stem 26 is at its lowermost position, ring 31 abuts against internal shoulder 25. When bit stem 26 is in its uppermost position, an external shoulder 33 on the bit stem abuts against the lower end of bushing 24.

Situated above bit stem 26 is the annular lower ram 34 whose outer diameter is a close sliding fit in guide 20. Lower ram 34 also functions as a valve as will be explained. It may be made quite heavy and functions as a blow-imparting means as well as a valve, in that its reciprocating motion adds a blow to the percussive action of the upper ram, in the operation of the drill, as will become evident. The upper end or head of lower ram 34 is enlarged in diameter as at 35, the diameter 35 being larger than the diameter of hammer 39 at its lower end. The purpose of this relationship will also be explained later. Lower ram 34 has a central passage 36 to permit the discharge of drilling fluid therethrough. Passage 36 is made small enough so that it functions as a constriction in the fluid stream whereby the velocity is changed, causing a pressure differential across lower ram 34. In this way, a substantial downward pressure differential is caused to act on lower ram 34 whenever drilling fluid discharges through it.

A spring 37 is placed around lower ram 34 abutting against the lower end of guide 20 and against a shoe 38 which is carried on the lower end of ram 34. The shoe 38 may be shrunk onto ram 34 or be held thereon by other means, and is conveniently made replaceable as it receives considerable pounding during operation of the drill. Ram 34, being of considerable mass, normally moves downward by its own weight plus the pressure differential of fluid flowing downward in its passage 36, but the downward impetus to ram 34 is further augmented by the use of spring 37.

On top of the lower ram 34 rests an elongate annular upper ram 39, having a central passage 40. Passage 40 is larger in diameter than passage 36 through lower ram 34 in order to set up a pressure differential across lower ram 34 to assist in providing downward impetus to the lower ram. It has been found desirable to have the upper part 41 of ram 39 made larger in diameter than the lower end, thus providing a shoulder 47. The shoulder 47 provides a differential area between the bottom and top of ram 39 so as to afford the fluid a lifting effect on ram 39 which lifting effect should, however, be insufficient to separate ram 39 from ram 34 during the upward travel of both members. An annular space 6 is provided

between the outer surface of upper ram 39 and liner 14, to permit adequate circulation of fluid. The spider arrangement of cylinders 15 and 16, separating arms 17, and ribs 18 are within annular space 6. Ribs 18 serve to center the upper ram 39 within liner 14. Immediately below the lower end of ram 39 is the head 35 of lower ram 34 within liner 19. Lower ram 34 is slidably sealed into guide 20 below its head 35. Annular space 6 opens into the space between cylinders 15 and 16 and around head 35 of lower ram 34 within liner 19 without obstructions to interrupt the free movement of drilling fluid between annular space 6 and guide 20. The upper end 41 of ram 39 penetrates the lower end of adapter 1 and is of proper diameter to form a sliding seal therewith.

A short distance below the top of ram 39 there are provided one or more radial openings 44 from the outside of the ram to the passage 40 therethrough. When the ram 39 is in its lowermost position, it still partially penetrates the lower end of adapter 1 but the openings 44 are not covered by the lower end of adapter 1 and fluid communication is established between the annular space 6 and the passages 40 and 36. The purpose of this is to permit drilling-off as will become evident later. The openings 44 also permit circulation of drilling fluid through the drill without activating the mechanism while the drill is being run into or out of the hole. Thus drilling-in may be accomplished with the drill rotating and with circulation of drilling fluid, but without activating the rams.

A spring 45 is placed above the upper end of ram 39 abutting the top of the ram and the base 5 of adapter 1. The ram 39 being of considerable mass normally moves downward by its own weight but the spring serves to give additional downward impetus, and also serves to decelerate the ram 39 when it has been elevated.

While the length of the various elements of the drill are not indicated in Figs. 1 and 2 of the accompanying drawings it is believed clear to those skilled in the art that the length of lower ram 34 and upper ram 39 may be made such as to provide the necessary mass for these parts, and the length of other parts may be adjusted accordingly. When the bit stem 26 is in its lowermost position with ring 31 against shoulder 25, and lower ram 34 is in its lowermost position against the top of the bit stem and with upper ram 39 resting on top of ram 34, the lengths of the parts are made so that the top 41 of the upper ram penetrates the lower end of adapter 1 a short distance but with the openings 44 fully uncovered. Because of the extreme simplicity of the drill the masses of lower ram 34 and of upper ram 39 may be made comparable so that the mechanism imparts a double blow to the drill bit for each cycle of operation of the drill.

For proper operation of the mechanism the diameter of the lower ram 34 should be smaller than the diameter of the upper ram 39. The diameter of the upper ram 39 below the shoulder 47 may be slightly smaller than the diameter 41 of the top of the upper ram 39 in order to facilitate separation of the upper ram 39 from the lower ram 34 when the upward motion of the lower ram is arrested at the lower end of spider inner cylinder 16, but the difference between these diameters should not be so large as to cause premature separation of these elements. A satisfactory seal is normally maintained between the top surface of ram 34 and the bottom surface of ram 39 when in contact, under residual forces not compensated by upward force of fluid on shoulder 47. As contact is made between these elements by a percussive blow of the upper ram, any foreign particles between them are crushed and the efficacy of the seal is thus automatically maintained.

In the operation of the above-described drill reference is made to the diagrams of Figs. 4 to 10 showing the various phases during the operation of the drill, and in which

diagrams the numerals indicate the same elements as in Figs. 1 to 3 previously described.

Referring to Figures 11 and 12, a modified form of the hammer drill comprises a fluid sealing means on the upper part 41 of upper ram 39, comprising an annular collar 50, welded or otherwise attached to the upper ram, positioned above shoulder 47 so that at the maximum elevation of upper ram 39 the collar 50 cooperates with an annular constriction 51 welded or otherwise rigidly fastened on the inner surface of liner 14 to seal off the downward flow of drilling fluid in annular space 6, thus cutting off the fluid pressure which is elevating the upper ram 39 and which is holding head 35 of lower ram 34 sealed against the lower end of inner sleeve 16. This relieves the fluid pressure, and assists spring 45 in decelerating the upward movement of upper ram 39, facilitating the release of the fluid seal between the head 35 of lower ram 34 and inner sleeve 16, and permitting lower ram 34 to start its downward movement, while at the same time fluid pressure builds up above the seal and assists spring 45 in imparting a downward impetus to upper ram 39. This modification is particularly valuable where the hammer drill is employed in deep well drilling.

The entire unit is suspended vertically in a well bore with an ordinary rotary drill pipe (not shown) attached to adapter 1. Means are provided at the surface for supplying drilling fluid to the central passage of the drill pipe as is well-known in the art. Starting with the lower end of the drill bit 46 several feet above the bottom of the hole, bit stem 26 is in its lowermost position with the ring 31 resting on the shoulder 25 of bushing 24. The lower ram 34 rests on top of the bit stem with its head 35 some distance below spider inner cylinder 16 and just above guide 20. On top of ram 34 rests upper ram 39, and the lengths of the liners are made so that the upper end of ram 39, i. e., the end above the openings 44, extends into the lower end of adapter 1 a short distance leaving openings 44 near the top of ram 39 uncovered. The arrangement of parts will be as shown in Fig. 4.

It is usually desirable to "rotate in" when a new bit has been attached to the drill in order to insure that the borehole is to gauge, and to flush out sediment and cuttings which may have settled to the bottom of the hole while the drill pipe was out of the hole to change bits. This is accomplished by establishing circulation of drilling fluid downward through the central passage of the drill pipe and rotating the bit as it is lowered through the last few feet to the bottom of the well bore. During this "rotating in" process, fluid is circulated through passages 2, 7, 6, 44, 40, 36 and 27 and out through passages 48 and 49 of the bit, returning up the hole outside of drill housing 3. Since there is free passage of fluid through the mechanism, no upward pressure differential exists, and accordingly rams 34 and 39 are not actuated with bit off-bottom as shown in Fig. 4. Thus, hammering will not take place to endanger the drill pipe or other parts as the drill is lowered into the hole. By continuing to lower and rotate the mechanism including bit stem 26 and bit 46, the cutting edge of the bit eventually touches the bottom of the hole. Further lowering of the drill pipe and attached parts will cause changes in the relative longitudinal positions of the internal parts 26, 34 and 39. The top of upper ram 39 will enter the lower end of adapter 1 a sufficient distance to close off openings 44 from fluid flow.

The parts will then be in essentially the position as shown diagrammatically in Fig. 5. Due to the fact that there is no immediate outlet for the fluids being supplied under pressure from the surface of the ground the pressure will build up through passages 2 and 7 and annular space 6 around upper ram 39 and around the upper end and head 35 of lower ram 34 which pressure is effectively sealed from escape by seal 20 and from escape through central passage 36 by the weight of

ram 39 resting on the head 35 of ram 34. The upper surface of the column comprising the rams 34 and 39 is exposed to a pressure equivalent to the static head of fluid in the well bore above the drill, on the upper surface of ram 39 through passages 40, 36, 27, 48 and 49. When this static pressure is equalled and exceeded by pressure of fluid from the surface pumps, since the diameter of lower ram 34 is less than the diameter of upper ram 39, the pump pressure will produce sufficient upward force to lift ram 34 and ram 39 as a unit, the weight of upper ram 39 tending to seal the junction between them. This phase of the operation is shown in Fig. 6. Pressure on shoulder 47 of ram 39 produces a lifting effect on ram 39 also, but the lifting ratio of areas on rams 39 and 34, as compared to their masses is greater for ram 34 therefore maintaining the required seal between both members. This seal continues in effect until head 35 of ram 34 comes into contact with and strikes the lower end of the spider inner cylinder 16. Thereupon the seal is broken (Fig. 7) but simultaneously a seal is established between inner cylinder 16 and head 35 of ram 34, also a seal is formed between the lower end of ram 39 and the inner wall of cylinder 16. These seals permit the fluid pressure to continue to work on the shoulder 47 of ram 39, forcing it upward until it emerges above spider inner cylinder 16. The emergence of the lower end of ram 39 from inner cylinder 16 breaks the seal between the two and permits the free flow of fluid through cylinder 16 and through passage 36 in ram 34 which tends to equalize the pressure across ram 34 allowing it to break its seal with the lower end of cylinder 16 and fall by its weight to its original position.

Furthermore, the downward rush of fluid through its passage 36 effects a pressure differential which gives lower ram 34 further downward impetus. Accordingly, the ram 34 moves rapidly downward as illustrated in Fig. 8. In thus falling it delivers a percussive blow to bit stem 26 which is transmitted to bit 46 attached thereto.

Shortly after lower ram 34 has started to move downward, the upper ram 39 also begins to move downward since there is no longer any pressure to raise it. Accordingly, the ram 34 and ram 39 both descend, though separated by some distance and with the lower ram 34 moving down somewhat faster than the upper ram 39 because of the downward force of fluid which acts on the lower ram, but not on the upper ram. Thereafter, the lower ram 34 strikes the top of the bit stem 26 imparting a blow thereto which blow is transmitted to the drill bit 46. This phase is illustrated in Fig. 9. The upper ram 39 at this phase is still falling.

A short interval after the lower ram 34 has struck the bit stem 26, the upper ram 39 strikes the top of ram 34, and this blow is transmitted through ram 34 to the bit stem and thence to the drill bit 46. This represents the completion of a cycle of operation, as shown in Fig. 10.

The mechanism is now (Fig. 10) in the same position as it was in Fig. 5 and is therefore ready to repeat the cycle of operation. Each cycle results in two percussive blows being struck on the formation through the drill bit 46. Due to the fact that the entire drill assembly is also being continuously rotated slowly, the various percussive blows exerted on the formation being drilled will be made at points angularly displaced from one another by several degrees, so that the drill bit will chip out the formation between successive points of impact. Fluid discharged from the mechanism will act as a flushing agent and will be substantially continuously discharged from the bit 46 into the well bore and serves to carry the chips to the surface of the well. Continuous operation of the drill therefore completely removes material from the bottom of the hole and results in advance of the drill through the formation.

The hammer drill will operate without the use of spring

37 and spring 45, but the use of these springs has been found to increase the frequency of operation. This is particularly desirable when hole conditions prescribe drilling with very heavy mud in which the mechanism tends to become sluggish. Successful operation with light to medium weight mud and without the use of the springs 37 and 45 results in longer tool life.

One of the advantages of the present embodiment of the hammer drill lies in the fact that the valving ram 34 as well as the upper ram 39 delivers a percussive blow and these are in rapid succession. By making use of the impetus of the valving ram 34 as well as that of the upper ram 39 the drill attains a higher degree of effectiveness than if one ram alone supplied the percussive action. The timing of the two blows may be adjusted by the size of the passage 36 through the lower ram 34, since the smaller this passage is made the faster the ram 34 is kicked down by the discharging fluid. As previously stated the length of the stroke of the lower ram 34 is determined by the distance above its head 35 at which spider inner cylinder 16 is positioned, and the length of the stroke of the upper ram 39 is determined by the length of the spider inner cylinder 16. Additional adjustment of the timing may be effected by adjusting the relative stiffness of spring 37 and spring 45 when these are used. The present embodiment of the drill permits the two blows to be made comparable because the lower ram 34 may be made of a mass comparable to that of upper ram 39.

An important characteristic of the present embodiment of a hammer drill is the fact that it achieves hydraulic balance. By this is meant that the hydraulic pressure actuating the mechanism is not exerted on the bit stem 26 or on the bit 46. Hence the percussive action will take place with comparatively little weight on the bit. The guide 20 serves as a restriction above which the fluid pressure is higher than below by an amount required to actuate the drill mechanism. The restriction 20 forms a barrier supported by housing 3 between the high pressure fluid required for hammer operation and the much lower fluid pressure required to circulate fluid through the ports in the drill bit. Therefore, there is very little pressure tending to eject the bit stem 26 and bit 46 from the end of the housing 3, and accordingly the drill may be operated with the bit applying to the formation between percussive blows little more than the weight of the bit 46 and bit stem 26, all other weights and pressures being supported from the surface through the drill pipe and housing 3. This characteristic of the drill results in the ability to drill straight hole under adverse conditions which usually require that the bit be rotated with only light weight on the formation. On the other hand, by lowering the drill pipe from the surface so that a substantial part of the drill pipe weight rests on the shoulder 33 (Fig. 2) any desired larger weight may be exerted on the formation. Further, the percussive action of the drill is entirely independent of the weight which is carried on the formation.

A further advantage of the present embodiment of the drill is in the fact that when the drill is set on bottom the telescoping bit stem forces the lower ram upward out of any accumulation of sand, mud or other debris which may have packed around the top of the lower ram while the drill was inactive during the trip into the hole. This upward motion of the lower ram breaks any such accumulation and permits the operating pressure to act on the lower ram so as to initiate the reciprocating action. As soon as the drill has completed a cycle or two of reciprocating action, any such accumulation will be flushed out and can no longer interfere with operation of the drill mechanism.

In the appended claims the term "lower ram" is used to designate valving element 34, and the term "upper ram" is used to designate the hammer element 39, but it is to be understood that the names given these and other

elements shown are descriptive and that other equivalent shapes may be given these elements and still remain within the scope of the claims.

I claim:

1. A fluid-operated well-drilling mechanism comprising a tubular housing, means introducing fluid under pressure within the upper end of said housing, a cylinder closed at its upper end longitudinally mounted within the upper end of said housing and annularly spaced within the said housing, a hollow elongate annular upper ram adapted for reciprocating longitudinal movement disposed in and sealed against the inside of said cylinder the lower end of said upper ram being of reduced diameter, a hollow elongate annular lower ram adapted for reciprocating longitudinal movement disposed below and in the path of said upper ram, a hollow cylindrical seal member of smaller internal diameter than the exterior diameter of said upper ram mounted on the inside of said housing, said seal member being longitudinally positioned intermediate the ends of said lower ram, said lower ram being slidably disposed in and sealed against said seal member, means affording said pressurized fluid access to the upper end of said lower ram, a cylindrical sleeve supported within said housing and longitudinally spaced above the upper end of said lower ram, said sleeve being disposed about the lower end of said upper ram and forming a sliding seal therewith, a flanged head on the upper end of said lower ram cooperating with said sleeve to limit the elevation of said lower ram to a distance which is less than the distance to which said upper ram is elevated, said flanged head forming a seal against the lower end of said sleeve on contact therewith to maintain fluid pressure for continuing the elevation of said upper ram after termination of the elevation of said lower ram, whereby fluid pressure tending to elevate said upper and lower rams is released simultaneously upon emergence of said upper ram from the upper end of said sleeve, permitting said upper and lower rams to fall separately and independently and deliver separate percussive blows, ribs positioned above said sleeve to guide the movement of said upper ram during its elevation, and a tubular bit stem slidably disposed in and sealed against the inside of said housing immediately below and in the path of said lower ram.

2. A fluid-operated well-drilling mechanism comprising a tubular housing, a cylinder closed at its upper end longitudinally mounted within the upper end of said housing and annularly spaced therein, means introducing fluid under pressure within the upper end of said housing below said cylinder, a hollow elongate annular upper ram adapted for reciprocating longitudinal movement slidably disposed in and sealed against the inside of said cylinder the lower end of said upper ram being of reduced diameter, a hollow elongate annular lower ram adapted for reciprocating longitudinal movement disposed below and in the path of said upper ram and in contact therewith when both of said rams are in lowermost position, said lower ram being provided with a longitudinal central passage therethrough, a hollow cylindrical seal member of smaller internal diameter than the exterior diameter of said upper ram mounted on the inside of said housing, said seal member being longitudinally disposed intermediate the ends of said lower ram, said lower ram being slidably disposed in and sealed against said seal member, a flanged head on the upper end of said lower ram of a diameter greater than the exterior diameter of said lower ram and provided with a central passage therethrough in register with the central passage in said lower ram, means affording said pressurized fluid access to the upper end of said lower ram, a cylindrical sleeve supported concentrically within said housing disposed about the lower end of said upper ram and forming a sliding seal therewith, said sleeve being longitudinally spaced above the upper end of and in the path of upward movement of said lower ram, the upward movement of said

lower ram being terminated on contact of the upper end thereof with the lower end of said sleeve and forming a seal therewith, whereby fluid pressure tending to elevate said rams is maintained after termination of the elevation of said lower ram and continues to elevate said upper ram until it emerges above the upper end of said sleeve thereby breaking the fluid seals, ribs positioned above said sleeve to guide the movement of said upper ram during its elevation, and a tubular bit stem slidably disposed in and sealed against the inside of said housing immediately below and in the path of said lower ram.

3. A fluid-operated well-drilling mechanism comprising a tubular housing, means introducing fluid under pressure within the upper end of said housing, a cylinder closed at its upper end mounted longitudinally within the upper end of said housing and annularly spaced within the said housing, a hollow elongate annular upper ram adapted for longitudinal reciprocating movement slidably disposed in and sealed against the inside of said cylinder, the lower end of said upper ram being of a reduced diameter, a hollow elongate annular lower ram adapted for longitudinal reciprocating movement disposed below and in the path of said upper ram and in contact therewith when both of said rams are in lowermost position, a hollow cylindrical seal member of smaller internal diameter than the exterior diameter of said upper ram mounted on the inside of said housing, said seal member being longitudinally disposed intermediate the ends of said lower ram, said lower ram being slidably disposed in and sealed against said seal member, a flanged head on the upper end of said lower ram of a diameter greater than the diameter of said lower ram, said head being disposed above said seal member, means affording said pressurized fluid access to the upper end of said lower ram, said lower ram including the head thereof being provided with a longitudinal central passage therethrough, a downwardly facing shoulder on the exterior surface of said upper ram intermediate the ends thereof at the point of reduced diameter, said shoulder constituting a lifting area for said upper ram, a lifting area for said lower ram comprising the under side of the head of said lower ram, the ratio of lifting area to mass for said lower ram being greater than the ratio of lifting area to mass for said upper ram, a cylindrical sleeve supported concentrically within said housing of smaller internal diameter than the diameter of the head of said lower ram, said sleeve being longitudinally spaced above the upper end of said lower ram and within the path of movement of said upper and lower rams, the upward movement of said lower ram being terminated on contact of the head thereof with the lower end of said sleeve and forming a seal therewith, said seal being maintained by continuing fluid pressure on the lifting area of said lower ram, said sleeve being disposed about the lower end of said upper ram, which is of reduced diameter, and forming a sliding seal therewith, whereby fluid pressure tending to elevate said rams is maintained after termination of the elevation of said lower ram and continues to elevate said upper ram until it emerges above the upper end of said sleeve, and a tubular bit stem slidably disposed in and sealed against the inside of said housing immediately below and in the path of said lower ram.

4. A fluid-operated well-drilling mechanism comprising a tubular housing, means introducing fluid under pressure within the upper end of said housing, a cylinder closed at its upper end mounted longitudinally within the upper end of said housing, and annularly spaced within the said housing, an elongate annular upper ram adapted for longitudinal reciprocating movement slidably disposed partially within and sealed against the inside of said cylinder, the lower end of said upper ram being of a reduced diameter, an elongate annular lower ram adapted for longitudinal reciprocating movement disposed below and in the path of said upper ram, a hollow cylindrical

seal member of smaller internal diameter than the exterior diameter of said upper ram mounted on the inside of said housing, said seal member being longitudinally disposed intermediate the ends of said lower ram, said lower ram being slidably disposed in and sealed against said seal member, said lower ram being provided with a flanged head on the upper end thereof of a diameter greater than the diameter of said lower ram, said head being disposed above said seal member, means affording said pressurized fluid access to the upper end of said lower ram, a downwardly facing shoulder on the exterior surface of said upper ram intermediate the ends thereof at the point of reduced diameter, said shoulder constituting a lifting area for said upper ram, a lifting area for said lower ram comprising the underside of the head of said lower ram, the ratio of lifting area to mass for said lower ram being greater than the ratio of lifting area to mass for said upper ram, a cylindrical sleeve supported concentrically within said housing spaced above and of smaller internal diameter than the diameter of the head of said lower ram, said sleeve being positioned within the path of movement of said upper and lower rams, the upward movement of said lower ram being terminated on contact of the head thereof with the lower end of said sleeve and forming a seal therewith, said seal being maintained by continuing fluid pressure on the lifting area of said lower ram, said sleeve being disposed about the lower end of said upper ram, which is of reduced diameter, and forming a sliding seal therewith, said seals between said upper ram and sleeve and between said lower ram and sleeve retaining fluid pressure within said housing for continuing the elevation of said upper ram after termination of the elevation of said lower ram, said lower ram including the head thereof being provided with a longitudinal central passage therethrough for discharge of said pressurized fluid upon release of said fluid seals by emergence of the lower end of said upper ram above said sleeve, and a tubular bit stem slidably disposed in and sealed against the inside of said housing immediately below and in the path of said lower ram.

5. A fluid-operated well-drilling mechanism comprising a tubular housing, means introducing fluid under pressure within the upper end of said housing, a cylinder closed at its upper end longitudinally mounted within the upper end of said housing and annularly spaced within the said housing, a hollow elongate annular upper ram adapted for longitudinal reciprocating movement slidably disposed in and sealed against the inside of said cylinder, the lower end of said upper ram being of reduced diameter, a hollow elongate annular lower ram adapted for reciprocating longitudinal movement disposed below and in the path of said upper ram and in contact therewith when both of said rams are in lowermost position, a cylindrical sleeve longitudinally positioned within said housing spaced above the upper end of said lower ram and forming a sliding seal about the lower end of said upper ram whereby fluid pressure tending to elevate said rams is maintained after termination of the elevation of said lower ram and continues to elevate said upper ram until it emerges above the upper end of said sleeve, means on said lower ram limiting the upward movement thereof on contact of the upper end of said lower ram with the lower end of said sleeve and forming a seal therewith, a hollow cylindrical seal member of smaller internal diameter than the exterior diameter of said upper ram mounted on the inside of said housing, said seal member being longitudinally positioned intermediate the ends of said lower ram, said lower ram being slidably disposed in and sealed against said seal member, means affording pressurized fluid access to the upper end of said lower ram whereby a lifting effect is exerted upon said ram, and a tubular bit stem slidably disposed in and sealed against the inside of said housing immediately below and in the path of said lower ram.

6. A fluid-operated well-drilling mechanism comprising a tubular housing, means introducing fluid under pressure within the upper end of said housing, a cylinder closed at its upper end longitudinally mounted within the upper end of said housing and annularly spaced within said housing, a hollow elongate annular upper ram adapted for longitudinal reciprocating movement slidably disposed in and sealed against the inside of said cylinder, the lower end of said upper ram being of reduced diameter, a hollow elongate annular lower ram adapted for longitudinal reciprocating movement disposed below and in the path of said upper ram and in contact therewith when both of said rams are in lowermost position, a cylindrical sleeve supported within said housing and longitudinally spaced above the upper end of said lower ram, and forming a sliding seal about the lower end of said upper ram, whereby fluid pressure tending to elevate said ram is maintained after termination of the elevation of said lower ram and continues to elevate said upper ram until it emerges above the upper end of said sleeve, means on said lower ram limiting the upward movement thereof on contact of the upper end of said lower ram with the lower end of said sleeve and forming a seal therewith, ribs positioned above said sleeve to guide the movement of said upper ram during its elevation, a hollow cylindrical seal member of smaller internal diameter than the exterior diameter of said upper ram mounted on the inside of said housing, said seal member being longitudinally positioned intermediate the ends of said lower ram, said lower ram being slidably disposed in and sealed against said seal member, means affording said pressurized fluid access to the upper end of said lower ram whereby a lifting effect is exerted upon said ram, and a tubular bit stem slidably disposed in and sealed against the inside of said housing immediately below and in the path of said lower ram.

7. A fluid-operated well-drilling mechanism comprising a tubular housing, means introducing fluid under pressure within the upper end of said housing, a cylinder closed at its upper end longitudinally mounted within the upper

end of said housing and annularly spaced within said housing, a hollow elongate annular upper ram adapted for longitudinal reciprocating movement slidably disposed in and sealed against the inside of said cylinder, the lower end of said upper ram being of reduced diameter, an upper annular constriction on the inner surface of said tubular housing opposite to and intermediate the ends of said upper ram, an annular enlargement on the outer surface of said upper ram cooperating with said upper constriction when said upper ram is elevated, whereby said pressurized fluid is confined thereabove and a downward impetus is imparted to said upper ram, a hollow elongate annular lower ram adapted for reciprocating longitudinal movement disposed below and in the path of said upper ram, a lower hollow cylindrical seal member mounted on the inside of said housing positioned intermediate the ends of said lower ram, said lower ram being slidably disposed in and sealed against said lower seal member, means affording pressurized fluid access to the upper end of said lower ram whereby a lifting effect is exerted upon said ram, a cylindrical sleeve supported within said housing longitudinally spaced above the upper end of said lower ram and forming a sliding seal about the lower end of said upper ram, whereby fluid pressure tending to elevate said rams is maintained after termination of the elevation of said lower ram and continues to elevate said upper ram until it emerges above the upper end of said sleeve, means on said lower ram limiting the upward movement thereof on contact of the upper end of said lower ram with the lower end of said sleeve and forming a seal therewith, ribs positioned above said sleeve to guide the movement of said upper ram during its elevation, and a tubular bit stem slidably disposed in and sealed against the inside of said housing immediately below and in the path of said lower ram.

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