

Dec. 25, 1951

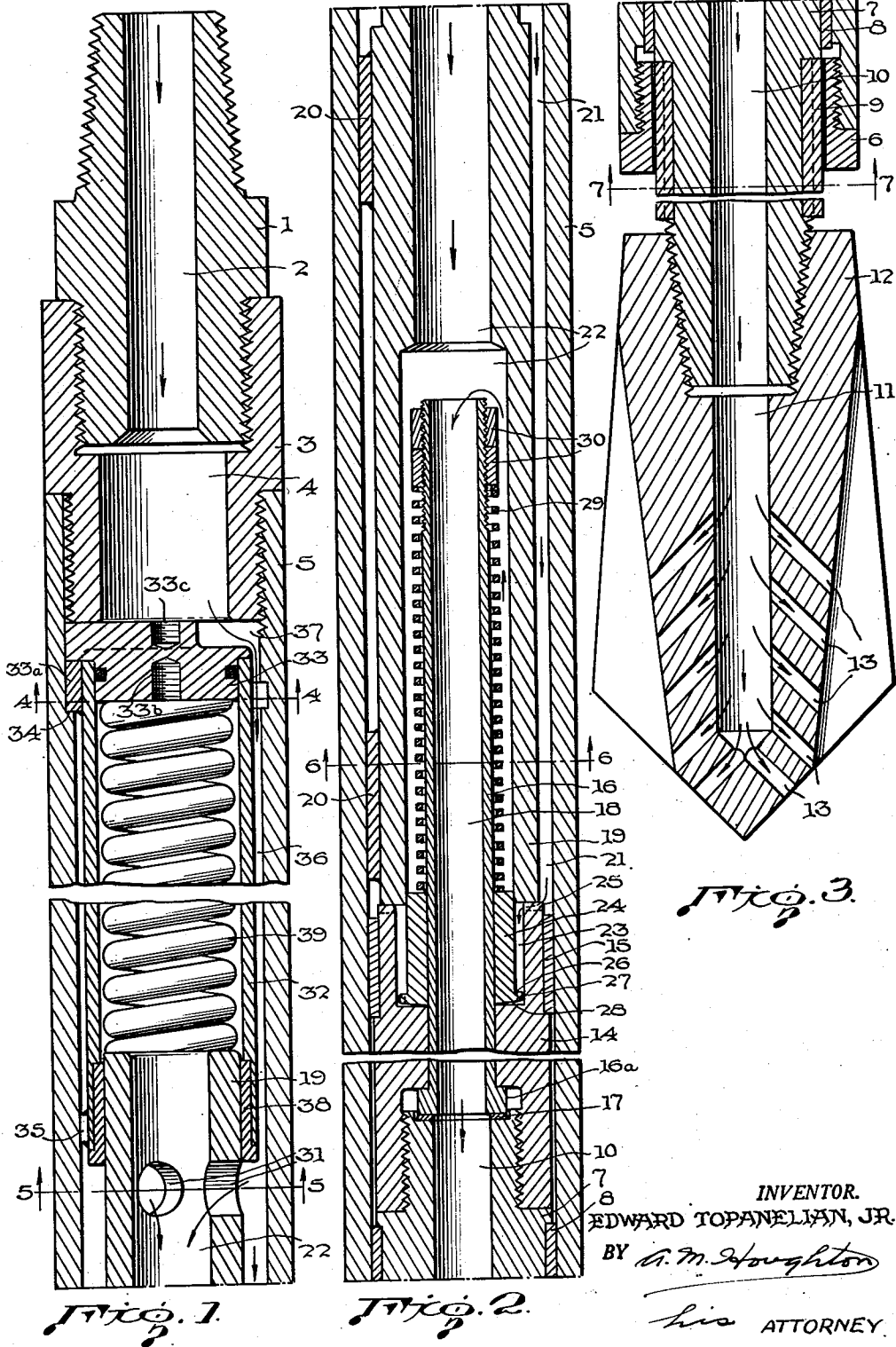
E. TOPANELIAN, JR

2,580,203

HAMMER DRILL

Filed Oct. 28, 1948

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

Fig. 4.

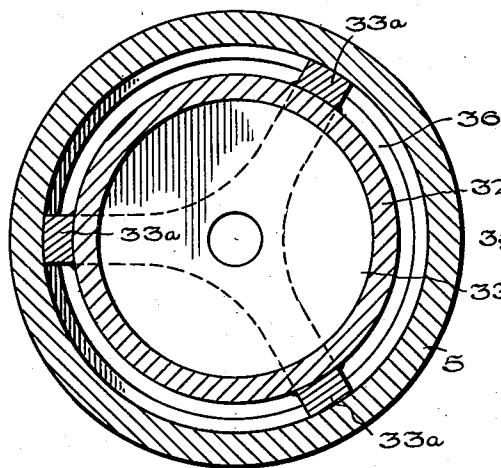


Fig. 5.

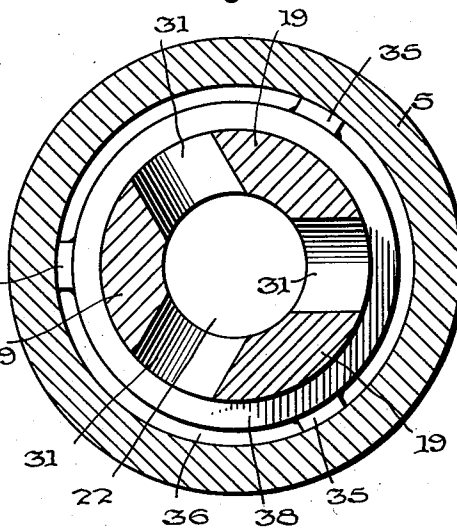


Fig. 6.

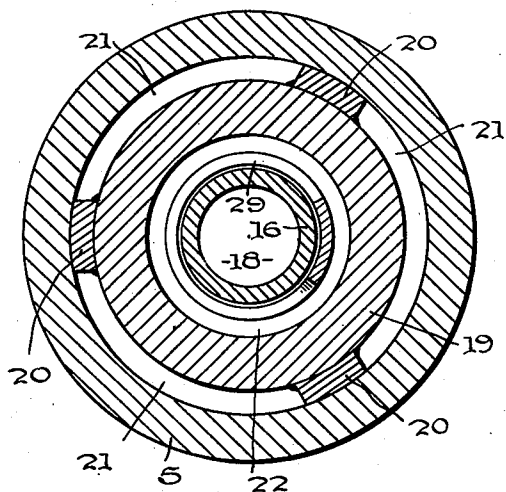
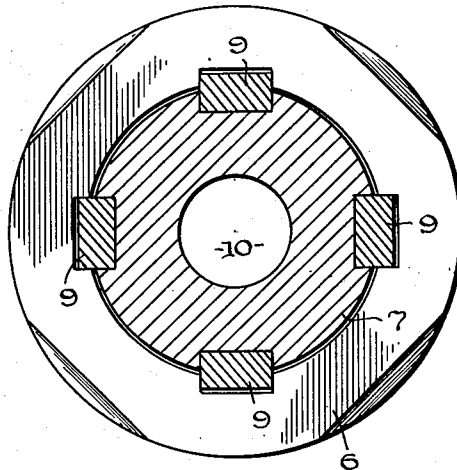


Fig. 7.



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4 Sheets-Sheet 3

Fig. 9.

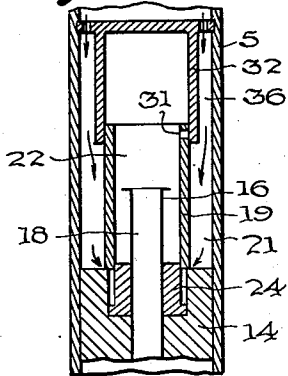


Fig. 8.

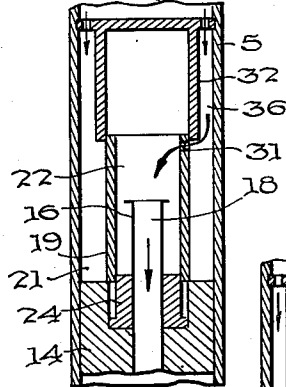


Fig. 12.

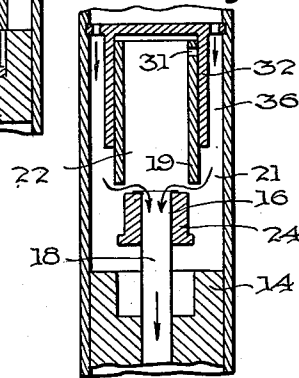


Fig. 10.

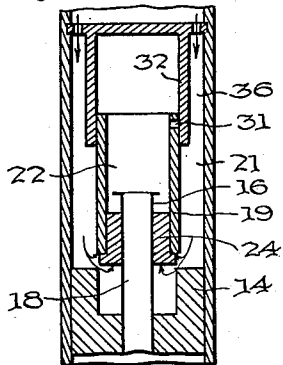


Fig. 11.

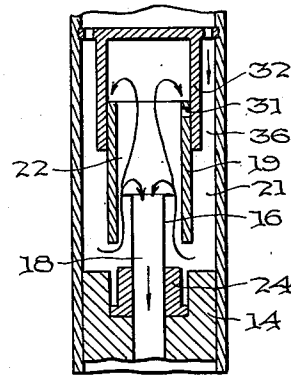
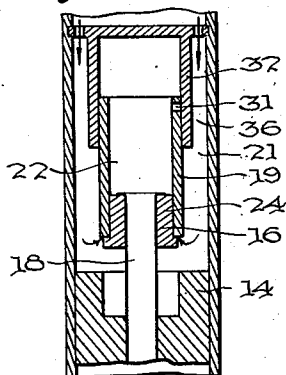


Fig. 13.

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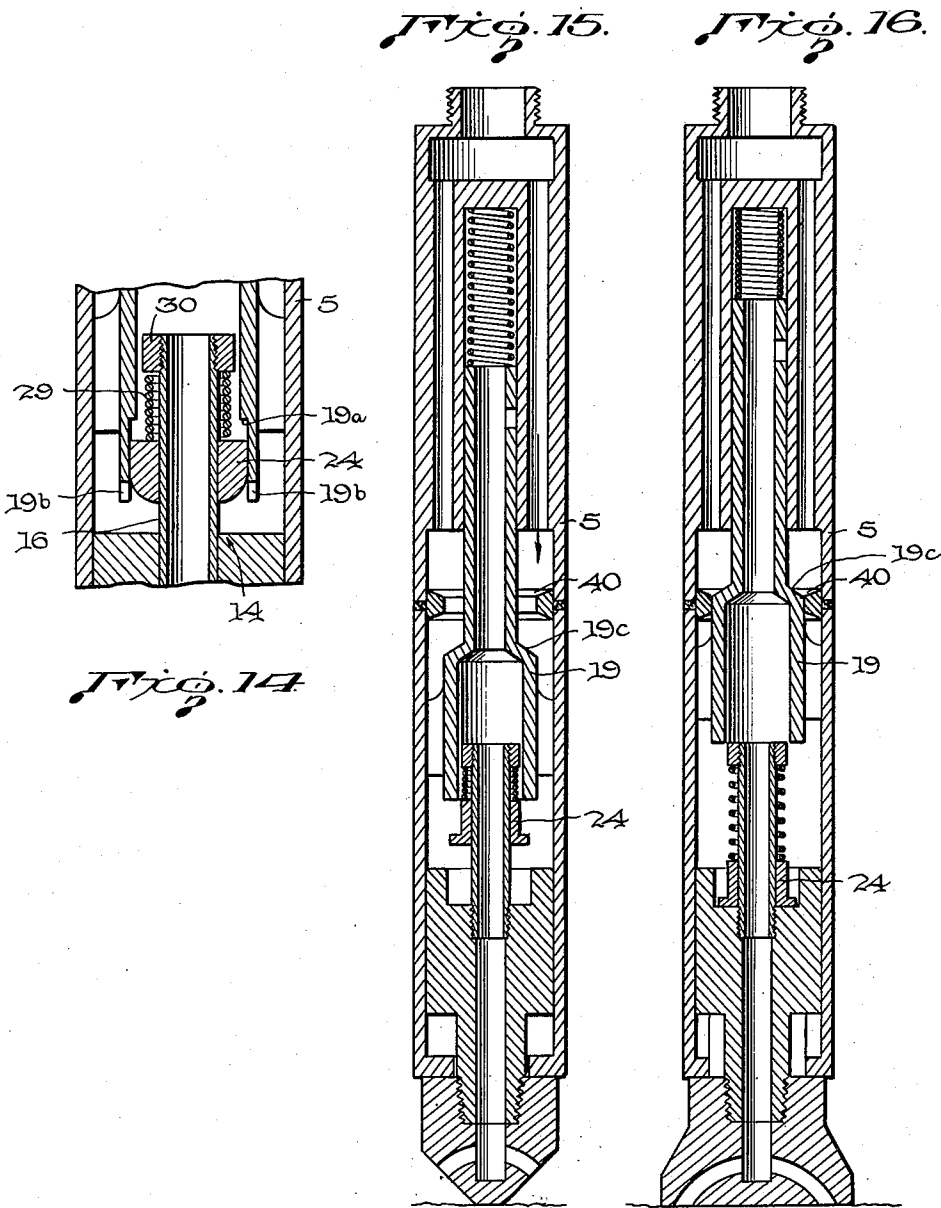
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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,580,203

HAMMER DRILL

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Application October 28, 1948, Serial No. 57,033

6 Claims. (Cl. 255—4.4)

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This invention relates to well drills and more particularly to a deep well drill combining the advantageous features of rotary and reciprocating drill mechanisms.

An object accomplished by my invention is the provision of a well drill which combines in a novel manner the more desirable features of rotary and reciprocating types of drills. A further object accomplished by my invention is the provision of a well drill having increased effectiveness against hard rock formations. Another object accomplished by my invention is the provision of a drill of the character described, having incorporated therein a fluid-operated mechanism for delivering blows to the bit without substantially interrupting the flow of fluid through the bit. Still another object accomplished by my invention is the provision of a rotary-reciprocating type well drill of such design that there is no reverse flow to any part of the mechanism tending to carry cuttings from the well into the drill. A still further object accomplished by my invention is the provision of a well drill of such design that the effect of "hydraulic hammer" is diminished, but advantageously used in some degree to actuate the hammer mechanism. A still further object accomplished by my invention is the provision of an impact-type drill characterized by a valve-operated hammer of such a nature and construction that the hammer may become unseated from the valve without shock. Other objects appear herein-after.

My invention is illustrated by the accompanying drawings and the descriptive matter relating thereto. Referring to the drawings,

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

Fig. 2 is a longitudinal section taken through the intermediate portion of the drill shown in Fig. 1;

Fig. 3 is a longitudinal section taken through the lower portion of the drill shown in Figs. 1 and 2 and the bit attached thereto;

Fig. 4 is a transverse sectional view taken along line 4—4 of Fig. 1;

Fig. 5 is a transverse sectional view taken along line 5—5 of Fig. 1;

Fig. 6 is a transverse sectional view taken along line 6—6 of Fig. 2;

Fig. 7 is a transverse sectional view taken along line 7—7 of Fig. 3;

Figs. 8 through 13, inclusive, are diagrammatic representations illustrating various phases

in the operation of my drill shown in detail in the preceding figures;

Fig. 14 illustrates an embodiment showing another method of engagement between hammer 19 and valve 24;

Fig. 15 diagrammatically illustrates another embodiment of my drill using a casing ring, with the hammer in an intermediate position; and

Fig. 16 is another view of the embodiment shown in Fig. 15, with the hammer engaging the casing ring.

A description of my drill is as follows:

Referring to Fig. 1, adapter 1 serves to connect the drilling assembly with a drill pipe (not shown) and is provided with a central passage 2 for the purpose of introducing drilling fluid under pressure into the drill mechanism. Adapter 1 is screwed into an adapter base 3 which also has a central passage 4 therein to accommodate the pressure fluid. This adapter base is threaded into a drill housing or casing 5 in which are located the operative parts of the drill. The lowermost portion of casing 5 is provided with a bushing 6, shown in Fig. 3, which serves to retain the internal assembly of the drill as well as to provide a driving torque for a bit-stem 7 slidably disposed within casing 5 and guided therein by means of replaceable sleeves 8. This driving torque between bushing 6 and bit-stem 7 is accomplished by means of keys 9 inserted in keyways between the two elements, as shown in Figs. 3 and 7, or by other well-known means, such as splines or a hexagonal or square fit between the elements 6 and 7. Bit-stem 7 contains a central passage 10 for the drilling fluid which connects with the central passage 11 of a bit 12 attached to the end of bit-stem 7. Bit 12 is further provided with passages 13 connecting central passage 11 with the well bore to facilitate the removal of cuttings and chips therefrom by means of flushing action of the drilling fluid. The upper portion of bit-stem 7 is threadedly connected to an anvil 14, shown in Fig. 2, which is also slidably disposed within casing 5 and guided therein by means of a replaceable sleeve 15. Parts 7 and 14 are suitably disposed to accommodate the base 16a of an eduction tube 16 which is sealed and retained between the two members by a compressible washer 17, and may be keyed to anvil 14 if desired. This eduction tube 16, having a central passage 18 connecting with passage 10 in bit-stem 7, extends through anvil 14 and thereabove into a considerable portion of casing 5. A reciprocable ram or hammer 19, suitably disposed from casing 5 to form annular passage 21 and guided therein by means of lugs

20 welded to the hammer, as shown in Figs. 2 and 6, is provided to produce percussive blows upon anvil 14 which in turn transmits the resulting shocks through the remainder of the drill mechanism to the drill bit 12. Both hammer and anvil may be provided with hardened bushing inserts to resist wear at the point of impact between the two elements. A central passage 22 is provided within hammer 19 connecting with passage 18 in eduction tube 16 to provide a further path for the operating fluid. Anvil 14 is provided with a recessed portion 23 adapted to accommodate a valve 24 which is slidably disposed on eduction tube 16. The annular surface of anvil 14 exposed to hammer blows is provided with passages 25 to form a connecting path for the pressure fluid in passages 21 to recess 23 in the anvil. Valve 24 is provided with a shoulder 26 adapted to engage the bottom of hammer 19 when the body of valve 24 has sufficiently entered the hammer bore in which it has a close sliding fit. The shoulder 26 of valve 24 is further provided with slots 27 and a taper clearance 28 at the lower end of the valve so that pressure fluid within recess 23 may be communicated to beneath the valve to provide an actuating force therefor. The upward movement of valve 24 on eduction tube 16 is limited by means of a helical spring 29 disposed about the eduction tube and retained thereon by means of locking nuts 30. However, a valve stop, such as a tubular valve stop extending over the upper portion of eduction tube 16 and beneath spring 29, could be advantageously used in addition to limit upward movement of valve 24. At the upper end of hammer 19, shown in Fig. 1, fluid communication is provided between the inside and outside thereof by means of holes 31, shown in Figs. 1 and 5, so that in the position of the parts as shown, pressure fluid will flow through the central passage 22 of hammer 19 and out through the bit. The upper portion of hammer 19 is received by a cylinder tube 32 which is closed at its top by cap 33 sealed thereto, as shown in Figs. 1 and 4. Tube 32 is suspended in casing 5 by means of lugs 33a welded to cylinder 32 and held against shoulder 34 of the casing by adapter base 3 screwed against cap 33. Cylinder 32 is suitably disposed from casing 5 by means of the aforementioned lugs 33a as well as lugs 35 welded to the lower portion thereof such that annular passage 36 is formed between the cylinder and casing. Cap 33 is shaped to form passages 37 connecting passage 36 with central passage 4 of the adapter base 3. The lower portion of cylinder 32 is provided with a replaceable bushing 38 to accommodate hammer 19 and form a good sealing but freely sliding fit therefor, so that upon slight upward movement of hammer 19 with respect to cylinder 32, passages 31 will become sealed off. The inside of cylinder 32 is provided with a helical spring 39 cooperating with hammer 19 to decelerate and return the hammer when it has been elevated.

The operation of the above-described drill is as follows:

The entire unit will be suspended vertically in a well bore with an ordinary rotary drill pipe attached to adapter 1 such that the bit will be situated several feet above the bottom of the hole. In this position, bit-stem 7 and anvil 14 together with the attached parts will be in their lowermost positions as retained by bushing 6. Hammer 19 resting on anvil 14 will also be in its lowermost position so that holes 31 near the top of the hammer will be uncovered. In other

words, all parts will be in the positions as shown in Figs. 1, 2 and 3 of the drawings. It is usually desirable to "rotate in" when a new bit has been attached to insure that the hole is full size, and to flush out sediment and cuttings which may have settled to the bottom while bits were being changed. This is accomplished merely by establishing the circulation of drilling fluid downward through the central passage of the drill stem and rotating the bit while it is lowered through the last few feet to the bottom of the well bore. During this "rotating in" process, fluid will be circulated through passages 2, 4, 37, 36, 31, 22, 18, 10, 11 and out through passages 13 of the bit returning up the hole outside of the drill housing 5. It should be noted that no flow occurs between hammer 19, valve 24 and anvil 14 because the passages provided by holes 31 will sufficiently bypass enough pressure fluid to the well bore. Since all the passageways are open, no pressure differential exists, and accordingly valve 24 and hammer 19 will not be actuated at this stage of operation. Thus, hammering will not take place to endanger the drill pipe or other parts as the drill is lowered. This stage of operation is shown diagrammatically in Fig. 8. In Figs. 8 to 13 the arrows indicate the action of the pressure fluid in operating the device. Upon continuing to lower the mechanism while rotating casing 5, thus producing rotation of bit-stem 7 and bit 12, the nose or cutting edge of bit 12 will eventually touch the bottom of the hole. Further lowering of the drill pipe and attached parts will then cause changes in the relative positions between casing 5 and the internal parts 7, 14 and 19. Since cylinder 32 is integral with casing 5, the cylinder will eventually close off passages 31 from fluid flow. The parts will essentially then be in the positions as shown diagrammatically in Fig. 9. Due to the fact that there is no immediate outlet for the fluid being supplied under pressure from surface pumps, the pressure will build up within passage 21 and will be transmitted through passages 25 and recess 23 and slots 27 to beneath valve 24. The upper surface of valve 24 is exposed to a pressure substantially equivalent to the static head of the fluid in the well bore at the depth of the valve, since the upper surface of the valve is afforded communication with the well bore through passages 22, 18, 10, 11 and 13. There is, therefore, a differential pressure existing across valve 24. Because the pressure beneath the valve is greater than that exerted on its upper surface, the valve will rise within the bore of hammer 19 until shoulder 26 of the valve engages the lower surface of the hammer. The parts will then be in the positions as shown diagrammatically in Fig. 10. The continued application of fluid pressure beneath the valve and hammer will raise valve 24 and hammer 19 as a unit. This is due to the fact that a differential pressure also exists across the hammer, the upper surface of hammer 19 being in communication with the well bore through central passage 22 of the hammer and passages 18, 10, 11 and 13, through which passages the fluid inside the hammer 19 and cylinder 32 is discharged to the annular space outside the drill. It is apparent that a large area is provided at the base of the hammer for initial acceleration of the hammer upward. This first stage of acceleration continues until the parts reach the relative positions as shown diagrammatically in Fig. 11, at which time the upward travel of valve 24 will

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be arrested by the compression of spring 29. However, a pressure differential still exists across the hammer and fluid pressure will still be applied to the lower surface thereof, although it is apparent that the effective hammer area acted upon by such pressure is reduced because valve 24 is now restrained from further upward movement. The hammer will therefore continue to move upward, and this second stage of acceleration will be of such a degree that the momentum of the hammer will continue to carry it upward and away from valve 24 until it is decelerated and returned downward by the forces of gravity and spring 39. The relative positions of the parts after hammer 19 has become disengaged from valve 24 and immediately before descent of the hammer are shown in Fig. 12. Referring to Fig. 12, it can be seen that a free flow of pressure fluid will take place around the base of the hammer into the upper end of eduction tube 16, and thence through the remaining lower parts outward into the well bore. The internal pressure exerted on the upper and lower surfaces of both hammer 19 and valve 24 will be approximately equalized so that the forces of gravity and springs 39 and 29 will be permitted to accelerate hammer 19 and valve 24 downward, respectively. Valve 24, having already had its upward movement arrested, is quickly returned to its lowermost position as shown in Fig. 13, while the upward momentum of hammer 19 is overcome by the action of spring 39 (and gravity) and is then returned to its lowermost position. The downward acceleration of hammer 19 and the momentum resulting therefrom will produce a considerable impact upon anvil 14 when the hammer comes in contact therewith, and this impact will be transmitted through the remaining lower parts of the drill to the cutting edge of bit 12, resulting in a percussive blow against the formation at the bottom of the hole. The slight overlap shown in Fig. 2 between hammer 19 and valve 24 is not sufficient to materially retard the hammer or cushion the percussive blow because valve 24 represents in fact an almost instantaneously-yielding outlet and relief for pressure fluid. The fluid pressure in the region 23 begins to rise as soon as hammer 19 overlaps with valve 24, and this early pressure rise is helpful in accelerating valve 24 upward and in developing the necessary pressure for the upward acceleration of the hammer for a new cycle of operation so that a rapid succession of blows exerted against the formation being drilled will result. Due to the fact that the entire drill is slowly rotated, the various percussive blows exerted on the well formation 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. Flushing fluid from the drill will continuously be discharged from the bit into the well bore to carry the chips to the surface of the well. Continuous operation of the drill will therefore completely remove material from the bottom of the hole and result in advance of the drill through the formation.

Certain modifications which may be made are deserving of specific mention. It will be noted that the lower inside portion of cap 33, shown in Fig. 1, is provided with a tapped blind hole 33b. This hole permits the attachment of spacer discs (not shown) within cylinder 19 above spring 39, if desired, to increase the spring pressure. The tapped hole 33c on the upper side of cap 33

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is provided simply for pulling purposes, i. e., so that cap 33 may conveniently be removed when disassembling the mechanism. It is important to note that, as explained below, both spring 29 and spring 39 may be eliminated from the drill without rendering the drill inoperative. With respect to the elimination of spring 39, it has been found by experimental observation that the force of gravity alone is sufficient to decelerate hammer 19 after it has been raised by fluid pressure and is sufficient also to return it to strike a blow on anvil 14 with substantial force. However, to speed up the return of hammer 19 and increase the number of blows per minute, spring 39 has been provided so that hammer 19 may be more quickly decelerated and returned. Spring 39 may be a partial or bumper spring within cylinder 32 or a full length spring as shown in Fig. 1, with or without initial compression when installed. With respect to the elimination of spring 29, tests have shown that under certain conditions the force of gravity alone is sufficient to effect return of valve 24 after it has become elevated and hammer 19 has broken away therefrom. However, to assure proper return of valve 24 in heavy drilling fluids, spring 29 has been provided. Spring 29 may also be a partial or bumper spring so as to give merely initial return impetus to the valve after it has been raised to the upper limit of its travel, or spring 29 may be a full length spring as shown in Fig. 2.

It should be noted that the means provided for engagement between valve 24 and hammer 19 may be variously modified. For example, valve 24 may be so constructed as to engage a shoulder 19a located within hammer 19, as shown in Fig. 14. In such an embodiment, the anvil 14 need not be recessed to accommodate the valve but may be flat, as shown. The base of hammer 19 would then be provided with slots 19b to permit operating fluid under pressure to circulate beneath a taper provided on the lower end of valve 24 when hammer 19 rests on anvil 14, so that valve 24 may be actuated by operating fluid.

In another embodiment (not shown) no shoulder may be provided, either in hammer 19 or on valve 24, so that valve 24 will reach the end of its travel before the hammer is forced upward, following which the hammer will be lifted upward from the valve in one stage of acceleration only.

Another embodiment of my drill is shown schematically in Figs. 15 and 16 wherein I provide an annular projection or casing ring 40 within casing 5 so that the outer periphery of the ring forms a continuous seal with the casing. The ring may be secured to the casing by boring holes through the casing and welding to the ring inside the hole, or by other suitable means. An outer shoulder 19c is provided on hammer 19 so that when the hammer becomes fully elevated, as in Fig. 16, a seal will be provided against operating fluid under pressure entering the drill above the hammer. However, the ring is provided with suitable running clearances over the shoulder of the hammer, and the inner periphery of the ring is tapered so that the upper end of the hammer can be readily guided there-through from below during assembly. When the hammer is not fully elevated, as in the position shown in Fig. 15, sufficient clearance exists between the upper portion of the hammer and the casing ring to assure free circulation of operating fluid to the base of the hammer. The purpose of the casing ring is to utilize the hydraulic force

of the operating fluid to limit the upward travel of the hammer, and further, to accelerate it downward. Thus, the use of a casing ring cuts down on the time lost when the hammer is decelerated on its upward stroke, and at the same time reduces excess fluid loss through the eduction tube occurring during the interval that the hammer was being decelerated and returned. The net effect is to increase the operating frequency of the drill. In one series of tests the operating frequency was increased from 400 strokes per minute to over 700 strokes per minute by simply adding a casing ring as described hereinabove.

The sequence of operations of the drill is not substantially affected by the use of a casing ring. When hammer 19 becomes sufficiently elevated to become disengaged from valve 24, shoulder 19c on hammer 19 will form a seal against casing ring 40, resulting in a sudden increase in pressure above the ring and hammer shoulder. The system will then resemble the action of a piston in a cylinder, and this pressure will arrest the upward travel of hammer 19 as well as provide considerable hydraulic force to accelerate it downward. When shoulder 19c engages casing ring 40 the flow of fluid through the rest of the drill will be momentarily cut off. In contrast to this, it is recalled that in the other embodiments of my drill where no casing ring is provided there is a free flow of fluid over hammer 19 and out through eduction tube 16 during the entire time that hammer 19 is disengaged from valve 24. However, this interruption of fluid flow when employing a casing ring is so slight and takes place so quickly that it amounts to only a flicker in the fluid discharge from the bit. Furthermore, there is sufficient compressibility in the fluid column so that, considered with the limited rate of shock-wave propagation in the fluid, no excessive "hydraulic hammer" results by using the casing ring. In fact, over-all operation is more smooth when the ring is used. In addition, over-all operating pressure may be somewhat lower because the required rate of fluid flow is reduced by the casing ring.

In the embodiment of Figs. 15 and 16 there is shown an annular projection on the casing in the shape of an annulus or ring 40. It is to be understood however that such shape is by way of illustration only and that any means may be used having a shape so as to cooperate with a corresponding shape on the hammer 19 to interrupt the flow of operating fluid to the base of the hammer when elevated.

One of the advantages of my drill is that fluid flow through the bit is never substantially interrupted, even while delivering blows to the bit, thus permitting maximum utilization of the effects of flushing fluid. As described above, when a casing ring is used there is a slight interruption in fluid flow, but this occurs for only a fraction of each cycle. Another advantage is that direct communication of fluid pressure is provided between the well bore and the hammer actuating cylinder through the bit, so that all fluid pumped down the drill stem is effective in removing cuttings. The upward acceleration of the hammer is effected in two stages, the first stage being that during which the valve 24 and the hammer 19 are raised together and the second stage being the subsequent one during which only the hammer 19 is raised. The first stage, due to the larger pressure area of both hammer and valve, provides a relatively large

impetus to the hammer at the start of its upward motion with minimum pressure rise in the operating fluid. Transition to the second stage of hammer acceleration, which is somewhat smaller than the first stage, occurs with minimum shock at the moment the valve 24 pulls away from the hammer 19 since no large differential pressure exists across the valve at the moment its movement is arrested and it leaves its seat in the hammer. The alternative method of operating my drill without springs, wherein the maximum effect of gravity is utilized, is advantageous where the use of springs is considered undesirable. It is to be noted that fluid flow through the mechanism is everywhere unidirectional and at no time is there any reversal of fluid flow in any portion of the drill mechanism which would tend to carry cuttings into the drill and produce operational failures. This advantageous feature is made possible because the power fluid supplies "make-up" fluid behind the hammer in the actuating cylinder 32 so that "make-up" is not required from the well bore, and further, because continuous flow is maintained through the bit in an outward direction. A still further advantage lies in the automatic relief provided for "hydraulic hammer" and the beneficial utilization of pressure rise resulting therefrom to effect initial operation of valve 24 and hammer 19. Another advantage is that the stroke of the hammer may be varied by adjusting the operation and travel of the hammer-actuating valve 24, e. g. by adjusting the position of the spring-retaining nuts, changing springs, inserting valve stops of different lengths or valves of different lengths or changing the location of the valve shoulder, etc. or length of eduction tube 16.

It will be apparent to those skilled in the art who have familiarized themselves with this disclosure of my invention that numerous modifications in addition to those hereinabove set forth may be made without departing from the spirit of the invention. Furthermore, the preferred embodiments specifically described herein are intended to be merely illustrative of my invention, and in no manner should they be considered as limitations thereof or as limiting the scope of the appended claims hereinafter made.

What I claim is:

1. In a fluid-operated deep well drill, the combination comprising a tubular casing, an inverted cup-like cylinder longitudinally mounted in said casing, means affording operating fluid access to the lower end of said cylinder, an elongate annular ram slidably disposed in and sealed against the inside of said cylinder and having a longitudinal central passage, an annular anvil block in the path of said ram slidably disposed in and sealed against the inside of said casing below the open end of said cylinder, a downward extension rigidly connected to said anvil block and adapted to be rotated by rotation of said casing and to carry a drilling tool, said extension having a longitudinal central passage connecting with the interior of said anvil block, an eduction tube extending upward from said anvil block into the interior of said ram and having a central passage connecting with the interior of said anvil block, an annular valve slidably disposed outside of and sealed against said eduction tube and adapted to seal the central passage of said ram when in engagement therewith, means permitting operating fluid access to the bottom face of said valve, and an abutment carried on the outer surface of said eduction

tube and spaced from said anvil block by an amount which limits the upward travel of said valve to an amount which is smaller than the upward travel of said ram.

2. In a fluid-operated deep well drill, the combination comprising a tubular casing, an inverted cup-like cylinder longitudinally mounted in said casing, means affording operating fluid access to the lower end of said cylinder, an elongate annular ram slidably disposed in and sealed against the inside of said cylinder and having a longitudinal central passage, a compression spring retained in the interior of said cylinder with its upper end against the upper end of said cylinder and its lower end providing a return for said ram upon being elevated, an annular anvil block in the path of said ram slidably disposed in and sealed against the inside of said casing below the open end of said cylinder, a downward extension rigidly connected to said anvil block and adapted to be rotated by rotation of said casing and to carry a drilling tool, said extension having a longitudinal central passage connecting with the interior of said anvil block, an eduction tube extending upward from said anvil block into the interior of said ram and having a central passage connecting with the interior of said anvil block, an annular valve slidably disposed outside of and sealed against said eduction tube and adapted to seal the central passage of said ram when in engagement therewith, means permitting operating fluid access to the bottom face of said valve, and an abutment carried on the outer surface of said eduction tube and spaced from said anvil block by an amount which limits the upward travel of said valve to an amount which is smaller than the upward travel of said ram.

3. In a fluid-operated deep well drill, the combination comprising a tubular casing, an inverted cup-like cylinder longitudinally mounted in said casing, means affording operating fluid access to the lower end of said cylinder, an elongate annular ram slidably disposed in and sealed against the inside of said cylinder and having a longitudinal central passage, an annular anvil block in the path of said ram slidably disposed in and sealed against the inside of said casing below the open end of said cylinder, a downward extension rigidly connected to said anvil block and adapted to be rotated by rotation of said casing and to carry a drilling tool, said extension having a longitudinal central passage connecting with the interior of said anvil block, an eduction tube extending upward from said anvil block into the interior of said ram and having a central passage connecting with the interior of said anvil block, an annular valve slidably disposed outside of and sealed against said eduction tube and adapted to seal the central passage of said ram when in engagement therewith, means permitting operating fluid access to the bottom face of said valve, an exterior abutment carried on the upper end of said eduction tube, and a compression spring retained on the exterior of said eduction tube with its upper end against said abutment and its lower end providing a return for said valve upon being elevated, said abutment and said spring being dimensioned to limit the upward travel of said valve to an amount which is smaller than the upward travel of said ram.

4. In a fluid-operated deep well drill, the combination comprising a tubular casing, an inverted

cup-like cylinder longitudinally mounted in said casing, means affording operating fluid access to the lower end of said cylinder, an elongate annular ram slidably disposed in and sealed against the inside of said cylinder and having a longitudinal central passage and a passage through the wall connecting the interior and exterior of said hammer, an annular anvil block in the path of said ram slidably disposed in and sealed against the inside of said casing below the open end of said cylinder, a downward extension rigidly connected to said anvil block and adapted to be rotated by rotation of said casing and to carry a drilling tool, said extension having a longitudinal central passage connecting with the interior of said anvil block, an eduction tube extending upward from said anvil block into the interior of said ram and having a central passage connecting with the interior of said anvil block, an annular valve slidably disposed outside of and sealed against said eduction tube and adapted to seal the central passage of said ram when in engagement therewith, means permitting operating fluid access to the bottom face of said valve, and an abutment carried on the outer surface of said eduction tube and spaced from said anvil block by an amount which limits the upward travel of said valve to an amount which is smaller than the upward travel of said ram.

5. In a fluid-operated deep well drill, the combination comprising a tubular casing, an inverted cup-like cylinder longitudinally mounted in said casing, means affording operating fluid access to the lower end of said cylinder, an elongate annular ram slidably disposed in and sealed against the inside of said cylinder and having a longitudinal central passage, a constriction on the inner surface of said casing, an enlargement on the outer surface of said ram cooperating with said constriction whereby when said ram is elevated the operating fluid is confined thereabove and a downward impetus imparted to said ram, an annular anvil block in the path of said ram slidably disposed in and sealed against the inside of said casing below the open end of said cylinder, a downward extension rigidly connected to said anvil block and adapted to be rotated by rotation of said casing and to carry a drilling tool, said extension having a longitudinal central passage connecting with the interior of said anvil block, an eduction tube extending upward from said anvil block into the interior of said ram and having a central passage connecting with the interior of said anvil block, an annular valve slidably disposed outside of and sealed against said eduction tube and adapted to seal the central passage of said ram when in engagement therewith, means permitting operating fluid access to the bottom face of said valve, and an abutment carried on the outer surface of said eduction tube and spaced from said anvil block by an amount which limits the upward travel of said valve to an amount which is smaller than the upward travel of said ram.

6. In a fluid-operated deep well drill, the combination comprising a tubular casing, an inverted cup-like cylinder longitudinally mounted in said casing, means affording operating fluid access to the lower end of said cylinder, an elongate annular ram slidably disposed in and sealed against the inside of said cylinder and having a longitudinal central passage, an annular anvil block in the path of said ram slidably disposed

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in and sealed against the inside of said casing below the open end of said cylinder, a downward extension rigidly connected to said anvil block and adapted to be rotated by rotation of said casing and to carry a drilling tool, said extension having a longitudinal central passage connected with the interior of said anvil block, an eduction tube extending upward from said anvil block into the interior of said ram and having a central passage connecting with the interior of said anvil block, an annular valve slidably disposed outside of and sealed against said eduction tube and adapted to partially penetrate and seal the lower end of said ram, means permitting operating fluid access to the bottom face of said valve, and an abutment carried on the outer surface

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of said eduction tube and spaced from said anvil block by an amount which limits the upward travel of said valve to an amount which is smaller than the upward travel of said ram.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,065,298	Currell	June 17, 1913
1,861,042	Zublin	May 31, 1932
1,892,517	Pennington	Dec. 27, 1932
2,388,741	Hays	Nov. 13, 1945