Dec. 27, 1932. H. PENNINGTON 1,892,517

WELL DRILLING APPARATUS

Filed Nov. 28, 1927

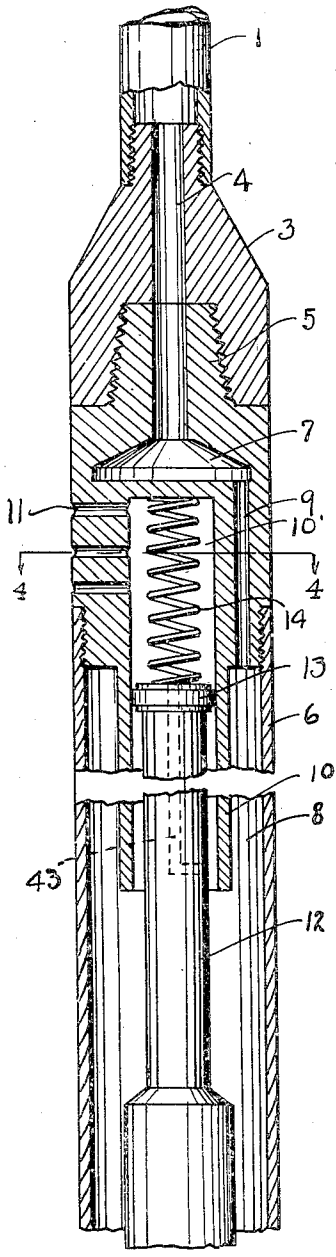


Fig. 1.

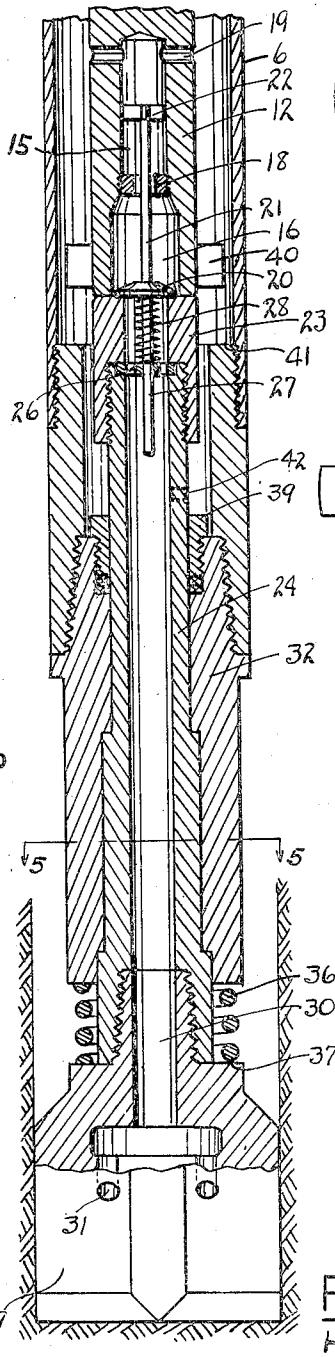


Fig. 2

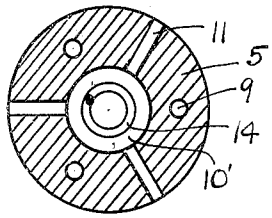


Fig. 4

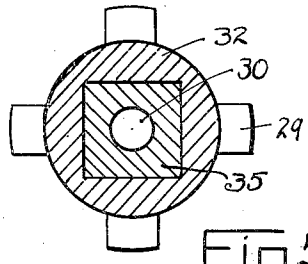


Fig 5.

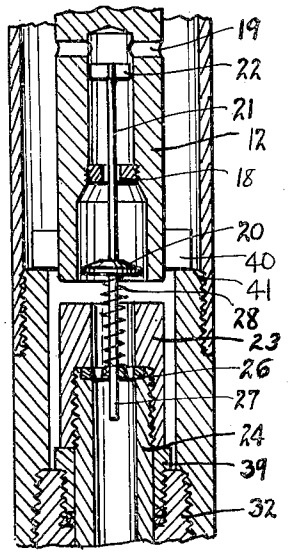


Fig. 3.

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UNITED STATES PATENT OFFICE

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WELL DRILLING APPARATUS

Application filed November 28, 1927. Serial No. 236,049.

My invention relates to well drills adapted particularly for drilling deep wells for oil, water, gas, sulphur, and the like. It pertains to well drills for use more especially in hard formations, but is adapted for use generally. It seeks to combine the merits of both the rotary and the percussion system of drilling.

It is an object of my invention to provide a drill which may be employed with the usual rotary drilling rig, but which also has the action of a percussion type of drill to strike sharp blows upon the formation as the drill is being rotated, this action being obtained without the use of any additional equipment in the rig at the surface of the well.

It is desired that the flushing system remove the cuttings from in front of the bit so that the bit always strikes a clean surface securing maximum penetration of the bit with each blow.

It is also an object to obtain a free falling blow upon the bit undampened by the strain of the drilling line, thereby obtaining greater effective contact with the bottom of the hole. I also arrange to obtain rotation of the drill for reaming the hole and maintain the bore of the hole to full gauge without also striking blows upon the bit while thus rotating. The tool may be rotated to enlarge a small gauged place in the bore without the operation of the hammer. Damage to the drill pipe is thus avoided. An object is, therefore, to allow the use of the hammer operation when desired, but to eliminate the hammer action when its action is undesirable.

I contemplate the use of the flushing fluid both for the purpose of removing the cuttings, as stated, and also as a motive element in producing a hammer action upon the rotary drill.

Other objects of the invention will more clearly appear in the description which follows.

Referring to the drawing herewith, wherein an apparatus embodying my invention is disclosed, Fig. 1 is a central longitudinal section through the upper end of a well drill employing my invention. Fig. 2 is a similar section of the lower end thereof. Fig. 3 is a broken detail showing the hammer in inoperative position. Fig. 4 is a transverse section on the plane 4—4 of Fig. 1. Fig. 5 is a similar section on the plane 5—5 of Fig. 2.

In carrying out my invention, I contemplate the equipment of a well with the usual rotary drilling outfit, wherein the drill bit is rotated at the lower end of a hollow drill stem, through which flushing water is pumped downwardly under pressure to the bottom of the well. This flushing fluid passes upwardly outside of the drill and drill stem and between the same and the wall of the well to the surface. There is in effect a U-tube arrangement wherein one leg of the U-tube is represented by the hollow drill stem and the other leg of the U-tube being represented by the space between the drill stem and the wall of the well. The heads of liquid in the two legs of the tube are balanced, but the pressure within the drill stem is ordinarily in excess of the pressure in the well bore due to the force of the pumps which deliver the flushing fluid under pressure through the constricted passages in the drill at the lower end of the drill stem.

I contemplate employing the pressure of the fluid pumped downwardly through the drill stem in actuating an hydraulic hammer which serves in its operation to deliver blows upon the bit during its rotation.

Referring to the drawing, the lower end of the drill stem, indicated at 1, is connected through a drill collar 3 to a flow coupling 5. The drill collar 3 is shown as having the usual tool joint construction, the upper end forming a pin engaging within the drill stem 1, and the lower end being enlarged to form a socket connected with the upper end of the flow coupling 5.

The said flow coupling has an upper head thereon with a casing 6 extending downwardly therefrom to enclose the operating parts of my hydraulically operated device. The casing has a threaded engagement over the upper end of the drive bushing 32, the function of which will be later referred to. The upper head of the casing 6 has a passage therein connecting with a similar passage 4

in the drill collar, said passage leading to a chamber 7 formed in said head and having outlet openings 9 therefrom through which fluid may be delivered to the chamber 8 within the casing 6. A cylinder 10 is formed on the lower end of the head 5, said cylinder including a downwardly extending sleeve which may be formed as a part of the head, said sleeve being an extension of a cylindrical recess 10′ in the lower end of the head. Lateral openings 11 connect the upper portion of the cylinder with the outside of the casing.

The cylinder 10 is constructed to receive a piston 13 formed upon the upper shank of a hammer 12. Said shank is cylindrical in shape and the piston 13 at its upper end forms a fluid tight sliding contact with the interior of the cylinder. Above the piston and between the same and the upper end of the chamber 10′ is a compression spring 14.

The hammer 12 is enlarged below the upper shank and has its lower end recessed to form a valve chamber 16 therein. The upper end of this chamber is connected with a chamber 15 above it by a constricted passage 18 formed by an inwardly extending flange between the two chambers. The upper chamber 15 is connected by a plurality of lateral passages 19 with the interior of the chamber 8 in the casing. The lower end of the hammer is thus formed into an annular member adapted to deliver a blow upon the anvil 23 below it. Laterally extending lugs 40 at the lower end of the hammer are adapted to limit its downward movement, as will be later described.

The anvil 23 is a collar or ring screwed upon the upper end of an anvil stem 24. It is preferably made of hardened metal, such as steel, adapted to receive the blows from the hammer. The anvil stem 24 to which it is secured is a tubular member, the upper end of which is cylindrical on its outer surface and adapted to form a fluid tight connection with the outer casing through means of packing 34 held in position by a gland 39, said packing and gland fitting within the upper recessed end of a drive bushing 32, previously referred to. The lower end of the anvil stem is squared on its outer face, as shown in Fig. 2, so as to form a rotative driving connection between said drive bushing and said anvil stem.

The lower end of the anvil stem is connected with the upper shank of the drill bit 29. Said drill bit may be of any preferred construction, the upper portion of the head being formed with a passage 30 therein through which the flushing fluid may pass to channels 31 in the lower head of the bit through which the fluid may be delivered in front of the cutting blades of the bit. A shoulder 37 around the upper end of the bit head is adapted to form a seat for a coiled spring 36 bearing at its upper end against the lower end of the drive bushing 32, this forming a sort of shock absorber between the said drive bushing and the drill bit.

The pressure fluid through which the hammer is operated is controlled through a valve arrangement placed within the hammer, anvil and anvil stem, as will be seen from the drawing. A valve 20 is placed within the chamber 16, said valve being seated at its lower side upon the anvil 23 so as to close the passage downwardly through the anvil stem and bit. Said valve 20 has a stem 27 extending downwardly and having a sliding support within a spider 26 formed in the anvil stem, and a coil spring 28 surrounding said stem bears at its upper end against said valve and at its lower end against said spider 26. Above the valve a stem or rod 21 is extended upwardly through the opening 18 into the chamber 15. The upper end of said rod 21 has wings or vanes 22 thereon, which act as a stop member to limit the relative upward movement of the hammer, away from the valve.

A shoulder 41 is formed upon the lower inner side of the casing 6 to co-operate with the lugs 40 upon the hammer to also limit the relative downward movement of said hammer within the casing.

In the operation of my drill, the drill stem and drill will be rotated in the usual manner to cause a scraping action of the bit 29 upon the bottom of the hole so as to cut off the material therefrom, which is adapted to be carried upwardly with the flushing fluid to the surface. During this rotating of the bit, flushing fluid is pumped downwardly through the drill stem, the passages 4, 7 and 9 to the chamber 8 within the casing. When the drill is thus resting upon the bottom of the hole and the drill in operation, the hammer will ordinarily rest upon the anvil 23, as shown in Fig. 1. The valve 20 will thus be closed, preventing the passage of liquid to the drill. There will, therefore, be a fluid pressure built up within the chamber 8 within the casing and this fluid pressure will tend to force the piston 13 upwardly within the cylinder. There will also be an upward component of pressure within the chambers in the lower end of the hammer which will not be balanced by the pressure on the upper end of the hammer within the chamber. When this pressure has reached a sufficient magnitude, the hammer will be raised thereby, the piston 13 moving upwardly against the action of the spring 14 within the cylinder. As this upward movement continues the flange 18 will contact with the wings 22 of the upper end of the valve rod 21, raising the valve from its seat. The raising of the valve will allow the pressure fluid within the chamber 8 to exhaust through the drill to the bottom of the hole and upwardly outside of the drill. The passage 43 in the hammer 12 allows water to flow to chamber

10′ and passage 11 to clear them after each stroke.

The pressure being thus relieved within the chamber 8, the hammer will drop through gravity and through the impulse of the spring 14 to deliver a blow upon the anvil 23. This downward movement of the hammer will not be materially impeded by the liquid within the chamber 8 due to the fact that the said liquid has a free opening past the valve, and for the further reason that the liquid from without the drill is free to move in through the passages 11 to the interior of the cylinder 10′. In the downward drop of the hammer the liquid displaced by said hammer will find an outlet through the drill, and as the liquid is free to move inwardly above the hammer, no upward impulse will be delivered to the column of fluid outside the drill.

After the valve 20 has been raised from its seat by the upward movement of the hammer, it will remain in its open position through the support of the spring 28; but when the hammer has delivered its blow upon the anvil and remains in its seated position thereon, the force of the flushing fluid accumulating within the chamber 8 will enter through the passages 19 into the chamber 15 and from thence into the chamber 16, above the valve which will be forced downwardly by this pressure upon its upper side and seated in closed position until the hammer is raised by a repetition of the operation just described.

The blow delivered upon the anvil will be transmitted through the anvil stem to the drill bit and will serve to force the drill into the formation in an effective manner. The blow and the recoil therefrom will not be communicated to the drill stem or to the casing 6, thereby avoiding any strain or deterioration upon the operating members. The spring 36 between the drill bit and drive bushing will ease the dropping of the said bushing and the drill stem following the blow.

When the tool is elevated by means of the drill stem to raise the bit off of the bottom of the hole, the anvil stem and bit will slide downwardly to the casing and drive bushing due to their weight. When the casing and drive bushing have been raised sufficiently the anvil 23 will rest upon the shoulder formed by the gland 39; thus the downward movement of the bit will be limited. Due to its weight, the hammer will also slide downwardly within the casing 6, but its downward movement will be arrested by the contact of lugs 40 with the shoulder 41. Due to the positioning of the lugs 40 and the anvil 23 relative to the shoulder 41 and the gland 39, respectively, the anvil and stem will move downwardly for a greater distance than will the hammer, allowing an opening between the hammer and anvil through which fluid may circulate through the passage 30 into the bore hole, and while an outlet is thus provided for the flushing fluid, the valve 20 will be maintained above its seat through the pressure of the spring 28. While the parts are in this position, the fluid cannot operate the hammer and when the drill bit is rotated through its connection with the drive bushing, the material cut away by the bit will be carried freely away by the fluid. In this manner when the drill is being introduced into the hole, or at any time thereafter, it will be possible to rotate the drill to pass any constricted place in the hole, and the hammer will be idle, and the cuttings will be washed away from the drill free of the bit in the manner previously described.

During the usual operation of the drill, it will be noted that the bulk of the operating fluid will be delivered intermittently in spurts through the passages of the drill as the valve is raised, and while the hammer is falling. This will have an effective action upon the cuttings, forcing them away from the drill and to the ground surface up the bore hole by frictional contact of flushing fluid with cuttings.

If such action of the flushing water is not sufficient to carry the cuttings to the surface, an additional amount of flushing fluid may be necessary, but, since additional fluid would reciprocate the hammer faster, it follows that some means is necessary of controlling the amount of fluid passing through the bit, without reference to the number of hammer strokes per minute, so that when a large hole is being drilled and a larger quantity of flushing fluid is necessary, than in a small hole, the velocity of flushing fluid may be increased without increasing the rate of striking of the hammer, and vice versa.

For this control, I may provide an opening 42 within the side wall of the anvil stem below the valve. This opening will deliver a certain limited amount of fluid to the bit in a continuous stream. Limited size of the opening will not, however, prevent the accumulation of pressure through the surplus of liquid within chamber 8; and hence, will not interfere with the effective operation of the hammer in the manner described.

It will be obvious then, that when a large hole is being drilled, and a large quantity of flushing fluid is necessary to carry cuttings to the surface, that the size of opening 42 may be so fixed that any definite amount of fluid may pass through such opening, while at the same time, fluid pressure in chamber 8 will be sufficient to elevate the hammer.

Since the hammer, and its packing 13, reciprocating within cylinder 10, requires a definite amount of flushing fluid for each stroke, it follows that for a certain speed of strokes per minute, a definite quantity of flushing fluid is displaced. This definite quantity may not be sufficient for flushing cuttings to the surface, hence opening 42, allow-

ing fluid to pass through the bit without being displaced by the hammer reciprocation, may be provided and fixed to secure any desired proportion between fluid required for hammer displacement and that passing through opening 42.

It will be apparent that I have provided a drilling tool capable of carrying out the objects previously set forth, and while I have shown and described a specific embodiment of the invention, I do not wish to limit myself to this particular construction or arrangement of parts, it being obvious that I may alter the construction and combination of all or a part of the salient features of my invention, as occasion requires, without departing from the spirit of the invention.

What I claim as new is:

1. In cobination, a rotary drill pipe, a casing connected therewith, a drive bushing on said casing, a drill having a limited sliding movement in said bushing, said casing and drill having passages therein for flushing fluid, and means directly actuated by said flushing fluid within said casing to deliver blows upon said drill during its rotation, and means including a valve to control the flow of fluid.

2. In combination, a rotary drill pipe, a casing connected therewith, a drive bushing on said casing, a drill having a limited sliding movement in said bushing, said casing and drill having passages therein for flushing fluid, a hammer in said casing, an anvil connected with said drill, said hammer being formed to present an unbalanced surface for upward fluid pressure, a valve adapted to close the passage of fluid through said casing and drill to confine pressure fluid in said casing to raise said hammer, and means carried by said hammer to open said valve to release said hammer to deliver a blow upon said anvil.

3. In combination, a rotary drill pipe, a casing connected therewith, a drive bushing on said casing, a drill having a limited sliding movement in said bushing, said casing and drill having passages therein for flushing fluid, a hammer in said casing, an anvil connected with said drill, said hammer being formed to present an unbalanced surface for upward fluid pressure, a valve adapted to close the passage of fluid through said casing and drill to confine pressure fluid in said casing to raise said hammer, and means connected with said hammer to open said valve to release said hammer to deliver a blow upon said anvil.

4. In combination, a rotary drill pipe, a casing connected therewith, a drive bushing on said casing, a drill having a limited sliding movement in said bushing, said casing and drill having passages therein for flushing fluid, a hammer in said casing, an anvil connected with said drill, said hammer being formed to present an unbalanced surface for upward fluid pressure, a valve adapted to close the passage of fluid through said casing and drill to confine pressure fluid in said casing to raise said hammer, and means carried by said hammer to open said valve to release said hammer to deliver a blow upon said anvil, and means normally holding said valve in open position, said valve forming a piston whereby it is closed by fluid pressure.

5. In a well drilling apparatus, a hammer, an anvil, a drilling bit connected with said anvil, a casing through which an operating fluid flows to reciprocate said hammer, and a hammer actuated valve for controlling the operation of said hammer.

6. In a well drilling apparatus, a hammer, an anvil, a drilling bit connected with said anvil, a casing through which an operating fluid flows to reciprocate said hammer and a valve located within said hammer and said anvil for controlling the flow of said fluid through said casing.

7. In a well drilling apparatus, a hammer, an anvil having an opening therein adapted to permit an operating fluid to flow therethrough, a drilling bit connected with said anvil, a casing through which said operating fluid flows to reciprocate said hammer and a valve located within said hammer and said anvil for controlling the flow of said fluid through said opening and said casing.

8. In a well drilling apparatus, a hammer, an anvil having an opening therein adapted to permit an operating fluid to flow therethrough, a drilling bit having water passages therein and connected with said anvil by means having an opening therein, a casing, and a valve located within said hammer and said anvil for controlling the flow of said fluid through said anvil and bit.

9. In a well drilling apparatus, a hammer, an anvil, a drilling bit connected with said anvil, a casing enclosing said hammer and through which an operating fluid flows to reciprocate said hammer, said casing being provided with a cylindrical guide within which the end of said hammer reciprocates and a valve located within said hammer and said anvil for controlling the flow of said fluid through said casing.

10. In a well drilling apparatus, a hammer, an anvil, a drilling bit connected with said anvil, a casing enclosing said hammer and through which an operating fluid flows to reciprocate said hammer, said casing being provided with a cylindrical guide within which the end of said hammer reciprocates and which has openings therein connected with the well, and a valve located within said hammer and said anvil for controlling the flow of said fluid through said casing.

11. In a well drilling apparatus, a hammer having an opening therein adapted to permit

an operating fluid to flow therethrough and provided with a constricted portion, an anvil, a drilling bit connected with said anvil, a casing enclosing said hammer, a valve located within said hammer and said anvil for controlling the flow of said fluid through said opening, said valve being provided with a projection adapted to contact with said constricted portion whereby said valve is raised by said hammer.

12. In a well drilling apparatus, a hammer having an opening therein adapted to permit an operating fluid to flow therethrough, a constricted portion which divides said opening into two chambers, the upper of which has a plurality of passages and the lower chamber being of larger diameter than the upper chamber, an anvil, a drilling bit connected with said anvil, a casing enclosing said hammer, a valve located within said lower chamber and said anvil for controlling the flow of said fluid through said upper and lower chambers, said valve being provided with a projection adapted to contact with said constricted portion whereby said valve is raised by said hammer.

13. In a well drilling apparatus, a hammer having an opening therein adapted to permit an operating fluid to flow therethrough, a constricted portion which divides said opening into two chambers, the upper of which has a plurality of passages and the lower chamber being of larger diameter than the upper, an anvil, a drilling bit, means connecting said anvil and bit, said connecting means being provided with a perforated constriction, a casing enclosing said hammer, a valve located within said lower chamber and said anvil for controlling the flow of said fluid through said upper and lower chambers, said valve being provided with a projection adapted to contact with said constricted portion whereby said valve is raised by said hammer, said valve projecting through said perforated constriction and having associated therewith a spring resting upon said perforated constriction.

14. In a well drilling apparatus, a hammer having an opening therein adapted to permit an operating fluid to flow therethrough, a casing through which said fluid flows, an annular anvil, a drilling bit, a hollow member connecting said anvil with the bit and having an opening communicating with said casing whereby some of the operating fluid may flow from said casing without flowing through said hammer and a valve for controlling the flow of the operating fluid through the opening in said anvil.

15. In a well drilling apparatus, a hammer, an anvil, a drilling bit, a member connecting said anvil with the bit, a casing, a sleeve connected with said casing and within which said connecting member is adapted to reciprocate, a spring positioned between said sleeve and the bit to prevent shocks from the bit from being transferred to said casing through said sleeve.

16. In a well drilling apparatus, a hammer, an anvil, a drilling bit, a member connecting said anvil with the bit, a valve carried by said member, a casing, a sleeve connected with said casing and within which said connecting member is adapted to reciprocate, a portion of said connecting member and the adjacent portion of the sleeve being of such cross-sectional form that rotation of the sleeve will cause rotation of the connecting member and the bit connected thereto.

17. In a well drilling apparatus, a hammer, an anvil, a casing enclosing said hammer and anvil, means for supporting said hammer and anvil in separated position whereby an operating fluid may flow through said casing while the hammer is inoperative.

18. In a well drilling apparatus, a hammer provided with a lateral projection, a casing enclosing said hammer and provided with an interior projection adapted to contact with said lateral projection whereby said hammer is supported, an anvil, a drilling bit, means connecting said anvil with the bit, means associated with said connecting means for supporting said anvil, said hammer and said anvil being supported so that said parts are separated whereby an operating fluid may flow through said casing while the hammer is inoperative.

19. In a well drilling apparatus, a hammer provided with a lateral projection, a casing enclosing said hammer and provided with an interior projection adapted to contact with said lateral projection whereby said hammer is supported, an anvil, a drilling bit, means connecting said anvil with the bit, means associated with said connecting means for supporting said anvil, a valve located within said hammer and anvil and means whereby said valve is supported by the hammer, said hammer and valve being supported so that said parts are separated from said anvil whereby an operating fluid may flow through said casing while the hammer is inoperative.

20. In a well drill, a rotary drill stem, a casing thereon, a drill bit having a limited vertical movement in said casing, an anvil on said bit, a hammer in said casing, a cylinder in said casing having communication with the outside of said casing, a piston on said hammer, in said casing, said casing, anvil and hammer having passages therein for pressure fluid, and means to control the passage of fluid through said anvil and drill bit whereby said hammer may be raised by said fluid and then released.

21. In a well drilling apparatus, a rotary drill bit, means whereby said drill may be rotated, means to conduct flushing fluid therethrough, means to strike blows upon

said drill during rotation thereof, said striking means being rendered inoperative by the raising of said means to rotate, and said striking means.

22. In a well drilling apparatus, a rotary drill bit, means whereby said drill may be rotated, means to conduct flushing fluid therethrough, means directly operated by said flushing fluid to strike blows upon said drill during rotation thereof, said striking means being rendered inoperative by the raising of said means to rotate.

23. In a well drilling apparatus, a drill stem, a drill bit, said drill stem and bit having passages therethrough for flushing fluid, means directly operated by said fluid to strike blows upon said bit during rotation, there being a limited longitudinal movement of said drill bit relative to said drill stem, said means being rendered inoperative by the raising of said drill stem relative to said drill.

24. In a well drilling apparatus, a drill bit, a hammer above said drill bit adapted to be elevated by fluid pressure away from said bit and depressed by gravity, and a spring for accelerating the movement of said hammer downward to strike a blow upon said bit.

25. In a well drilling apparatus, a drill pipe, a drill bit thereon, a hammer above and separate from said bit, fluid pressure actuated means to raise said hammer, said hammer being adapted to drop by gravity, a spring to accelerate the dropping of said hammer, and means cushioning the weight of said pipe to assist in driving said bit downwardly.

26. In a well drilling apparatus, a drill stem, a drill bit, a casing connecting said drill bit and drill stem, a reciprocating hammer in said casing adapted to be elevated by fluid pressure and lowered by gravity, said casing having openings thereto above said hammer to permit the entrance of liquid to replace that discharged by the dropping of said hammer.

27. In a well drilling apparatus, a casing, a hammer therein adapted to be elevated by fluid pressure, an anvil having an opening through the same, a valve seating on said anvil to close said opening, means of closing said valve while said hammer is being elevated, and a plurality of means for opening said valve to relieve said pressure and allow said hammer to lower.

28. In a well drilling apparatus, a drill pipe, adapted to be rotated, a hammer, a drill bit, means actuated by the pressure of fluid delivered through said drill stem to elevate said hammer while said drill is rotating, and hammer actuated means to release said pressure, the fluid displaced in the hammer when elevated being adapted to pass directly into the bore hole.

29. In a well drilling apparatus in a well having an inner fluid column and an outer fluid column, a hollow member, an entrance therein for admission of said inner column, said outer column surrounding said hollow member, and a reciprocating hammer operable by unbalancing said fluid columns, and means within said hollow member for receiving from the outer column the amount of fluid displaced by the hammer in its descent.

30. In a well drilling apparatus, in a well, a hammer, a drill bit resting on the bottom of the bore hole, means for rotating said bit, fluid operated means for elevating said hammer to fall and strike a blow upon said drill bit, and means for preventing acceleration of fluid by said falling hammer in the bore hole above the apparatus.

31. In combination, a rotary well drill, means to rotate said drill, an anvil on said drill, means to strike blows upon said anvil during operation of said drill, said means including a hammer, and means carried by said hammer to control the passage of flushing liquid to said drill.

32. In combination, a rotary well drill, means to rotate said drill, an anvil on said drill, means to strike blows upon said anvil during rotation of said drill, said means including a hammer, and means carried by said hammer to control the passage of flushing liquid to said drill, said second means being responsive to the pressure of the flushing liquid.

33. In combination, a rotary well drill, means to rotate said drill, an anvil on said drill, means comprising a hammer operated by flushing liquid to strike blows upon said anvil during rotation of said drill, and means carried by said hammer to control the flow of flushing liquid to said drill.

34. In a hammer bit, a casing, a drill head carried by the lower end thereof, a hammer arranged for reciprocation in said casing to strike said drill head, means to cause a flow of fluid thru said bit, upper and lower surfaces on said hammer, said upper surface being concealed from the pressure of the flow of fluid whereby the unbalanced pressure will raise said hammer.

35. A method of drilling wells comprising subjecting a reciprocating hammer to an unbalanced internal pressure whereby it is elevated, causing the hammer to release the unbalanced portion of the pressure whereby the hammer may drop through a balanced medium and rotating the drill while it is being struck.

36. In a combination percussion and rotary drill bit operative by a drill stem and a flow of pressure fluid, a casing, a drill head, a hammer normally resting on said drill head when the bit is in cutting position, means to expose said hammer to an unbalanced fluid pressure whereby it will be elevated and a valve arranged to be opened after a predetermined elevation of said hammer to release the

unbalanced pressure whereby said hammer may fall.

37. In a combination percussion and rotary drill bit, a hammer, upper and lower surfaces thereon, said lower surfaces being adapted for exposure to the fluid pressure in the drill stem, a portion of said upper surfaces being adapted for exposure to the fluid pressure in the well bore whereby an unbalanced force tends to raise said hammer.

38. In a combination percussion and rotary drill bit, a hammer, upper and lower surfaces thereon, said lower surfaces being adapted for exposure to the fluid pressure in the drill stem, a portion of said upper surfaces being adapted for exposure to the fluid pressure in the well bore whereby an unbalanced force tends to raise said hammer, and means in said bit whereby the pressure on said lower surfaces may be equalized to that on said portion of the upper surfaces.

39. In a combination percussion and rotary drill bit, a hammer, upper and lower surfaces thereon, said lower surfaces being adapted for exposure to the fluid pressure in the drill stem, a portion of said upper surfaces being adapted for exposure to the fluid pressure in the well bore whereby an unbalanced force tends to raise said hammer, and means in said bit whereby the pressure on said lower surfaces may be equalized to that on said portion of the upper surface, said means including a valve operable by said hammer.

40. In a hammer bit, a casing, an anvil therein, a hammer having a recessed lower end adapted to strike said anvil, a fluid passage thru said hammer and said anvil, and a valve mounted to close said passage.

41. In a hammer bit, a casing, an anvil therein, a hammer having a recessed lower end adapted to strike said anvil, a fluid passage thru said hammer and said anvil, and a valve mounted to close said passage, a stem on said valve arranged to be engaged by said hammer after predetermined movement whereby said valve will be opened.

42. In a hammer bit, a casing, an anvil therein, a hammer having a recessed lower end adapted to strike said anvil, a fluid passage thru said hammer and said anvil, and a valve mounted to close said passage, said valve being mounted to receive the force of the fluid pressure when said hammer contacts said anvil, whereby said valve will be moved to closed position.

43. In a drill bit of the character described, a casing, a hammer adapted to reciprocate therein, a hollow anvil, to receive the impact of said hammer, a fluid passage thru said hammer to connect with said hollow anvil, and means including a valve operable to close said passage when said hammer strikes said anvil.

44. In a drill bit of the character described, a casing, a hammer adapted to reciprocate therein, a hollow anvil, to receive the impact of said hammer, a fluid passage thru said hammer to connect with said hollow anvil, and means operable to close said passage when said hammer strikes said anvil, whereby fluid pressure in said casing will act on said hammer to elevate the same.

45. A drill bit of the class described including in combination, a casing, a hammer, and a drill head, inlet and outlet fluid passages to said casing, means to close said outlet passage, a head on said hammer sealed off from the fluid pressure in said casing whereby the pressure in said casing when said means is closed will be unbalanced to elevate said hammer, and a spring acting on said head to accelerate the downward movement thereof.

46. A drill bit of the class described including in combination, a casing, a hammer, and a drill head, inlet and outlet fluid passages to said casing, means to close said outlet passage, a head on said hammer sealed off from the fluid pressure in said casing whereby the pressure in said casing when said means is closed will be unbalanced to elevate said hammer, and cooperating flanges on said means and said hammer to open said means after predetermined upward movement of said hammer whereby the unbalanced pressure will be released.

47. In a combination percussion and rotary drill bit, a reciprocating hammer adapted to strike the drill bit head, fluid pressure means to actuate said hammer, comprising a constant flow of pressure fluid and a single valve operable to open and closed positions in response to the movement of said hammer.

48. In a combination percussion and rotary drill bit, a reciprocating hammer adapted to strike the drill bit head, fluid pressure means to actuate said hammer, comprising a constant flow of pressure fluid, a single valve operable to open and closed positions in response to the movement of said hammer, and a spring to assist the gravitational movement of said hammer.

In testimony whereof I hereunto affix my signature this 18 day of November, A. D. 1927.

HARRY PENNINGTON.