Jan. 26, 1954 S. EVANS 2,667,144

ROTARY AND IMPACT TOOL

Filed Nov. 21, 1949 2 Sheets-Sheet 1

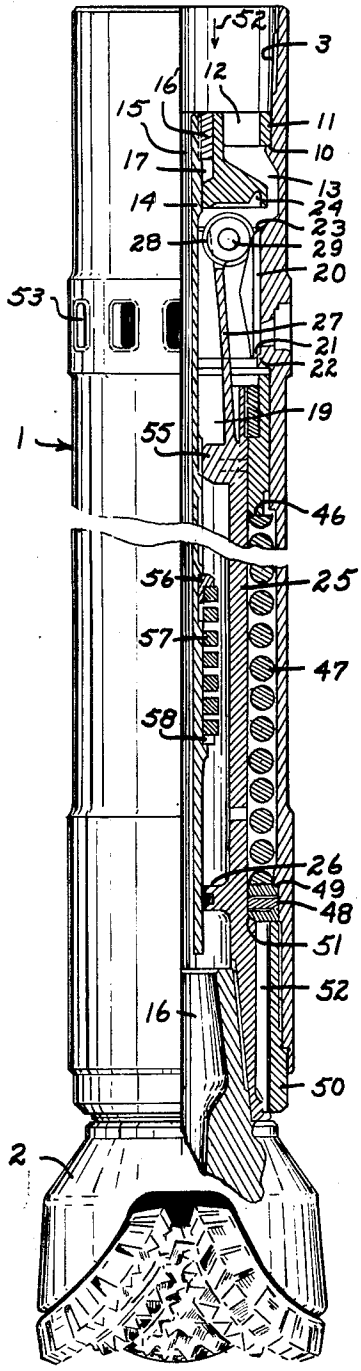


Fig 1

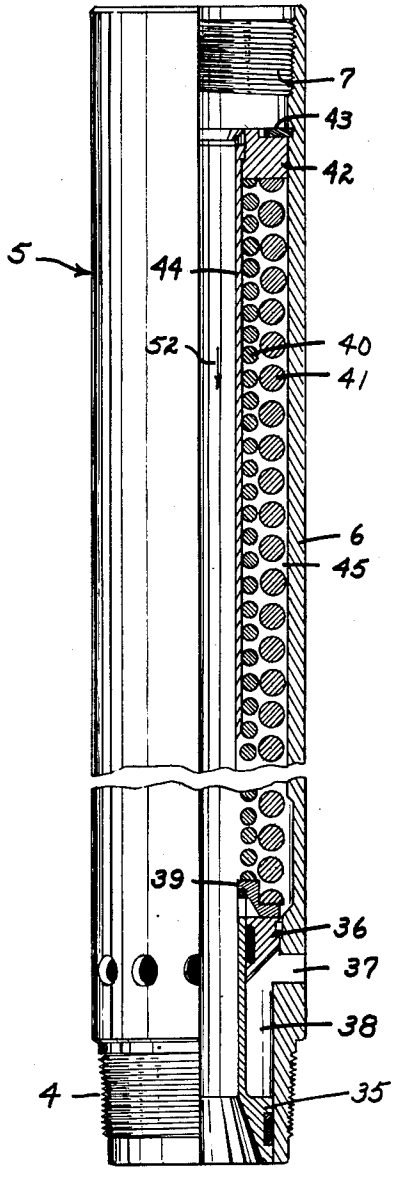


Fig 2

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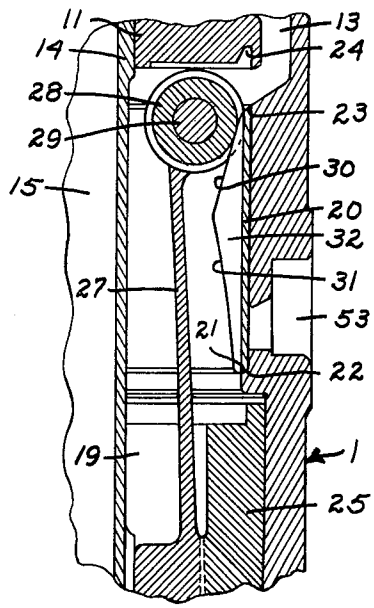


Fig. 3

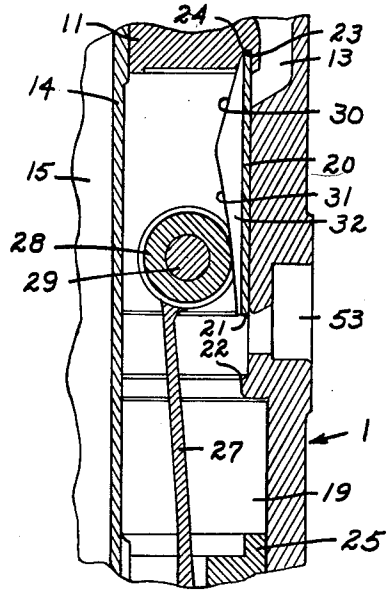


Fig. 4

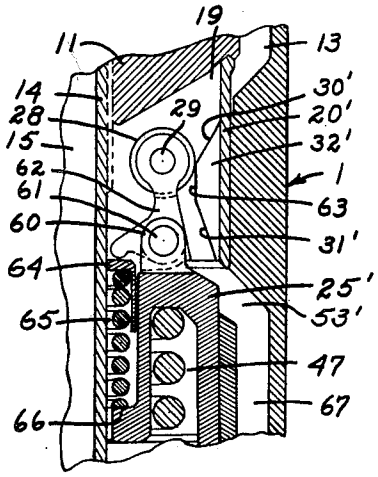


Fig. 5

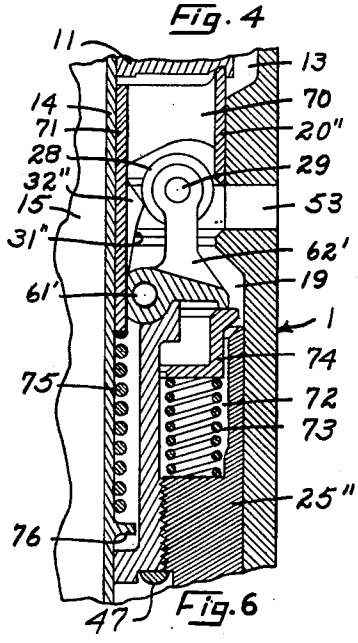


Fig. 6

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ROTARY AND IMPACT TOOL

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15 Claims. (Cl. 121—30)

1

This invention relates to an impact tool and more particularly to a fluid actuated device especially adapted to use in forming earth bores such as oil and gas wells by the rotary method of drilling.

While the description of the invention hereinafter is directed primarily to the drilling of wells, it is to be understood that the invention is not confined thereto, but may be used wherever energy is desired in the form of impacts to accomplish a given purpose.

When drilling wells by the rotary method of drilling, a bit is secured to the lower end of a tubular drill string. While this drill string and bit are rotated, with the bit on bottom, fluid is pumped downwardly through the drill string and out through the bit to effect cooling thereof and to carry the cuttings removed from bottom upwardly within the well bore. Frequently, pressures of many thousands of pounds are applied to the bit to induce cutting action upon bottom and, particularly where earth strata are inclined, there is a tendency for the well bore to deviate from the vertical. Furthermore, great difficulty is experienced in drilling in some extremely hard formations, such as chert and the rate of drilling in such formations is extremely slow.

It is a primary object of the invention to facilitate drilling and to overcome difficulties as above indicated and others that are experienced when using conventional apparatus and techniques.

Another object of the invention is to provide a device capable of imparting impact energy to a rotary earth boring drill so that combined action of rotation and impact will effect drilling.

Another object is to provide an impact tool that will produce impacts at a rapid rate so that a relatively large amount of energy may be supplied for action, but without excessive energy per stroke.

It is also an object to provide an impact tool having a wide range in length of stroke whereby the tool may be readily maintained in operating position.

Still another object is to provide a tool in which the range of pressure fluctuation is small whereby loss of energy and destructive effects upon equipment are minimized.

The invention also comprehends the provision of a combination rotary and impact tool capable of drilling a straight hole, or of straightening hole theretofore produced and deviating from the vertical.

Still another object is to provide, in one form

2

of the invention, an impact tool having a piston actuated by pressure fluid pumped downwardly to the tool and cooperating means for intermittent admission of pressure fluid to the piston and intervening isolation of the piston from the pumped fluid so that the return stroke of the piston is unaffected by the fluid pumped during the period of isolation.

A still further object is to provide means for successively admitting pumped fluid to the operating piston and isolating the piston from the fluid being pumped and means for storing energy for the succeeding stroke during the period of isolation.

The foregoing objects, together with other objects and advantages of the invention, will be more fully apparent from the following description considered in connection with the accompanying drawings in which:

Fig. 1 is an elevational view, partly in section, showing one form of the invention;

Fig. 2 is an elevational view, partly in section, showing the accumulator used in connection with the structure shown in Fig. 1 and comprising an upward continuation thereof;

Fig. 3 is a detail showing one form of the valve structure of the device, parts being shown in their relative positions at the beginning of the downward stroke of the impact assembly;

Fig. 4 is a view similar to that shown in Fig. 3, but shows the relative position of parts when the impact assembly is in its lowermost position;

Fig. 5 is a detail sectional view showing alternate form of piston and valve actuating mechanism;

Fig. 6 is a detail showing a still different form of the piston and valve actuating mechanism.

A form of the invention is shown in Figs. 1 and 2 as comprising a body 1 having a cone type of bit 2 attached to the lower end thereof. The body 1 is threaded internally at 3 for engagement with complementary threads on the lower end of a drill string, or the threads 4 of the accumulator, when used, shown generally at 5 and comprising the body extension 6 threaded at 7 at its upper end for attachment to the drill string thereabove.

The body 1 is counterbored to provide the shoulder 10 upon which rests baffle or spider 11 having a series of openings 12 to admit fluid to the annular passage 13 as such fluid is pumped downwardly through the drill string to which the device is attached. The spider 11 has a central opening to receive the barrel 14 having passage 15 so that a stream of pumped fluid may pass

downwardly into the chamber 16 and thence through the flushing passages in the bit 2.

Attention is directed to the fact that the barrel 14 fits slidably within the spider 11 and has a collar 15' secured thereto and resting upon an annulus 17 of resilient material, it being intended that this structure shall be capable of resisting shock and at the same time providing a fluid seal between the barrel and the spider.

A valve 20 fits slidably within the body 1 and the lower end thereof is provided with a seating surface 21 adapted to engage the complementary valve seat 22 on the interior of the body. Similarly, the upper end of the valve 20 has a valve surface 23 adapted to engage the complementary seat 24 on the nether side of the spider 11. The valve is shown in engagement with this seat in Fig. 4 and when in such position, passage 13 is closed to flow of fluid downwardly therethrough.

Slidably mounted within the body 1 and below the valve seat 22, is an annular piston 25 having inward projection 26 near its lower end, there being a seal between this projection and the barrel 14 to prevent leakage of fluid past the piston at this point. It is apparent that the piston 25 thus forms the bottom of an annular piston chamber 19.

The piston 25 terminates at its upper end in a plurality of leaf spring elements 27, each being bifurcated at its upper end to receive valve actuating roller 28 mounted on pin 29 passing through these bifurcations. The rollers 28 are adapted to ride upon the inwardly converging surfaces 30 and 31 on the inwardly extending ribs 32 on the valve 20. As the piston assembly moves downwardly from the position shown in Fig. 3 and as the rollers 28 pass over the crest formed by the surfaces 30 and 31, the valve 20, under the influence of leaf springs 27, is caused to move upwardly so that it will engage the valve seat 24 whereupon the piston 20 is isolated from fluid being pumped downwardly through the drill string and in the direction indicated by the arrows 52 in Figs. 1 and 2.

As above indicated, closure of the valve 20 upon its seat 24 terminates flow of fluid through the passage 13 so that continued flow is maintained only through the barrel 14. Quite obviously, this condition tends to produce pulsations in the hydraulic system. To minimize this condition and to store energy proximate the device to be used in a succeeding stroke, I provide the accumulator 5 which, as above explained, comprises body extension 6 threaded at 4 and 7 for connection, respectively, to the body 1 and the drill pipe with which the device is used. The annular piston 35 within the extension 6 fits slidably within the ring 36 mounted in the extension proximate breather openings 37. These openings permit liquid to freely flow to and from the space 38 above the piston 35.

The piston 35 carries a ring 39 engaged by one or more compression springs shown as 40, 41 having their opposite ends in abutment with collar 42 secured in the extension 6 by suitable means such as the snap retainer ring 43. A protective sleeve or liner 44 is secured to the collar 42 and extends downwardly therefrom to confine the movement of springs 40 and 41 to the annular space 45 between such sleeve and the extension 6.

It is to be noted that the piston 25 has a downwardly facing shoulder 46 which engages the upper end of a compression spring 47. The opposite end of this spring is in engagement with disk, or Belleville, spring 48 underlying a shoulder 49 on the interior of the body 1. The disk spring is held in place against the shoulder 49 by collar 50 threadably secured in the lower end of the body 1. The lower end of the disk spring 48 is engageable by the arcuate shoulder 51 on the piston 25 whereby the assembly just described is resiliently decelerated and brought to rest at an upward limit of travel as will be more fully described hereafter.

The piston 25 has inwardly extending projections 55 which move in close contiguity with the outer surface of the barrel 14. These projections are capable of engaging the ring 56, reciprocable for a limited distance on the surface of the barrel 14, and which is held in an uppermost position by the spring 57 having its lower end in abutment with the ring 53, resting on an upwardly facing shoulder on the barrel. This arrangement serves as a bumper for the piston 25 in event the tool is held in a sufficiently elevated position that the piston 25 tends to move downwardly beyond the point of engagement of the projections 55 with the ring 56.

There is a splined connection 52 between the piston 25 and the body 1 so that reciprocatory movement may be had therebetween, but at the same time, rotary driving action by the body will be imparted to the piston and the bit 2 secured thereto. This enables rotation of the bit in the manner well-known in the rotary method of drilling.

In further explaining the operation of the device, thus far described, it will be noted that the spring 47 normally holds the piston 25 in an uppermost position with the shoulder 51 on the piston in engagement with the disk spring 48. The valve 20 is then in its lowermost position shown in each of Figs. 1 and 3 and fluid pumped downwardly, as indicated by the arrow 52, will exert pressure upon, and effect downward movement of the piston 25. This will cause the bit 2 to advance and effect a desired impact upon the surface to be disintegrated. It is understood, of course, that rotative effort will simultaneously be applied to the drill stem, to which the device is attached, so that cutting action from both rotation and impact will be effected.

As the piston 25 approaches its lowermost position, the rollers 28 ride over the crests formed at the meeting of converging surfaces 30 and 31 on the respective ribs 32 on the valve 20 whereby an upward component of force is exerted on the valve which then moves upwardly so that the seating surface 23 on the valve engages the seat 24 whereby the admission of fluid to the piston 25 is cut off.

The movement of the valve upwardly uncovers ports 53 in the body 1 and such ports serve as exhaust openings for the fluid from above the piston 25 as it moves upwardly toward its uppermost position under the influence of the spring 47. It is to be understood that, prior to the initiation of the return movement of the piston 25, the desired impact of the bit 2 on bottom has taken place.

As the piston 25 rises, the rollers 28 initially ride upon the surface 31 and thence upon the surfaces 30, whereby a downward force is exerted on the valve 20 which moves the valve downwardly, closes the ports 53 and thereafter engages the seat 22, whereupon the component parts of the assembly are in the initially assumed position of Fig. 3.

The influx of fluid above the piston 25 effects deceleration of the piston and associated parts

of the piston-and-bit assembly and the upward movement of the piston is finally terminated by engagement of the shoulder 51 with the disk spring 48. This spring absorbs kinetic energy from the piston and thus prevents shock that would otherwise result. Also, the energy absorbed by the disk spring is returned to the piston assembly as the succeeding downward stroke, above explained, is initiated.

It is also to be understood that when the accumulator 5 is used, the piston 35 thereof moves upwardly after the valve 20 engages the seat 24, and in this manner energy is restored in the spring or springs, 40 and 41 so that fluid displacement will subsequently take place from downward movement of the piston 35 to transfer the stored energy to the piston 25 on the succeeding downward stroke of the latter.

An important feature of the invention resides in the fact that the device is capable of effecting a relatively large range of length of strokes. In devices in accordance with the invention, it has been found that stroke lengths from one and one-fourth inch to two and one-fourth inches can be had and are extremely effective. For such a range of stroke lengths, the splined connection 52 should be in the neighborhood of two and one-half inches, and for such illustrative dimension, the tool should be so held that the bit is between one and one-fourth inch and two and one-fourth inches, maximum, off bottom during drilling. This range of off-bottom distance enables ease of control in lowering the tool and drill string at the proper rate to obtain most effective cutting action.

In the form of the piston and valve mechanism shown in Fig. 5, the piston is shown at 25' and has paired upstanding ears 60 to receive pivot pin 61 upon which bell-crank 62 is adapted to rock. This bell-crank lever is bifurcated at its upper end and carries the roller 28 upon pin 29 so that the roller rides upon the rib 32' on the valve 20'. The rib 32' on the valve is slightly modified from that previously described in that the inwardly converging surfaces 30' and 31' merge into a flat inner surface 63. This feature causes a slight delay in the movement of the valve from a given terminal position and hence provides a somewhat greater stroke of the piston.

The bell-crank lever 62 is constantly urged in a clockwise direction by a collar 64 slidably surrounding the barrel 14 and pressed upwardly by the spring 65, having its lower end resting upon the shoulder 66 on the inner periphery of the piston.

The port 53' for the exhaust of fluid from above the piston 25', when the valve 20' is in its uppermost position, communicates with a passage 67 in the wall of the body 1, and this passage preferably terminates inwardly below the seal 26 so that the exhausted fluids pass downwardly through the conventional flushing passages in the bit 2 to clean and cool the cutters thereon and also to impinge upon the bottom of the hole and thus assist in disintegration of the bottom.

In the modification shown in Fig. 6, the valve 20'' has inwardly extending webs 70 which carry an integral sleeve 71 on their inner ends. This sleeve has ribs 32'', each of which is engaged by a roller 28 carried by a bell-crank lever 62' mounted on a pin 61' carried by the piston 25'' which has an annular groove 72 to receive springs 73 which constantly urge the actuator rings 74 upwardly, whereby the bell-crank levers 62' are urged in a counter-clockwise direction and the rollers 28 are held in engagement with the ribs 32''. This form also utilizes a spring 75 which engages a shoulder 76 on the barrel 14 and the lower end of the sleeve 71. The compressive force exerted by this spring supplements the upward component of force exerted on the valve 20'' by the rollers 28 riding upon the surfaces 31'' of the ribs 32''.

Broadly, the invention comprehends a fluid actuated impact tool capable of effecting both rotary and impact action to disintegrate earth formations and to thereby form bore holes in the earth.

The invention claimed is:

1. An impact device comprising, a body adapted to be attached to the lower end of a drill pipe and having at least one port between the interior and exterior thereof, a baffle in said body above said port forming an annular passage axially of the body, a piston mounted to reciprocate within the body and forming the bottom of a chamber below said baffle, an annular valve slidably mounted in the body and movable to alternately close said port and said passage, whereby pumped fluid is intermittently directed to and from said chamber.

2. An impact device comprising, a body adapted to be attached to the lower end of a drill pipe and having at least one port between the interior and exterior thereof, a baffle extending transversely of the body above said port and forming an annular passage within the body and above the port, a piston mounted to reciprocate within the body below said baffle thereby forming a chamber in the body above the piston, a valve seat on said baffle, a second valve seat within the body below said port, and an annular valve slidably mounted in the body and movable to alternately engage said seats to open and close said passage and said port so that fluid pumped into the body is intermittently directed to and from said chamber.

3. An impact device comprising, a body adapted to be attached to the lower end of a drill pipe and having at least one port between the interior and exterior thereof, a baffle extending transversely of the body above said port and forming an annular passage within the body, a barrel secured in said baffle and extending downwardly, said barrel providing a fluid by-pass from above the baffle to a point therebelow and forming, with the body, an annular chamber, an annular piston mounted to reciprocate within and forming the bottom of said chamber, and an annular valve slidably mounted in the body and movable to alternately close and open said passage and port respectively so that fluid pumped into the body is intermittently directed to and from said chamber.

4. An impact device comprising, a body, adapted to be attached to the lower end of a drill pipe, a piston in said body, a valve seat within the body, a valve movable to and from said seat, said valve including opposed camming surfaces thereon, and means carried by the piston and engageable with said camming surfaces for moving said valve to and from said seat so that pumped fluid is alternately applied to and discharged from above the piston.

5. In a fluid operated impact tool wherein a piston is normally resiliently urged upwardly within the tool body counter to the direction of movement of actuating pressure fluid the improvement comprising, means for alternately ad-

mitting pressure fluid to the piston and isolating the piston from the pressure fluid, means for exhausting fluid from above the piston during the periods of isolation, and additional means for storing pressure fluid energy supplied during the periods of isolation.

6. An impact tool comprising a body, a piston therein, resilient means normally biasing said piston to an uppermost position, means for alternately admitting pressure fluid to and from the chamber above the piston, and additional means for resilient engagement by the piston at the end of its upward stroke to absorb energy therefrom and thereafter accelerate the piston in a downward direction at the beginning of the succeeding downward stroke.

7. An impact tool comprising a body, a piston therein, means for producing reciprocatory movement of the piston from fluid pumped downwardly into the body, and means for decelerating the piston proximate the end of its upward stroke and thereafter accelerating the piston at the beginning of the succeeding downward stroke.

8. An impact tool comprising a body, a piston therein, means for producing reciprocatory movement of the piston from fluid pumped downwardly into the body, means for decelerating the piston proximate the end of its upward stroke and thereafter accelerating the piston at the beginning of the succeeding downward stroke, said last mentioned means comprising a disk spring mounted within the body, and an abutment on the piston engageable thereby.

9. In combination, a fluid actuated impact device, including a piston and means for intermittently admitting fluid to and exhausting fluid from above the piston, and an accumulator connected to said impact device to absorb energy from the fluid stream, during the period the piston rises for a succeeding stroke.

10. In combination, a fluid actuated impact device including, a piston and means for successively admitting fluid flow to the piston and isolating the piston from the fluid flow, and an accumulator connected to the impact device to absorb energy from the fluid stream during the period the piston rises for a succeeding stroke.

11. A device of the class described comprising, a body adapted to be attached to the lower end of a drill pipe, a piston therein, means for successively admitting fluid flow to and isolating the piston from fluid flow downwardly through the drill pipe, an upward extension on said body, and means in said extension for successively absorbing and releasing energy of the fluid stream to minimize pulsations in the stream as said first mentioned means successively isolates and admits fluid flow to the piston.

12. A device of the class described comprising, a body adapted to be attached to the lower end of a drill pipe, a piston therein, means for successively admitting fluid flow to and isolating the piston from fluid flow downwardly through the drill pipe, an upward extension on said body, and means in said extension for successively absorbing and releasing energy of the fluid stream to minimize pulsations in the stream, said last mentioned means including an annular piston having its opposite sides subjected respectively to the fluid pressures interiorly and exteriorly of the body.

13. In a device of the class described, a body, a piston reciprocable therein, spaced valve seats within the body, a valve slidable axially of the body to alternately engage said seats, converging surfaces on said valve and extending longitudinally thereof, and a spring pressed element carried by the piston and riding upon said surfaces so that the valve is urged from seat to seat as the element rides alternately upon said surfaces.

14. In a device of the class described, a body, a piston reciprocable therein, spaced valve seats within the body, a valve slidable axially of the body to alternately engage said seats, radially extending ribs on said valve, converging surfaces on the free edge of each of said ribs, and means carried by the piston to alternately apply a resilient pressure upon said surfaces so that the valve is urged from seat to seat.

15. An impact device comprising, a body adapted to be attached to the lower end of a drill pipe and having at least one port between the interior and exterior thereof, a baffle extending transversely of the body above said port and forming an annular passage within the body and above the port, a piston mounted to reciprocate within the body below said baffle thereby forming a chamber in the body above the piston, a valve seat on said baffle, a second valve seat within the body below said port, an annular valve slidably mounted in the body and movable to alternately engage said seats to open and close said passage and said port so that fluid pumped into the body is intermittently directed to and from said chamber, and means forming a fluid by-pass from above the baffle to a point therebelow to by-pass a portion of the pumped fluid.

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