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E. E. DAVIS ET AL

2,559,012

PERCUSSION DRILL

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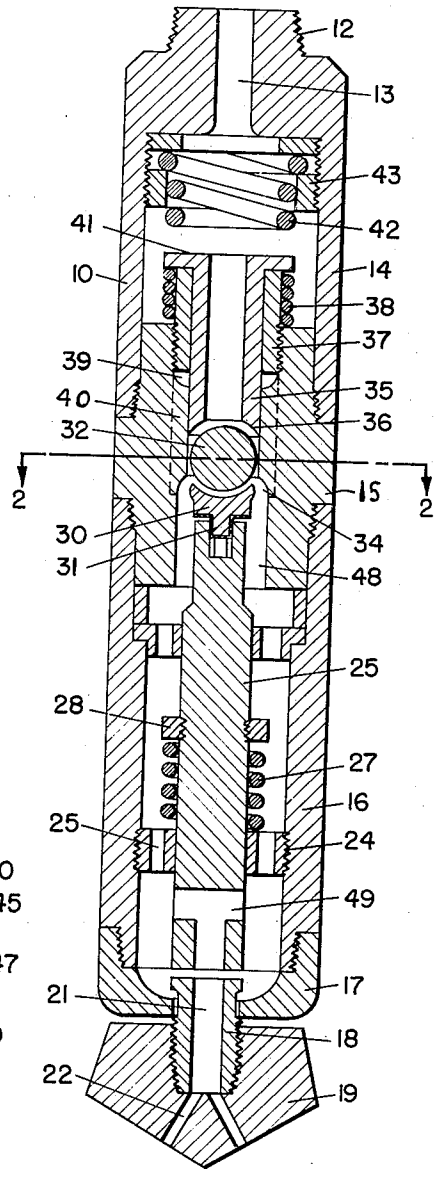


Fig. 1

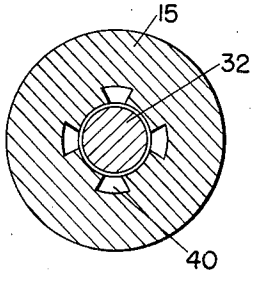


Fig. 2

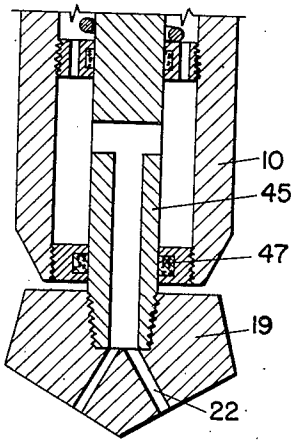


Fig. 3

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PERCUSSION DRILL

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4 Claims. (Cl. 255—4.4)

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This invention relates to percussion tools for drilling earth formations, and pertains particularly to improvements in a percussion drill such as described in a co-pending application Serial No. 636,497 filed July 26, 1946, by Ross Bassinger, now Patent No. 2,507,585, issued May 16, 1950, for "Percussion Tools for Wells."

The drill described in said application comprises a bit rigidly connected to an anvil element attached to the lower end of an elongated tubular housing or conductor. Reciprocating within the tubular conductor for impact against the anvil is a mandrel or cylindrical hammer element supported by and urged upwards by a coil spring. The upper end of the hammer forms or carries a piston element adapted to enter, toward the end of the upward stroke, a control sleeve supported by and urged upwards by a second spring within the tubular conductor. The entry of the piston into the sleeve interrupts the flow of the drilling fluid through the tubular conductor, and the resulting rise of fluid pressure forces down both the control sleeve and the piston-hammer member, compressing both springs. The downward motion of the control sleeve is arrested first, the piston-hammer thereupon continuing its motion so that at the end of the downward stroke the piston is withdrawn from the control sleeve while the hammer strikes the anvil. This releases the fluid pressure within the tubular conductor and permits the springs to return the reciprocating elements to the top point of their stroke, whereupon the cycle is repeated.

The drill described hereabove had been used with considerable success in formations of various degrees of hardness, and has given a rate of penetration performance comparing very favorably with that of the conventional rotary drills.

It has however been found desirable to improve the above drill in several regards, and specifically with regard to an increase of its operating frequency, an increase of the force of its impact against the formation, and an increase of the useful operating life of some of its component parts.

It is therefore an object of this invention to provide an improved bit capable of operating, if desired, at a relatively high frequency of 600 strokes or more per minute.

It is also an object of this invention to provide a drill having a longer useful life and capable of remaining in operation on the bottom for considerably longer periods than the original drill herein described.

It is further a particular object of the present

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invention to provide a percussion drill wherein the control sleeve and piston structure of the original drill as desribed hereinabove is replaced by a reciprocating ball valve control structure, the abrasion of said control structure being minimized by a substantial elimination of fluid flow along axial lines, and by the lapping action of the ball bouncing against the seat of the valve, whereby the useful life of said structure is greatly increased.

These and other objects of this invention will be understood from the following description, taken with reference to the appended drawings, wherein:

Fig. 1 is a diagrammatic view in vertical cross-section of the present drill.

Fig. 2 is a horizontal cross-section taken along line 2—2 of Fig. 1.

Fig. 3 is a diagrammatic view of an alternative arrangement of the lower end of the present drill.

Referring to Fig. 1, the numeral 10 designates in general a tubular housing or conductor attachable to the end of a drill string by means of a screw-threaded pin 12 provided with a fluid flow passage 13. The conductor 10 may consist of any suitable number of tubular members, such as shown at 14, 15 and 16, and has at its lower end a closure member 17 carrying a cylindrical anvil 18 having a bit 19 of any desired type connected thereto, all of said parts being connected to each other by suitable screw-threaded or other means, as diagrammatically shown in the drawing, in a manner well known to the art.

The anvil 18 and drill bit 19 have channel means 21 and 22 respectively for the discharge of drilling fluid.

Anchored within the axial bore of the conductor 10 is a guide or spider 24, having fluid passages 25 therethrough. Arranged in axial register with the anvil 18, and passing through an axial bore of the spider 24 in sliding engagement therewith, is a cylindrical hammer element 25 supported and urged upwards by a powerful coil spring 27, held between the spider 24 and an annular stop member 28 fixedly carried by the hammer 25.

The upper portion of the hammer 25 carries a replaceable insert 30 secured to the hammer by means of a tapered shank 31. The insert has a substantially spherical downwardly concave face serving as a support for a ball 32 freely held thereon for reciprocation with the hammer within a restricted portion 34 of the axial bore through the conductor 10. The ball 32 may be made of any suitable material such as rubber, plastic,

bronze, steel, etc., being, if desired, of hollow construction when metallic balls are used.

Arranged above the ball 32, and cooperating therewith to form a ball valve structure, is a control sleeve 35, having a lower end 36 formed to seat on the ball 32. A flame-hardened flat seat, giving line contact on the ball, or a spherical seat may equally well be used, protracted operation tending in any case to convert a flat seat into a spherical one. The control sleeve 35 is in sliding contact with an outer sleeve 37, affixed to the conductor element 15, which has a somewhat restricted axial bore, thus dividing the space within the conductor 10 into an upper or high-pressure chamber and a lower or low-pressure chamber. The control sleeve 35 is supported on and urged upwards by means of a coil spring 38.

An annular space 39, in communication with a plurality of axial passages 40 (more clearly seen in Fig. 2) permits fluid communication between the upper and the lower portions of the bore through conductor 10 when the sleeve 35 is at the upper end of its stroke. The sleeve 35 is arrested at the upper end of its stroke by the pressure of its upper flange 41 against a spring 42, held within the upper portion of the conductor 10 by any suitable means, such as a retaining ring 43.

The above description of the present bit is given in only very general terms, since many modifications thereof are possible without departing from the spirit of the invention. For example, instead of the hammer, anvil and bit structure of Fig. 1, the present drill may comprise a bit attached directly for reciprocation to the hammer element 45, which serves in that case merely as a reciprocating supporting stem passing through suitable packing means 47 provided in the bottom closure of the drill.

The operation of the present drill is as follows. When the device is at rest, for example, with the bit 19 resting on the bottom of the hole and no fluid circulation supplied to the drill, the two springs 38 and 27 are partially expanded, holding the control sleeve 35 and the hammer 25 in their uppermost position. The flange 41 of the control sleeve 35 is thus in contact with the lower end of the stop spring 42, the lower end of the control sleeve 35 is within the axial ribs which form passages 40, and the ball 32 is forced upward into its seat 36 in control sleeve 35 by virtue of spring 27. The entire upward force of partially expanded springs 38 and 27 is counter-balanced by spring 42 which has considerable stiffness.

As the pumps are started, and drilling fluid is pumped down the drilling string, said fluid passes through the bore 13 and sleeve 35 until it strikes the closed ball valve at the bottom of sleeve 35. The pressure in the upper portion of the conductor 10 above said valve immediately starts to increase at a rapid rate, forcing the whole structure 35—32—36—25 downward and compressing both spring 38 and spring 27. The control sleeve 35 comes to the end of its stroke first when the lower side of the flange 41 strikes the upper rim of control sleeve guide 37. The ball 32 and the hammer 25 thereupon continue downwards, due to the inertia moment of the heavy hammer element, until the spring 27 is substantially completely compressed between the stop member 28 and the spider 24, the hammer 25 delivering at this moment a sharp blow against the anvil 18. The amount of the overtravel of the hammer is relatively small, such as about ½ inch, being however sufficient to permit the fluid pressure in the upper portion of the conductor 10 to be relieved

by the flow past the open valve into the relatively enlarged portion 48 of the bore of the conductor and downwards through the openings in the guiding spider elements and the passage 49 in the hammer, which is provided to insure free flow at the moment when the hammer is delivering the blow to the anvil and is in contact therewith.

The upward stroke of the sleeve 35 and of the ball-hammer structure 32—35 starts substantially instantaneously at the end of their respective downward strokes.

The sleeve 35 starts its upward travel first, and is then followed by the ball-hammer structure, which is propelled upwards by the powerful motor string 27 as well as by the bounce or rebound off anvil 18. Thus, at or near the end of the upward stroke, the control sleeve is overtaken by the ball-hammer member, and the valve is again closed. The upward stroke is thereupon rapidly brought to an end not only by fluid pressure, which begins to build up again above the valve as the latter is closed, but also by the pressure of the relatively strong spring 42 against the flange 41 of the control sleeve 35. The spring 42 also protects the control sleeve 35 from injury by contact, under the pressure of the hammer, against any stationary part of the drill structure. The cycle is thereafter continuously repeated as long as a pressure fluid is supplied to the drill through the drill string.

The drill of the present invention has several advantages over the original drill described in application Ser. No. 686,497, referred to hereinabove.

First, the intensity of the blow delivered by the present device against the formation is approximately doubled as compared with that of the original drill. By effecting measurements involving the use of a seismic detector, it was ascertained that the amplitude of the blow-responsive oscillations generated in the ground by the present device was substantially twice that of the oscillations generated by the original device of similar size and operated under the same conditions.

Second, due to the quick-shutting action of the ball-valve mechanism, and to the stroke-reversing action of the spring 42, the operating frequency and therefore the total amount of energy delivered by the drill ground for drilling purposes is much greater with the present device than with the original tool. Thus the frequency of operation of the latter ranges from 180 to about 240 strokes per minute, depending on the type of formation being drilled. The present device operates at normal frequencies of about 600 strokes per minute in formations such as shale or sand, and is capable of reaching frequencies of the order of 1200 strokes per minute in formations such as lime.

Both the intensity and frequency of the blows are also increased in the present device due to the increased piston area which is made available by applying the annular cross-sectional area of the control sleeve for useful work in propelling the hammer downward, rather than leaving it idle as in the original device.

Third, and most important, the useful operating life of the present device, and specifically of the most sensitive part thereof, the control sleeve and valve structure, is also greatly increased as compared with the original device.

In the original device, as the reciprocating mandrel or piston entered the control valve, shutting off the flow of the pressure fluid, said fluid,

often of an abrading nature, tended to squeeze or leak past the piston along axial lines between the walls of the piston and those of the control sleeve. This intensified the wearing effect developed, likewise along axial lines, by the reciprocating piston, and resulted in axial ridges being eroded after relatively few hours of operation on the inside walls of the control sleeve and the outside walls of the piston. The pressure fluid leakage along these ridges considerably decreased the operating efficiency of the original drill precisely at a time when the bit, having become somewhat dulled, required a maximum power input to maintain the desired rate of penetration.

With the present device, any leakage tending to occur between the ball and the valve seat **36** is directed along radial and substantially horizontal lines, and whatever erosion ensues is not aggravated by the friction of an axially reciprocating piston, since no piston enters the control valve. On the contrary, the ball **32**, being freely supported on the insert **30**, and being subjected to random bouncing during operation, continuously presents new surface portions to the valve seat. The wearing of the ball and of the seat thus proceeds in a uniform manner, the ball actually exerting a lapping or honing effect on the valve seat. The present drill is thus as a rule capable of 70 or more hours of continuous operation, whereas the average life of the control sleeve and piston mechanism of the original drill, and therefore the time during which said drill was capable of operating on the bottom, was on the average of the order of 15 hours.

We claim as our invention:

1. A percussion drill comprising a normally vertically disposed tubular conductor having an axial flow passage therethrough, an elongated hammer element mounted for reciprocation in said passage, spring means urging said hammer element upwards, and pressure flow control means for moving said hammer element downwards to deliver a percussive blow, said means comprising a tubular sleeve mounted for reciprocation in said passage above said hammer element coaxially therewith, a ball freely supported in said passage by the upper end of said hammer element in register with said sleeve, said ball being adapted to close said tubular sleeve when in contact with the lower end thereof, second spring means urging said sleeve upwards, and third spring means mounted in said passage above said sleeve for contacting and arresting said sleeve at the end of the upward stroke thereof.

2. A percussion drill comprising a tubular conductor having an axial flow passage therethrough, a cylindrical hammer mounted for reciprocation in said passage, spring means urging said hammer in one direction, and pressure flow control means for moving said hammer in the opposite direction to deliver a percussive blow, said control means comprising a tubular sleeve mounted for reciprocation in said passage longitudinally of said hammer and co-axially therewith, a ball freely supported in said passage between the adjacent ends of said hammer and said

tubular sleeve, said ball being adapted to close said tubular sleeve when seated against the end opening thereof, second spring means urging said sleeve away from said hammer, and third spring means mounted in said passage for intermittently contacting said sleeve and opposing its motion away from said hammer.

3. A percussion tool for drilling through earth formations comprising a tubular conductor adapted to be attached to the lower end of a drill string, said conductor having an axial flow passage therethrough, an elongated hammer element mounted for reciprocation in said passage, spring means in said passage urging said hammer element upwards when said conductor is connected to a drill string, and pressure flow control means for moving said hammer downwards to deliver blow energy to the formations, said control means comprising a restriction in said passage, a free rolling ball supported on the upper end of said said hammer element axially thereof within said restriction, a sleeve mounted for reciprocation within said restriction above said ball; said sleeve having a lower end in register with said ball, second spring means surrounding said sleeve above said restriction and urging said sleeve upwards, and third spring means mounted in said passage above said sleeve for contacting and arresting said sleeve at the end of its upward stroke.

4. A well percussion tool comprising a tubular housing, means having an axial bore therein dividing the interior of said housing into an upper high pressure chamber and a low pressure chamber below the high pressure chamber, an opening to the high pressure chamber for supplying a pressure fluid thereto, an opening from the low pressure chamber for exhausting fluid therefrom, a sleeve member fitting slidably for reciprocation within the bore dividing said two chambers from each other, a cylindrical hammer member mounted for reciprocation within the housing, first and second spring means urging said sleeve and hammer members respectively toward the high pressure chamber, a free rolling ball valve element supported on the upper end of said hammer member and axially movable therewith within said axial bore, said second spring means causing said ball valve element to seat against the lower end of said sleeve member to close the axial bore between the chambers, thereby establishing a pressure differential tending to force said members in the other direction, an anvil carried by said housing below said members and serving to stop the movement of said hammer in a direction away from said high pressure chamber after the ball supported on the hammer had been unseated from said sleeve member, thereby releasing the pressure differential between the two chambers, and third spring means mounted in the high pressure chamber to limit the movement of said sleeve member in the direction of said high pressure chamber upon the release of said pressure differential.

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No references cited.