

July 20, 1965

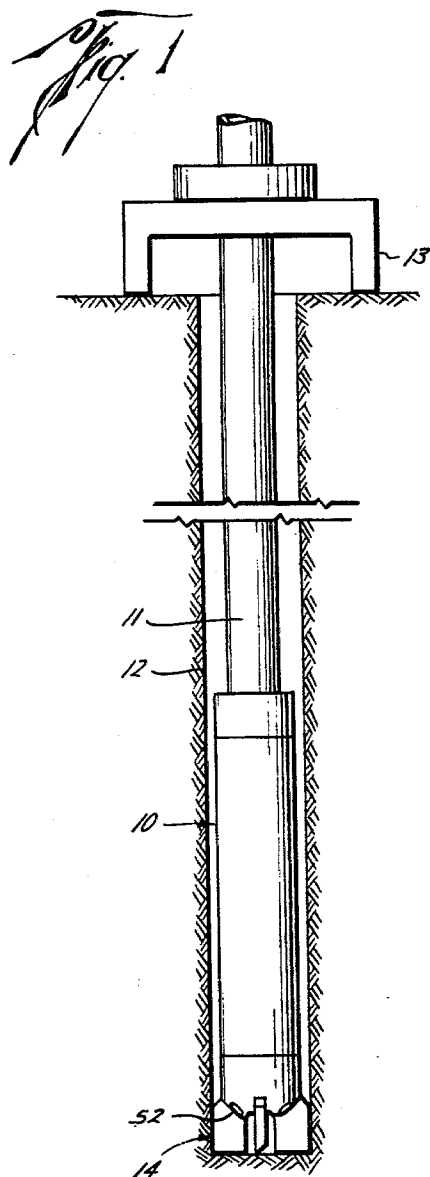
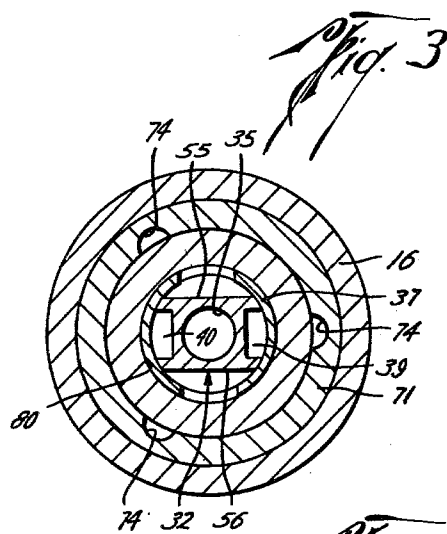
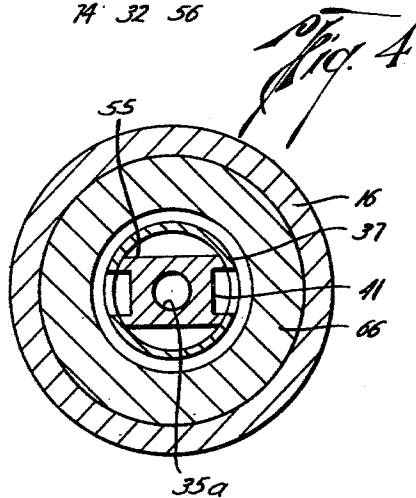
S. L. COLLIER

3,195,657

PERCUSSION DRILL

Original Filed Dec. 5, 1960

3 Sheets-Sheet 1



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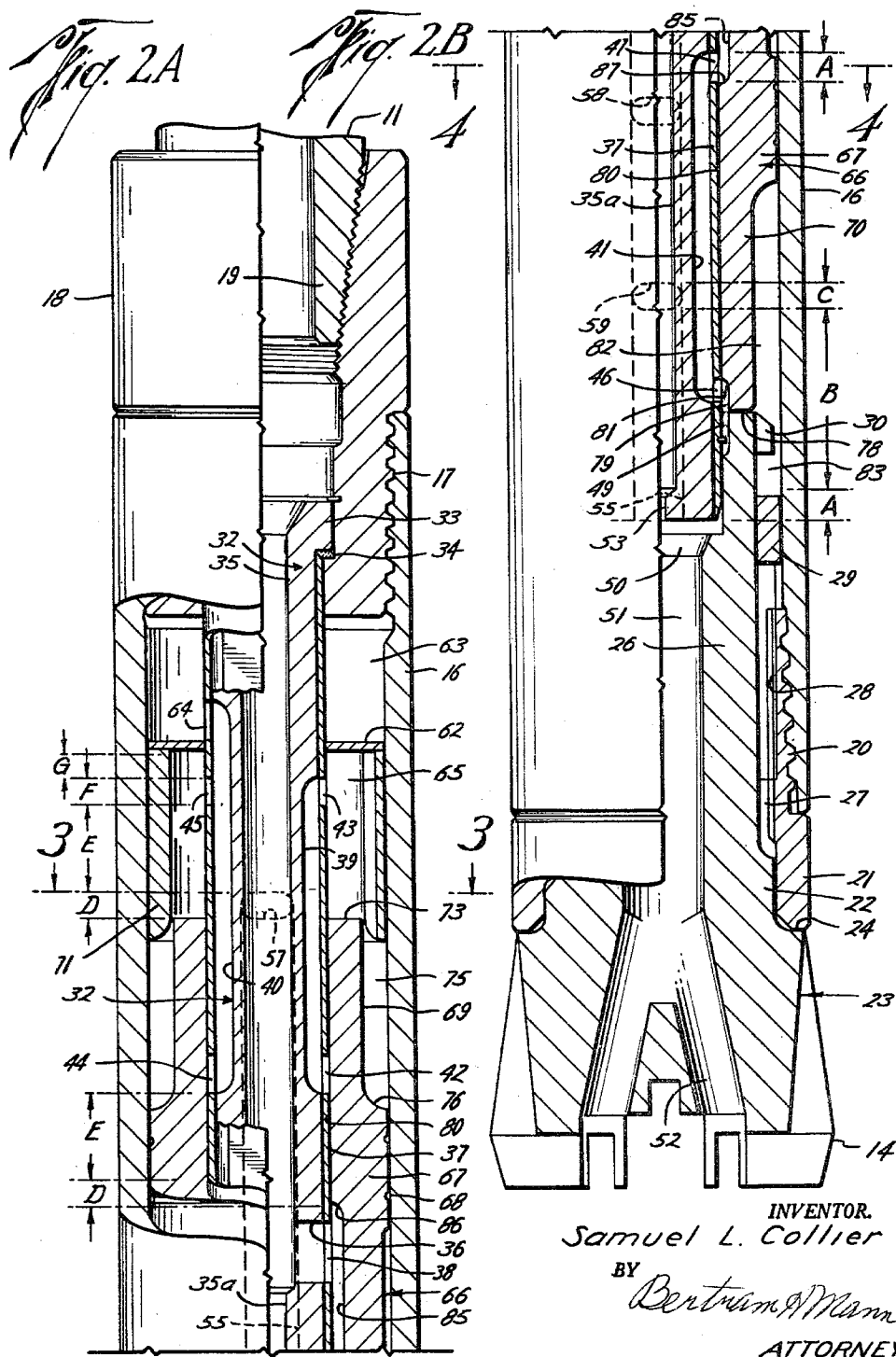
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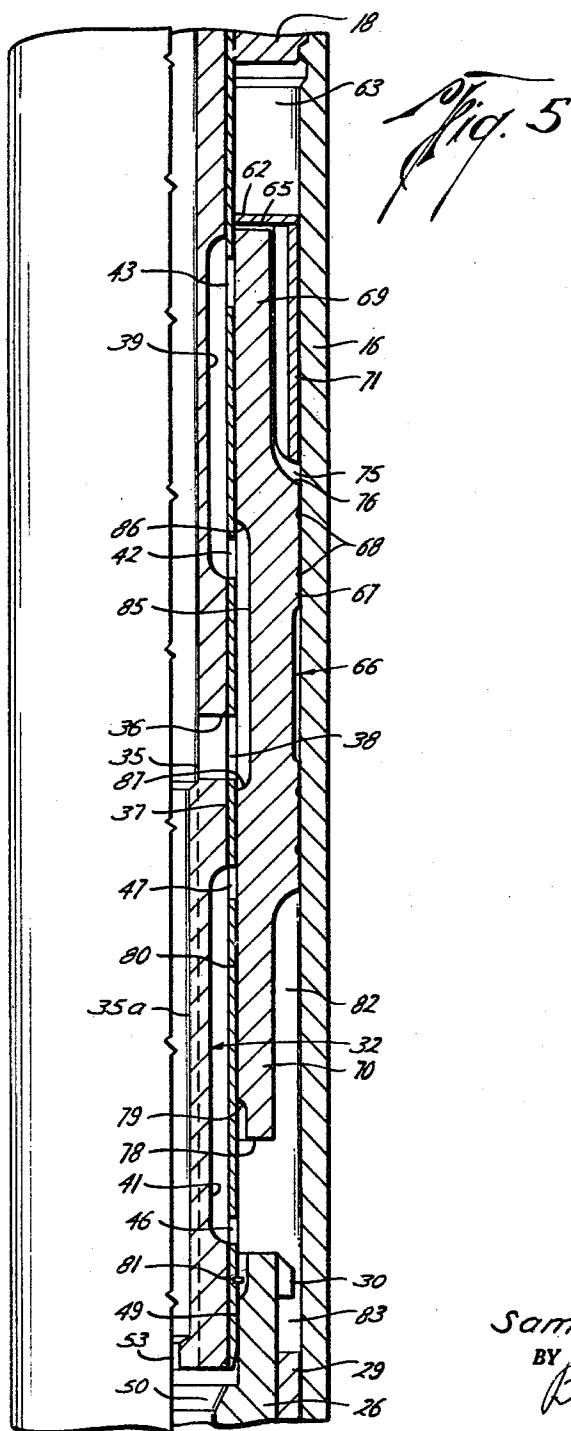
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PERCUSSION DRILL

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Original application Dec. 5, 1960, Ser. No. 73,613.
Divided and this application June 26, 1964, Ser. No. 378,126

2 Claims. (Cl. 173—137)

This application is a division of my copending application, Serial No. 73,613, filed December 5, 1960. Certain features of this application are disclosed and claimed in my copending application, Serial No. 264,351, filed March 11, 1963.

This invention relates to percussion drilling apparatus and consists particularly in novel means for increasing the reciprocation rate and therefore the power output of the tool.

Percussion drilling tools which utilize a reciprocating hammer piston for beating upon an anvil at the forward end of the tool incorporate valving means for alternately applying the operating pressured fluid to and exhausting the same from at least one end of the hammer piston. Due to the high operating speed of the piston, a significant time interval is required in stopping and reversing the rearward motion of the piston. This time requirement, necessarily, limits the frequency of beating and, therefore, the power output of the tool.

Accordingly, it is an object of the present invention to provide means for reducing the time required in retarding and re-accelerating the hammer piston at the rear end of the hammer stroke so that the turn-around is expedited and the beating frequency thereby increased with corresponding gain of power output.

Another object is to provide novel means for sharply reducing the volume of the rear pressure chamber to which the piston is exposed as it approaches the end of its rearward stroke to quickly reverse the piston, while making available a much larger volume of pressured air, after the reversal for driving the piston forwardly.

These objects and other more detailed objects are attained in my novel gaseous pressure-operated percussion tool in which the rear pressure chamber includes a main part in which the piston reciprocates and an auxiliary part connected to the main chamber part by a port in the wall of the latter. This port is positioned in the wall of the main chamber part so as to be closed by the piston as it approaches the rear end of its stroke whereby the volume of the pressured gas to which the rear wall of the piston is exposed is sharply reduced. This causes a sharp increase in the reactive force applied to the piston and expedites the reversal of the piston movement. Shortly after such reversal, the port is again uncovered to release the pressured gas in the auxiliary chamber part to supplement the forces driving the piston forwardly.

In the accompanying drawings:

FIG. 1 is a diagrammatic representation of my novel percussion tool supported in a drilled hole in the ground;

FIGS. 2A and 2B are enlarged side views, partially cut away and sectioned on the longitudinal center line of the tool and showing, respectively, the upper and lower portions of the tool;

FIGS. 3 and 4 are horizontal sections taken substan-

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tially on lines 3—3 of FIG. 2A and 4—4 of FIG. 2B; and

FIG. 5 is an enlarged vertical transverse half section showing the percussion motor with the piston in its elevated position.

FIG. 1 shows a percussion drilling tool, generally designated 10, supported from a drill string 11 in a bore hole 12 by means of platform structure schematically designated 13. Pressured operating fluid will be introduced into the upper end of the drill string and the exhaust fluid and cuttings withdrawn from the well annulus by suitable means, not shown. A percussion bit 14 is shown at the bottom of the tool.

The percussion tool itself, as illustrated in FIGS. 2A—5, inclusive, includes a cylindrical casing 16 forming the working chamber and threadedly secured at 17 to an upper sub 18 which, in turn, is threadedly secured to pin 19 at the bottom extremity of the drill string 11. Casing 16, at its bottom extremity, is threadedly attached to a nut structure 20 having a lower cylindrical portion 21 slidably receiving a cylindrical intermediate part 22 of the combined anvil and bit structure 23 of which bit 14 forms the lower extremity. During normal, on-bottom operation, the bottom of nut portion 21 rests upon a horizontal, annular shoulder 24 on anvil-bit part 23.

The upper portion 26 of the anvil-bit structure has external splines 27 which mate with internal splines 28 on the nut structure to permit relative longitudinal sliding movements of the anvil and casing, while enforcing joint rotation thereof. A ring 29 lodged against the inner face of the casing guides the anvil and acts as a stop, co-operating with lugs 30 on the anvil to limit the dropping of the anvil relative to the casing.

A tubular porting structure, generally designated 32, extends axially through casing 16 and has a shoulder 33 at its upper extremity resting against and supported by the annular shoulder 34 in upper sub 18. The interior passage 35 of tubular structure 32 has a reduced intermediate portion 35a and communicates intermediately through main pressure supply ports 36 with the exterior of the structure. Received upon the tubular structure is a thin sleeve 37 having ports 38 communicating with previously mentioned pressure ports 36, a pair of diametrical matching ports 36, 38 being provided. The tubular structure is also provided with partial flutes 39, 40, and 41 within sleeve 37, and communicating at their ends respectively with ports 42 and 43, 44 and 45, and 46 and 47 in the sleeve. Bottom flute 41 and its ports 46 and 47 are duplicated on the opposite side of the tubular structure.

The bottom extremity of sleeve 37 is closely but slidably received in a similarly shaped bore 49 in anvil part 26. Axial exhaust ducts 50 and 51 connect bore 49 with discharge passages 52 in the bit. The restricted, lower part 35a of the operating fluid passage in structure 32 communicates through choke 53 with the exhaust ducting in the anvil for bypassing a part of the operating fluid during operation of the tool.

As best shown in FIGS. 3 and 4, the tubular structure, also, is provided with opposite, segmental, longitudinal recesses 55 and 56 communicating with exhaust ports 57 and 59 and "blowing" port 58 in the sleeve 37. The segmental recesses communicate, at their lower ends, with the exhaust ducting in the anvil.

A transverse partition 62 is provided in casing 16 at a point spaced somewhat below the bottom end of upper sub 18 to form an auxiliary expansion compartment or chamber 63 which communicates through a port 64 with flute 40 in the central tubular structure. Thus, when port 45 is exposed, the space 65 at the rear or upper end of the working chamber communicates with compartment 63.

Reciprocable within the working chamber and slidable on sleeve 37 on the central tubular structure is a hollow, cylindrical hammer piston, generally designated 66, having a central portion 67 provided with oil collecting grooves 68 which slidably fit the interior of the casing. Tubular extensions 69 and 70 project upwardly and downwardly from the central portion of the piston, upper extension 69 being shaped to fit rather closely within a filler ring 71 lodged in the casing. The space 65 between the upper or rearward end 73 of the piston and partition 62 forms a main upper compression chamber which is connected by grooves 74 in the filler to a toroidal space 75 between filler 71 and a shoulder 76 on the piston by means as previously mentioned. Space 65 is also connected with separate auxiliary expansion chamber 63 through port 45, flute 40, and port 64.

Lower piston extension 70 is arranged on its lower surface 78 to strike the upper surface of the anvil. A countersink 79 at the lower end of the inner central aperture 80 of the piston serves to direct operating fluid from flutes 41 and ports 46 into the lower pressure chamber formed by countersink 79, a registering countersink 81 in the upper end of the anvil, toroidal space 82 about lower piston extension 70, and registering, toroidal space 83 about the upper extremity of the anvil above collar 29. Centrally of the axial aperture 80 in the piston there is provided a shuttle groove 85 which constantly communicates with pressure ports 36, 38 and connects the same either with upper ports 42, 44 or lower ports 47. The piston is provided with port control or valving edges or shoulders 86 and 87 at opposite ends of the shuttle groove.

The operation of the percussion tool is as follows: when the tool is resting on the bottom of the hole, with the weight of the drill string and casing bearing through nut structure 21 upon the bit, and the supply of pressured operating fluid turned on, this fluid passes from the drill string into central aperture 35 of the tubular structure, thence through main pressure ports 36, 38 into shuttle groove 85 in the piston. This groove, in its lower operating position, will direct the operating fluid through ports 47 in sleeve 37 into bottom flutes 41, thence through ports 46 into the bottom pressure chamber space 79, 81, 82, 83. Since, at the same time, the upper pressure chamber space is exhausted through ports 57, as will be explained, the hammer piston will lift.

After the piston lifts the distance A (FIG. 2B), annular shoulder 87 at the bottom of shuttle groove 85 in the piston will pass beyond and close port 47 to terminate charging of the bottom pressure chamber spaces. Thereafter, during the travel B, the charge in the bottom pressure chamber will expand. During the final part C of the upward travel, the bottom of countersink 79 in the bottom of the piston will pass over the edge of bottom exhaust port 59, thus exhausting the bottom pressure chamber space through segmental cutouts 55 and 56 in the central tubular structure into exhaust ducting 50, 51 in the anvil.

With reference to FIG. 2A, the initial portion D of the upward travel of the piston will cause the upper surface 73 of the piston, during travel D, to pass over and close upper exhaust port 57. Thereafter, during the portion E of the upward travel, there will be a slight compression of the fluid in the upper pressure chamber spaces 65 and 63. During the portion F of the upward travel, when the upper valving edge 86 of piston shuttle groove 85 passes over ports 42 and 44, pressured operating fluid

will be supplied through flutes 39 and 40 and ports 43 and 45 into upper pressure chamber space 65. At the same time, separate expansion chamber space 63 will be charged through flute 40 and upper port 64. At the end of interval F, port 45 will be closed by the piston which will eliminate supplementary expansion space 63 from the effective space to which the piston is exposed. Consequently, the effective volume of the rear compressive space to which the piston is exposed will be sharply reduced with the result that there will be a very sharp increase in pressure per unit of piston travel in the remaining compressive space (see FIG. 5). This increase in compression in the rear chamber will cushion and sharply retard the rearward travel of the piston and bring the piston to a stop.

The expansion of the resultant highly-compressed gases in chamber 65 will sharply accelerate the initial forward movement of the piston. In other words, the reduction of the effective compressive space, to which the piston is exposed at the end of its rearward travel, will have the effect of shortening and, therefore, greatly expediting the turn-around of the piston. The net effect of this will be that the time required per cycle of piston movement will be reduced and the frequency of beating, thus, increased.

During the portion F of forward travel of the piston, the upper chamber compressive spaces 65, 63, and 75 will be subjected to line pressure. During the portion E of the forward or working stroke of the piston, the charge in the augmented expansion chamber will expand. The total effective size of the expansion chamber, during this period, is sufficient to prevent an excessive drop of the fluid pressure therein. During the final portion D of the working stroke, when the piston has reached its maximum speed and at the end of which the anvil is struck a percussive blow, upper exhaust port 57 will be traversed by the upper surface 73 of the piston and again opened to exhaust the upper expansion chambers.

In case it is desired to provide the maximum exhaust around the motor for cleaning out the hole, casing 16 is lifted, the ring stop 29 limiting the lift of the casing relative to the anvil. When this occurs, the piston remains in contact with the anvil so that shuttle groove 85 will pass over intermediate exhaust port 58. Thereafter the total operating fluid will be bypassed through cutouts 55 and 56 in the tubular structure, thence into anvil exhaust duct 50, 51, 52. The bottom pressure chambers will be completely sealed from this bypassed fluid so there will be no tendency to lift the piston. At the same time, a portion of the operating fluid will flow upwardly through the exhaust passages, then through the exposed upper exhaust ports 57 into the upper pressure chamber space to positively hold the piston down.

While the particular type of percussion motor illustrated operates very efficiently, other types may be utilized with the novel means herein disclosed for cushioning and expediting the turn-around of the piston. The exclusive use of all modifications as come within the scope of the appended claims is contemplated.

I claim:

1. Percussion drilling apparatus comprising a casing forming a working chamber having a connection at its rear end for operating fluid and an anvil at its forward end, a hammer piston reciprocable in said chamber, valving means to alternately direct fluid from said connection into the rear end portion of said chamber and to exhaust said portion to cause said piston to beat upon said anvil, a compartment adjacent said working chamber rear end portion, wall structure separating said compartment from said chamber rear portion, and a passage extending through said wall structure from said compartment to a port in the wall of said chamber rear portion, said port being positioned to be traversed and closed by said piston, as it approaches the rear end of its travel, to reduce the effective compression space to which said piston is ex-

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posed and, thereby, expedite the piston turn around while providing the volume of compressed working fluid in said compartment to supplement the working fluid applied to said piston during the forward stroke thereof.

2. Percussion drilling apparatus comprising a casing 5 forming a working cylinder and having a connection at one end for operating fluid and an anvil at the other end, a hammer piston reciprocable in said cylinder and forming forward and rear working chambers, respectively, at the anvil and fluid connection ends thereof, valving means 10 for directing operating fluid into said chambers and exhausting the same therefrom for causing said piston to beat upon said anvil, partition means for dividing said rear chamber into a plurality of parts, passaging connecting said rear chamber parts with each other and said fluid connection, and means provided by the hammer piston to

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restrict said passaging as said piston approaches the rear end of its stroke during operation to reduce the effective compression space to which said piston is exposed for cushioning and expediting the turn-around thereof.

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MILTON KAUFMAN, *Examiner*.