Jan. 7, 1958 W. J. BECKHAM 2,819,041

PERCUSSION TYPE ROCK BIT

Filed Feb. 24, 1953 3 Sheets-Sheet 1

Fig. 1

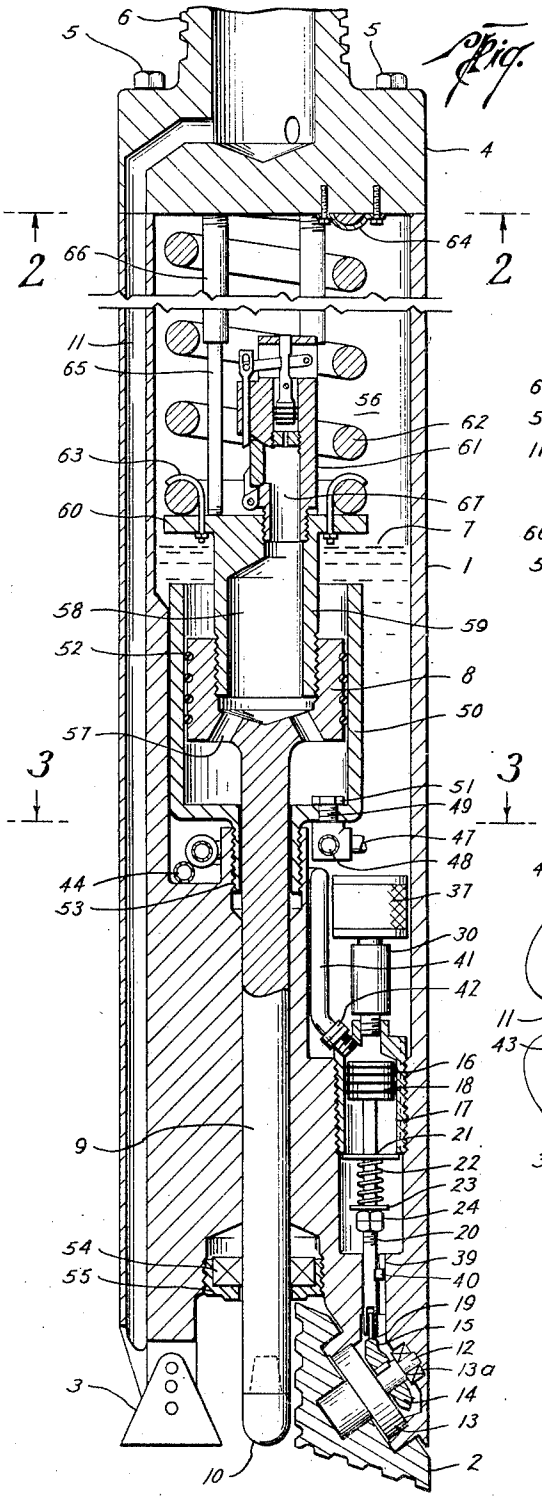


Fig. 2

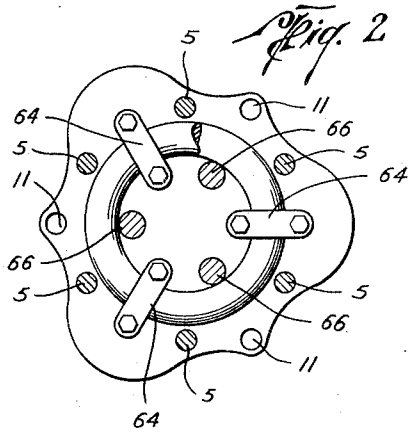
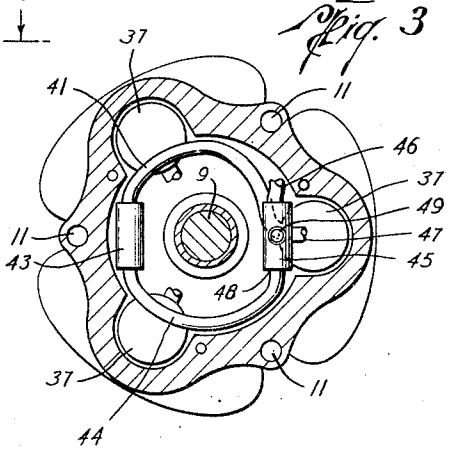


Fig. 3



William J. Beckham
INVENTOR.

BY Frank B Pugsley

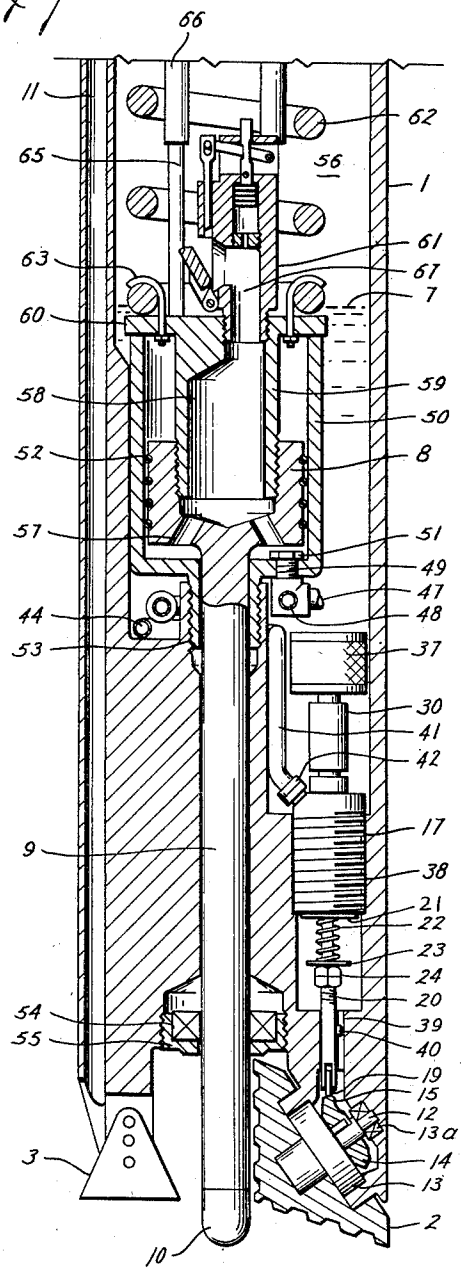
ATTORNEY

Jan. 7, 1958 W. J. BECKHAM 2,819,041

PERCUSSION TYPE ROCK BIT

Filed Feb. 24, 1953 3 Sheets-Sheet 2

Fig. 4



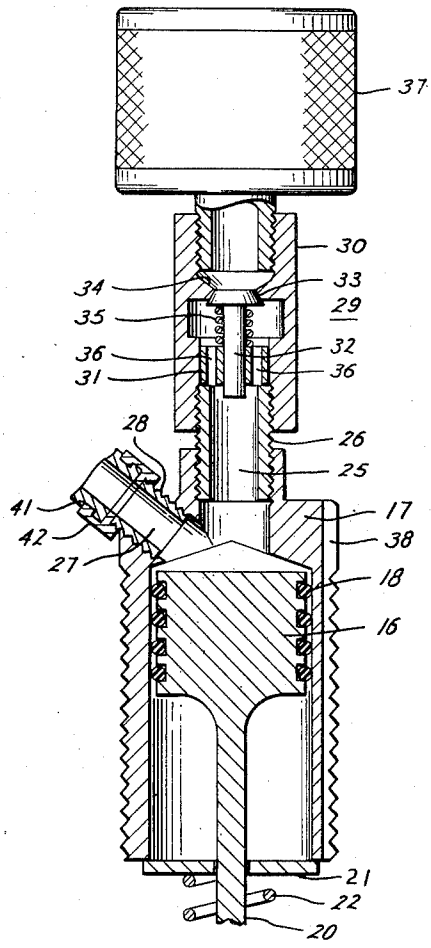


Fig. 5

William J. Beckham
INVENTOR.

BY Frank B Pugsley

ATTORNEY

Jan. 7, 1958 W. J. BECKHAM 2,819,041

PERCUSSION TYPE ROCK BIT

Filed Feb. 24, 1953 3 Sheets-Sheet 3

Fig. 6

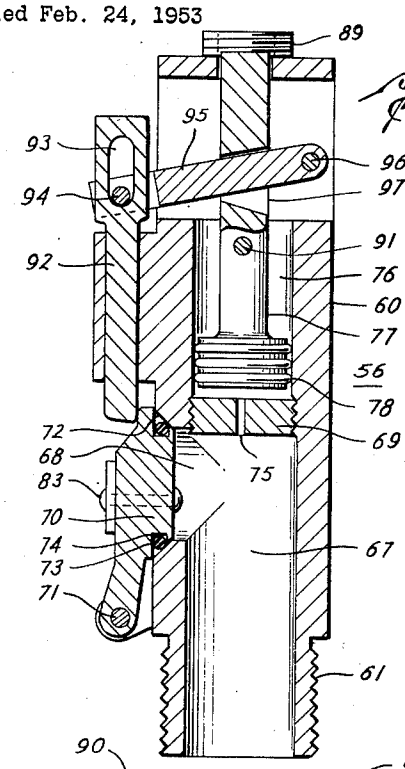


Fig. 7

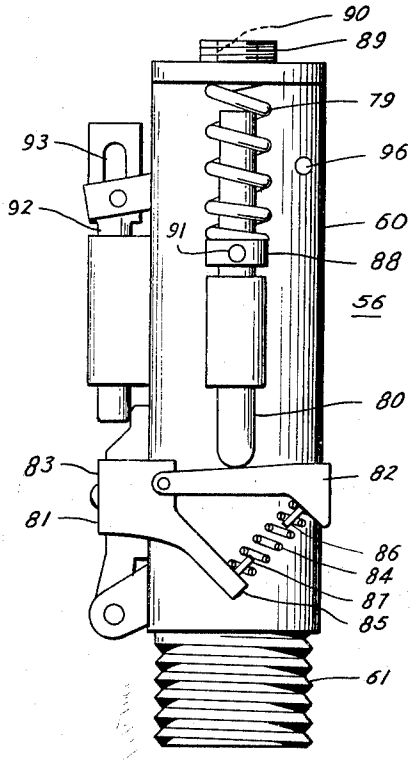
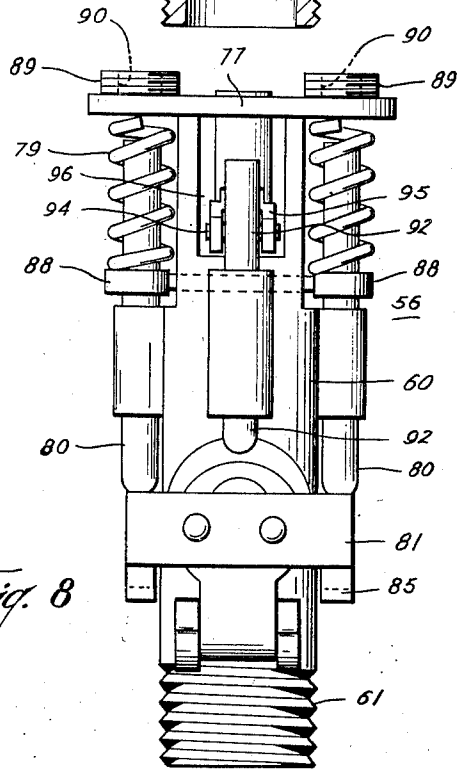


Fig. 8



William J. Beckham
INVENTOR.

BY Frank B Pugsley

ATTORNEY

United States Patent Office 2,819,041 Patented Jan. 7, 1958

2,819,041

PERCUSSION TYPE ROCK BIT

William J. Beckham, Houston, Tex.

Application February 24, 1953, Serial No. 338,237

13 Claims. (Cl. 255—4.4)

This invention relates to well drills, and more particularly to roller bits in which the cutting action is aided by an impact or percussion member.

Roller bits are frequently referred to as rock bits because they are designed to cut through relatively hard formations in the earth's strata, such as hard limestone and other rock, rather than soft formations such as shale and sand. The teeth on the rollers gradually wear or cut away the formation, but in hard rock the drilling rate is slow. When conventional bits rather than rock bits are used for drilling hard rock, it is necessary to provide an impact or percussion member to strike the rock formation at the bottom of the hole or to strike the bit itself. This impact member or hammer must strike hard enough and fast enough to chip the rock at a relatively rapid rate for the conventional bit to make progress. The combination of a percussion member with a roller or rock bit provides the best known means for drilling through extremely hard strata, however, as the cutters rapidly break the rock chipped by the impact member into particles which are small enough to be carried up the bore hole by the drilling mud.

Prior to my invention most percussion type bits have utilized air pressure, mud pressure, or water pressure supplied from the surface to operate the hammer members. Some few, moreover, have utilized the difference in rotational travel between the drill pipe and the bit, when the bit has encountered a hard formation, to wind up and release the impact device. While each of these means of operating the impact plunger has had a limited success, none have been completely satisfactory.

Consequently, it is an object of my inventon to combine a rock bit with an impact member in such a manner that the impact member is actuated in response to rotation of the cutters.

It is another object of my invention to provide a new and improved percussion type roller bit in which the energy for actuating the percussion member is built up gradually and released suddenly in a periodic and regular fashion.

A further object of my invention is to provide an improved valve device which will remain closed to permit a predetermined fluid pressure to build up within a cylinder, and which will then automatically open and remain open a selected period of time to permit a substantially complete release of such pressure.

A still further object of my invention is to provide a novel arrangement of hydraulic motor means, operated in response to rotation of the bit cutters, for building up the necessary hydraulic pressure for operating the percussion member.

In carrying out my invention in a presently preferred form I utilize a rock drill bit of the type designed for use with oil well rotary drilling units in which the drill pipe is rotated by a rotary table. Such bits generally comprise three cone shaped steel cutters supported on bearings carried by the bottom portion of the bit body or frame. These cutters are of the standard type used in

drilling through extremely hard formation, which serve to cut the walls and bottom of the hole, pulverizing the rock into small particles. My invention improves the action of such standard rock bit cutters, however, by providing means operated by the rotation of one or more of the cutters for actuating a percussion member.

My operating means for the impact member preferably comprises a hydraulic actuator including, in the frame of the drill bit, a cylinder disposed above each cutter. Reciprocably mounted in each cylinder is a piston operated by rotation of the cutter; for example, the piston may have a rod connected to it which is associated with one or more cams formed on or attached to the free end of the cutter shaft. As the weight of the drill pipe is carried by the cutters, sufficient force becomes available at each cutter, upon rotation of the drill stem and the cutters by the rotary table, to actuate one or more small pistons to produce considerable hydraulic pressure.

As the cone cutters rotate the small pistons are reciprocated thereby to pump a stream of oil into a large master cylinder, preferably located in the center of the drill bit frame. This flow of oil serves to build up pressure beneath a piston in the master cylinder, which pressure will move the piston upwardly against the bias of a spring or other suitable resisting force. The spring, in effect, stores the energy applied beneath the piston until a predetermined spring force is attained whereupon, by the action of a relief valve, the pressure below the piston is suddenly reduced. Immediately the restraining spring drives the piston downwardly until the plunger or impact member carried by the piston strikes against the hard formation at the bottom of the hole, chipping and breaking it so that the cutters can more effectively and rapidly pulverize the formation.

I provide suitable ports in my drill bit for the introduction of drilling mud and washing water at the bottom of the bit, and provide suitable means such as a reservoir in the bit frame for supplying a proper liquid for use in the hydraulic system. The plunger operating mechanism is protected from contact with the drilling mud and washing water by the drill casing, so that only the hydraulic fluid comes into contact with the moving parts.

While the features of my invention which I believe to be novel are set forth with particularity in the appended claims, my invention itself, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings. In these drawings Fig. 1 is a sectional elevation view through the longitudinal axis of my drill bit, showing the plunger in retracted position; Fig. 2 is a section looking along the lines 2—2 of Fig. 1; Fig. 3 is a section looking along the lines 3—3 of Fig. 1; Fig. 4 is a view similar to Fig. 1 but showing the plunger in its impact position; Fig. 5 is an enlarged sectional elevation of the small hydraulic cylinder and related structure shown in Fig. 1; Fig. 6 is an enlarged sectional side view of the valve mechanism for controlling the master cylinder, as shown in Fig. 1; Fig. 7 is a side elevation of the valve device of Fig. 6; and Fig. 8 is a plan view of the valve device of Fig. 6.

Referring now to Fig. 1 of the drawings I have shown a sectional view through the body or frame 1 of my drill bit, in which one of a plurality of cone-shaped steel cutters 2 can be seen along with one of a plurality of scraper members 3. It will be understood that three cutters spaced equiangularly around the circumference of the bit frame and three similarly spaced scrapers are used in the preferred form of my invention. The bit preferably includes a cap portion 4 attached to the frame by means of bolts or screws 5, which cap has a threaded

upper end 6 suitable for attachment to the end of the drill pipe in the conventional manner. The frame 1 forms a chamber 7 which serves as a reservoir for hydraulic liquid as well as housing a part of the impact operating mechanism. It may be filled to the level indicated either by removing the cap 4 or by utilizing an opening, not shown, in the frame 1. The impact mechanism itself includes a piston 8 within the chamber 7 operatively connected to a plunger or hammer 9, and having a hardened steel cap 10 screwed or otherwise attached thereto. In order to permit washing in the vicinity of the impact member and bit cutters, and to provide drilling mud to the bottom of the hole, I further provide a passageway 11 in the frame 1 communicating between the end 6 of the frame cap and the bottom of the bit.

It should be understood in considering the following description that each hydraulic pressure mechanism is preferably identical, and that the single mechanism shown and described in relation to its cutter is typical and illustrates the construction of each of the others.

The cutter 2 is non-rotatably mounted on a shaft or pin 12 which is journaled in suitable bearings 13 and 13*a* carried by the bit frame. Usually ball or roller bearings are employed for this purpose. Non-rotatably mounted on the shaft 12 is a cam 14 which has at least one and preferably three lobes 15. Consequently, upon rotation of the drill pipe, the bit frame rotates by virtue of the direct connection through the end portion 6 of the cap 5. The cutter 2 then rotates at about twice the speed, measured in revolutions, of the drill pipe, the exact ratio depending on the relative diameters of the bit frame and the cutter. Thus with a drill pipe or stem rotation of sixty revolutions per minute, the cutter may be driven at approximately one hundred and twenty revolutions per minute. The use of a plurality of cam lobes on the cam, which rotates with the cutter as a unit, further multiplies the rotational velocity in a manner explained hereinafter.

In order to provide hydraulic pressure for actuating the percussion member 9, I utilize the rotation of the cam 14 to drive a small hydraulic piston 16. The piston 16 is reciprocated within a cylinder 17 in the bit frame and forms a seal with the cylinder inner wall by means of piston rings 18, which may for example, be of neoprene. A roller type cam follower 19 is carried on the lower end of a rod 20, which is connected to the bottom of the piston, engages the surface of the cam 14 so that the piston is driven upwardly within the cylinder upon contact with each of the three cam lobes 15. Thus the piston will be reciprocated three times for each revolution of the cutter. The cam rod 20 is slidably mounted in the frame 1 and passes through an opening in a plate 21, which forms the bottom of the cylinder 17, to connect with the piston 16. It is spring biased to a downward position by means of a coil spring 22 which bears at its upper end against the plate 21 and at its lower end against a plate 23, which in turn is supported on a nut 24. The nut 24 serves not only to support the plate 23 so that the cam rod 20 will be biased downwardly, but also serves to provide adjustment means by which the compression of the spring 22 can be varied. In this manner the cam follower roller 19 will be kept in contact with the surface of the cam 14 at all times.

As best shown in Fig. 5 there is an intake passage 25, in the upper end of the cylinder 17, preferably formed by use of a threaded nipple 26 which is screwed into the top of the cylinder. There is also a discharge passageway 27 at the upper end of the cylinder 17 which may be formed by a threaded nipple 28 adjacent the intake passage 25. At the upper end of the nipple 26 is a one way valve 29 which permits flow into the passageway 25 in the direction of the cylinder, but prevents reverse flow. The valve 29 comprises a body or casing 30 which may be screwed onto the upper end of the nipple 26. The casing 30 has a central passageway and serves as a housing for a bushing 31 which constitutes a guide bearing for a slidable valve stem 32. The valve stem 32 has mounted on its upper end a tapered valve element 33 adapted to fit a valve seat 34 formed in the body 30. The valve element 33 is urged upwardly by a spring 35 or other suitable means, so that it is normally closed against the passage of fluid through the central passageway of the valve body 30. The valve stem guide bushing 31, moreover, is provided with a plurality of passageways 36 through which hydraulic liquid can flow when the valve element 33 unseats. The springs 22 and 35 should be selected of such size and spring constants that the restraining force on the valve member 33 is small compared to the downward bias on the piston 16, so that upon downward travel of the piston the pressure differential created will be sufficient to unseat the valve, as explained more fully below.

While not essential to the utilization of my invention it is highly desirable to provide an oil strainer 37 which may, for example, be carried on the upper end of the valve casing in the manner shown in Fig. 5, by screwing an integral nipple formed on the lower end of the strainer into the upper end of the casing. The liquid flowing to the cylinder must then pass through the strainer and its depending nipple portion and through the central passageway in the valve body 30. Upon each downward stroke of the piston 16, in response to the urging of the spring 22, as soon as the reduction in pressure below the movable valve member 33 becomes sufficient to create a pressure differential across the valve member great enough to overcome the bias of the relatively weak spring 35, the valve 29 will pass hydraulic oil from the strainer 37 to the interior of the cylinder 17.

It will be understood, of course, that suitable means will be provided for lubricating the moving parts, as by supplying hydraulic oil to them from the reservoir 7. For example a groove 38 in the outer threaded wall of the cylinder 17 and a slot 39 in the portion of the frame 1 surrounding the cam rod may be provided to lubricate the cam surface, cam follower, and cutter bearing. Moreover, the cam rod may be conveniently held against rotation, relative to the frame 1, by means of a key 40 slidably movable within the slot 39.

When any one of the cam lobes 15 come into contact with the cam follower 19, the cam rod 20 and consequently the piston 16 are driven upwardly, thereby presssurizing the liquid previously drawn into the cylinder. This increase in pressure securely seats the valve member 33 to prevent fluid from flowing through the valve 29. Consequently, as the piston continues its upward movement the fluid is forced instead through the discharge passageway 27 into a suitable conduit such as the hose 41. This hose may be coupled to the discharge nipple 28 by means of a coupling bracket 42. As best shown in Fig. 1 taken in connection with Fig. 3 the hydraulic fluid flows through the hose 41 into a one way valve 43 which preferably is of identical construction to that of the valve 29. In other words the valve 43 permits the flow of hydraulic fluid through it from the cylinder 17, but seats in response to fluid pressure at its discharge side and the pressure of its own spring to prevent reverse flow. A hose 44 extends from the discharge side of the valve 43 to a header 45 having intakes 46, 47 and 48, respectively, to accommodate the hose connections from each of the hydraulic cylinder means. It will be understood, of course, that each hose has a valve similar to the valve 43. The header 45 in addition has a discharge passageway 49 communicating with a cylinder 50 in which the master piston reciprocates. In the form shown, a tapered fitting 51 with an oil passage through it is provided in the bottom of the cylinder 50, and the header 43 is attached to it, preferably by a threaded connection. Thus fitting 51 forms the passage 49.

In the initial setting of the cutters, the cams are prefer-

ably positioned so that each one of the three small pistons for delivering liquid to the master cylinder 50 will operate on a liquid delivery stroke when the valves in the hose lines from the other small cylinders will be closed. This is not essential, however, as my hydraulic system will function properly without precise timing of the small pistons and even if all three pistons are operated simultaneously, as may become the case in actual drilling practice. Whenever the pressure in a hose line between a small cylinder and its valve falls below the pressure in the header 45, that valve will close because of its one-way construction, and hydraulic liquid will not begin reverse flow. On the other hand so long as this pressure exceeds that of the header, there will be no tendency toward reverse flow. Consequently my hydraulic motor means is not dependent upon the timing of the cutter operated pistons.

As previously explained the piston 8 is adapted to reciprocate within the cylinder 50, being driven upwardly in the cylinder in response to a build up of liquid pressure beneath it. This piston may be provided with piston rings 52 of any suitable material, such as neoprene. Also as previously explained a plunger 9 is connected to the bottom of the piston 8 for sliding movement in a passageway formed in the frame 1 of the bit. Near its upper end the plunger may be guided during its reciprocation by a bushing portion 53 formed on the bottom on the cylinder 50. This bushing portion of the cylinder serves not only to guide the plunger but may be secured in threaded engagement with the bit frame to fix the cylinder 50 in position within the chamber 7. The plunger is further guided by the central bore in the bit frame, and a seal 54 is provided near the lower end to prevent the oil or other hydraulic liquid, passing into the bore from the cylinder, from escaping. The seal may advantageously be held in a cap 55 screwed into the bit frame. In such an arrangement the seal is pressed into a recess in the cap, and the cap is provided with a central passageway to accommodate the plunger.

In order effectively to utilize the hydraulic pressures developed by the small piston and cylinder arrangements to operate the plunger or striker 9, I provide a control valve 56 which serves as a quick opening relief valve and time delay device to permit rapid and substantially complete exhaustion of the pressure beneath the piston 8. I provide fluid pressure to the control valve 56 through a plurality of ports 57 formed in the piston 8, which serve to deliver a portion of the hydraulic oil in the cylinder 50 to the control valve mechanism. As will be explained more fully hereinafter a passageway 58 leads from the ports 57 to the control valve 56, which passageway must become filled with hydraulic oil before hydraulic pressure will begin to build up beneath the piston 8. Thereafter additional oil supplied to the cylinder 50 will cause a rapid rise of fluid pressure whereupon the piston will be moved upwardly as the first step toward causing the impact member 9 to deliver a blow to the formation being drilled.

One convenient means of forming the passageway 58, as well as supporting the valve 56, is shown in Figs. 1 and 4. A bushing 59 having a threaded lower end is screwed into a central recess in the piston 8, which central recess communicates with the ports 57. The upper end of the bushing 59 forms a shoulder 60 which has several functions as will be explained later in the specification. The passage 58 may be reduced in cross section near the upper end of the bushing 59 to receive the threaded lower end portion of a body 61 which houses the valve 56. In this manner both the bushing 59 and the valve 56 are carried by and fixed to the piston 8, so they will move up and down in response to piston movement. Moreover, as is evident from an inspection of Fig. 1 or Fig. 4 the piston 8 will move upwardly in response to continued delivery of hydraulic oil under pressure from the small cylinders so long as the valve 56 does not pass any appreciable amount of oil. Upon opening of the valve 56, however, the pressure in the passage 58 and consequently in the space within the cylinder 50 below the piston 8 will be relieved so that no further upward forces of any consequence will be acting on the piston. Moreover, by making the passage through the valve 56 of sufficient diameter to readily accommodate the flow from the discharge opening 49, of the header 45, and by making the total cross sectional area of the ports 57 at least as large, there will then be no substantial forces, other than friction, tending to prevent the piston 8 from returning to the bottom of the cylinder 50. As it is obviously desirable that the plunger 9 strike the bottom of the formation with a relatively large striking force, I provide a spring 62 between the flange 60 and the cap 4. This spring may be held in place on the flange 60 of the bushing 59 by means of a plurality of curved straps 63 and may be held in place beneath the cap 4 by means of a plurality of cleats 64. The straps 63 and the cleats 64 may be suitably attached to the flange 60 and the cap 4 by means of nuts and screws respectively. The spring 62 is of such a length that, when the valve 56 opens to permit the piston 8 to move downwardly, it will support the piston to prevent it from striking the bottom of the cylinder. This not only avoids striking the top of the fitting 51 but prevents any other sharp impact which would decrease the life of the parts.

Since the length of travel of the piston within the cylinder 50 is limited by space requirements to approximately two inches, I prefer to use a main spring having a constant in the order of two thousand pounds per inch, so that upon full upward travel of the piston a force in the order of four thousand pounds will be stored for later utilization in driving the plunger or striker 9 downwardly against the hard formation at the bottom of the hole. The amount of pressure required to be developed in the cylinder 50 below the piston 8 will depend, of course, on the effective area of the piston. It has been found, moreover, that by the use of relatively small pistons in conjunction with the cutters that pressures in the order of one thousand pounds per square inch can be readily developed. The pressure at which the valve 56 will open is preset at a calculated figure dependent on the effective piston area, usually about seven or eight hundred pounds per square inch, so that the desired amount of force will be stored in the spring before the pressure in the cylinder 50 is released to permit the spring pressure to drive the plunger downwardly.

I provide guide means for the spring 62 comprising a plurality of rods 65 attached to the flange 60 just within the circle formed by the bottom coil of the spring. Each rod 65 is positioned so that its upper or free end enters into the lower end of one of several tubes 66 attached to the bottom of the bit frame cap 4. The upper end of the rod 65 just barely enters the lower end of the tube 66 when the piston is in the position shown in Fig. 4, but approximately two inches of the rod 65 slides upwardly into the tube 66 during the upward travel of the piston 8. While not essential to the operation of my hydraulic mechanism, this guide arrangement serves to prevent any tendency of the spring 62, or the bushing 59, to tilt, thereby preventing unnecessary strain on the piston 8 and cylinder 50 in maintaining correct alignment.

While any suitable control valve which will open in response to a predetermined pressure and will remain open for a predetermined time interval after relief of such pressure would be suitable, I have shown a novel control valve especially adapted for use with my percussion type rock bit. This valve will be better understood if the following description is taken in conjunction with Figs. 6, 7 and 8.

Extending about half way up from the bottom through the body 60 of the valve 56 is a vertical passage 67 opening into a horizontal passage 68. The vertical passage 67 is blocked at its upper end by a plug member 69 and

the horizontal passage 68 may be closed by a movable valve member 70. The movable valve member or flapper 70 is pivotally mounted on the valve body 60 by means of a pin 71, and may swing from a closed position to an open position of as much as thirty degrees, for example, from the vertical. The flapper 70 is adapted to seat against a valve seat or face 72 formed in the body 60. The flapper may be tapered for matching engagement with the face 72 and may further be provided with a suitable seal 73 to further insure against leakage. The seal ring 73 is preferably recessed in a slot portion 74 of the flapper so that the tapered portion can fit snugly against the face 72 when the flapper is fully closed and the ring 73 compressed in sealing engagement with said face. This portion of my valve is entirely conventional and any suitable closure member and seal may be used in carrying out my invention.

Turning now to the control portion of the valve 56, the plug 69 is provided with a small orifice 75 communicating between the passage 67 and the lower portion of a passage 76, also within the valve body. The latter passage 76 serves as a cylinder within which a control piston 77 may reciprocate. This control piston 77 is provided with an enlarged piston head portion having suitable piston rings 78 adapted to seal against the cylinder wall. The orifice 75 permits the flow of fluid from the master cylinder 50 and the passageways 58 and 67 into the cylinder 76 below the control piston. While there is a throttling effect provided by the orifice 75, the build up of pressure within the cylinder 50 is slow enough to permit a substantially simultaneous pressure build up beneath the piston 77. When the predetermined pop-off pressure has been reached the control piston 77 will have been been moved upwardly a sufficient distance to permit opening of the flapper 70, as will be more fully explained.

As shown in Figs. 7 and 8 the upward movement of the piston 77 is opposed by the bias of a pair of springs 79 carried on a pair of rods 80 substantially parallel to the control piston and also slidable within the valve body 60. These rods 80, which serve primarily as valve closure members, bear against a yoke 81 riveted or otherwise suitably attached to the back of the flapper 70. It is preferable that the connection between the rods 80 and the yoke 81 be through a cushioning arm member 82, as best seen in Fig. 7, which member is pivotally connected to a base portion 83 of the yoke. Pressure exerted by the rods 80 upon the pivoted arm 82 is transferred to the main portion of the yoke 81 by means of a pair of springs 84, the upper ends of which bear against the arm 82 and the lower ends of which bear against a projection 85 of the yoke. The springs 84 are kept in position by means of pins 86 and 87 respectively attached to the arms 82 and the projections 85. Consequently, the engagement by the rods 80 with the arms 82 biases the flapper 70 toward its closed position.

As previously explained the rods 80 carry springs 79, and these springs apply pressure for normally keeping the rods in engagement with the arms 82. These springs 79 bear at their lower ends against integral flange portions 88 on the rods and each bears at its upper end against an adjusting screw 89. Each screw 89 may be provided with a central opening 90 therethrough to accommodate the upper end of the rod 80 with which it is associated, thereby to permit full upward movement of the rod in a manner to be further described. Each of the pair of screws 89 is supported in the upper portion of the valve body 60 and may be adjusted to vary the initial spring compression in order to predetermine the force necessary to move the rods 80 out of their valve closure position. This, moreover, predetermines the amount of force necessary to elevate the control piston 77, as a pin 91, extending through the control piston 77, attaches it to the rods 80 at their respective shoulder portions 88. Consequently, the combined spring forces of the two springs 79 act to resiliently oppose upward travel of the control piston. By proper choice of the spring constant for the springs 79, and by adjustment of the screws 89, the hydraulic pressure necessary to move the control piston 77 the desired distance for permitting opening of the flapper 70, which equals the previously mentioned pop-off pressure, is accurately predetermined.

To hold the flapper 70 in its closed position against the hydraulic pressure in the passages 67 and 68 I provide a latch 92 slidably mounted in the valve body and engageable with the back of the top portion of the flapper. The engaging surfaces of the latch and flapper are preferably beveled so that upon downward movement of the latch 92 these surfaces will provide a cam action to force the flapper tightly against the valve seat. An elongated slot 93 is provided in the upper portion of the latch 92. This slot receives a pin 94 carried by an arm 95, which in turn is pivotally mounted on a pin 96 carried by the valve body 60. The arm 95 is provided to control the position of the latch 92, including both elevating it to free the flapper to permit it to open in response to hydraulic pressure, and forcing it downwardly to latch the flapper in its closed position. This latch actuating arm 95 is forked at its free end so as to form a yoke through which the upper end of the latch passes. The pin 94 is inserted between the two prongs of the arm 95 and, as previously explained, passes through the slot 93 in the latch. The slot, however, is sufficiently elongated that considerable free play or lost motion is permitted before the pin 94 will begin to move the latch.

The latch actuating arm 95 is itself operated by movement of the control piston 77, which is provided with a slot 97 through which the arm 95 extends. Consequently, movement of the control piston provides a force acting on a lever arm equal the distance from the piston to the pin 96, which force moves the arm 95 in the same direction as the piston travel. The pin 94 at the free end of the arm 95 travels an effective distance greater than the movement of the piston 77 in a ratio equal to the ratio of the distance between it and the pin 96 compared to the effective lever arm between the piston and the pin 96. When the pin 94 reaches the upper end of the slot 93, further upward movement of the piston will elevate the latch 92 to free the flapper 70. The opposite is true, of course, upon downward movement of the piston.

The operation of the valve 56 is relatively simple, yet very effective. It is best understood, moreover, when described in conjunction with the operation of the entire percussion type rock bit. As previously explained rotation of the drill pipe causes rotation of the bit frame 1, which in turn causes the cutter 2 to rotate on its axis and cuts and crushes the formation beneath it, under pressure impressed upon it by the weight of the drill pipe itself. This rotation is translated into an upward stroke of the small piston 16 each time a cam lobe 15 comes into engagement with the cam follower wheel 19. Each upward stroke forces a small amount of hydraulic liquid through the header 45 into the master cylinder 50. Since the valve 56 is initially closed, successive operations of the pistons 16 serve to fill the space below the main piston 8 within the cylinder 50, the passage 58, and the passage 67. As soon as sufficient pressure builds up in the cylinder 50 to overcome the force of the spring 62, the main piston 8 begins its upward travel, compressing the spring 62 and storing a return force therein.

The pressure for elevating the piston 8 also causes the valve control piston 77 to move upwardly, in opposition to the bias of the springs 79. This upward movement carries with it the valve closure rods 80, thereby relieving the pressure on the yoke 81 which has hitherto tended to oppose opening of the flapper 70. The flapper does not immediately open, however, as the latch 92 prevents it from moving. When the pin 94, however, has been moved upwardly by the piston 77 the entire length of the slot 93, further upward travel of the control piston 77 will withdraw the latch 92 from engagement with

the flapper 70, and the flapper will immediately open, thereby permitting almost immediate release of the pressure within the valve passages 67 and 68 and within the cylinder 50. The extent of opening of the flapper 70 is controlled only by the distance which the flapper closure rods 80 have been elevated by the piston movement, as contact between these rods and the arms 82 will cause compression of the spring 84 even to the extent of permitting the guides 86 and 87 to abut or alternately to permit the spring to close completely, if necessary, to limit further travel of the flapper. This relieves the pressure below the piston 8 and permits the spring 62 to drive the piston downwardly, causing sharp impact between the cap 10 carried on the plunger 9 and the formation at the bottom of the hole. This will chip away part of the formation, which chips will be moved by the scrapers 3 into the path of the cutters 2, whereupon they will be crushed and broken into smaller particles and carried away in the mud stream.

The valve 56 inherently provides a time delay device to prevent any substantial closing of the flappers 70 during the downward movement of the piston 8. This is desirable to prevent any substantial back pressure from building up beneath the piston in response to delivery of hydraulic liquid thereto by the continued operation of the small pistons 16. This time delay feature is provided by the orifice 75 which, though permitting exhaustion of the pressure beneath the control piston 77 within the cylinder 76 after opening of the flapper, so throttles the flow of hydraulic liquid that the piston cannot immediately return to its lower position. Therefore the rods 80 are maintained at a sufficient heighth that they will not close the flapper until after the plunger 9 has completed its impact stroke. As the pressure in the cylinder 76 below the piston 77 is gradually reduced, the piston 77 is returned to its lower position in response to the urging of the springs 79. As this downward stroke begins, the rods 80 begin their downward movement for the purpose of closing the flapper. Because of the length of the slot 93 the latch 92 will not be forced downwardly until the rods 80 have substantially closed the flapper, and this latch will therefore remain in its elevated position because of the friction between it and the valve body. In the event the latch were to fall by gravity to its valve closing position, it would be gently pushed out of the way by the flapper as it closed, however, so that such an event would not cause the valve to become inoperative. As the piston 77 approaches the bottom of the cylinder, the valve rods exert sufficient pressure on the arms 82 to substantially close the flapper against the valve face 72. A tight closure is insured when the piston 77 moves the remaining distance to the bottom of the cylinder, since the pin 94 engages the bottom of the slot 93 and drives the latch 92 into engagement with the flapper, as shown in Figs. 6, 7 and 8. The tapered leading edge of the latch cams the flapper securely into engagement with the valve face, and the latch thereafter holds it against opening until the next upward stroke of the control piston 77.

While I have shown a particular embodiment of my invention, it will be understood, of course, that I do not wish to be limited thereto since many modifications may be made; and I therefore contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A percussion type rotary drilling mechanism comprising a drill bit adapted to be rotated within an oil well bore hole, at least one cutter mounted on the lower end thereof for rotation on said bit during rotation of said bit in the well bore hole, an impact member carried by said bit and hydraulic means operable by said cutter in response to rotation of said cutter relative to said bit to actuate said impact member whereby said impact member will repeatedly strike the formation in said bore hole.

2. A percussion type rotary drilling mechanism comprising a hollow cylindrical drill bit adapted to be rotated within a bore hole, a plurality of cutters mounted on the lower end thereof for rotation on said bit in response to rotation of said bit, an impact plunger slidably mounted for reciprocation in said bit, said plunger being so supported that in its lowermost position it extends below said cutters, and means including a fluid pressure generating unit actuated by said cutters in response to rotation thereof relative to said bit to operate said plunger to cause repeated impacts against the formation at the bottom of the bore hole.

3. A rotary drilling mechanism comprising a drill bit adapted to be rotated within a bore hole, at least one cutter rotatably mounted on the lower end of said bit for engagement with the formation at the bottom of the bore hole, a cam rotated in response to rotation of said cutter, a cam follower reciprocated by said cam, a fluid pressure system operated in response to reciprocation of said cam follower, said fluid pressure system comprising at least one pressure generating unit and a main operating unit; said pressure generating unit including a piston connected to said cam follower, said main operating unit including a piston slidably mounted in said bit and an impact member slidably mounted in said bit and reciprocable in response to operation of said main unit piston, said impact member being positioned to strike the bottom hole formation upon downward movement of said main unit piston; and a passageway from said generating unit to said main operating unit to deliver fluid under pressure thereto to operate said main unit piston.

4. A percussion type rotary drilling mechanism comprising a drill bit adapted to be rotated within a bore hole, at least one cutter rotatably mounted on the lower end of said bit for engagement with the formation at the bottom of the bore hole, a cam rotated in response to rotation of said cutter, a cam follower reciprocated by said cam, a hydraulic pressure system operated in response to reciprocation of said cam follower, said hydraulic system comprising at least one pressure generating unit and a main operating unit; each of said pressure generating units having a cylinder, liquid supply means for said cylinder a piston slidable within said cylinder to pressurize said liquid, and a connection between said piston and said cam follower for operating said piston; said main operating unit having a cylinder within said bit and a piston operating within said cylinder, said main unit piston carrying an impact member slidably mounted in said bit and positioned to strike the bottom hole formation upon downward movement of said main unit piston, and a passageway from said generating unit to said main operating unit to deliver liquid under pressure thereto to operate said main unit piston.

5. A percussion type rotary drilling mechanism comprising a drill bit adapted to be rotated within a bore hole, at least three cutters rotatably mounted on the lower end of said bit for engagement with the formation at the bottom of the bore hole, a separate cam connected to each of said cutters, a separate cam follower engageable with each of said cams, a hydraulic pressure system operated in response to reciprocation of said cam followers, said hydraulic system comprising a pressure generating unit for each cam follower and a single main operating unit; each of said pressure generating units having a cylinder, liquid supply means for said cylinder a piston slidable within said cylinder to pressurize said liquid, and a connection between said piston and said cam follower for operating said piston; said main operating unit having a cylinder within said bit and a piston operating within said cylinder, said main unit piston carrying an impact member slidably mounted in said bit and positioned to strike the bottom hole formation upon downward movement of said main unit piston, and a passageway from said gen-

erating units through a common header to said main operating unit to deliver liquid under pressure thereto to operate said main unit piston.

6. In a rotary drilling mechanism of the type used in drilling through hard formations at the bottom of bore holes, having a drill bit with rotatably mounted cutters thereon and an impact member associated therewith, the improvement in means for operating said impact member comprising: reciprocable means operated by rotation of one of said cutters, a hydraulic system operated in response to movement of said reciprocable means for actuating said impact member, said hydraulic system comprising a pressure generating unit and a main operating unit, liquid supply means for said pressure generating unit, a piston in said main operating unit, said piston being connected to said impact member, conduit means from said generating unit to said main operating unit for delivery of liquid under pressure thereto to elevate said piston, biasing means opposing elevation of said piston and exerting a restoring force downwardly thereon in opposition to the pressure of the liquid, and a control valve operable to relieve the pressure in said main operating unit to initiate a downward stroke of said piston.

7. In a rotary drilling mechanism adapted for drilling the formation at the bottom of a bore hole, having a drill bit with rotatably mounted cutters thereon and a percussion member associated therewith, the improvement in means for operating said percussion member comprising: a hydraulic system operated in response to rotation of at least one of said cutters, said hydraulic system comprising a pressure generating unit and a main operating unit; said generating unit having a cylinder, liquid supply means for said cylinder, a piston, and means operated by rotation of one of said cutters for reciprocating said piston within said cylinder; said main operating unit having a main cylinder, a main piston within said main cylinder and connected to said percussion member, conduit means from said generating unit cylinder to said main cylinder for delivery of hydraulic liquid under pressure thereto to elevate said main piston, biasing means opposing elevation of said main piston and exerting a restoring force downwardly thereon in opposition to the hydraulic pressure, and a control valve operable to relieve said hydraulic pressure in said main cylinder.

8. In a rotary drilling mechanism adapted for drilling the formation at the bottom of a bore hole, having a drill bit with rotatably mounted cutters thereon and a percussion member associated therewith, the improvement in means for operating said percussion member comprising: a cam rotated in response to rotation of one of said cutters, a cam follower for said cam, a hydraulic system operated in response to reciprocation of said cam follower by said cam for actuating said percussion member, said hydraulic system comprising a reservoir for liquid within said bit, a pressure generating unit communicating with said reservoir, and a main operating unit; said generating unit having a cylinder, a piston within said cylinder, and means connecting said piston to said cam follower for reciprocating said piston; said means operating unit having a main cylinder, a main piston within said main cylinder and connected to said percussion member, conduit means from said generating unit cylinder to said main cylinder for delivery of hydraulic liquid under pressure thereto to elevate said main piston, biasing means opposing elevation of said main piston and exerting a restoring force downwardly thereon in opposition to the hydraulic pressure, and a control valve operable in response to the build-up of a predetermined restoring force to relieve said hydraulic pressure in said main cylinder.

9. In a rotary drilling mechanism of the type employed in drilling hard formations at the bottom of bore holes, having a drill bit with rotatably mounted cutters thereon and a percussion member associated therewith, the improvement in means for operating said percussion member comprising: a cam rotated in response to rotation of one of said cutters, a cam follower for said cam, a fluid pressure system for actuating said percussion member operated in response to reciprocation of said cam follower by said cam, said fluid pressure system comprising a pressure generating unit, a main operating unit, and a source of fluid for supplying said pressure generating unit; said main operating unit including a piston operatively connected to said percussion member; a passageway from said generating unit to said main operating unit for delivery of fluid under pressure thereto to elevate said piston, biasing means opposing elevation of said piston and exerting a restoring force downwardly thereon in opposition to the fluid pressure, and a control valve adapted to open in response to the build-up of a predetermined fluid pressure in said main operating unit to relieve the pressure therein, said control valve having time delay means preventing closing during the downward stroke of said piston.

10. In a rotary drilling mechanism adapted for drilling the formation at the bottom of a bore hole, having a drill bit with rotatably mounted cutters thereon and a percussion member associated therewith, the improvement in means for operating said percussion member comprising: a cam rotated in response to rotation of one of said cutters, a cam follower for said cam, a hydraulic system operated in response to reciprocation of said cam follower by said cam for actuating said percussion member, said hydraulic system comprising a liquid reservoir within said bit, a pressure generating unit communicating with said reservoir, and a main operating unit; a piston in said main operating unit, said piston being connected to said percussion member, a passageway from said generating unit to said main operating unit for delivery of hydraulic liquid under pressure thereto to elevate said piston, spring means opposing elevation of said piston and exerting a restoring force downwardly thereon in opposition to the hydraulic pressure, and a control valve carried on said piston operable to relieve said hydraulic pressure in said main operating unit to initiate a downward stroke of said piston.

11. In a rotary drilling mechanism adapted for drilling the formation at the bottom of a bore hole, having a drill bit with rotatably mounted cutters thereon and an impact plunger associated therewith, the improvement in means for operating said impact plunger comprising: a cam rotated in response to rotation of one of said cutters, a cam follower for said cam, a hydraulic system operated in response to reciprocation of said cam follower by said cam for actuating said plunger, said hydraulic system comprising a pressure generating unit and a main operating unit; said generating unit having a cylinder, liquid supply means for said cylinder, a piston, and means connecting said piston to said cam follower for reciprocating said piston within said cylinder; said main operating unit having a main cylinder, a main piston within said main cylinder and connected to said plunger, conduit means from said generating unit cylinder to said main cylinder for delivery of hydraulic liquid under pressure thereto to elevate said main piston, spring means opposing elevation of said main piston and exerting a restoring force thereon in opposition to the hydraulic pressure, and a control valve operable to relieve said hydraulic pressure in said main cylinder whereby said spring means drive said piston and plunger downwardly.

12. In a rotary drilling device having a drill bit with a rotatably mounted cutter thereon and an impact plunger associated therewith, the improvement in means for operating said impact plunger comprising: a hydraulic system operated in response to rotation of said cutter, a piston operatively connected to said plunger and adapted to be elevated in response to hydraulic pressure, biasing means opposing elevation of said piston and exerting a restoring force downwardly thereon in opposition to the hydraulic pressure and a control valve operable in response to a predetermined hydraulic pressure to relieve

said hydraulic pressure; said control valve comprising a fluid inlet, a fluid outlet, closure means releasably closing said fluid outlet, a latch holding said closure means in its closed position, means operable in response to said hydraulic pressure to remove said latch, and time delay means preventing the return of said latch for a predetermined period.

13. A percussion type rotary drilling bit comprising a hollow body adapted to be rotated within a well bore to perform a drilling operation, a cutter rotatably mounted on the lower end of said body for rotation relative thereto in response to rotation of said body during the drilling operation, a percussion plunger slidably mounted for axial reciprocating movement within said body, said plunger

being movable upon actuation thereof to strike the bottom of the well bore, and means operated by the cutter in response to rotation thereof to intermittently actuate said percussion plunger.

References Cited in the file of this patent

UNITED STATES PATENTS

1,861,042	Zublin	May 31, 1932
2,033,527	Kitching	Mar. 10, 1936
2,234,798	Craig	Mar. 11, 1941
2,241,712	McNamara	May 13, 1941
2,324,552	Bailey	July 20, 1943
2,563,083	Topanelian	Aug. 7, 1951

U. S. DEPARTMENT OF COMMERCE

PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,819,041 January 7, 1958

William J. Beckham

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 7, line 34, before the word "moved" strike out "been"; column 11, line 59, for "said means operating" read -- said main operating --.

Signed and sealed this 1st day of April 1958.

(SEAL)

Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents