Jan. 20, 1970 R. K. CATTERSON 3,490,549

HYDRAULIC PERCUSSIVE DRILL

Filed Aug. 13, 1968 2 Sheets-Sheet 1

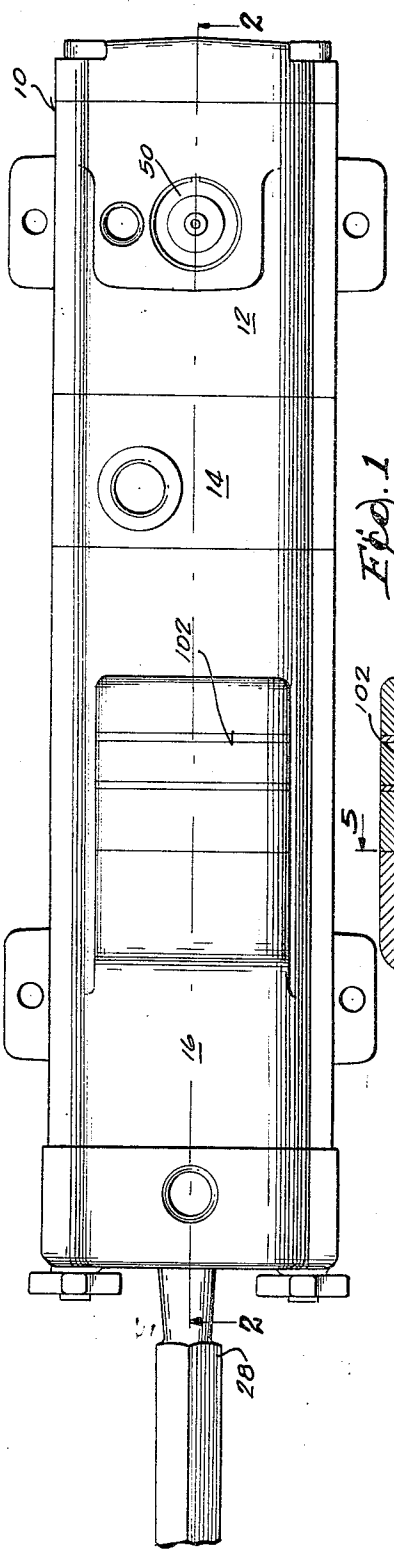


Fig. 1

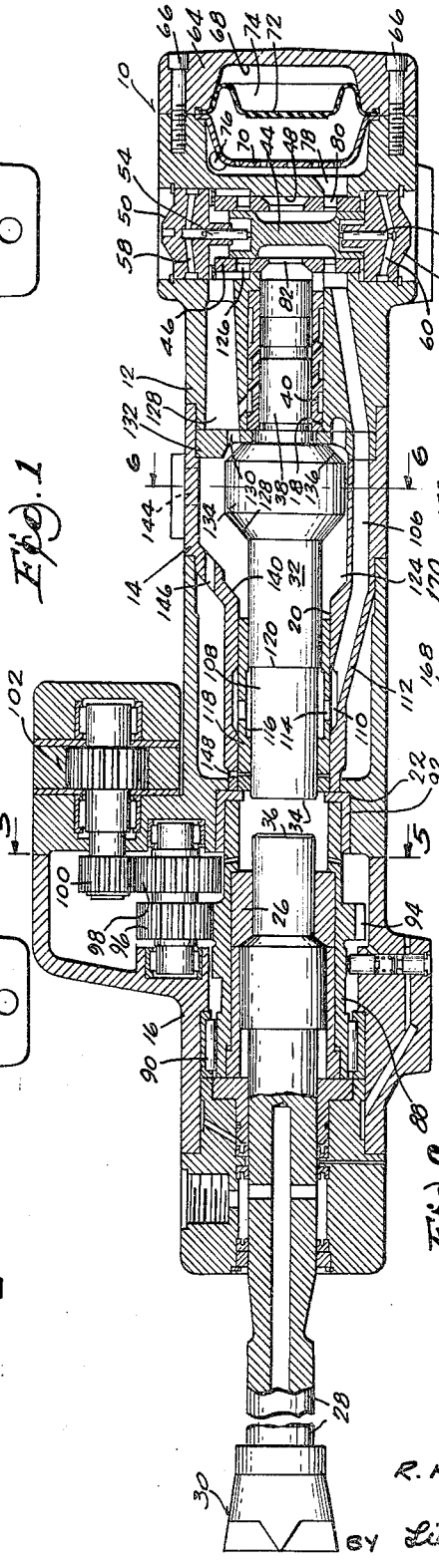


Fig. 2

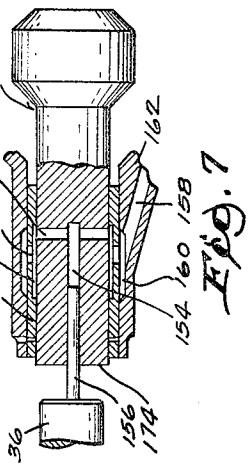


Fig. 7

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HYDRAULIC PERCUSSIVE DRILL

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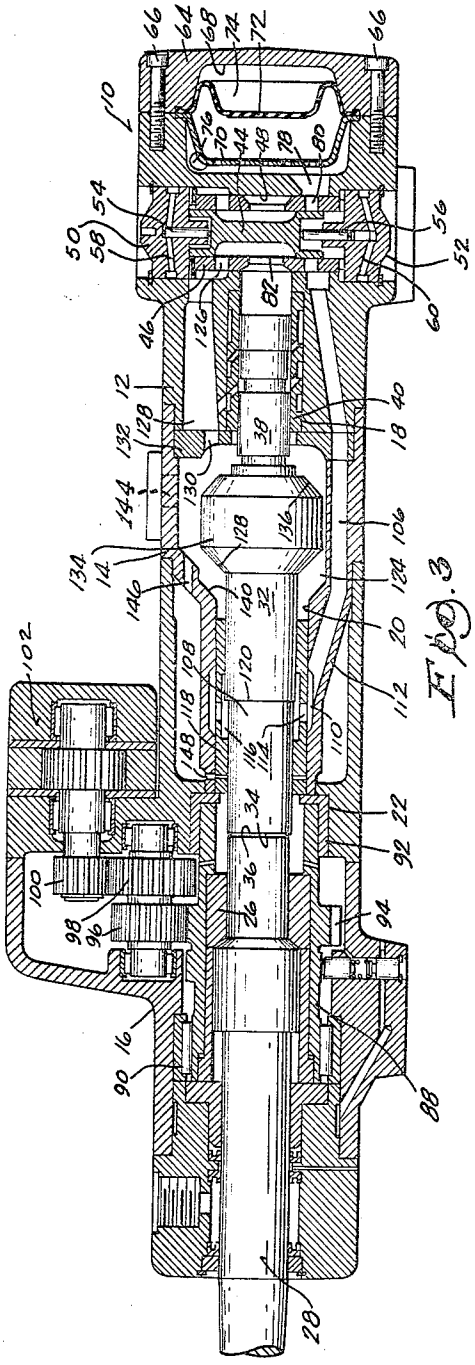


Fig. 3

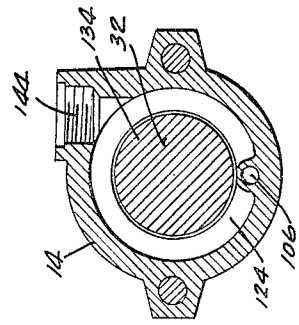


Fig. 6

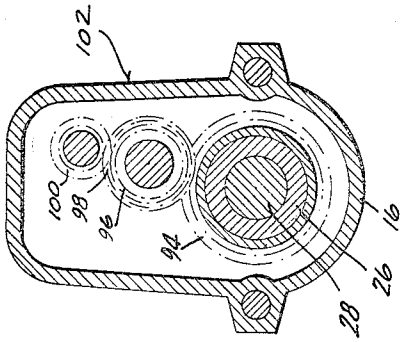


Fig. 5

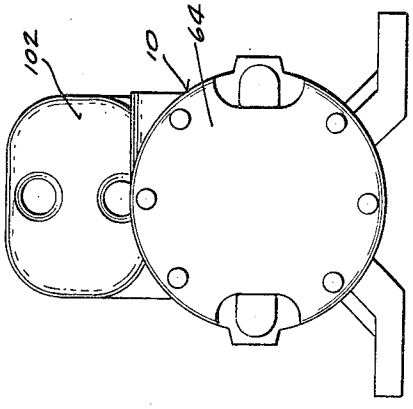


Fig. 4

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HYDRAULIC PERCUSSIVE DRILL

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Int. Cl. B25d 9/04
U.S. Cl. 173—134 10 Claims

ABSTRACT OF THE DISCLOSURE

A hydraulically actuated rock drill having percussive drilling action and provided with means for snubbing the hammer upon over-travel as well as means for minimizing the possibilities of cavitation in the piston and valve areas.

RELATED PATENTS

The present application is related to United States Patent No. 3,230,711, dated Jan. 25, 1966 to James C. Swain, George E. Manning, and David L. Thomas.

BACKGROUND

In the drilling of rock and ore, it is customary to employ percussive drilling tools which utilize pressurized fluid for delivering a succession of impact blows to a striking element or hammer which, in turn, transmits the same to a drill steel chuck for performance of the work. In most instances, these devices have heretofore utilized pneumatic motors operable by compressed air as the power source. However, it has more recently been proposed to use percussive drills powered by hydraulic fluid under pressure and acting on a reciprocating piston to motivate the striker, and one such hydraulically actuated drill is shown and described in the above-identified patent.

In these hydraulically actuated percussive drills, the impact blows imparted to the striker or hammer are necessarily at a high velocity in order to perform the required work, and considerable shock is therefore encountered during reciprocation of the striker. This is, of course, particularly true when the drill steel is running loose or free and the striker tends to overtravel on the impact stroke. Means must accordingly be provided for snubbing the hammer and absorbing the shock during such overtravel, and while prior attempts have been made in this direction, they have not all proven entirely satisfactory for various reasons.

Also, it has been found that cavitation in the vicinity of the actuating piston and valve areas has presented a rather severe problem in these hydraulically actuated devices. For example, the hammer or striker and the actuating piston come to an abrupt stop at the end of the return stroke, and the oil flowing out of the actuating piston chamber continues on from its own inertia, thus creating a vapor cavity in the vicinity of the piston. Upon shifting of the valve, high pressure oil is admitted to the piston chamber, and this oil collapses the vapor bubbles and causes severe damage to the surrounding metal parts. This condition is particularly prevelant when drilling in hard rock when the return velocity of the striker or hammer is naturally higher, thus increasing the tendency of the oil to separate from the piston at the end of the stroke and emphasizing the cavitation problem.

SUMMARY

It is therefore an object of the present invention to provide improvements in hydraulically actuated percussive drills of either the drifter or stoper type which obviate the aforesaid problems encountered with prior devices of this type.

One important object of this invention is to provide a hydraulic percussive tool which embodies highly effective shock absorbing or cushioning means for snubbing the striker element upon overtravel thereof to thereby prevent the striker from impacting against the housing or casing.

Another important object of the invention is to provide improvements in hydraulically actuated percussive tools by means of which the cavitation problem resulting from the rapid transfer of actuating fluid in the piston and valve areas is greatly minimized.

Still another object of the invention is to provide an improved hydraulically actuated percussive drill wherein the hydraulic fluid is subjected to a throttling action as it is exhausted on the return stroke of the striking element and actuating piston to thereby increase the pressure of the actuating fluid in the upstream passages and thus minimize the possible formation of cavitation bubbles while also utilizing the hydraulic fluid for effectively snubbing the striking element during overtravel.

These and other objects and advantages of the invention will become apparent from the following detailed description.

THE DRAWINGS

A clear conception of the several features constituting the present invention and of the mode of operation of a typical hydraulically actuated drifter type drill embodying the improvements may be had by referring to the drawings accompanying and forming a part of this specification, wherein like reference characters designate the same or similar parts in the various views.

FIGURE 1 is a plan view of a typical drifter type rock drill embodying the features of the present invention;

FIGURE 2 is a longitudinal section through the drill taken along the line 2—2 of FIGURE 1 with the hammer and actuating piston at the end of a return stroke and about to commence an impact stroke;

FIGURE 3 is a section like that of FIGURE 2 but with the hammer and actuating piston at the end of an impact stroke and about to commence a return stroke;

FIGURE 4 is an end view of the drill taken from the rear;

FIGURE 5 is a transverse section through the drill taken along the line 5—5 of FIGURE 2;

FIGURE 6 is another transverse section taken along the line 6—6 of FIGURE 2; and

FIGURE 7 is a fragmentary part-sectional view showing an alternate arrangement for returning the hammer.

DETAILED DESCRIPTION

While the features constituting the present invention have been shown and described herein as being advantageously applied to and incorporated in a hydraulically actuated rock drill of the drifter type, it is not intended or desired to thereby unnecessarily limit or restrict the utility thereof by reason of such specific embodiment since the improvements may obviously be embodied to advantage in various types of hydraulic impact devices. Also, for a detailed description of the operation and control of the drill motor, the impacting and rotary modes of operation, the hydraulic system, and the operation of the fluid flow control valve, reference is made to prior United States Patent No. 3,230,711 hereinabove fully identified.

In general, the hydraulic drifter drill shown herein as embodying the invention comprises, a main housing or casing **10** having essentially three sections, namely, a rear control and piston housing section **12**, an intermediate striker or hammer confining section **14**, and a front chuck and drill steel carrying section **16**. The casing sections **12**, **14**, and **16** are secured together in longitudinal align-

ment in a suitable manner and are provided with axially alined bores **18**, **20**, and **22** respectively.

A chuck **26** is rotatably confined within the bore **22** of the front section **16**, and a drill steel **28** having a work performing bit **30** is carried by the chuck **26** for rotation therewith and for axial sliding movement relative thereto. Mounted for reciprocatory movement within the bore **20** of the intermediate casing section **14** is a striker or hammer **32** having a front nose portion **34** adapted to contact the adjacent rear portion **36** of the drill steel attachment or shank bar upon movement of the striker in a forward direction. In turn, the striker or hammer **32** is motivated in a forward direction to thereby forcibly impact against the drill steel attachment **28** by means of a hydraulically actuated impact or actuating piston **38**, the actuating piston **38** being slidably housed within a ported sleeve **40** secured in the bore **18** of the casing section **12**.

Also housed within the rear casing section **12** is a control valve **44** which may be of the reciprocating spool type slidable within a ported sleeve **46** secured in a transverse bore **48** intersecting the rear end of the piston confining bore **18**. The opposite ends of the transverse bore **48** are closed by members **50**, **52**, each of which carries a valve actuating pilot piston **54**, **56**, respectively, actuated by fluid pressure conducted through ports **58**, **60** formed in the respective members **50**, **52** dependent upon the position of the actuating piston **38** to shift the control valve **44**.

The rear of the casing section **12** is closed by a cap **64** secured thereto as by means of machine screws **66**, the adjacent faces of the casing section **12** and cap **64** being recessed to provide a chamber **68**. Spanning the chamber **68** is an apertured wall-forming plate **70** which cooperates with a flexible diaphragm **72** to form an accumulator, the area **74** in back of the diaphragm being suitably pressurized as by a compressible gas. Pressurized hydraulic actuating fluid is admitted to the chamber **68** forwardly of the apertured wall **70** through an inlet port **76** and is selectively admitted to the spool valve chamber, as formed by the ported sleeve **46**, through ports **78**, **80** dependent upon the position of the valve spool **44**.

Generally speaking, the percussive operation of the hydraulic drifter drill thus far described is similar to that of the stoper drill disclosed in Patent No. 3,230,711, and reference is made to such prior patent for a detailed description thereof. Briefly, pressurized hydraulic fluid is admitted via inlet port **76** under the control of an operator. The spool valve **44** is automatically positionable along the ported sleeve **46** by the pilot pistons **54**, **56** which are actuated in response to the position of the actuating piston **38**. With the valve **44** in the position shown in FIGURE 2, pressurized hydraulic fluid is admitted through ports **78**, **80** and about the reduced portion of spool **44** to the rear face of piston **38** through port **82** in the sleeve **46**. The piston **38** is thereby forcibly driven forwardly to impact upon the rear face of the striking element or hammer **32** which, in turn, forcibly impacts upon the end **36** of the drill steel attachment **28** to thereupon drive the same toward the work.

The spool valve **44** is operated automatically as follows: A constant pressure from the pressure source is maintained in conduit **60** and acts on the pin or piston **56** which is of lesser area than the pin or piston **54**. When the piston **38** is at the beginning of the acceleration stroke as shown in FIGURE 2, it communicates this same pressure to the pin **54** of larger area through conduit **58** and thus drives the spool **44** to the position shown. When the desired acceleration has been attained, piston **38** communicates conduit **58** to exhaust, thus releasing the pressure on pin **54**. The spool **44** is thereupon driven to its limit of travel shown in FIGURE 3, and the underside or rear of the piston **38** is communicated to exhaust pressure to initiate the return stroke. The hammer **32** and actuating piston **38** may, of course, be returned to their starting positions either by means of a return spring as fully disclosed in the prior patent hereinabove referred to or hydraulically as shown herein. In operation, this cycle is constantly repeated with the actuating piston **38** and striking element **32** being reciprocated to impart a succession of percussive blows to the drill steel **28**.

In addition to this percussive action, the drill steel may also be rotated as it performs its work. For this purpose, the chuck **26** is splined to a ring gear **88** which is rotatably supported in bearings **90**, **92**. The teeth **94** of ring gear **88** mesh with the teeth of a gear **96** driven through gears **98**, **100** by a suitable fluid motor **102**. The hydraulic gear motor **102** may be operated to rotate the drill steel or shank bar **28** through the double reduction spur gear drive either independently of or simultaneously with its percussive operational mode, and for a more detailed description of the rotational mode, reference is again made to the above identified prior patent.

While the basic hydraulic system of the present device is similar to that previously used in that high pressure oil from the accumulator **68** passes through the automatic valve **44** to the actuating piston **38** which, in turn, accelerates the striker or hammer **32** and causes the same to impact against the drill rod **28**, the striking element **32** in the present instance is returned by hydraulic pressure instead of by a mechanical spring. This is accomplished by applying a constant hydraulic pressure via port **78** and passageway **106** from the accumulator **68** to an annular area **108** of reduced diameter on the hammer **32**, the annular reduced area **108** being exposed to the passage **106** by way of an annular groove **110** in the wall **112** which communicates with ports **114** opening to an annular groove **116** in the sleeve **118** within which the hammer **32** is guided. Thus, with the pressure on the rear of the actuating piston **38** removed by the valve **44** when in the position shown in FIGURE 3, the fluid pressure acting on the annular shoulder **120** defining the reduced portion **108** of the hammer **32** returns the hammer, and thus the piston **38**, to starting position as in FIGURE 2.

In addition, the present invention contemplates the provision of means for flooding the hammer cavity **124** with return pressure oil. To this end, the spool valve sleeve **46** is provided with a port **126** communicating with the hammer cavity **124** via passageway **128** and port **130** formed in the wall **132** between the piston section **12** and hammer section **14**, the flow through port **126** again being controlled by the automatic valve **44**. Thus, as the hammer **32** and piston **38** are returned with the valve spool **44** moved toward the position shown in FIGURE 3, the port **126** is opened to permit oil from the actuating piston chamber to be discharged through the port **126**, passageway **128** and port **130** to the hammer cavity **124**. The hammer cavity is accordingly flooded with return pressure oil.

The present invention also contemplates the provision of means for snubbing the hammer **32** at the end of both the impact and the return stroke by throttling the oil between a portion of the hammer and the wall which defines the hammer cavity. To accomplish this snubbing action, the hammer **32** is formed with a rear head **134** of enlarged diameter, the rear peripheral edge of which is tapered as at **136** and the front peripheral edge of which is also tapered as at **138**. The tapered rear edge **136** of the hammer head **134** extends outwardly beyond the port **130** and cooperates with the wall **132** to restrict flow through the port **130** to thus snub the hammer **32** upon its return stroke while also restricting and throttling the flow of oil exhausted from the rear of the actuating piston **38** and through valve **44**, port **126**, passage **128** and port **130**. The tapered front edge **138** of the hammer head **134** also acts as a snubber portion upon the forward stroke of the hammer **32** through cooperation with a similarly tapered annular portion **140** formed on the interior of the wall **112**. Since the hammer cavity **124** is flooded with oil as aforesaid, a certain amount of oil becomes trapped between the cooperating tapered snubbing

portions **138, 140** of the hammer head and the casing wall respectively upon the forward or impact stroke in the event of overtravel of the hammer **32**. Excess oil is, of course, exhausted from the hammer cavity **124** through a discharge port **144**, and some of the oil may be communicated to the sleeve **118** via ports **46, 48** for lubrication purposes.

An alternate arrangement for hydraulically returning the hammer to starting position at the end of each forward stroke is shown in FIGURE 7. In this modification, the hammer which is designated **152** is provided with an axial bore **154** for slidably confining a piston **156** which is extendable through the forward end **174** of the hammer. The bore **154** is placed in communication with the passageway **158** by way of an annular groove **160** in the wall **162** confining the hammer section, a port **164** in the sleeve **166** within which the hammer **152** is slidably confined, an annular inner groove **168** in the sleeve **166**, and a port **170** communicating with the chamber **154**. Piston **156** is subjected to source pressure independent of the position of the valve **44** in the same manner as hereinabove described with reference to the pin **56** with constant pressurized fluid being conducted via passageway **158**, annular groove **160**, ports **164**, groove **168** and port **170** to chamber **154** rearwardly of the piston **156**. Piston **156** is accordingly projected outwardly beyond the end **174** of the hammer **152** and into contact with the adjacent end of the drill rod **36**. Thus, with the accelerating force removed as in FIGURE 3, the hammer and piston are driven to the initial position shown in FIGURE 7. As the hammer **152** moves forwardly on its impact stroke, a back pressure is exerted within the chamber **154** which provides sufficient force to return the hammer to its starting position as shown in FIGURE 3 at the end of each impact stroke.

By reason of the improved arrangement which causes the hammer cavity **124** to become flooded with return oil pressure as hereinabove described, coupled with the snubbing action provided by the tapered portion **136** of the head **134** of the hammer and the resultant throttling of oil through port **130**, the oil pressure in the valve passages and in the actuating piston chamber is increased, thereby eliminating or at least minimizing any tendency for cavitation in these areas at the end of the return stroke. Also, by providing snubbing areas at both ends of the hammer head, the shocks attendant the hammer action are effectively absorbed, and the hammer is moreover ecectively snubbed by the cooperating tapered surfaces **138, 140** during overtravel on the impact stroke such as might be caused when the drill is freely reciprocating within a void or especially soft formations. The improved apparatus also provides for hydraulic return of the hammer and actuating piston to thereby eliminate the need for mechanical devices such as springs for effecting the return stroke.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

I claim:

1. A percussive drill, comprising, a housing, a drilling tool slidable axially within said housing and having a work-performing portion extending therefrom, a striker slideably confined within said housing in axial alignment with said tool, an actuating piston slideably confined within said housing in axial alignment with said striker, valve means communicable with a source of hydraulic fluid under pressure for alternately admitting and discharging pressurized hydraulic fluid to and from the end of said piston remote from said striker to actuate said piston and cause the striker to deliver a succession of impact blows to said tool, and means for throttling the hydraulic fluid as it is discharged by said valve means to thereby increase the pressure of the discharging fluid.

2. A percussive drill according to claim **1**, wherein the striker is provided with the means for throttling the discharging hydraulic fluid.

3. A percussive drill according to claim **1**, wherein a striker cavity is formed within the housing and the discharging hydraulic fluid is admitted to the striker cavity under control of the valve means.

4. A percussive drill according to claim **3**, wherein the striker is formed with an enlarged portion confined for movement within the cavity and which provides the means for throttling the discharging hydraulic fluid.

5. A percussive drill according to claim **3**, wherein the discharging hydraulic fluid is admitted to the striker cavity through a port in the end wall of the cavity.

6. A percussive drill according to claim **5**, wherein the striker is formed with an enlarged portion having a tapered area adjacent the end wall port which provides the means for throttling the discharging hydraulic fluid.

7. A percussive drill according to claim **6**, wherein the enlarged portion of the striker also has a tapered area remote form the end wall port which cooperates with an annularly tapered area of the striker cavity to resist movement of the striker toward the tool.

8. A percussive drill according to claim **5**, wherein the valve means is an automatically operable spool valve movable from a position wherein pressurized hydraulic fluid is admitted to the end of the piston to initiate the impact movement to a position wherein the fluid is discharged from the end of the piston through the end wall port of the striker cavity.

9. A percussive drill according to claim **1**, wherein the striker is formed with a reduced end portion remote from the actuating piston, and means is provided for conducting pressurized hydraulic fluid to said reduced end portion to return the striker to starting position after delivery of each impact blow.

10. A percussive drill according to claim **1**, wherein the striker is provided with a pilot piston remote from the actuating piston, and means is provided for conducting pressurized hydraulic fluid to said pilot piston to cause the same to return the striker to starting position after delivery of each impact blow.

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U.S. Cl. X.R.

60—51