United States Patent [19]

Romell et al.

[11] **3,741,072**

[45] **June 26, 1973**

[54] **HYDRAULIC FLUID ACTUATED PERCUSSION TOOL**

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[22] Filed: **Feb. 17, 1971**

[21] Appl. No.: **116,014**

[52] **U.S. Cl.** **91/290,** 91/277, 138/31

[51] **Int. Cl.** **F011 25/04,** F011 31/00

[58] **Field of Search** 91/290, 291, 277; 138/30, 31; 92/134

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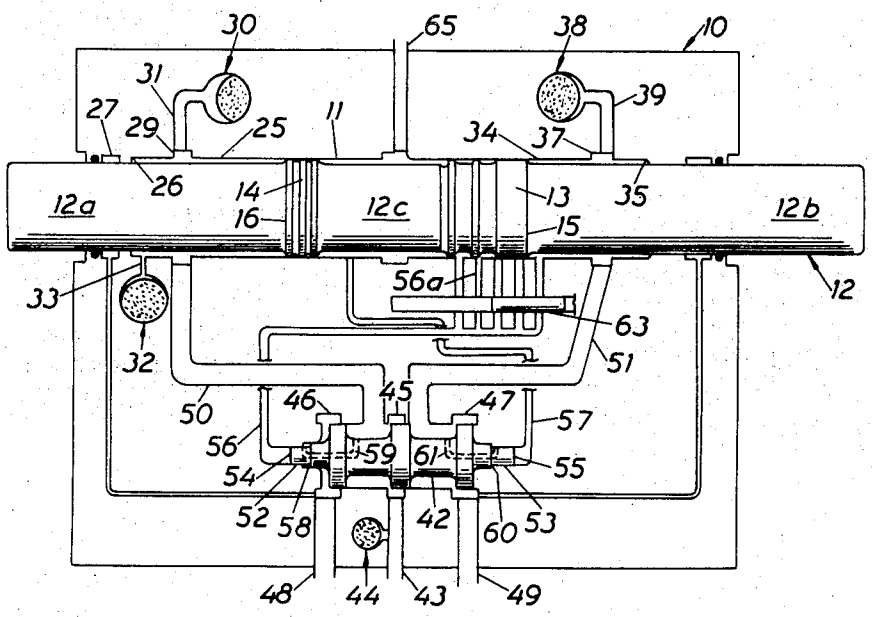
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[57] **ABSTRACT**

A hydraulic percussion tool such as a drill, a crusher or a ram, having a hammer piston reciprocating in a cylinder. A hammer piston controlled valve is arranged to pressurize and drain alternately two pressure chambers formed between the cylinder and the hammer piston so as to cause reciprocation of the hammer piston. Energy accumulators are connected directly to the pressure chambers.

4 Claims, 5 Drawing Figures



PATENTED JUN 26 1973

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SHEET 1 OF 2

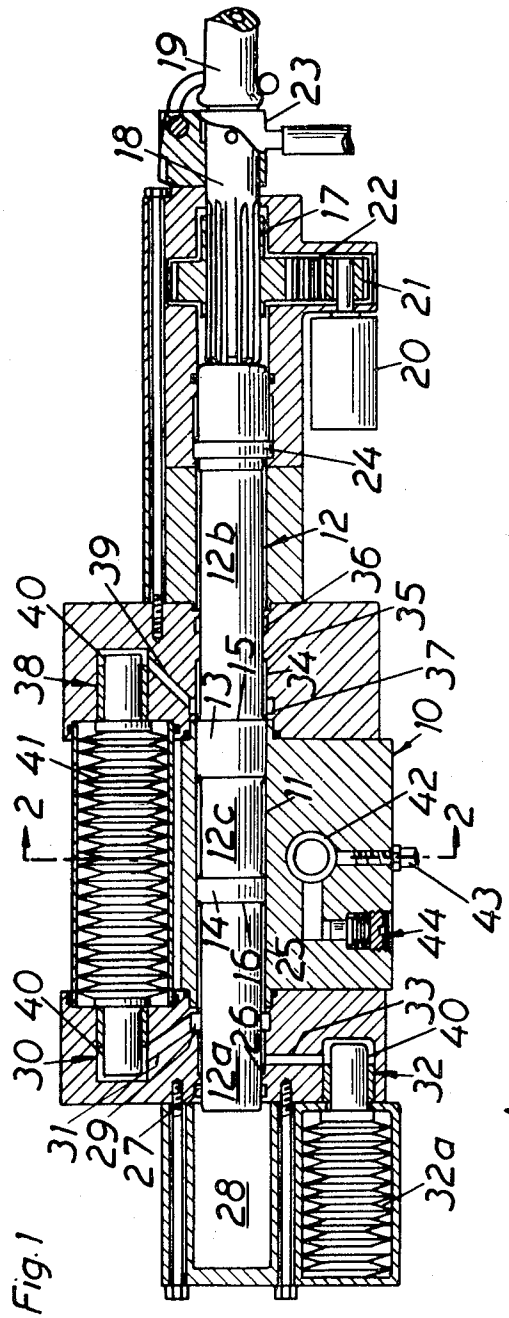


Fig.1

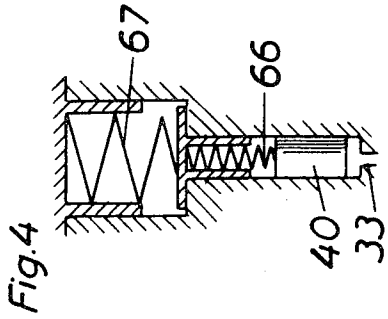


Fig.4

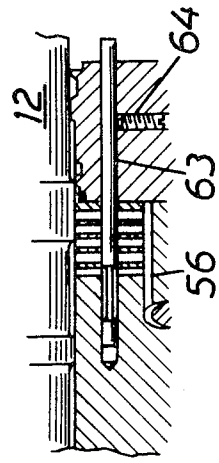


Fig.3

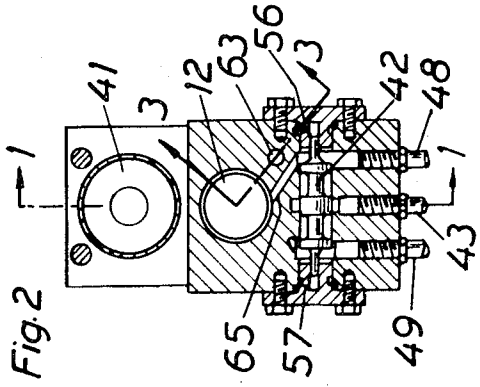


Fig.2

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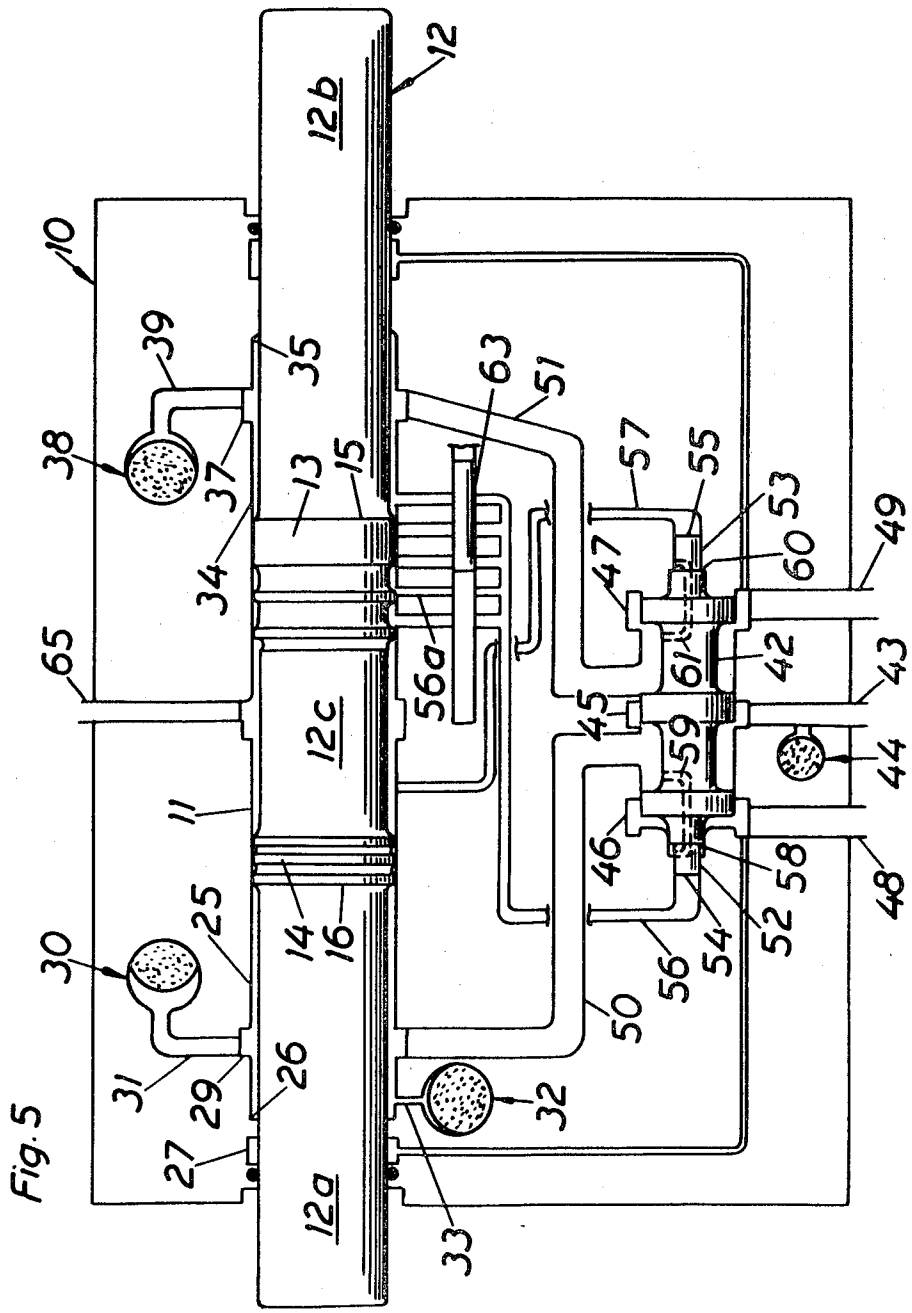


Fig. 5

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HYDRAULIC FLUID ACTUATED PERCUSSION TOOL

BACKGROUND OF THE INVENTION

This invention relates to hydraulic fluid actuated percussion tools of the type which comprises a hammer which reciprocates in a cylinder and is arranged to provide shock energy in a chisel, a drill rod or the like. Particularly it relates to a tool which has a hammer piston controlled distributing valve arranged to pressurize and drain alternately two pressure chambers formed between the cylinder and the piston so as to reciprocate the hammer piston.

The flow which is necessary to provide the reciprocatory movement of the hammer piston varies periodically with the velocity of the piston and the position of the valve. As the source of pressurized hydraulic fluid is usually used a positive displacement pump, the flow of which cannot be varied in time with the movement of the piston. In prior art, the periodical variation of the flow is compensated by means of a hydraulic fluid accumulator in the conduit for supplying fluid to the valve. When, during a return stroke, the valve shifts to connecting the mentioned second pressure chamber to the source of pressurized hydraulic fluid, fluid will then be urged through the valve and out into the accumulator. Therefore, the flow through the valve will momentarily be much larger than the flow delivered by the pump, and the fluid friction losses in the valve can be considerable.

It is an object of the invention to provide an effective pressurized hydraulic fluid driven percussion tool in which kinetic energy is absorbed from the hammer piston during a part of the return stroke and returned to the hammer piston during the work stroke, and in which the fluid friction losses are small.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described in more details with reference to the accompanying drawings in which an embodiment of a percussion tool according to the invention is shown as an example.

In the figures, FIG. 1 is a longitudinal section along line 1—1 in FIG. 2 through the percussion tool, FIG. 2 is a transverse section along line 2—2 in FIG. 1, FIG. 3 is a fragmentary longitudinal section along line 3—3 in FIG. 2, FIG. 4 is an alternative design of some details shown in FIGS. 1–3, and FIG. 5 is a circuit diagram of the percussion tool shown in FIGS. 1–3. Corresponding details have been given the same reference numeral in the various figures.

The percussion tool shown in the figures is made as a rock drill which consists of a housing **10** which constitutes a cylinder **11** for a reciprocating hammer piston **12**. It is to be understood that the expression "cylinder" is used in the claims and in the specification to define the chamber in which the hammer piston reciprocates, and that the cylinder is not limited to have a straight cylindrical form, but may for instance have stepped portions. The hammer piston consists of a cylindrical rod with two piston portions **13, 14** having piston surfaces **15, 16.** These piston portions have annular pressure equalizing grooves (shown in FIG. **5** only) which improve the centering in the cylinder and counteract oblique load of the piston if such load should occur. The portion of the hammer piston that extends rearwardly from the piston portion **14** is denoted by **12***a*, and the portion that extends forwardly from the piston portions **13** is denoted by **12***b*. The rod portion between the piston portions **13, 14** is denoted by **12***c*. A sleeve **17** is arranged in the forward end of the housing **10** so as to receive a shank **18** of a drill string **19** (shown as a drill steel). The sleeve **17** has internal splines and the shank **18** has mating external splines so that the drill string will rotate conjointly with the sleeve. A pressurized hydraulic fluid driven rotary motor **20**, e.g. a sliding vane motor, is attached to the housing **10** and it has a drive gear **21** which rotates the sleeve **17** over a gear **22** which is partly concealed in FIG. **1.** Flushing fluid is supplied to the axial hole of the drill rod **19** through a swivel **23** which is slipped onto the shank **18.** The shank **18** can be moved into the sleeve **17** to abut against the axially movable anvil block **24** which then moves to a rear stop position as shown in FIG. **1.** The anvil block is an anvil to the hammer piston **12** but it could be omitted and the end surface of the shank **18** be an anvil to the hammer piston. A rear annular pressure chamber **25** is defined by the cylinder **11,** the rod portion **12***a*, the piston surface **16** on the piston portion **14,** and the front surface of a sealing ridge **26.** The oil that leaks through the circular clearance space between the sealing ridge **26** and the rod portion **12***a* is collected in a circular groove **27** which, as shown in FIG. **5,** may be drained directly to tank through a conduit not shown, but, advantageously, it is drained by means of a pump so that there will be suction in the groove. By this arrangement the fluid is prevented from leaking to the closed end chamber **28** which encloses the rear end of the rod portion **12***a*. The cylinder **11** has another circular groove **29** to which an accumulator **30** is connected by means of a passage **31.** By means of a passage **33,** another accumulator **32** is connected to the cylinder **11** at the rear of the pressure groove **29.**

A forward annular pressure chamber **34** is defined in the same way by the cylinder **11,** the rod portion **12***b*, the piston surface **15** on the piston portion **13,** and the rear surface of a circular sealing ridge **35.** Advantageously, a collecting groove **36** is drained in the same way as the collecting groove **27.** Outside the collecting grooves **27, 36** sealing rings are disposed so as to seal against the hammer piston. An accumulator **38** is connected to a circular pressure groove **37** by means of a passage **39.** Each of the accumulators **30, 32, 38** has a spring-loaded piston **40** which is slidable in a cylinder. The pistons **40** of the accumulators **30, 38** are loaded by a common spring unit **41** formed by a pile of Belleville-springs braced between the piston. The piston of the accumulator **32** which is also identified by reference numeral **40** is loaded by a pile of Belleville-springs **32***a*.

A distributing valve in the form of a slide **42** is supplied with pressurized hydraulic fluid through a supply conduit **43.** An accumulator **44** is permanently connected to the supply conduit **43** so as to receive the hydraulic fluid that is supplied when the slide **42,** as shown in FIG. **2,** blocks the supply conduit **43** for a short moment when shifting position. The accumulator **44** is so loaded that it is substantially inactive at the pressures at which the accumulators **30, 38** are active. In FIG. **5,** the various passages of the housing **10** are schematically illustrated. The above mentioned accumulators **30, 32, 38, 44** are in this figure shown as gas pressure loaded accumulators. The inlet **43** leads to an annular inlet chamber **45** in the cylinder of the valve.

The cylinder of the valve has also two annular outlet chambers **46, 47** to which return conduits **48, 49** are connected. These return conduits lead to a non-illustrated sump from which a non-illustrated positive displacement pump sucks hydraulic fluid so as to supply the supply conduit with a constant flow of pressurized hydraulic fluid over a non-illustrated control valve.

With the slide **42** in its righthand end position (FIG. 5), pressurized hydraulic fluid is supplied to the rear pressure chamber through a combined supply and drain passage **50** while the forward pressure chamber **34** drains to the return conduit **49** through another combined supply and drain passage **51.** With the slide **42** in its non-illustrated lefthand end position, pressurized hydraulic fluid is instead supplied to the forward pressure chamber **34** through the passage **51** simultaneously as the rear pressure chamber is draining through the passage **50.**

The slide **42** has projecting end portions **52, 53,** the end surfaces **54, 55** of which are actuated by the pressure in control passages **56, 57** which end in the cylinder **11.** The terminate portion **52** has an annular piston surface **58** which is actuated by the pressure in the passage **50** via a passage **59** in the slide, and the end portion **53** has a similar piston surface **60** which is actuated by the pressure in the passage **51** via a passage **61** in the slide. The piston surfaces **58, 60** constitute holding surfaces and are therefore of smaller area than the end faces **54, 55** which constitute shifting surfaces.

The control passage **56** has five branches which end in the cylinder **11.** The reference numeral **56a** denotes one of these branches. The pin **63** can be set into various positions so as to block one or several of these branches. By reason of this arrangement, the rear point of reversal of the piston and consequently the percussion energy per blow can be varied. By means of a locking screw **64** (FIG. 3), the pin **63** can be locked in the various positions. A passage **65** is connected to drain, suitably as shown in FIG. **2,** to one of the annular chambers **46, 47,** so as to constantly drain the space between the piston portions **13, 14.** Thus, one of the control passages **56, 57** will always be drained through this passage **65** when the other one of these control passages is supplied with pressurized hydraulic fluid.

The operation will now be described with reference to FIG. **5.**

Assume that the slide **42** is in the position shown in FIG. **5** so that the rear pressure chamber **25** is supplied with pressurized hydraulic fluid and the forward pressure chamber **34** is being drained. Assume further that the hammer piston **12** is moving forwards. The pin **63** blocks the three right branches of the control passage **56.** In the position in which the hammer piston **12** is shown in FIG. **5,** the control passage **57** is being drained through the draining passage **65** and the control passage **56** has been drained into the forward pressure chamber **34** all the way until the piston portion **13** has covered the branch **56***a* of the passage **56.** The slide **42** is positively retained in its position because the pressure in the supply passage **50** is transmitted to the holding surface **58** of the slide. As the hammer piston **12** continues its forward movement (to the right in FIG. **5**), the control passage **56** is again opened to its draining position, in this case to the drain passage **65.** Thereafter, when the piston portion **14** passes the mouth of the control passage **57,** its opens the latter to the rear pressure chamber **25** from which the pressure is conveyed through the control passage **57** to the end face **55** of the slide. Now, the slide shifts to its non-illustrated position (to the left in FIG. **5**) so that the forward pressure chamber **34** is pressurized while the rear pressure chamber **25** is drained. This takes place just before the hammer piston strikes the anvil block **24** and the hammer piston **12** does not retard appreciably before delivering the blow. The hammer piston **12** rebounds after the inpingement, but the flow of pressurized hydraulic fluid supplied through the supply passage **51** to the forward pressure chamber **34** is at the beginning larger than what can be received by the pressure chamber. Therefore, the accumulator **38** receives fluid at the beginning, but when the hammer piston **12** has reached the speed which corresponds to the flow supplied by the pump, the accumulator **38** starts discharging to the pressure chamber **34** and thus further increases the speed of the hammer piston **12.** The slide **42** remains in its lefthand position because the pressure in the supply passage **51** is conveyed to the holding surface **60** of the slide. The control passage **57** is already in communication with the drain passage **65** when the piston surface **15** of the piston portion **13** passes the branch passage **56***a* of the control passage **56** so that the pressure of the forward pressure chamber **34** is transmitted through the control passage **56** to the end face **54** of the slide. The slide **42** shifts therefore into its righthand position (shown in FIG. **5**) where it remains because of the fluid pressure upon the holding surface **58.** Pressurized hydraulic fluid is now supplied from the inlet **43** to the rear pressure chamber **25** and the hammer piston **12** retards due to the hydraulic fluid pressure upon the piston surface **16.** The accumulator **30** now receives the hydraulic fluid flow supplied through the supply conduit **50** as well as the hydraulic fluid that is forced out from the pressure chamber **25** because of the rearward movement of the hammer piston **12** which decreases the volume of the pressure chamber **25.** During normal return strokes, the hammer piston **12** reverses its movement because of the pressure in the rear pressure chamber **25** before moving so far to the rear that the piston surface **16** reaches the rear edge of the groove **29,** and the accumulator **30** is therefore continuously in communication with the pressure chamber **25.** The accumulator **32** is so loaded as to be inactive during this operation. The accumulator **30** is also supplied with pressurized hydraulic fluid during the first part of a work stroke since the pressurized fluid flow through the supply passage **50** is larger at the beginning than what the pressure chamber **25** can receive. However, when the hammer piston **12** reaches the speed that corresponds to this supplied flow, the accumulator **30** starts instead to supply pressurized hydraulic fluid to the pressure chamber **25** and thus increases the speed of the hammer piston further.

Thus, kinetic energy of the hammer piston from the return stroke is stored in the accumulator **30** and this energy is delivered back to the hammer piston during the succeeding work stroke.

If the drill rod shank **18** should not be pressed against the anvil block **24** or if no shank **18** should have been inserted through the sleeve **17,** then the hammer piston will not rebound even if the anvil block **24** should happen to be in the rear position, but the hammer piston will then pass by its normal forward point of reversal and its piston surface **15** will pass by the groove **37** so that the accumulator **38** and the supply passage **51** both

are shut off from the forward pressure chamber 34 which now acts as a damping chamber. However, the supply passage 51 is still in communication with the accumulator 38 through the pressure groove 37. The pressure in the pressure chamber/damping chamber 34 is now instantaneously increased for instance to a pressure two or three times the pump pressure. Thereby, hydraulic fluid flow is forced to the rear through the clearance space between the piston portion 13 and the cylinder 11 and out into the pressure groove 37. Simultaneously the slight amount of hydraulic fluid which passes by the sealing ridge 35 out into the collecting groove 36 is increased. The hammer piston 12 will therefore be braked to a quiet but cushioned stop. Owing to leakage past the piston portion 13 from the pressure groove 37 to the pressure chamber 34, the hammer piston 12 will then move slowly rearwardly until the piston surface 15 reaches the pressure groove 37, whereupon the hammer piston 12 starts to accelerate to its normal return stroke.

The hammer piston 12 may get an exceptionally hard rebound from the anvil block 24 after certain impacts. This happens especially if the percussion tool is used as a feather and wedge device for splitting a stone block. If the percussion energy in a specific blow is too small to split the stone block, as much as 80 percent of the percussion energy may be returned to the hammer piston as kinetic energy. This results in the speed of the hammer piston 12 being so high that the piston surface 16 passes the pressure groove 29, and thus the accumulator 30 and the supply passage 50 both become closed off from the rear pressure chamber 25. However, the supply passage 50 will still be in communication with the accumulator 30 by means of the pressure groove 29. The two accumulators 30 and 38 should have level characteristic curves since they are connected to the inlet 43 from the pump all the time they are active; i.e. they should be so loaded that the hydraulic fluid pressure therein increases slowly with the accumulated hydraulic fluid amount. The accumulator 32, on the other hand, can preferably have a very steep characteristic curve and, furthermore, it may be so loaded that it is inactive until the point where the pressure in the pressure chamber substantially exceeds the pump pressure. As a result, the pressure in the pressure chamber 25 increases instantaneously to a degree which for instance may be twice the pump pressure when the piston surface 16 passes the pressure groove 29 before the accumulator 32 starts receiving any hydraulic fluid. The result is that the hammer piston 12 is braked to a stop very rapidly, but with a cushioned effect, by the accumulator 32, and this braking energy is returned to the hammer piston 12 in the succeeding work stroke. Therefore, the hammer piston 12 will now transmit to the anvil block a percussion energy, which is considerably larger than that of a normal blow. The distance of the piston travel will not be substantially increased because of the high braking pressure in the accumulator 32.

The advantage of this automatic and very large increase in percussion energy when a normal stroke is not sufficient is very important especially in connection with large crushers or rams designed to be mounted on the arm of a digging machine or the like. The rotary motor 20 is of course not necessary in a crusher or ram according to the invention, but the attachment of the work tool can be simplified compared with the attachment of the drill shown in the figures.

According to the invention, the two accumulators 30 and 32 can be replaced by a two-stage accumulator which, instead of the accumulator 32, is connected to the passage 33. Such a two-stage accumulator is schematically shown in FIG. 4. The spring 66 corresponds to the spring which loads the accumulator 30, and the spring 67 corresponds to the spring which loads the accumulator 32.

The invention can also be varied in other ways within the scope of the claims.

What I claim is:

1. A hydraulic fluid actuated percussion tool comprising a housing forming a cylinder, a hammer piston reciprocable in the cylinder between a forward percussion stroke and a rearward rebound stroke to deliver percussion energy to a work tool, a first variable volume pressure chamber in said cylinder for urging the piston forward during the percussion stroke defined between the piston and the cylinder, a second variable volume pressure chamber in said cylinder for urging the piston rearward during the rebound stroke defined between the piston and the cylinder, valve means connected to a source of pressurized hydraulic fluid and to said first chamber by first passage means and to said second chamber by second passage means for cyclically pressurizing and draining said chambers to reciprocate the hammer piston, a first accumulator connected to said first passage means and to said first pressure chamber for storing kinetic energy from the rearward rebound strokes of a predetermined normal percussion force of the piston and reversing it to the forward percussion strokes, a second fluid accumulator connected to said first pressure chamber at a point located rearwardly of the connection of said first passage means to the first pressure chamber, said second accumulator being normally inactive to reciprocate the piston at the motive pressure of the hydraulic fluid while being effective to reverse said piston to the forward percussion stroke at pressures higher than the motive pressure of the hydraulic fluid, produced by the hammer piston overtravelling its normal rearward reversing point so as to cover said first passage means when rebounded by a percussion stroke exceeding the normal percussion force.

2. A tool as claimed in claim 1 in which said passage for supplying fluid to said first pressure chamber and the passage to the first accumulator terminate in a common annular groove in the cylinder.

3. A hydraulic fluid actuated percussion tool comprising a housing forming a cylinder, a hammer piston reciprocable in the cylinder between a forward percussion stroke and a rearward rebound stroke to deliver percussion energy to a work tool, a first variable volume pressure chamber for urging the piston forward during the percussion stroke defined between the piston and the cylinder, a second variable volume pressure chamber for urging the piston rearward during the rebound stroke defined between the piston and the cylinder, hammer piston controlled distribution valve means connected to a source of pressurized hydraulic fluid, to the first pressure chamber by means of a first connection passage, and to the second pressure chamber by means of a second connection passage, the distribution valve means having a first position in which it pressurizes the first connection passage and drains the second

and a second position in which it drains the first connection passage and pressurizes the second connection passage, the hammer piston actuating the valve means to shift from the second position to the first position while moving rearward during the rebound stroke and actuating the valve means to shift from the first to the second position when close to its impact position, a first accumulator connected to said first supply passage for storing kinetic energy from the rebound strokes of the piston of a predetermined normal percussion force and reversing it to the forward percussion strokes, a second fluid accumulator connected to said first pressure chamber at a point located rearwardly of the connection of said first supply passage to the first pressure chamber and being normally inactive at the motive pressure of the hydraulic fluid while effective to reverse said piston to its forward percussion stroke at pressures higher than the motive pressure of the hydraulic fluid, produced by the hammer piston overtravelling its normal rearward reversing point so as to cover said first passage means upon rebound from a percussion stroke exceeding the normal percussion force.

4. A tool as claimed in claim 3 in which said supply passage for supplying fluid to said first pressure chamber and the passage to the first accumulator terminate in a common annular groove in the cylinder.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,741,072 Dated June 26, 1973

Inventor(s) Gunnar Vigg Riss Romell and Ake Torsten Eklof

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

[73] Assignee - ATLAS COPCO AKTIEBOLAG

[30] FOREIGN APPLICATION PRIORITY DATA

February 19, 1970 Sweden.....2090/1970

Signed and sealed this 23rd day of July 1974.

(SEAL)
Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S GOVERNMENT PRINTING OFFICE : 1969 O—366-334.