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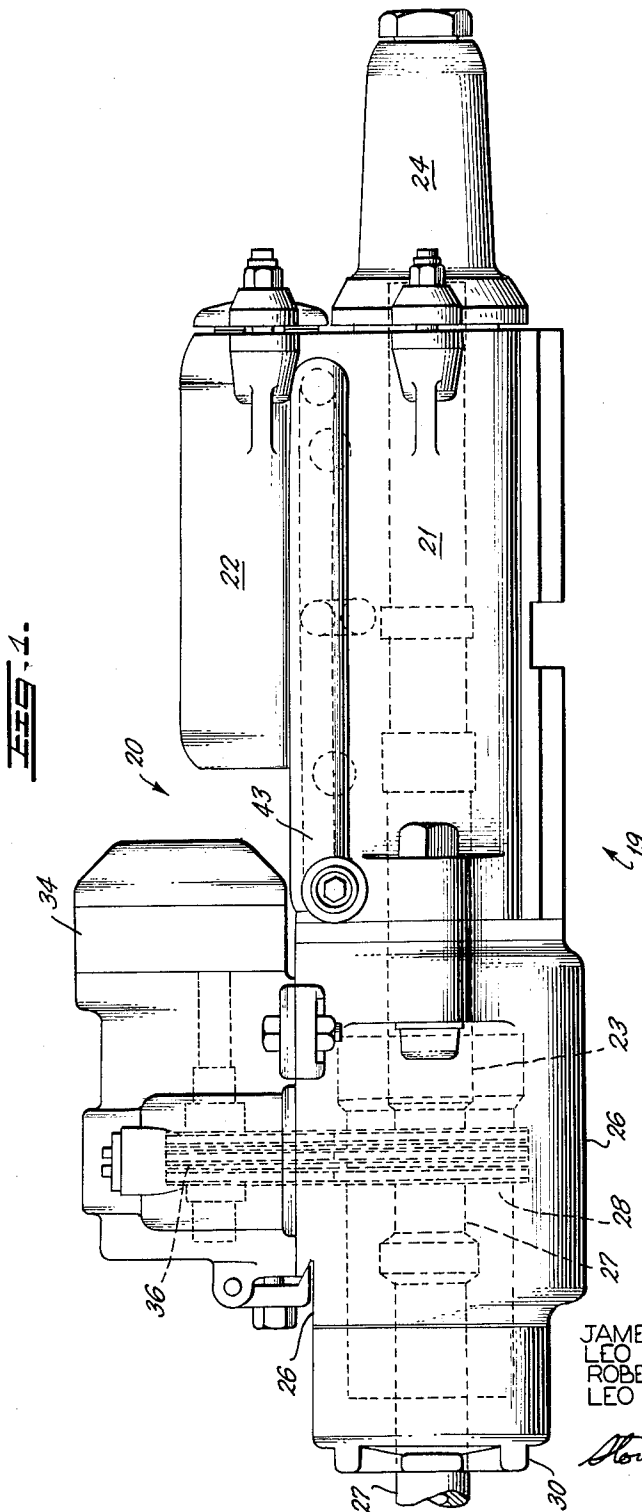
J. C. HENNING ETAL

3,232,176

PERCUSSION TOOL

Filed July 31, 1962

4 Sheets-Sheet 1



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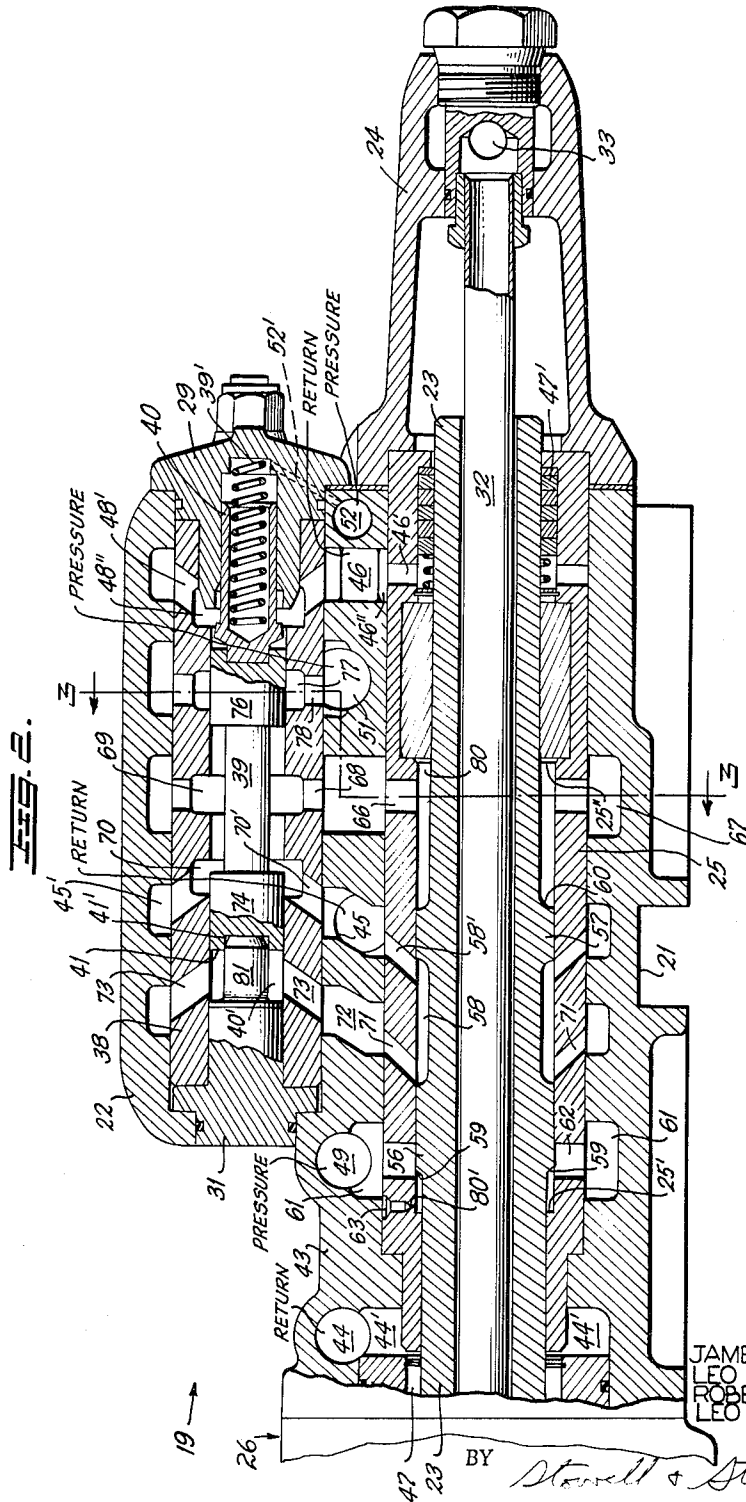
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4 Sheets-Sheet 2



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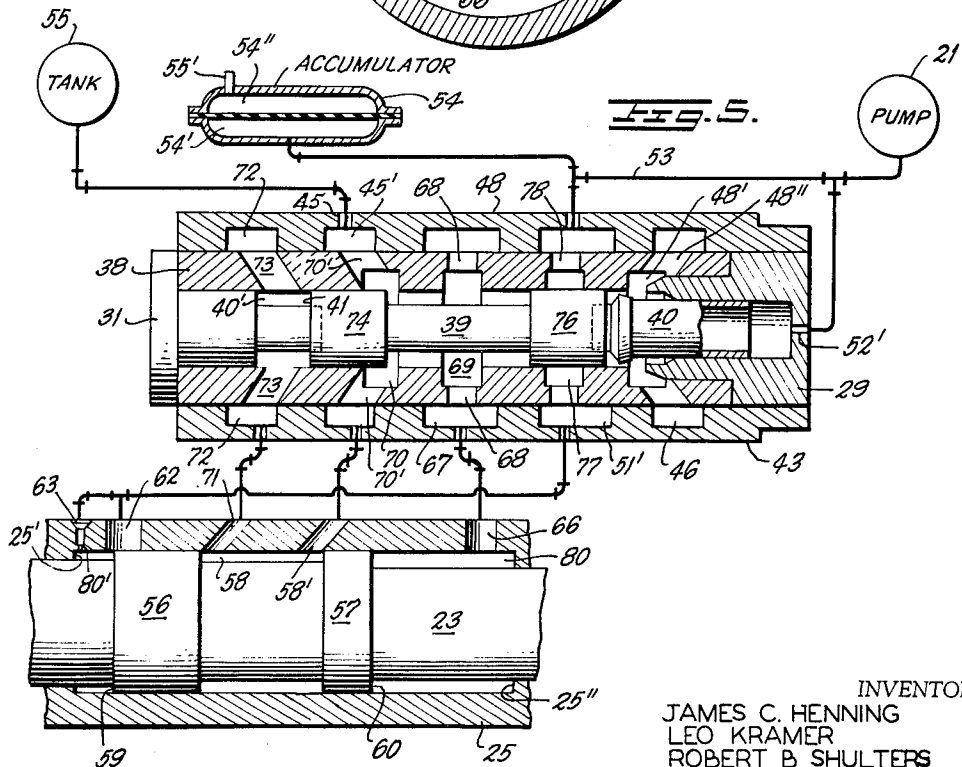
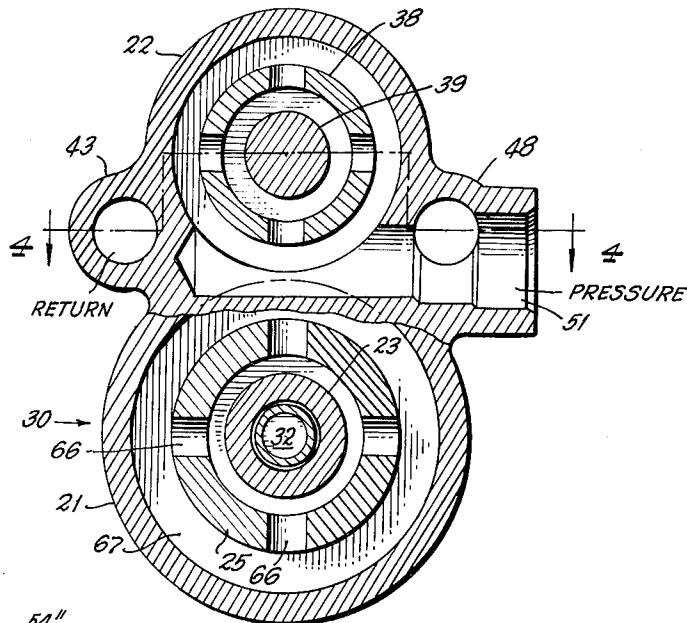
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FIG. 3.



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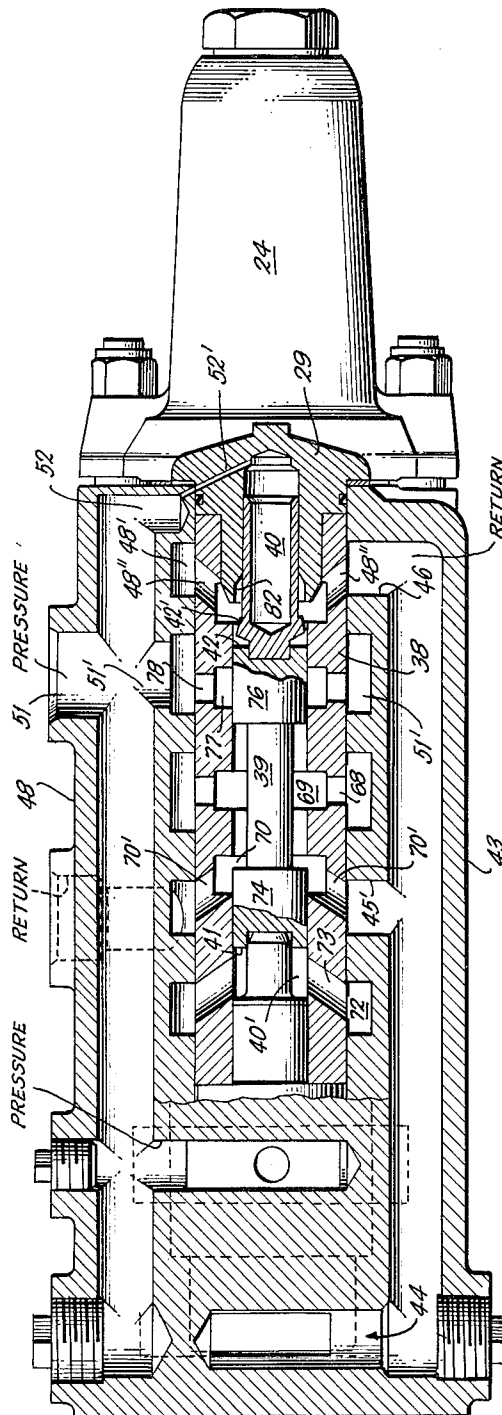
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Fig. 4.



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PERCUSSION TOOL

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4 Claims. (Cl. 91—300)

The present invention relates to percussion tools such as rock drills and in particular to percussion tools that are hydraulically driven by substantially non-compressible fluids.

The primary object of the invention is the provision of a hydraulically driven percussion device, and a method of operating the same, having increased efficiency in terms of energy output per unit of input.

A specific related object attaining the foregoing object is the provision of ways and means by which the duration of impact between anvil and hammer is relatively long thus maximizing energy transmittal to the tool actuated thereby.

In its broadest form, the invention comprises a hydraulic percussion device which includes a differential-area reciprocable hammer and a control valve directly responsive to the position of the hammer.

A specific form of the invention comprises an improved system for utilization of input energy in a hydraulic percussion device of the type including a pressured hydraulic system having an accumulator, a pressure fluid reciprocable differential area hammer, and a control valve with a reciprocable differential area spool operative in response to hammer position to reverse the direction of the hammer travel including means maintaining the smaller area of said hammer in continuous communication with said pressured hydraulic system, means including said control valve for alternately connecting the pressured hydraulic system to the larger area end of said hammer, means maintaining the smaller area end of said reciprocable spool in continuous communication with said pressured hydraulic system, and means including said hammer for alternately connecting said pressured hydraulic system to the larger area end of said spool.

Referring to the drawings:

FIG. 1 is a side elevational view of a percussion tool embodying the present invention;

FIG. 2 is a sectional view through the hammer and valve mechanism of the device shown in FIG. 1;

FIG. 3 is a section substantially on line 3—3 of FIG. 2;

FIG. 4 is a section substantially on line 4—4 of FIG. 3; and

FIG. 5 is a schematic view illustrating the hydraulic flows through the percussion tool illustrated in FIGS. 1 through 4.

As best seen in FIGS. 1 and 2 the unit comprises a tool generally designated 19 basically comprising a main body 20 which includes both a hammer housing collectively designated 21 and a valve housing, collectively designated 22.

The hammer housing 21 is provided with a central sleeve 25 in which there is reciprocally positioned a hammer 23. The housing is closed at the top by a cap or back-head 24.

Attached to the lower end of the hammer housing 21 is an anvil housing, collectively designated 26, containing a striker bar or anvil 27 and a rotatable member 28. The anvil 27 is slidably mounted for longitudinal reciprocation inside the rotating member 28 and the rotating member is in turn journaled in suitable bearings for rotation inside

the housing. A lower head cap 30 closes the housing. The anvil extends through the cap and it may be threaded at its lower portion, not shown, to accept a coupling for a drill steel or the like to which is eventually affixed, at its farthest end, a drill bit.

Extending longitudinally through the top cap 24, the hammer and into the anvil 27 is a tube 32 which provides a passage for compressed air for use in hole blowing. Pressured air is supplied through a suitable supply port 33.

Rotation of the anvil and attachments is accomplished in the embodiment shown by means of an independent rotational motor 34 preferably of the high torque hydraulic type which drives rotating member 28 by means of a chain 36. The motor 34 is clamped to the anvil housing 26.

In the embodiment shown, the rotational motor 34 is controlled by an entirely independent hydraulic circuit and forms no particular part in the specific operation of the hammer assembly and control valve. Therefore, this description will be confined to details of the hammer assembly and its operation.

As hereinbefore described attached to and functionally connected to the hammer housing 21 is the control valve housing 22 which includes a central sleeve 38 and suitable top and bottom closures 29 and 31. A valve spool 39 is reciprocally mounted in the bore of the sleeve 38.

The bottom end 41 of the spool 39 has a cross-sectional area measured by the maximum outer diameter of the spool while the top end 42 has its effective cross-sectional area measured by the outer diameter of a small mounted hollow extension 40. This extension is fitted loosely in a recess in the spool end and is held in place therein by system pressure fluid or, where desired, a spring 39' illustrated only in FIG. 2 may also be employed. Such arrangement avoids concentric pressures on the spool which would develop if the extension was held in place by a press fit.

The main housing is provided on one side with a hydraulic return manifold 43, FIG. 3, which is always in direct communication with return ports 44, 45 and 46, FIGS. 3 and 4. Of these, return ports 44 and 46 serve the function of accommodating leakage past the hammer 23 to prevent pressure buildup adjacent seals 47 between the hammer housing 21 and the anvil housing 26 and seals 47' at the top of the hammer housing adjacent the cap 24. Thus, hydraulic fluid leaking around the seals 47 and 47' merely returns to the hydraulic tank or sump 55 via the annular groove 44' formed between the hammer housing and anvil housing; and ports 46' and annular groove 46'' adjacent the top seals. Cooperating groove 48' and ports 48'' return to tank hydraulic fluid leaking past the upper end of valve spool 39 and extension piece 40.

The return port 45 is utilized in the operative cycle of the tool to dump fluid on the upstroke of the hammer 23 and on the downstroke of the valve spool 39, all as will hereinafter be explained in connection with operation of the device.

A pressured fluid manifold 48, best shown in FIG. 3, is mounted along the other side of the main housing 21 and this manifold is in continuous communication with pressure inlet ports 49, 51 and 52, FIGS. 2 and 4.

As will be seen by referring to the system diagram (FIG. 5) the pressure manifold 48 is always in communication with the pressured fluid supply line 53 and the hydraulic accumulator 54.

As best seen in FIG. 2, the hammer 23 is equipped with spaced-apart lands 56 and 57 which between them define a control passage or groove 58. These lands also provide the effective areas against which pressured fluid acts to effect reciprocation of the hammer. The areas comprise annulus 59 at the lower or outer face of the bottom

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land 56 and annulus 60 at the top or outer face of land 57.

The portion of the sleeve 25 in which the lands of the hammer reciprocate is of uniform inside diameter and terminates at shoulders 25' and 25'' at its lower and upper ends respectively. The hammer itself is of a lesser outer diameter upwardly of land 57 than it is downwardly of land 56, thus providing a smaller area on lower annulus 59 than on upper annulus 60. These differential areas are important because the smaller area annulus 59 is always in communication with pressure fluid through pressure port 49, annular groove 61 and ports 62 and 63 in sleeve 25. Hence the relatively larger annulus at the top provides the required downward force, when pressurized, to overcome the constant pressure exerted against the lower annulus 59.

The top of the valve spool 39 is also maintained under constant system pressure through the pressure port 52 and connecting conduits 52' (shown in dotted lines in FIG. 2). This acts to initiate movement of the spool upon release of pressure from its opposite end. The continuous direct communication of one end of the valve spool and hammer with the pressure system through the pressure manifold 48 is important for conservation of energy input.

The remaining passages and ports will be referred to in the following description of operation.

Operation

If the system as shown in the drawings is placed under pressure by the pump 21' the pressured fluid acts against the annular area 59 causing the hammer 23 to move to the right or up position. Fluid urged ahead of the upper annulus 60 passes out through ports 66 in the sleeve into an annular groove 67 in the valve housing 21 thence through port 68 into an annular groove 69 in the valve sleeve 38 whence it flows out through groove 70 and ports 70' into the common groove 45' thence through return outlet 45 to return to the tank 55.

As the hammer continues upward travel, the land 56 first closes a triggering port 71 which communicates through common groove 72 in the hammer and valve main housings and connecting port 73 into the bore 40 of the valve sleeve 38. The first action is simply to block port 71, but continued upward travel of the hammer brings the trailing edge of land 56 past port 71. This admits pressured fluid from pressure inlet 49, groove 61, passages 62, 71, 72 and 73 to the bottom 41 of the valve spool 39 thereby initiating its shift to the right or upward with respect to the entire tool.

As the valve spool 39 moves to the right, the hammer also continues in its upward motion. The upward shift of spool 39 causes its lower land 74 to block off annular groove 70 thus blocking further flow to return port 45 of fluid displaced ahead of annulus 60. As the spool 39 continues further upward movement, its upper land 76 opens communication with groove 77 and port 78 in the valve housing whereby pressured fluid from port 51 and annular groove 51' flows through the sleeve bore thence, via groove 69, ports 68, groove 67 and ports 66 into the hammer sleeve 25 where it acts against upper annulus 60 of the hammer, first to effect deceleration of the hammer, then accelerate the hammer in the opposite (downward) direction.

During the period of deceleration inertia of the hammer effects a further upward movement displacing fluid from above annulus 60 into the pressure system thus effecting a pressure increase in the accumulator 54 which aids the system pressure in accelerating downward movement of the hammer. As shown in FIG. 5 the accumulator 54 includes a hydraulic fluid storage zone 54' and a compressed air storage zone 54''. The compressed air storage zone 54'' may be provided with a valved inlet 55' for directing compressed air thereinto at the desired pressure.

If the hammer movement is not reversed prior to the

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time land 57 closes off port 66, the land enters into the fluid confining snubber zone 80 with the result that there is a rapid increase in fluid pressure which stops the hammer motion and initiates its reverse movement in the manner of a hydraulic spring.

A restricted orifice 80' for passage 63 is in communication with constant pressure inlet 49 and also with the area adjacent the bottom of the hammer. This restricted orifice serves two purposes: if the hammer travel closes off port 62 then the orifice will restrict the flow of pressured fluid and serve as a snubbing device for the hammer, and it also serves to maintain a flow of pressure oil to the bottom of the hammer.

As the hammer moves down, land 56 first blocks off port 71 thus temporarily "locking" the spool in the up position. Continued motion of the hammer opens port 71 to the passage 58 defined between the lands 56 and 57 whereby zone 40' adjacent the bottom of valve sleeve 38 is connected to the return 45 through ports 71, 72 and 73, passage 58 and port 58'. This relieves pressure on the bottom of the valve spool whereby the constant pressure maintained on the exposed area of the extension piece 40 effects shifting of the spool downward or to the left. This shift brings spool land 76 over port 77 to block pressured fluid from inlet 51 from annulus 60. At the same time, land 74 uncovers port 70 thereby releasing pressure on annulus 60 by connecting it to return port 45.

Snubbing devices are also provided for the valve spool 39. For downward travel, snubbing is accomplished by means of the cylindrical cutout portion 41' and a fixed stub 81 which is adapted to fit into the cutout portion and in so doing traps hydraulic fluid thus snubbing action of the spool.

At the opposite end of the spool upward movement is snubbed by means of the tapered section 42' which fits into a recess 82 on the cap 29 of the spool housing.

During downward travel of the hammer, pressured fluid displaced ahead of annulus 59 is not returned to the tank 55. Instead, this displaced fluid is recycled through the pressure inlet port 49 back into the pressure system where it furnishes part of the pressured fluid entering port 51. This is important because it reduces the total volumetric demand of the system, thus enabling the use of a smaller pump with resultant decrease in power requirement and, since it also reduces liquid flow, frictional losses are reduced. However, after port 77 is closed by land 76, fluid displaced by the final stages of downward hammer movement goes to the accumulator 54 to effect a pressure increase therein. This pressure increase, in conjunction with the rebound energy from impact of the hammer against the anvil, increases the initial upward velocity of the hammer. Also, the system is greatly simplified by elimination of the valving that would otherwise be required to direct this pressured fluid to the tank 55 on the down stroke of the hammer.

As previously noted, a similar sequence occurs during the last part of upward hammer travel after the spool 39 has shifted to the right to open pressure port 51 to admit pressure fluid to the annulus 60. That is to say, fluid displaced ahead of annulus 60 as the hammer decelerates, is forced through ports 66, 67 and 68, and annulus 69 to port 51 with the result that fluid is directed to the accumulator 54 to charge the latter.

The same general sequence of operation is also present in the control valve cycle. That is, fluid is returned to tank 55 only on the valve spool down stroke; and pressured fluid displaced on the valve spool upstroke is returned to the pressure system where it is available to act against the bottom of the spool. This reduces the quantity of pressured fluid required from the pump 21' to maintain a fully pressured system and simplifies valving by eliminating a return to sump cycle.

Generally speaking, no lubrication is required for the reciprocating elements of the tool because they are con-

stantly bathed in hydraulic fluid which is itself a lubricant.

From the foregoing description it will be seen that the present invention fully accomplishes the aims and objects hereinbefore set forth to provide improvements in hydraulically actuated reciprocating tools.

What is claimed is:

1. In a hydraulic percussion device the combination of a body portion, a pressure liquid reciprocable differential area piston-hammer slidably mounted in said body portion, said piston-hammer having a large surface area portion at one end and a small area portion at the other end, a control valve, said control valve including a differential area flow control spool mounted for reciprocating movement by pressure fluid acting against the differential areas thereof, said differential areas comprising the entire end surface areas effective to shift said spool and including a larger area portion at one end of the spool and a smaller area portion at the other end of the spool, pressure liquid flow control means on said piston-hammer to reverse the direction of travel of the flow control spool and then said piston-hammer, means maintaining the smaller area portion of said piston-hammer in continuous communication with a source of pressure liquid, means including said control valve for alternately connecting the pressure liquid at the smaller area end portion of the piston-hammer and the source of pressure liquid to the larger area end portion of the piston-hammer and alternately blocking communication between the larger area portion of said piston-hammer and the larger area portion of the control spool, means continuously connecting the source of pressure liquid with the entire smaller area portion of said control spool to thereby continuously urge said spool in a direction toward the larger area portion of said spool, said pressure liquid flow control means on said piston-hammer cooperating with grooves in said body portion and with said control valve spool for alternately connecting the pressure liquid at the smaller area portion of the spool and the source of pressure liquid to the larger area portion of said reciprocable spool.

2. In a hydraulic percussion device the combination of a body portion, a pressure liquid reciprocable differential area piston-hammer slidably mounted in said body portion to provide a power stroke and a return stroke therefor, said piston-hammer having a large surface area portion at one end and a small area portion at the other end, a control valve, said control valve including a differential area flow control spool mounted for reciprocating movement by pressure fluid acting against the differential areas thereof, said differential areas comprising the entire end surface areas effective to shift said spool and including a larger area portion at one end of the spool and a smaller area portion at the other end of the spool, pressure liquid flow control means on said piston-hammer to reverse the direction of travel of the flow control spool and then said piston-hammer, means maintaining the smaller area end portion of said piston-hammer in continuous communication with a source of pressure liquid to provide the return stroke of said piston-hammer, means including said control valve for alternately connecting the pressure liquid at the smaller area end portion of the piston-hammer and the source of pressure liquid to the larger area end portion of the piston-hammer and alternately blocking communication between the larger area portion of said piston-hammer and the larger area portion of the control spool to provide the power stroke of said piston-hammer, means continuously connecting the source of pressure liquid with the entire smaller area portion of said control spool to thereby continuously urge said spool in a direction toward the larger area portion of said spool, said pressure liquid flow control means on said piston-hammer cooperating with grooves in said body portion and with said control spool for alternately connecting the pres-

sure liquid at the smaller area portion of the spool and the source of pressure liquid to the larger area end portion of said reciprocable spool.

3. A hydraulic tool actuating system including a source of hydraulic pressure fluid, a hydraulic pressure accumulator, a tool having a body portion, a pressure liquid reciprocable differential area piston-hammer slidably mounted in said body portion, said piston-hammer having a large surface area portion at one end and a small area portion at the other end, a control valve, said control valve including a differential area flow control spool mounted for reciprocating movement by pressure liquid acting against the differential areas thereof, said differential areas comprising the entire end surface areas effective to shift said spool and including a larger area portion at one end of the spool and a smaller area portion at the other end of the spool, pressure liquid flow control means on said piston-hammer to reverse the direction of travel of the flow control spool and then said piston-hammer, pressure liquid conduit means maintaining the smaller area end portion of said piston-hammer in continuous communication with the hydraulic pressure liquid at the smaller area end portion of the piston-hammer and the source of pressure liquid and the hydraulic pressure accumulator, means including said control valve for alternately connecting the hydraulic pressure liquid at the smaller area portion of said spool and the source of pressure liquid and the hydraulic pressure accumulator to the larger area end portion of the piston-hammer and alternately blocking communication between the larger area portion of said piston-hammer and the larger area portion of the control spool, conduit means continuously connecting the source of pressure liquid with the entire smaller area portion of said control spool to thereby continuously urge said spool in a direction toward the larger area portion of said spool, said pressure liquid flow control means on said piston-hammer cooperating with grooves in said body portion and with said control valve spool for alternately connecting the hydraulic pressure liquid and the pressure accumulator to the larger area portion of said reciprocal spool.

4. A hydraulic tool actuating system including a source of hydraulic pressure liquid, a pneumatic-hydraulic pressure accumulator, a tool body having a bore therein, a pressure liquid reciprocable differential area piston-hammer slidably mounted in the bore in said body portion to provide a power stroke and a return stroke, said piston-hammer having a large surface area portion at one end and a small area portion at the other end, a control valve, said control valve including a differential area flow control spool mounted for reciprocating movement by pressure liquid acting against the differential areas thereof, said differential areas comprising the entire end surface areas effective to shift said spool and including a larger area portion at one end of the spool and a smaller area portion at the other end of the spool, pressure liquid flow control means on said piston-hammer to reverse the direction of travel of the flow control spool and then said piston-hammer, conduit means maintaining the smaller area end portion of said piston-hammer in continuous communication with the source of hydraulic pressure liquid and the pneumatic-hydraulic pressure accumulator to provide the return stroke of said piston-hammer, control lands on said piston-hammer cooperating with grooves in said body portion and with said control valve for alternately connecting the hydraulic pressure liquid at the smaller area end portion of the piston-hammer and the source of hydraulic pressure liquid and the pneumatic-hydraulic pressure accumulator to the larger area end portion of the piston-hammer and alternately blocking communication between the larger area portion of said piston-hammer and the larger area portion of the control spool to provide the power stroke of said piston-hammer, conduit means continuously connecting the source of pressure liquid with the entire

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smaller area portion of said control spool to thereby continuously urge said spool in a direction toward the larger area portion of said spool, and means including said pressure liquid flow control means on said piston-hammer and the grooves in said body portion for alternately connecting the source of hydraulic pressure liquid and the pneumatic-hydraulic pressure accumulator to the larger area portion of said reciprocable spool.

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