Sept. 16, 1941. W. F. MAYER 2,256,099

PUMPING APPARATUS

Filed July 18, 1938 3 Sheets-Sheet 1

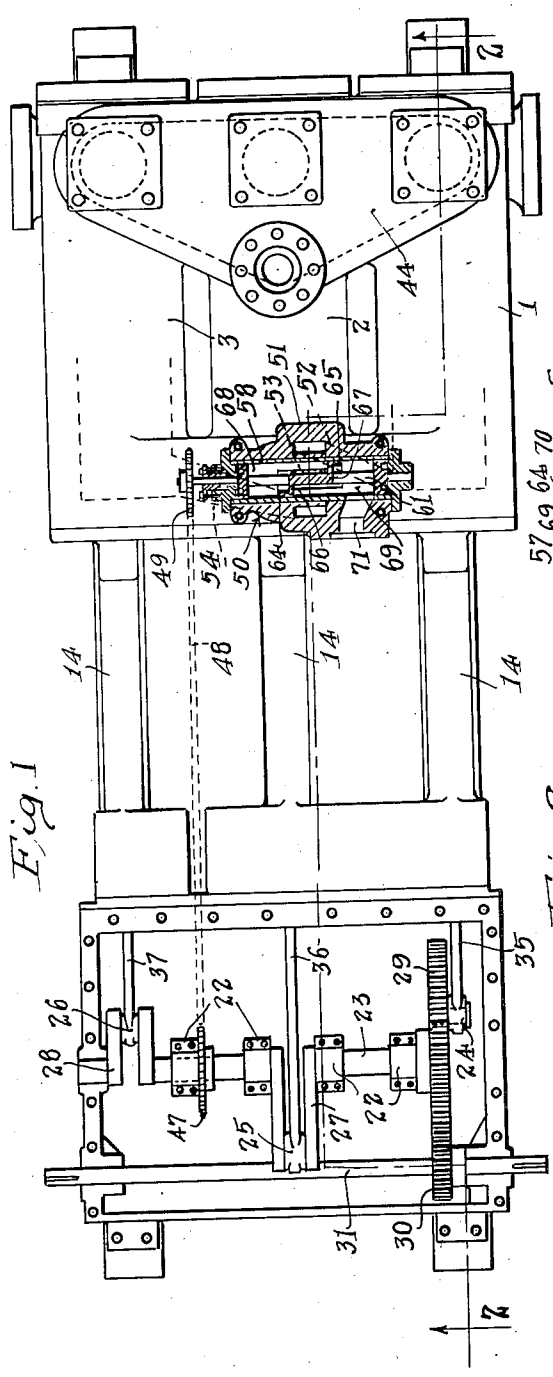


Fig. 1

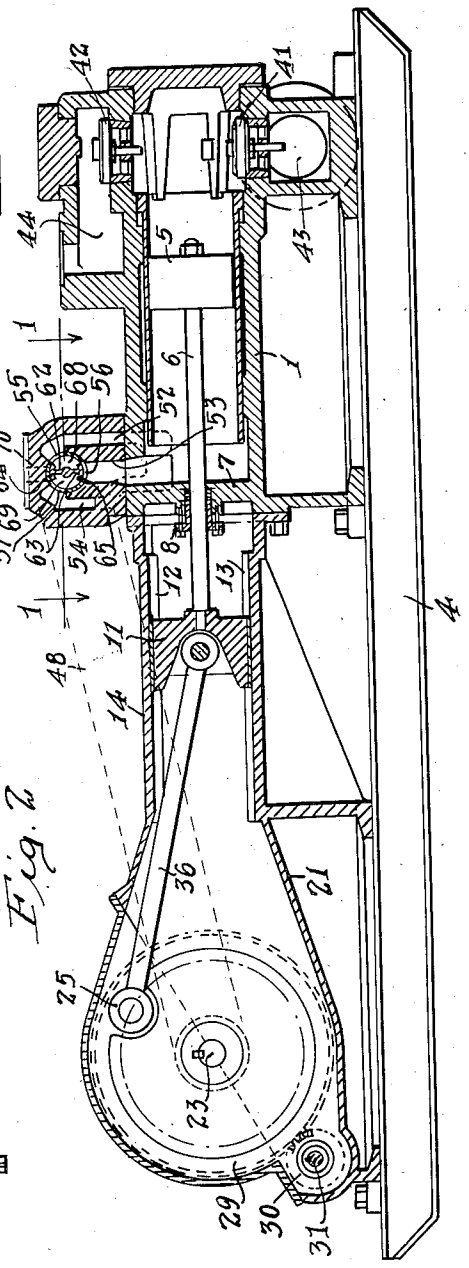


Fig. 2

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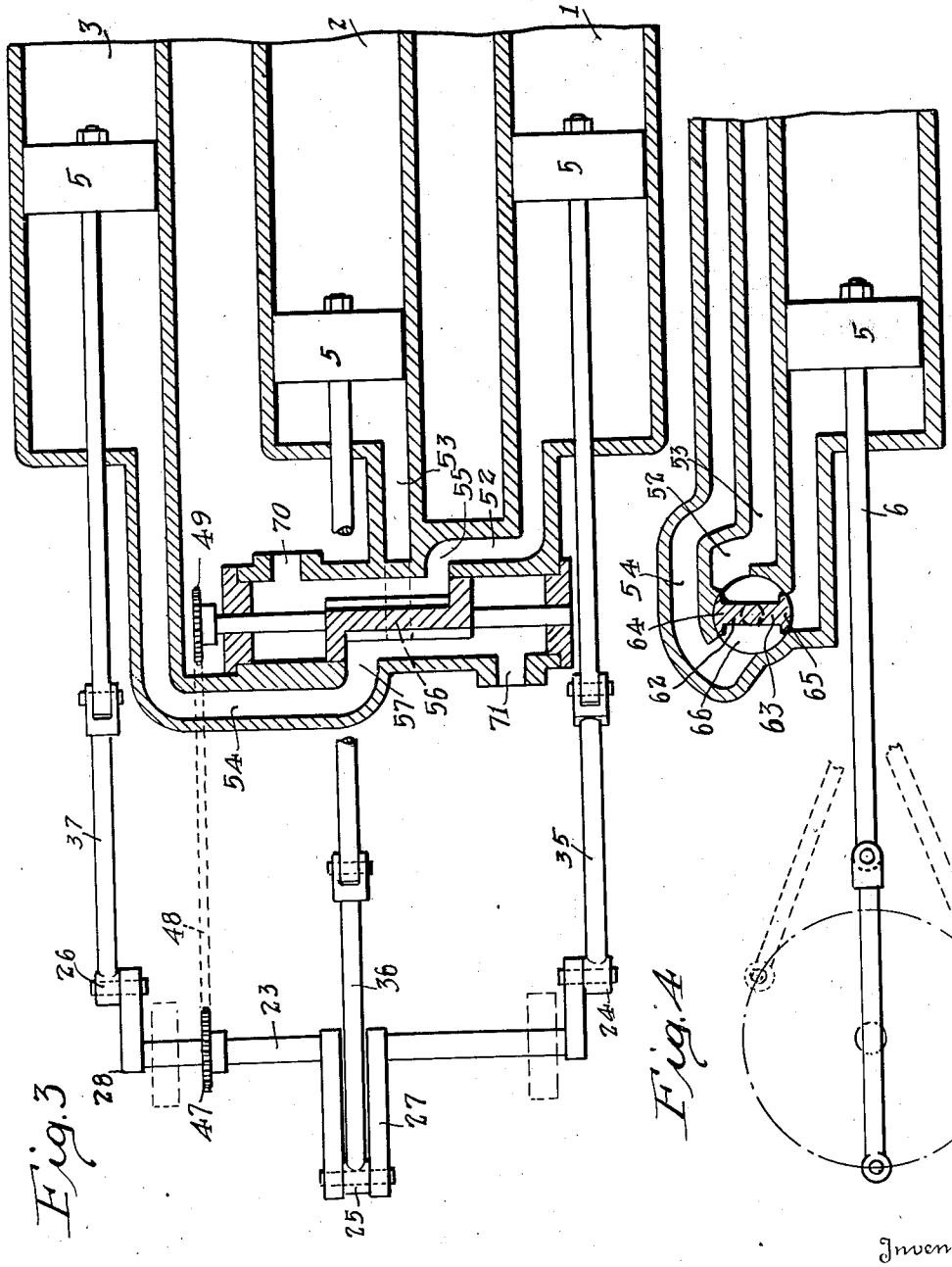


Fig. 3

Fig. 4

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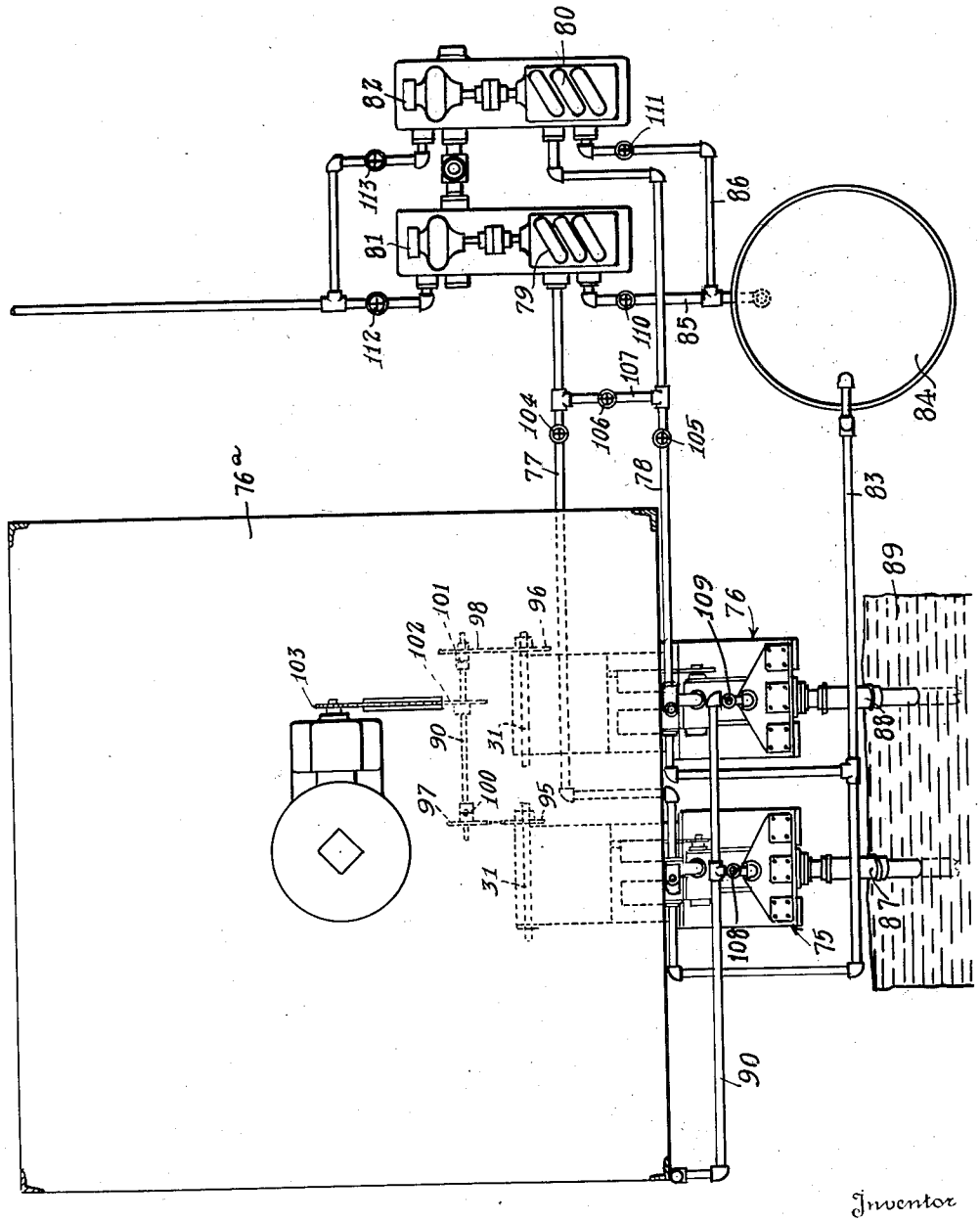


Fig. 5

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2,256,099

PUMPING APPARATUS

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1 Claim. (Cl. 103—10)

This invention relates generally to pumping apparatus, and particularly to a hydraulically actuated, multiple cylinder pump.

One of the most troublesome items of equipment used in drilling deep oil wells by the rotary method is the mud pump used to circulate drilling mud through the well during the drilling operation. Because of the friction losses in long strings of drill pipe the circulation pressure is high, and there is a general trend to exceedingly large volume. Pressures of 1000 to 15,000 pounds per sq. in. and volumes of 600 to 1000 gallons per minute are not uncommon in deep drilling as practised at the present time, and greater pressures and volumes would be employed if equipment capable of developing them were available. In addition to the high pressure and volume requirements imposed on mud pumps, the drilling mud handled by the pumps is often of a very abrasive nature due to the practical impossibility of removing all of the drill cuttings before the mud is recirculated through the well.

From the foregoing, it is apparent that mud pumps for oil well service are required to operate under extremely difficult conditions. The type of pump which has proven most satisfactory up until the present time is the direct-connected steam pump, although power-operated pumps have come into use in recent years. Both of these types, however, have many drawbacks, chief of which is the fact that the pressure differential across the pistons is the full mud discharge pressure, and the piston rods are under compression, limiting the stroke to a relatively short length.

A principal object of this invention is to provide a pump which is particularly adapted to oil well drilling service, being so constructed that it is capable of handling abrasive drilling mud at high pressures and in large volumes, with a minimum of wear and at maximum efficiency.

A further object is to provide a multiple cylinder, hydraulically actuated pump in which the power liquid acts directly on the pistons, whereby the pressure differential across the pistons is reduced to a minimum and the length of the stroke is not limited by piston rods under compression.

A still further object is to provide a multiple cylinder hydraulic piston pump wherein the pistons are mechanically interconnected to maintain them in proper phase relationship.

A still further object is to provide a hydraulic pump which is also capable of being employed as a motor, the arrangement being such that either function may be performed alone, or both simultaneously.

Further objects and advantages will be apparent from the following description, taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a top plan view of the pump, with the power fluid distributing valve shown in section, substantially on line 1—1 of Fig. 2;

Fig. 2 is a longitudinal vertical section taken on line 2—2 of Fig. 1;

Figs. 3 and 4 illustrate schematically the arrangement of the motive liquid distributing valve and its connections with the cylinders; and

Fig. 5 is a plan view of a layout at a well, utilizing a pair of pumps either as mud pumps or as motors, or both simultaneously.

Referring to the drawings, it will be observed that the pump comprises three cylinders 1, 2 and 3 disposed with their axes parallel and lying in a horizontal plane. The cylinders may be formed as a unitary casting, as shown, or may be separate units individually secured to a base 4. Reciprocable in each cylinder is a piston 5, secured to one end of a piston rod 6. The rod 6 projects through an end wall 7 of the cylinder, being sealed in fluid-tight relation thereto by a stuffing box 8. The outer end of the piston rod is secured to a cross-head 11 slidable in guideways 12 and 13 formed in the inner walls of a guide frame 14 bolted at one end to the cylinder frame.

The opposite end of the guide frame 14 is secured to a crankcase 21 bolted to the base 4. Journaled in the crankcase in bearings 22 is a crankshaft 23 on which are mounted a plurality of crank pins 24, 25, 26. It will be observed that crank pins 25 and 26 are formed on cranks 27 and 28, respectively, whereas crank pin 24 is formed on a spur gear 29 keyed to the shaft 23. The gear 29 meshes with a pinion 30 keyed to a shaft 31 journaled in the crank case and projecting at each end through the crankcase.

The crank pins 24, 25, and 26 are disposed in longitudinal alignment with the respective crossheads 11, and are connected thereto by connecting rods 35, 36, and 37. As shown in Fig. 2, the crank pins are equally angularly spaced about the axis of the crank shaft.

Referring once more to the cylinder end of the pump, associated with each cylinder is a mud suction valve 41 and a mud discharge valve 42. The suction valves control inlet passages between the respective cylinders 1, 2, and 3 and a common suction header 43 extending transversely

across the mud end of the pump in planes below the cylinders. The header is adapted to be connected to a suitable source of pump liquid, such as the mud pit at a well being drilled. The discharge valves 42 are arranged above the respective suction valves, and communicate with a discharge header 44 having an outlet 45 adapted to be connected to a discharge line.

The structure described thus far closely resembles a power-operated, single acting triplex pump wherein the pistons are mechanically actuated by rotation of the crank shaft by power supplied through a driving element secured to one of the projecting ends of the shaft 31. This resemblance, however, extends only to the parts thus far described, the function of the crank shaft and the parts connecting it with the pistons being entirely different in the apparatus described herein. Instead of being actuated mechanically, as in power pumps, the pistons of my pump are actuated by a motive liquid applied directly thereto, under the control of a distributing valve mechanism. The motive liquid is preferably supplied under steady flow and pressure conditions, as from a centrifugal pump.

Referring now to the distributing valve mechanism, a driving sprocket 47 is secured to the crank shaft 23 and is operatively connected through a drive chain 48 with a driven sprocket 49 secured to the spindle of a multiway rotary valve generally designated 50. The valve comprises a housing 51 in which are formed a plurality of fluid passages 52, 53, 54 communicating at one of their ends respectively with the cylinders 1, 2, and 3. The opposite ends of the passages communicate with equi-angularly spaced ports 55, 56, 57 in a valve sleeve 58 secured in the valve bore. In the three-cylinder arrangement shown, the ports extend through arcs of 60° and are spaced at 60° intervals. The rotary valve comprises a spindle 61 provided on its central portion with a pair of diametrically disposed vanes 62 and 63 on the outer ends of which are arcuate valve members 64 and 65 respectively, extending through 60° arcs and spaced longitudinally of the spindle 61 on opposite sides of the central region including the ports 55, 56, 57, as shown in Fig. 1. Semi-circular end walls 66 and 67 close the space between the vanes 62 and 63 on opposite sides thereof and at opposite ends of the valve structure. By this arrangement the valve bore is divided into two chambers 68 and 69 with which the ports 55, 56, 57 are selectively connectible by rotation of the spindle.

A motive liquid inlet 70 communicates with the chamber 68 and is adapted to be connected to a source of motive liquid under pressure. An outlet 71 for spent motive liquid communicates with the chamber 69, for discharging spent motive liquid back to the source.

The operation of the pump will be understood from the foregoing description. The pistons are maintained in proper phase relationship by the crankshaft, the latter being driven constantly by the overlapping pumping strokes and in turn effecting the return strokes of the pistons. Through the driving connection from the crankshaft to the distributing valve, the latter is rotated in synchronism with the crankshaft to successively admit and exhaust motive liquid to and from the cylinders in properly timed relation to the movements of the latter.

The valve arrangement described provides for constant fluid passage area for the inlet and the discharge of motive liquid, one valve gradually opening as another closes. In Fig. 4, illustrating schematically the sequence of valve operation, the inlet to cylinder 1 is about to be closed and that to cylinder 2 will be gradually opened as the valve rotates in a clockwise direction. Cylinder 3 is discharging at full capacity and will continue to do so through an additional 60° of rotation of the valve. At that time the discharge from cylinder 3 will be gradually cut off, and simultaneously cylinder 1 will begin to discharge.

A distinctive feature of my invention is the possibility of utilizing the pump as a motor, either simultaneously with the pumping operation or solely as a motor. By providing a power take-off element such as a sprocket, gear, or pulley, on either projecting end of the shaft 31, the pump may be employed as a hydraulic motor, the suction and discharge headers of the pump being vented, or the discharge valves 42 being removed, to avoid consumption of power by pumping action. Upon removal of the discharge valves the reciprocation of the pistons 5 in their cylinders will merely cause any pump liquid in the cylinders to surge back and forth between the respective cylinders through the discharge header 44.

Inasmuch as the different pistons are connected to the crankshaft in equally spaced phase relation, the total volume of the pump liquid portion of the cylinders remains constant throughout the cycle; consequently pump liquid is neither drawn into nor discharged from the pump when the cylinders are interconnected. The static head of liquid resulting from the difference in elevation between the discharge header 44 and the suction header 43, plus the weight of the suction valves 41, maintains the latter on their seats, thereby rendering the suction connection to the pump ineffective.

When operating as a motor and pump simultaneously, the power input of the motive liquid will be divided between the pistons and the power take-off element, the pressure differential across the pistons increasing with the load on the power take-off element.

This feature is particularly useful in drilling a deep well, as there are many auxiliary operations incidental to the actual drilling, such as making up and breaking out sections of pipe, "tailing in" single stands of pipe, and other operations involving the use of a wire line. For such operations a calf wheel, a wire line drum, or a cathead on the main draw-works is employed, usually driven by the main hoisting engine. The engine operates at only a small fraction of its capacity at such times, and it is obvious that material economies could be effected by utilizing a source of power more nearly that required for these operations. By connecting the power take-off element on the shaft 31 of the apparatus disclosed herein to the calf wheel or cathead, the latter may be driven by the hydraulic motor, either while pumping or after disconnecting the mud end of the pump.

The pump may be connected to serve as a driving motor for the rotary table, if desired. A practical example of such an arrangement is shown in Figure 5. In this figure a pair of pumps 75 and 76 are mounted adjacent a derrick floor 76a beneath the level thereof, the mud ends of the pumps extending under the floor. The pumps, which may be constructed as shown in Figs. 1 to 4, are connected by lines 77 and 78 to a pair of centrifugal pumps 79, 80 driven by steam turbines 81, 82. The discharge water from the

pumps is returned through line 83 to a tank 84, from which suction lines 85 and 86 lead back to the centrifugal pumps. Mud suction lines 87, 88 extend from the mud pit 89 to the pumps, and a common mud discharge line 90 extends from the pumps to the usual swivel (not shown) suspended in the derrick.

Power take-off sprockets 95, 96 mounted on the projecting ends of the shafts 31 are connected in driving relation with sprockets 97, 98 mounted on a counter-shaft 99, the sprockets 97, 98 being selectively connectible with the shaft by suitable clutches 100, 101. Driving connection between the countershaft and the rotary table is established by inter-connected sprockets 102 and 103.

Shut-off valves 104, 105 are provided in the motive liquid supply lines 77, 78 extending from the centrifugal pumps to the respective mud pumps, and shut-off valves 108, 109 are provided between the mud discharge headers of the mud pumps and the common discharge line 90. Either pump may thus be cut out of service. A valve 106 in a cross-connection 107 between the supply lines 77 and 78 enables either mud pump to be connected to either centrifugal pump by suitable manipulation of the valves 104, 105. Suitable valves 110, 111 are interposed in the motive liquid suction lines 85, 86, and valves 112, 113 are provided for controlling the admission of steam to the turbines 81, 82.

In the arrangement shown, either one or both pumps may operate either as mud pumps or as motors, or one may operate as a pump while the other operates as a motor for driving the rotary table or other driven element. It will be understood that a rotary table has been shown as the driven element solely for purpose of illustration, and that any other driven element of a rotary well drilling rig, such as a calf wheel or a cathead, could be connected to the countershaft.

I claim:

A hydraulic power system comprising a source of motive liquid under pressure, a supply of liquid to be pumped, a rotary driven element, and hydraulic apparatus actuated by said motive liquid and adapted to drive said rotary driven element and pump said pump liquid, said apparatus comprising a base, a plurality of cylinders mounted thereon, pistons reciprocable in the cylinders and dividing the latter into motive liquid ends and pump liquid ends, valve means for successively admitting motive liquid to the motive liquid ends of said cylinders to actuate said pistons in one direction, the pump liquid ends of said cylinders having valved suction and discharge connections for pump liquid, means including a rotary element rotatably mounted on said base and interconnecting said pistons, a power takeoff element operatively connected to said rotary element, means for connecting said power takeoff element in driving relation with said driven element, whereby the apparatus functions simultaneously as a hydraulic motor and as a hydraulic pump, and for disconnecting said power takeoff element from said driving element, whereby the apparatus functions solely as a hydraulic pump, and means for interconnecting the pump liquid ends of said cylinders, as by removal of the pump liquid discharge valves, to render the pump liquid connections ineffective whereby the apparatus functions solely as a hydraulic motor.

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