March 21, 1950 M. W. HUBER 2,501,054

UNLOADER FOR PUMPS

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Fig.1

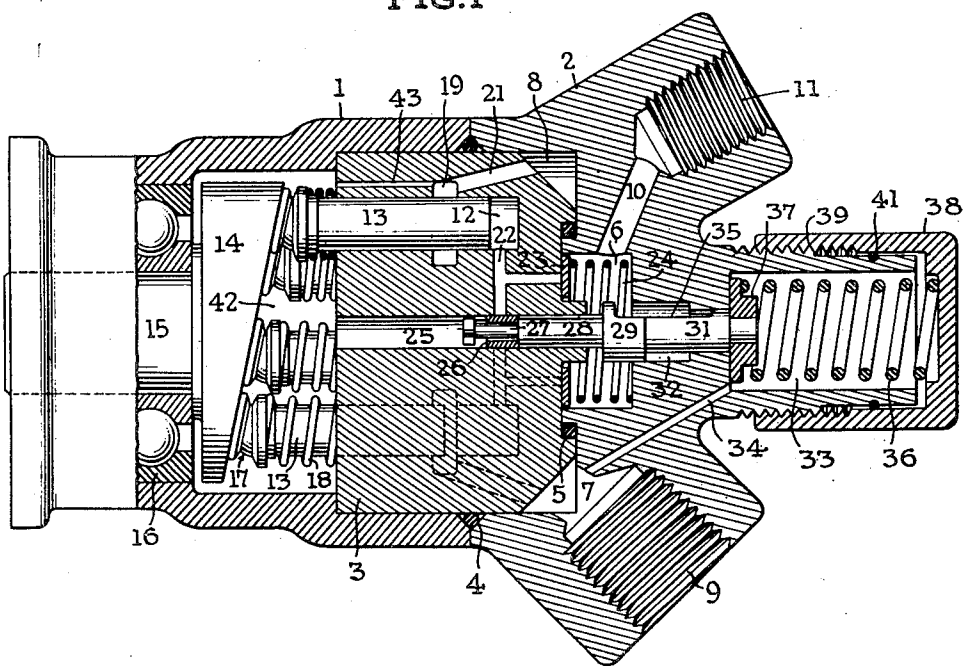


Fig.2

DISCHARGE PRESSURE RISING
VALVE ABOUT TO UNLOAD PUMP

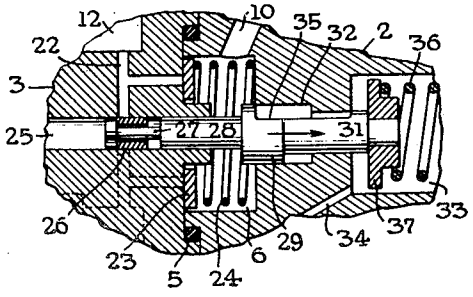
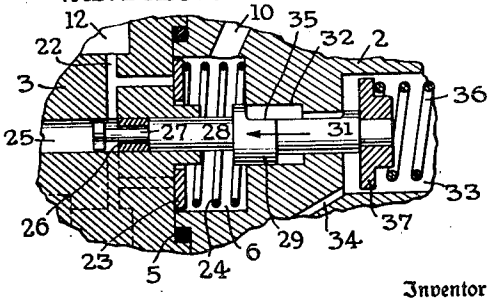


Fig.3

DISCHARGE PRESSURE FALLING
VALVE ABOUT TO LOAD PUMP



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UNLOADER FOR PUMPS

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5 Claims. (Cl. 103—42)

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This invention relates to multi-cylinder pumps and particularly to an unloading mechanism which is responsive to changes in discharge pressure. The unloading valve affords a direct cross connection between the various working spaces of the multi-cylinder pump. When the valve is open the pump is completely unloaded. When the valve is closed the pump is loaded. Since an intermediate or throttling position of the valve would waste energy and cause heating, it is important to arrange the motor mechanism so that it will shift the valve quickly from each of the named positions to the other.

In order to produce a very simple motor to shift the unloading valve, use is made of a single acting differential piston and a return spring. Discharge pressure moves this piston in one direction against the spring as discharge pressure rises, and the spring returns the piston as discharge pressure falls. The differential piston itself controls ports whose opening and closing changes the effective area of the differential piston. The arrangement is such that as discharge pressure changes gradually in one or the other direction, the piston creeps to a critical position and when it reaches that critical position suddenly moves full stroke in the same direction for the remainder of its travel.

Since the motor piston controls the ports which produce this action, the critical position just mentioned is the same for both directions of motion of the piston. However, it is desired that these sudden full stroke motions shall move the valve from closed position to open position and also from open position to closed position and, consequently, it is necessary to provide lost motion between the unloading valve and the actuating motor. The extent of this lost motion should slightly exceed the width of the unloading ports, measured in the direction of motion of the unloading valve.

While not limited to use with pumps of the parallel cylinder single-acting type, the invention offers unusual advantages with a pump of this description, and will be described as so embodied.

In the drawing:

Fig. 1 is an axial section of a nine-cylinder pump embodying the invention. The cylinders are parallel and arranged in circular series. The plungers are single-acting and are actuated by a swash-plate. In this view the discharge pressure is well below the unloading point.

Fig. 2 is a fragmentary view of the unloading valve and motor about to unload the pump.

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Fig. 3 is a similar view showing the unloading valve and motor about to load the pump.

In the following description all statements of direction refer to the pump positioned as shown in Fig. 1.

The pump housing comprises two parts 1 and 2 connected by threaded fastenings not visible in the drawing. Together they enclose a shouldered space in which a cylinder block 3 is closely confined. A ring gasket 4 seals the joint between the parts 1 and 2, and between each of them and the block 3. A second ring gasket 5 seals the block 3 to housing part 2 so as to isolate the high pressure discharge space 6 from the suction or intake space 7.

The block 3 is cylindrical in form and is beveled or peripherally chamfered to afford an annular inlet passage 8 in communication with intake space 7 and hence with the threaded suction connection 9 which is formed in housing part 2. A passage 10 connects discharge space 6 with the discharge connection 11 also formed in housing part 2.

The block 3 is provided with a circular series of cylinder bores 12 (nine being indicated) in each of which a corresponding plunger 13 is reciprocated by a rotary swash-plate 14. The swash-plate is fixed on a rotary drive shaft 15 which turns in a combined thrust and radial bearing generally indicated by the numeral 16, the bearing being mounted in housing part 1. Only part of the bearing 16 is visible, but it is of conventional form and requires no detailed description.

Each plunger 13 carries a universally tiltable shoe 17 which engages the swash-plate 14. Such engagement is maintained by coil compression springs 18 which encircle respective plungers and react between block 3 and a flange on the plunger. The springs are strong enough to draw the plungers through their suction strokes.

When a plunger is fully retracted its end exposes an inlet channel or port 19 encircling the corresponding bore 12. Passages 21 connect each channel 19 with annular inlet passage 8.

Dischage passages 22 lead from each cylinder bore 12, and are branched, one branch of each leading to chamber 6 where it terminates in the seat of a flexible flat ring valve 23 which is the discharge valve. This valve is seated by a coil compression spring 24. This single flexible valve controlling a plurality of discharge ports is compact and convenient, but the invention imposes no limit on the type of discharge valve. The use of any suitable type is contemplated.

The other branches of discharge passages 22 all lead to an axial bore 25 in cylinder block 3 where they are controlled by unloading valve 26 slidable in bore 25. Unloading valve 26 has a lost motion connection 27 with the plunger 28. The branches of passage 22 all terminate in circular series, so that valve 26 in its two positions (to be described) either blanks them all, or exposes them all, in which latter event they are all connected together.

Plunger 28 is connected with the motor piston which comprises a piston head 29 and a plunger 31 both coaxial with plunger 28. Plunger 31 is larger than plunger 28 and smaller than piston head 29 which last is interposed between the two plungers. Piston head 29 enters and fits a cylinder bore 32, formed in part 2 and communicating at its left end with chamber 6. Plunger 31 works in and fits a bore which leads from the right hand end of bore 32 to a chamber 33. Chamber 33 is connected by passage 34 with inlet chamber 7.

Head 29 and plunger 31 are each cut away for a part of the length of each, as indicated at 35. The location and length of the cut away portions 35 are such that as the parts 28, 29, 31 move together to the right and just before valve 26 starts to expose ports 22, see Fig. 2, head 29 starts to close the open (left hand) end of cylinder bore 32 and the cut away portion 35 starts to connect bore 32 with chamber 33.

In the position shown in Fig. 1 discharge pressure in chamber 6 urges the parts 28, 29, 31 gradually to the right by acting on an effective area which equals the cross-section of plunger 31 diminished by the cross-section of plunger 28. After the parts reach the position of Fig. 2 and cylinder bore 32 is isolated from chamber 6 and connected with chamber 33, the effective area is increased and equals the cross-section area of head 29 diminished by the cross-section area of plunger 28.

The parts 28, 29, 31 are biased to the left by a coil compression spring 36 which reacts between a spring seat 37 on the end of plunger 31 and a removable cap 38 which encloses chamber 33 and also serves as means for adjusting the stress on spring 36. For the latter purpose the cap 38 is threaded at 39 on housing part 2. The joint is sealed by a gasket 41.

To prevent fluid pressure from influencing the parts 28, 29, 31 axial passage 25 extends clear through block 3 to chamber 42 in which swashplate 14 is housed. Chamber 42 is maintained at suction pressure by passage 43, which leads to one of the inlet ports 19, as shown. Furthermore, the valve 26 has a passage leading from end to end. It follows that plungers 28 and 31 are each subject on their ends to suction pressure at all times. Furthermore leakage of high pressure liquid along plunger 28, should it occur, cannot develop pressure between the end of plunger 28 and the valve 26.

Operation

Assume that discharge pressure is rising in chamber 6. The parts 28, 29, 31 move slowly to the right until the unloading point is reached with said parts in the position shown in Fig. 2. Valve 26 still closes ports 22 and cut-away portion 35 is about to disconnect cylinder 32 from chamber 6 and open it to chamber 33. When that happens parts 28, 29, 31 move full stroke to the right opening valve 26 wide.

Assume now that pressure in chamber 6 starts to fall. Parts 28, 29, 31 move slowly to the left, first leaving valve 26 at rest because of the lost-motion connection 27. When these parts reach the position shown in Fig. 3 valve 26 will still be open. When cut-away portion 35 opens cylinder 32 to chamber 6, this chamber is disconnected from chamber 33. Hence the spring 36 immediately is effective to move the parts 28, 29, 31 full stroke, closing valve 26 quickly.

It is important to observe that the lost motion provided by connection 27 need only slightly exceed the width of ports 22 measured in the direction of motion of valve 26. The cut-away at 35 should be such as to connect cylinder 32 with either chamber 6 or 33 as it disconnects it from the other. A very slight clearance (negative lap) is tolerable and may even conduce to smoother action. It is practicable but not necessary that the lost motion between motor parts 28, 29, 31 and valve 36 be taken up just as the critical position (Figs. 2 and 3) is reached by the motor piston, for the valve 26 can be given sufficient lap to assure tight closure of ports 22, and still be satisfactorily timed, if the motions of the motor beyond the critical point be made adequate.

While the unloaded mechanism is peculiarly adaptable to the type of pump illustrated in Fig. 1, any pump having two or more working spaces in which the cycles are so timed that cross connection of working spaces will unload the pump offers a possible field for application of the invention.

The unloader responds only to discharge pressure, it affords only two conditions; fully loaded and fully unloaded. Where this type of control is desired it offers outstanding advantages because it is inexpensive and durable, involves a minimum number of parts, and is precise in action, and free of throttling action to a remarkable extent.

I claim:

1. The combination of a pump having a high pressure discharge connection, unloading ports and an unloading valve shiftable in opposite directions to positions in which respectively it serves to unload and load the pump by opening and closing said ports; an unloading motor having an abutment subject in one direction to pressure in said discharge connection and movable through a stroke which exceeds the motion of the unloading valve between its open and closed positions, said motor including change-over valve means actuated by motion of said abutment and effective at a change-over position substantially at mid-stroke of the abutment to change the effective area of the abutment, so that discharge pressure develops a larger motive force per unit pressure in that half of said stroke in which the unloading valve is in unloading position; yielding means urging said motor in a direction to load the pump; and a lost-motion actuating connection between said abutment and unloading valve arranged to permit the abutment to reach said change-over position in each direction of motion before the valve is moved thereby to throttling positions intermediate said loading and unloading positions.

2. The combination defined in claim 1 in which the unloading motor abutment comprises two connected pistons of unequal diameters working in two communicating cylinders open at their ends, one to the high pressure discharge connection and the other to a space at low pressure, and the change-over valve comprises a port

formed in said pistons and controlled by terminal portions of said cylinders, so as to subject said pistons selectively to the differential between said pressures.

3. The combination defined in claim 1 in which the unloading ports are arranged in circular series around a cylindrical valve seat, and the unloading valve is of the piston type having a port extending through it from end to end whereby the valve is rendered indifferent to fluid pressure.

4. The combination defined in claim 1 in which the pump comprises a plurality of parallel cylinders arranged in circular series around an axial bore to which the unloading ports lead from the respective cylinders, and the unloading valve is reciprocable in said axial bore by the unloading motor comprising cylinders and pistons coaxial therewith.

5. The combination defined in claim 1 in which there is a cylinder-block fixed between a supporting body and a cap in which the discharge chamber is formed, said cylinder-block having a plurality of pump-cylinder bores arranged in circular series around an axial valve-seat bore to which said unloading ports lead from the pump-cylinder bores, and in which said unloading valve is reciprocable; and the movable abutment of the unloading motor comprises a differential piston working in a two-diameter cylinder formed in the cap coaxially with said valve-seat bore, and connected with said unloading valve by a plunger which extends from the differential piston across the discharge chamber and into said valve-seat bore, said plunger filling the end of said bore and thus serving to isolate the discharge chamber from the unloading ports and valve.

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No references cited.