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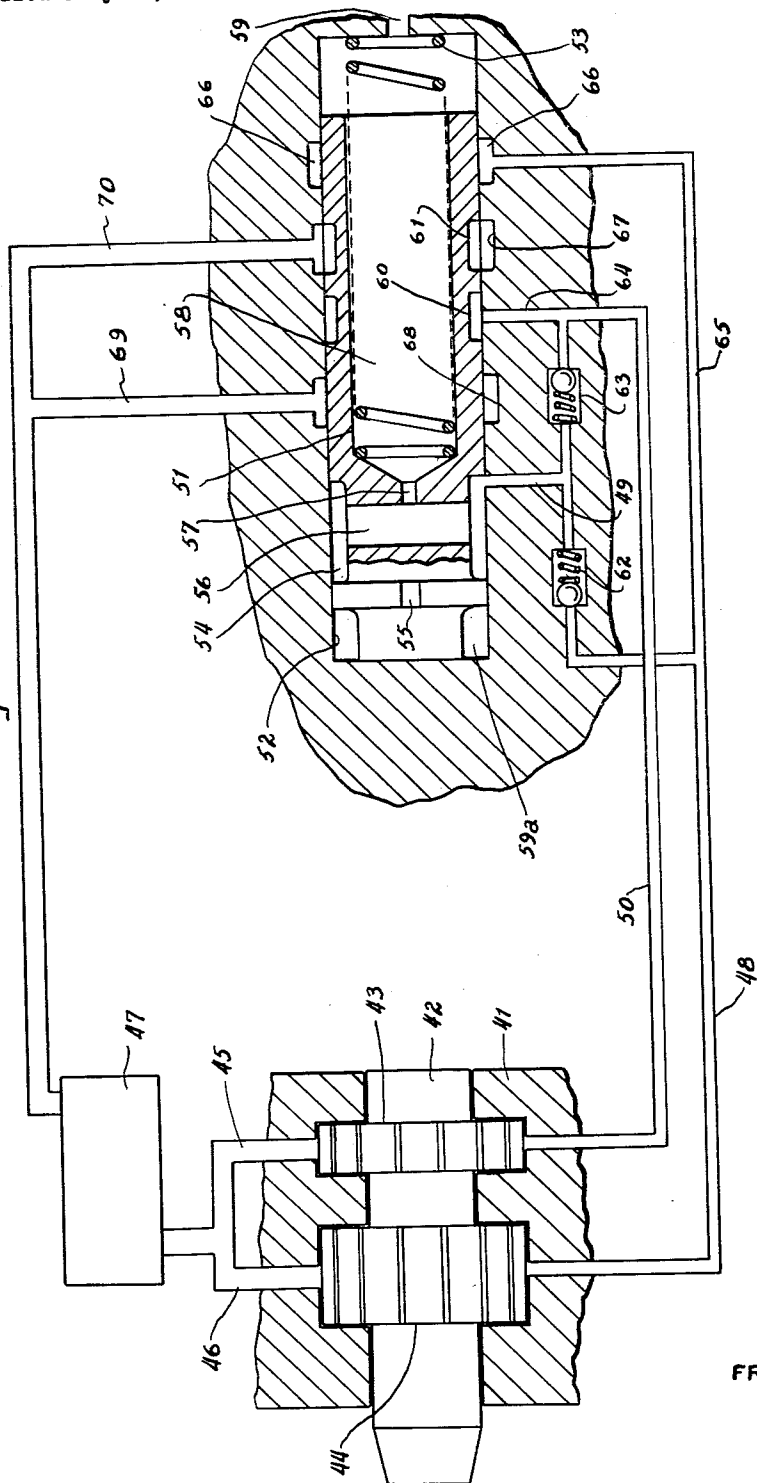
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PUMP, IN PARTICULAR FOR CONTROL SYSTEMS

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Fig. 2



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The invention relates to a pump, in particular a rotary vane pump, preferably for use in hydraulic control systems. The delivery rate of conventional pumps is known to vary with speed, the delivery rate of the pump increasing with increasing rotational speed, which is disadvantageous especially in hydraulic control systems because it causes the auxiliary boost to vary as a function of the velocity. In order to keep the delivery rate constant, it is known that a bypass or flow-control valve may be provided to expand a portion of the delivery below the working pressure in accordance with the speed of the pump. At high pump speeds, however, this gives rise to considerable hydraulic reactance, thus reducing efficiency.

The object of the invention is to provide an arrangement substantially diminishing the reactive power. According to the invention, it is proposed that a pump be provided with several circuits, all but one of which are successively and automatically disconnectable according to the delivery rate or speed of the pump, so that at maximum rotational speed of the pump, only one circuit is under delivery pressure. The disconnected circuits follow along without pressure, or under the circulatory pressure. In particular, the arrangement is so devised that the pressure chambers of the pump are connected by lines to the working chamber of a valve having a grooved cylindrical slide and provided with a throttling orifice for passage of hydraulic medium. The lines connecting the pressure chambers to the working chamber of the valve, are, with one exception, provided with one check valve each. From these lines, branches issue ahead of the check valves in the direction of flow and open into different annular grooves of the valve body. In order to cause the valve to disconnect the several circuits successively according to the delivery rate, or the differential pressure in the valve cylinder, the axial spacings of the edges of the preferably annular grooves communicating with the branch lines and those of recesses arranged in the slide to correspond to the cylinder grooves in communication with the return lines are of unlike dimensions.

To relieve the bearing of the pump rotor, according to the invention, so-called pressure chambers are provided at the periphery of the rotor or at the bearing, preferably opposite to the working chambers of the pump. When a circuit is disconnected, the corresponding pressure chamber or chambers are automatically supplied with pressure medium. For this purpose, the relief chambers are provided with connections leading to annular grooves in the valve body, which are successively brought into communication with the working chamber of the valve as the slide is displaced. Thus it becomes possible, according to the size and position of these pressure pockets, for the rotor bearing to be hydraulically relieved even when one or more of the working chambers is disconnected.

The device according to the invention will now be more fully described with reference to the accompanying drawing, but it should be understood that this is given by way of illustration and not of limitation and that many changes in the details may be made without departing from the spirit of the invention.

The drawing shows a schematic cross section of an embodiment of a pump with valve according to the invention.

A rotary vane pump is designated by reference numeral

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1, and its valve by reference numeral 2. Pressure medium from a tank 3 is supplied via line 4 and branches to suction chambers 5, 6 and 7. The pressure chambers 8, 9 and 10 of the pump are connected via lines 11, 12 and 13 with the working chamber 14 of the valve. The valve slide 16, backed up by a spring 15 against the valve body, is cylindrical and provided at the head with a throttling orifice 17 for passage of hydraulic medium. Via line 18, the pressure medium delivered is supplied to the hydraulic cylinder or motor, not shown. The valve slide itself is provided with annular grooves 19 and 20.

Lines 11 and 12 are each provided with a check valve 21, 22. Ahead of the check valves, lines 23 and 24 respectively branch off and lead to grooves 25 and 26 in the valve body 2. Additional grooves 27 and 28 are provided in the valve body, which in neutral position match only the annular recesses 19 and 20 in the slide 16, and are connected via return lines 29 and 30 to the tank 3. The axial spacings x , y of the edges of the grooves 25 and 26 connected to branch lines 23 and 24 and the grooves 19 and 20 provided in the slide are of unlike dimensions, so that coverage of the two grooves in valve body and slide will not be simultaneous.

The bearing of the pump rotor is relieved by means of pressure chambers 31, 32 and 33, shown located opposite the three working chambers of the pump in the drawing. Pressure chamber 33 is connected via line 34 to an annular groove 35 in the valve body. The two pressure chambers 31 and 32 are connected via line 36 to a groove 37 in the valve body. Groove 37 is passed by in neutral position by the slide 16 for a length v equivalent to the axial edge spacing x , so that simultaneously upon displacement of the slide a connection is made between valve body grooves 25 and 28 and between valve body groove 37 and the working chamber 14. The distance w by which the slide 16 must be displaced to establish a connection between groove 35 and working chamber 14 is equivalent to the axial spacing y of the valve body groove.

The mode of operation of the device according to the invention is as follows.

At low pump speed, the hydraulic medium delivered is supplied via lines 11, 12 and 13 to the working chamber 14 of the valve, and passes unimpeded via orifice 17 and line 18 to the hydraulic motor not shown. Upon rise in speed, orifice 17 is throttled so that a pressure differential builds up between chamber 14 and line 18, acting on slide 16 and displacing it. At a certain speed, and hence a certain pressure differential, the displacement will be such as to establish a connection between valve body grooves 25 and 28 via slide groove 19, and hence a connection of pressure line 23 with the return line 30 leading to the tank, thus cutting out this circuit. At the same time, a connection is established between the working chamber 14 and line 36 leading to pressure chambers 31 and 32 serving to relieve the rotor, and the said line is supplied with hydraulic medium. Upon further pressure rise, line 24 branching off from pressure line 12 is connected to return line 29, so that the hydraulic medium delivered is no longer supplied via check valve 22 to working chamber 14, but to tank 3. Simultaneously with establishment of a connection between the pressure line and the return line, the line 34 leading to the third relief chamber 33 is connected via annular groove 35 to working chamber 14. At maximum speed of the pump, therefore, only one circuit remains effective, while the other two circuits are automatically cut out. The cut-off points of particular circuits may be determined by choice of spring characteristic and axial spacings of groove edges; in order for the cut-offs to be successive, distance y must be greater than distance x .

Of course, this arrangement, illustrated in terms of a pump with three working chambers, may alternatively

be extended to pumps having a larger number of working chambers.

In another embodiment of such a multi-circuit pump, the latter may comprise a plurality of pump units of unlike delivery rates united in a single block, which units are connected and disconnected according to the total delivery rate. For example, by an arrangement of two pump units in a single block circuited so that initially both units are connected, that of smaller capacity is disconnected upon increase in speed, to be reconnected and that of larger capacity to be disconnected upon further increase in speed, and hence in delivery, a three-circuit pump is obtained. The several circuits are cut in and out according to delivery rate in the same manner as in the embodiment first described, namely via a flow control valve, which may be of the same type as that represented in the drawing.

In FIG. 2 of the drawing an embodiment of such a multiple-circuit pump is illustrated by way of example. In the housing 41 of the multiple-circuit pump, a drive shaft 42 is mounted, on which the rotors of two pumps 43 and 44 operating independently of each other are arranged, pump 44 having the greater delivery capacity of the two. The intake chambers of pumps 43 and 44 are connected via lines 45 and 46 to the reservoir 47. The exhaust chambers are connected via lines 48 and 49, or 50 and 49, respectively, to the annular chamber 54 formed by the housing 52 of the slide valve 51. The slide valve 51 is tubular in form and braced by a spring 53 against the housing 52 of the slide valve. The annular chamber 54 communicates with a radial hole 56 with an axial throttling passage 57 through which the pressure medium enters the housing chamber 55 in communication via line 59 with the working cylinder or hydraulic motor. This tubularly constructed end of the slide valve is provided with annular grooves 60 and 61. The left-hand end of the slide valve as seen in the drawing serves for damping, while the channel 55 serves to allow fluid to reach the chamber 59a.

Lines 48 and 50 are each provided with check valves 62 and 63. Ahead of these check valves, lines 64 and 65 branch off, line 64 opening into the annular chamber formed by the annular groove 60, while line 65 opens into the annular chamber formed by the groove 66 in the housing. The housing is further provided with two more annular grooves 67 and 68, communicating via lines 69 and 70 with the reservoir 47.

When the multiple-circuit pump is placed in operation, hydraulic fluid is supplied via lines 48, 50 and 49 to annular chamber 54, whence it passes via radial hole 56 and throttle passage 57 into channel 58 and then into the working chambers of the hydraulic cylinder or motor. Upon rise in drive r.p.m. and hence in capacity of the pump, the pressure built up ahead of the throttle point produces a displacement of the slide valve against the action of the spring. As soon as the annular chamber formed by the annular groove 60 communicates with the one formed by the groove 67 in the housing, the fluid delivered by pump 43 passes into the return line 70, so that only pump 44 is being utilized to actuate the working cylinder or hydraulic motor in the manner described. Upon further rise in rotational speed, there is a further displacement of the slide valve and hence a communication of the annular chamber formed by the groove 61 in the slide with that formed by the groove 66 in the housing, so that the fluid delivered by pump 44 passes via line 70 to the reservoir 47. The controlling edges are so arranged that at the moment when a connection of line 65 to return line 70 occurs, the connection of line 64 to line 70 is interrupted so that pump 43 is again being utilized to deliver fluid. The slide valve 51, by virtue of the construction and arrangement of the annular groove 54 serves simultaneously as an excess pressure valve, since in event of excessive delivery communication

can be set up between annular chamber 59a and the annular chamber formed by annular groove 63, connected via line 69 to the reservoir 47. The arrangement of the pumps of unlike delivery capacity in one housing in conjunction with the flow control valve described permits the delivery to be kept constant over a wide range of rotational speeds, independently of fluctuation in the latter.

What I claim is:

1. In combination with a hydraulic fluid reservoir, a multiple circuit pump comprising a pump housing with a plurality of working chambers with suction and outlet ports coordinated to each other circumferentially thereof and with pressure chambers intermittently arranged between said working chambers and oppositely coordinated to the individual working chambers, a vane carrying rotor journaled for rotation in said pump housing to draw fluid in through said suction ports and expel it from said outlet ports; a flow control valve including a valve body with a cylindrical bore and a plurality of spaced circular recesses extending radially of said bore into said body, said valve body having an inlet opening at one end thereof connected to said outlet ports and an outlet opening connecting the pump to a device to be operated; a cylindrical valve member slidable in said bore and having a closed end provided with an orifice located opposite to the inlet opening of said valve body and an open end, said valve member having a plurality of spaced circular recesses on its outer cylindrical face adapted to cooperate with predetermined recesses in said valve body to form annular by-pass conduits therein; a spring in said valve member, having one end abutting against the closed end of said valve and its other end against the other end of said valve body; first fluid lines connecting the hydraulic fluid reservoir with the suction ports in the pump housing, second fluid lines connecting the pressure chambers in the pump housing with certain of these recesses in said valve body, whereby fluid pressure is applied to certain of said pressure chambers when corresponding opposed working chambers are out of operation.

2. The pump according to claim 1, comprising check valves in all but one of the fluid lines connecting said outlet ports to the inlet of the valve body.

3. In combination with a hydraulic fluid supply reservoir, a multiple circuit pump comprising a pump housing, having working chambers with suction and outlet ports coordinated to each other circumferentially thereof and with pressure chambers intermittently arranged between said working chambers and oppositely coordinated to the individual working chambers; a pump rotor journaled for rotation in said housing to draw fluid in through said suction ports and expel it from said outlet ports; a flow control valve including a valve body provided with a cylindrical bore and a plurality of spaced circular recesses extending radially of said bore into said body, said valve body having an inlet opening at one end thereof connected to said working chambers and an outlet opening connecting the pump to a device to be operated; a cylindrical valve member slidable in said bore and having a closed end provided with an orifice located opposite to the inlet opening of said valve body, and an open end, said valve member having at least a pair of spaced circular recesses on its outer cylindrical face, adapted to cooperate with predetermined recesses in said valve body to form annular by-pass conduits therein; a spring in said valve member, having one end abutting against the closed end of said valve and its other end against the other end of said valve body; first means connecting the hydraulic fluid reservoir with the suction ports in the pump housing, second means connecting the pressure chambers with certain of the recesses; said valve member being displaceable by liquid pressure medium in dependence on the pump's speed, whereby fluid pressure is applied to certain of said pressure chambers when

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corresponding opposed working chambers are out of operation.

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