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(54) Hydraulic ~~control system.~~

(57) A hydraulic control system comprising a hydraulic actuator (20) and a variable displacement pump (22). A pilot pressure operated meter-in valve (27) controls the direction and velocity of the actuator through a pair of actuator lines (A, B). A pilot pressure operated meter-out valve (34d, 35d) is associated with each actuator line (A, b) for controlling the flow out of the actuator when that actuator line returns the flow to tank. A spring loaded poppet valve (41, 42) is associated with each actuator line (A, B) and a passage (90) extends from at least one of the poppet valves (41) to the meter-out valve (34d) and is operable, when the meter-out valve (34d) is closed after being open, to reduce the pressure holding the meter-out valve (34d) closed, thereby permitting the spring loaded poppet valve (41) to open at a relatively low pressure developed in one (A) of the lines associated with the one meter-out valve (34d), thereby allowing the one meter-out valve (34d) to open.

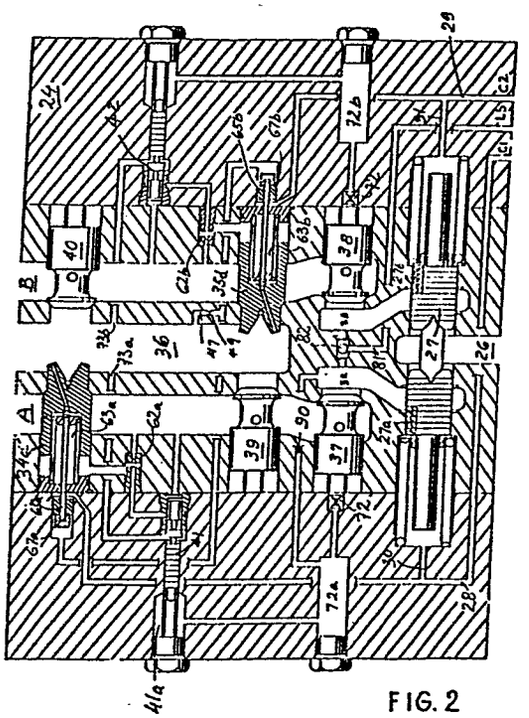

FIG. 2

EP 0 160 265 A2

Hydraulic Control System

This invention relates to a hydraulic control system according to the preamble of claim 1.

Such hydraulic systems are found, for example, on mobile equipment, such as excavators and cranes, and are used to control an actuator, such as a hydraulic cylinder or hydraulic motor. The actuator normally has two openings or ports to be used alternately as inlet or outlet.

A known system of that kind (US-A-4,201,052) has several valves housed in a valve body designed to be mounted directly on the actuator. The valves comprise an independent pilot operated meter-in valve, a pair of load drop check valves, a pair of independently operated, normally closed meter-out valves, a pair of load pressure responsive valves, and a pair of anti-cavitation valves. The meter-in valve functions to direct fluid flow to one or the other of the actuator ports. The normally closed meter-out valves are associated with each of the actuator ports for controlling fluid flow from the port opposite to the actuator port to which the meter-in valve is directing fluid. The meter-out valves function as variable orifices metering fluid between the appropriate actuator port and a low pressure zone such as a reservoir tank. Each of the meter-out valves has associated therewith a load pressure responsive element which acts on the meter-out valves in response to load pressure to enable the meter-out valves to also provide pressure relief protection. The anti-cavitation valves are associated with each of the actuator ports and are adapted to open the appropriate port to tank.

The valve body is directly mounted to the actuator port manifold and is supplied by one full flow

high pressure line, a pair of pilot pressure lines, and a load sensing line. The operation of the valves is controlled through the pilot lines from a manually operated hydraulic remote control valve. In the absence of a command signal from the hydraulic remote control, the meter-in valve assumes a centered or neutral position with the check valves, the meter-out elements, the pressure responsive valves, and the anti-cavitation valves, all in closed position. In the neutral position, the valve system prevents uncontrolled lowering of loads and in the case of over-running loads, prevents fluid flow from the high pressure fluid source to the actuator even in the event of a ruptured line. Due to the normally closed meter-out valves, such a hydraulic control system does not lend itself to free float, swing or coast the actuator.

In many applications, the need arises for such characteristic. In these applications the implement at the end of the cylinder or a swing device for a boom are allowed to coast to a stop due to frictional forces in the system.

Accordingly it is an object of the present invention to provide a hydraulic control system of the aforementioned type which is operable with free floating, swinging or coasting actuators.

This problem is solved in accordance with the teaching of claim 1.

Fig. 1 is a schematic drawing of a hydraulic control system for an actuator having two openings;

Fig. 2 is a sectional view of an embodiment of a modified hydraulic control system.

Referring to Fig. 1, the hydraulic control system embodying the invention comprises an actuator 20, herein shown as a linear hydraulic cylinder, having an output shaft 21 that is moved in opposite directions by hydraulic fluid supplied from a variable displacement pump 22 which has load sensing control 79 through 82 as is fully described in EP oo85,962 A3. The hydraulic control system further includes a manually operated controller 23 that directs

high or low pilot pressure through pilot port C1 or C2 to a valve system 24 for controlling the direction of movement of the actuator 20. Fluid from the pump 22 is directed through supply lines 25 and 26 and a pump port P to a meter-in valve 27 that functions to direct and control the flow of hydraulic fluid to one or the other actuator lines A or B connected to the actuator 20. The pilot ports C1 and C2 lead through pilot control lines 28, 30 and pilot control lines 29, 31, respectively, to the opposed ends of the meter-in valve 27. Depending upon the direction of movement of the meter-in valve 27, hydraulic fluid passes through passages 32, 33 and actuator lines A or B to one or the other end of the actuator 20.

The hydraulic control system further includes normally closed exhaust valves 34d, 35d, each positioned between lines A or B and a return passage 36 leading to a tank port T. The exhaust valves 34d, 35d control the return flow of fluid to tank.

The hydraulic control system further includes spring loaded poppet valves 37, 38 in the passages 32,33 and spring-loaded anti-cavitation valves 39, 40 which are opened when pressure in the return passage 36 is higher than in the passage 32 or 33. In addition, spring loaded poppet valves 41, 42 (Fig. 2) are associated with each valve 34d, 35d acting as pilot operated relief valves. A bleed line 47 having an orifice 49 extends from the return passage 36 to the exhaust valves 34d, 35d and to the pilot control lines 28, 29 through check valves 77, 78 (Fig. 1).

The system also includes a back pressure valve 44 connected to the tank port T and associated with the return passage 36. Back pressure valve 44 functions to minimize cavitation when an overrunning or a lowering load tends to drive the actuator 20 down. A charge pump relief valve 45 is provided to take excess flow above the inlet requirements of the pump 22 and apply it to the back pressure valve 44 to augment the fluid available to the actuator.

Meter-in valve 27 comprises a bore in which a spool is positioned. At low pilot pressure ("normally") the spool is maintained in a neutral position by springs and blocks the flow from the supply line26 to the passages 32, 33. When high pilot pressure is applied to either end of the spool, the spool moves until a force balance exists among the high pilot pressure, the spring load and the flow forces. The direction of movement determines which of the passages 32, 33 is provided with fluid under pressure from supply line 26. The single meter-in valve 27 may be replaced by two meter-in valves as shown in DE-3,011,088 A1.

When high pilot pressure is applied to either control line 28, 30 or 39, 31 leading to the meter-in valve 27 and to exhaust valves 34d or 35d, such exhaust valve is actuated to admit flow from the return actuator line A or B to the passage 36, whereas the other exhaust valve remains closed.

As is fully described in EP oo85,962 A3, the meter-out or exhaust valves 34d, 35d are of the poppet type and have back pressure spaces 63a and 63b, respectively, which are connected to the actuator lines A and B through orifices 62a and 62b, respectively, and can be vented by retracting a stem 65a and 65b, respectively, each is connected to a piston 67a and 67b, respectively. When pilot pressure is admitted through control line 28, piston 67a and stem 65a are moved and back pressure space 63a vented so that pressure in the return actuator line A opens exhaust valve 34d. Similar operation is carried out with pilot pressure in control line 29 and exhaust valve 35d. The exhaust valves 34d, 35d are also controlled by the poppet valves 41, 42.

These poppet valves 41, 42 are acted upon, on one side, by pressure in the actuator line A or B, and on the other side, by the same pressure, yet delayed. To that end, a restricted passage 72 through check valve 37 leads to an accumulator volume 72a and to a spring cavity 41a of the poppet valve 41. So poppet valve 41 is sensitive for sudden pressure rises in actuator line A and lowers

the respond pressure (Ansprechwert) of the exhaust valve 34d for a short time. This is accomplished by venting the back pressure space 63a of exhaust valve 34d to low presure in return passage 36 via a passage 73a. A similar arrangement is with poppet valve 42 including another accumulator volume 72b, orifice 62b and passage 73b. When the pressure rise has passed, poppet valve 41 or 42 returns in its normal position shutting off the passage 73a or 73b, so that back pressure in valve 34d or 35d is again built up.

When meter-in valve 27 is centered (low pilot pressures), restricted passages 27a, 27b in the valve spool connect pilot line 30 to passage 32 and pilot line 31 to passage 33.

Furthermore, in accordance with the present invention, a passage 90 is provided to connect passage 32 to the accumulator volume 72a and therethrough to the spring cavity 41a of the poppet valve 41. So low pilot pressure is extended to spring cavity 41a, i.e. pressure holding the poppet valve 41 closed is reduced and allowing to open valve 41 when a relatively low pressure (approximately 200 psi) is developed in actuator line A. Back pressure in space 63a is vented through passage 73a and pressure in actuator line A is allowed to open the exhaust valve 34d to the return passage 36.

Thus it can be seen that addition of a simple passage to the valve system 24 provides for a float or coast characteristic of the actuator movement in one direction. If a float or coast characteristic is desired for the other direction of movement, a similar passage (92 in Fig. 1) between passage 33 and the accumulator volume 72b is added which reduces the back pressure of the exhaust valve 35d in the neutral position of the meter-in valve 27. According to the requirements, one or the other or both passages 90, 92 are used to bleed off the back pressure holding the respective poppets of the valves 34d or 35d closed, thus allowing them to open in response to low pressures in the actuator lines A or B.

Fig. 1 shows an embodiment for one source operated exhaust valve, whereas Fig. 2 shows two pilot sources operated exhaust valves, i.e. each back pressure space 63a, 63b can be vented by pilot valves 67a, 67b or 41, 42.

Claims

1. A hydraulic control system comprising
a pump (22) for supplying fluid under pressure,
a hydraulic actuator (20) having a movable element (21) and at least one opening adapted to function alternately as an inlet and an outlet for the fluid,
a line system (26, 32, 33, 36) connecting said pump (22) to said actuator opening and to a tank,
a meter-in valve (27) positioned in said line system so as to shut off or to admit fluid to be supplied to said actuator opening,
exhaust valves (34d, 35d) connected between said actuator opening and said tank so as to admit fluid to flow to tank or to shut off such flow, and
a pilot controller (23) for applying fluid at high or low pilot pressure to said meter-in valve (27) and said exhaust valves (34d, 35d) so as to determine the position of such valves,
said meter-in valve (27) at said low pilot pressure being in its closed position and at said high pilot pressure in its admitting position,
each said exhaust valve (34d, 35d) having a back pressure space (63a, 63b) which can be vented by applying high pilot pressure,
characterized in that
passage (90) is provided to bleed off the pressure in the back pressure space (63a) of one exhaust valve (34d) when said meter-in valve (27) is in its neutral position.

2. The hydraulic control system according to claim 1, characterized in that
a second passage (92) is provided to bleed off the pressure in the back pressure space (63b) of the second exhaust valve (35d) when said meter-in valve (27) is in its central position.

3. The hydraulic control system according to claim 1 or 2, wherein each said meter-out valve (34d, 35d) has a normally closed spring loaded poppet valve (41, 42) connected with each line (32, 33; A, B) extending from said meter-in valve (27) and each of said meter-out valves (34d, 35d), and said passage (90) extending from one of said spring loaded poppet valves (41) and one of said lines (32) associated with one of the meter-out valves (34d) and operable, when said meter-out valve (34d) is closed after being open, to reduce the pressure holding the spring loaded poppet valve (41) closed, thereby permitting the spring loaded poppet valve (41) to open at a relatively low pressure developed in said one of said lines (A) associated with said one meter-out valve (34d), thereby allowing said one meter-out valve (34d) to open.

4. The hydraulic control system set forth in claim 3 including a second passage (92) extending from the other said spring loaded poppet valve (42) associated with the other meter-out valve (35d) and the other of said lines (B) and operable, when said meter-out valve (35d) is closed after being open, to reduce the pressure holding the spring loaded poppet valve (42) closed, thereby permitting the spring loaded poppet valve (42) to open at a relatively low pressure developed in said other (B) of said lines associated with said other meter-out valve (35d), thereby allowing said other meter-out valve (35d) to open.

5. The hydraulic control system set forth in any of claims 1 to 4 wherein said meter-in valve (27), meter-out valves (34d, 35d),spring loaded poppet valves (41, 42) and connecting passages (32, 33, A, B, 90, 92) are provided in a valve body (24).

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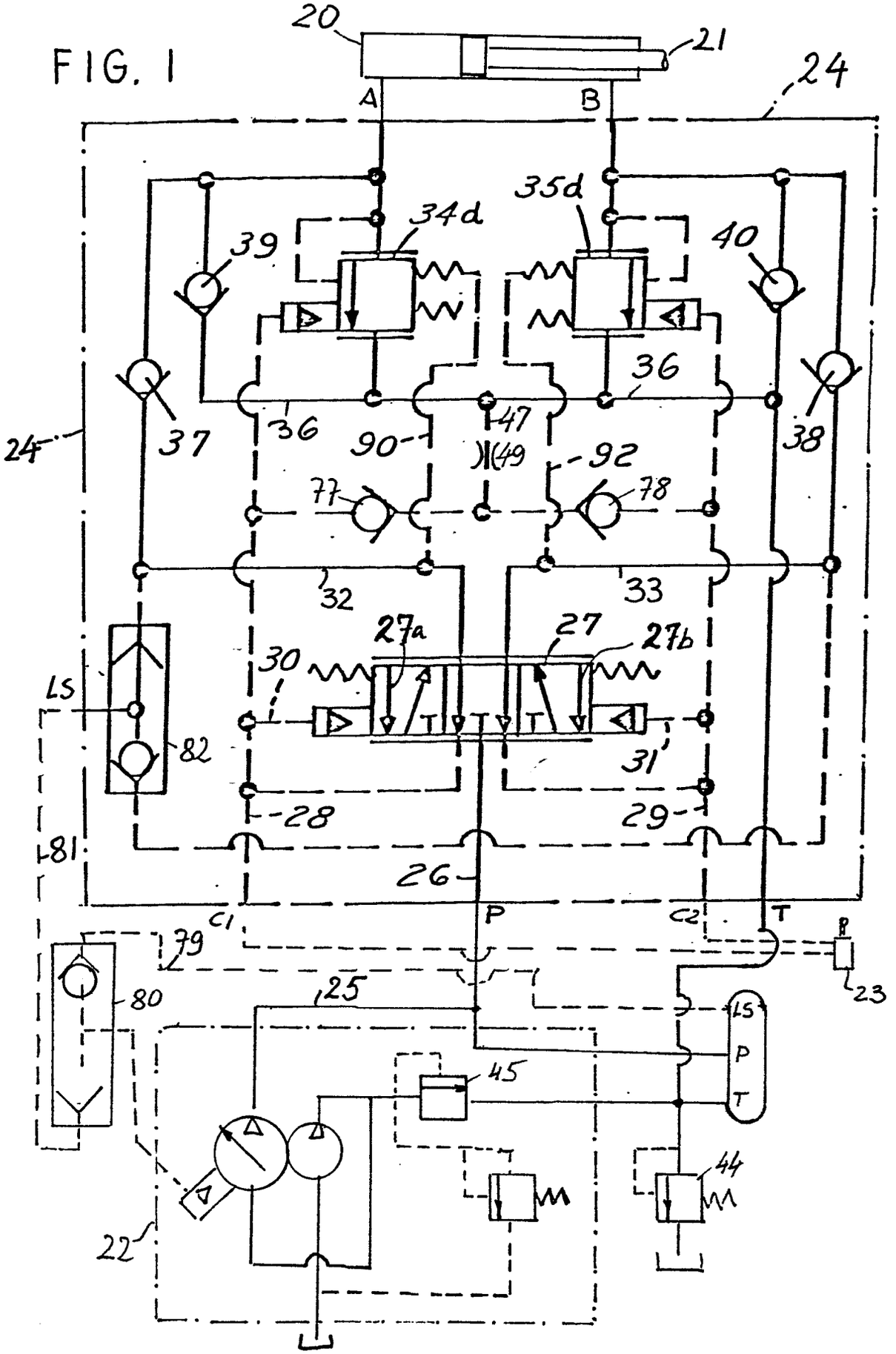
FIG. 1



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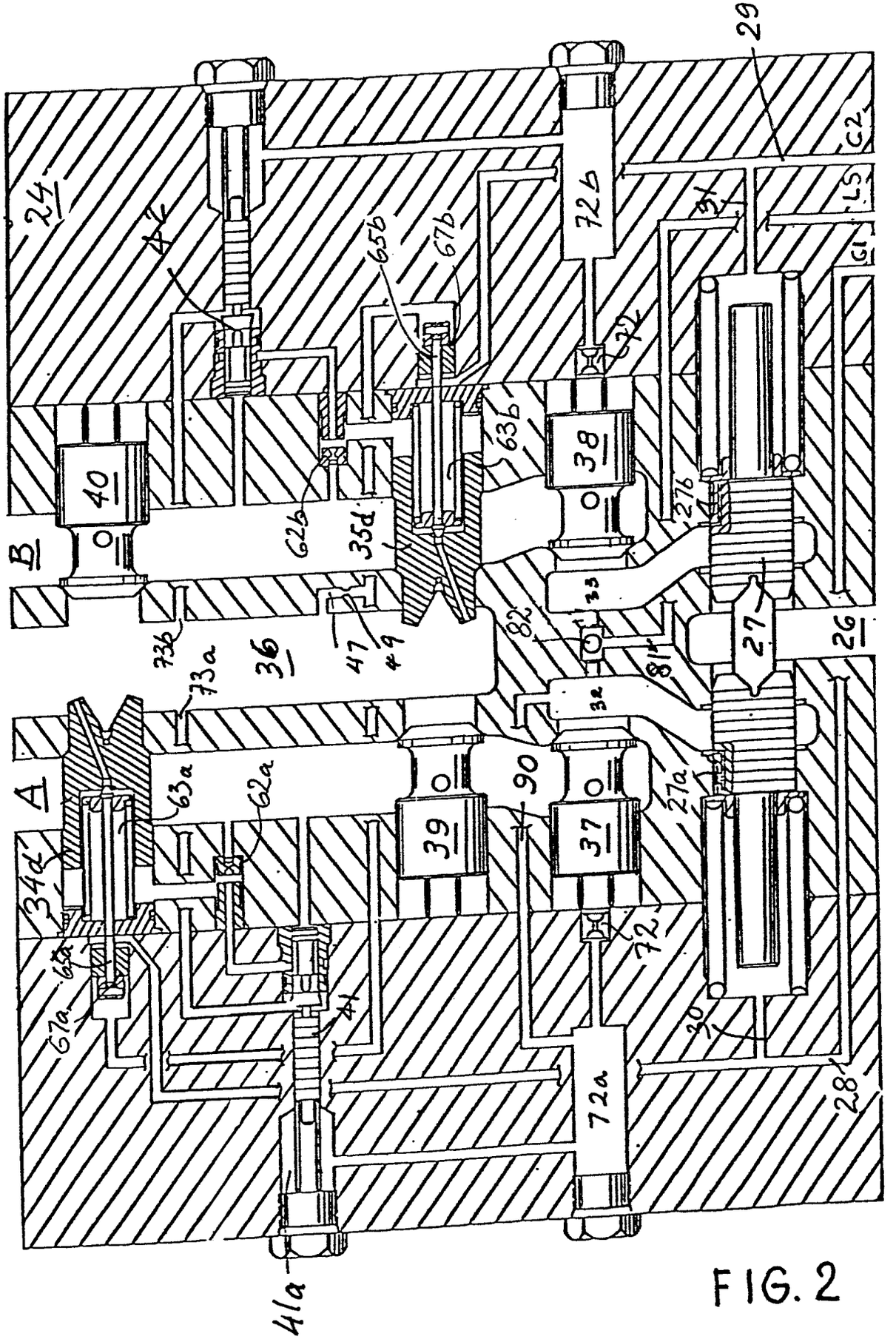

FIG. 2