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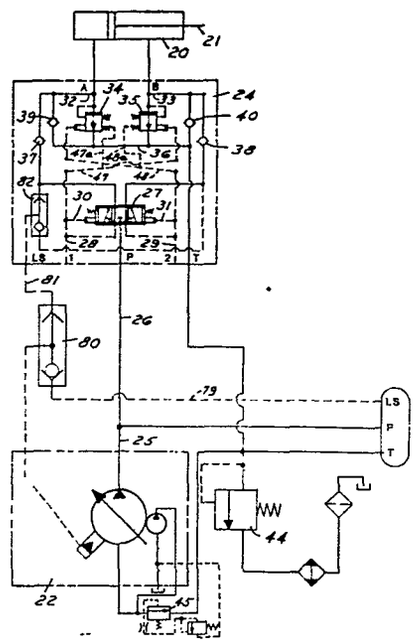
(54) Hydraulic control system for a hydraulic actuator.

(57) A hydraulic control system comprising a hydraulic actuator (20) having opposed openings adapted to alternately function as inlets and outlets for moving the element (21) of the actuator in opposite directions, a pump for supplying fluid to the actuator, and a meter-in valve (27) to which the fluid from the pump is supplied. The meter-in valve (27) is pilot controlled by alternately supplying fluid at pilot pressure to the meter-in valve (27) for controlling the direction of movement of the actuator. A pair of lines (32, 33) extend from the meter-in valve (27) to the respective openings of the actuator. Valves (34, 35) are positioned between a tank passage and each opening of the actuator for controlling the flow of fluid between the actuator and the tank passage; and at least one of these valves (34, 35) is normally open and pilot operated.



EP 0 080 135 A1

POWER TRANSMISSION

This invention relates to power transmission in hydraulic systems that are found, for example, on mobile equipment such as excavators and cranes.

Background and Summary of the Invention

In United States Patent No. 4,201,052, incorporated herein by reference, there is disclosed a pilot pressure operated high pressure load sensing valve system incorporated in a valve body designed to be mounted directly on an actuator to be controlled such as a hydraulic cylinder or hydraulic motor. The valve system accurately controls the position and speed of operation of the actuator.

In brief, the valve system disclosed in the aforementioned patent comprises an independent pilot operated meter-in element; a pair of load drop check valves; a pair of independently operated normally closed meter-out elements; a pair of load pressure responsive valves; and a pair of anti-cavitation valves. The meter-in element functions to direct fluid flow to one or the other of the actuator ports. The normally closed meter-out elements 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 element is directing fluid. The meter-out elements 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 elements has associated therewith the load pressure responsive valves which act on the meter-out elements in response to load pressure to enable the meter-out elements 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 system 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 valve system 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 element 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 overrunning loads, prevents fluid flow from the high pressure fluid source to the actuator even in the event of a ruptured line. Since the valve system is a load sensing system, the pump output is made to match that which is required by the load. In contrast, in a non-load sensing system, the pump output may exceed that required by the load with the excess power being dissipated as heat.

Under certain conditions, it may not be possible or desirable to mount the valve system directly to an actuator. Such conditions may exist due to space limitations on the actuator or where it is desirable to limit the number of supply and pilot lines, such as to the topmost section of a telescoping boom or when a brake, such as in a winch-type application, is required between the actuator and valve system. Under these conditions, the valve system is mounted on the equipment

remote from the actuator with a pair of lines running to the actuator port manifold. In one of these situations, it may be desirable to interpose a conventional counterbalance valve between one of the actuator port lines and the valve system. The counterbalance valve provides for controlled lowering and holding of the load at the actuator port manifold.

In another situation when a stable load is involved, it may be desirable to interpose a pilot operated check valve between the actuator port and the valve system. The pilot operated check valve provides for positive holding of the load, that is, holding the load stable with zero drift.

Also, in many applications, the need arises for a linear hydraulic cylinder to have a float position or a rotary hydraulic motor to have a free swing or coast position. In either of these applications, the implement at the end of the cylinder or a swing drive for a boom are allowed to coast to a stop due to frictional forces in the system.

The valve system disclosed in the aforementioned patent does not lend itself to use in the circuit applications mentioned above; namely, the use of counterbalance valves, pilot operated check valves, brakes and free float or swing of the actuator. This is mainly due to the normally closed condition of the meter-out valve elements.

Accordingly, it is an object of the present invention to provide a valve system of the aforementioned type which is operable with the use of counterbalance

valves, pilot operated check valves, brakes, and free floating or swinging actuators.

In accordance with the invention, the above described control valve system is provided with a pair of normally open exhaust valves positioned between a tank passage and actuator ports so that with the meter-in valve in the neutral position, both actuator ports are open to the tank passage through the normally open meter-out valves and the actuator will be free to move, as, for example, in the case of a free coasting boom. However, when a pilot signal is applied to the meter-in valve to move the actuator in one direction, pilot pressure is also applied to close the appropriate exhaust valve preventing flow of fluid from the pump to the tank passage with the other exhaust valve remaining open to the tank passage. Where a counterbalance valve is utilized in association with one opening of an actuator for controlling lowering and holding of a load, a single normally open exhaust valve is provided between that actuator opening and the tank passage. Where an external brake is provided for holding a load, a single normally open exhaust valve is also provided between the actuator opening and the tank passage.

Description of the Drawings

FIG. 1 is a schematic drawing of the hydraulic circuit embodying the invention.

FIG. 2 is a schematic drawing of another modified hydraulic circuit.

FIG. 3 is a schematic drawing of another modified hydraulic circuit.

FIG. 4 is a schematic drawing of another modified hydraulic circuit.

FIG. 5 is a fragmentary sectional view of a meter-out valve utilized in the system.

Description

Referring to FIG. 1, the hydraulic 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 system 22 which has load sensing control in accordance with conventional construction. The hydraulic system further includes a manually operated controller, not shown, that direct a pilot pressure to a valve system 24 for controlling the direction of movement of the actuator, as presently described. Fluid from the pump 22 is directed to the line 25 and line 26 to a meter-in valve 27 that functions to direct and control the flow of hydraulic fluid to one or the other end of the actuator 20. The meter-in valve 27 is pilot pressure controlled by controller, not shown, through lines 28, 29 and lines 30, 31 to the opposed ends thereof, as presently described. Depending upon the direction of movement of the valve, hydraulic fluid passes through lines 32, 33 to one or the other end of the actuator 20.

The hydraulic system further includes a normally-open exhaust valve 34, 35 positioned between each end of the actuator in lines 32, 33 and a tank passage 36. The exhaust valves control the flow of fluid between the actuator and tank passage 36, as presently described.

The hydraulic system further includes spring loaded poppet valves 37, 38 in the lines 32, 33 and spring-loaded anti-cavitation valves 39, 40 which are adapted

to open the lines 32, 33 to the tank passage 36. In addition, spring-loaded poppet valves, not shown, are associated with each valve 34, 35 acting as pilot operated relief valves. A line 47 connects exhaust valve 35 with pilot control line 28 and a line 48 connects valve 34 with pilot control line 29 so that when pilot pressure is applied to one side of meter-in valve 27, the appropriate valve 34, 35 is closed.

The system also includes a back pressure valve 44 associated with the return or tank line. Back pressure valve 44 functions to minimize cavitation when an over-running or a lowering load tends to drive the actuator 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 and in the absence of pilot pressure the spool is maintained in a neutral position by springs. The spool normally blocks the flow from the pressure passage 26 to the passages 32, 33. When pilot pressure is applied to either end of the spool, the spool moves until a force balance exists among the 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 passage 26.

When pilot pressure is applied to either line 28 or 29, leading to exhaust valves 34 or 35, the valve is actuated to block flow from the pressurized line 32 or 33 to tank passage 36.

It can thus be seen that the same pilot pressure which functions to determine the direction of opening of the meter-in valve and therefor the direction of movement of the actuator also functions to close the appropriate exhaust valve so that the fluid will flow into the actuator. The opposite exhaust valve is not acted on by the pilot pressure therefor remaining open to the tank passage and allowing fluid from the opposite end of the actuator to flow to tank.

Provision is made for sensing the maximum load pressure is one of a multiple of valve systems 24 controlling a plurality of actuators and applying the higher pressure to the load sensitive variable displacement pump 22. Each valve system 24 includes a line 81 extending to a shuttle valve 80 that receives load pressure from an adjacent actuator through line 79. Shuttle valve 80 senses which of the pressures is greater and shifts to apply the higher pressure to pump 22. Thus, each valve system in succession incorporates shuttle valves 80, 82 which compare the load pressure therein with the load pressure of an adjacent valve system and transmit the higher pressure to the adjacent valve system in succession and finally apply the highest load pressure to pump 22.

The single meter-in valve 27 may be replaced by two meter-in valves as shown in DE-30 11 088 A 1 and having a common assignee with the instant application.

The details of the preferred construction of the other elements of the hydraulic circuit are more specifically

described in the aforementioned United States Patent No. 4,201,052.

In accordance with the invention, one or both of the valves 34, 35 is a normally open exhaust valve rather than normally closed meter-out valves as in the aforementioned United States patent. In the case where both exhaust valves are normally open as shown in FIGS. 1 and 2 the exhaust valves are vented, as presently described, through vent lines 47a or 48a. Where only one exhaust valve is normally open, as shown in FIGS. 3 and 4 both the exhaust valve 35b or 35c and the normally closed meter-out valve 34b or 34c are vented through a common vent line 29a.

Thus, as shown in FIG. 1, both exhaust valves 34, 35 are normally open so that the actuator will be free to move, as in the case of a swinging boom, when the meter-in valve is in a neutral position. However, when a pilot signal is provided to move the actuator in one direction, pilot pressure is applied through line 47 or 48 to close the appropriate exhaust valve.

Thus, when a pilot signal is applied to the meter-in valve to move the actuator in one direction, the exhaust valve associated with the port to the actuator through which fluid is to be supplied is closed by the pilot signal. When the meter-in valve is returned to a neutral position, the exhaust valve is returned to its normally open position and the actuator is permitted to have a float position in the case of a hydraulic cylinder or to have a free swing or coast position in the case of a rotary hydraulic motor.

Although the invention has been described in connection with a flow control meter-in valve system in FIG. 1, it may also be utilized in a pressure control meter-in valve system as shown in FIG. 2. As shown in FIG. 2, a pressure control meter-in valve system has feedback pressure of line 83 opposing the pilot pressure at 31 and feedback pressure of line 84 opposing pilot pressure applied at 30. This gives smoother stopping and starting of loads and accurate positioning of loads which would otherwise not be obtained with the flow control meter-in valve system.

Where the system is used in an environment requiring a counterbalance valve 85, as shown in FIG. 3, between one port of the actuator and an exhaust valve 35b, only one normally open exhaust valve 35b is provided and the meter-out valve 34b associated with the other actuator port is normally closed. Thus, the counterbalance valve 85 can function to control overrunning loads by limiting the flow through the valve. When the meter-in valve is actuated by a pilot signal to elevate the actuator, fluid can flow through the check valve of the counterbalance valve 85 to the actuator. At the same time, a pilot signal through line 87 closes exhaust valve 35b. Meter-out valve 34b functions in a conventional manner to allow exhaust from the other port of the actuator.

Where an external brake 88 is used as in FIG. 4 to control overrunning loads, similarly only one normally open exhaust valve 35c is provided and is associated with one port of the rotary hydraulic actuator while a normally closed meter-out valve 34c is associated with the other port. A line 89 extends from brake 88 to the load line associated with the other port.

Referring to FIG. 5, each normally open exhaust valve 34, 35, 35b, 35c is of identical construction and, for purposes of clarity, only valve 35 is described.

The exhaust valve 35 includes a differential area bores 60 and 72 in which a poppet 61 is positioned between supply passage 33 and tank passage 36. The valve includes a passage 62 having an orifice 62a extending from supply passage 33 to a chamber 63 behind the poppet. One or more passages 64 formed within the poppet 61 extend from chamber 63 to the tank passage 36. A stem 65 is adapted to close the connection between chamber 63 and passages 64 under the action of a pilot pressure piston 66 which is positioned between chambers 69 and 71. A spring 67, in the absence of any pressure in the system, holds stem 65 in the open position and yieldingly urges poppet 61 to the closed position as shown in FIG. 5. However, in use the valve functions as a normally open valve; to this end the orifice 62a, the spring rate of spring 67, and the differential area of the poppet 66, i.e. the area of bore 60 less the area of bore 72, are selected so that a small and relatively insignificant pressure in line 33 will cause the poppet 61 to open and provide a flow path between passage 33 and tank passage 36. A passage 68 connects chamber 69 to pilot pressure in pilot line 28. The pressure in chamber 69 acts on one end of piston 66. Chamber 71, which is at the other end of piston 66, is vented through a passage 70, which as previously mentioned, connects with the appropriate vent line 48a or 29a as shown in FIGS. 1-4.

Claims

1. A hydraulic control system for use with a hydraulic actuator (20) having a movable actuator element (21) and an actuator opening (A, B) adapted to function alternately as an outlet and an inlet for moving the actuator element (21), a pilot controller for controlling a supply of fluid at pilot pressure (via 28, 29, 30, 31), a pump (22) for supplying fluid at pump pressure to the actuator (20), said system comprising
a line (26, 32, 33) adapted for connection with the actuator opening (A, B),
a normally open valve (35, 35b, 35c) associated with said line (33) for controlling fluid flow from the actuator (20), said valve (35, 35b, 35c) being pilot operated (via 47, 87) by pilot pressure from said pilot controller,
a meter-in valve (27) positioned in said line (26, 32, 33) for controlling fluid flow from said pump (22) to the actuator (20), said meter-in valve (27) being operable by pilot pressure from said pilot controller.

2. The hydraulic control system set forth in claim 1 including a second line extending to another opening of the actuator, and a second valve associated with said line and being normally open and pilot operated.

3. The hydraulic control system set forth in claim 1 including a counterbalance valve associated with said actuator.

4. The hydraulic control system set forth in claim 1 including a hydraulic brake associated with the load being moved by the actuator.

5. A hydraulic control system comprising

a hydraulic actuator having opposed openings adapted to alternately function as inlets and outlets for moving the element of the actuator in opposite directions,

a pump for supplying fluid to said actuator,

a tank passage for returning fluid to a reservoir,

meter-in valve means to which the fluid from the pump is supplied,

said meter-in valve means being pilot operated by alternately supplying fluid at pilot pressure to said meter-in valve means for controlling the direction of movement of the actuator,

a pair of lines extending from said meter-in valve means to said respective openings of said actuator,

valve means positioned between said tank passage and each opening of the actuator for controlling the flow of fluid therebetween

at least one of said last-mentioned valve means being normally open,

said normally open valve means being pilot operated by the pilot pressure.

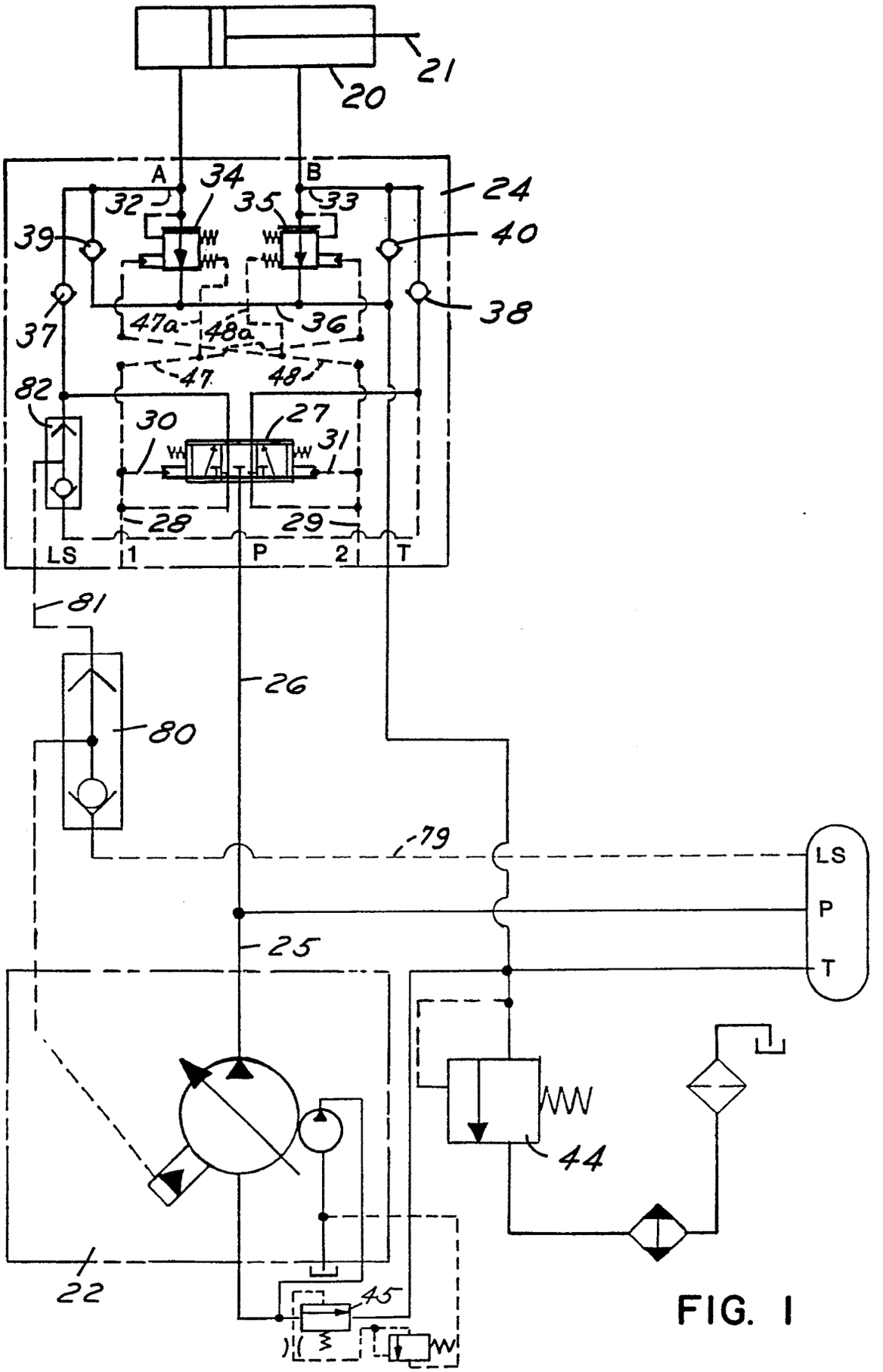

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FIG. 1

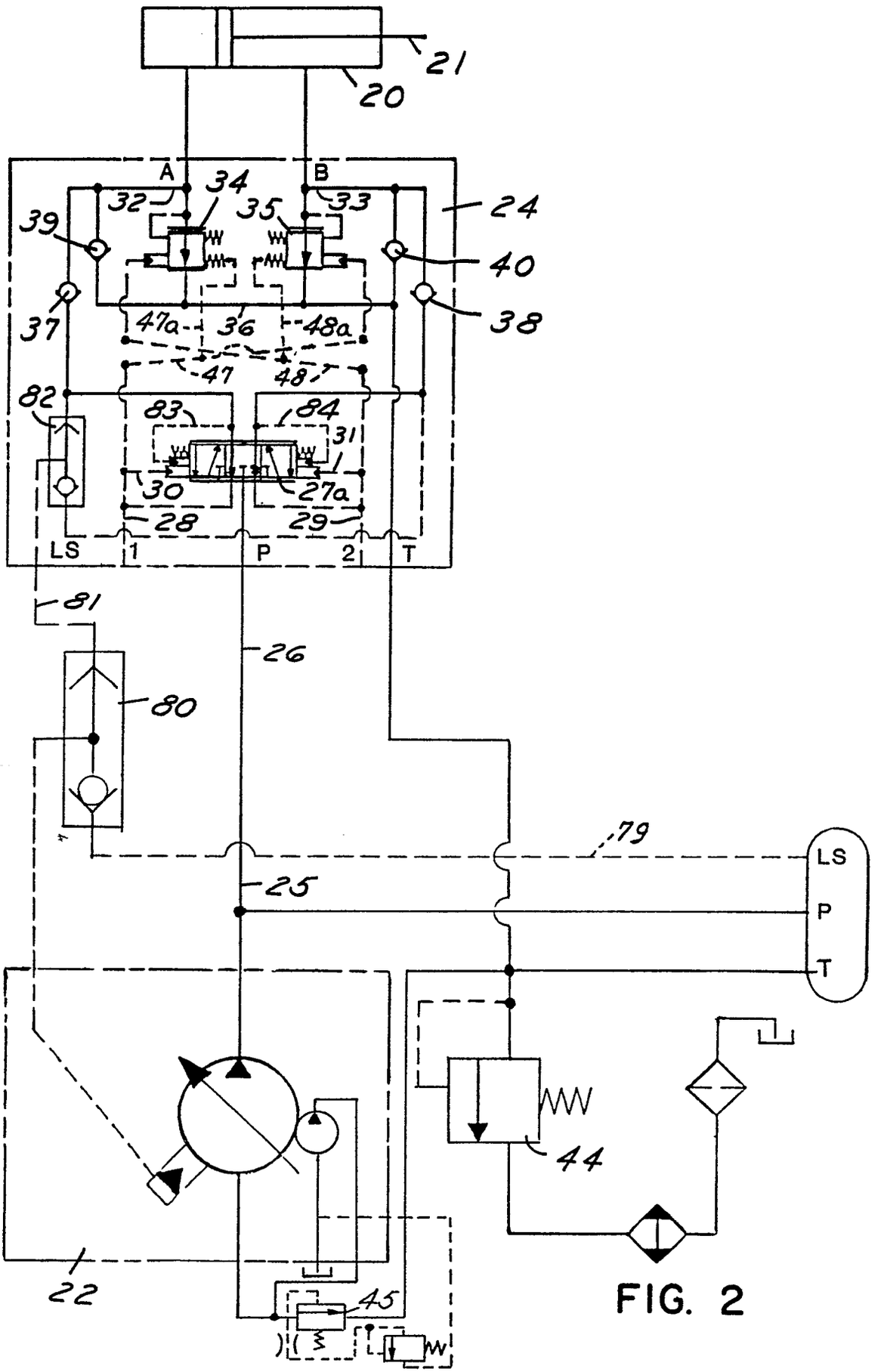
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FIG. 2

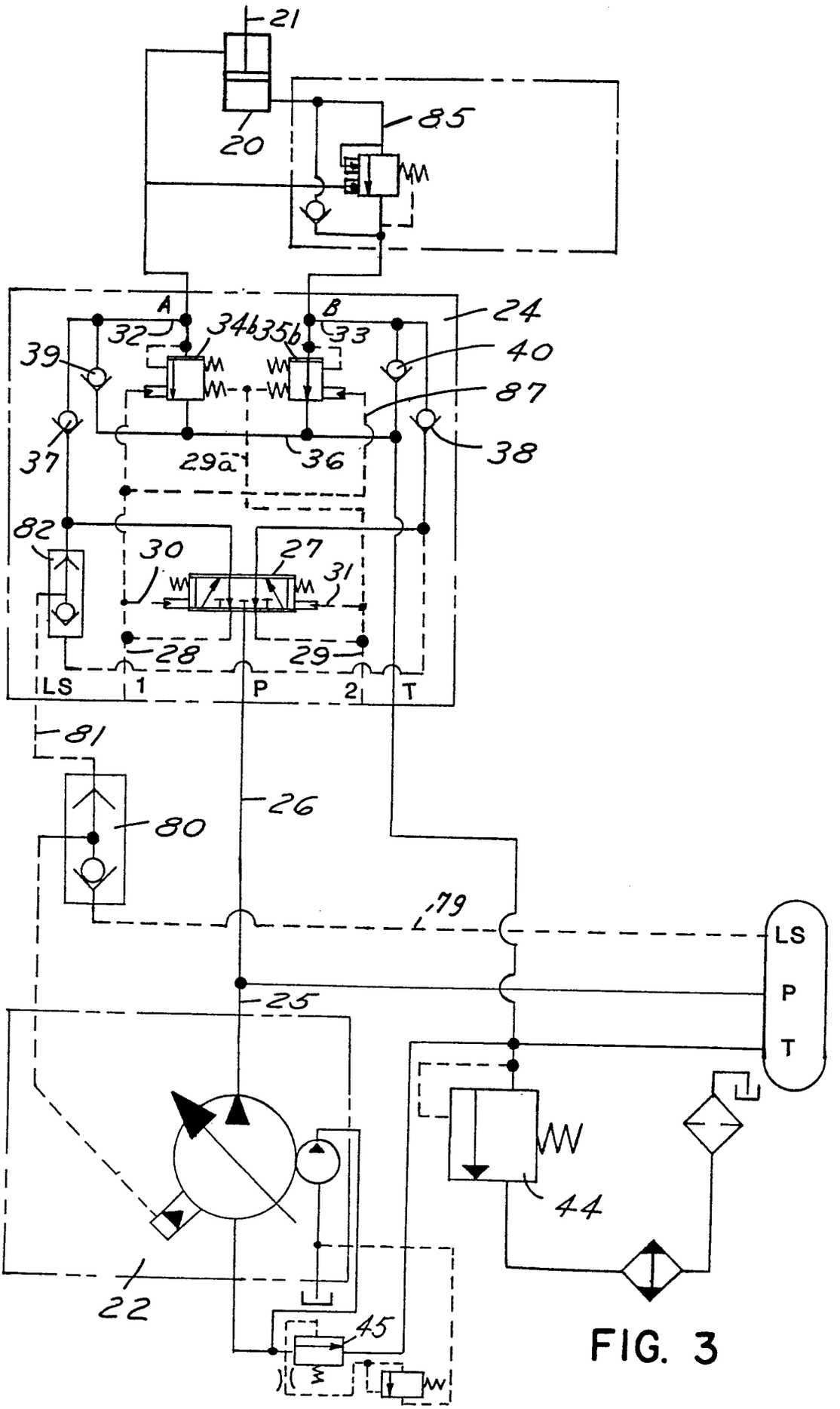
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FIG. 3

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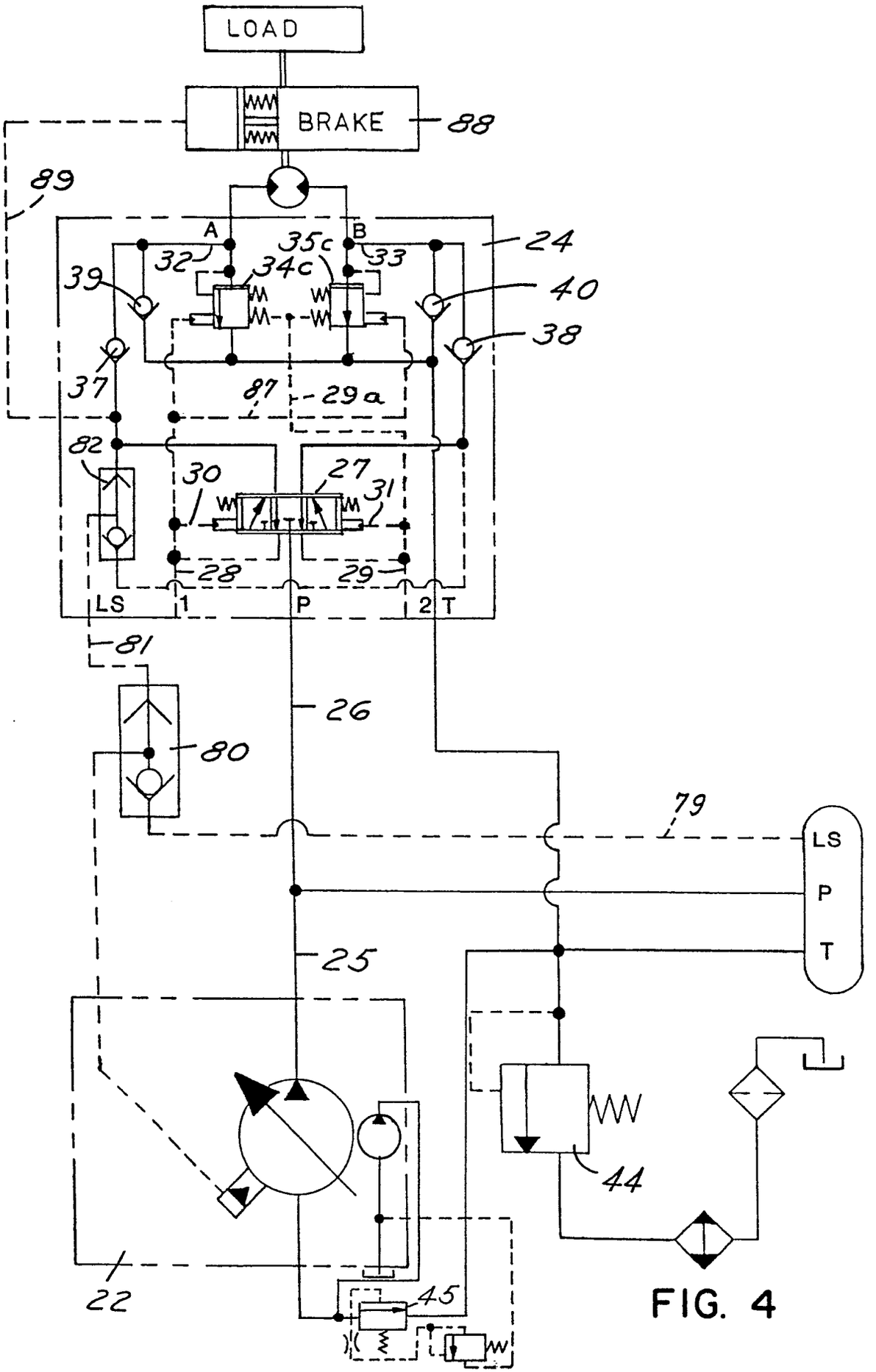
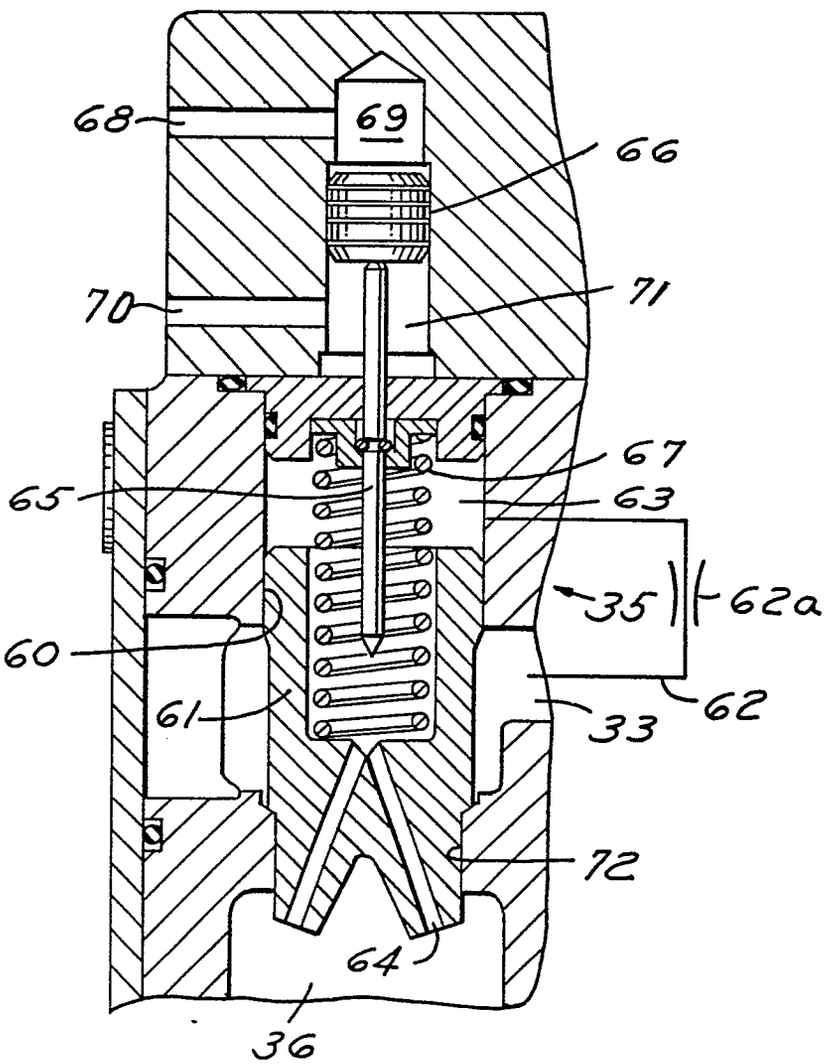


FIG. 4

FIG.5



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EUROPEAN SEARCH REPORT

Application number 0080135

EP 82 11 0471

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
D,A	US-A-4 201 052 (R.H. BREEDEN et al.) * Complete document *	1,5	F 15 B 13/02
A	DE-B-1 601 729 (HYDRAULIC UNIT SPECIALTIES CO.)		

TECHNICAL FIELDS SEARCHED (Int. Cl. ³)

F 15 B 13/02
F 15 B 13/042
F 15 B 11/08

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	01-02-1983	LEMBLE Y.A.F.M.

CATEGORY OF CITED DOCUMENTS

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