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(54) **Hydraulic control system for a hydraulic actuator.**

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Description

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 overrunning loads, prevents fluid flow from the high pressure fluid source to the actuator even in the event of a ruptured line.

Under certain conditions of application, it may not be possible or desirable to mount the valve body with the several valves ("valve system") directly to the 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 device for a boom are allowed to coast to a stop due to frictional forces in the system.

A hydraulic control system of the referred-to kind (US—A—4,201,052) does not lend itself to be used 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 valves.

Accordingly, it is an object of the present invention to provide a hydraulic control 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.

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

In the case of an actuator having two openings the hydraulic control system is provided with a pair of normally open exhaust valves (instead of the normally closed meter-out valves mentioned above) positioned between a tank passage and the 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 high pilot pressure is applied to the meter-in valve to move the actuator in one direction, such 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. When 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. When 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.

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

Fig. 2 is a schematic drawing of another modified hydraulic control system;

Fig. 3 is a schematic drawing of a further modified hydraulic control system having a counterbalance valve;

Fig. 4 is a schematic drawings of another modified hydraulic control system having a hydraulic brake; and

Fig. 5 is a fragmentary sectional view of an exhaust valve utilized in the 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 in accordance with conventional construction. The hydraulic control system further includes a manually operated controller, not shown, that directs high or low pilot pressure through pilot port 1 or 2 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 line ports A or B connected to the actuator 20. The pilot ports 1 and 2 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 lines 32, 33 and ports A or B to one or the other end of the actuator 20.

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

The hydraulic control 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 61 (Fig. 5) are associated with each valve 34, 35 acting as pilot operated relief valves. A control line 47 connects exhaust valve 35 with pilot control lines 28 and a control line 48 connects valve 34 with pilot control line 29 so that when high pilot pressure is applied to one side of meter-in valve 27, the appropriate valve 34 or 35 is closed.

The system also includes a back pressure valve 44 connected to the tank port T and associated with the return or tank line. 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 line 26 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.

When high pilot pressure is applied to either control line 28, 47 or 29, 48, leading to exhaust valves 34 or 35, such exhaust 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 high pilot pressure which functions to determine the direction of opening of the meter-in valve 27 and therefor the direction of movement of the actuator 20 also functions to close the appropriate exhaust valve 34 or 35 so that the fluid will flow into the actuator 20. The opposite exhaust valve 35 or 34 is not acted on by the high pilot pressure therefore remaining open to the tank passage 36 and allowing fluid from the opposite end of the actuator 20 to flow to tank.

Provision is made by elements 79—82 for sensing the maximum load pressure in one of a multiple of valve systems 24 controlling a plurality of actuators 20 and applying the higher load pressure to the variable displacement pump 22. A shuttle valve 82 is connected to passages 32 and 33 and senses which of the pressures in 32 and 33 is the higher one to transmit same to a line 81. Line 81 extends through a load sensing port LS to a shuttle valve 80 that receives load pressure from an adjacent actuator through line 79. Shuttle valve 80 senses which of the load pressures is higher 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—A—3,011,088.

The details of the preferred construction of the other elements of the hydraulic circuit are more specifically described in US—A—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 US—A—4,201,052. In the case where both exhaust valves 34, 35 are normally open as shown in Figs. 1 and 2, the exhaust valves 34, 35 are vented, as presently described, through vent lines 47a or 48a. Where only one exhaust valve 35b, 35c is normally open, as shown in Figs. 3 and 4, both the exhaust valves 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 27 is in a neutral position. However, when high pilot pressure is provided to move the actuator in one direction, such pilot pressure is also applied through line 47 or 48 to close the appropriate exhaust valve 35 or 34.

Thus, when high pilot pressure is applied to the meter-in valve 27 (f.i. through 29, 31) to move the actuator 20 in one direction, the exhaust valve 34 associated with the port A to the actuator 20 through which fluid is to be supplied is closed by the high pilot pressure. When the meter-in valve 27 is returned to a neutral position, the exhaust valve 34 is returned to its normally open position and the actuator 20 is permitted to have a float condition in the case of a hydraulic cylinder or to have a free swing or coast condition in the case of a rotary hydraulic motor.

Although the invention has been described in connection with a flow control meter-in valve system 27 in Fig. 1, it may also be utilized in a pressure control meter-in valve system 27a as shown in Fig. 2. Such a pressure control meter-in valve system 27a has feedback pressure of line 83 opposing the pilot pressure at 31 and feedback pressure of line 84 opposing the 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 27.

Where the hydraulic control system is used in an environment requiring a counterbalance valve 85, as shown in Fig. 3, between one port of the actuator and the port B to the exhaust valve 35b, only one normally open exhaust valve 35b is provided and the meter-out valve 34b associated with the other port A connected to 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 85. When the meter-in valve 27 is actuated by high pilot pressure through control line 28, 30 to elevate the actuator 20, fluid can flow through the check valve of the counterbalance valve 85 to the actuator 20. At the same time the pilot pressure through control 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 connected to port B while a normally closed meter-out valve 34c is associated with the other port connected to port A. A line 89 extends from brake 88 to the load line 32 leading to port A.

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 bores 60 and 72 of different area 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 chambers 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 lines 48a or 29a as shown in Figs. 1—4.

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 valve means (34, 35; 34b, 35b; 34c, 35c) 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 for applying fluid at high or low pilot pressure to said meter-in valve (27) and said exhaust valve means 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,
characterized in that said exhaust valve means include at least one exhaust valve (34, 35, 35b, 35c) which at said low pilot pressure, is in its normally open position, and at said high pilot pressure, when fluid flow from the pump (22) is applied to the actuator (20), is in its closed position.

2. The hydraulic control system set forth in claim 1, wherein said actuator (20) has two actuator openings and two normally open exhaust valves (34, 35), each of which is pilot-operated and associated with one of said actuator openings.

3. The hydraulic control system set forth in claims 1 or 2, wherein a counterbalance valve (85) is connected between one of said actuator openings and its associated normally open exhaust valve (35b).

4. The hydraulic control system set forth in claim 1 including a hydraulic brake (88) associated with the load being moved by the actuator, wherein said actuator has another, second opening being associated with a normally closed exhaust valve (34c), said normally closed exhaust valve (34c) being pilot-operated to be opened when said normally open exhaust valve (35c) is pilot-operated to be closed, and wherein said hydraulic brake (88) is connected (via 89) to said line system (26, 32) to receive fluid under pressure, when said second opening is supplied with fluid.

5. A hydraulic control system set forth in any of the claims 1 through 4, wherein said meter-in valve (27), said exhaust valves (34, 35; 34b, 35b; 34c, 35c) together with poppet valves (37, 38) and anticavitation valves (39, 40) are mounted to form a valve system (24) for controlling the direction of movement of the actuator, said valve system (24) having a pump port (P), a tank port (T), pilot ports (1, 2) and actuator line ports (A, B) and being mounted on equipment remote from the actuator (20) and wherein a pair of lines connect said valve system (24) with said actuator openings.

Patentansprüche

1. Hydraulisches Steuersystem
mit einer Pumpe (22) zur Lieferung von Druckflüssigkeit, einem hydraulischen Stellglied (20) mit einem bewegbaren Element (21) und mindestens einer Öffnung, die nacheinander als Einlaß und Auslaß der Flüssigkeit dienen kann, mit einem Leitungssystem (26, 32, 33, 36), welches die Pumpe (22) mit der Stellgliedöffnung und einem Tank verbindet.
mit einem Einlaßbemessungsventil (27), welches so in dem Leitungssystem angeordnet ist, daß die der Stellgliedöffnung zuzuführende Flüssigkeit abgesperrt oder zugelassen wird, mit einer Auslaßventileinrichtung (34, 35; 34b, 35b; 34c, 35c), die zwischen der Stellgliedöffnung und dem Tank so geschaltet ist, daß die Flüssigkeit zum Tank fließen kann oder der Fluß abgesperrt wird, und
mit einer Pilotsteuereinrichtung zur Anlage von Flüssigkeit mit hohem oder niedrigem Pilotdruck an das Einlaßbemessungsventil (27) und die Auslaßventileinrichtung, um die Lage dieser Ventile zu bestimmen,
wobei das Einlaßbemessungsventil (27) bei dem niedrigen Pilotdruck in seiner geschlossenen Lage und bei dem hohen Pilotdruck in seiner Durchlaßlage geschaltet ist,
dadurch gekennzeichnet, daß die Auslaßventileinrichtung mindestens ein Auslaßventil (34, 35, 35b, 35c) einschließt, welches bei niedrigem Pilotdruck in seiner normalerweise offenen Lage ist und bei hohem Pilotdruck, wenn ein Flüssigkeitsstrom der Pumpe (22) dem hydraulischen Stellglied (20) zugeführt wird, in seiner geschlossenen Lage ist.

2. Hydraulisches Steuersystem nach Anspruch 1, dadurch gekennzeichnet, daß das hydraulische Stellglied (20) zwei Stellgliedöffnungen und zwei normalerweise offene Auslaßventile (34, 35) aufweist, welche jeweils pilotbetätigt und jeweils einer Stellgliedöffnung zugeordnet sind.

3. Hydraulisches Steuersystem nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß ein Differenzdruckregelventil (85) zwischen der einen Stellgliedöffnung und dem normalerweise offenen Auslaßventil (35b) angeordnet ist.

4. Hydraulisches Steuersystem nach Anspruch 1 mit einer hydraulischen Bremse (88), die der von dem hydraulischen Stellglied zu bewegenden Last zugeordnet ist, dadurch gekennzeichnet, daß der Motor eine weitere zweite Öffnung in Zuordnung zu einem normalerweise geschlossenen Auslaßventil (34c) aufweist, daß das normalerweise geschlossene Auslaßventil (34c) pilotbetätigt geöffnet wird, wenn das normalerweise offene Auslaßventil (35c) pilotbetätigt geschlossen ist und daß die hydraulische Bremse (88) mit dem Leitungssystem (26, 32) zum Empfang von Druckflüssigkeit verbunden wird (über 89), wenn der zweiten Stellgliedöffnung Flüssigkeit zugeführt wird.

5. Hydraulisches Steuersystem nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß das Einlaßbemessungsventil (27), die Auslaßventile (34, 35; 34b, 35b; 34c, 35c) zusammen mit Rückschlagventilen (37, 38) und Nachsaugventilen (39, 40) zur Bildung eines Ventilsystems (24) zur Steuerung der Bewegungsrichtung des hydraulischen Stellgliedes miteinander vereinigt sind, wobei das Ventilsystem (24) eine Pumpenöffnung (P), eine Tanköffnung (T), Pilotöffnungen (1, 2) und Arbeitsleitungsöffnungen (A, B) aufweist und an einem Geräteteil entfernt vom Motor (10) montiert ist, wobei zwei Arbeitsleitungen das Ventilsystem (24) mit den Stellgliedöffnungen verbinden.

Revendications

1. Système de commande hydraulique comprenant une pompe (22) servant à délivrer un fluide sous pression, un dispositif d'actionnement hydraulique (20) comportant un organe mobile (21) et au moins une ouverture apte à fonctionner en alternance en tant qu'admission et sortie pour le fluide,
un système de canalisations (26, 32, 33, 36) raccordant ladite pompe (22) à ladite ouverture du dispositif d'actionnement et à une réservoir,
une valve de dosage d'entrée (27) disposée dans ledit système de canalisations de manière à bloquer ou admettre le fluide devant être envoyé à ladite ouverture du dispositif d'actionnement,
des moyens formant valve d'échappement (34, 35; 34b, 35b; 34c, 35c), branchés entre ladite ouverture du dispositif d'actionnement et ledit réservoir de manière à admettre le fluide pour

qu'il circule jusqu'au réservoir ou de manière à bloquer un tel écoulement, et

un dispositif de commande pilote servant à appliquer le fluide à une pression pilote élevée ou faible à ladite valve de dosage d'entrée (27) et auxdits moyens formant valve d'échappement de manière à déterminer la position de telles valves,

ladite valve de dosage d'entrée (27) étant dans sa position fermée, pour ladite pression pilote faible, et dans sa position d'admission pour ladite pression pilote élevée, caractérisé en ce que lesdits moyens formant valves d'échappement incluent au moins une valve d'échappement (34, 35, 35b, 35c) qui est dans sa position normalement ouverte, pour ladite pression pilote faible, et est dans sa position fermée pour ladite pression pilote élevée, lorsque l'écoulement du fluide provenant de la pompe (22) est appliqué au dispositif d'actionnement (20).

2. Système de commande hydraulique selon la revendication 1, dans lequel ledit dispositif d'actionnement (20) comporte deux ouvertures et deux valves d'échappement (34, 35) normalement ouvertes et dont chacune est pilotée et est associée à l'une desdites ouvertures du dispostif d'actionnement.

3. Système de commande hydraulique selon la revendication 1 ou 2, dans lequel une valve d'équilibrage (85) est branchée entre l'une desdites ouvertures du dispositif d'actionnement et la valve d'échappement normalement ouverte (35b), qui lui est associée.

4. Système de commande hydraulique selon la revendication 1, incluant un frein hydraulique (28) associé à la charge qui est déplacée par le dispositif d'actionnement, et dans lequel ledit dispositif d'actionnement comporte une autre seconde ouverture associée à une valve d'échappement (34c) normalement fermée, ladite valve d'échappement (34c) normalement fermée étant pilotée de manière à être ouverte lorsque ladite valve d'échappement normalement ouverte (35c) est commandée de manière à être fermée, et dans lequel ledit frein hydraulique (88) est raccordé (par l'intermédiaire de 89) audit système de canalisations (26, 32) de manière à recevoir le fluide sous pression, lorsque ladite seconde ouverture est alimentée par le fluide.

5. Système de commande hydraulique selon l'une quelconque des revendications 1 à 4, dans lequel ladite valve de dosage d'entrée (27), lesdites valve d'échappement (34, 35; 34b, 35b; 34c, 35c) ainsi que les valves-champignons (37, 38) et des valves d'anticavitation (39, 40) sont montées de façon à former un système de valves (24) servant à commander la direction de déplacement du dispositif d'actionnement, ledit système de valves (24) comportant un orifice (P) pour la pompe, un orifice (T) pour le réservoir, des orifices pilotes (1, 2) et des orifices (A, B) des canalisations du dispositif d'actionnement, et étant monté sur un équipement distant du dispositif d'actionnement (20) et dans lequel un couple de canalisations relient ledit système de valves (24) auxdites ouvertures du dispositif d'actionnement.

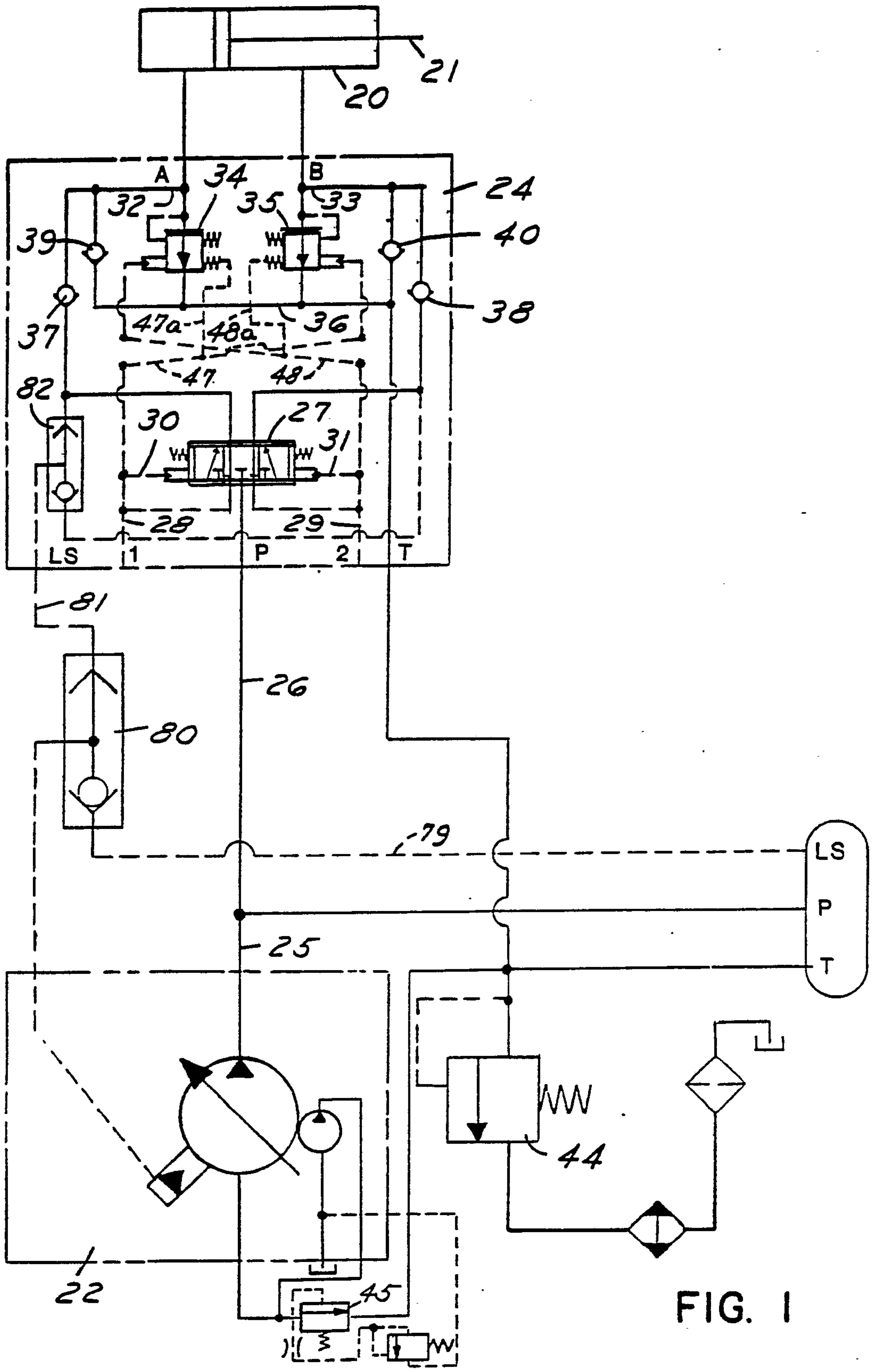

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FIG. I

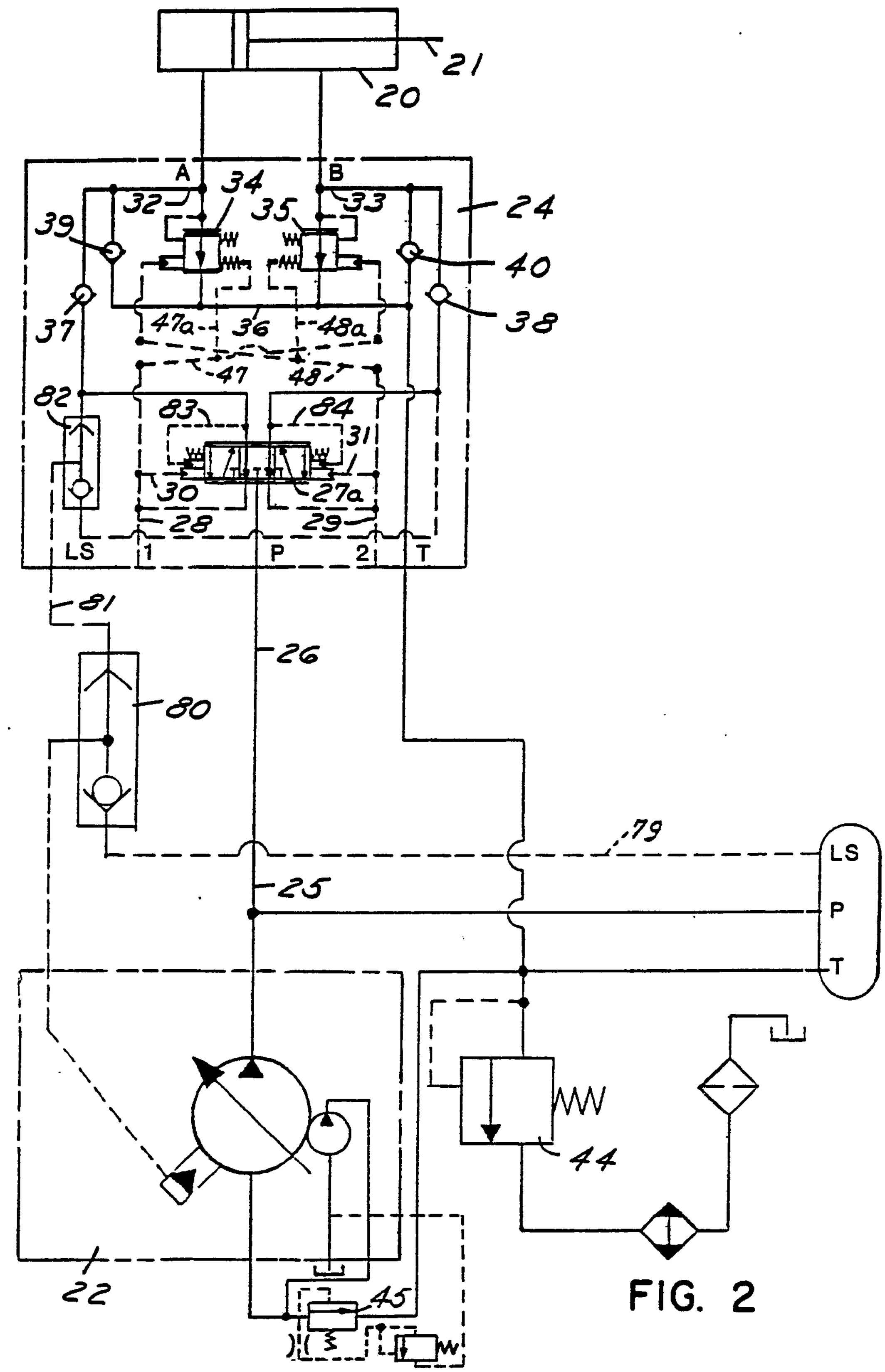
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FIG. 2

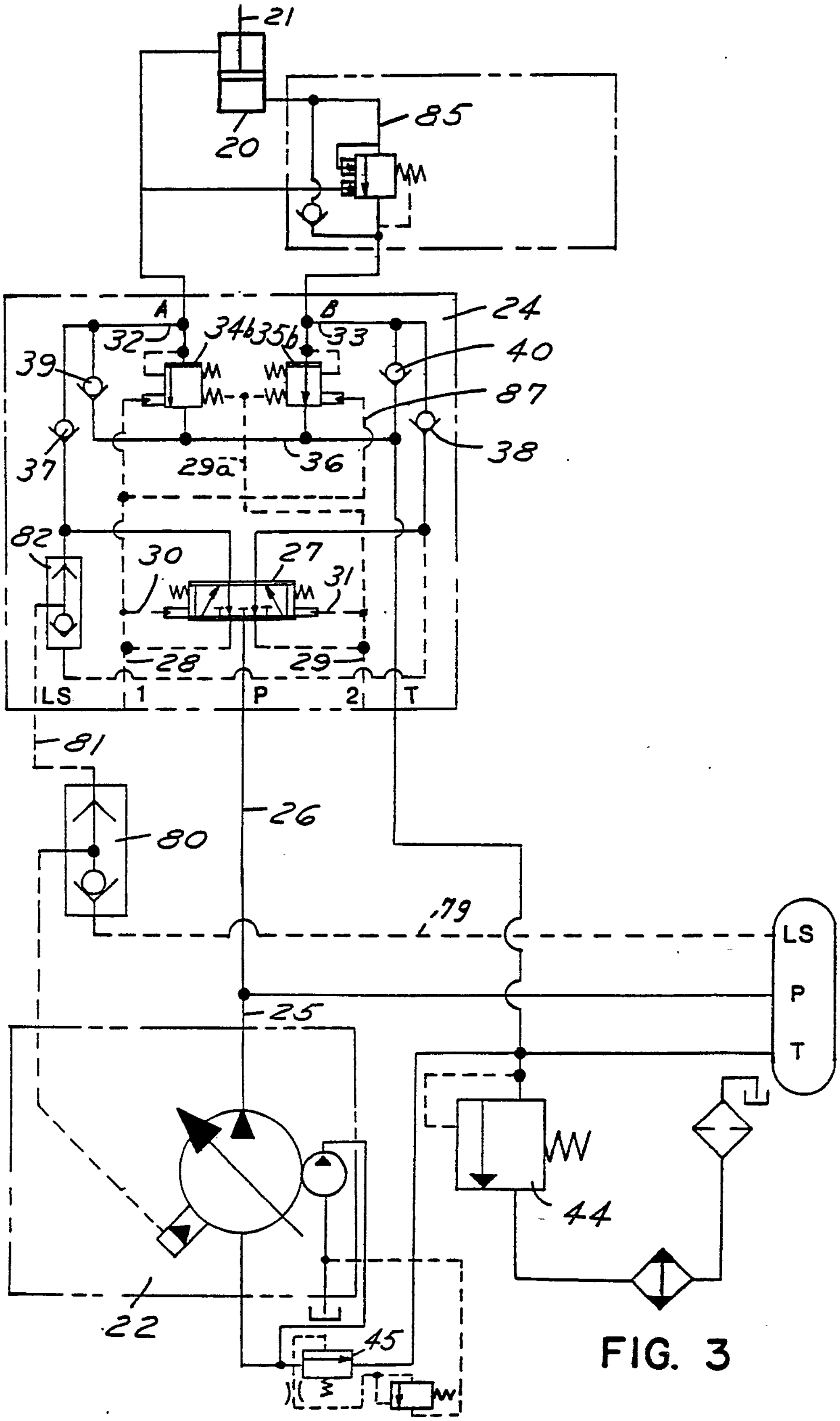
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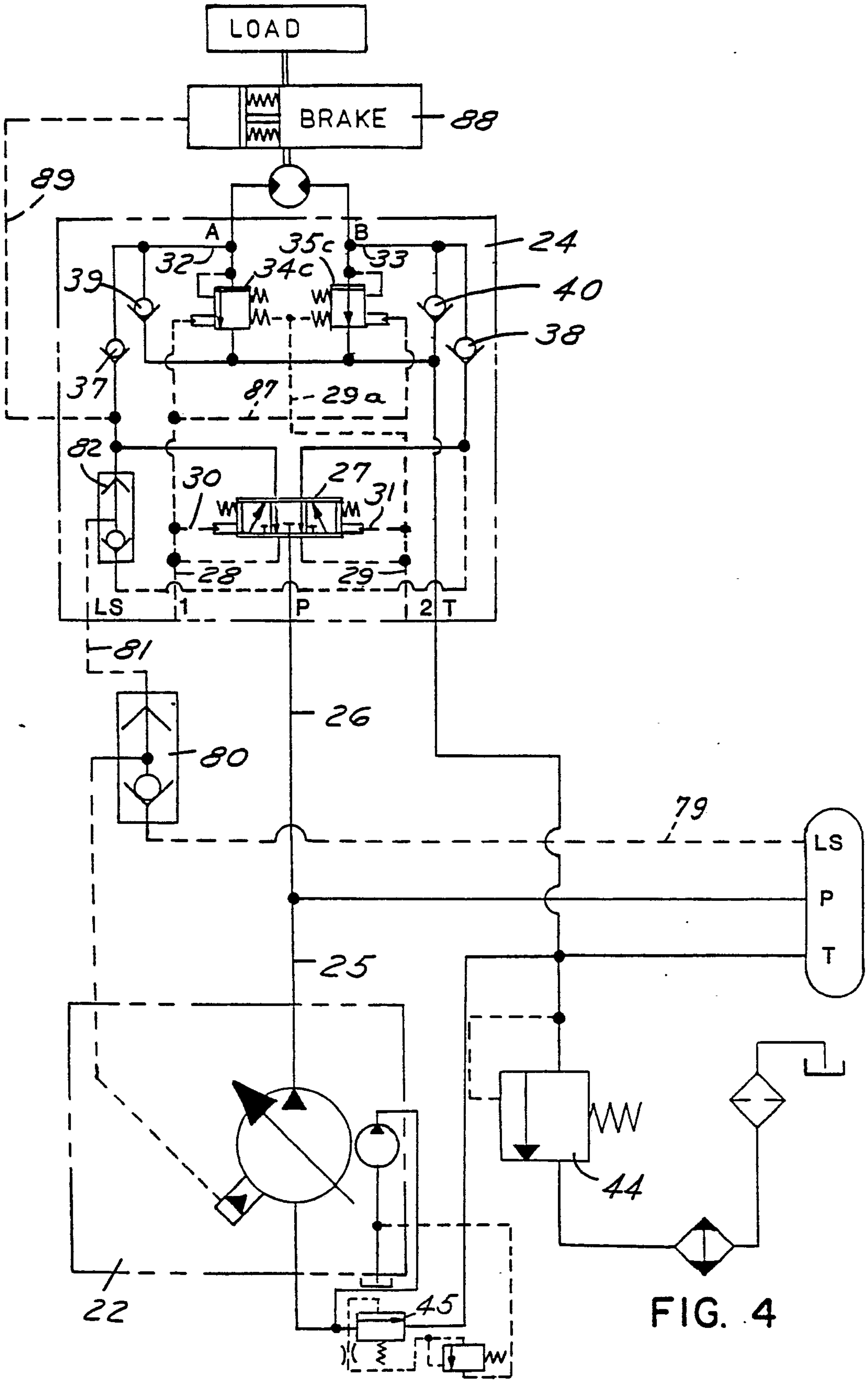
FIG. 3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P
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FIG. 4

FIG.5