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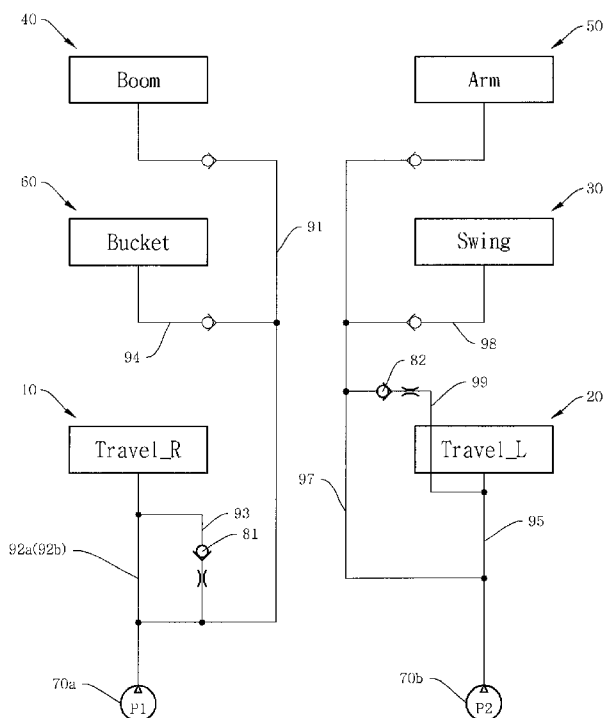
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(54) Title: ELECTRIC OIL PRESSURE SYSTEM OF CONSTRUCTION EQUIPMENT

FIG. 5



(57) Abstract: Disclosed is an electric oil pressure system of a construction equipment, the electric oil pressure system including: a regeneration circuit unit included in control valves 130 and 140 for controlling a channel of the operation oil supplied to the first and second group actuators, the regeneration circuit unit connecting oil pressure lines of each head side and each load side of the first and second group actuators so as to supply a part of operation oil, which is discharged from any one of each head side and each load side of the first and second group actuators, to the other side, when the working apparatus connected with the first and second group actuators is driven by one selected from its weight and inertia; and an actuator-used oil quantity calculation unit 110, which calculates an measurement value of oil pressure of each head side and each load side of the first and second group actuators, a measurement pressure value of oil discharged from each pump, and a measurement value of an opening ratio of each control valve so as to obtain a quantity of regenerated oil Q_{regen} , which is again supplied to the first and second group actuators through the regeneration circuit unit, wherein the swash plate controller 1220 calculates a quantity of currently used oil Q_{SCyl} and a quantity of oil Q_{pump} to be discharged from the first and second pumps 70a and 70b by subtracting the quantity of regenerated oil Q_{regen} from a quantity of required oil Q_{set} input through operation of the joystick, thereby calculating an angle of each swash plate of the first and second pumps 70a and 70b.

ELECTRIC OIL PRESSURE SYSTEM OF CONSTRUCTION EQUIPMENT

Technical Field

The present invention relates to an electric oil pressure system of construction equipment, and more particularly to an electric oil pressure system, which is operated by an electric joy stick or a remote controller, thereby providing the proper quantity of oil consumed in an actuator and oil pressure.

Background Art

In general, construction equipment includes an engine, a pump for generating oil pressure by using the power of the engine, a controller for controlling the oil pressure generated in the pump through an oil pressure valve, and an actuator operated by an oil pressure.

Particularly, the construction equipment described above operates each actuator by controlling the quantity of oil and oil pressure by means of an oil pressure controlling system.

For example, when the construction equipment performs a specific job, the actuator performs an operation of a boom, an arm, a bucket, a swing, a travel-right, or a travel-left.

Moreover, the construction equipment includes a plurality of pumps. One of the pumps relates to a left travel operation, a swing operation, and an arm operation among operations of the actuators described above, and another pump relates to a right travel operation, a boom operation, a the bucket operation among operations of the actuators described above.

However, there is a problem with the above mentioned conventional oil pressure controlling system.

During the operation of the construction equipment, an actuator for performing a left travel operation and an

actuator for performing a right travel operation are driven so that the construction equipment moves forwards or backwards, or changes a direction.

Meanwhile, while the construction equipment travels, the boom, the arm, the bucket, or the swing can be driven. When a separate actuator, which doesn't relate to traveling, is driven, overload is given to a pump relating to the corresponding actuator, or the amount of operation oil is biased to an actuator for performing a left travel operation or an actuator for a right travel operation. Therefore, there is a problem in that straightness of the construction equipment's movement cannot be secured.

That is, when the operation oil is distributed unevenly so that the amount of oil discharged from one pump of a plurality of pumps is larger than the amount of oil discharged from another pump, it is impossible to secure the safety of the construction equipment's operation.

Meanwhile, in the conventional oil pressure controlling system, it is impossible to predict or grasp quantity of oil used in each actuator. Therefore, there is a problem that an engine and the pump are driven excessively so as to allow sufficient oil to be used in each actuator.

Also, because of excessive driving of the engine and the pump, fuel efficiency of the construction equipment is reduced, and energy is wasted.

Disclosure

Technical Problem

Therefore, the present invention has been made in view of the above-mentioned problems, and it is an object of the present invention to provide an electric oil pressure system of a construction equipment, which accurately predicts the

quantity of required oil, which corresponds to the operation of a driver, so as to effectively operate a plurality of pumps, thereby improving energy efficiency.

5 The object of the present invention is not limited to the object mentioned above, and another object of the present invention not mentioned above can be clearly understood by those skilled in the art through the following description.

Technical solution

10 According to an aspect of the present invention, there is provided an electric oil pressure system of a construction equipment, the electric oil pressure system including: first and second pumps for supplying operation oil to connected first and second group actuators in order to operate a working
15 apparatus, the first and second pumps discharging a changeable quantity of operation oil; a first oil pressure line, through which operation oil discharged from the first pump flows into the first group actuator; a second oil pressure line, through which operation oil discharged from the second pump flows into
20 the second group actuator; a direction control valve for changing a flowing direction of operation oil so as to allow operation oil of the first oil pressure line and operation oil of the second oil pressure line to be joined; a swash plate controller, which calculates a quantity of currently used oil
25 Q_{scyl} and a quantity of oil to be currently discharged from the first and second pumps Q_{pump} based on a quantity of required oil Q_{set} input through operation of a joystick, adds/subtracts a quantity of oil, which is joined when the operation oil of the first oil pressure line and the operation oil of the second
30 oil pressure line are joined, to/from the quantity of oil to be discharged Q_{pump} , and calculates an angle of each swash plate of the first and second pumps so as to allow a quantity of oil, which corresponds to a result value obtained through the

adding/subtracting, to be discharged; and an electro proportional pressure reducing valve driving unit for controlling an angle of each swash plate of the first and second pumps according to a result value determined by the
5 swash plate controller.

Also, the electric oil pressure system may further include regeneration circuit unit included in first and second control valves for controlling a channel of the operation oil supplied to the first and second group actuators, the
10 regeneration circuit unit connecting oil pressure lines of each head side and each load side of the first and second group actuators so as to supply a part of operation oil, which is discharged from any one of each head side and each load side of the first and second group actuators, to the other
15 side, when the working apparatus connected with the first and second group actuators is driven by one selected from its weight and inertia; and an actuator-used oil quantity calculation unit, which calculates an measurement value of oil pressure of each head side and each load side of the first and
20 second group actuators, a measurement pressure value of oil discharged from each pump, and a measurement value of an opening ratio of each control valve so as to obtain a quantity of regenerated oil Q_{regen} , which is again supplied to the first and second group actuators through the regeneration circuit
25 unit, wherein the swash plate controller may calculate a quantity of currently used oil Q_{scyl} and a quantity of oil to be discharged from the first and second pumps Q_{pump} by subtracting the quantity of regenerated oil Q_{regen} from a quantity of required oil Q_{set} input through operation of the joystick,
30 thereby calculating an angle of each swash plate of the first and second pumps.

Also, the electric oil pressure system may include: a discharged oil quantity calculation unit, which calculates a

detection value obtained by detecting an angle of each swash plate of the first and second pumps in driving, a detection value obtained by detecting the number of rotations of the first and second pumps, and a detection value obtained by
5 detecting discharge pressure of operation oil discharged by the first and second pumps, thereby obtaining a quantity of oil discharged by the pumps Q_{spump} , wherein the swash plate controller calculates an angle of each swash plate of the first and second pumps, the angle of the swash plate allowing
10 a quantity of remaining oil, which is obtained by excepting the quantity of regenerated oil Q_{regen} and the quantity of discharged oil Q_{spump} from the quantity of required oil Q_{set} , to be further discharged from the first and second pumps.

Also, wherein each opening ratio of the first and second
15 control valve is obtained by calculating spool positions of the first and second control valves, which have been measured by first and second spool position detection parts, and the number of rotations of the first and second pumps is obtained by calculating a rotation speed of an engine, which has been
20 detected by an engine speed detection unit.

Also, the first pump may supply operation oil to the first group actuator including a right travel motor in a normal state, and the second pump may supply operation oil to the second group actuator including a left travel motor in a
25 normal state, wherein, when a complex operation including a traveling operation and a typical work is performed, through switching of the direction control valve, the first pump may supply operation oil to the first group actuator and the second group actuator, except for the left travel motor, and
30 the second pump may supply operation oil only to the right travel motor and the left travel motor, and wherein the swash plate control unit controls an angle of each swash plate of the first and second pumps by reflecting switching between

actuators relating to the first pump and actuators relating to the second pump.

Also, a quantity of oil to be supplemented from the first pump 70a Q_{rest} may be obtained by an equation,

5

$$Q_{rest} = c_q A_{pt\_travel\_L} \sqrt{\frac{2(p_1 - p_2)}{\rho}},$$

wherein Q_{rest} refers to a quantity of oil to be supplemented from pump 1 through a boom operation, an arm operation, a bucket operation, and a swing operation, $A_{pt\_travel\_L}$ refers to an open area of a center bypass channel in a right travel spool, P_1 refers to pressure of the first pump 1, P_2 refers to pressure of the second pump 2, C_q refers to coefficient of a quantity of oil, and ρ refers to fluid density.

Also, a quantity of oil to be supplemented from the second pump 70b Q_{travel_2} may be obtained by an equation,

20

$$Q_{travel\_2} = c_q A_{drive} \sqrt{\frac{2(p_2 - p_1)}{\rho}},$$

wherein Q_{travel_2} refers to a quantity of oil to be supplemented from the second pump through a travel operation, A_{drive} refers to orifice area, P_1 refers to pressure of the first pump, P_2 refers to pressure of the second pump, C_q refers to coefficient of a quantity of oil, and ρ refers to fluid density.

Advantageous Effects

As described above, an electric oil pressure system of construction equipment according to one embodiment of the present invention can detect operational state of each

actuator, and control the flow direction controlling valve by performing electric calculations respective to a detected signal, thereby preventing operation oil from being unevenly distributed to any one side. As a result, the safety of driving the construction equipment is secured.

Also, the electric oil pressure system of construction equipment according to an embodiment of the present invention can accurately predict and control the quantity of oil so that operation time of an engine and a pump can be reduced to be an optimal time. Also, the quantity of oil and oil pressure can effectively be controlled, and fuel efficiency can be improved.

Brief Description of the Drawings

The foregoing and other objects, features and advantages of the present invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a view showing an example of construction equipment;

FIG. 2 is a view showing an oil pressure circuit for describing an electric oil pressure system of construction equipment according to one embodiment of the present invention;

FIG. 3 is a view showing an example of a controller of an electric oil pressure system of construction equipment according to one embodiment of the present invention;

FIG. 4 is a view showing an example of an oil pressure circuit for describing an electric oil pressure system of construction equipment according to one embodiment of the present invention;

FIG. 5 is a schematic view showing the oil pressure circuit of FIG.4;

FIG. 6 is a view showing an example of an oil pressure circuit for describing the driving of a specific actuator of an electric oil pressure system of a construction equipment according to one embodiment of the present invention during
5 the traveling of a construction equipment;

FIG. 7 is a schematic view showing an example of the oil pressure circuit of FIG.6; and

FIG. 8 is a view showing an oil pressure circuit for describing an example of regeneration of oil discharge in an
10 electric oil pressure system of construction equipment according to one embodiment of the present invention.

Best Mode

An electric oil pressure system of a construction
15 equipment according to an embodiment of the present invention includes: first and second pumps 70a and 70b for supplying operation oil to connected first and second group actuators in order to operate a working apparatus, the first and second pumps discharging a changeable quantity of operation oil; a
20 first oil pressure line 91, through which operation oil discharged from the first pump 70a flows into the first group actuator; a second oil pressure line 97, through which operation oil discharged from the second pump 70b flows into the second group actuator; a direction control valve 80 for
25 changing a flowing direction of operation oil so as to allow operation oil of the first oil pressure line 91 and operation oil of the second oil pressure line 97 to be joined; a swash plate controller 1220, which calculates a quantity of currently used oil Q_{scyl} and a quantity of oil Q_{pump} to be
30 currently discharged from the first and second pumps 70a and 70b based on a quantity of required oil Q_{set} input through operation of a joystick, adds/subtracts a quantity of oil, which is joined when the operation oil of the first oil

pressure line 91 and the operation oil of the second oil pressure line 97 are joined, to/from the quantity of oil to be discharged Q_{pump} , and calculates an angle of each swash plate of the first and second pumps 70a and 70b so as to allow a quantity of oil, which corresponds to a result value obtained through the adding/subtracting, to be discharged; and an electro proportional pressure reducing valve driving unit 230 for controlling an angle of each swash plate of the first and second pumps 70a and 70b according to a result value determined by the swash plate controller 1220.

Mode for Invention

Hereinafter, an advantage and a characteristic of the present invention and a method for achieving them will be clear with reference to an embodiment, which will be described below with accompanying drawings.

In the following description, the same elements will be designated by the same reference numerals although they are shown in different drawings.

Hereinafter, an electric oil pressure system according to an embodiment of the present invention will be described with reference to FIGs. 1 to 4.

FIG. 1 is a view showing an example of construction equipment, FIG. 4 is a view showing an example of an oil pressure circuit for describing an electric oil pressure system of construction equipment according to one embodiment of the present invention, and FIG. 5 is a schematic view showing the oil pressure circuit of FIG.4.

As shown in FIGs.1 and 4, a construction equipment includes an upper body rotating on an upper side of a lower part, a boom arranged on a front part of the upper body in such a manner that it can perform an angular rotation in an up-down direction, an arm arranged outside of the boom in such

a manner that it can perform an angular rotation in an up-down direction, and a bucket arranged outside of the arm in such a manner that it can perform an angular rotation in an up-down direction.

5 Moreover, working actuators 40, 50, and 60 for driving the boom, the arm, and the bucket, which have been described above, respectively, are arranged. Also, a first pump 70a or a second pump 70b for supplying operation oil to the above described working actuators and an engine are arranged at the
10 upper body described above.

Also, a first travel motor 10 and a second travel motor 20, which relates to traveling of the construction equipment, are further arranged, and a first actuator 30 for rotating the upper body described above is arranged.

15 The first pump 70a or the second pump 70b described above changes and outputs the quantity of operation oil and oil pressure according to control angle of a swash plate. At this time, discharged operation oil is supplied to each of the working actuators described above.

20 The respective working actuators described above may be the first actuator 30 for rotating the upper body, a second actuator 40 for elevating the boom, a third actuator 50 for folding or unfolding the arm, and a fourth actuator 60 for driving the bucket.

25 Also, a direction controlling valve 80 may be arranged between the first pump 70a or the second pump 70b and the respective working actuators described above. The above-described direction controlling valve 80 has two positions and four ports. Therefore, when the direction controlling valve 80
30 is positioned at a first position, an input port and an output port are directly connected with each other, and when it is positioned at a second position, the input port and the output port cross each other.

The first pump 70a or the second pump 70b, which has been described above, regenerates operation oil by using potential energy of the boom, the arm, and the bucket and inertia energy generated by the rotation of the upper body, thereby saving energy and reducing the load of the engine and the first pump 70a or the second pump 70b. Also, the first and second pumps 70a and 70b can be controlled by using the potential energy and the inertia energy, which are described above. This will be described in detail with reference to FIGs. 2 and 3.

FIG. 2 is a view showing an oil pressure circuit for describing the electric oil pressure system of construction equipment according to one embodiment of the present invention, and FIG. 3 is a view showing an example of a controller of the electric oil pressure system of construction equipment according to one embodiment of the present invention.

The working actuators, which drive the boom, the arm, and the bucket, respectively, are arranged at the construction equipment. A pump 110 and an engine 120 for supplying operation oil to the working actuator described above are arranged at the above-described upper body.

The pump 110 described above changes and outputs quantity of operation oil and pressure thereof by controlling the angle of the swash plate. At this time, discharged operation oil is supplied to each actuator described above.

Also, a swash plate angle detection unit 111 is arranged at one side of the above-described pump 110 so as to detect the angle of the swash plate described above. A discharged oil pressure detection unit 112 is arranged at another side of the pump 110, from which operation oil is discharged, so as to detect the pressure of discharged operation oil.

An engine speed detection unit 121 is arranged at one side of the engine 120 described above so as to detect speed of the engine 120, and power output from the engine 120 is supplied to the pump 110 described above.

5 An actuator pressure detection part, which is connected with the corresponding working actuator in such a manner that it allows operation oil to be delivered and can be driven by the above-described pump 110 and detects oil pressure of a head side and a load side of the working actuator described
10 above, is arranged.

For example, the working actuator described above may be a first actuator 150 for driving the arm and the second actuator 160 for driving the boom. The actuator pressure detection unit may be arranged at each working actuator.

15 For example, as shown in FIGs. 2 and 8, in order to detect oil pressure applied to the first actuator 150 described above, a first head side pressure detection unit 151 may be arranged on a head side of the first actuator 150, and a first load side pressure detection unit 152 may be arranged
20 on a load side of the first actuator.

Also, as shown in FIG. 2, in order to detect oil pressure applied to the second actuator 160 described above, a second head side pressure detection unit 161 is arranged on a head side of the second actuator, and a second load side
25 pressure detection unit 162 is arranged on a load side of the second actuator.

Also, as a control valve for controlling the working actuators described above, a first control valve 130 may be arranged on the first actuator 150, and a second control valve
30 140 may be arranged on the second actuator 160.

Also, a plurality of spools for switching channels, which are connected with each head side and each load side of the actuators 150 and 160, respectively, to each other, a

channel 132, a check valve 133, and an orifice, etc. may be included in the first and second control valves 130 and 140. Techniques about spools, channels (orifices), etc. are well known. Therefore, descriptions of them will be omitted.

5 Also, a spool position detection unit for detecting the position of each spool is arranged on one side of the control valve described above. For example, a first spool position detection unit 131 is arranged on the first control valve 130 described above, and a second spool position detection unit
10 141 is arranged on the second control valve 140 described above.

 The first and second control valves 130 and 140 described above can change the progressing direction of operation oil according to the movement of the spool, and the
15 spool is moved according to an applied electric control signal.

 That is, the position of the spool of the control valve described above can be calculated by using a result value measured by the first spool position detection unit 131 and
20 the second spool position detection unit 141, and the result value, which has been calculated above, can be used as basic data for calculating an opening ratio of the control valve.

 Also, a regeneration circuit part, which connects oil pressure lines of the head side and the load side of the
25 actuator with each other, thereby supplying a part of operation oil discharged from one of the head side and the load side of the actuator to the other side of the actuator when a working apparatus connected with the actuator described above is driven by weight or inertia, is further arranged.

30 Moreover, a controller C, which receives detection result values from the swash plate angle detection unit 111 described above, the discharged oil pressure detection unit 112, the engine speed detection unit 121, the actuator

pressure detection part, and the spool position detection part, calculates them, and controls the pump 110 and the control valve according to calculated result values, is further arranged.

5 Moreover, an electronic joystick 1300 can be arranged in the controller C described above, and the electronic joystick 1300 is operated by a driver of the construction equipment. An electric control signal is generated when the electronic joystick 1300 is operated, and the control signal is applied
10 to the controller C described above.

The controller C will be described in detail with reference to FIG. 3.

The controller C described above includes a valve controller 1100 and a pump controller 1200.

15 The valve controller 1100 described above includes an actuator-used oil quantity calculation unit 110 for calculating an oil quantity value Q_{scyl} used in the working actuator described above, a spool controller 120 for calculating a difference in oil quantity values between a
20 required oil quantity value Q_{set} generated by controlling the electric joystick 1300 described above and a result value from the actuator-used oil quantity calculation unit 110 so as to obtain a spool control result value, and an electro
25 proportional pressure reducing valve driving unit 230 for driving the spool of the control valve by using the result value calculated by the spool controller 120.

In the actuator-used oil quantity calculation unit 110 described above, a result value obtained by detecting the position of a spool in the control valve described above is
30 authorized, a result value detected in the actuator pressure detection unit described above is authorized, and a result value detected in the discharged oil pressure detection unit 112 is authorized.

The pump controller 1200 described above includes a discharged oil quantity calculation unit 210 for calculating the quantity of oil discharged from the pump 110, a swash plate controller 220 for calculating the oil quantity value Q_{pump} , which is obtained by subtracting the quantity of regenerated oil obtained by calculating a value detected in the actuator pressure detection unit described above from the quantity of required oil Q_{set} required by controlling the electric joystick, and the quantity of oil discharged from the pump 110, thereby calculating an incline angle of the swash plate, and an electro proportional pressure reducing valve driving unit 230 for controlling the pump 110 by using a result value determined in the swash plate controller 220.

In the discharged oil quantity calculation unit 210 described above, the detection value detected in the swash plate angle detection unit 111 described above and the detection value detected in the engine speed detection unit 121 described above are authorized. Also, a detection value detected in the swash plate angle detection unit 111 is authorized in the swash plate controller 220.

Hereinafter, the quantity of regenerated oil in the electric oil pressure system of the construction equipment according to an embodiment of the present invention will be described with reference to FIG. 3.

First, a command signal generated from the electric joystick 1300 is received in the controller C.

The command signal described above may be a signal corresponding to the required oil quantity Q_{set} in accordance with a speed of the actuator.

In the actuator-used oil quantity calculation unit 110 described above, a detection value of spool displacement is authorized from the first spool position detection parts 131 arranged at the first control valve 130 or the second spool

position detection unit 141 arranged on the second control valve 140, a detection valve is authorized from the first or second head side pressure detection unit 151 or 161 described above and the first and second load side pressure detection unit 152 or 162, and a detection value of the discharged oil pressure detection unit 112 is authorized.

At this time, the actuator-used oil quantity calculation unit 110 predicts the quantity of oil currently used by the actuator through the orifice equation of equation (1) below.

$$Q_{scyl} = C_q A(x) \sqrt{\frac{2(p_{pump} - P_{cyl})}{\rho}} \quad \dots \text{equation (1)}$$

In equation (1), Q_{scyl} : the quantity of oil used in the actuator,

P_{pump} : pump discharge pressure,

P_{cyl} : load pressure of the actuator,

$A(x)$: area of the opening of a valve, which is prescribed as spool position x ,

C_q : coefficient of the quantity of oil,

ρ : fluid density.

The spool controller 120 described above receives an error value between the quantity of oil to be used in the actuator Q_{set} , which is required by operating the electric joystick 1300, and the quantity of oil currently used in the actuator Q_{scyl} , thereby determining the position of the spool of the first or second control valve 130 or 140.

Herein, various control algorithms are implemented so as to allow the error value to rapidly become extinct. For example, the spool position order X_{spool} determined in the spool controller is converted to an electric signal (supply current) through the electro proportional pressure reducing valve driving unit 230, and the position of the spool of the

first or second control valve 130 or 140 described above is changed by the electric signal.

The pump controller 1200 described above controls the angle of the swash plate of the pump 110 so as to allow the pump to discharge as much oil as the working actuator requires.

The pump controller 1200 includes the discharged oil quantity calculation unit 210 for predicting the quantity of currently discharged oil, the swash plate angle controller 220 for comparing the quantity of oil required by the pump with the quantity of currently discharged oil, calculating them, and generating a control command for controlling the angle of the swash plate, and the electro proportional pressure reducing valve driving unit 230 for driving an electro proportional pressure reducing valve, which generates pressure for adjusting the angle of the swash plate.

The quantity of oil required by the pump Q_{pump} described above is defined by equation (2) below.

$$Q_{\text{pump}} = Q_{\text{set}} - Q_{\text{regen}} \quad \dots \text{equation (2)}$$

In equation (2), Q_{pump} : the quantity of oil required in the pump,

Q_{set} : the value of the quantity of required oil, which is generated by controlling the electric joystick, and

Q_{regen} : the quantity of regenerated oil.

The discharged oil quantity calculation unit 210 described above receives an authorized detection value from the swash plate angle detection unit 111 and an authorized detection value from the engine speed detection unit 121 so as to calculate the quantity of oil currently discharged from the pump through equation (3) below.

$$Q_{spump} = \omega \cdot \Delta V \quad \dots \text{equation (3)}$$

In equation (3),

Q_{spump} : the quantity of currently discharged oil,

5 ω : rotation speed of the engine, and

V : the quantity of oil discharged from the pump.

The swash plate controller 220 described above receives an error value between the quantity of oil required from the pump Q_{pump} and the quantity of currently discharged oil Q_{spump} and receives a detection value from the discharged oil
10 pressure detection unit 112 of the pump 110 so as to calculate the swash plate angle.

Herein, various control algorithms can be implemented so as to allow error values to rapidly become distinct. For
15 example, the swash plate angle control algorithm may be a flow control algorithm or a horsepower algorithm.

A swash plate angle command X_{angle} determined by the swash plate controller 220 described above is converted to a control signal (supply current) through the electro
20 proportional pressure reducing valve driving unit 230.

In general, there is a difference between the quantity of oil required by the pump Q_{pump} and the quantity of oil required by controlling the electric joystick Q_{set} because of an oil quantity regeneration effect of the valve. The quantity
25 of oil required by the pump Q_{pump} has to be calculated in consideration of oil quantity regeneration which is changed according to a characteristic of the working actuator.

The regeneration of the quantity of oil, which has been described above, refers to a function implemented in the
30 control valve, in which operation oil, which is discharged from one side of the cylinder (or a motor) due to potential energy generated when the arm crowds and the boom is elevated down and inertia energy generated when the upper body is

rotated, is re-supplied to the other side of the cylinder (or the motor) so that the quantity of required oil is reduced.

That is, when the arm crowds or the boom is elevated down, the quantity of oil discharged from the actuator isn't
5 allowed to flow to a tank due to the weight of the arm or the boom, but is used as a part of the quantity of oil introduced into the actuator, thereby reducing energy and increasing the speed of the construction equipment.

Therefore, the quantity of oil required by the pump
10 Q_{pump} , which is actually discharged from the pump, corresponds to a value obtained by subtracting the quantity of regenerated oil Q_{regen} from the quantity of required oil Q_{set} , which is required by controlling the electric joystick.

The working actuator according to an embodiment of the
15 present invention may be the first actuator 150 for driving the arm or the second actuator 160 for driving the boom.

The first actuator 150 described above drives the arm and uses the quantity of regenerated oil when the first actuator 150 performs an extending operation.

20 When the arm crowds, the quantity of oil in the load side of the first actuator 150 is discharged due to the weight of the arm.

The quantity of oil passes through the main spool A_{out} of the first control valve 130 and a channel 135 of a
25 regeneration release circuit and flows into the tank.

Meanwhile, the speed of the oil, which has passed through the main spool, is controlled by a miter-out controlling method so that pressure p^* of the oil is higher than pressure of oil of the head side of the cylinder of the
30 first actuator 150.

Therefore, as shown in FIG. 8, a part of the quantity of oil of the load side passes through the first inner channel

132 and joins the quantity of oil of the pump to be supplied to cylinder head of the first actuator 150.

The above-described quantity of regenerated oil Q_{regen} , which is used in the first actuator 150, can be calculated through equation (4) and equation (5) below.

$$Q_{\text{regen}} = c_q A_{\text{regen}} \sqrt{\frac{2(p^* - p_{\text{pump}})}{\rho}} \quad \dots \text{equation (4)}$$

$$p^* = p_{\text{rod}} - \frac{\rho \alpha^2 Q_{\text{scyl}}^2}{2c_q^2 A_{\text{out}}^2} \quad \dots \text{equation (5)}$$

10 In equations (4) and (5), Q_{regen} : the quantity of regenerated oil,

A_{regen} : the area of a channel of a regeneration valve (a check valve),

P^* : pressure between the spool and the regeneration release circuit,

P_{pump} : pump discharge pressure,

C_q : flow of the quantity of oil,

ρ : fluid density,

$\alpha = A_{\text{rod}}/A_{\text{head}}$: the ratio of the area of the head of the cylinder in the arm to the area of the head thereof,

Q_{scyl} : the quantity of oil used in the actuator,

A_{out} : the area of the opening of the spool connected from the actuator to the tank, and

P_{rod} : load pressure of the lode side of the arm.

25 Also, when the boom is lower, the quantity of regenerated oil is generated.

When the boom is elevated down, a part of the quantity of oil in the head side of the actuator 160 passes through the second inner channel 142 due to the weight of the boom so as to be regenerated in the load side of the boom. At this time, the quantity of regenerated oil Q_{regen} , which is regenerated in

the second actuator 160, can be calculated through equation (6).

$$Q_{regen} = c_q A_{regen} \sqrt{\frac{2(p_{head} - p_{pump})}{\rho}} \quad \dots \text{equation (6)}$$

5

In equation (6), Q_{regen} : the quantity of regenerated oil,
 A_{regen} : the area of the channel of the regeneration valve
 (the check valve),

P_{pump} : pump discharge pressure,

10 C_q : coefficient of the quantity of oil,

ρ : fluid density, and

P_{head} : load pressure of the head side of the boom.

Therefore, the quantity of required oil, which will be
 discharged by actually operating the pump, can be calculated
 15 through equation (7) below.

$$Q_{pump} = \sum Q_{set} - \sum Q_{regen} \quad \dots \text{equation (7)}$$

In equation (7), Q_{pump} : the quantity of oil to be
 20 discharged by operating the pump,

Q_{set} : the quantity of oil required by controlling the
 electric joystick, and

Q_{regen} : the quantity of oil regenerated in the first or
 second actuators 150 and 160.

25 On the other hand, as shown in FIG. 5, the first pump
 70a relates to a first group actuator including the first
 travel motor 10, the second actuator 40, and the fourth
 actuator 60, thereby supplying the operation oil. The second
 pump 70b relates to a second group actuator including the
 30 second travel motor 20, the third actuator 50, and the first
 actuator 30, thereby supplying the operation oil.

Also, operation oil discharged from the first pump 70a flows to a first oil pressure line 91 to be supplied to the first group actuator described above, and operation oil discharged from the second pump 70b flows to a second oil pressure line 97 to be supplied to the second group actuator described above.

Also, a direction controlling valve 80, which allowing a flowing direction of operation oil to be changed or allowing the operation oil to be joined, can be further arranged at the first oil pressure line 91 and the second oil pressure line 97, which have been described above.

The actuator, to which the first pump 70a and the second pump 70b according to an embodiment of the present invention, which have been described above, relate, is defined by equation (8) and equation (9) below.

$$Q_{pump1} = Q_{travel\_L} + Q_{Swing} + Q_{Boom2} + Q_{Arm1} \quad \dots \text{equation (8)}$$

$$Q_{pump2} = Q_{travel\_R} + Q_{Bucket} + Q_{Boom1} + Q_{Arm2} \quad \dots \text{equation (9)}$$

In equations (8) and (9),

Q_{pump1} : the quantity of oil discharged from the first pump 70a,

Q_{pump2} : the quantity of oil discharged from the first pump 70b,

Q_{travel_L} : the quantity of oil required in the first travel motor 10,

Q_{travel_R} : the quantity of oil required in the second travel motor 20,

Q_{swing} : the quantity of oil required in the first actuator 30, which is a rotation motor,

Q_{boom2} and Q_{boom1} : the quantity of oil required in the second actuator 40 for operating the boom,

Q_{arm1} and Q_{arm2} : the quantity of oil required in the third actuator 50 for operating the arm, and

Q_{bucket} : the quantity of oil required in the fourth actuator 60 for operating the bucket.

5 Therefore, in a state where travelling of the construction equipment has been stopped, that is, in a state where the first and second travel motors 10 and 20 aren't driven, respective working actuators described above can be driven, and such a state is the normal state.

10 Afterward, when the construction equipment is moved, the first and second travel motors 10 and 20 are driven. Also, it is possible to drive the actuator while the construction equipment moves. For example, as shown in FIG. 6, when the fourth actuator 60 for operating the bucket is driven, the
15 direction controlling valve 80 described above is operated so that an oil pressure circuit is changed.

At this time, the actuator, to which the first pump 70a and second pump 70b described above relate, is defined by equation (10) and equation (11) below.

20

$$Q_{pump1} = Q_{travel\_R} + Q_{travel\_L} + Q_{rest} \quad \dots \text{equation (10)}$$

$$Q_{pump2} = Q_{travel\_2} + Q_{bucket} + Q_{swing} + Q_{Boom1} + Q_{Boom2} + Q_{Arm2} + Q_{Arm1} \\ \dots \text{equation (11)}$$

25

The quantity of oil to be supplemented to equation (10) can be calculated through equation (12) below, without the need for installing a separate sensor.

30

$$Q_{rest} = c_q A_{pt\_travel\_L} \sqrt{\frac{2(p_1 - p_2)}{\rho}} \quad \dots \text{equation (12)}$$

In equation (12), Q_{rest} : the quantity of oil supplemented from the pump through a boom operation, an arm operation, a bucket operation, and a swing operation,

$A_{pt\_travel\_L}$: the area of an opened center bypass channel of
5 a right travel spool,

P_1 : pressure 1 of the first pump,

P_2 : pressure 2 of the second pump,

C_q : coefficient of the quantity of oil,

ρ : fluid density.

10 Also, the quantity of oil to be supplemented to equation (11) can be calculated through equation (13) below, without the need for installing a separate sensor.

$$Q_{travel\_2} = c_q A_{drive} \sqrt{\frac{2(p_2 - p_1)}{\rho}} \quad \dots \text{equation (13)}$$

15

In equation (13), Q_{travel_2} : the quantity of oil supplemented from the second pump through a travel operation,

A_{drive} : orifice area,

P_1 : pressure of the first pump,

20 P_2 : pressure of the second pump,

C_q : coefficient of the quantity of oil, and

ρ : fluid density.

Meanwhile, as described above, change of the configuration of the oil pressure circuit can be recognized
25 through spool displacement sensed by a displacement sensor e in the actuator-used oil quantity calculation unit.

Hereinafter, the change of the configuration of the oil pressure circuit will be described in detail with reference to FIGs. 4 to 7 showing another embodiment according to the
30 present invention.

If the direction controlling valve 80 isn't operated, and oil pressure is supplied to a working actuator, to which

the first and second pumps 70a and 70b relate, under a basic configuration, any one of the first and second pumps 70a and 70b has to supply operation oil to another working actuator because the first and second travel motors 10 and 20 are being
5 driven. Therefore, shortage of oil pressure can occur, and what is worse, it can not be certain that the first pump 70a and the second pump 70b rotate with the same number of rotations so that straightness of the construction equipment's movement may not be ensured.

10 However, in the electric oil pressure system of a construction equipment according to an embodiment of the present invention, when a signal for driving the working actuator described above is applied, the position of the direction controlling valve 80 is changed from a first
15 position to a second position so that the second pump 70b described above is connected with the first travel motor 10 described above, and the first pump 70a described above is connected with the working actuator described above.

Therefore, the second pump 70b relates to the first
20 travel motor 10 and the second travel motor 20 so that straightness of the construction equipment' movement can be ensured, and the working actuator can be operated during traveling of the construction equipment.

Also, a plurality of control valves for controlling the
25 working actuator described above and the first and second travel motors 10 and 20 described above may be arranged. Particularly, a plurality of detection parts for detecting the position of a spool of each control valve can be arranged on the control valves described above.

30 A controller C, which receives detection values from a plurality of detection parts, performs a calculation respective to the values, and sends a command signal to the direction controlling valve 80 according to the calculated

result values, can be arranged, and the controller C is connected with an electric joystick 1300 arranged at an operation room of the construction equipment.

Meanwhile, a first check valve 81, which supplies
5 operation oil discharged from the first pump 70a to the first travel motor 10 and prevents counter-flowing of operation oil, can be further arranged.

When the position of the direction controlling valve 80 described above is changed to the second position so that the
10 second pump 70b relates to the first and second travel motors 10 and 20, the first check valve 81 allows a part of operation oil discharged from the first pump 70a to be supplied to the first travel motor 10.

Meanwhile, a second check valve 82, which supplies
15 operation oil discharged from the second pump 70b described above to the working actuator described above and prevents counter-flowing of the operation oil, can be further arranged. Also, a second control valve 200 for controlling driving of the second travel motor 20 described above can be further
20 arranged.

Particularly, when the second control valve 200 described above is stopped, operation oil discharged from the second pump 70b passes by a center bypass port of the second control valve 200 to be delivered to the second check valve
25 82, and the operation oil passed by the second check valve 82 can be supplied to some of working actuators. In more detail, the operation oil can be supplied to the first actuator 30 and the third actuator 50.

Hereinafter, an example of operation of the electric oil
30 pressure system of the construction equipment according to an embodiment of the present invention will be described with reference to FIGs. 5 and 6.

In FIG. 5, it can be understood that actuators, to which the first pump 70a relates, and actuators, to which the second pump 70b relates, are clearly distinguished from each other.

Particularly, the first pump 70a relates to the second
5 actuator 40 for driving the first travel motor 10 and the boom and the fourth actuator 60 for driving the bucket. The second pump 70b relates to the third actuator 50 for driving the second travel motor 20 and the arm and the first actuator 30 for performing the swing operation of the upper body.

10 Particularly, in a state where the construction equipment doesn't travel, that is, in a state where the first and second motors 10 and 20 are not driven, each working actuator is driven.

Hereinafter, when the construction equipment travels,
15 the first and second travel motors 10 and 20 are driven.

As described above, when the working actuator is driven during traveling of the construction equipment, the operation of the working actuator is detected by the spool position detection unit arranged at each control valve, and a driving
20 signal is delivered to the controller C.

The controller C described above determines if the working actuator operates or not while the first and second travel motors 10 and 20 are driven. When it is determined that the working actuator is driven while the first and second
25 travel motors 10 and 20 are driven, the position of the direction controlling valve 80 is changed into the second position.

That is, as shown in FIG. 6, the oil pressure circuit is changed when the direction controlling valve 80 is operated.
30 The oil pressure circuit of FIG. 6 can be briefly shown in the concept view of FIG. 7.

As shown in FIG. 6 or 7, the first pump 70a supplies operation oil to the working actuator and the second pump 70b

is used exclusively for the first and second travel motors 10 and 20.

At this time, a part of the operation oil discharged from the first pump 70a can join operation oil of an oil pressure line supplied from the second pump 70b through the first check valve 81.

Therefore, the second pump 70b can evenly supply a fixed quantity of operation oil to the first travel motor 10 and the second travel motor 20 so that it is possible to accurately move the construction equipment, and especially, straightness of the construction equipment's movement can be secured.

Particularly, the quantity of required oil Q_{set} is calculated based on a signal output from an electronic operation device, and the quantity of oil currently discharged from the pump and the quantity of currently used oil Q_{cyl} is subtracted through a sensor installed at the control valve and the oil pressure line. As a result, the quantity of oil Q_{pump} , which has to be additionally discharged from the pump, is calculated. When operation oil discharged from the first pump 70a and operation oil discharged from the second pump 70b join each other, the quantity of discharged oil Q_{pump} is modified in consideration of the quantity of the joined oil, and then, an angle of the swash plate of the first pump 70a or the second pump 70b can be controlled.

Additionally, the working actuator can be driven during the construction equipment's movement so that it is possible to perform complex work.

In the conventional art, a driving operation is excessively performed so as to compensate for shortage of oil pressure, which is generated according to operation of the working actuator during the operation of the first pump 70a or the second pump 70b. Meanwhile, in the electric oil pressure system of a construction equipment according to an embodiment

of the present invention, the optimal quantity of oil required for driving the first and second travel motors 10 and 20 and the working actuator can be discharged without the need for performing such an excessive driving operation shown in the convention art. As a result, fuel efficiency can be improved.

Moreover, as described above, the detection value obtained in each detection unit is calculated in the controller C, and the first or the second control valve 130 or 140 and the pump 110 are controlled so that the optimal quantity of oil, which corresponds to the quantity of required oil, can be discharged.

That is, as described above, in the electric oil pressure system according to an embodiment of the present invention, it is possible to supply and distribute the accurate quantity of oil while sufficiently performing a function of regenerating the quantity of oil in a conventional open center flow control oil pressure system and a function of operating two pumps and securing reliability of a product which has been already authorized.

While the present invention has been shown and described with reference to certain an exemplary embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and the necessary character of the invention.

Accordingly, an exemplary embodiment of the present invention has been described for illustrative purposes and not for limiting purposes. The scope of the invention is not to be limited by the above embodiments but by the claims and the equivalents thereof.

Industrial Applicability

The electric oil pressure system according to an embodiment of the present invention can be employed in construction equipment. Also, although a plurality of pumps are included, and the pumps relate to each specific actuator,
5 it is possible to prevent operation oil from being unevenly distributed to any one side, thereby securing the safety of the construction equipment's operation.

Claims

1. An electric oil pressure system of a construction equipment, the electric oil pressure system comprising:

5 first and second pumps 70a and 70b for supplying operation oil to connected first and second group actuators in order to operate a working apparatus, the first and second pumps discharging a changeable quantity of operation oil;

10 a first oil pressure line 91, through which operation oil discharged from the first pump 70a flows into the first group actuator;

a second oil pressure line 97, through which operation oil discharged from the second pump 70b flows into the second group actuator;

15 a direction control valve 80 for changing a flowing direction of operation oil so as to allow operation oil of the first oil pressure line 91 and operation oil of the second oil pressure line 97 to be joined;

20 a swash plate controller 1220, which calculates a quantity of currently used oil Q_{scyl} and a quantity of oil Q_{pump} to be currently discharged from the first and second pumps 70a and 70b based on a quantity of required oil Q_{set} input through operation of a joystick, adds/subtracts a quantity of oil, which is joined when the operation oil of the first oil pressure line 91 and the operation oil of the second oil pressure line 97 are joined, to/from the quantity of oil to be discharged Q_{pump} , and calculates an angle of each swash plate of the first and second pumps 70a and 70b so as to allow a quantity of oil, which corresponds to a result value obtained
25 through the adding/subtracting, to be discharged; and
30

an electro proportional pressure reducing valve driving unit 230 for controlling an angle of each swash plate of the

first and second pumps 70a and 70b according to a result value determined by the swash plate controller 1220.

2. The electric oil pressure system as claimed in
5 claim 1, further comprising:

a regeneration circuit unit included in control valves 130 and 140 for controlling a channel of the operation oil supplied to the first and second group actuators, the regeneration circuit unit connecting oil pressure lines of
10 each head side and each load side of the first and second group actuators so as to supply a part of operation oil, which is discharged from any one of each head side and each load side of the first and second group actuators, to the other side, when the working apparatus connected with the first and
15 second group actuators is driven by one selected from its weight and inertia; and

an actuator-used oil quantity calculation unit 110, which calculates an measurement value of oil pressure of each head side and each load side of the first and second group
20 actuators, a measurement pressure value of oil discharged from each pump, and a measurement value of an opening ratio of each control valve so as to obtain a quantity of regenerated oil Q_{regen} , which is again supplied to the first and second group actuators through the regeneration circuit unit,

25 wherein the swash plate controller 1220 calculates a quantity of currently used oil Q_{scyl} and a quantity of oil Q_{pump} to be currently discharged from the first and second pumps 70a and 70b by subtracting the quantity of regenerated oil Q_{regen} from a quantity of required oil Q_{set} input through operation of
30 the joystick, thereby calculating an angle of each swash plate of the first and second pumps 70a and 70b.

3. The electric oil pressure system as claimed in claim 2, further comprising:

a discharged oil quantity calculation unit 210, which calculates a detection value obtained by detecting an angle of each swash plate of the first and second pumps 70a and 70b in driving, a detection value obtained by detecting the number of rotations of the first and second pumps 70a and 70b, and a detection value obtained by detecting discharge pressure of operation oil discharged by the first and second pumps 70a and 70b, thereby obtaining a quantity of oil Q_{spump} discharged by the pumps,

wherein the swash plate controller 1220 calculates an angle of each swash plate of the first and second pumps 70a and 70b, the angle of the swash plate allowing a quantity of remaining oil, which is obtained by excepting the quantity of regenerated oil Q_{regen} and the quantity of discharged oil Q_{spump} from the quantity of required oil Q_{set} , to be further discharged from the first and second pumps 70a and 70b.

4. The electric oil pressure system as claimed in claim 1, wherein each opening ratio of the first and second control valve 130 and 140 is obtained by calculating spool positions of the first and second control valves 130 and 140, which have been measured by first and second spool position detection parts 131 and 141, and the number of rotations of the first and second pumps 70a and 70b is obtained by calculating a rotation speed of an engine, which has been detected by an engine speed detection unit 121.

5. The electric oil pressure system as claimed in claim 1, wherein the first pump 70a supplies operation oil to the first group actuator including a right travel motor in a normal state, and the second pump 70b supplies operation oil

to the second group actuator including a left travel motor in a normal state,

wherein, when a complex operation including a traveling operation and a typical work is performed, through switching of the direction control valve, the first pump 70a supplies operation oil to the first group actuator and the second group actuator, except for the left travel motor, and the second pump 70b supplies operation oil only to the right travel motor and the left travel motor, and

wherein the swash plate control unit 1220 controls an angle of each swash plate of the first and second pumps 70a and 70b by reflecting switching between actuators relating to the first pump 70a and actuators relating to the second pump 70b.

15

6. The electric oil pressure system as claimed in claim 1, wherein a quantity of oil Q_{rest} to be supplemented from the first pump 70a is obtained by an equation,

$$Q_{rest} = c_q A_{pt\_travel\_L} \sqrt{\frac{2(p_1 - p_2)}{\rho}},$$

20

Wherein Q_{rest} refers to a quantity of oil to be supplemented from pump 1 through a boom operation, an arm operation, a bucket operation, and a swing operation,

$A_{pt\_travel\_L}$ refers to an open area of a center bypass channel in a right travel spool,

25

P_1 refers to pressure of the first pump 1,

P_2 refers to pressure of the second pump 2,

C_q refers to coefficient of a quantity of oil, and

30

ρ refers to fluid density.

7. The electric oil pressure system as claimed in claim 1, wherein a quantity of oil Q_{travel_2} to be supplemented from the second pump 70b is obtained by an equation,

5

$$Q_{travel\_2} = c_q A_{drive} \sqrt{\frac{2(p_2 - p_1)}{\rho}},$$

Wherein Q_{travel_2} refers to a quantity of oil to be supplemented from the second pump through a travel operation,

A_{drive} refers to orifice area,

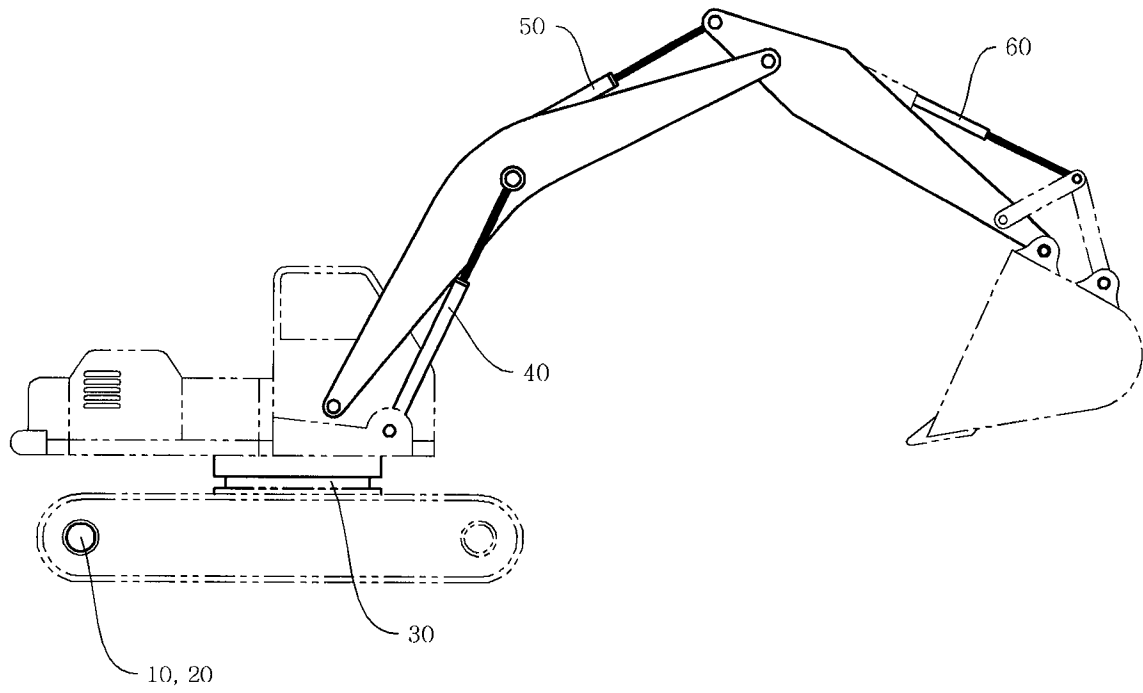
10 P_1 refers to pressure of the first pump,

P_2 refers to pressure of the second pump,

C_q refers to coefficient of a quantity of oil, and ρ refers to fluid density.

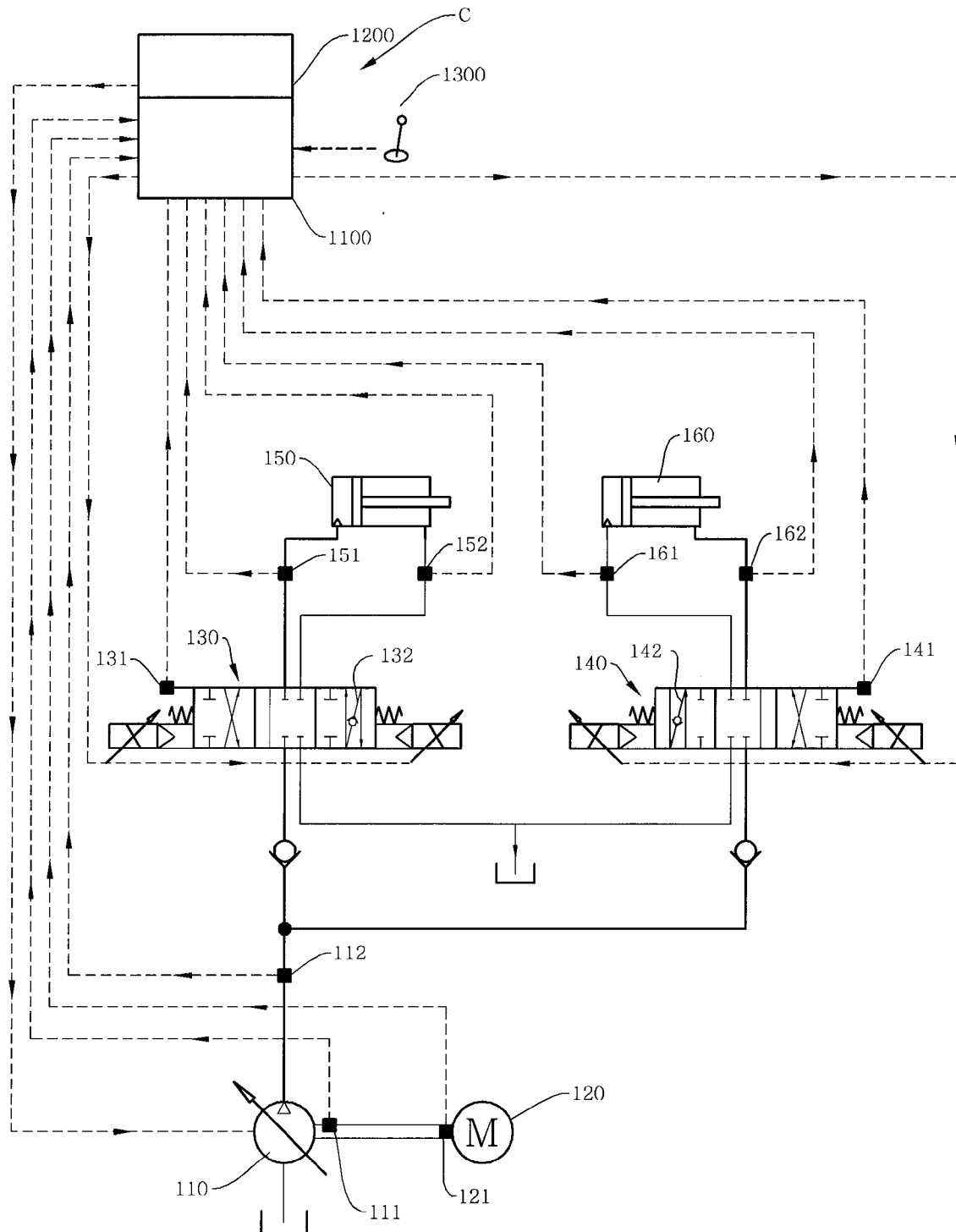
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FIG. 1

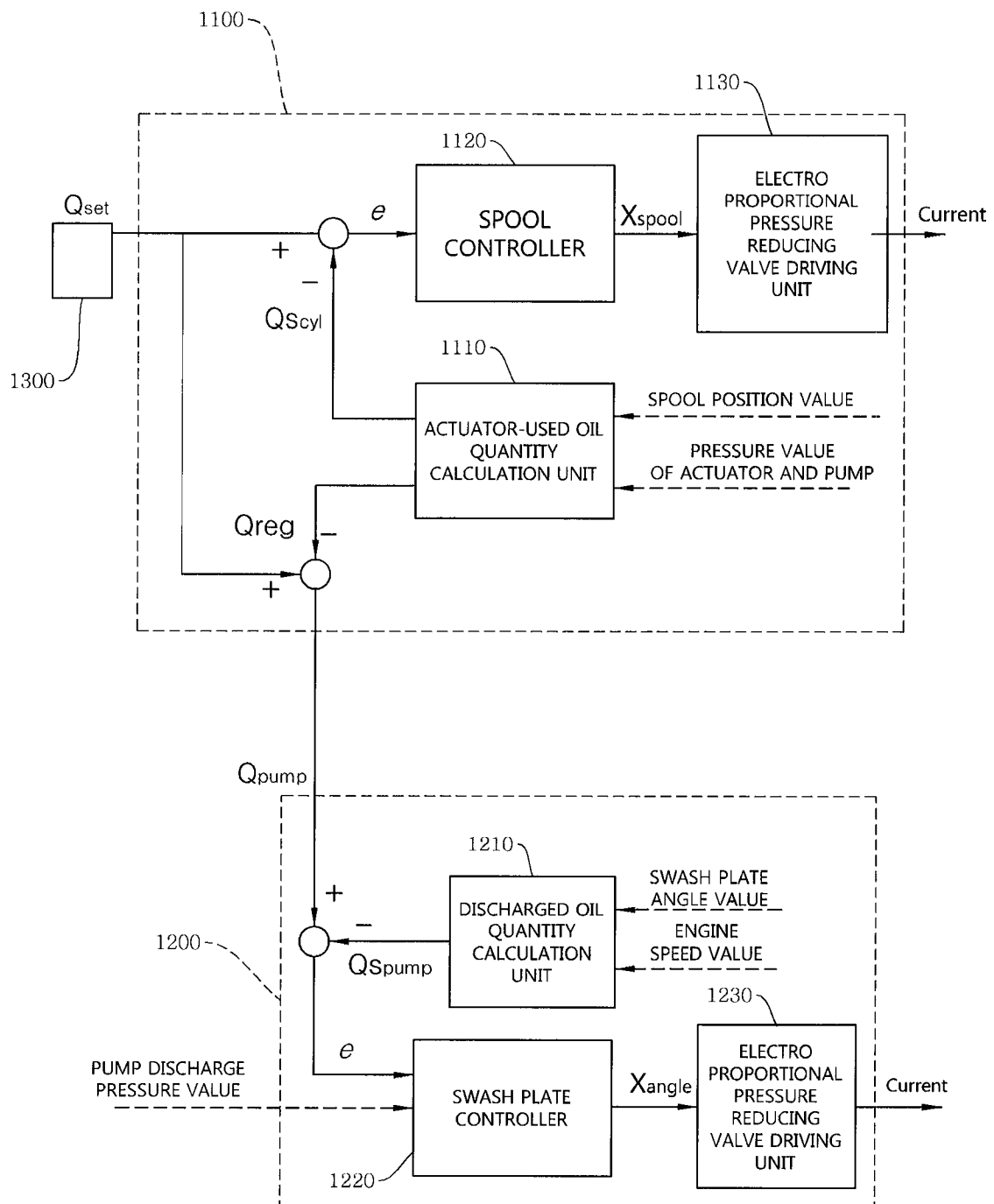


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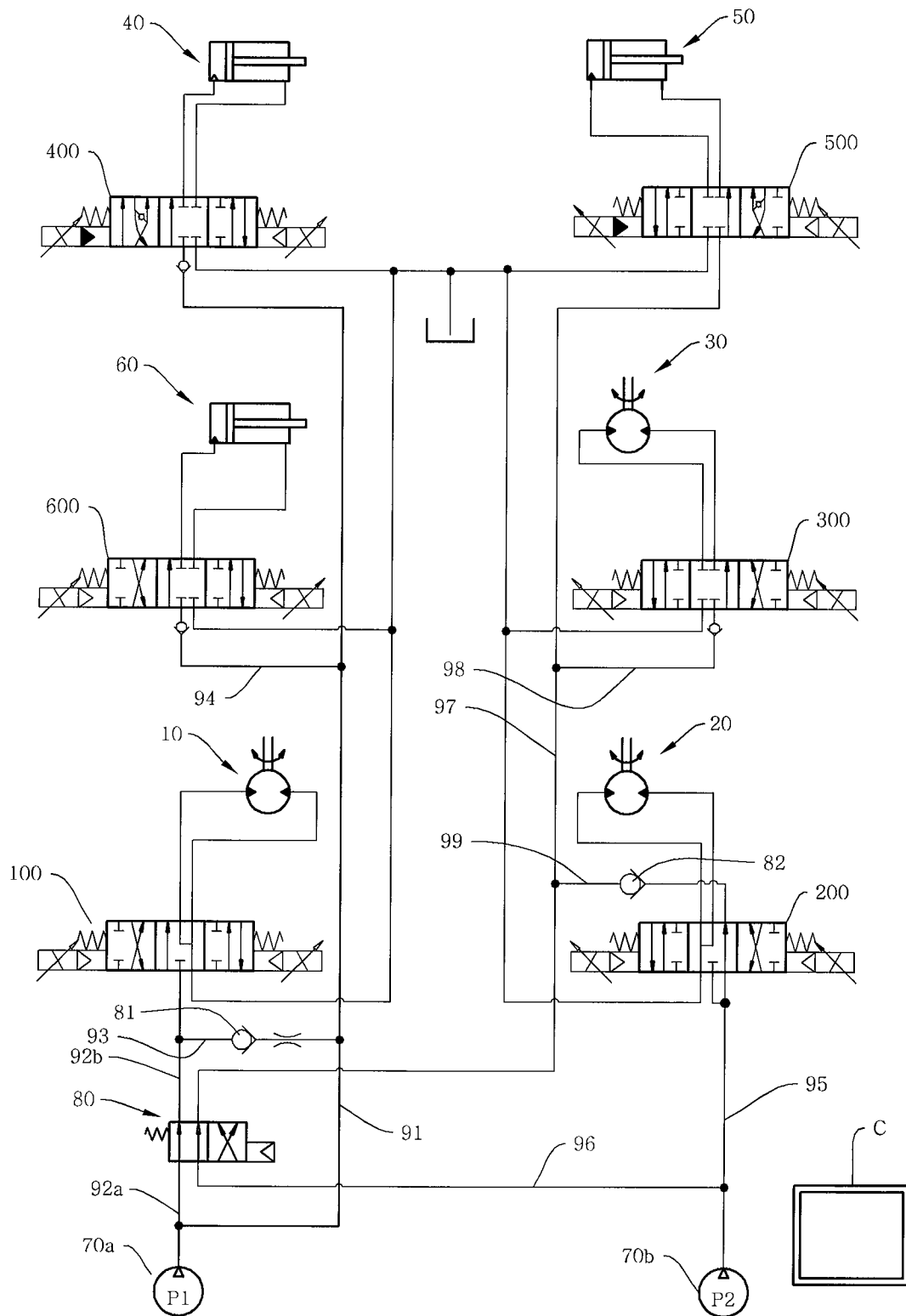
FIG. 2



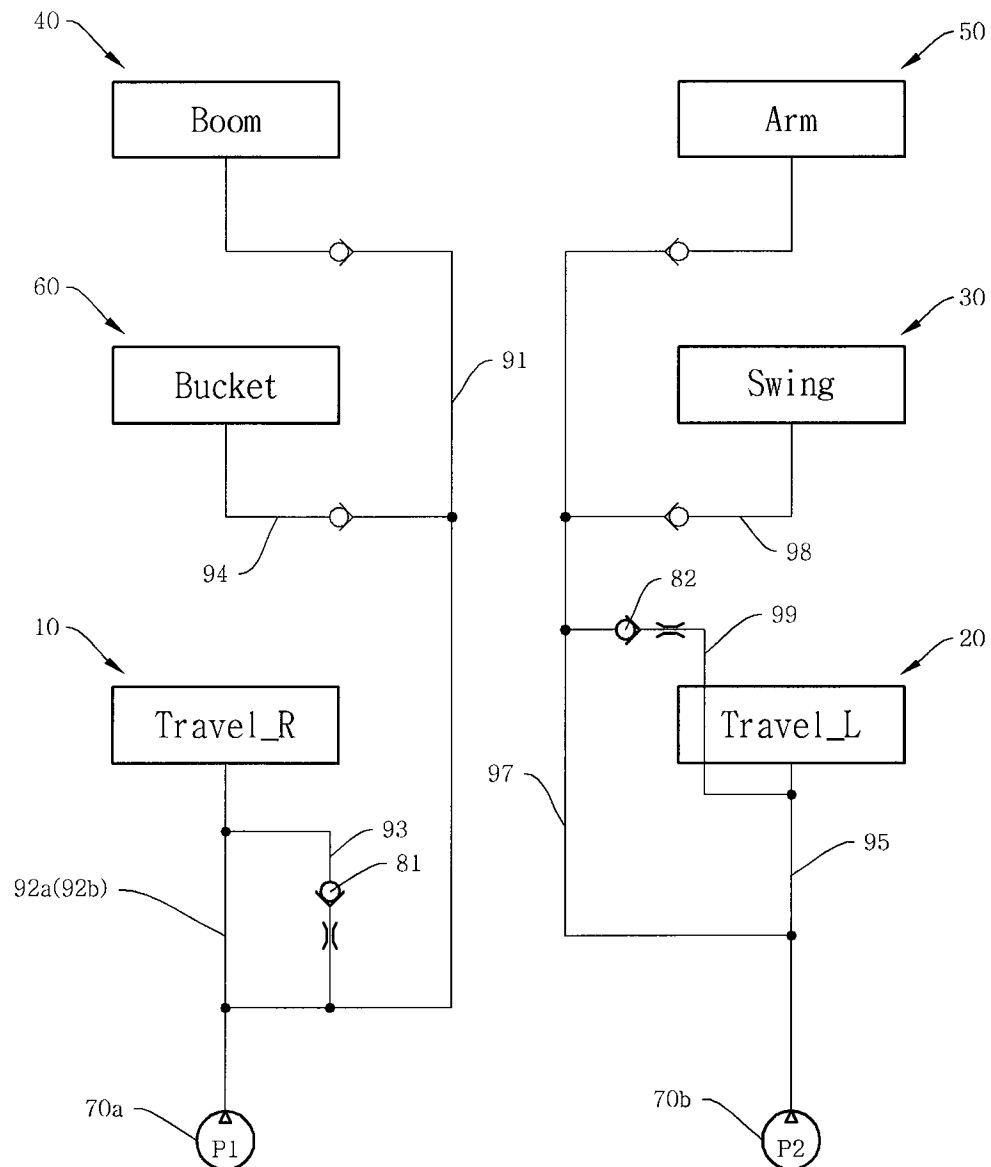
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FIG. 3



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FIG. 4

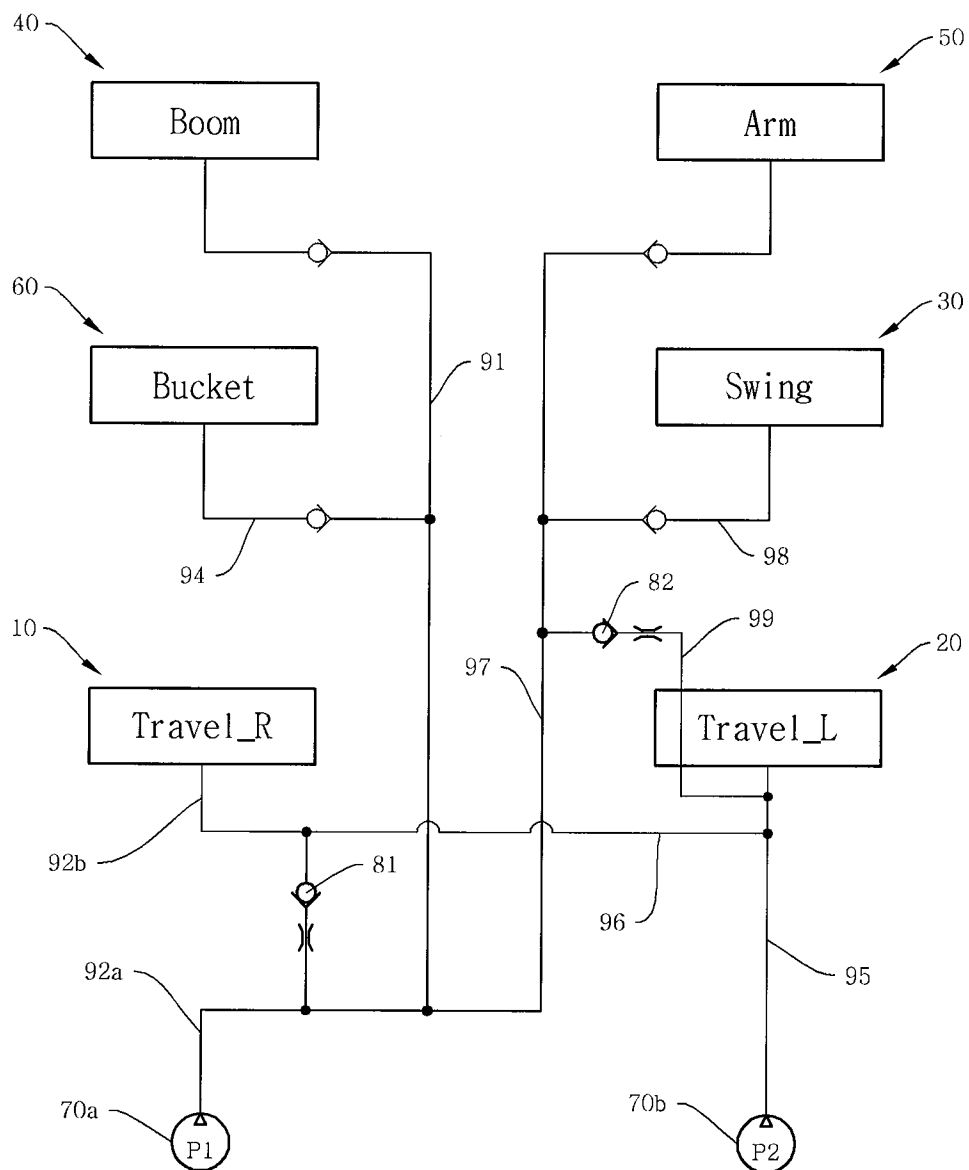


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FIG. 5



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FIG. 7



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FIG. 8

