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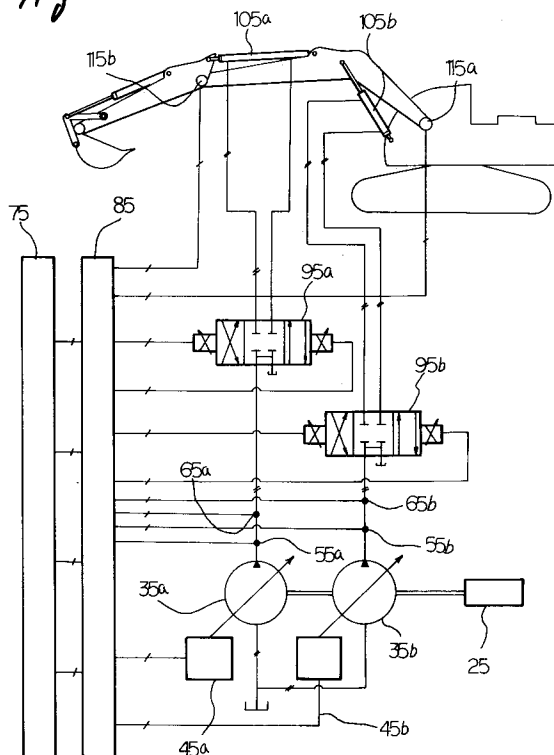
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D-81476 München (DE)(54) **Apparatus and method for controlling hydraulic construction equipment.**

(57) An apparatus and a method for controlling a moving speed of each bucket and a moving speed ratio between each bucket to be proportional to a degree of operation of each operation indicator and an operation ratio between each operation indicator regardless of changes in various working conditions or load pressures. The apparatus has means for receiving an operation command from an input portion and converting said operation command into an operation signal, means for calculating a required discharge oil amount of a pump which is proportional to said operation signal and a required moving speed of an actuator which is proportional to the degree of operation and the operation ratio of said operation signal, means for adjusting said required discharge oil amount and said required moving speed based on a maximum dischargeable oil amount of said pump, means for subtracting a real discharge oil amount and a real moving speed from said adjusted discharge oil amount and said adjusted moving speed, means for controlling the discharge oil amount of said pump according to the control signal from said subtracting means, and means for controlling the moving speed of said actuator according to the control signal from said subtracting means.

Fig. 1

Background of the invention

1. Field of the invention

The present invention relates to an apparatus and a method for controlling hydraulic construction equipment, and more particularly to an apparatus and a method for controlling a moving speed of each bucket and a moving speed ratio between each bucket to be proportional to a degree of operation of each operation indicator and an operation ratio between each operation indicator regardless of changes in various working conditions or load pressures.

2. Description of the prior art

Generally, the hydraulic construction equipment such as excavators, loaders and dozers have the buckets moved by using a plurality of variable displacement pumps and a plurality of hydraulic cylinders, and these buckets are operated by various operation indicators such as joystick, pedal, lever, etc.

The design of such equipment is attempted so that the moving speed of each bucket and the moving speed ratio between each bucket can be proportional to the degree of operation of each operation indicator and the operation ratio between each operation indicator, and the oil amount supplied from the pump is proportional to the degree of operation of each operation indicator in order to produce the moving speed required by each bucket.

However, since the pump has the limit value of the mechanical maximum discharge amount of oil, and the load pressure varies depending on the working conditions such as excavation, dumping and ground leveling, there have been problems that the sum of the oil amounts required to produce the moving speed of the bucket corresponding to the degree of operation required by the operation indicator often exceeds the maximum dischargeable amount of oil for a given load pressure. Moreover, in case of the combined moving of the buckets, the actual speed ratio of each bucket does not accurately correspond to the operation ratio of the operation indicator.

In other words, since the moving speed of each bucket and the moving speed ratio between of each bucket are not accurately proportional to the degree of operation of each operation indicator and the operation ratio between each operation indicator, there has been drawback of lowering the work efficiency.

Summary of the invention

It is an object of the present invention to provide an apparatus and a method for controlling a moving speed of each bucket and a moving speed ratio between each bucket to be accurately proportional to a degree of operation of each operation indicator and an operation ratio between each operation indicator regardless of changes in various working conditions and load pressures in a hydraulic construction equipment.

According to one aspect of the present invention, there is provided an apparatus for controlling a hydraulic construction equipment, comprising: means for receiving an operation command from an input portion and converting said operation command into an operation signal; means for calculating a required discharge oil amount of a pump which is proportional to said operation signal and a required moving speed of an actuator which is proportional to the degree of operation and the operation ratio of said operation signal; means for adjusting said required discharge oil amount and said required moving speed based on a maximum dischargeable oil amount of said pump; means for subtracting a real discharge oil amount and a real moving speed from said adjusted discharge oil amount and said adjusted moving speed; means for controlling the discharge oil amount of said pump according to the control signal from said subtracting means; and means for controlling the moving speed of said actuator according to the control signal from said subtracting means.

According to another aspect of the present invention, there is provided a method for controlling a hydraulic construction equipment, comprising the steps of: (1) calculating a necessary discharge oil amount required for the moving of actuators according to a reference input signal for controlling an oil amount of pumps with a left-hand and a right-hand sides, another reference input signal for controlling a moving speed of said actuators, and maximum dischargeable oil amount signal of said pumps; (2) determining a required discharge oil amount for the left-hand side pump according to a comparison between a sum of a necessary oil amounts required for the moving of the actuators corresponding to the left-hand side pump and a maximum dischargeable oil amount of the left-hand side pump; (3) determining a required discharge oil amount for the right-hand side pump according to a comparison between a sum of a necessary oil amounts required for the moving of the actuators corresponding to the right-hand side pump and a maximum dischargeable oil amount of the right-hand side pump; and (4) generating a reference input signal for controlling the oil amount of said pumps and another reference input signal for con-

trolling the moving speed of said actuators according to said required discharge oil amounts of said second and third steps.

Brief description of the drawings

Fig. 1 is a schematic hydraulic circuit diagram illustrating an overall hydraulic system of an excavator

Fig. 2 is a block diagram of the control unit of the present invention

Fig. 3 is a flow diagram of the control unit of the present invention

Detailed description of the preferred embodiments

In the following, the present invention will be described in detail with reference to the accompanying drawings.

Fig. 1 is a schematic hydraulic circuit diagram illustrating an overall hydraulic system of an excavator which represents one of the typical hydraulic construction equipment.

As shown in Fig. 1, the hydraulic system of the present invention has an engine 25 as a power source, a first and a second variable displacement pumps 35a, 35b operated by the engine 25, a first and a second pump regulation valves 45a, 45b for controlling the discharge oil of the first and second pumps 35a, 35b respectively, a first and a second pressure detectors for detecting the discharge pressures from the first and the second pumps 35a, 35b, a first and a second oil amount detectors 65a, 65b for detecting the discharge oil amounts from the first and the second pumps 35a, 35b, and operation indicator 75 of the buckets using a switch or a touch sensor, a controller 85 containing a microcomputer for controlling the overall operation by receiving the input signal from the operation indicator, a first and a second solenoid controlled proportion valves 95a, 95b for controlling the oil amount by receiving the electrical signals from the controller 85, a dipper stick cylinder 105a for actuating the dipper stick of the excavator, a boom cylinder for actuating the boom of the excavator, a boom speed detector 115a located at the joint part of the upper frame of the excavator and the boom, and a dipper stick speed detector 115b located at the joint part of the boom and the dipper stick.

In the following, the operation of the hydraulic construction equipment in the above will be described.

Based on the degree of operation put in through the operation indicator 75, and the data detected from the dipper stick speed detector 115b and the boom speed detector 115a, the signal values are calculated by the controller 85. Once the

engine 25 is operated by the calculated signal values, the first and the second pump regulation valves 45a, 45b control the first and the second variable displacement pumps 35a, 35b to supply the sum of the oil amounts proportional to the degree of operation given by the operation indicator 75, and the first and the second solenoid controlled proportion valves 95a, 95b control the oil amounts supplied to the dipper stick cylinder 105a and the boom cylinder 105b to be proportional to the degree of operation and the operation ratio given by the operation indicator 75.

Fig. 2 represents the block diagram of the controller of the present invention.

After the operation signals given by the operation indicator 20 are detected by an operation calculator 30, the required discharge amount of oil proportional to the degree of operation, i.e., the reference input signal Q_{ref} for controlling the oil amount of the pump, the required moving speed of the bucket proportional to the degree of operation and the operation ratio of the operation signals, i.e., the reference input signal V_{ref} for controlling the moving speed of the bucket, and the maximum dischargeable oil amount signals Q_{max} detected by the first and the second pressure detectors 55a, 55b are calculated.

Then, based on the reference input signal Q_{ref} for controlling the oil amount of the pump, the reference input signal V_{ref} for controlling the moving speed of the bucket, and the maximum dischargeable oil amount signal Q_{max} , a speed and oil amount control unit 40 adjusts the reference input signals Q_{ref} and V_{ref} to $+Q_{ref2}$ and $+V_{ref2}$ respectively, and sends these adjusted input signals to an oil amount controller 50 and a speed controller 70.

The oil amount controller 50 performs the calculation for controlling the discharge amount of the pump based on the reference input signal $+Q_{ref2}$ and the real discharge oil amount signal Q_{real} with an error (E_q) detected from the oil amount detectors 65a, 65b shown in Fig. 1, and sends out an oil amount control signal V_{pump} to the first and the second pump regulation valves 45a, 45b of the pump 60.

On the other hand, the speed controller 70 performs the calculation for controlling the moving speed of the bucket based on the reference input signal $+V_{ref2}$ and the real moving speed V_{real} with an error E_v detected from the boom speed detector 115a and the dipper stick speed detector 115b shown in Fig. 1, and sends out a speed control signal V_{mcv} to the first and the second solenoid controlled proportion valves 95a, 95b of the bucket 80.

The operation of the control unit 40 will be described in more detail with reference to the flow

diagram shown in Fig. 3.

The operation calculator 30, according to the operation signal given by the operation indicator 20, produces the reference input signal Q_{ref} for controlling the oil amount proportional to the degree of operation, the reference input signal V_{ref} for controlling the moving speed proportional to the degree of operation and the operation ratio, and the maximum dischargeable oil amount signal Q_{max} (step 1).

The necessary oil amount required for the actuation of each bucket is calculated by the reference input signal V_{ref} for controlling the moving speed through well-known calculation process (step 2).

After the required oil amounts are calculated from step 1 and step 2, it is determined whether or not the adding-up condition of pump can be satisfied (step 3).

Here, the adding-up condition of the pumps means that when more than one buckets are actuated in combination, the oil amounts discharged from more than one pumps are added up and supplied to any one of the buckets.

If the adding-up condition can be satisfied in step 3, the sum of the oil amounts Q_{sum} , total that should be discharged from both pumps for the actuation of the bucket is calculated (step 4). The case of not satisfying the adding-up condition will be described later on.

The required discharge amount of the left-hand side pump $Q_{uc, left}$ and the required discharge amount of the right hand side pump $Q_{uc, right}$ are determined with each amount equal to the 50% of the sum of oil amounts $Q_{sum, total}$ calculated in step 4 (step 5).

The required discharge amount of the left-hand side pump $Q_{uc, left}$ is compared with the maximum dischargeable amount of the left-hand side pump $Q_{max, left}$ (step 6). As a result of the comparison in step 6, if $Q_{uc, left}$ is larger than $Q_{max, left}$, $Q_{uc, left}$ is set to be equal to $Q_{max, left}$ and the difference amount $Q_{uc, left} - Q_{max, left}$ is added to the required discharge amount of the right-hand side pump (step 7).

The difference amount can be added to the required discharge amount of the right-hand side pump since the adding-up condition in step 3 has been satisfied. On the other hand, if the required discharge amount of the left-hand side pump is less than the maximum discharge amount of the right-hand side pump in step 6, the required discharge amount of the right-hand side pump $Q_{uc, right}$ determined in step 5 is compared with the maximum discharge amount of the right-hand side pump $Q_{max, right}$ (step 8).

If $Q_{uc, right}$ is less than $Q_{max, right}$, the 10th step is continued. If the $Q_{uc, right}$ is larger than

$Q_{max, right}$, $Q_{uc, right}$ is set to be equal to $Q_{max, right}$ and the difference amount $Q_{uc, right} - Q_{max, right}$ is added to the required discharge amount of left-hand side pump (step 9). Since the adding-up condition of step 3 has been satisfied, the difference amount can be added to the discharge amount of left-hand side pump.

After the required discharge amount of left-hand side and right-hand side pumps from steps 6 and 8, the sum of the required discharge amounts calculated in step 4 that should be discharged from both pumps for the actuation of buckets is compared with the sum of the maximum dischargeable amount of both pumps (i.e., the maximum dischargeable amounts of left-hand side pump + the maximum dischargeable amount of right-hand side pump) (step 10).

If the sum of the required discharge amounts that should be discharged from both pumps for the actuation of buckets are less than the sum of the maximum dischargeable amount of both pumps, then, since the further operation is not needed, the 18th step is continued where the reference signals are produced.

However, if the sum of the required discharge amounts that should be discharged from both pumps for the actuation of buckets are larger than the sum of the maximum dischargeable amounts of both pumps, the sum of the required discharge amount is set to be equal to the sum of the maximum dischargeable amounts. The, sum of the maximum dischargeable amount is distributed in the same proportions as those of the necessary discharge amounts required for the actuation of buckets in their respective moving directions which have been calculated in step 2, and based on the distributed amounts, the required moving speed of each bucket is calculated (step 11).

According to the calculated data, the reference signals for controlling the oil amount and the moving speed are produced respectively (step 18).

If the adding-up condition is not satisfied, the required discharge amount of left-hand side pump is calculated is the sum of the discharge amounts that should be discharged from the left-hand side pump for the actuation of buckets (step 12).

The sum of the discharge amounts that should be discharged from the left-hand side pump is compared with the maximum dischargeable amounts from the left-hand side pump (step 13).

As a result of the comparison in step 13, if the sum of the discharge amounts that should be discharged from the left-hand side pump is less than the maximum dischargeable amount from the left-hand side pump, the maximum dischargeable amount can be used and step 15 is continued since the determination of the required dischargeable amount of the left-hand side pump is not

necessary.

However, if the sum of the required discharge amounts that should be discharged from the left-hand side pump is larger than the maximum dischargeable amount from the left-hand side pump, the sum of the required discharge amounts is set to be equal to the maximum dischargeable amount from the left-hand side pump. Then, the maximum dischargeable amount is distributed in the same proportions as those of the discharge amount from the left-hand side pump required for the actuation of each bucket in the respective moving directions, and based on the distributed discharge amounts, the required moving speed of each bucket using the left-hand side pump is calculated(step 14).

After the required discharge amount from the left-hand side pump and the calculation for buckets have been determined, the required discharge amounts from the right-hand side pump are calculated as the sum of the required discharge amounts that should be discharged from the right-hand side pump(step 15).

The calculated sum of the required discharge amounts that should be discharged from the right-hand side pump is compared with the maximum dischargeable amounts from the right-hand side pump(step 16).

As a result of this comparison, if the sum of the required discharge amounts that should be discharged from the right-hand side pump is less than the maximum dischargeable amount from the right-hand side pump, the 18th step is continued since the determinations of the required discharge amount of the right-hand side pump and the moving speeds of buckets are not necessary.

However, if the sum of the required discharge amounts from the right-hand side pump is larger than the maximum dischargeable amount from the pump, the sum of the required discharge amount is set to be equal to the maximum dischargeable amount from the right-hand side pump. Then, the maximum dischargeable amount is distributed in the same proportions as those of the discharge amounts from the right-hand side pump required for the actuation of each bucket in the respective moving directions, and based on the distributed discharge amounts, the required moving speed of each bucket using the right-hand side pump is calculated(step 17).

The reference input signal for controlling the oil amounts Q_{ref} and the reference input signal for controlling the moving speed V_{ref} are calculated by the steps described in the above, and are sent to the oil amount controller 50 and the speed controller 70, respectively.

As described in the above, the present invention which can be applied in the hydraulic construction equipment has advantages of the work auto-

mation and efficiency by controlling optimally the moving speed of each bucket and the speed ratio between each bucket to be accurately proportional to the degree of operation of each operation indicator and the operation ratio between each operation indicator regardless of changes in working conditions and load pressures

Claims

1. A method for controlling a hydraulic construction equipment, comprising the steps of:

(1) calculating a necessary discharge oil amount required for the moving of actuators according to a reference input signal for controlling an oil amount of pumps with a left-hand and a right-hand sides, another reference input signal for controlling a moving speed of said actuators, and maximum dischargeable oil amount signal of said pumps;

(2) determining a required discharge oil amount for the left-hand side pump according to a comparison between a sum of a necessary oil amounts required for the moving of the actuators corresponding to the left-hand side pump and a maximum dischargeable oil amount of the left-hand side pump;

(3) determining a required discharge oil amount for the right-hand side pump according to a comparison between a sum of a necessary oil amounts required for the moving of the actuators corresponding to the right-hand side pump and a maximum dischargeable oil amount of the right-hand side pump; and

(4) generating a reference input signal for controlling the oil amount of said pumps and another reference input signal for controlling the moving speed of said actuators according to said required discharge oil amounts of said second and third steps.

2. The method of claim 1, wherein said second step comprising the steps of:

(1) comparing a required discharge oil amount of the left-hand side pump with a maximum dischargeable oil amount of the left-hand side pump; and

(2) setting said required discharge oil amount to be said maximum dischargeable oil amount when said required discharge oil amount is larger than said maximum dischargeable oil amount.

3. The method of claim 1, wherein said third step comprising the steps of:

- (1) comparing a required discharge oil amount of the right-hand side pump with a maximum dischargeable oil amount of the right-hand side pump; and
 (2) setting said required discharge oil amount to be said maximum dischargeable oil amount when said required discharge oil amount is larger than said maximum dischargeable oil amount.
4. A method for controlling a hydraulic construction equipment, comprising the steps of:
 (1) calculating a necessary discharge oil amount required for the moving of actuators moved in a combination way according to a reference input signal for controlling an oil amount of pumps with a left-hand and a right-hand sides, another reference input signal for controlling a moving speed of said actuators, and maximum dischargeable oil amount signal of said pumps;
 (2) determining a sum of necessary oil amounts of said pumps required for the moving of said actuators, and calculating required discharge oil amounts to be supplied to the left-hand side pump and the right-hand side pump by the same amount respectively;
 (3) determining required discharge oil amounts of the left-hand and the right-hand side pumps according to said required discharge oil amounts of said second step and dischargeable oil amounts of the left-hand and the right-hand side pumps;
 (4) determining a necessary discharge oil amount required for the moving of said actuators according to said sum of said second step and maximum dischargeable oil amounts of said pumps; and
 (5) generating a reference input signal for controlling the oil amount of said pumps and another reference input signal for controlling the moving speed of said actuators according to said required discharge oil amounts of said fourth step.
5. The method of claim 4, wherein said third step comprising the steps of:
 (1) comparing the required discharge oil amount of the left-hand side pump with the dischargeable oil amount of the left-hand side pump;
 (2) setting said required discharge oil amount to be said dischargeable oil amount when said required discharge oil amount is larger than said dischargeable oil amount by the comparison of the first step, and adding the difference between said required
- discharge oil amount and said dischargeable oil amount to the required discharge oil amount of the right-hand side pump;
 (3) comparing the required discharge oil amount of the right-hand side pump with the dischargeable oil amount of the right-hand side pump when the required discharge oil amount of the left-hand side pump is smaller than the dischargeable oil amount of the left-hand side pump; and
 (4) setting said required discharge oil amount to be said dischargeable oil amount when said required discharge oil amount is larger than said dischargeable oil amount by the comparison of the third step, and adding the difference between said required discharge oil amount and said dischargeable oil amount to the required discharge oil amount of the left-hand side pump.
6. A method for controlling a hydraulic construction equipment, comprising the steps of:
 (1) calculating a necessary discharge oil amount required for the moving of actuators moved in a combination way according to a reference input signal for controlling an oil amount of pumps with a left-hand and a right-hand sides, another reference input signal for controlling a moving speed of said actuators, and maximum dischargeable oil amount signal of said pumps;
 (2) detecting an adding-up condition of whether or not the oil amounts discharged from said pumps are combined and supplied to any one of said actuators;
 (3) determining a sum of necessary oil amounts of said pumps required for the moving of said actuators when said adding-up condition is satisfied, and calculating required discharge oil amounts to be supplied to the left-hand side pump and the right-hand side pump by the same amount respectively;
 (4) determining required discharge oil amounts of said pumps according to said required discharge oil amounts of the third step and dischargeable oil amounts of the left-hand side pump and the right-hand side pump;
 (5) determining necessary oil amounts required for the moving of said actuators according to said sum of the third step and said dischargeable oil amounts of said pumps;
 (6) generating a reference input signal for controlling the oil amount of said pumps and another reference input signal for controlling the moving speed of said actuators

according to said necessary required oil amounts of the fifth step;

(7) determining the required discharge oil amount of the left-hand side pump to be a sum of necessary oil amount of the left-hand side pump when said adding-up condition of the second step is not satisfied, and calculating required discharge oil amount of the left-hand side pump according to said required discharge oil amount of the left-hand side pump and a maximum dischargeable oil amount of the left-hand side pump;

(8) determining the required discharge oil amount of the right-hand side pump to be a sum of necessary oil amount of the right-hand side pump, and calculating required discharge oil amount of the right-hand side pump according to said required discharge oil amount of the right-hand side pump and a maximum dischargeable oil amount of the right-hand side pump; and

(9) generating a reference input signal for controlling the oil amount of said pumps and another reference input signal for controlling the moving speed of said actuators according to said required discharge oil amount of the seventh and the eighth steps.

7. The method of claim 6, wherein said third step comprising the steps of;

(1) comparing the required discharge oil amount of the left-hand side pump with the dischargeable oil amount of the left-hand side pump;

(2) setting said required discharge oil amount to be said dischargeable oil amount when said required discharge oil amount is larger than said dischargeable oil amount by the comparison of the first step, and adding the difference between said required discharge oil amount and said dischargeable oil amount to the required discharge oil amount of the right-hand side pump;

(3) comparing the required discharge oil amount of the right-hand side pump with the dischargeable oil amount of the right-hand side pump when the required discharge oil amount of the left-hand side pump is smaller than the dischargeable oil amount of the left-hand side pump; and

(4) setting said required discharge oil amount to be said dischargeable oil amount when said required discharge oil amount is larger than said dischargeable oil amount by the comparison of the third step, and adding the difference between said required

discharge oil amount and said dischargeable oil amount to the required discharge oil amount of the left-hand side pump.

8. The method of claim 6, wherein said seventh step comprising the steps of:

(1) comparing a required discharge oil amount of the left-hand side pump with a maximum dischargeable oil amount of the left-hand side pump; and

(2) setting said required discharge oil amount to be said maximum dischargeable oil amount when said required discharge oil amount is larger than said maximum dischargeable oil amount.

9. The method of claim 6, wherein said eighth step comprising the steps of:

(1) comparing a required discharge oil amount of the right-hand side pump with a maximum dischargeable oil amount of the right-hand side pump; and

(2) setting said required discharge oil amount to be said maximum dischargeable oil amount when said required discharge oil amount is larger than said maximum dischargeable oil amount.

10. An apparatus for controlling a hydraulic construction equipment, comprising:

means for receiving an operation command from an input portion and converting said operation command into an operation signal;

means for calculating a required discharge oil amount of a pump which is proportional to said operation signal and a required moving speed of an actuator which is proportional to the degree of operation and the operation ratio of said operation signal;

means for adjusting said required discharge oil amount and said required moving speed based on a maximum dischargeable oil amount of said pump;

means for subtracting a real discharge oil amount and a real moving speed from said adjusted discharge oil amount and said adjusted moving speed;

means for controlling the discharge oil amount of said pump according to the control signal from said subtracting means; and

means for controlling the moving speed of said actuator according to the control signal from said subtracting means.

Fig: 1

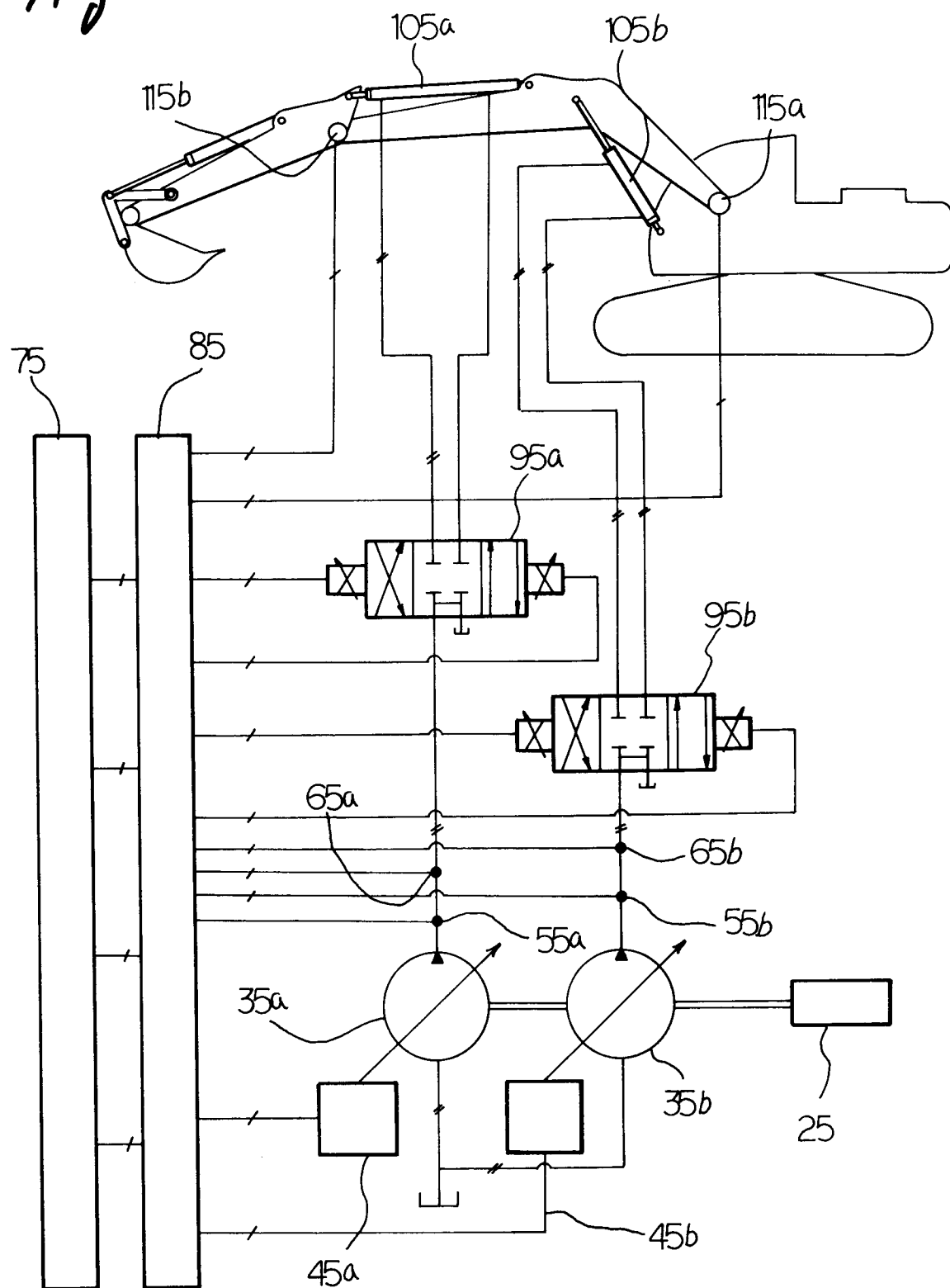


Fig. 2

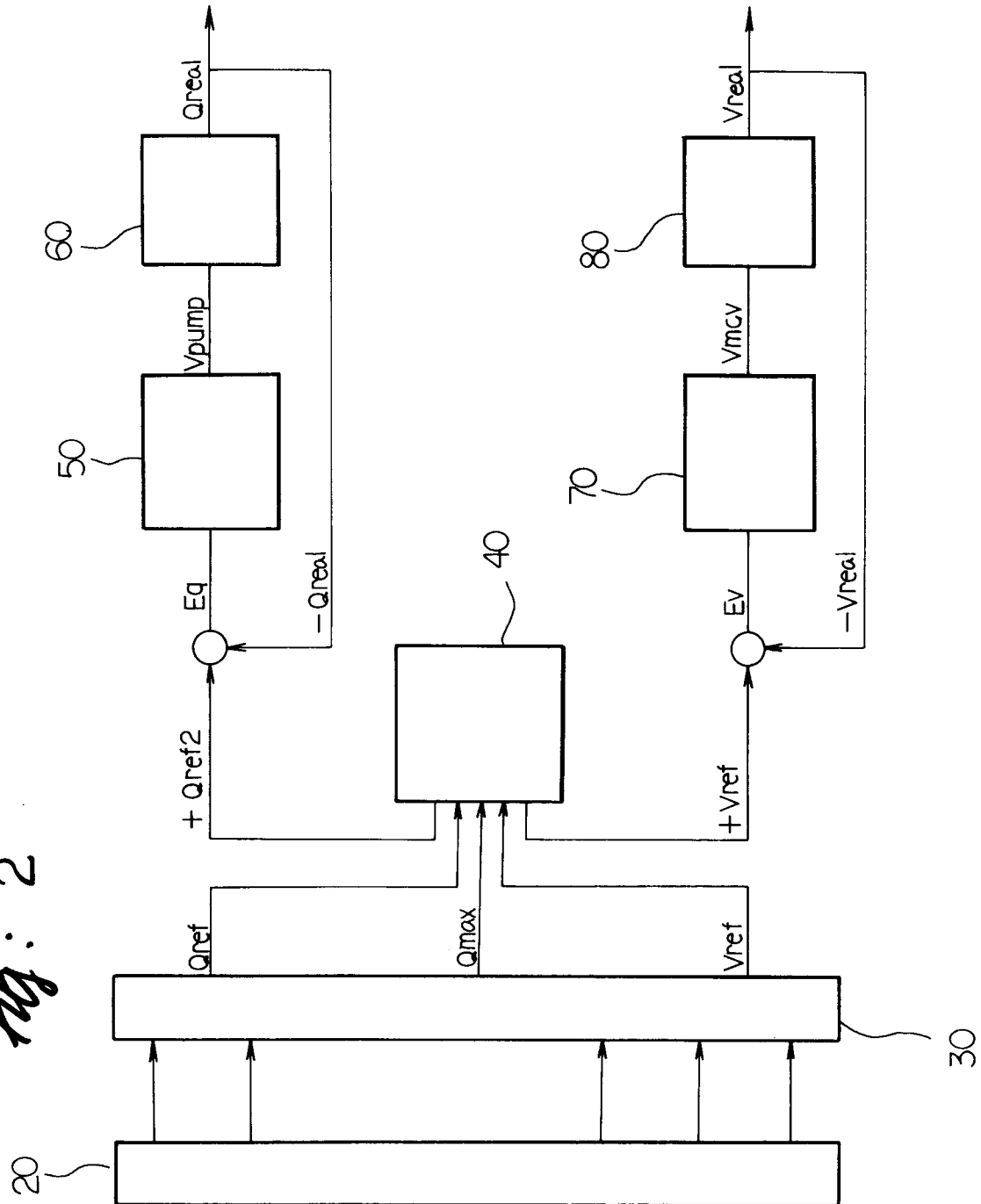


Fig: 3

