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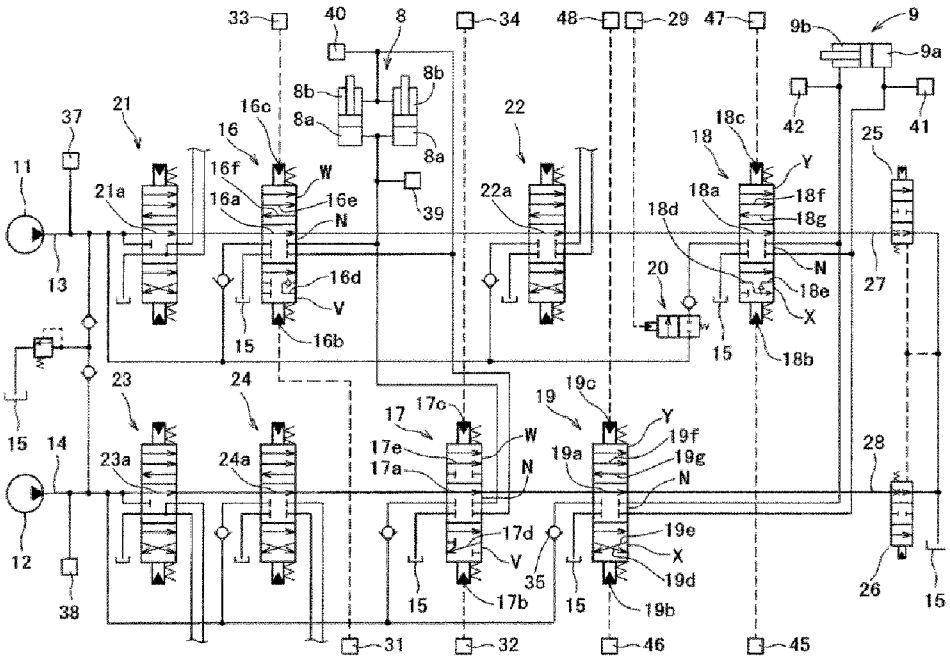

FIG. 2

(57) Abstract: [Problem to Be Solved] To make it possible to control supply, discharge, and recycled flow rates independently of each other for the boom cylinder in a construction machine comprising first and second boom spool valves respectively connected to first and second hydraulic pumps. [Solution] When the boom cylinder (8) is contracted, the first boom spool valve (16) is configured to control the recycled flow rate from head side oil chamber (8A) to rod side oil chamber (8B), the second boom spool valve (17) is configured to control the discharge flow rate from head side oil chamber (8A) to oil tank (15), and both first and second boom spool valves (16, 17) are configured not to supply pressure oil from, first and second hydraulic pumps (11, 12) to the boom cylinder (8).

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Description

HYDRAULIC CONTROL CIRCUIT FOR A CONSTRUCTION MACHINE

Field of the Invention

The present invention relates to a technical field of hydraulic control circuit used in construction machines such as a hydraulic excavator.

Background Art

In general, some construction machines, such as a hydraulic excavator for example, have a boom vertically movably supported by a body and are configured to move the boom vertically with expansion and contraction operations of a boom cylinder. As for hydraulic control circuit for these construction machines, first and second hydraulic pumps are installed as hydraulic pressure supply sources for multiple hydraulic actuators to be installed in these construction machines, and as for hydraulic actuator, such as the boom cylinder mentioned above for example, which needs a large flow rate corresponding to each work content, in order to enable pressure oil supply from both first and second hydraulic pumps, a circuit equipped with first and second spool valves connected to each of first and second hydraulic pumps has been ever widely used for controlling oil supply and discharge for hydraulic actuators (refer to Fig. 3 in PTL 1, for example).

Now, the spool valve mentioned above to be installed in conventional hydraulic control circuit for construction machine is configured to conduct a direction change-over control for changing over hydraulic oil supply/discharge direction for hydraulic actuator, a supply flow control for controlling supply flow rate from hydraulic pump to hydraulic actuator, and a discharge flow control for controlling discharge flow rate from hydraulic actuator to hydraulic pump simultaneously, so an opening areas for oil supply and oil discharge are uniquely determined according to a moved position of the spool valve. Furthermore, when recycling drain oil from one oil chamber in hydraulic actuator to another in order

to reduce fuel consumption and when the spool valve mentioned above is to be used to control recycled flow rate as well, an opening area for oil recycle will be uniquely determined according to the moved position of the spool valve. Therefore, a relationship among a supply flow rate, discharge flow rate, and further recycled flow rate cannot be changed according to the content of various works, such as a stand-alone work to drive a boom cylinder alone, compound work to drive other hydraulic actuator as well, light load work, and heavy load work, for example, impeding an improvement of efficiency and operability. However, moving the boom vertically is a highly frequent manipulation in construction machine including hydraulic excavator and is often operated in combination with other hydraulic actuator, so it is required to improve efficiency and operability of the manipulation.

Therefore, it is disclosed in the PTL 1 that a control valve is installed for controlling pressure oil amount to be supplied to the first and second spool valves at upstream side of first and second spool valves controlling oil supply and discharge for hydraulic actuator. In this case, the control valve enables to change pressure oil supply amount to be supplied from first and second spool valves to hydraulic actuator according to the work content and others by changing pressure oil amount to be supplied to first and second spool valves even if the moved position of spool valve is a same.

Meanwhile, some technique controls supply and discharge flow rates for the hydraulic actuator with each valve individually by providing a flow control valve for controlling the supply flow rate from the hydraulic pump to the hydraulic actuator and a direction change-over valve arranged at a downstream side of the flow control valve for changing over a supply/discharge direction of hydraulic oil to the hydraulic actuator and controlling the discharge flow rate from the hydraulic actuator (refer to PTL 2, for example).

Citation List

[Patent Document]

PTL 1: Patent No. 5778086

PTL 2: Japanese Unexamined Patent Application Publication No. 2017-20604

Summary of Invention

[Problem to Be Solved by the Invention]

However, in the PTL 1, a supply valve passage (second internal passage), which is installed in the spool valve in order to supply pressure oil to the hydraulic actuator, is configured to change the flow rate according to the spool position and a control unit for controlling a control valve is configured to satisfy opening areas of control valve and spool valve are the same extent as the opening of conventional spool. That is, since the control valve and spool valve installed in series with each other are configured to control the supply flow rate respectively separately when supplying delivery oil from hydraulic pump to hydraulic actuator, the control is complicated and it is hard to control the flow rate accurately.

Meanwhile, in PTL 2, since the flow control valve only controls the supply flow rate to the hydraulic actuator and a direction control valve does not control the supply flow rate, so this configuration will not cause a same problem as that of PTL 1. However a configuration of the PTL 2, first and second hydraulic pumps are installed as a hydraulic supply source for the boom cylinder, only one spool valve (direction change-over valve) is installed for the boom cylinder, and the delivery oil from first and second hydraulic pumps is merged after controlling the flow rate with a flow control valve and then supplied to the spool valve. Therefore, there are problems that the conventional circuit mentioned above, i.e., a circuit equipped with first and second spool valves connected to each of first and second hydraulic pumps for controlling oil supply/discharge of the boom cylinder, cannot be used as is, a new spool valve may be required in accordance with total flow rate from first and second hydraulic pumps, and a valve unit with a new circuit configuration needs to be manufactured, thereby causing higher cost.

In addition, as for a recycled flow control mentioned above, it has been requested to control the flow rate independently of supply/discharge flow controls by using the spool valve without using dedicated recycle valve separately; these are challenges to be solved by this invention.

[Means for Solving the Problem]

The present invention is created to solve these challenges; the invention of claim 1 is a hydraulic control circuit for a construction machine, comprising: a boom being vertically movably supported by a body and moving vertically in dependence upon extension and contraction operations of a boom cylinder; first and second hydraulic pumps as hydraulic supply source; and first and second boom spool valves being connected respectively to the first and second hydraulic pumps and controlling oil supply and discharge for the boom cylinder; wherein, when the boom cylinder is contracted, the first boom spool valve is configured to control recycled flow rate from a head side oil chamber of boom cylinder to a rod side oil chamber, the second boom spool valve is configured to control discharge flow rate from the head side oil chamber of the boom cylinder to an oil tank; and when the boom cylinder is contracted, both first and second boom spool valves are configured not to supply pressure oil from first and second hydraulic pumps to the boom cylinder.

The invention of claim 2 is the hydraulic control circuit for a construction machine of claim 1, wherein, when the boom cylinder is extended, first boom spool valve is configured to control a supply flow rate from first hydraulic pump to a head oil chamber of boom cylinder and a discharge flow rate from a rod side oil chamber to an oil tank, and second boom spool valve is configured to control the supply flow rate from second hydraulic pump to the head side oil chamber of boom cylinder.

The invention of claim 3 is the hydraulic control circuit for a construction machine of claim 1 or 2, providing a means to determine whether it is a body lift-up operation for lifting up a part of the body based on a pressure in the head side

oil chamber when the boom cylinder is contracted, wherein the first boom spool valve is configured to control the supply flow rate from first hydraulic pump to the rod side oil chamber of boom cylinder when it is determined a body lift-up operation by the determination means.

The invention of claim 4 is the hydraulic control circuit for a construction machine of any of claims 1 to 3, comprising first and second bypass valves respectively controlling a flow rate of first and second bypass oil passages for feeding delivery oil of first and second hydraulic pumps to oil tank.

[Effects of the Invention]

According to the invention of claim 1, recycle and discharge flow rates for the boom cylinder can be controlled independently of each other by using first and second boom spool valves when the boom cylinder is contracted, and in addition, pressure oil supply from first and second hydraulic pumps to the boom cylinder is no longer needed, thereby contributing high efficiency, improvement of operability, and cost suppression.

According to the invention of claim 2, when the boom cylinder is contracted, supply/discharge flow rates for the boom cylinder can be controlled independently of each other by using first and second boom spool valves.

According to the invention of claim 3, the body lift-up operation can be performed smoothly, and in addition, the supply flow rate to the boom cylinder can be controlled independently when lifting up the body.

According to the invention of claim 4, the delivery flow rate of first and second hydraulic pumps can be controlled accurately.

Brief Description of the Drawings

Fig. 1 is a side view of a hydraulic excavator.

Fig. 2 is a hydraulic control circuit illustrating a first embodiment.

Fig. 3 is a drawing illustrating opening characteristics of first and second boom spool valves according to the first embodiment; Fig. 3A illustrates the

opening characteristics of first boom spool valve at lowering side operation position; Fig. 3B illustrates the opening characteristics of first boom spool valve at raising side operation position; Fig. 3C illustrates the opening characteristics of second boom spool valve at lowering side operation position; and Fig. 3D illustrates the opening characteristics of second boom spool valve at raising side operation position.

Fig. 4 is a drawing illustrating opening characteristics of first and second stick spool valves according to the first embodiment; Fig. 4A illustrates the opening characteristics of first stick spool valve at in-side operation position; Fig. 4B illustrates the opening characteristics of first stick spool valve at out-side operation position; Fig. 4C illustrates the opening characteristics of second stick spool valve at in-side operation position; and Fig. 4D illustrates the opening characteristics of second stick spool valve at out-side operation position.

Fig. 5 is a block diagram illustrating input/output of control unit according to the first embodiment.

Fig. 6 is a drawing illustrating incorporated state of a poppet valve according to the first embodiment.

Fig. 7 is a hydraulic control circuit illustrating a second embodiment.

Fig. 8 is a drawing illustrating opening characteristics of first boom spool valve according to second embodiment; Fig. 8A illustrates its opening characteristics at lowering side operation position; and Fig. 8B illustrates its opening characteristics at raising side operation position.

Description of Embodiment

Now, an explanation is provided below about embodiments of the present invention based on drawings.

First of all, an explanation about first embodiment of the present invention is provided based on Figs. 1 to 6; Fig. 1 is a drawing illustrating hydraulic excavator 1 as an example of construction machine according to this invention, wherein the hydraulic excavator 1 is composed of a crawler type lower traveling body 2, an

upper swiveling body 3 swivelably supported on the lower traveling body 2, a front working machine 4 mounted on the upper swiveling body 3, and others; and furthermore, the front working machine 4 is composed of a boom 5 whose base end part is supported vertically swingably by upper swiveling body 3, a stick 6 longitudinally swingably supported at an end part of the boom 5, a bucket 7 swivelably mounted at an end part of the stick 6, and others; wherein the hydraulic excavator 1 is provided with various hydraulic actuators, such as a boom cylinder 8, stick cylinder 9, and bucket cylinder 10 for swinging the boom 5, stick 6, and bucket 7 respectively; left and right traveling motors (not shown) for moving the lower traveling body 2; a swiveling motor (not shown) for swiveling the upper swiveling body 3. Note that the constitution of hydraulic excavator 1 is similar to those according to second and third embodiments mentioned later and Fig. 1 is common to first to third embodiments. Also, in description below, a swing of stick 6 bringing the end part of stick close to the body is assumed to be stick-in (in-side swing) and the swing of stick 6 moving the end part of stick away from the body is assumed to be stick-out (out-side swing).

When oil is supplied into head side oil chamber 8a and discharged from rod side oil chamber 8b, the boom cylinder 8 is configured to extend and the boom 5 is configured to rise; meanwhile, when the oil is supplied into the rod side oil chamber 8b and discharged from the head side oil chamber 8a, the boom 5 is configured to lower. When the oil is supplied into the head side oil chamber 9a and discharged from the rod side oil chamber 9b, the stick cylinder 9 is configured to extend and the stick 6 is configured to swing toward in-side; meanwhile, when oil is supplied into the rod side oil chamber 9b and discharged from the head side oil chamber 9a, the stick cylinder 9 is configured to contract and the stick 6 is configured to swing toward out-side; now based on Fig. 2, an explanation is provided about oil feed/discharge control for these boom cylinder 8 and stick cylinder 9; in Fig. 2, reference numbers 11, 12 denote first and second hydraulic pumps as hydraulic supply source for various hydraulic actuators installed on the

hydraulic excavator 1 mentioned above, reference numbers 13, 14 denote first and second oil passages through which delivery oil is supplied from first and second hydraulic pumps 11, 12, reference number 15 denotes an oil tank, reference numbers 16, 17 denote first and second boom spool valves for controlling oil supply and discharge for the boom cylinder 8, reference numbers 18, 19 denote first and second stick spool valves for controlling oil supply and discharge for the stick cylinder 9; the first boom spool valve 16 and first stick spool valve 18 are connected to the first pump oil passage 13, and the second boom spool valve 17 and second stick spool valve 19 are connected to the second pump oil passage 14 respectively. Furthermore, at an upstream side of the first stick spool valve 18, a poppet valve 20 mentioned later is disposed, which controls the supply flow rate from first hydraulic pump 11 to first stick spool valve 18.

In addition, since the boom cylinder 8 and stick cylinder 9 are hydraulic actuator which requires large flow rate, the first and second boom spool valves 16, 17 and the first and second stick spool valves 18, 19 are installed so that pressure oil can be supplied from both the first and second hydraulic pumps 11, 12. Also, in the Fig. 2, reference numbers 21, 22 denote a left travel spool valve and bucket spool valve both connected to first pump oil passage 13, reference numbers 23, 24 denote a right travel spool valve and rotation spool valve both connected to second pump oil passage 14, wherein these spool valves 21 to 24 change over between neutral and operation position according to operations of corresponding manipulator to control oil supply and discharge for corresponding hydraulic actuator (left travel motor, bucket cylinder 10, right travel motor, and rotation motor); but detailed description about these spool valves 21 to 24 is omitted.

Also in Fig. 2, reference numbers 25, 26 denote first and second bypass valves; the first bypass valve 25 controls a flow rate of first center bypass oil passage 27 passing through center bypass passages 21a, 16a, 22a, and 18a in order, which are formed by spool valves 21, 16, 22, and 18 and connected to first pump oil passage 13, and leading to first hydraulic pump 11 and oil tank 15, and the

second bypass valve 26 controls a flow rate of second center bypass oil passage 28 passing through center bypass passages 23a, 24a, 17a, and 19a in order, which are formed by spool valves 23, 24, 17, and 19 and connected to second pump oil passage 14, and leading to second hydraulic pump 12 and the oil tank 15. In this case, the center bypass passages 21a, 16a, 22a, 18a, 23a, 24a, 17a, and 19a formed by the spool valves 21, 16, 22, 18, 23, 24, 17, and 19 have roughly a certain opening area regardless of change-over position or spool's displaced amount of spool valves 21, 16, 22, 18, 23, 24, 17, and 19, and in addition, the first and second bypass valves 25, 26 are configured to control increase or decrease of the flow rate of first and second center bypass oil passages 27, 28, i.e. bypass flow rate feeding from first and second hydraulic pumps 11, 12, to oil tank 15, by controlling increase or decrease of opening area based on control signal output by control unit 30 mentioned later to first and second bypass valve solenoid valves 49, 50. As the bypass flow rate is controlled to be increased or decreased by the first and second bypass valves 25, 26, the delivery flow rate from first and second hydraulic pumps 11, 12 is controlled to be increased or decreased, and thus, the delivery flow rate from first and second hydraulic pumps 11, 12 can be supplied to spool valves 21, 16, 22, 18, 23, 24, 17, and 19 in just proportion.

In addition, according to this embodiment, as first and second bypass oil passages of this invention, first and second center bypass oil passages are provided passing through each spool's center bypass passage, at its lowermost stream, first and second bypass valves are disposed, but at uppermost stream of these spools, first and second bypass oil passages can be provided for feeding the oil from first and second hydraulic pumps to the oil tank and first and second bypass valves can be disposed in the first and second bypass oil passages. In this case, center bypass passage formed on each spool valve can be abolished.

Next, an explanation is provided in detail about oil supply and discharge control for the boom cylinder 8.

First of all, the first boom spool valve 16 is a three position change-over valve having pilot ports 16b, 16c at lowering (contracted) and raising (extended) sides, wherein, when a pilot pressure is not input into both pilot ports 16b, 16c, the valve is positioned at neutral position N, where pressure oil is not supplied to nor discharged from the boom cylinder 8, but when the pilot pressure is input into the lowering side pilot port 16b, the valve switches to a lowering side operation position V to open a recycle valve passage 16d for supplying the discharge oil from head side oil chamber 8a of boom cylinder 8 to rod side oil chamber 8b. Also, the first boom spool valve 16 is configured, when the pilot pressure is input into raising side pilot port 16c, to switch to raising side operation position W and open head side supply valve passage 16e for supplying the delivery oil from first hydraulic pump 11 to head side oil chamber 8a of boom cylinder 8 and open rod side discharge valve passage 16f for feeding the discharge oil from the rod side oil chamber 8b of boom cylinder 8 to the oil tank 15. Note that, in the recycle valve passage 16d, a check valve to block an oil flow from rod side oil chamber 8b to head side oil chamber 8a.

Also, the second boom spool valve 17 is the three position change-over valve having pilot ports 17b, 17c at lowering (contracted) and raising (extended) sides, wherein, when the pilot pressure is not input into both pilot ports 17b, 17c, the valve17 is positioned at neutral position N, where the pressure oil is not supplied to nor discharged from the boom cylinder 8, but when the pilot pressure is input into the lowering side pilot port 17b, the valve 17 switches to the lowering side operation position V to open a head side discharge valve passage 17d for feeding the discharge oil from head side oil chamber 8a of boom cylinder 8 to oil tank 15. Also, the second boom spool valve 17 is configured, when the pilot pressure is input into raising side pilot port 17c, to switch to the raising side operation position W and open the head side supply valve passage 17e for supplying the delivery oil from second hydraulic pump 12 to head side oil chamber 8a of boom cylinder 8.

Furthermore, in the Fig. 2, reference numbers 31, 32 denote first and second lowering side solenoid valves for outputting the pilot pressures to the lowering side pilot ports 16b, 17b for the first and second boom spool valves 16, 17, reference numbers 33, 34 denote first and second raising side solenoid valves for outputting the pilot pressure to raising side pilot ports 16c, 17c, wherein these first and second lowering and raising side solenoid valves 31 to 34 start to output the pilot pressure corresponding to the control signal based on the control signal from the control unit 30 mentioned later. Then, the spool of first and second boom spool valves 16, 17 is changed by the pilot pressure to be output from first and second lowering and raising side solenoid valves 31 to 34 to lowering and raising side pilot ports 16b, 17b, 16c, and 17c of first and second boom spool valves 16, 17, so that the valves 16, 17 switch to the lowering and raising side operation positions V, W; in this case, a spool's displaced amount is controlled to be increased or decreased according to increase or decrease of pilot pressure.

Here, Fig. 3 illustrates the opening characteristics of recycle valve passage 16d of the first boom spool valve 16 at lowering side operation position V, the head side supply valve passage 16e and rod side discharge valve passage 16f at raising side operation position W, and the head side discharge valve passage 17d of the second boom spool valve 17 at lowering side operation position V and head side supply valve passage 17e at raising side operation position W; as shown in the Fig. 3, the opening area of these valve passages 16d, 16e, 16f, 17d, and 17e is set to be large as the spool's displaced amount becomes large. As the opening area of valve passages 16d, 16e, 16f, 17d, and 17e increases or decreases in coordination with spool's displacement, the recycled flow rate from head side oil chamber 8a of boom cylinder 8 to rod side oil chamber 8b, the supply flow rate from first hydraulic pump 11 to head side oil chamber 8a, the discharge flow rate from rod side oil chamber 8b to oil tank 15, the discharge flow rate from head side oil chamber 8a to oil tank 15, and the supply flow rate from second hydraulic pump 12 to head side oil chamber 8a are controlled to be increased or decreased.

That is to say, when first and second boom spool valves 16, 17 are located at lowering side operation position V, the recycle valve passage 16d of first boom spool valve 16 controls the recycled flow rate from head side oil chamber 8a to rod side oil chamber 8b and the head side discharge valve passage 17d of second boom spool valve 17 controls the discharge flow rate from head side oil chamber 8a to oil tank 15. Meanwhile, when first and second boom spool valves 16, 17 are located at raising side operation position W, the head side supply valve passage 16e and rod side discharge valve passage 16f of first boom spool valve 16 control the supply flow rate from first hydraulic pump 11 to head side oil chamber 8a and the discharge flow rate from rod side oil chamber 8b to oil tank 15, and also, the head side supply valve passage 17e of second boom spool valve 17 controls the supply flow rate from second hydraulic pump 12 to head side oil chamber 8a.

In contrast, as shown in Fig. 5, the control unit 30 is configured to be input signals from boom actuator, stick manipulator, operation detection means 36 for detecting each operation of various manipulators including manipulators for other hydraulic actuators installed on the hydraulic excavator 1 (according to this embodiment, the right/left traveling motors, bucket cylinder 10, swiveling motor), first and second pump pressure sensors 37, 38 for respectively detecting delivery pressure from first and second hydraulic pumps 11, 12, head side/rod side boom pressure sensors 39, 40 for respectively detecting pressure in head/rod side oil chambers 8a, 8b of boom cylinder 8, head side/rod side stick pressure sensors 41, 42 for detecting pressure in head/rod side oil chambers 9a, 9b of stick cylinder 9, various pressure detection sensors for other hydraulic actuators (not shown, but pressure sensors for respectively detecting pressure in head/rod side oil chambers of bucket cylinder 10, for example), engine controller 43, and others, and based on these input signals, output control signals to first and second lowering/rising side solenoid valves 31 to 34 for outputting pilot pressure to the first and second boom spool valves 16, 17, first and second in-side/out-side solenoid valves 45 to 48 mentioned later for outputting pilot pressure to first and second stick spool valves

18, 19, poppet valve solenoid valve 29 for outputting pilot pressure to poppet valve 20, various solenoid valves (not shown) for outputting pilot pressure to spool valves for other hydraulic actuators (in this embodiment, left travel spool valve 21, bucket spool valve 22, right travel spool valve 23, and swiveling spool valve 24), first bypass valve solenoid valve 49 for outputting pilot pressure to the first bypass valve 25, and second bypass valve solenoid valve 50 for outputting pilot pressure to second bypass valve 26.

Then, an explanation is provided about a control of first and second boom spool valves 16, 17 conducted by the control unit 30; when a signal of boom lowering operation is input from operation detection means 36, the control unit 30 outputs the control signal to first and second lowering side solenoid valves 31, 32. Thus, the pilot pressure is input into the lowering side pilot ports 16b, 17b of first and second boom spool valves 16, 17 to switch both first and second boom spool valves 16, 17 to lowering side operation position V. Then, as mentioned above, the first boom spool valve 16 at the lowering side operation position V controls the recycled flow rate from head side oil chamber 8a of boom cylinder 8 to rod side oil chamber 8b and the second boom spool valve 17 at the lowering side operation position V controls the discharge flow rate from head side oil chamber 8a to oil tank 15. Thus, the oil is discharged from head side oil chamber 8a and supplied into rod side oil chamber 8b to contract the boom cylinder 8 and lower the boom 5; here, based on the various signals (signal and others from the operation detection means 36 and various pressure sensors 37 to 42) input into the control unit 30, the control unit 30 calculates the recycle and discharge flow rates required to the boom cylinder 8 and outputs respective control signals to first and second lowering side solenoid valves 31, 32 in order to control them independently of each other. These independent controls of recycle and discharge flow rates are enabled since the first boom spool valve 16 controls only the recycled flow rate during lowering operation of boom 5 (contraction of boom cylinder 8) and the second boom spool valve 17 controls only the discharge flow rate.

Here, when the boom 5 is lowering, both first and second boom spool valves 16, 17 are configured not to supply the delivery oil from first and second hydraulic pumps 11, 12 to rod side oil chamber 8b of boom cylinder 8. That is because, during lowering operation of boom 5 (contraction of boom cylinder 8), a discharge amount from head side oil chamber 8a of boom cylinder 8 is remarkably large compared with a supply amount to rod side oil chamber 8b (about twice, for example) based on the relationship of piston's pressured area, in addition, the head side oil chamber 8a is highly pressured as whole weight of front working machine 4 is applied, and therefore, recycle oil from head side oil chamber 8a is enough for the oil supply to rod side oil chamber 8b. Then, during the lowering of boom 5, first and second hydraulic pumps 11, 12 can be configured not to supply the delivery oil to boom cylinder 8, contributing to energy saving.

Meanwhile, when a signal of boom raising operation is input from operation detection means 36, the control unit 30 outputs the control signal for outputting pilot pressure to first and second raising side solenoid valves 33, 34. Thus, the pilot pressure is input into raising side pilot ports 16c, 17c of first and second boom spool valves 16, 17 to switch both first and second boom spool valves 16, 17 to raising side operation position W. Then, as mentioned above, the first boom spool valve 16 at the raising side operation position W controls the supply flow rate from first hydraulic pump 11 to head side oil chamber 8a and the discharge flow rate from rod side oil chamber 8b to oil tank 15, and the second boom spool valve 17 at the raising side operation position W controls the supply flow rate from second hydraulic pump 12 to head side oil chamber 8a. Thus, the oil is supplied into head side oil chamber 8a and discharged from rod side oil chamber 8b to extend the boom cylinder 8 and raise the boom 5; here, based on the various signals (signal and others from operation detection means 36 and various pressure sensors 37 to 42, and engine controller 43) input into the control unit 30, the control unit 30 calculates the supply and discharge flow rates required to the boom cylinder 8 and outputs the control signal to each of first and second raising

side solenoid valves 33, 34 in order to control them independently. These independent controls of supply and discharge flow rates are enabled since the first boom spool valve 16 controls the supply and discharge flow rates from first hydraulic pump 11 during raising operation of boom 5 (extension of boom cylinder 8) and the second boom spool valve 17 controls the supply flow rate from second hydraulic pump 12.

Note that, as for first boom spool valve 16 during raising of boom 5, the relationship between the opening areas of head side supply valve passage 16e and rod side discharge valve passage 16f is uniquely decided with a spool displaced amount; the supply/discharge flow rates for boom cylinder 8 can be controlled independently of each other by controlling the increase and decrease of opening area of head side supply valve passage 17e, which is connected to second boom spool valve 17 that controls the supply flow rate only, so that total supply flow rate from first and second boom spool valves (first and second hydraulic pumps 11, 12) 16, 17 will be the supply flow rate required by boom cylinder 8.

Next, an explanation is provided in detail about oil supply and discharge control for the stick cylinder 9.

First, the poppet valve 20 has a check function, is capable of metering, and is provided at an upstream side of first stick spool valve 18, i.e. at a supply oil passage from first hydraulic pump 11 to first stick spool valve 18. Also, the poppet valve 20 is started by pilot pressure output from the poppet valve solenoid valve 29 based on the control signal output by the control unit 30 to the poppet valve solenoid valve 29 to control the supply flow rate from first hydraulic pump 11 to first stick spool valve 18. The supply flow rate of first hydraulic pump 11 supplied from poppet valve 20 to first stick spool valve 18 is, as mentioned later, configured to be supplied as-is to stick cylinder 9 without being increased or decreased by the first stick spool valve 18.

Also, the first stick spool valve 18 is the three position change-over valve having in-side (extended side) and out-side (contracted side) pilot ports 18b, 18c;

wherein, when the pilot pressure is not input into both pilot ports 18b, 18c, the valve 18 is positioned at neutral position N, where the pressure oil is not supplied to nor discharged from the stick cylinder 9, but when the pilot pressure is input into in-side pilot port 18b, the valve 18 switches to an in-side operation position X to open the head side supply valve passage 18d for supplying the delivery oil from first hydraulic pump 11 supplied through poppet valve 20 to head side oil chamber 9a of stick cylinder 9 and open recycle valve passage 18e for supplying the delivery oil from the rod side oil chamber 9b to head side oil chamber 9a. Also, the first stick spool valve 18 is configured, when the pilot pressure is input into out-side pilot port 18c, to switch to out-side operation position Y and open rod side supply valve passage 18f for supplying the delivery oil from first hydraulic pump 11 supplied through the poppet valve 20 to rod side oil chamber 9b and open head side discharge valve passage 18g for feeding delivery oil from head side oil chamber 9a to oil tank 15; as mentioned later, the head side supply valve passage 18d and rod side supply valve passage 18f are configured to supply the supply flow rate as-is from poppet valve 20 to stick cylinder 9 without increasing or decreasing the flow rate. Note that, in the recycle valve passage 18e, a check valve to block the oil flow from head side oil chamber 9a to rod side oil chamber 9b.

Also, the second stick spool valve 19 is the three position change-over valve having in-side (extended side) and out-side (contracted side) pilot ports 19b, 19c; wherein, when the pilot pressure is not input into both pilot ports 19b, 19c, the valve 19 is positioned at neutral position N, where the pressure oil is not supplied to nor discharged from stick cylinder 9, but when the pilot pressure is input into in-side pilot port 19b, the valve 19 switches to the in-side operation position X to open the head side supply valve passage 19d for supplying the delivery oil from second hydraulic pump 12 to head side oil chamber 9a of stick cylinder 9 and open rod side discharge valve passage 19e for feeding the discharge oil from rod side oil chamber 9b to oil tank 15. Also, the second stick spool valve 19 is configured, when the pilot pressure is input into out-side pilot port 19c, to

switch to out-side operation position Y and open rod side supply valve passage 19f for supplying delivery oil from second hydraulic pump 12 to rod side oil chamber 9b and open head side discharge valve passage 19g for feeding the discharge oil from head side oil chamber 9a to oil tank 15.

Here, as an allocation structure of poppet valve 20 is shown in Fig. 6, the poppet valve 20 is, in a valve block where first and second stick spool valves 18, 19 are incorporated, incorporated in a pump port connected to first hydraulic pump 11 for supplying the delivery oil from first hydraulic pump 11 to first stick spool valve 18. Also, in Fig. 6, a reference number 35 denotes the check valve incorporated in the pump port connected to second hydraulic pump 12 for supplying the delivery oil from second hydraulic pump 12 to second stick spool valve 19; wherein the check valve 35 is configured to block a backflow from second stick spool valve 19 to second hydraulic pump 12. That is to say, in the pump port in the valve block where spool valves such as first and second stick spool valves 18, 19 are incorporated, in general, the check valve such as the check valve 35 mentioned above is incorporated to block the backflow from spool valve to hydraulic pump; according to this embodiment, in place of this check valve, a pocket valve 20 having a check function and being capable of metering is configured to be incorporated in the pump port; thus, there is no need to ensure a space for the poppet valve 20 separately and it is easy to dispose the poppet valve 20 there.

Furthermore, in the Fig. 2, reference numbers 45, 46 denote first and second in-side solenoid valves for outputting pilot pressures to the in-side pilot ports 18b, 19b of first and second stick spool valves 18, 19, reference numbers 47, 48 denote first and second out-side solenoid valves for outputting pilot pressure to out-side pilot ports 18c, 19c; wherein these first and second in-side/out-side solenoid valves 45 to 48 start to output pilot pressure corresponding to the control signal based on the control signal from the control unit 30. Then, the pilot pressure output from first and second in-side/out-side solenoid valves 45 to 48 to the in-side and out-

side pilot ports 18b, 19b, 18c, 19c of first and second stick spool valves 18, 19 displace each spool of first and second stick spool valves 18, 19, so that the valves 18, 19 switch to in-side and out-side operation positions X, Y; in this case, each spool's displaced amount is controlled to be increased or decreased according to a change of pilot pressure.

Here, Fig. 4 illustrates the opening characteristics of head side supply valve passage 18d and recycle valve passage 18e at in-side operation position X of the first stick spool valve 18, rod side supply valve passage 18f and head side discharge valve passage 18g at out-side operation position Y, head side supply valve passage 19d and rod side discharge valve passage 19e at in-side operation position X of second stick spool valve 19, and rod side supply valve passage 19f and head side discharge valve passage 19g at out-side operation position Y; as shown in the Fig. 4, in the head side and rod side supply valve passages 18d, 18f and rod side supply valve passage 18f of the first stick spool valve 18, the opening area is set to become maximum just when the spool displaces from the neutral position N, i.e. even when the spool's displaced amount is small. Thus, the first stick spool valve 18 is configured to supply the supply flow rate as-is from first hydraulic pump 11 supplied through poppet valve 20 to the head side and rod side oil chambers 9a, 9b of stick cylinder 9 without increasing or decreasing the flow rate. That is, the supply flow rate from the first hydraulic pump 11 to the stick cylinder 9 is not controlled at first stick spool valve 18, and the supply flow rate controlled at the poppet valve 20 is supplied as-is to the stick cylinder 9.

Meanwhile, the opening area of recycle valve passage 18e of first stick spool valve 18 and head side discharge valve passage 18g, head side supply valve passage 19d of second stick spool valve 19, rod side discharge valve passage 19e, rod side supply valve passage 19f, and head side discharge valve passage 19g is configured to become larger as the spool's displaced amount gets large. As the opening area of valve passages 18e, 18g, 19d, 19e, 19f, and 19g increases or decreases in coordination with the spool's displacement, the recycled flow rate

from rod side oil chamber 9b of stick cylinder 9 to head side oil chamber 9a, the discharge flow rate from head side oil chamber 9a to oil tank 15, the supply flow rate from second hydraulic pump 12 to head side oil chamber 9a, the discharge flow rate from rod side oil chamber 9b to oil tank 15, the supply flow rate from second hydraulic pump 12 to rod side oil chamber 9b, and the discharge flow rate from head side oil chamber 9a to oil tank 15 are controlled to be increased or decreased.

That is to say, when first and second stick spool valves 18, 19 are positioned at in-side operation position X, the supply flow rate from first hydraulic pump 11 to head side oil chamber 9a is controlled with the poppet valve 20, the recycled flow rate from rod side oil chamber 9b to head side oil chamber 9a is controlled with recycle valve passage 18e of first stick spool valve 18, and the supply flow rate from second hydraulic pump 12 to head side oil chamber 9a and the discharge flow rate from rod side oil chamber 9b to oil tank 15 are controlled with head side supply valve passage 19d and rod side discharge valve passage 19e of second stick spool valve 19. Meanwhile, when first and second stick spool valves 18, 19 are positioned at out-side operation position Y, the supply flow rate from first hydraulic pump 11 to rod side oil chamber 9b is controlled with poppet valve 20, the discharge flow rate from head side oil chamber 9a to oil tank 15 is controlled with head side discharge valve passage 18g of first stick spool valve 18, and the supply flow rate from second hydraulic pump 12 to rod side oil chamber 9b and the discharge flow rate from head side oil chamber 9a to oil tank 15 are controlled with rod side supply valve passage 19f of second stick spool valve 19 and head side discharge valve passage 19g.

Thereafter, an explanation is provided about a control of poppet valve 20 and first and second stick spool valves 18, 19 conducted by the control unit 30; when a stick-in signal is input from operation detection means 36, the control unit 30 outputs the control signal to poppet valve solenoid valve 29 for outputting pilot pressure. Thus, the poppet valve 20 starts to supply the delivery oil from first

hydraulic pump 11 to first stick spool valve 18 while the flow rate of delivery oil is controlled. Furthermore, the control unit 30 outputs the control signal to first and second in-side solenoid valves 45, 46 for outputting pilot pressure. Thus, the pilot pressure is input into in-side pilot ports 18b, 19b of first and second stick spool valves 18, 19 to switch both first and second stick spool valves 18, 19 to in-side operation position X. Then, as mentioned above, the poppet valve 20 controls the supply flow rate from first hydraulic pump 11 to head side oil chamber 9a, the first stick spool valve 18 at in-side operation position X controls the recycled flow rate from rod side oil chamber 9b to head side oil chamber 9a, and the second stick spool valve 19 at in-side operation position X controls the supply flow rate from second hydraulic pump 12 to head side oil chamber 9a and the discharge flow rate from rod side oil chamber 9b to oil tank 15. Thus, the oil is supplied into head side oil chamber 9a and discharged from rod side oil chamber 9b to extend the stick cylinder 9 and swing the stick 6 to in-side; here, based on the various signals (signal and others from the operation detection means 36, various pressure sensors 37 to 42, and engine controller 43) input into the control unit 30, the control unit 30 calculates the supply, recycle, and discharge flow rates required to stick cylinder 9 and outputs respective control signals to poppet valve solenoid valve 29 and first and second in-side solenoid valves 45, 46 in order to control them independently of each other. These independent controls of supply, recycle, and discharge flow rates are enabled since, during in-side operation of stick 6 (extension of stick cylinder 9), the poppet valve 20 controls the supply flow rate from first hydraulic pump 11, the first stick spool valve 18 controls the recycled flow rate, and the second stick spool valve 19 controls the supply and discharge flow rates from second hydraulic pump 12.

Note that, during the in-side operation of stick 6, the relationship between opening areas of head side supply valve passage 19d and rod side discharge valve passage 19e of second stick spool valve 19 is uniquely decided with the spool displaced amount; the supply/discharge flow rates for the stick cylinder 9 can be

controlled independently of each other by controlling the increase and decrease of opening area of poppet valve 20, which controls only the supply flow rate, so that total supply flow rate from the poppet valve 20 (supply flow rate from first hydraulic pump 11) and second stick spool valve 19 (supply flow rate from second hydraulic pump 12) is controlled to be the supply flow rate required by stick cylinder 9.

Meanwhile, when a stick-out operation signal is input from operation detection means 36, the control unit 30 outputs the control signal to poppet valve solenoid valve 29 for outputting pilot pressure. Thus, the poppet valve 20 starts to supply the delivery oil from first hydraulic pump 11 to first stick spool valve 18 while the flow rate of delivery oil is controlled. Furthermore, the control unit 30 outputs the control signal to first and second out-side solenoid valves 47, 48 for outputting the pilot pressure. Thus, the pilot pressure is input into out-side pilot ports 18c, 19c of first and second stick spool valves 18, 19 to switch both first and second stick spool valves 18, 19 to out-side operation position Y. Then, as mentioned above, the poppet valve 20 controls the supply flow rate from first hydraulic pump 11 to rod side oil chamber 9b, the first stick spool valve 18 at out-side operation position Y controls the discharge flow rate from head side oil chamber 9a to oil tank 15, and the second stick spool valve 19 at out-side operation position Y controls the supply flow rate from second hydraulic pump 12 to rod side oil chamber 9b and the discharge flow rate from head side oil chamber 9a to oil tank 15. Thus, the oil is supplied into rod side oil chamber 9b and discharged from head side oil chamber 9a to contract stick cylinder 9 and swing stick 6 to out-side; here, based on the various signals (signal and others from the operation detection means 36, various pressure sensors 37 to 42, and engine controller 43) input into the control unit 30, the control unit 30 calculates the supply and discharge flow rates required to stick cylinder 9 and outputs respective control signals to poppet valve solenoid valve 29 and first and second out-side solenoid valves 47, 48 in order to control them independently of each other. These independent

controls of supply and discharge flow rates are enabled since, during out-side operation of stick 6 (contraction of stick cylinder 9), the poppet valve 20 controls the supply flow rate from first hydraulic pump 11, the first stick spool valve 18 controls the discharge flow rate, and the second stick spool valve 19 controls the supply and discharge flow rates from second hydraulic pump 12.

Note that, during the out-side operation of stick 6, the relationship between opening areas of rod side supply valve passage 19f and head side discharge valve passage 19g of second stick spool valve 19 is uniquely decided with the spool displaced amount; the supply/discharge flow rates for stick cylinder 9 can be controlled independently of each other by controlling the increase and decrease of opening area of poppet valve 20, which controls only the supply flow rate, so that total supply flow rate from poppet valve 20 (supply flow rate from first hydraulic pump 11) and second stick spool valve 19 (supply flow rate from second hydraulic pump 12) is controlled to be the supply flow rate required by stick cylinder 9 or by controlling the increase and decrease of opening area of head side discharge valve passage 18g of first stick spool valve 18, which controls only the discharge flow rate, so that total discharge flow rate from first stick spool valve 18 and second stick spool valve 19 is controlled to be the discharge flow rate required to stick cylinder 9.

According to first embodiment as configured above, the hydraulic control circuit of hydraulic excavator 1 comprises first and second hydraulic pumps 11, 12 as hydraulic supply source and first and second boom spool valves 16, 17 being connected respectively to the first and second hydraulic pumps 11, 12 and controlling oil supply and discharge for boom cylinder 8; wherein, when the boom cylinder 8 is contracted (lowering operation of boom 5), the first boom spool valve 16 controls the recycled flow rate from head side oil chamber 8a of boom cylinder 8 to rod side oil chamber 8b, the second boom spool valve 17 controls the discharge flow rate from head side oil chamber 8a of boom cylinder 8 to oil tank 15, and both first and second boom spool valves 16, 17 do not to supply pressure oil from first

and second hydraulic pumps 11, 12 to boom cylinder 8 when the boom cylinder 8 is contracted.

That is to say, during the contraction of boom cylinder 8, the first boom spool valve 16 controls only the recycled flow rate from head side oil chamber 8a to rod side oil chamber 8b, so the first boom spool valve 16 can control the recycled flow rate independently. Also, the second boom spool valve 17 controls only the discharge flow rate from head side oil chamber 8a to oil tank 15, so the second boom spool valve 17 can control the discharge flow rate independently.

As the result, during the contraction of boom cylinder 8, the recycle and discharge flow rates for the boom cylinder 8 can be controlled independently of each other, and according to various work contents of stand-alone work for driving the boom cylinder 8 alone, compound work for driving other hydraulic actuator (stick cylinder 9, bucket cylinder 10, for example) as well, light load work, heavy load work, and others, the relationship between the supply and discharge flow rates can be changed, contributing high efficiency and improvement of operability. Furthermore, this control is done by making use of first and second boom spool valves 16, 17, which are generally used in hydraulic control circuit of hydraulic excavator 1 conventionally, so the valve unit for conventional circuit configuration can be used as-is, attaining cost reduction. Furthermore, during the contraction of boom cylinder 8, both first and second boom spool valves 16, 17 do not supply pressure oil from first and second hydraulic pumps 11, 12 to boom cylinder 8, contributing energy conservation. In addition, during the contraction of boom cylinder 8 (lowering operation of boom 5), the discharge amount from head side oil chamber 8a of boom cylinder 8 is remarkably large compared to the supply amount to rod side oil chamber 8b because of relationship of piston's pressured area, and in addition, the head side oil chamber 8a is highly pressured by whole weight of front working machine 4, so the recycle oil from head side oil chamber 8a is enough for the oil supply to rod side oil chamber 8b.

Furthermore in this regard, during the extension of boom cylinder 8 (raising of boom 5), the first boom spool valve 16 controls the supply flow rate from first hydraulic pump 11 to head oil chamber 8a of boom cylinder 8 and the discharge flow rate from rod side oil chamber 8b to oil tank 15, and the second boom spool valve 17 controls the supply flow rate from second hydraulic pump 12 to head side oil chamber 8a of boom cylinder 8.

That is to say, during the extension of boom cylinder 8, the second boom spool valve 17 controls only the supply flow rate from second hydraulic pump 12 to head side oil chamber 8a, so the second boom spool valve 17 can control the supply flow rate from second hydraulic pump 12 independently. Also, the first boom spool valve 16 controls the supply flow rate from first hydraulic pump 11 to head side oil chamber 8a and the discharge flow rate from rod side oil chamber 8b to oil tank 15; in this case, the discharge flow rate can be controlled independently with the first boom spool valve 16 by giving precedence to the discharge flow rate control. Furthermore, the first boom spool valve 16 cannot control the supply flow rate independently, but the first boom spool valve 16 can control total supply flow rate from both first and second hydraulic pumps 11, 12 independently when the second boom spool valve 17 also controls to increase or decrease the supply flow rate from second hydraulic pump 12. As the result, even when the boom cylinder 8 is extended, the supply and discharge flow rates for the boom cylinder 8 can also be controlled independently, contributing high efficiency and improvement of operability largely.

Furthermore in this regard, the hydraulic control circuit of hydraulic excavator 1 comprises the first and second bypass valves 25, 26 that control the flow rate of first and second bypass oil passages 27, 28 respectively for feeding the delivery oil from first and second hydraulic pumps 11, 12 to oil tank 15. Thus, the first and second bypass valves 25, 26 can control the flow rate from first and second hydraulic pumps 11, 12 to oil tank 15 so that the delivery flow rate from first and second hydraulic pumps 11, 12 can be controlled accurately.

In addition, according to this embodiment, the stick cylinder 9 as well as boom cylinder 8 is configured to be able to control the supply, discharge, and recycled flow rates independently of each other by making use of first and second stick spool valves 18, 19, thus both the boom cylinder 8 and stick cylinder 9, which are installed in the hydraulic excavator 1 and are hydraulic actuator needing large flow rates, can control the supply, discharge, and recycled flow rates independently of each other by utilizing first and second spool valves (first and second boom spool valves 16, 17 and first and second stick spool valves 18, 19), contributing high efficiency, improvement of operability, and cost suppression.

Next, second embodiment of the present invention is described in reference to hydraulic control circuit diagram shown in Fig. 7; since anything other than first boom spool valve 55 mentioned later is the same as first embodiment, an explanation is omitted about it.

First boom spool valve 55 according to the second embodiment comprises, similar to first boom spool valve 16 according to first embodiment, lowering and raising side pilot ports 55b, 55c, wherein the valve 55 switches from neutral position N to the lowering side and raising side operation positions V, W when the pilot pressure is input into lowering side and raising side pilot ports 55b, 55c, wherein first and second areas V1, V2 are provided in the lowering side operation position V of first boom spool valve 55 according to second embodiment. In this case, spool's displaced amount of second area V2 from neutral position N is set larger than that of first area V1. Then, when the valve 55 is positioned in first area V1, the recycle valve passage 55d is opened for supplying the discharge oil from head side oil chamber 8a of boom cylinder 8 to rod side oil chamber 8b. Also, when the valve 55 is positioned in second area V2, it is configured to open the recycle valve passage 55d and the rod side supply valve passage 55g for supplying delivery oil from first hydraulic pump 11 to rod side oil chamber 8b. Note that, in Fig. 7, reference number 55a denotes a center bypass passage installed on first boom spool valve 55.

Here, Fig 8a illustrates opening characteristics of recycle valve passage 55d and rod side supply valve passage 55g in first and second areas V1, V2 at the lowering side operation position V; the opening characteristics of recycle valve passage 55d are same as those of recycle valve passage 16d when the first boom spool valve 16 according to the first embodiment is at lowering side operation position V, and the opening characteristics of rod side supply valve passage 55g are configured to be closed in first area V1 and have larger opening area just after entering into second area V2. Also, since the opening area of the rod side supply valve passage 55g becomes larger soon, when the first boom spool valve 55 is positioned in second area V2, the valve passage 55g is configured to supply delivery oil from first hydraulic pump 11 quickly to rod side oil chamber 8b of boom cylinder 8.

Note that, when the first boom spool valve 55 according to second embodiment is in raising side operation position W, similar to the case where first boom spool valve 16 according to first embodiment is in raising side operation position W, the valve 55 opens head side supply valve passage 55e for supplying delivery oil from first hydraulic pump 11 to head side oil chamber 8a of boom cylinder 8 and rod side discharge valve passage 55f for feeding discharge oil from rod side oil chamber 8b of boom cylinder 8 to oil tank 15; opening characteristics of these head side supply valve passage 55e and rod side discharge valve passage 55f are configured to be same as those of head side supply valve passage 16e and rod side discharge valve passage 16f of first boom spool valve 16 according to first embodiment (refer to Fig. 8b).

Meanwhile, according to second embodiment, when a boom lowering operation signal is input from operation detection means 36, the control unit 30 decides whether the signal denotes the body lift-up operation (lowers boom 5 while the bucket 7 is on earth to lower the boom 5 relatively against the body so that a part of the body is lifted up) based on a pressure in head side oil chamber 8a of boom cylinder 8 input from head side boom pressure sensor 39. Note that,

according to second embodiment, the control unit 30 configures a judgment means for the present invention.

Here, the judgment whether the signal denotes the body lift-up operation or not is conducted based on the pressure value in head side oil chamber 8a of boom cylinder 8 input from head side boom pressure sensor 39. That is to say, when lowering the boom 5 in air (lowering boom 5 while the bucket 7 is not on earth), the pressure in head side oil chamber 8a of boom cylinder 8 is high since total weight of front working machine 4 is applied on pressure oil in head side oil chamber 8a. Meanwhile, when lowering boom 5 while a force resisting the lowering of boom 5 is acting due to the bucket 7 being on earth, and others, a tensile force is applied on boom cylinder 8 so that the pressure in head side oil chamber 8a is reduced more than when lowering the boom 5 in air; during the body lift-up operation, a strong tensile force acts on the boom cylinder 8 since the boom 5 is lowered against the body weight so that the pressure in head side oil chamber8 is reduced further. Therefore, when the pressure in head side oil chamber 8a of boom cylinder 8 is reduced to less than predefined setting value Ps, the signal is deemed a body lift-up operation; also, when the pressure is not less than setting value Ps, the signal is not deemed the body lift-up operation.

Furthermore, when an operation signal for lowering boom is input from operation detection means 36, similar to first embodiment, the control unit 30 outputs control signal to first and second lowering side solenoid valves 31, 32 for outputting pilot pressure to switch first and second boom spool valves 55, 17 to lowering side operation position V; in this case, when the operation signal is not deemed the body lift-up operation (the pressure in head side oil chamber 8a of boom cylinder 8 is not less than predefined setting value Ps), the control signal is output to first lowering side solenoid valve 31 to output pilot pressure for positioning first boom spool valve 55 in first area V1 (spool's displaced amount for entering into first area V1). Thus, the first boom spool valve 55 is positioned in

first area V1 and opens recycle valve passage 55d for supplying the discharge oil from head side oil chamber 8a of boom cylinder 8 to rod side oil chamber 8b.

On the other hand, when an operation signal for lowering boom is input from operation detection means 36 and when the operation signal is deemed the body lift-up operation (the pressure in head side oil chamber 8a of boom cylinder 8 is less than setting value Ps), the control unit 30 outputs control signal to first lowering side solenoid valve 31 to output pilot pressure for positioning first boom spool valve 55 in second area V2 (spool's displaced amount for entering into second area V2). Thus, the first boom spool valve 55 is positioned in second area V2, opens recycle valve passage 55d wider than when sitting in first area V1 for supplying the discharge oil from head side oil chamber 8a of boom cylinder 8 to rod side oil chamber 8b, and opens rod side supply valve passage 55g for supplying delivery oil from first hydraulic pump 11 to rod side oil chamber 8b. Note that, when the first boom spool valve 55 is positioned in second area V2, the first boom spool valve 55 opens recycle valve passage 55d for supplying the discharge oil from head side oil chamber 8a to rod side oil chamber 8b, but during the body lift-up operation, since the pressure in rod side oil chamber 8b is higher than head side oil chamber 8a, the oil is not recycled and the check valve provided in recycle valve passage 55d prevents a backflow (oil flow from rod side oil chamber 8b to head side oil chamber 8a).

As such, according to second embodiment, when lifting up the body during the boom's lowering operation (contraction of boom cylinder 8), the first boom spool valve 55 is positioned in second area V2 and opens rod side supply valve passage 55g. Thus, the delivery oil is to be supplied from first hydraulic pump 11 to rod side oil chamber 8b of boom cylinder 8, enabling a smooth body lift-up operation against the weight of the body by lowering the boom 5.

In addition, when the first boom spool valve 55 is positioned in first area V1 at lowering side operation position V, similar to when the first boom spool valve 16 according to first embodiment is positioned in the lowering side operation

position V, the recycle valve passage 55d controls the recycled flow rate from head side oil chamber 8a to rod side oil chamber 8b. Also, when the first boom spool valve 55 is positioned in second area V2 at lowering side operation position V, the rod side supply valve passage 55g controls the supply flow rate from first hydraulic pump 11 to rod side oil chamber 8b (as mentioned above, the oil is not recycled from head side oil chamber 8a to rod side oil chamber 8b). That is, when the first boom spool valve 55 at lowering side operation position V is positioned in first area V1, the valve 55 is configured to control the recycled flow rate only, and also, when located in second area V2, the valve 55 is configured to control the supply flow rate only. Furthermore, similar to when the first boom spool valve 16 according to first embodiment is positioned at raising side operation position W, the first boom spool valve 55 sitting at raising side operation position W controls the supply and discharge flow rates from first hydraulic pump 11. Also, since the second boom spool valve 17 is similar to that of first embodiment, when located at lowering side operation position V, the valve 17 controls the discharge flow rate only, and when positioned at raising side operation position W, the valve 17 controls the supply flow rate only from second hydraulic pump 12. Thus, also according to the second embodiment, the first and second boom spool valves 16, 17 can control the supply, recycle, and discharge flow rates independently of each other, causing the same effect as the first embodiment.

Note that it is to be understood that the present invention is not confined to the first and second embodiments; for instance, both the first and second stick spool valves provided in each of the embodiments are a spool valve of pilot operated type changing with the pilot pressure; these first and second stick spool valves can be configured with a spool valve of electromagnetic proportional type where the control signal is directly input from control unit.

Industrial Applicability

The present invention can be used in a hydraulic control circuit for construction machines such as hydraulic excavator comprising the boom vertically movably supported by the body.

Claims

1. A hydraulic control circuit for a construction machine, comprising: a boom being vertically movably supported by a body and moving vertically in dependence upon extension and contraction operations of a boom cylinder; first and second hydraulic pumps as hydraulic supply source; and first and second boom spool valves being connected respectively to the first and second hydraulic pumps and controlling oil supply and discharge for the boom cylinder; wherein, when the boom cylinder is contracted, the first boom spool valve is configured to control a recycled flow rate from a head side oil chamber of the boom cylinder to a rod side oil chamber, the second boom spool valve is configured to control a discharge flow rate from the head side oil chamber of the boom cylinder to an oil tank, and when the boom cylinder is contracted, both the first and second boom spool valves are configured not to supply pressure oil from first and second hydraulic pumps to the boom cylinder.

2. The hydraulic control circuit for construction machine of claim 1, wherein, when the boom cylinder is extended, the first boom spool valve is configured to control supply flow rate from first hydraulic pump to a head oil chamber of the boom cylinder and discharge flow rate from rod side oil chamber to oil tank, and the second boom spool valve is configured to control supply flow rate from second hydraulic pump to head side oil chamber of the boom cylinder.

3. The hydraulic control circuit for construction machine of claim 1 or 2, providing a means to determine whether a body lift-up operation is requested for lifting up a part of the body based on a pressure in the head side oil chamber when the boom cylinder is contracted, wherein, when the determination means determines the body lift-up operation is requested, the first boom spool valve is

configured to control the supply flow rate from first hydraulic pump to rod side oil chamber of the boom cylinder.

4. The hydraulic control circuit for construction machine of any of claims 1 to 3, comprising first and second bypass valves respectively controlling a flow rate of first and second bypass oil passages for feeding delivery oil of the first and second hydraulic pumps to oil tank.

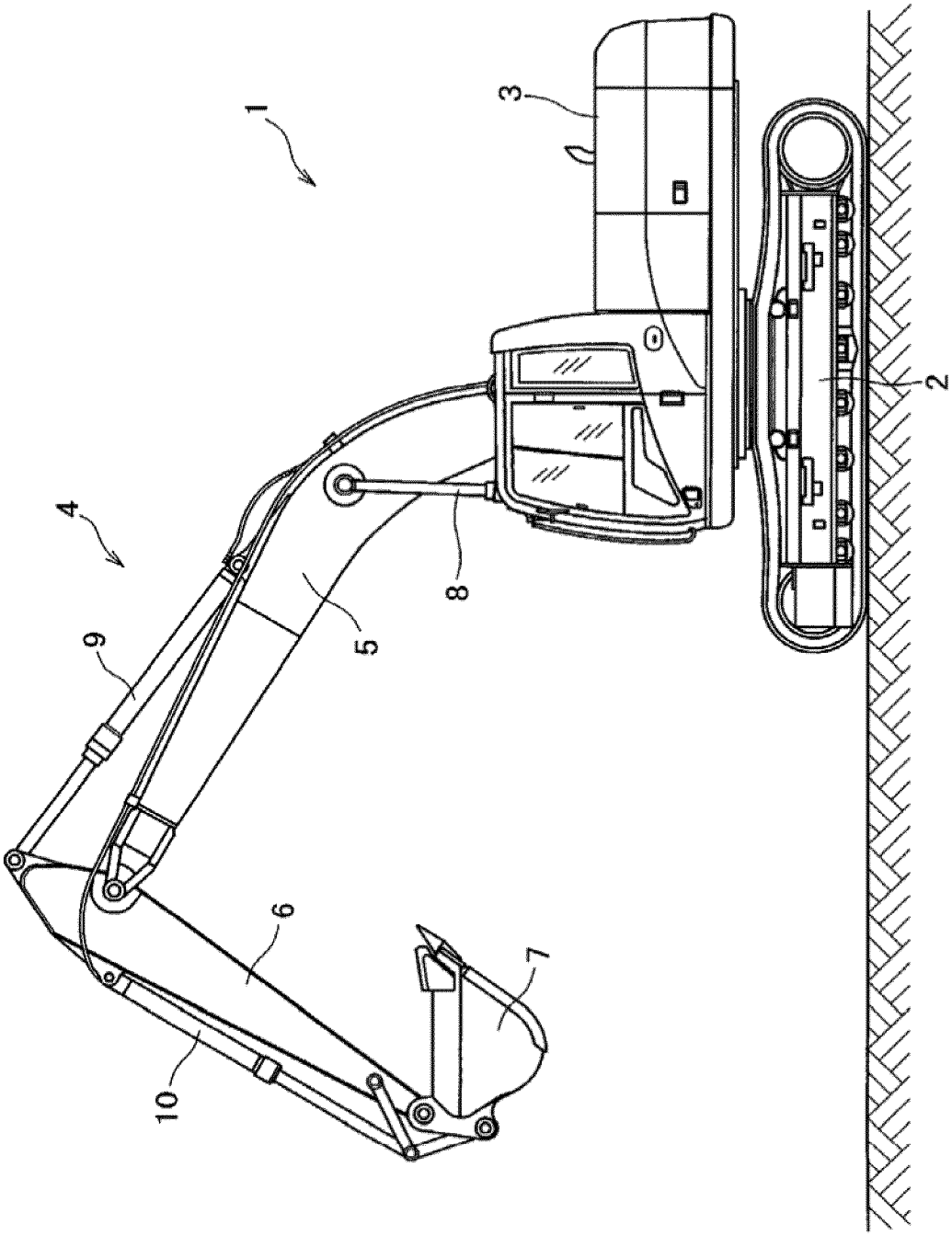
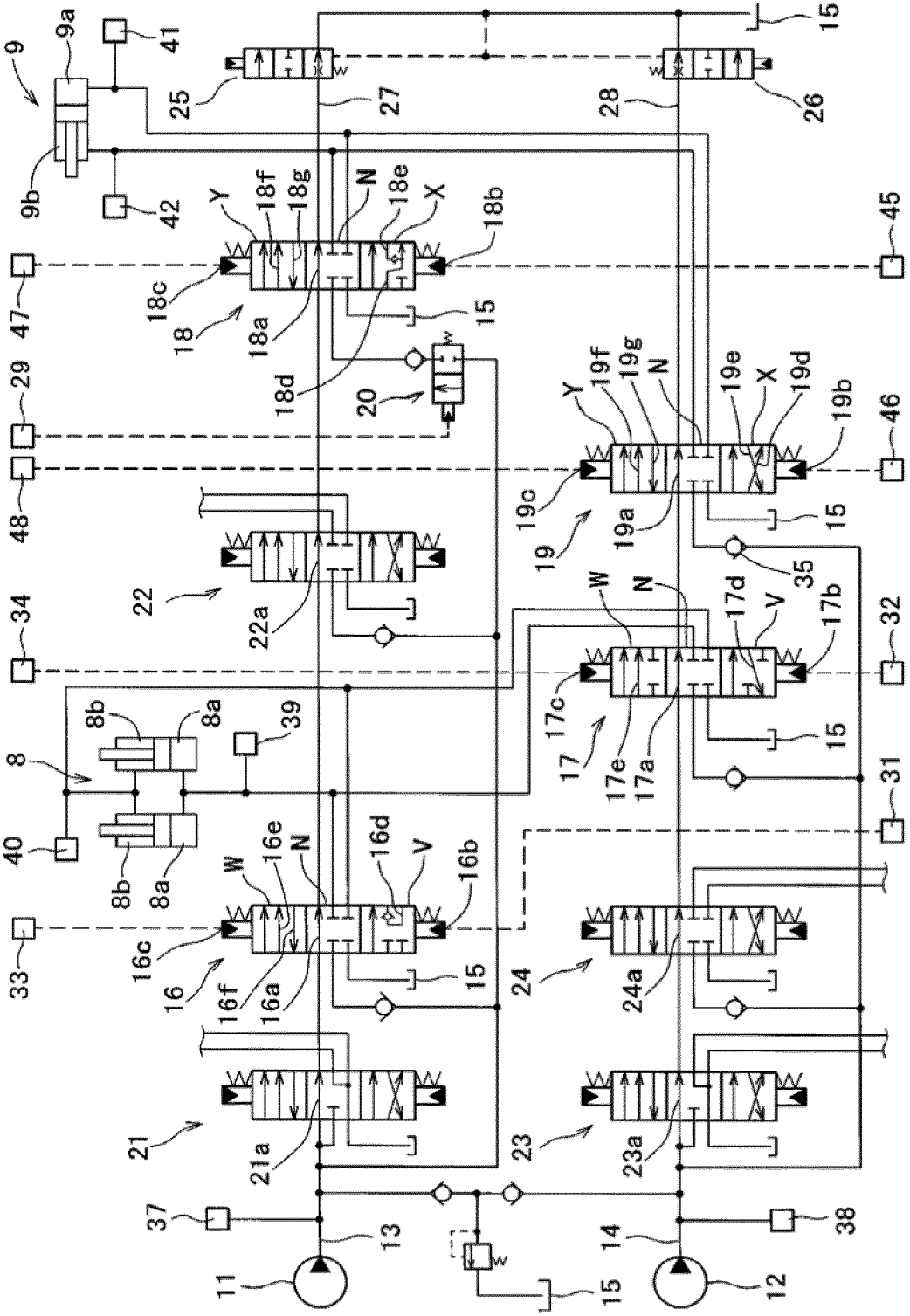


FIG. 1


9
9a
9b
41
42
25
26
27
28
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46
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48
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18d
18e
18f
18g
19
19a
19b
19c
19d
19e
19f
19g
20
22
22a
34
35
32
17
17a
17b
17c
17d
17e
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8a
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16b
16c
16d
16e
16f
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14
11
12
N
X
Y
V
W

FIG. 2

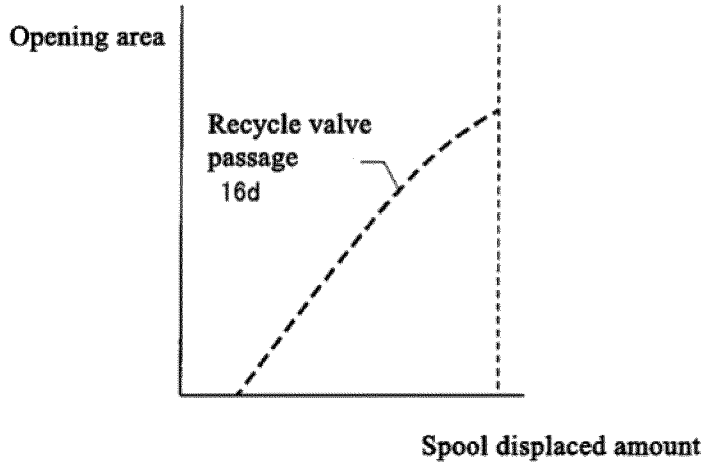
Opening area
Recycle valve passage 16d
Spool displaced amount

FIG. 3A

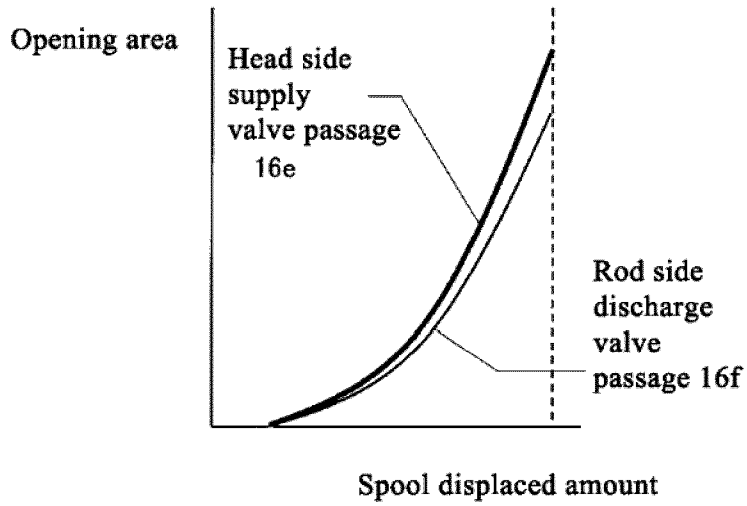
Opening area
Head side supply valve passage 16e
Rod side discharge valve passage 16f
Spool displaced amount

FIG. 3B

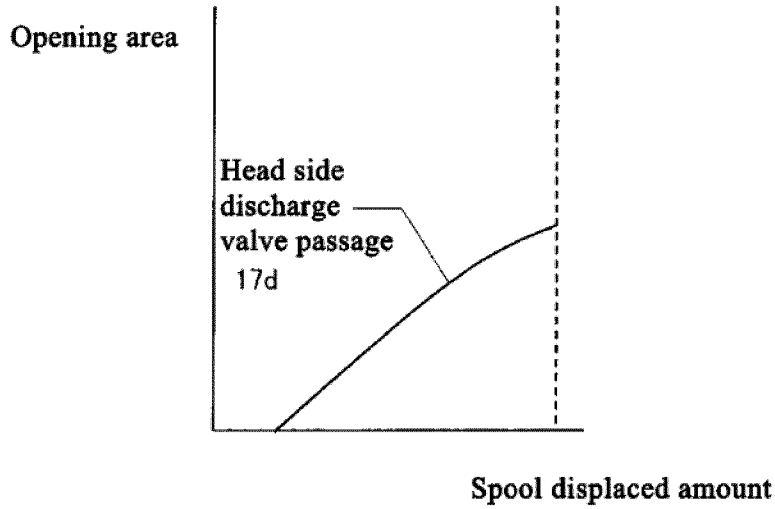
Opening area
Head side
discharge
valve passage
17d
Spool displaced amount

FIG. 3C

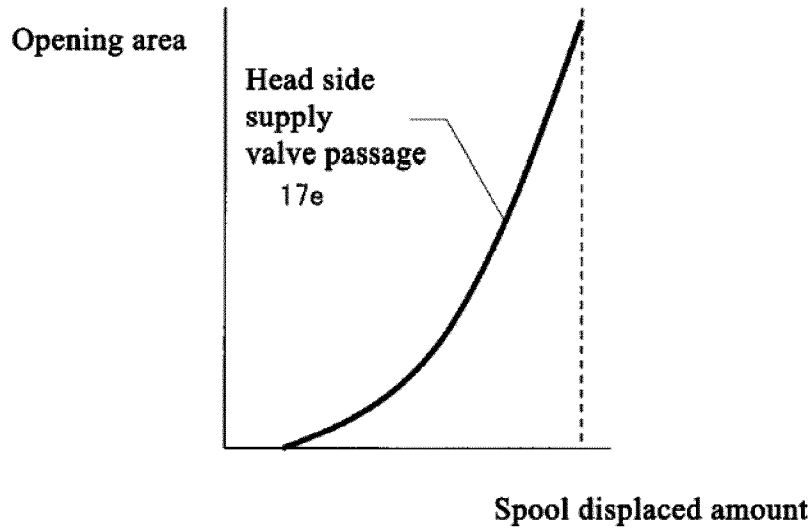
Opening area
Head side
supply
valve passage
17e
Spool displaced amount

FIG. 3D

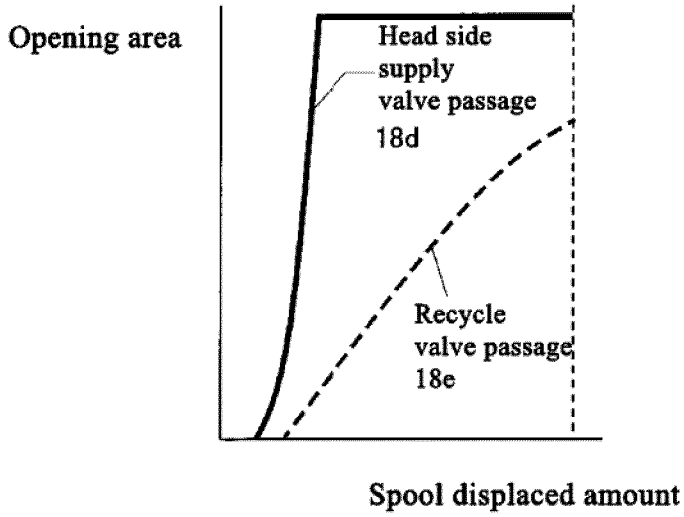
Opening area
Head side supply valve passage 18d
Recycle valve passage 18e
Spool displaced amount

FIG. 4A

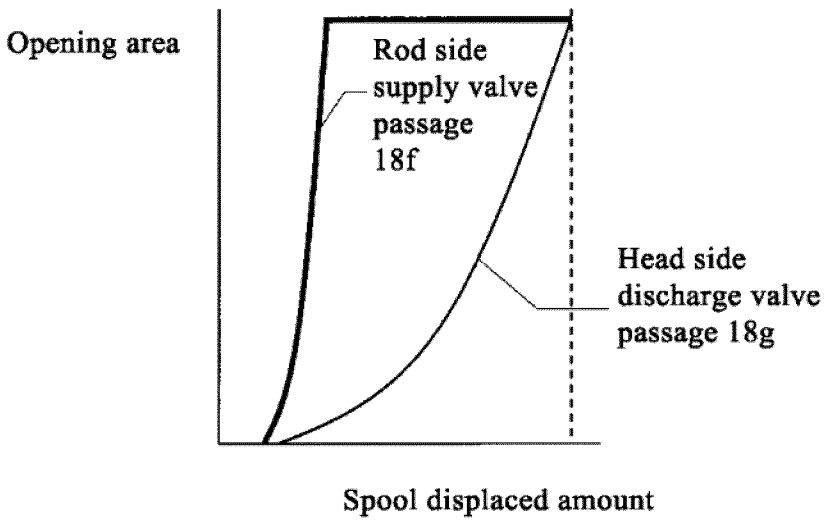
Opening area
Rod side supply valve passage 18f
Head side discharge valve passage 18g
Spool displaced amount

FIG. 4B

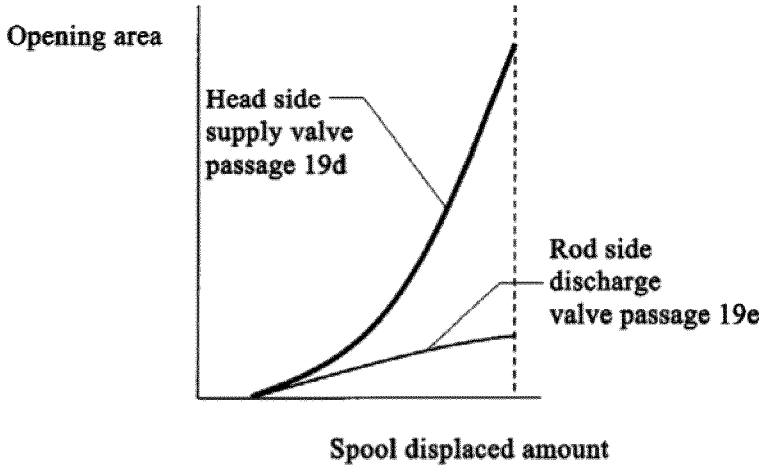
Opening area
Head side
supply valve
passage 19d
Rod side
discharge
valve passage 19e
Spool displaced amount

FIG. 4C

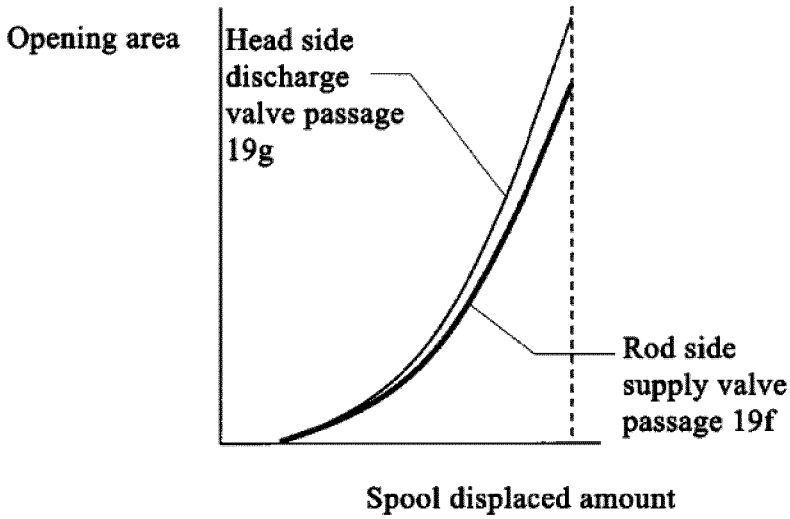
Opening area
Head side
discharge
valve passage
19g
Rod side
supply valve
passage 19f
Spool displaced amount

FIG. 4D

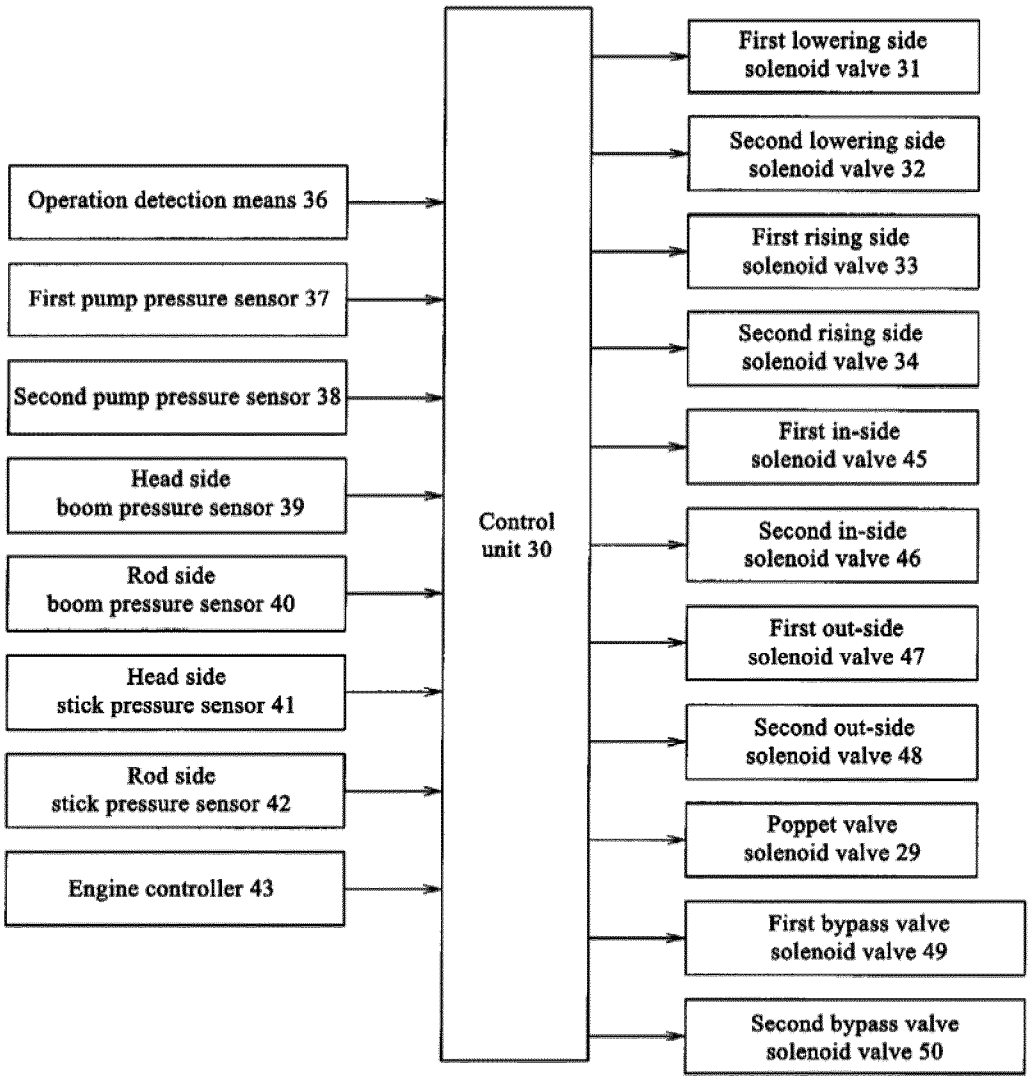
Operation detection means 36
First pump pressure sensor 37
Second pump pressure sensor 38
Head side boom pressure sensor 39
Rod side boom pressure sensor 40
Head side stick pressure sensor 41
Rod side stick pressure sensor 42
Engine controller 43
Control unit 30
First lowering side solenoid valve 31
Second lowering side solenoid valve 32
First rising side solenoid valve 33
Second rising side solenoid valve 34
First in-side solenoid valve 45
Second in-side solenoid valve 46
First out-side solenoid valve 47
Second out-side solenoid valve 48
Poppet valve solenoid valve 29
First bypass valve solenoid valve 49
Second bypass valve solenoid valve 50

FIG. 5

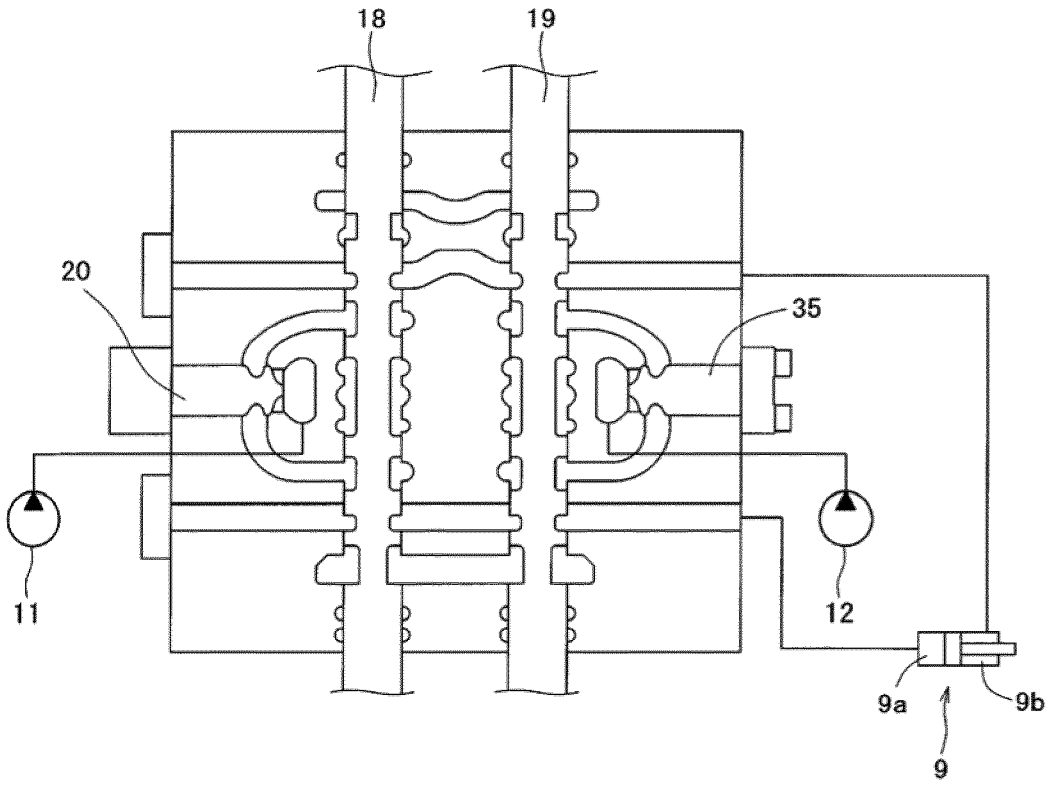

FIG. 6

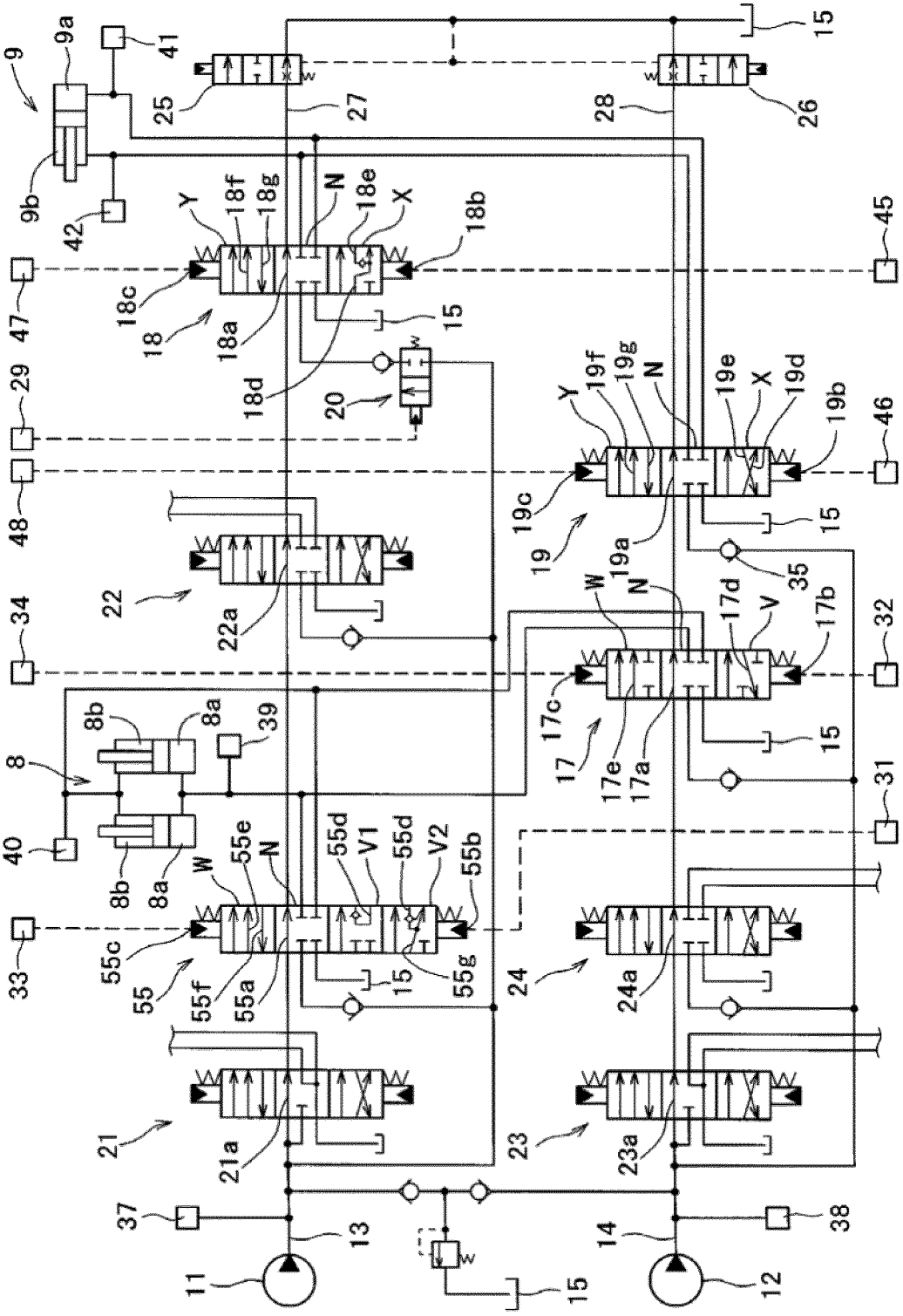
9
9a
9b
41
42
25
27
28
26
15
45
47
18c
18
18a
18d
18f
18g
18e
18b
20
29
48
19c
19
19a
19f
19g
19e
19d
19b
46
22
22a
34
32
17c
17
17e
17a
17d
17b
35
8
8b
8a
39
40
55c
55
55f
55a
55e
55d
V1
V2
55b
55g
33
31
24
24a
21
21a
23
23a
37
38
13
14
11
12

FIG. 7

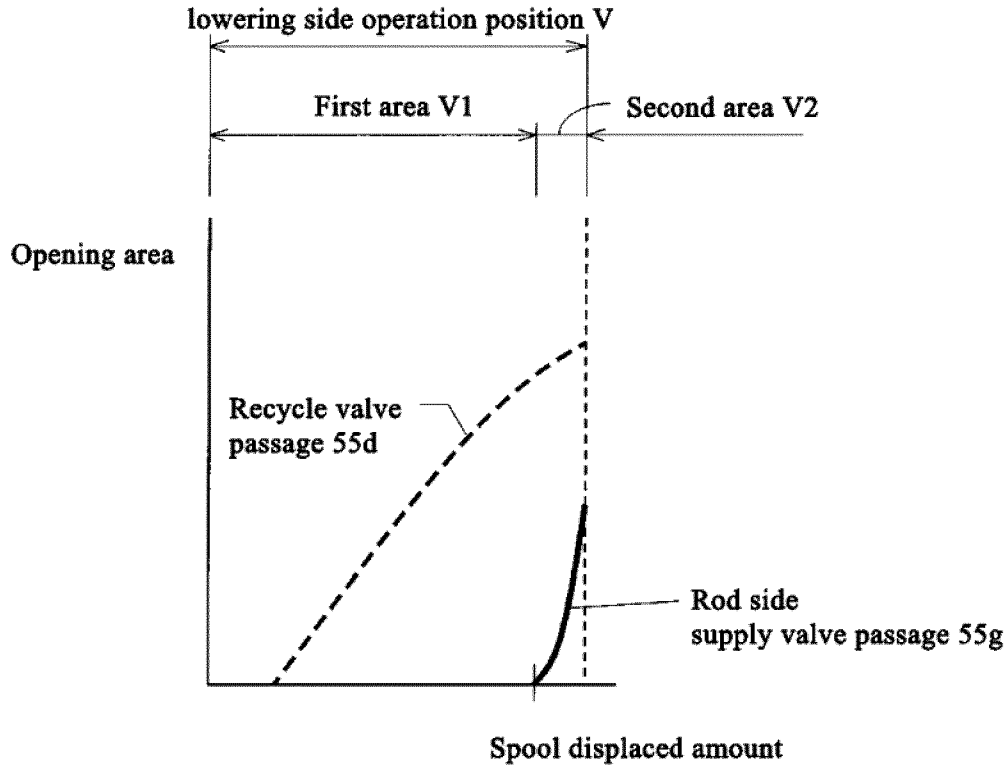
lowering side operation position V
First area V1
Second area V2
Opening area
Recycle valve passage 55d
Rod side supply valve passage 55g
Spool displaced amount

FIG. 8A

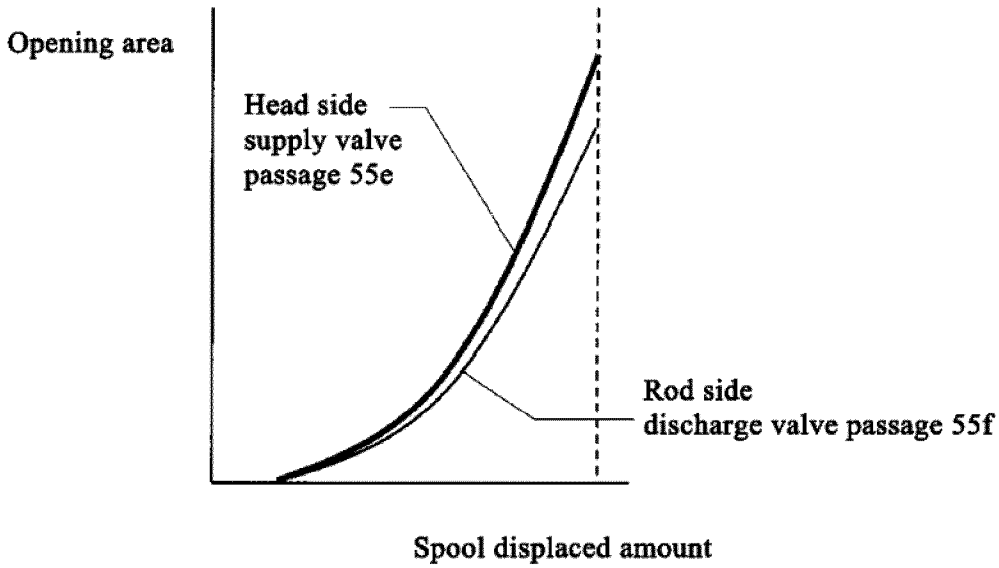
Opening area
Head side supply valve passage 55e
Rod side discharge valve passage 55f
Spool displaced amount

FIG. 8B

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/025455

A. CLASSIFICATION OF SUBJECT MATTER
INV. F15B11/17 E02F9/22 F15B11/024
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F15B E02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 892 535 B2 (VOLVO CONSTR EQUIP HOLDING SE [SE]) 17 May 2005 (2005-05-17) figures 1,3	1-4
A	EP 2 474 746 A1 (HITACHI CONSTRUCTION MACHINERY [JP]) 11 July 2012 (2012-07-11) figures 1-2	1-4
X,P	WO 2018/234339 A1 (CATERPILLAR SARL [CH]) 27 December 2018 (2018-12-27) the whole document	1-4

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
3 March 2020	11/03/2020

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Bindreiff, Romain

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2019/025455

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		WO 2018234339 A1	27-12-2018