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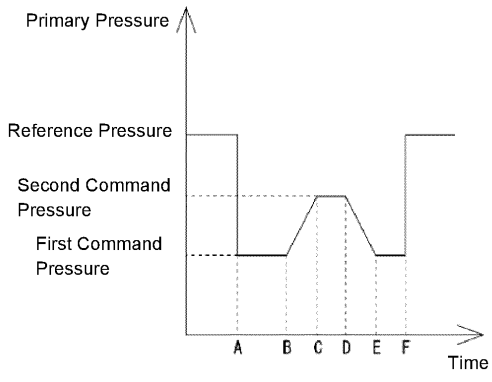
(54) HYDRAULIC CIRCUIT FOR WORK VEHICLE

(57) A hydraulic circuit (100) includes a first actuator (11), a second actuator (12), a hydraulic pump (13), a first direction switching valve (15), a second direction switching valve (16), a pilot pump (14), a first operation device (17), a second operation device (18), an electromagnetic pressure reduction valve (19) that controls a primary pressure of pilot hydraulic oil supplied to the second operation device (18), and an ECU (10). While the first operation device (17) is operated, the ECU (10) transmits, to the electromagnetic pressure reduction valve (19), a first command to reduce the primary pressure from a reference pressure to a first command pressure and keep the first command pressure. When the second operation device (18) is also operated, the ECU (10) transmits, to the electromagnetic pressure reduction valve (19), a second command to gradually increase the primary pressure from the first command pressure to a second command pressure.

Fig. 2



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Description

TECHNICAL FIELD

[0001] The present invention relates to a hydraulic circuit for a work vehicle.

BACKGROUND ART

[0002] In Patent Literature 1 below, in a construction machine that includes a hydraulic control circuit for driving a plurality of hydraulic actuators including a travel actuator, as a technique of preventing a rapid reduction in a travel speed due to a reduction in a flow rate of hydraulic oil that is supplied from a hydraulic pump to the travel actuator at the time of transition from single operation of the travel actuator to combined operation of the travel actuator and another actuator, the following technique is disclosed that return oil of pilot hydraulic oil acting on a pilot pressure receiving section on a return side of a direction switching valve is throttled by a flow rate control valve when the combined operation of the travel actuator and another actuator is performed in the state where the travel actuator is operated and that a rapid reduction in the flow rate of the hydraulic oil supplied to the travel actuator is prevented by slowing an opening speed of a spool and gradually increasing the hydraulic oil amount of the other actuator when a pilot pressure acts on a pilot pressure receiving section on an inlet side of the direction switching valve.

[0003] In Patent Literature 2 below, as a technique for preventing adverse effects such as degraded operability while securing a cushioning function during a sudden operation, in a hydraulic circuit of a construction machine that includes: a pressure reducing valve that supplies, as the pilot pressure, a secondary pressure corresponding to an operation amount to a pilot line to a pilot port of a control valve; and a pilot hydraulic pressure source as a primary pressure source of this pressure reducing valve, a technique of providing, on a primary side of the pressure reducing valve, a first throttle and a bleed-offline that communicates the pilot line with a tank and installing a second throttle in the bleed-offline is disclosed.

CITATION LIST

Patent Literature

[0004]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2005-121155
Patent Literature 2: Japanese Unexamined Patent Application Publication No. 2006-125627

DISCLOSURE OF INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0005] In Patent Literature 1, in order to throttle the return oil, the flow rate control valve is installed in a return oil passage for the pilot hydraulic oil that acts on the pilot pressure receiving section on the return side of the direction switching valve. Thus, there is a problem that the flow rate control valve has to be installed per remote control valve that controls the actuator, the flow rate of which is desired to be controlled, during the combined operation, which increases cost. In Patent Literature 2, the first throttle is arranged on the primary side of the pressure reducing valve to suppress a significant increase in an absolute value of the pilot pressure. Thus, there is no need for arranging means for throttling the pilot hydraulic oil per the pressure receiving section of the direction switching valve. However, since the bleed-offline that includes the second throttle for slowing a rise of the pilot pressure is arranged on the secondary side of the pressure reducing valve, there is a problem that the bleed-offline has to be arranged per pressure receiving section of the direction switching valve, which increases cost.

[0006] In view of the above problems, the present invention has a purpose of providing a hydraulic circuit in an inexpensive configuration for a work vehicle, the hydraulic circuit capable of preventing a shock caused by a rapid reduction in an oil amount that occurs at the time of transition from single operation for driving a single hydraulic actuator to combined operation for driving a plurality of hydraulic actuators in the work vehicle that includes the plurality of hydraulic actuators.

MEANS FOR SOLVING THE PROBLEMS

[0007] A hydraulic circuit for a work vehicle according to the present invention includes: a first actuator; a second actuator; a hydraulic pump that supplies hydraulic oil to the first actuator and the second actuator; a first direction switching valve that switches a direction of and adjusts a flow rate of the hydraulic oil supplied to the first actuator; a second direction switching valve that switches a direction of and adjusts a flow rate of the hydraulic oil supplied to the second actuator; a pilot pump that supplies pilot hydraulic oil to the first direction switching valve and the second direction switching valve; a first operation device capable of switching, according to an operation, a direction and a pressure of the pilot hydraulic oil supplied to the first direction switching valve; a second operation device capable of switching, according to an operation, a direction and a pressure of the pilot hydraulic oil supplied to the second direction switching valve; a pressure control unit that is provided in an oil passage between the second operation device and the pilot pump and controls a primary pressure of the pilot hydraulic oil supplied to the second operation device; and a control command transmitter that transmits a control command

to the pressure control unit.

[0008] While the first operation device is operated, the control command transmitter transmits, to the pressure control unit, a first command to reduce the primary pressure from a reference pressure to a first command pressure and keep the primary pressure at the first command pressure.

[0009] When the second operation device is operated in a state where the first operation device is operated, the control command transmitter transmits, to the pressure control unit, a second command to gradually increase the primary pressure from the first command pressure to the second command pressure.

[0010] In the present invention, control command transmitter may transmit, to the pressure control unit, a command to gradually reduce the primary pressure from the second command pressure to the first command pressure when the second operation device in the state where the first operation device is operated.

[0011] In the present invention, the first actuator may be a first travel hydraulic motor, and the second actuator may be a work hydraulic actuator.

[0012] The present invention may further include: a first circuit system that includes the first travel hydraulic motor and a first hydraulic pump for supplying the hydraulic oil to the first travel hydraulic motor; a second circuit system that includes the work hydraulic actuator, a second travel hydraulic motor, and a second hydraulic pump for supplying the hydraulic oil to the work hydraulic actuator and the second travel hydraulic motor; and a merging switching valve that merges the hydraulic oil of the first circuit system and the hydraulic oil of the second circuit system.

[0013] According to the present invention, at the time of transition from single operation for driving the first actuator only to combined operation for simultaneously driving the first actuator and the second actuator, the pressure of the pilot hydraulic oil that is supplied to the second operation device corresponding to the second actuator is gradually increased from the first command pressure to the second command pressure. Thus, it is possible to prevent a shock caused by a rapid reduction in an oil amount of the hydraulic oil supplied to the first actuator. In addition, only by installing a branch passage leading to the plural operation devices on a downstream side of the pressure control unit, the control of the present invention can be adopted for the plural actuators. Therefore, it is possible to provide the hydraulic circuit with the inexpensive configuration.

BRIEF DESCRIPTION OF DRAWINGS

[0014]

FIG. 1 is a view illustrating a hydraulic circuit in a work vehicle according to a first embodiment.

FIG. 2 is a graph illustrating a situation where a primary pressure of pilot hydraulic oil that is supplied to a second remote control valve is controlled.

FIG. 3 is a side view illustrating a work vehicle according to a second embodiment.

FIG. 4 is a view illustrating a hydraulic circuit in the work vehicle according to the second embodiment.

DESCRIPTION OF EMBODIMENTS

[0015] A description will hereinafter be made on embodiments of the present invention with reference to the drawings.

<First Embodiment>

[0016] FIG. 1 illustrates a hydraulic circuit 100 according to a first embodiment. The hydraulic circuit 100 includes a first actuator 11, a second actuator 12, a hydraulic pump 13, a pilot pump 14, a first direction switching valve 15, a second direction switching valve 16, a first operation device 17, and a second operation device 18.

[0017] The first actuator 11 is a hydraulic motor that is driven by hydraulic oil supplied from the hydraulic pump 13. The second actuator 12 is a hydraulic cylinder that is driven by the hydraulic oil supplied from the hydraulic pump 13. However, the first actuator 11 may be a hydraulic cylinder, and the second actuator 12 may be a hydraulic motor.

[0018] The hydraulic pump 13 is driven by an engine, which is not illustrated, to discharge the hydraulic oil. The hydraulic oil discharged from the hydraulic pump 13 is supplied to the first direction switching valve 15 and the second direction switching valve 16 via an oil passage 13a and an oil passage 13b. In FIG. 1, oil passages of the hydraulic oil that is supplied from the hydraulic pump 13 to the first actuator 11 and the second actuator 12 are indicated by solid lines.

[0019] The first direction switching valve 15 is a direction switching valve of a pilot type capable of adjusting a flow rate of the hydraulic oil by switching a direction of the hydraulic oil supplied to the first actuator 11. The second direction switching valve 16 is a direction switching valve of the pilot type capable of adjusting the flow rate of the hydraulic oil by switching a direction of the hydraulic oil supplied to the second actuator 12.

[0020] The pilot pump 14 discharges the pilot hydraulic oil as a command input to the first direction switching valve 15 and the second direction switching valve 16. In FIG. 1, oil passages of the pilot hydraulic oil that is supplied from the pilot pump 14 to the first direction switching valve 15 and the second direction switching valve 16 are indicated by broken lines. The pilot pump 14 generates a pilot pressure to be applied to the first direction switching valve 15 and the second direction switching valve 16. The pilot pump 14 is driven by the engine, which is not illustrated, and discharges the hydraulic oil so as to generate the pilot pressure in an oil passage 14a. The oil passage 14a is branched into oil passages 14b, 14c, 14d, 14e.

[0021] The first direction switching valve 15 can be switched to any of plural positions by sliding a spool. In the case where the pilot pressure is applied to none of a pilot port 15a and a pilot port 15b of the first direction switching valve 15, an urging force of a spring keeps the first direction switching valve 15 at a neutral position. In the case where the first direction switching valve 15 is at the neutral position, the hydraulic oil is not supplied from the oil passage 13b to the first actuator 11.

[0022] Meanwhile, in the case where the pilot pressure is applied to the pilot port 15a or the pilot port 15b of the first direction switching valve 15, the first direction switching valve 15 is switched from the neutral position to another position, and the hydraulic oil is supplied to the first actuator 11 via an oil passage 11a or an oil passage 11b. With the hydraulic oil that is supplied via the oil passage 11a or the oil passage 11b, the first actuator 11 is rotationally driven in a positive direction or a reverse direction.

[0023] The second direction switching valve 16 can be switched to any of plural positions by sliding a spool. In the case where the pilot pressure is applied to none of a pilot port 16a and a pilot port 16b of the second direction switching valve 16, an urging force of a spring keeps the second direction switching valve 16 at a neutral position. In the case where the second direction switching valve 16 is at the neutral position, the hydraulic oil is not supplied from the oil passage 13a to the second actuator 12.

[0024] Meanwhile, in the case where the pilot pressure is applied to the pilot port 16a or the pilot port 16b of the second direction switching valve 16, the second direction switching valve 16 is switched from the neutral position to another position, and the hydraulic oil is supplied to the second actuator 12 via an oil passage 12a or an oil passage 12b. With the hydraulic oil that is supplied via the oil passage 12a or the oil passage 12b, the second actuator 12 is contracted.

[0025] The first direction switching valve 15 includes a first detection direction switching valve 15c therein. The first detection direction switching valve 15c can be switched to any of plural positions by sliding a spool. In the case where the first direction switching valve 15 is kept at a neutral position, the first detection direction switching valve 15c is also kept at a neutral position. In the case where the first direction switching valve 15 is switched from the neutral position to another position, in conjunction therewith, the first detection direction switching valve 15c is also switched from the neutral position to another position.

[0026] In the case where the first detection direction switching valve 15c is at the neutral position, the first detection direction switching valve 15c does not close the oil passage 14b. Accordingly, the hydraulic oil can flow through the oil passage 14b via the first detection direction switching valve 15c. Meanwhile, in the case where the first detection direction switching valve 15c is at the position other than the neutral position, the first detection direction switching valve 15c closes the oil passage 14b.

[0027] A first pressure switch 141 is connected to the oil passage 14b. It is configured that, when the first operation device 17 is operated to move the first detection direction switching valve 15c from the neutral position to the position other than the neutral position, the oil passage 14b is closed, the pressure is generated in a throttle downstream portion of the oil passage 14b, and this pressure is detected by the first pressure switch 141. The first pressure switch 141 detects the operation of the first operation device 17 and outputs this detection signal to an engine control unit (ECU) 10, which will be described below.

[0028] The second direction switching valve 16 includes a second detection direction switching valve 16c therein. The second detection direction switching valve 16c can be switched to any of plural positions by sliding a spool. In the case where the second direction switching valve 16 is kept at a neutral position, the second detection direction switching valve 16c is also kept at a neutral position. In the case where the second direction switching valve 16 is switched from the neutral position to another position, in conjunction therewith, the second detection direction switching valve 16c is also switched from the neutral position to another position.

[0029] In the case where the second detection direction switching valve 16c is at the neutral position, the second detection direction switching valve 16c does not close the oil passage 14c. Accordingly, the hydraulic oil can flow through the oil passage 14c via the second detection direction switching valve 16c. Meanwhile, in the case where the second detection direction switching valve 16c is at the position other than the neutral position, the second detection direction switching valve 16c closes the oil passage 14c.

[0030] A second pressure switch 142 is connected to the oil passage 14c. It is configured that, when the second operation device 18 is operated to move the second detection direction switching valve 16c from the neutral position to the position other than the neutral position, the oil passage 14c is closed, the pressure is generated in a throttle downstream portion of the oil passage 14c, and this pressure is detected by the second pressure switch 142. The second pressure switch 142 detects the operation of the second operation device 18 and outputs this detection signal to the ECU 10, which will be described below.

[0031] The first operation device 17 has a first remote control valve 170 for switching a direction and the pressure of the pilot hydraulic oil to be supplied to the first direction switching valve 15. The first remote control valve 170 is connected to the oil passage 14d. The first remote control valve 170 is also connected to the pilot port 15a and the pilot port 15b of the first direction switching valve 15 via an oil passage 17a and an oil passage 17b, respectively. The first remote control valve 170 supplies, as the pilot hydraulic oil, the hydraulic oil that is supplied from the pilot pump 14 via the oil passage 14d to the first direction switching valve 15. By operating the

first operation device 17, the position of the first direction switching valve 15 is switched, the direction of the hydraulic oil to be supplied to the first actuator 11 is switched, and the flow rate of the hydraulic oil can thereby be adjusted.

[0032] The second operation device 18 has a second remote control valve 180 for switching a direction and the pressure of the pilot hydraulic oil to be supplied to the second direction switching valve 16. The second remote control valve 180 is connected to the oil passage 14e. The second remote control valve 180 is also connected to the pilot port 16a and the pilot port 16b of the second direction switching valve 16 via an oil passage 18a and an oil passage 18b, respectively. The second remote control valve 180 supplies, as the pilot hydraulic oil, the hydraulic oil that is supplied from the pilot pump 14 via the oil passage 14e to the second direction switching valve 16. By operating the second operation device 18, the position of the second direction switching valve 16 is switched, the direction of the hydraulic oil to be supplied to the second actuator 12 is switched, and the flow rate of the hydraulic oil can thereby be adjusted.

[0033] An electromagnetic pressure reduction valve 19 (an example of the pressure control unit) is provided in the oil passage 14e between the second remote control valve 180 and the pilot pump 14. The electromagnetic pressure reduction valve 19 can control a primary pressure of the pilot hydraulic oil that is discharged from the pilot pump 14 and supplied to the second remote control valve 180. The electromagnetic pressure reduction valve 19 can control the pressure according to a magnitude of an input current.

[0034] The hydraulic circuit 100 includes the ECU 10 (an example of the control command transmitter) that transmits a control command to the electromagnetic pressure reduction valve 19. The ECU 10 transmits the control command according to the operations of the first operation device 17 and the second operation device 18. When receiving the detection signal from the first pressure switch 141, the ECU 10 determines that the first operation device 17 is operated. When receiving the detection signal from the second pressure switch 142, the ECU 10 determines that the second operation device 18 is operated.

[0035] Next, a description will be made on control of the electromagnetic pressure reduction valve 19 by the ECU 10 with reference to FIG. 2. FIG. 2 is a graph illustrating a situation where the primary pressure of the pilot hydraulic oil that is supplied to the second remote control valve 180 is controlled.

[0036] When the first operation device 17 starts being operated (at time A in FIG. 2), the ECU 10 reduces the primary pressure of the pilot hydraulic oil for the electromagnetic pressure reduction valve 19 from a reference pressure to a first command pressure. Then, while the first operation device 17 is operated (the time A to B in FIG. 2), the ECU 10 transmits a first command to the electromagnetic pressure reduction valve 19 so as to keep the primary pressure of the pilot hydraulic oil at the first command pressure. The reference pressure is a pressure of the hydraulic oil that is discharged from the pilot pump 14.

[0037] Next, when the second operation device 18 is operated in a state where the first operation device 17 is operated (the time B in FIG. 2), the ECU 10 transmits, to the electromagnetic pressure reduction valve 19, a second command to gradually increase the primary pressure of the pilot hydraulic oil from the first command pressure to a second command pressure. The second command pressure is higher than the first command pressure and is lower than the reference pressure. Ratios of the reference pressure, the first command pressure, and the second command pressure are appropriately set. A period (the time B to C in FIG. 2) in which the primary pressure is gradually increased from the first command pressure to the second command pressure is also appropriately set.

[0038] Thereafter, while the first operation device 17 and the second operation device 18 are operated (the time C to D in FIG. 2), a command is transmitted to the electromagnetic pressure reduction valve 19 to keep the primary pressure of the pilot hydraulic oil at the second command pressure. In this way, at the time of transition from single operation for driving the first actuator 11 only to combined operation for simultaneously driving the first actuator 11 and the second actuator 12, the pilot pressure to be supplied to the second direction switching valve 16 via the second remote control valve 180 is gradually increased from the first command pressure to the second command pressure via the second remote control valve 180. As a result, the hydraulic oil from the hydraulic pump 13 is not rapidly supplied to the second actuator 12, and thus a shock caused by a rapid reduction in an oil amount of the hydraulic oil that is supplied to the first actuator 11 can be prevented.

[0039] Next, when the second operation device 18 is no longer operated in the state where the first operation device 17 is operated (the time D in FIG. 2), the ECU 10 transmits, to the electromagnetic pressure reduction valve 19, a command to gradually reduce the primary pressure of the pilot hydraulic oil from the second command pressure to the first command pressure. Thereafter, while only the first operation device 17 is operated (time E to F in FIG. 2), the ECU 10 transmits, to the electromagnetic pressure reduction valve 19, a command to keep the primary pressure of the pilot hydraulic oil at the first command pressure.

[0040] Furthermore, when the first operation device 17 is no longer operated (the time F in FIG. 2), the ECU 10 transmits, to the electromagnetic pressure reduction valve 19, a command to increase the primary pressure from the pilot pump 14 to a reference value and keep the primary pressure at the reference value.

<Second Embodiment>

[Structure of Work Vehicle]

[0041] First, a description will be made on a schematic structure of a hydraulic shovel 1 as an example of a work vehicle with reference to FIG. 3. However, the work vehicle is not limited to the hydraulic shovel 1 and may be another vehicle such as a wheel loader. The hydraulic shovel 1 includes a traveling device 2, a work device 3, and a turning device 4.

[0042] The traveling device 2 is driven by receiving power from an engine 42 and drives the hydraulic shovel 1. The traveling device 2 includes a left and right pair of crawlers 21, 21 and a left and right pair of travel motors 22L, 22R. When the left and right travel motors 22L, 22R as hydraulic motors respectively drive the left and right crawlers 21, 21, the hydraulic shovel 1 can travel forward and backward. The traveling device 2 is also provided with a blade 23 and a blade cylinder 24 that is a hydraulic actuator for rotating the blade 23 in a vertical direction.

[0043] The work device 3 is driven by receiving the power from the engine 42 to excavate gravel or the like. The work device 3 includes a boom 31, an arm 32, and a bucket 33 and independently drives these components to enable excavation work. The boom 31, arm 32, and the bucket 33 each correspond to the working section, and the hydraulic shovel 1 has plural working sections.

[0044] One end of the boom 31 is supported by a front portion of the turning device 4, and the boom 31 is rotated by a boom cylinder 31a that is movable in a freely extendable/contractable manner. One end of the arm 32 is supported by the other end of the boom 31, and the arm 32 is rotated by an arm cylinder 32a that is movable in a freely extendable/contractable manner. One end of the bucket 33 is supported by the other end of the arm 32, and the bucket 33 is rotated by a bucket cylinder 33a that is movable in a freely extendable/contractable manner. The boom cylinder 31a, the arm cylinder 32a, and the bucket cylinder 33a correspond to the hydraulic actuator that drives the working section.

[0045] The turning device 4 turns the work device 3. The turning device 4 includes an operation section 41, the engine 42, a turntable 43, a turning motor 44, and the like. The turning motor 44 as a hydraulic motor drives the turntable 43 and thereby turns the work device 3. In addition, plural hydraulic pumps (not illustrated in FIG. 3) that are driven by the engine 42 are disposed in the turning device 4. These hydraulic pumps supply the hydraulic oil to the boom cylinder 31a, the arm cylinder 32a, the bucket cylinder 33a, and the like.

[0046] An operator seat 411 is arranged in the operation section 41. A left and right pair of work operation levers 412L, 412R is arranged on left and right sides of the operator seat 411, and a pair of travel levers 413L, 413R is arranged in front of the operator seat 411. When an operator is seated on the operator seat 411 and operates the work operation levers 412L, 412R, the travel levers 413L, 413R, or the like to control the engine 42, each of the hydraulic motors, each of the hydraulic actuators, or the like, the operator can travel the hydraulic shovel 1, turn the hydraulic shovel 1, perform the work using the hydraulic shovel 1, and the like.

[Structure of Hydraulic Circuit]

[0047] A description will be made on a hydraulic circuit 5 provided in the hydraulic shovel 1 with reference to FIG. 4. The hydraulic circuit 5 has: first to third hydraulic actuators 121, 122, 123 (the boom cylinder 31a, the arm cylinder 32a, and the bucket cylinder 33a), the left travel motor 22L, the right travel motor 22R, the turning motor 44, a first hydraulic pump 51, a second hydraulic pump 52, a direction switching valve 53, a pilot pump 54, and a remote control valve 55. In FIG. 4, a circuit related to the blade cylinder 24 and the like is not illustrated for convenience of the description.

[0048] In a second embodiment, the first hydraulic pump 51 primarily supplies the hydraulic oil to the right travel motor 22R, the third hydraulic actuator 123, and the turning motor 44. The second hydraulic pump 52 primarily supplies the hydraulic oil to the first hydraulic actuator 121, the second hydraulic actuator 122, and the left travel motor 22L.

[0049] The direction switching valve 53 is provided in a manner to correspond to each of the hydraulic actuators and is configured to be able to switch the direction and the flow rate of the hydraulic oil that is supplied from the first hydraulic pump 51 or the second hydraulic pump 52 to each of the hydraulic actuators. The plural direction switching valves 53 will collectively be referred to as control valves. More specifically, in the second embodiment, a direction switching valve 53a for a first hydraulic actuator corresponding to the first hydraulic actuator 121, a direction switching valve 53b for a second hydraulic actuator corresponding to the second hydraulic actuator 122, a direction switching valve 53c for a left travel motor corresponding to the left travel motor 22L, a direction switching valve 53d for a right travel motor corresponding to the right travel motor 22R, a direction switching valve 53e for a third hydraulic actuator corresponding to the third hydraulic actuator 123, and a turning direction switching valve 53f corresponding to the turning motor 44 are provided. A structure of each of the direction switching valves 53 is the same as the first direction switching valve 15 or the second direction switching valve 16 in the first embodiment, and thus a detailed description thereon will not be made.

[0050] Each of the direction switching valves 53 includes a detection direction switching valve therein. The detection direction switching valve provided in each of the direction switching valve 53c for the left travel motor and the direction switching valve 53d for the right travel motor closes or opens an oil passage 54a from the pilot pump 54. Meanwhile, the detection direction switching valve provided in each of the direction switching valve

53a for the first hydraulic actuator, the direction switching valve 53b for the second hydraulic actuator, the direction switching valve 53e for the third hydraulic actuator, and the turning direction switching valve 53f closes or opens an oil passage 54b from the pilot pump 54. A structure of each of the detection direction switching valves is the same as that of the first detection direction switching valve 15c or the second detection direction switching valve 16c in the first embodiment, and thus a detailed description thereon will not be made.

[0051] The first pressure switch 141 is connected to the oil passage 54a. When the travel levers 413L, 413R are operated to move the detection direction switching valve of the direction switching valve 53c for the left travel motor or the direction switching valve 53d for the right travel motor from a neutral position to a position other than the neutral position, the oil passage 54a is closed, the pressure is generated in a throttle downstream portion of the oil passage 54a, and this pressure is detected by the first pressure switch 141. The first pressure switch 141 detects the operations of the travel levers 413L, 413R and outputs this detection signal to the ECU 10.

[0052] The second pressure switch 142 is connected to the oil passage 54b. When the work operation lever 412R is operated to move the detection direction switching valve of the direction switching valve 53a for the first hydraulic actuator from a neutral position to a position other than the neutral position, the oil passage 54b is closed, the pressure is generated in a throttle downstream portion of the oil passage 54b, and this pressure is detected by the second pressure switch 142. The second pressure switch 142 detects the operation of the work operation lever 412R and outputs this detection signal to the ECU 10.

[0053] The pilot pump 54 discharges the pilot hydraulic oil as a command input to the direction switching valves 53 (53a, 53b, 53c, 53d, 53e, 53f). In FIG. 4, the oil passage between the pilot pump 54 and the direction switching valve 53 is not partially illustrated.

[0054] The remote control valve 55 is configured to be able to switch and adjust the direction of the pilot hydraulic oil that flows into the direction switching valves 53 according to the operations of the work operation levers 412L, 412R and the travel levers 413L, 413R. The remote control valve 55 is provided for each of the hydraulic actuators and each of the corresponding direction switching valves 53. For example, as illustrated in FIG. 4, a remote control valve 55a for the first hydraulic actuator that corresponds to the work operation lever 412R for contracting the first hydraulic actuator 121 is provided, and the remote control valve 55a for the first hydraulic actuator switches the direction of the pilot hydraulic oil as the command that is supplied to the direction switching valve 53a for the first hydraulic actuator. Meanwhile, a remote control valve 55b for the left travel motor that corresponds to the travel lever 413L for rotating the left travel motor 22L is provided, and the remote control valve 55b for the left travel motor switches the direction of the pilot hydraulic oil as the command that is supplied to the direction switching valve 53c for the left travel motor. Similarly, a remote control valve 55c for the right travel motor that corresponds to the travel lever 413R for rotating the right travel motor 22R is provided, and the remote control valve 55c for the right travel motor switches the direction of the pilot hydraulic oil as the command that is supplied to the direction switching valve 53d for the right travel motor. Although not illustrated in FIG. 4, the remote control valves 55 corresponding to the other direction switching valves 53d, 53e, 53f are provided.

[0055] The electromagnetic pressure reduction valve 19 is provided in an oil passage between the remote control valve 55a for the first hydraulic actuator and the pilot pump 54. The electromagnetic pressure reduction valve 19 can control the primary pressure of the pilot hydraulic oil that is discharged from the pilot pump 14 and is supplied to the remote control valve 55a for the first hydraulic actuator.

[0056] The hydraulic circuit 5 includes the ECU 10 that transmits the control command to the electromagnetic pressure reduction valve 19. The ECU 10 transmits the control command according to the operation of each of the work operation levers 412L, 412R and the travel levers 413L, 413R.

[0057] The hydraulic circuit 5 includes a merging switching valve 56. The merging switching valve 56 is a direction switching valve of the pilot type capable of merging the hydraulic oil discharged from the first hydraulic pump 51 and the second hydraulic pump 52. The merging switching valve 56 can be switched to a position 56X or the position 56Y by sliding a spool. In the case where the pilot pressure is applied to a pilot port 56a and a pilot port 56b of the merging switching valve 56, the merging switching valve 56 is switched to the position 56Y. In the case where the pilot pressure is not applied to the pilot port 56a or the pilot port 56b of the merging switching valve 56, an urging force of a spring keeps the merging switching valve 56 at the position 56X. An oil passage from the remote control valve 55c for the right travel motor is connected to the pilot port 56a, and an oil passage from the remote control valve 55b for the left travel motor is connected to the pilot port 56b. As a result, when the left and right travel levers 413L, 413R are simultaneously operated, that is, a travel operation is performed, the merging switching valve 56 is switched to the position 56Y.

[0058] In the case where the merging switching valve 56 is at the position 56X, the hydraulic oil discharged from the first hydraulic pump 51 and the hydraulic oil discharged from the second hydraulic pump 52 flow separately without being merged, the hydraulic oil discharged from the first hydraulic pump 51 is supplied to the direction switching valve 53d for the right travel motor, the direction switching valve 53e for the third hydraulic actuator, and the turning direction switching valve 53f, and the hydraulic oil discharged from the second hydraulic pump 52 is supplied to the direction switching valve 53a

for the first hydraulic actuator, the direction switching valve 53b for the second hydraulic actuator, and the direction switching valve 53c for the left travel motor.

[0059] In the case where the merging switching valve 56 is at the position 56Y, the hydraulic oil discharged from the first hydraulic pump 51 and the hydraulic oil discharged from the second hydraulic pump 52 are merged.

[0060] When the travel levers 413L, 413R are operated, the ECU 10 reduces the primary pressure of the pilot hydraulic oil for the electromagnetic pressure reduction valve 19 from the reference pressure to the first command pressure. While the travel levers 413L, 413R are operated, the ECU 10 transmits, to the electromagnetic pressure reduction valve 19, the first command to keep the primary pressure of the pilot hydraulic oil at the first command pressure.

[0061] Next, when the work operation lever 412R is operated in the state where the travel levers 413L, 413R are operated, the ECU 10 transmits, to the electromagnetic pressure reduction valve 19, the second command to gradually increase the primary pressure of the pilot pressure oil from the first command pressure to the second command pressure. Thereafter, while the travel levers 413L, 413R and the work operation lever 412R are operated, a command is transmitted to the electromagnetic pressure reduction valve 19 to keep the primary pressure of the pilot hydraulic oil at the second command pressure. In this way, when the first hydraulic actuator 121 is driven during travel, the pilot pressure that is applied to the direction switching valve 53a for the first hydraulic actuator is gradually increased from the first command pressure to the second command pressure. As a result, the hydraulic oil from the first hydraulic pump 51 and the second hydraulic pump 52 is not rapidly supplied to the first hydraulic actuator 121, and thus it is possible to prevent a rapid reduction in a travel speed caused by the rapid reduction in the oil amount of the hydraulic oil supplied to the travel motors 22L, 22R. In addition, in the second embodiment, the hydraulic oil discharged from the first hydraulic pump 51 and the hydraulic oil discharged from the second hydraulic pump 52 are merged by the merging switching valve 56 during the travel. Thus, it is possible to effectively prevent the rapid reduction in the oil amount of the hydraulic oil supplied to the travel motors 22L, 22R.

[0062] Next, when the work operation lever 412R is no longer operated in the state where the travel levers 413L, 413R are operated, the ECU 10 transmits, to the electromagnetic pressure reduction valve 19, the command to gradually reduce the primary pressure of the pilot hydraulic oil from the second command pressure to the first command pressure. Thereafter, while only the travel levers 413L, 413R are operated, the ECU 10 transmits, to the electromagnetic pressure reduction valve 19, the command to keep the primary pressure of the pilot hydraulic oil at the first command pressure.

[0063] Furthermore, when the travel levers 413L, 413R are no longer operated, the ECU 10 transmits, to the electromagnetic pressure reduction valve 19, a command to increase the primary pressure from the pilot pump 54 to a reference value from a first command value and keep the primary pressure at the reference value.

[0064] In the second embodiment, only by installing a branch passage leading to the plural operation devices on the downstream side of the electromagnetic pressure reduction valve 19, the control of the present invention can be adopted for the plural actuators corresponding to the plural operation devices. Thus, there is no need to provide plural electromagnetic proportional valves, each of which controls a secondary pressure of respective one of the operation devices. Therefore, it is possible to provide the hydraulic circuit with the inexpensive configuration.

[0065] The description has been made so far on the embodiments of the present invention with reference to the drawings. However, it should be considered that the specific configuration is not limited to that described in each of these embodiments. The scope of the present invention is indicated not only by the description of the above embodiments but also by the claims and further includes all modifications that fall within and are equivalent to the scope of the claims.

DESCRIPTION OF REFERENCE NUMERALS

[0066]

100	hydraulic circuit
10	ECU
11	first actuator
12	second actuator
13	hydraulic pump
14	pilot pump
15	first direction switching valve
16	second direction switching valve
17	first operation device
18	second operation device
19	electromagnetic pressure reduction valve
5	hydraulic circuit
51	first hydraulic pump
52	second hydraulic pump
53	direction switching valve
54	pilot pump
55	remote control valve
56	merging switching valve

Claims

1. A hydraulic circuit for a work vehicle comprising:

a first actuator;
a second actuator;
a hydraulic pump that supplies hydraulic oil to the first actuator and the second actuator;
a first direction switching valve that switches a

direction of and adjusts a flow rate of the hydraulic oil supplied to the first actuator;
a second direction switching valve that switches a direction of and adjusts a flow rate of the hydraulic oil supplied to the second actuator;
a pilot pump that supplies pilot hydraulic oil to the first direction switching valve and the second direction switching valve;
a first operation device capable of switching, according to an operation, a direction and a pressure of the pilot hydraulic oil supplied to the first direction switching valve;
a second operation device capable of switching, according to an operation, a direction and a pressure of the pilot hydraulic oil supplied to the second direction switching valve;
a pressure control unit that is provided in an oil passage between the second operation device and the pilot pump and controls a primary pressure of the pilot hydraulic oil supplied to the second operation device; and
a control command transmitter that transmits a control command to the pressure control unit, wherein
while the first operation device is operated, the control command transmitter transmits, to the pressure control unit, a first command to reduce the primary pressure from a reference pressure to a first command pressure and keep the primary pressure at the first command pressure, and
when the second operation device is operated in a state where the first operation device is operated, the control command transmitter transmits, to the pressure control unit, a second command to gradually increase the primary pressure from the first command pressure to the second command pressure.

2. The hydraulic circuit for a work vehicle according to claim 1, wherein
when the second operation device is no longer operated in the state where the first operation device is operated, the control command transmitter transmits, to the pressure control unit, a command to gradually reduce the primary pressure from the second command pressure to the first command pressure.

3. The hydraulic circuit for a work vehicle according to claim 1 or 2, wherein
the first actuator is a first travel hydraulic motor, and the second actuator is a work hydraulic actuator.

4. The hydraulic circuit for a work vehicle according to claim 3 further comprising:

a first circuit system that includes the first travel hydraulic motor and a first hydraulic pump for supplying the hydraulic oil to the first travel hydraulic motor;
a second circuit system that includes the work hydraulic actuator, a second travel hydraulic motor, and a second hydraulic pump for supplying the hydraulic oil to the work hydraulic actuator and the second travel hydraulic motor; and
a merging switching valve that merges the hydraulic oil of the first circuit system and the hydraulic oil of the second circuit system.

Fig. 1

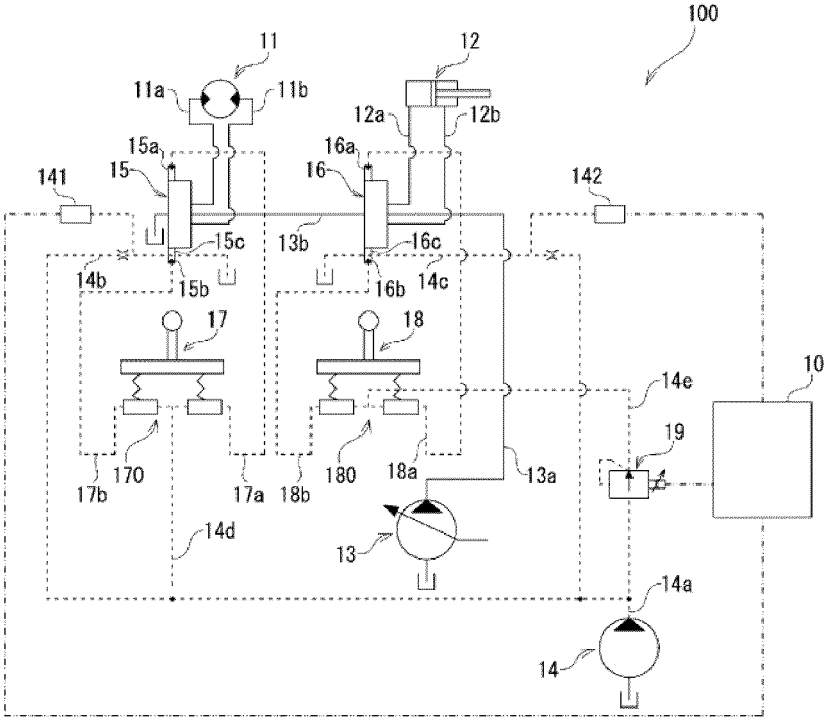

100
11
12
11a
11b
12a
12b
15a
16a
15
16
141
142
13b
15c
16c
14b
15b
16b
14c
17
18
10
14e
19
17b
170
17a
18b
180
18a
13a
14d
13
14a
14

Fig. 2

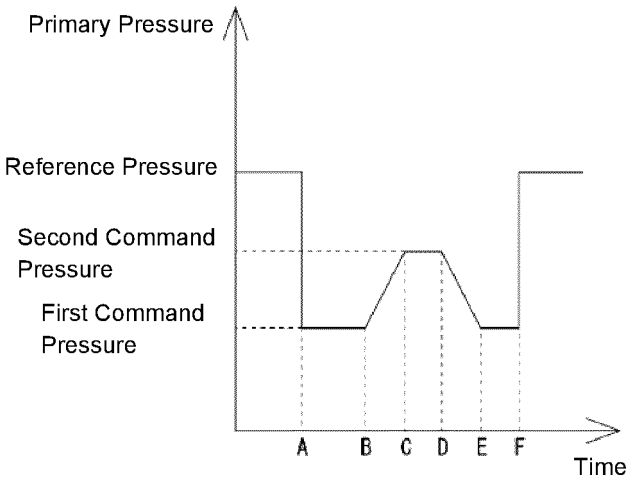

Primary Pressure
Reference Pressure
Second Command Pressure
First Command Pressure
A
B
C
D
E
F
Time

Fig. 3

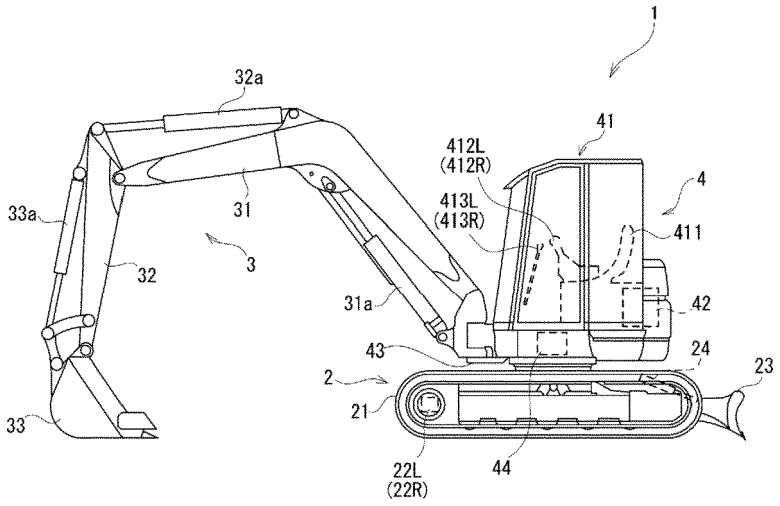
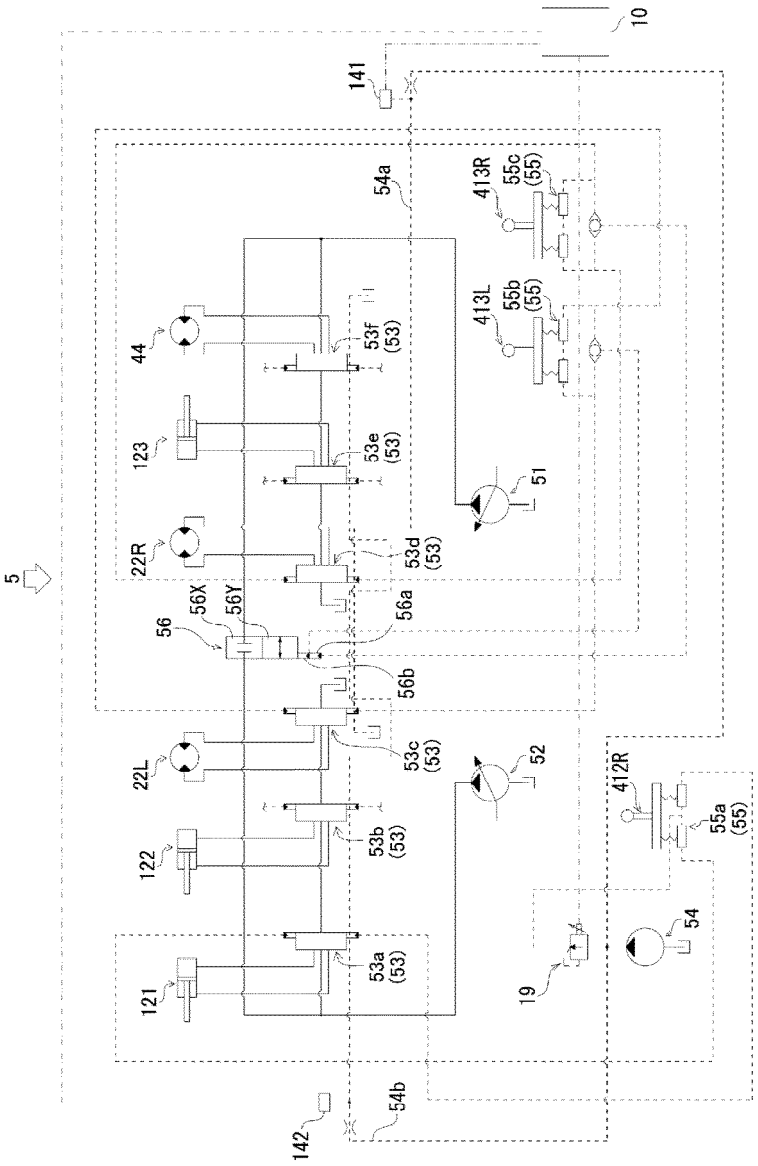

1
32a
41
412L
(412R)
4
413L
(413R)
411
33a
31
3
32
31a
42
43
24
23
2
21
33
22L
(22R)
44

Fig. 4


10
141
54a
413R
55c (55)
413L
55b (55)
44
53f (53)
123
53e (53)
51
22R
53d (53)
5
56X
56Y
56
56a
56b
53c (53)
52
22L
412R
55a (55)
122
53b (53)
54
121
53a (53)
19
54b
142

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/008773

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. F15B11/08(2006.01)i, E02F9/22(2006.01)i, F15B11/00(2006.01)i, F15B11/02(2006.01)i, F15B11/17(2006.01)i

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)
Int. Cl. F15B11/00-11/22, F15B21/14, E02F9/22

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2019
Registered utility model specifications of Japan	1996-2019
Published registered utility model applications of Japan	1994-2019

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2013/153984 A1 (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 17 October 2013, paragraphs [0033]-[0060], [0092]-[0096], fig. 1A, 6 & US 2015/0027112 A1, paragraphs [0045]-[0072], [0109]-[0113], fig. 1A, 6 & EP 2837831 A1 & CN 104246237 A & JP 2013-217466 A	1-4
Y	JP 8-85974 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 02 April 1996, paragraphs [0022]-[0029], fig. 1, 3 (Family: none)	1-4
Y	JP 2011-196436 A (YANMAR CO., LTD.) 06 October 2011, paragraphs [0022]-[0028], [0120]-[0124], fig. 8 & WO 2011/114929 A1	4

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12.04.2019	23.04.2019
Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/008773

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 8-93001 A (KOMATSU LTD.) 09 April 1996, paragraphs [0021], [0023], fig. 2 (Family: none)	1-2
A	JP 64-6501 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 11 January 1989, page 7, lower right column, line 1 to page 9, upper left column, line 1 (Family: none)	1-2
A	WO 2014/068973 A1 (KAWASAKI HEAVY INDUSTRIES, LTD.) 08 May 2014, fig. 4, 5 & US 2015/0292184 A1, fig. 4, 5 & EP 2916011 A1 & CN 104302931 A & KR 10-2015-0018834 A	1-2

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2005121155 A **[0004]**
- JP 2006125627 A **[0004]**