



(11) **EP 3 951 086 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
09.02.2022 Bulletin 2022/06

(21) Application number: **20779487.6**

(22) Date of filing: **27.03.2020**

(51) International Patent Classification (IPC):
E02F 9/20 (2006.01) **E02F 9/22** (2006.01)
F15B 11/042 (2006.01) **F15B 11/044** (2006.01)
F15B 11/08 (2006.01) **F15B 21/14** (2006.01)

(52) Cooperative Patent Classification (CPC):
E02F 9/20; E02F 9/22; F15B 11/042; F15B 11/044;
F15B 11/08; F15B 21/14

(86) International application number:
PCT/JP2020/014184

(87) International publication number:
WO 2020/196871 (01.10.2020 Gazette 2020/40)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **28.03.2019 JP 2019065019**

(71) Applicant: **SUMITOMO HEAVY INDUSTRIES, LTD.**
Tokyo 141-6025 (JP)

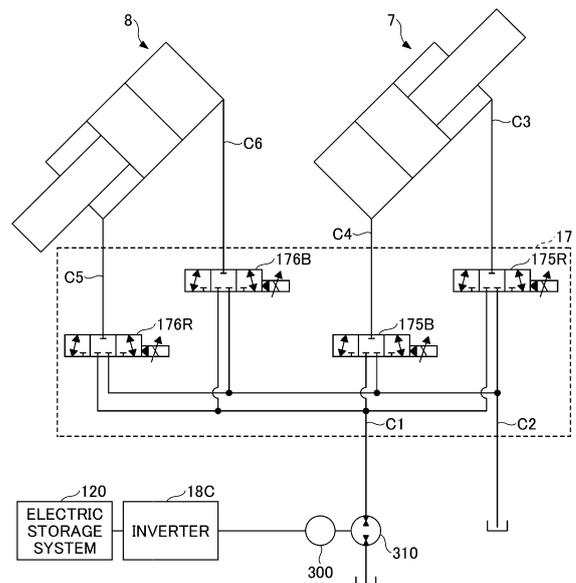
(72) Inventor: **ITSUJI, Yoshiyasu**
Yokosuka-shi, Kanagawa 237-8555 (JP)

(74) Representative: **Louis Pöhlau Lohrenz**
Patentanwälte
Postfach 30 55
90014 Nürnberg (DE)

(54) **EXCAVATOR**

(57) An excavator according to an embodiment of the present invention includes flow control valves respectively at rod sides and bottom sides of a plurality of hydraulic cylinders. The flow control valves are configured to control flow rates in accordance with pilot pressures.

FIG.5



EP 3 951 086 A1

Description

[Technical Field]

[0001] The present disclosure relates to an excavator.

[Background Art]

[0002] Conventionally, an excavator capable of performing regeneration to cause hydraulic oil flowing out from a returning-side oil chamber of a hydraulic cylinder to flow into a supply-side oil chamber and performing regeneration to cause hydraulic oil flowing out of a returning-side oil chamber of a hydraulic cylinder into a supply-side oil chamber of another hydraulic cylinder is known (see, for example, Patent Document 1).

[Prior Art Documents]

[Patent Documents]

[0003] [Patent Document 1] Japanese Unexamined Patent Application Publication No. 2015-172393

[Summary of Invention]

[Problem to be Solved by Invention]

[0004] However, in the above-described excavator, a valve is provided for performing regeneration in addition to a flow control valve which controls a flow of hydraulic oil to a hydraulic cylinder.

[0005] Therefore, it is desirable to provide an excavator capable of performing regeneration using a flow control valve.

[Means for Solving Problem]

[0006] An excavator according to an embodiment of the present invention includes flow control valves respectively at rod sides and bottom sides of a plurality of hydraulic cylinders. The flow control valves are configured to control flow rates in according to pilot pressures.

[Advantageous Effects of Invention]

[0007] Accordingly, an excavator capable of performing regeneration using flow control valves is provided.

[Brief Description of Drawings]

[0008]

Fig. 1 is a side view of a hybrid excavator according to one embodiment.

Fig. 2 is a diagram depicting a transition of an operating state of the hybrid excavator according to the embodiment.

Fig. 3 is a diagram depicting an example of a configuration of a driving system of the hybrid excavator according to the embodiment.

Fig. 4 is a diagram depicting an example of a structure of an electric storage system of the hybrid excavator according to the embodiment.

Fig. 5 is a diagram depicting an example of a configuration of control valves.

Fig. 6 is a diagram depicting a state of the control valves in a first driving mode.

Fig. 7 is a diagram depicting a state of the control valves in a second driving mode.

Fig. 8 is a diagram depicting a state of the control valves in a third driving mode.

Fig. 9 is a diagram depicting a state of the control valves in a fourth driving mode.

Fig. 10 is a diagram depicting a state of the control valves in a fifth driving mode.

Fig. 11 is a diagram depicting a state of the control valves in a sixth driving mode.

Fig. 12 is a diagram depicting a state of the control valves in a seventh driving mode.

[Mode for Carrying Out Invention]

[0009] Hereinafter, non-limiting exemplary embodiments of the present disclosure will be described with reference to the accompanying drawings. In all the accompanying drawings, the same or corresponding reference numerals are given to the same or corresponding parts or components, and the duplicate descriptions will be omitted.

[0010] Referring to Fig. 1, a configuration example of a hybrid excavator will be described. Fig. 1 is a side view depicting a hybrid excavator in accordance with an embodiment.

[0011] An upper swiveling body 3 is mounted to a lower traveling body 1 of the hybrid excavator through a swiveling mechanism 2. A boom 4 is attached to the upper swiveling body 3. An arm 5 is attached to an end of the boom 4, and a bucket 6 is attached to an end of the arm 5. The boom 4, the arm 5, and the bucket 6 are working elements hydraulically driven by a boom cylinder 7, an arm cylinder 8, and a bucket cylinder 9, respectively.

The upper swiveling body 3 is provided with a cabin 10 and is equipped with a power source such as an engine.

[0012] Next, an excavating and loading operation, which is an example of an operation of the hybrid excavator according to the embodiment, will be described with reference to Fig. 2. Fig. 2 is a diagram depicting a transition in an operating state of the hybrid excavator according to the embodiment.

[0013] First, as depicted as a state CD1, an operator swivels the upper swiveling body 3, lowers the boom 4 with the bucket 6 above an excavation position, with the arm 5 open, and with the bucket 6 open, and lowers the bucket 6 so that an end of the bucket 6 is at a desired height from an excavation target. Normally, when

swiveling the upper swiveling body 3 and lowering the boom 4, an operator visually checks the position of the bucket 6. In addition, swiveling the upper swiveling body 3 and lowering the boom 4 are generally performed simultaneously. The above-described operation is called a boom-lowering and swiveling operation, and a corresponding operation section is called a boom-lowering and swiveling operation section.

[0014] The operator closes the arm 5 until the arm 5 becomes substantially perpendicular to the ground surface, as depicted as the state CD2, when the operator determines that a tip of the bucket 6 has reached a desired height. Thus, soil is excavated up to a predetermined depth and the excavated soil is scraped and collected by the bucket 6 until the arm 5 becomes substantially perpendicular to the ground surface. The operator then closes the arm 5 and bucket 6 further, as depicted as the state CD3, and thus, closes the bucket 6 until the bucket 6 becomes substantially perpendicular to the arm 5, as depicted as the state CD4. That is, the bucket 6 is closed until the upper edge of the bucket 6 becomes generally horizontal, and places the collected soil in the bucket 6. The above-described operation is referred to as an excavating operation and a corresponding operation section is referred to as an excavating operation section.

[0015] Next, when the operator determines that the bucket 6 has been closed until the bucket 6 becomes substantially perpendicular to the arm 5, the operator lifts the boom 4 until the bottom of the bucket 6 becomes at a desired height from the ground, with the bucket 6 closed, as depicted as the state CD5. This operation is called a boom-lifting operation, and a corresponding operation section is called a boom-lifting operation section. Subsequently or simultaneously, the operator swivels the upper swiveling body 3 and thus swivels and moves the bucket 6 to a soil discharge position, as depicted by an arrow AR1. This operation including a boom-lifting operation is called a boom-lifting and swiveling operation, and a corresponding operation section is called a boom-lifting and swiveling operation section.

[0016] A reason of lifting the boom 4 until the bottom of the bucket 6 reaches the desired height is as follows: for example, if the bucket 6 is not lifted higher than a height of a load bed of a dump truck when soil in the bucket 6 is discharged to the load bed, the bucket 6 hits the load bed.

[0017] Next, when the operator determines that the boom-lifting and swiveling operation has been completed, the operator opens the arm 5 and the bucket 6 while lowering the boom 4 or stopping the boom 4, as depicted as the state CD6, to discharge the soil in the bucket 6. This operation is called a dumping operation and a corresponding operation section is called a dumping operation section.

[0018] Next, when the operator determines that the dumping operation has been completed, the operator swivels the upper swiveling body 3 in a direction of an arrow AR2 as depicted as the state CD7, and moves the

bucket 6 up to precisely above the excavation position. At this time, the operator lowers the boom 4 simultaneously with the swiveling, and thus lowers the bucket 6 to a desired height from the excavation target. This operation is part of the boom-lowering and swiveling operation described as the state CD1. The operator then moves the bucket 6 downward to a desired height as depicted as the state CD1 to again perform operations starting from an excavating operation.

[0019] The operator repeats a cycle including "boom-lowering and swiveling operation", "excavating operation", "boom-lifting and swiveling operation", and "dumping operation" described above to proceed with an excavating and loading process.

[0020] Next, an example of a configuration of a driving system of the hybrid excavator according to the embodiment will be described with reference to Fig. 3. Fig. 3 is a diagram depicting an example of a configuration of a driving system of the hybrid excavator according to the embodiment. In Fig. 3, a double line denotes a mechanical power system, a solid line (thick line) denotes a high pressure oil hydraulic line, a broken line denotes a pilot line, and a solid line (thin line) denotes an electric driving and controlling system.

[0021] An engine 11 as a mechanical driving unit and a motor-generator 12 as an assistive driving unit are connected to two input shafts of a transmission 13, respectively. A main pump 14 and a pilot pump 15, as oil hydraulic pumps, are connected to an output shaft of the transmission 13. Control valves 17 are connected to the main pump 14 via high pressure oil hydraulic lines 16.

[0022] A regulator 14A is a device for controlling a discharge amount of the main pump 14. For example, a discharge amount of the main pump 14 is controlled by adjusting a swash plate tilt angle of the main pump 14 in accordance with a discharge pressure of the main pump 14, a control signal from the controller 30, and the like.

[0023] The control valves 17 are controllers for controlling an oil hydraulic system of the hybrid excavator. Oil hydraulic motors 1A (right) and 1B (left) for the lower traveling body 1, the boom cylinder 7, the arm cylinder 8, and the bucket cylinder 9 are connected to the control valves 17 via the high pressure hydraulic lines. Hereinafter, the oil hydraulic motors 1A (right) and 1B (left) for the lower traveling body 1, boom cylinder 7, arm cylinder 8, and bucket cylinder 9 are collectively referred to as oil hydraulic actuators.

[0024] An electric storage system 120 including a capacitor as an electric storage unit is connected to the motor-generator 12 via an inverter 18A. A swiveling motor 21 as an electric powering operation element is connected to the electric storage system 120 via an inverter 20. A resolver 22, a mechanical brake 23, and a swiveling transmission 24 are connected to a rotating shaft 21A of the swiveling motor 21. A manual operating device 26 is connected to the pilot pump 15 via a pilot line 25. The swiveling motor 21, the inverter 20, the resolver 22, the mechanical brake 23, and the swiveling transmission 24

are included in a first load driving system.

[0025] The manual operating device 26 includes a lever 26A, a lever 26B, and a pedal 26C. The lever 26A, lever 26B, and pedal 26C are connected to the control valves 17 and a pressure sensor 29 via oil hydraulic lines 27 and 28, respectively. The pressure sensor 29 functions as an operating state detector for detecting an operating state of each of the hydraulic actuators and is connected to a controller 30 for controlling driving of the electrical system.

[0026] In the embodiment, a boom regenerative motor-generator 300 for obtaining boom regenerative power is connected to the electric storage system 120 via an inverter 18C. The motor-generator 300 is driven as a generator by an oil hydraulic pump-motor driven by hydraulic oil flowing out of the boom cylinder 7. The motor-generator 300 converts potential energy of the boom 4 (hydraulic energy of hydraulic oil flowing out of the boom cylinder 7) to electrical energy utilizing a pressure of hydraulic oil flowing out of the boom cylinder 7 when the boom 4 moves downward under its own weight. In Fig. 3, for convenience of illustration, the oil hydraulic pump-motor 310 and the motor-generator 300 are depicted at distant positions, but in practice, the rotational axis of the motor-generator 300 is mechanically connected to the rotating shaft of the oil hydraulic pump-motor 310. That is, the oil hydraulic pump-motor 310 is rotated by hydraulic oil flowing out of the boom cylinder 7 when the boom 4 moves downward, and is provided for converting hydraulic energy of hydraulic oil obtained when the boom 4 moves downward under its own weight into rotating force. In addition, the motor-generator 300 converts electrical energy stored in the electric storage system 120 into kinetic energy of the rotating shaft of the oil hydraulic pump-motor 310. Thus, the oil hydraulic pump-motor 310 can discharge hydraulic oil to an actuator such as the boom 4.

[0027] Electric power generated by the motor-generator 300 is supplied to the electric storage system 120 as regenerated power through the inverter 18C. A second load driving system includes the motor-generator 300 and the inverter 18C.

[0028] Referring now to Fig. 4, a configuration example of the electric storage system 120 of the hybrid excavator according to the embodiment will be described. Fig. 4 is a diagram depicting an example of a configuration of the electric storage system 120 of the hybrid excavator according to the embodiment.

[0029] The electric storage system 120 includes a capacitor 19, a step-up and step-down converter 100, and a DC bus 110. The capacitor 19 includes a capacitor voltage detecting unit 112 for detecting a capacitor voltage value and a capacitor current detecting unit 113 for detecting a capacitor current value. The capacitor voltage value and the capacitor current value detected by the capacitor voltage detecting unit 112 and the capacitor current detecting unit 113 are supplied to the controller 30.

[0030] The step-up and step-down converter 100 performs control to switch between a step-up operation and a step-down operation in accordance with operating states of the motor-generator 12, the swiveling motor 21, and the motor-generator 300 so that a DC bus voltage value falls within a fixed range. The DC bus 110 connects together the inverters 18A, 18C, and 20, as well as the step-up and step-down converter 100, to transfer electric power among the capacitor 19, the motor-generator 12, the swiveling motor 21, and the motor-generator 300.

[0031] Referring again to Fig. 3, the controller 30 will now be described in detail. The controller 30 is a control device as a main control unit that performs driving control of the hybrid excavator. The controller 30 is an arithmetic processing unit including a central processing unit (CPU) and an internal memory, and operates by executing a program for driving control stored in the internal memory.

[0032] The controller 30 converts a signal supplied from the pressure sensor 29 to a swiveling speed command and performs driving control of the swiveling motor 21. In this case, the signal supplied from the pressure sensor 29 corresponds to a signal representing an operating amount when the manual operating device 26 (a swiveling operating lever) is operated by the operator to swivel the swiveling mechanism 2.

[0033] The controller 30 performs operation control (switching between an electric powering (assistive) operation and a generating operation) of the motor-generator 12, and performs control of charging and discharging the capacitor 19 by driving and controlling the step-up and step-down converter 100 used as a step-up and step-down control unit. Specifically, the controller 30 performs control of switching the step-up and step-down converter 100 between charging and discharging the capacitor 19 based on a state of charge of the capacitor 19, an operating state (an electric powering (assistive) operation or a generating operation) of the motor-generator 12, an operating state (a powering operation or a regenerative operation) of the swiveling motor 21, and an operating state (a powering operation or a regenerative operation) of the motor-generator 300.

[0034] Control of switching the step-up and step-down converter 100 between a step-up operation and a step-down operation is performed based on a DC bus voltage value detected by the DC bus voltage detecting unit 111, a capacitor voltage value detected by the capacitor voltage detecting unit 112, and a capacitor current value detected by the capacitor current detecting unit 113.

[0035] In the above-described configuration, power generated by the motor-generator 12, which is an assistive motor, is supplied to the DC bus 110 of the electric storage system 120 via the inverter 18A and supplied to the capacitor 19 via the step-up and step-down converter 100. Regenerative power generated by the swiveling motor 21 is supplied to the DC bus 110 of the electric storage system 120 via the inverter 20 and supplied to the capacitor 19 via the step-up and step-down converter 100. Power generated by the boom regenerative motor-gen-

erator 300 is supplied to the DC bus 110 of the electric storage system 120 via the inverter 18C and supplied to the capacitor 19 via the step-up and step-down converter 100. It should be noted that power generated by the motor-generator 12 or the motor-generator 300 may be supplied directly to the swiveling motor 21 via the inverter 20, power generated by the swiveling motor 21 or the motor-generator 300 may be supplied directly to the motor-generator 12 via the inverter 18A, and power generated by the motor-generator 12 or the swiveling motor 21 may be supplied directly to the motor-generator 300 via the inverter 18C.

[0036] The capacitor 19 may be replaced with another electric storage unit capable of being charged and discharged so that power can be exchanged with the DC bus 110 via the step-up and step-down converter 100. Although the capacitor 19 is depicted in Fig. 4 as an electric storage unit, a rechargeable secondary battery, such as a lithium ion battery, a lithium ion capacitor, or any other type of a power source capable of providing and receiving power may be used as an electric storage unit in place of the capacitor 19.

[0037] Referring now to Fig. 5, a configuration example of the control valves 17 of the hybrid excavator according to the embodiment will now be described. Fig. 5 is a diagram depicting an example of the configuration of the control valves 17.

[0038] As depicted in Fig. 5, the control valves 17 include rod-side flow control valves 175R and 176R and bottom-side flow control valves 175B and 176B. The rod-side flow control valves 175R and 176R and the bottom-side flow control valves 175B and 176B are connected to each other via the oil hydraulic pump-motor 310 and a first oil passage C1. The oil hydraulic pump-motor 310 functions as an oil hydraulic motor utilizing hydraulic oil flowing out of the boom cylinder 7, and also functions as an oil hydraulic pump. The rod-side flow control valves 175R and 176R and the bottom-side flow control valves 175B and 176B are connected to each other through a second oil passage C2 connected with a hydraulic oil tank. The rod-side flow control valves 175R and 176R and the bottom-side flow control valves 175B and 176B are, for example, spool valves which switch valve positions in accordance with pressures (pilot pressures) of hydraulic oil supplied to pilot ports via the oil hydraulic line 27 to switch between states of communication with and states of shutting off from the first oil passage C1 and the second oil passage C2.

[0039] The rod-side flow control valve 175R is connected to a rod-side oil chamber of the boom cylinder 7 through a boom cylinder rod-side oil passage C3, and controls a flow of hydraulic oil to a rod side of the boom cylinder 7. The rod-side flow control valve 175R switches a connection destination of the boom cylinder rod-side oil passage C3 between the first oil passage C1 and the second oil passage C2.

[0040] The bottom-side flow control valve 175B is connected to a bottom-side oil chamber of the boom cylinder

7 through a boom cylinder bottom-side oil passage C4 and controls a flow of hydraulic oil to a bottom side of the boom cylinder 7. The bottom-side flow control valve 175B switches a connection destination of the boom cylinder bottom-side oil passage C4 between the first oil passage C1 and the second oil passage C2.

[0041] The rod-side flow control valve 176R is connected to a rod-side oil chamber of the arm cylinder 8 through an arm cylinder rod-side oil passage C5 and controls a flow of hydraulic oil to a rod side of the arm cylinder 8. The rod-side flow control valve 176R switches a connection destination of the arm cylinder rod-side oil passage C5 between the first oil passage C1 and the second oil passage C2.

[0042] The bottom-side flow control valve 176B is connected to a bottom-side oil chamber of the arm cylinder 8 via an arm cylinder bottom-side oil passage C6 to control a flow of hydraulic oil to a bottom side of the arm cylinder 8. The bottom-side flow control valve 176B switches a connection destination of the arm cylinder bottom-side oil passage C6 between the first oil passage C1 and the second oil passage C2.

[0043] Next, a state of the control valves 17 in a first driving mode will now be described with reference to Fig. 6. Fig. 6 is a diagram depicting a state of the control valves 17 in the first driving mode. In Fig. 6, black arrows and white arrows indicate that there are flows of hydraulic oil, where the thicker the arrows are, the greater the flow rates are. The black arrows represent a flow of hydraulic oil flowing out of the boom cylinder 7 and a flow of hydraulic oil flowing out of the oil hydraulic pump-motor 310, and the white arrows represent flows of hydraulic oil flowing out of the arm cylinder 8.

[0044] The first driving mode is a mode in which the boom 4 performs a boom-lowering operation under its own weight at a low speed, and the arm 5 performs an arm-lifting operation by being powered at a high speed. The hybrid excavator is in the first driving mode, for example, during a boom-lowering swiveling operation (the states CD6-CD7 depicted in Fig. 2). In the first driving mode, a pressure of the bottom-side oil chamber (hereinafter, referred to as a "bottom pressure") is higher than a pressure of the rod-side oil chamber (hereinafter, referred to as a "rod pressure") with respect to the boom cylinder 7, and a rod pressure is higher than a bottom pressure with respect to the arm cylinder 8. However, because a downward movement of the boom 4 is slow with respect to the arm 5 that needs to be operated at high speed, only hydraulic oil discharged from the boom cylinder 7 cannot meet an amount of hydraulic oil required by the arm cylinder 8. Accordingly, to compensate for an insufficient flow (a difference between the required flow rate and the discharge flow rate), the controller 30 starts rotating the motor-generator 300 and the oil hydraulic pump-motor 310 to cause the oil hydraulic pump-motor 310 to function as an oil hydraulic pump.

[0045] In the first driving mode, the rod-side flow control valve 175R allows the boom cylinder rod-side oil pas-

sage C3 to communicate with the second oil passage C2, and the bottom-side flow control valve 175B allows the boom cylinder bottom-side oil passage C4 to communicate with the first oil passage C1. The rod-side flow control valve 176R allows the arm cylinder rod-side oil passage C5 to communicate with the first oil passage C1, and the bottom-side flow control valve 176B allows the arm cylinder bottom-side oil passage C6 to communicate with the second oil passage C2. The controller 30 also starts rotating the motor-generator 300 and the oil hydraulic pump-motor 310 to cause the oil hydraulic pump-motor 310 to function as an oil hydraulic pump.

[0046] As a result, hydraulic oil flowing out of the boom cylinder 7 and hydraulic oil discharged by the oil hydraulic pump-motor 310 when the boom 4 moves downward under its own weight merge in the first oil passage C1 to reach the arm cylinder rod-side oil passage C5, flows into the rod-side oil chamber of the arm cylinder 8, and is used to open the arm 5. The hydraulic oil discharged by the oil hydraulic pump-motor 310 is used to compensate for a shortage for a case where only the hydraulic oil flowing out of the boom cylinder 7 is insufficient when the boom 4 moves downward under its own weight.

[0047] Hydraulic oil flowing out of the bottom-side oil chamber of the arm cylinder 8, in whole or in part, reaches the boom cylinder rod-side oil passage C3 through the second oil passage C2, flows into the rod-side oil chamber of the boom cylinder 7, and is used to lower the boom 4. The rest of the hydraulic oil is discharged to the hydraulic oil tank through the second oil passage C2.

[0048] Thus, in the first driving mode, the hybrid excavator drives the arm cylinder 8, using hydraulic oil flowing out of the bottom-side oil chamber of the boom cylinder 7 upon lowering of the boom. That is, potential energy of the boom 4 can be effectively utilized as hydraulic energy for driving the arm 5.

[0049] Next, a state of the control valves 17 in a second driving mode will now be described with reference to Fig. 7. Fig. 7 is a diagram depicting a state of the control valves 17 in a second driving mode. In Fig. 7, black arrows and white arrows indicate that there are flows of hydraulic oil, and the thicker the arrows are, the greater the flow rates are. The black arrows represent flows of hydraulic oil flowing out of the boom cylinder 7, and the white arrows represent flows of hydraulic oil flowing out of the arm cylinder 8.

[0050] The second driving mode is a mode in which the boom 4 performs a boom-lowering operation under its own weight at a high speed and the arm 5 performs an arm-lifting operation under its own weight at a low speed. The hybrid excavator is in the second driving mode, for example, during a boom-lowering swiveling operation (the states CD6-CD7 depicted in Fig. 2). In the second driving mode, a bottom pressure is greater than a rod pressure with respect to the boom cylinder 7, and a rod pressure is greater than a bottom pressure with respect to the arm cylinder 8. In this case, because a downward movement of the boom 4 is at a high speed

with respect to the arm 5 that operates at a low speed, a flow rate of hydraulic oil discharged from the boom cylinder 7 can sufficiently provide an amount of hydraulic oil required by the arm cylinder 8. Therefore, in order to effectively utilize an excess flow rate (a difference between the required flow rate and the discharge flow rate) for a regeneration operation, a predetermined control signal is output to the inverter 18C to cause the motor-generator 300 to perform a regeneration operation.

[0051] In the second driving mode, the rod-side flow control valve 175R allows the boom cylinder rod-side oil passage C3 to communicate with the first oil passage C1, and the bottom-side flow control valve 175B allows the boom cylinder bottom-side oil passage C4 to communicate with the first oil passage C1. The rod-side flow control valve 176R allows the arm cylinder rod-side oil passage C5 to communicate with the first oil passage C1, and the bottom-side flow control valve 176B allows the arm cylinder bottom-side oil passage C6 to communicate with the second oil passage C2. The controller 30 outputs a predetermined control signal to the inverter 18C and causes the motor-generator 300 to perform a regeneration operation.

[0052] As a result, part of hydraulic oil flowing out of the boom cylinder 7 when the boom 4 moves downward under its own weight reaches the boom cylinder rod-side oil passage C3 through the first oil passage C1, flows into the rod-side oil chamber of the boom cylinder 7, and is used to lower the boom 4. Part of the hydraulic oil reaches the arm cylinder rod-side oil passage C5 through the first oil passage C1, flows into the rod-side oil chamber of the arm cylinder 8, and is used to open the arm 5. In addition, the rest of the hydraulic oil is supplied to the oil hydraulic pump-motor 310 through the first oil passage C1, and causes the oil hydraulic pump-motor 310 to function as an oil hydraulic motor.

[0053] Hydraulic oil flowing out of the bottom-side oil chamber of the arm cylinder 8 is discharged to the hydraulic oil tank through the second oil passage C2.

[0054] Thus, in the second driving mode, the hybrid excavator drives the boom cylinder 7 and the arm cylinder 8 and rotates the oil hydraulic pump-motor 310, using hydraulic oil flowing out of the bottom-side oil chamber of the boom cylinder 7 upon lowering of the boom. That is, potential energy of the boom 4 can be effectively utilized as hydraulic energy for driving the boom 4 and the arm 5, and can be effectively utilized as kinetic energy for rotating the oil hydraulic pump-motor 310.

[0055] Next, a state of the control valves 17 in a third driving mode will now be described with reference to Fig. 8. Fig. 8 is a diagram depicting a state of the control valves 17 in a third driving mode. In Fig. 8, black arrows indicate that there are flows of hydraulic oil, and the thicker the arrows are, the greater the flow rates are. The black arrows represent flows of hydraulic oil flowing out of the boom cylinder 7.

[0056] In the third driving mode, the boom 4 performs a boom-lowering operation under its own weight, and the

arm 5 performs an arm-lowering operation under its own weight. The hybrid excavator is in the third driving mode, for example, during a boom-lowering swiveling operation (the states CD7-CD1 depicted in Fig. 2). In the third driving mode, a bottom pressure is lower than a rod pressure with respect to the boom cylinder 7, and a rod pressure is higher than a bottom pressure with respect to the arm cylinder 8.

[0057] In the third driving mode, the rod-side flow control valve 175R allows the boom cylinder rod-side oil passage C3 to communicate with the first oil passage C1, and the bottom-side flow control valve 175B allows the boom cylinder bottom-side oil passage C4 to communicate with the first oil passage C1. The rod-side flow control valve 176R allows the arm cylinder rod-side oil passage C5 to communicate with the first oil passage C1, and the bottom-side flow control valve 176B allows the arm cylinder bottom-side oil passage C6 to communicate with the first oil passage C1. The controller 30 outputs a predetermined control signal to the inverter 18C and causes the motor-generator 300 to perform a regeneration operation.

[0058] As a result, part of hydraulic oil flowing out of the boom cylinder 7 when the boom 4 moves downward under its own weight reaches the boom cylinder rod-side oil passage C3 through the first oil passage C1, flows into the rod-side oil chamber of the boom cylinder 7, and is used to lower the boom 4. Part of the hydraulic oil reaches the arm cylinder bottom-side oil passage C6 through the first oil passage C1, flows into the bottom-side oil chamber of the arm cylinder 8, and is used to close the arm 5. The rest of the hydraulic oil is supplied to the oil hydraulic pump-motor 310 through the first oil passage C1 so that the oil hydraulic pump-motor 310 functions as an oil hydraulic motor.

[0059] Hydraulic oil flowing out of the rod-side oil chamber of the arm cylinder 8 reaches the arm cylinder bottom-side oil passage C6 through the first oil passage C1, flows into the bottom-side oil chamber of the arm cylinder 8, and is used to close the arm 5.

[0060] Thus, in the third driving mode, the hybrid excavator drives the boom cylinder 7 and the arm cylinder 8 and rotates the oil hydraulic pump-motor 310, using hydraulic oil flowing out of the bottom-side oil chamber of the boom cylinder 7 and hydraulic oil flowing out of the rod-side oil chamber of the arm cylinder 8 upon lowering of the boom and lowering of the arm. That is, potential energy of the boom 4 and the arm 5 can be effectively utilized as hydraulic energy for driving the boom 4 and the arm 5, and can be effectively utilized as kinetic energy for rotating the oil hydraulic pump-motor 310.

[0061] Next, a state of the control valves 17 in a fourth driving mode will now be described with reference to Fig. 9. Fig. 9 is a diagram depicting a state of the control valves 17 in a fourth driving mode. In Fig. 9, black arrows and white arrows indicate that there are flows of hydraulic oil, and the thicker the arrows are, the greater the flow rates are. The black arrows represent flows of hydraulic

oil flowing out of the boom cylinder 7, and the white arrows represent flows of hydraulic oil flowing out of the arm cylinder 8.

[0062] The fourth driving mode is a mode in which the boom 4 performs a boom-lowering operation under its own weight, and the arm 5 performs an arm-lowering operation by being powered. The hybrid excavator is in the fourth driving mode, for example, upon a transition from a boom-lowering and swiveling operation to an excavating operation (the state CD1 depicted in Fig. 2). In the fourth driving mode, a bottom pressure is greater than a rod pressure with respect to the boom cylinder 7, and a rod pressure is smaller than a bottom pressure with respect to the arm cylinder 8.

[0063] In the fourth driving mode, the rod-side flow control valve 175R allows the boom cylinder rod-side oil passage C3 to communicate with the first oil passage C1, and the bottom-side flow control valve 175B allows the boom cylinder bottom-side oil passage C4 to communicate with the first oil passage C1. The rod-side flow control valve 176R allows the arm cylinder rod-side oil passage C5 to communicate with the second oil passage C2, and the bottom-side flow control valve 176B allows the arm cylinder bottom-side oil passage C6 to communicate with the first oil passage C1. In addition, the controller 30 starts rotating the motor-generator 300 and the oil hydraulic pump-motor 310 to cause the oil hydraulic pump-motor 310 to function as an oil hydraulic pump.

[0064] As a result, hydraulic oil flowing out of the boom cylinder 7 and hydraulic oil discharged by the oil hydraulic pump-motor 310 when the boom 4 moves downward under its own weight merge at the first oil passage C1, part of the hydraulic oil reaches the boom cylinder rod-side oil passage C3 through the first oil passage C1, flows into the rod-side oil chamber of the boom cylinder 7, and is used to lower the boom 4. The rest of the hydraulic oil flows into the arm cylinder bottom-side oil passage C6 through the first oil passage C1, flows into the bottom-side oil chamber of the arm cylinder 8, and is used to close the arm 5. The hydraulic oil discharged by the oil hydraulic pump-motor 310 is used to compensate for a shortage for a case where only the hydraulic oil flowing out of the boom cylinder 7 is insufficient when the boom 4 moves downward under its own weight.

[0065] Hydraulic oil flowing out of the rod-side oil chamber of the arm cylinder 8 is discharged to the hydraulic oil tank through the second oil passage C2.

[0066] Thus, in the fourth driving mode, the hybrid excavator drives the boom cylinder 7 and the arm cylinder 8, using hydraulic oil flowing out of the bottom-side oil chamber of the boom cylinder 7 upon lowering of the boom. That is, potential energy of the boom 4 can be effectively used as hydraulic energy for driving the boom 4 and the arm 5.

[0067] Next, a state of the control valves 17 in a fifth driving mode will now be described with reference to Fig. 10. Fig. 10 is a diagram depicting a state of the control valves 17 in a fifth driving mode. In Fig. 10, black arrows

and white arrows indicate that there are flows of hydraulic oil, and the thicker the arrows are, the greater the flow rates are. The black arrows represent flows of hydraulic oil discharged by the oil hydraulic pump-motor 310, and the white arrows represent flows of hydraulic oil discharged from the boom cylinder 7 and the arm cylinder 8.

[0068] The fifth driving mode is a mode in which the boom 4 performs a boom-lifting operation by being powered, and the arm 5 performs an arm-lowering operation by being powered. The hybrid excavator is in the fifth driving mode, for example, at a beginning of an excavating operation (states CD1-CD2 depicted in Fig. 2). In the fifth driving mode, a bottom pressure is smaller than a rod pressure with respect to the boom cylinder 7, and a rod pressure is smaller than a bottom pressure with respect to the arm cylinder 8.

[0069] In the fifth driving mode, the rod-side flow control valve 175R allows the boom cylinder rod-side oil passage C3 to communicate with the second oil passage C2, and the bottom-side flow control valve 175B allows the boom cylinder bottom-side oil passage C4 to communicate with the first oil passage C1. The rod-side flow control valve 176R allows the arm cylinder rod-side oil passage C5 to communicate with the second oil passage C2, and the bottom-side flow control valve 176B allows the arm cylinder bottom-side oil passage C6 to communicate with the first oil passage C1. In addition, the controller 30 starts rotating the motor-generator 300 and the oil hydraulic pump-motor 310 to cause the oil hydraulic pump-motor 310 to function as an oil hydraulic pump.

[0070] As a result, part of hydraulic oil discharged by the oil hydraulic pump-motor 310 reaches the boom cylinder bottom-side oil passage C4 through the first oil passage C1, flows into the bottom-side oil chamber of the boom cylinder 7, and is used to lift the boom 4. The rest of the hydraulic oil flows into the arm cylinder bottom-side oil passage C6 through the first oil passage C1, flows into the bottom-side oil chamber of the arm cylinder 8, and is used to close the arm 5.

[0071] In addition, hydraulic oil flowing out of the rod-side oil chamber of the boom cylinder 7 and the rod-side oil chamber of the arm cylinder 8 are discharged to the hydraulic oil tank through the second oil passage C2.

[0072] Thus, in the fifth driving mode, when it is not possible to use hydraulic oil flowing out of the bottom-side oil chamber of the boom cylinder 7 upon lowering of the boom, the hybrid excavator drives the boom cylinder 7 and the arm cylinder 8 using hydraulic oil discharged by the oil hydraulic pump-motor 310.

[0073] Next, a state of the control valves 17 in a sixth driving mode will now be described with reference to Fig. 11. Fig. 11 is a diagram depicting a state of the control valves 17 in a sixth driving mode. In Fig. 11, black arrows and white arrows indicate that there are flows of hydraulic oil, and the thicker the arrows are, the greater the flow rates are. The black arrows represent flows of hydraulic oil flowing out of the boom cylinder 7 and flows of hydraulic oil flowing out of the oil hydraulic pump-motor 310,

and the white arrows represent flows of hydraulic oil flowing out of the arm cylinder 8.

[0074] The sixth driving mode is a mode in which the boom 4 performs a boom-lifting operation by a reaction force, and the arm 5 performs an arm-lowering operation by being powered. The hybrid excavator is in the sixth driving mode, for example, at the middle of an excavating operation (the state CD2 depicted in Fig. 2). In the sixth driving mode, a bottom pressure is greater than a rod pressure with respect to the boom cylinder 7, and a rod pressure is smaller than a bottom pressure with respect to the arm cylinder 8.

[0075] In the sixth driving mode, the rod-side flow control valve 175R allows the boom cylinder rod-side oil passage C3 to communicate with the first oil passage C1, and the bottom-side flow control valve 175B allows the boom cylinder bottom-side oil passage C4 to communicate with the second oil passage C2. The rod-side flow control valve 176R allows the arm cylinder rod-side oil passage C5 to communicate with the second oil passage C2, and the bottom-side flow control valve 176B allows the arm cylinder bottom-side oil passage C6 to communicate with the first oil passage C1. In addition, the controller 30 starts rotating the motor-generator 300 and the oil hydraulic pump-motor 310 to cause the oil hydraulic pump-motor 310 to function as an oil hydraulic pump.

[0076] As a result, hydraulic oil flowing out of the boom cylinder 7 and hydraulic oil discharged by the oil hydraulic pump-motor 310 when the boom 4 moves upward by a reaction force merge at the first oil passage C1, and part of the hydraulic oil flows through the first oil passage C1 to the arm cylinder bottom-side oil passage C6, flows into the bottom-side oil chamber of the arm cylinder 8, and is used to close the arm 5. The hydraulic oil discharged by the oil hydraulic pump-motor 310 is used to compensate for a shortage for a case where only the hydraulic oil flowing out of the boom cylinder 7 is insufficient when the boom 4 moves upward by a reaction force.

[0077] Hydraulic oil flowing out of the rod-side oil chamber of the arm cylinder 8 reaches the boom cylinder bottom-side oil passage C4 through the second oil passage C2 in whole or in part, flows into the bottom-side oil chamber of the boom cylinder 7, and is used to lift the boom 4. The rest of the hydraulic oil is discharged to the hydraulic oil tank through the second oil passage C2.

[0078] Thus, in the sixth driving mode, the hybrid excavator drives the arm cylinder 8, using hydraulic oil flowing out of the rod-side oil chamber of the boom cylinder 7 upon lifting of the boom. That is, reaction energy of the boom 4 can be effectively used as hydraulic energy for driving the arm 5. The boom cylinder 7 is driven by hydraulic oil flowing out of the rod-side oil chamber of the arm cylinder 8 upon lowering of the arm. That is, potential energy of the arm 5 can be effectively used as hydraulic energy for driving the boom 4.

[0079] Next, a state of the control valves 17 in a seventh driving mode will now be described with reference to Fig. 12. Fig. 12 is a diagram depicting a state of the

control valves 17 in a seventh driving mode. In Fig. 12, black arrows and white arrows indicate that there are flows of hydraulic oil, and the thicker the arrows are, the greater the flow rates are. The black arrows represent flows of hydraulic oil flowing out of the boom cylinder 7 and flows of hydraulic oil flowing out of the oil hydraulic pump-motor 310, and the white arrows represent flows of hydraulic oil flowing out of the arm cylinder 8.

[0080] The seventh driving mode is a mode in which the boom 4 performs a boom-lowering operation under its own weight and the arm 5 performs an arm-lowering operation by being powered. The hybrid excavator is in the seventh driving mode, for example, in a cycle of an excavating operation (the states CD2-CD3 depicted in Fig. 2). In the seventh driving mode, a bottom pressure is greater than a rod pressure with respect to the boom cylinder 7, and a rod pressure is smaller than a bottom pressure with respect to the arm cylinder 8.

[0081] In the seventh driving mode, the rod-side flow control valve 175R allows the boom cylinder rod-side oil passage C3 to communicate with the first oil passage C1, and the bottom-side flow control valve 175B allows the boom cylinder bottom-side oil passage C4 to communicate with the first oil passage C1. The rod-side flow control valve 176R allows the arm cylinder rod-side oil passage C5 to communicate with the second oil passage C2, and the bottom-side flow control valve 176B allows the arm cylinder bottom-side oil passage C6 to communicate with the first oil passage C1. In addition, the controller 30 starts rotating the motor-generator 300 and the oil hydraulic pump-motor 310 to cause the oil hydraulic pump-motor 310 to function as an oil hydraulic pump.

[0082] As a result, hydraulic oil flowing out of the boom cylinder 7 and hydraulic oil discharged by the oil hydraulic pump-motor 310 when the boom 4 moves downward under its own weight merge at the first oil passage C1, part of the hydraulic oil reaches the boom cylinder rod-side oil passage C3 through the first oil passage C1, flows into the rod-side oil chamber of the boom cylinder 7, and is used to lower the boom 4. The rest of the hydraulic oil reaches the arm cylinder bottom-side oil passage C6, flows into the bottom-side oil chamber of the arm cylinder 8, and is used to close the arm 5. The hydraulic oil discharged by the oil hydraulic pump-motor 310 is used to compensate for a shortage for a case where only the hydraulic oil flowing out of the boom cylinder 7 is insufficient when the boom 4 moves downward under its own weight.

[0083] Hydraulic oil flowing out of the rod-side oil chamber of the arm cylinder 8 is discharged to the hydraulic oil tank through the second oil passage C2.

[0084] Thus, in the seventh driving mode, the hybrid excavator drives the boom cylinder 7 and the arm cylinder 8 using hydraulic oil flowing out of the rod-side oil chamber of the boom cylinder 7 upon lowering of the boom. That is, potential energy of the boom 4 can be effectively used as hydraulic energy for driving the boom 4 and the arm 5.

[0085] As described above, the hybrid excavator of the embodiment includes the flow control valves respectively at the rod sides and the bottom sides of the plurality of hydraulic cylinders for controlling flow rates in accordance with pilot pressures. Therefore, it is possible to perform regeneration using the flow control valves, without needing extra valves for regeneration in addition to the flow control valves for controlling flows of hydraulic oil to the hydraulic cylinders.

[0086] The embodiments disclosed herein should be considered in all respects to be exemplary and not restrictive. With respect to the above described embodiments, omissions, substitutions, or modifications may be made in various forms without departing from the appended claims and spirit thereof.

[0087] The present international application claims priority under Japanese Patent Application No. 2019-065019, filed March 28, 2019, the entire contents of which are incorporated herein by reference.

[Description of Symbols]

[0088]

25	1	Lower traveling body
	1A	Oil hydraulic motor
	2	Swiveling mechanism
	3	Upper swiveling body
	4	Boom
30	5	Arm
	6	Bucket
	7	Boom cylinder
	8	Arm cylinder
	9	Bucket cylinder
35	10	Cabin
	11	Engine
	12	Motor-generator
	13	Transmission
	14	Main pump
40	14A	Regulator
	15	Pilot pump
	16	High pressure oil hydraulic line
	17	Control valve
	18A	Inverter
45	18C	Inverter
	19	Capacitor
	20	Inverter
	21	Swiveling motor
	21A	Rotating shaft
50	22	Resolver
	23	Mechanical brake
	24	Swiveling transmission
	25	Pilot line
	26	Operating device
55	26A	Lever
	26B	Lever
	26C	Pedal
	27	Oil hydraulic line

28	Oil hydraulic line			
29	Pressure sensor			
30	Controller			
100	Step-up and step-down converter			
110	DC bus	5		
111	DC bus voltage detecting unit			
112	Capacitor voltage detecting unit			
113	Capacitor current detecting unit			
120	Electric Storage system			
175B	Bottom-side flow control valve	10		
175R	Rod-side flow control valve			
176B	Bottom-side flow control valve			
176R	Rod-side flow control valve			
300	Motor-generator		5.	The excavator as claimed in claim 4,
310	Oil hydraulic pump-motor	15		
C1	First oil passage			wherein
C2	Second oil passage			when the first oil hydraulic cylinder implements gravity lowering, hydraulic oil flowing out of the first oil hydraulic cylinder into the first oil passage is supplied to the oil hydraulic pump-motor.
C3	Boom cylinder rod-side oil passage			
C4	Boom cylinder bottom-side oil passage			
C5	Arm cylinder rod-side oil passage	20		
C6	Arm cylinder bottom-side oil passage			

Claims

1. An excavator comprising
 flow control valves respectively at rod sides and bottom sides of a plurality of oil hydraulic cylinders, the flow control valves being configured to control flow rates in accordance with pilot pressures. 25
2. The excavator as claimed in claim 1, comprising:
 a first oil passage connecting the flow control valves with an oil hydraulic pump-motor which functions as an oil hydraulic motor utilizing hydraulic oil flowing out of the plurality of oil hydraulic cylinders and functions as an oil hydraulic pump; and 35
 a second oil passage connecting the flow control valves with a hydraulic oil tank, 40
 wherein
 each of the flow control valves is configured to switch between allowing and preventing communication with the first oil passage and between allowing and preventing communication with the second oil passage. 45
3. The excavator as claimed in claim 2, 50
 wherein
 the oil hydraulic pump-motor is mechanically connected with a generator.
4. The excavator as claimed in claim 2, comprising: 55
 a first oil hydraulic cylinder included in the plurality of oil hydraulic cylinders,
5. The excavator as claimed in claim 4,
 wherein
 when the first oil hydraulic cylinder implements gravity lowering, hydraulic oil flowing out of the first oil hydraulic cylinder into the first oil passage is supplied to another oil hydraulic cylinder. 25
6. The excavator as claimed in claim 4,
 wherein
 when the first oil hydraulic cylinder implements gravity lowering, hydraulic oil flowing out of the first oil hydraulic cylinder into the first oil passage is supplied to the rod side of the first oil hydraulic cylinder. 30
7. The excavator as claimed in claim 4,
 wherein
 when the first oil hydraulic cylinder implements gravity lowering, hydraulic oil flowing out of the first oil hydraulic cylinder into the first oil passage is supplied to the first oil passage 35
 is supplied to the rod side of the first oil hydraulic cylinder. 40

FIG.1

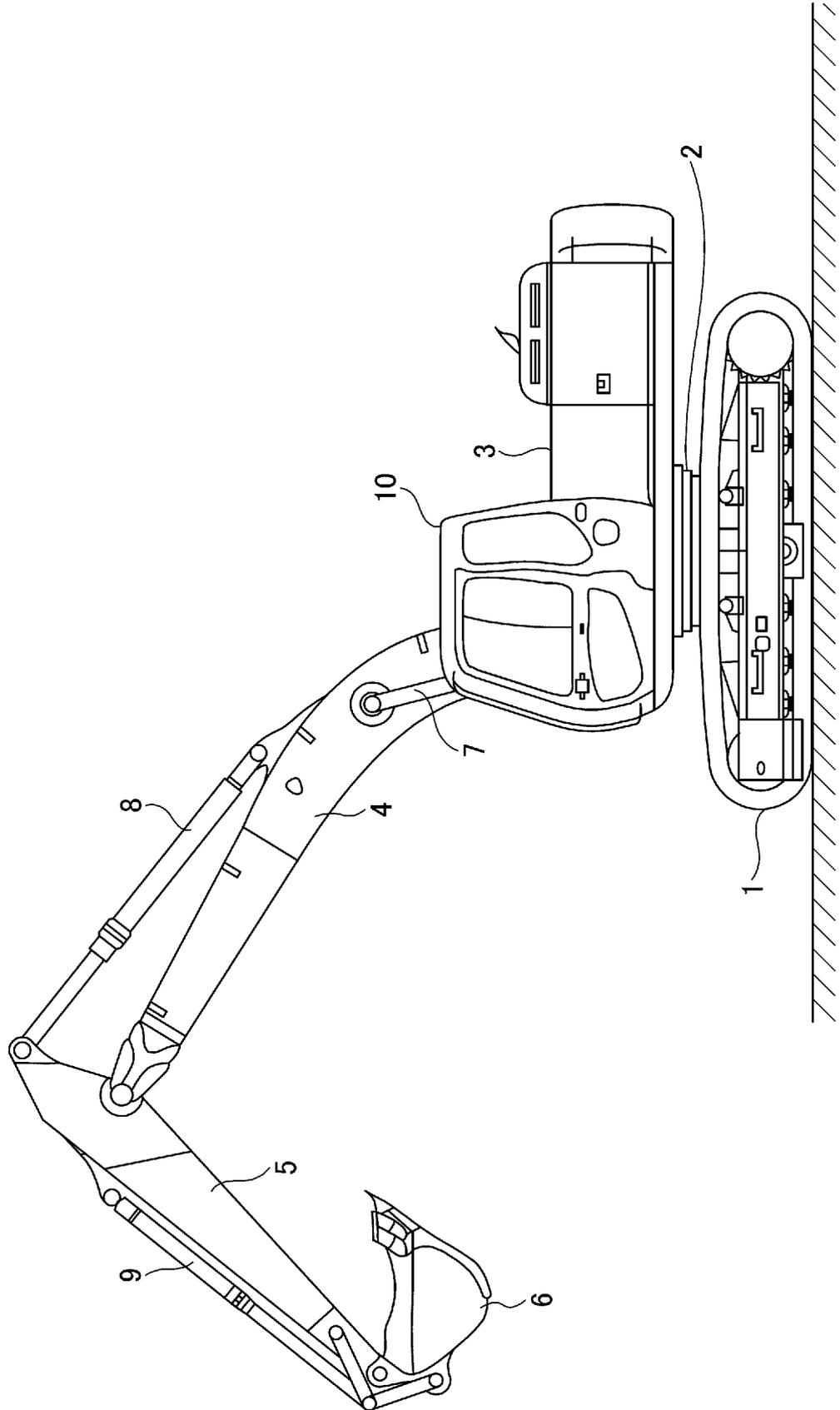
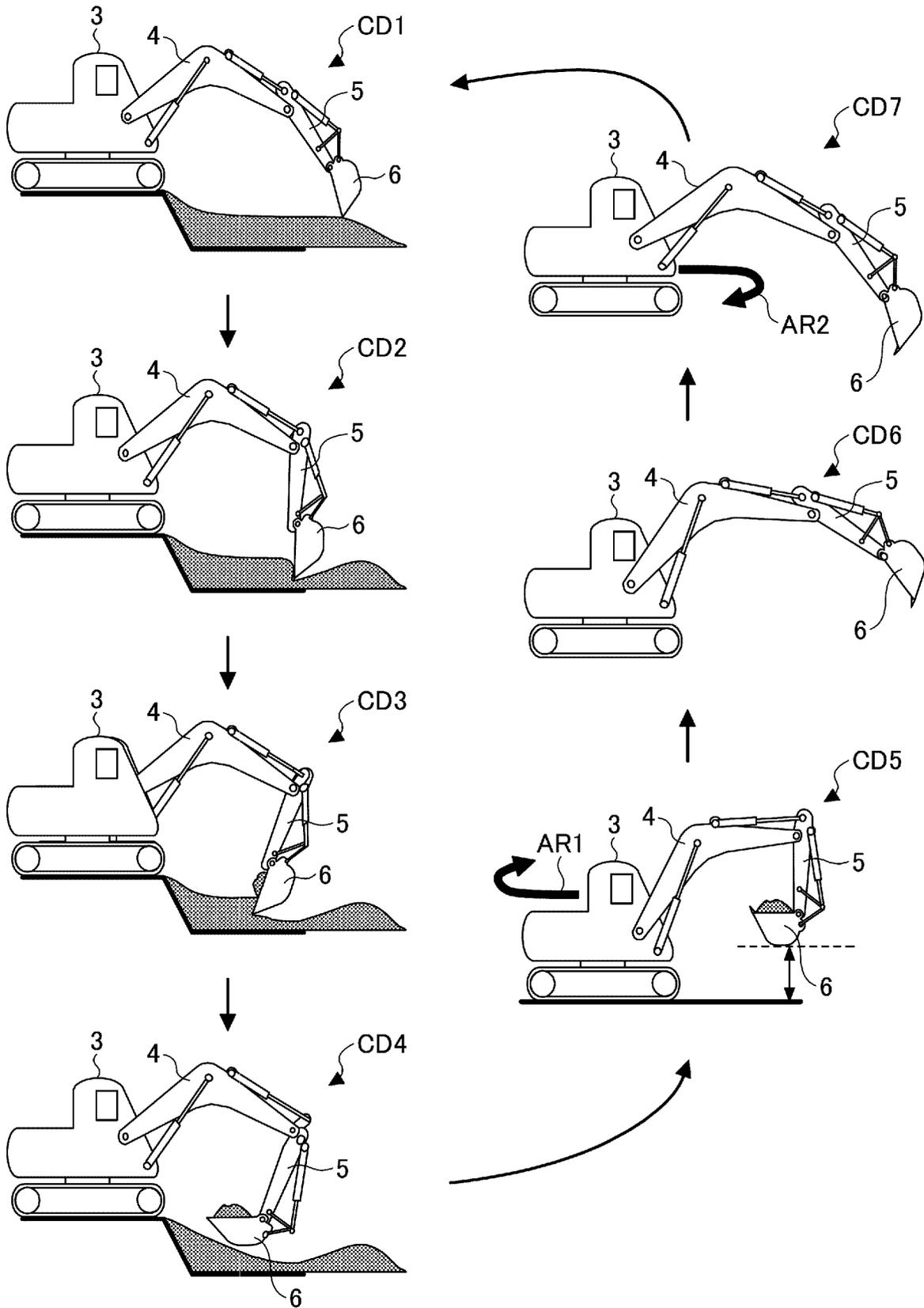


FIG.2



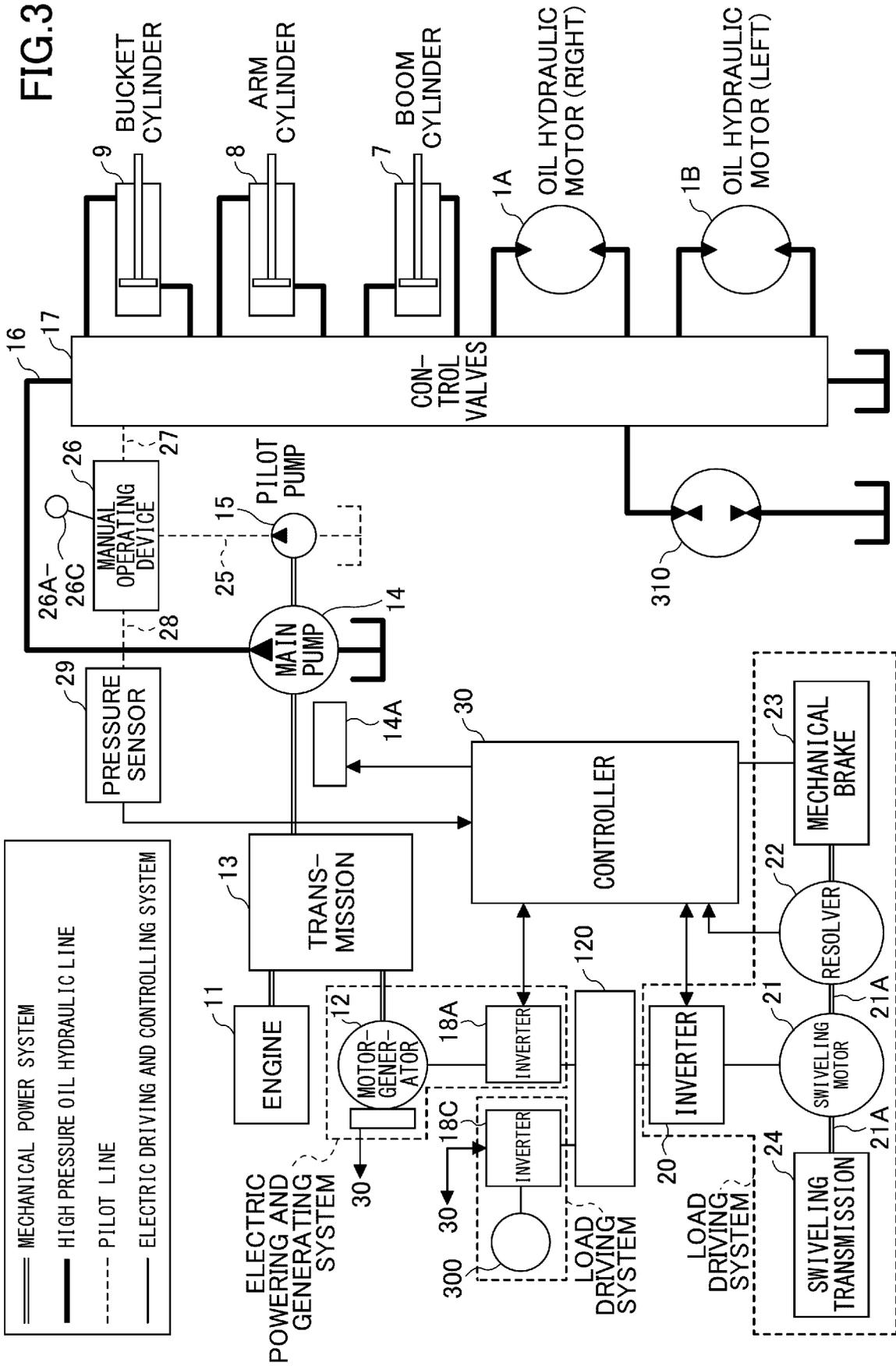


FIG.4

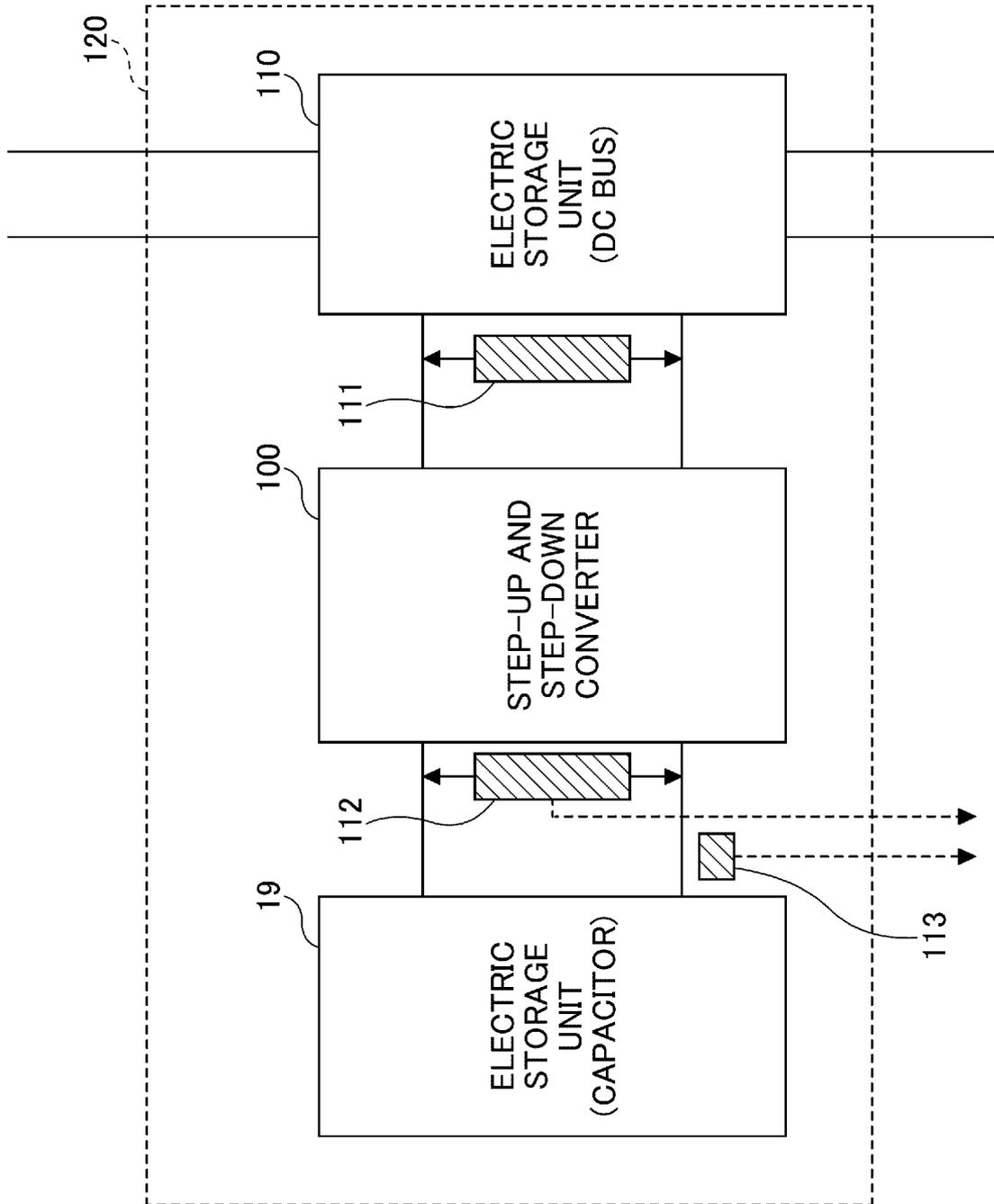


FIG.5

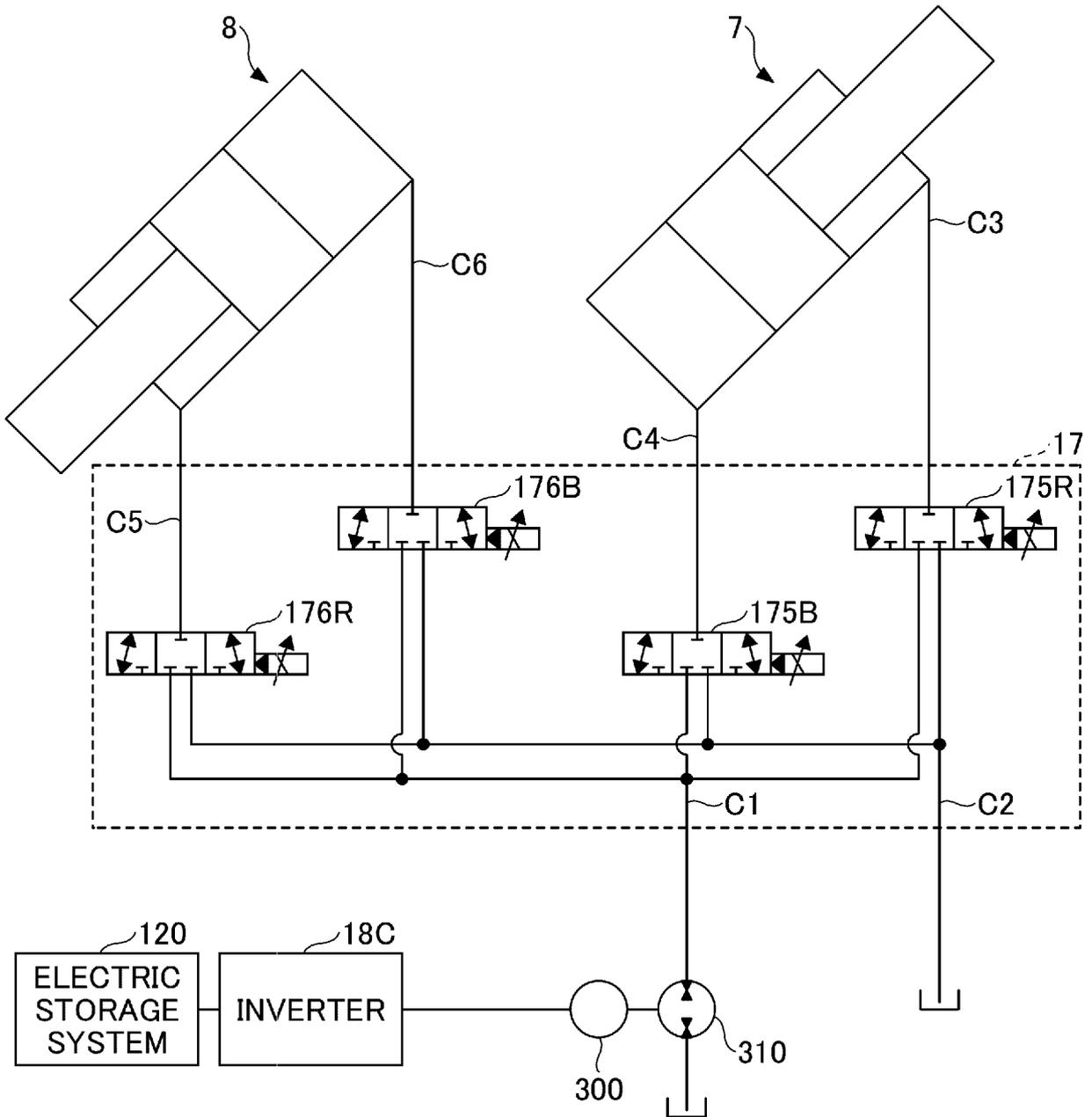


FIG.6

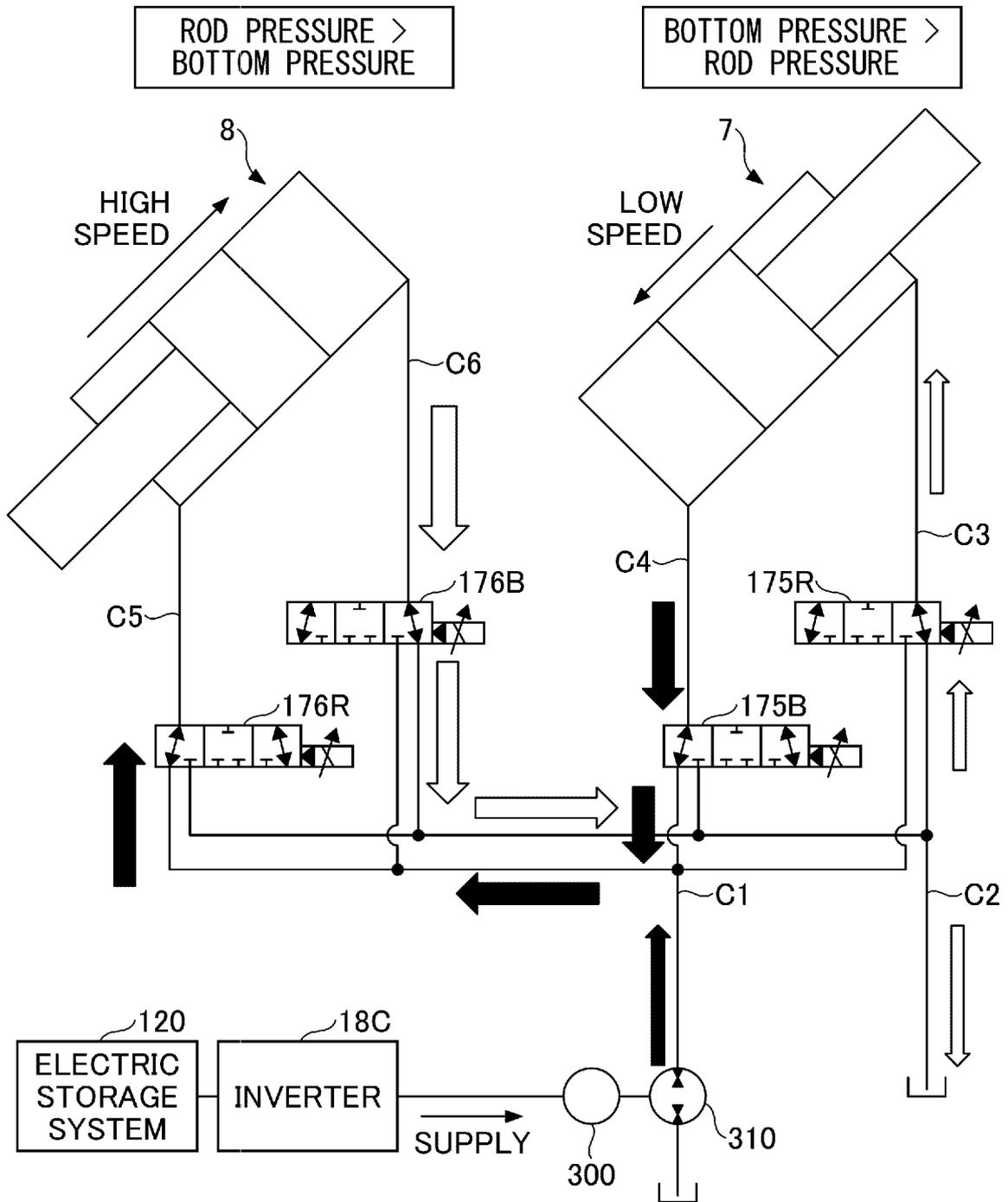


FIG.7

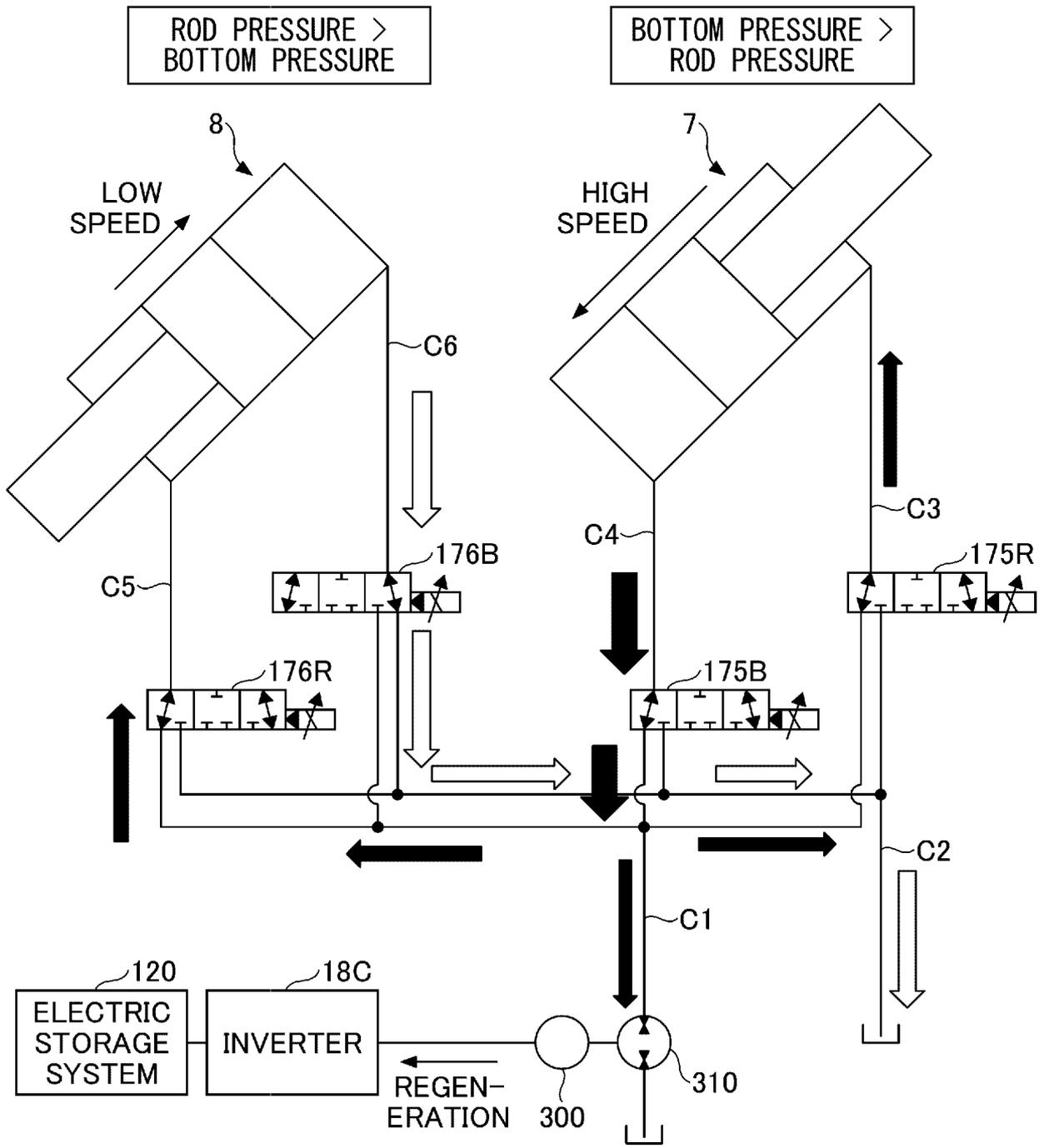


FIG.8

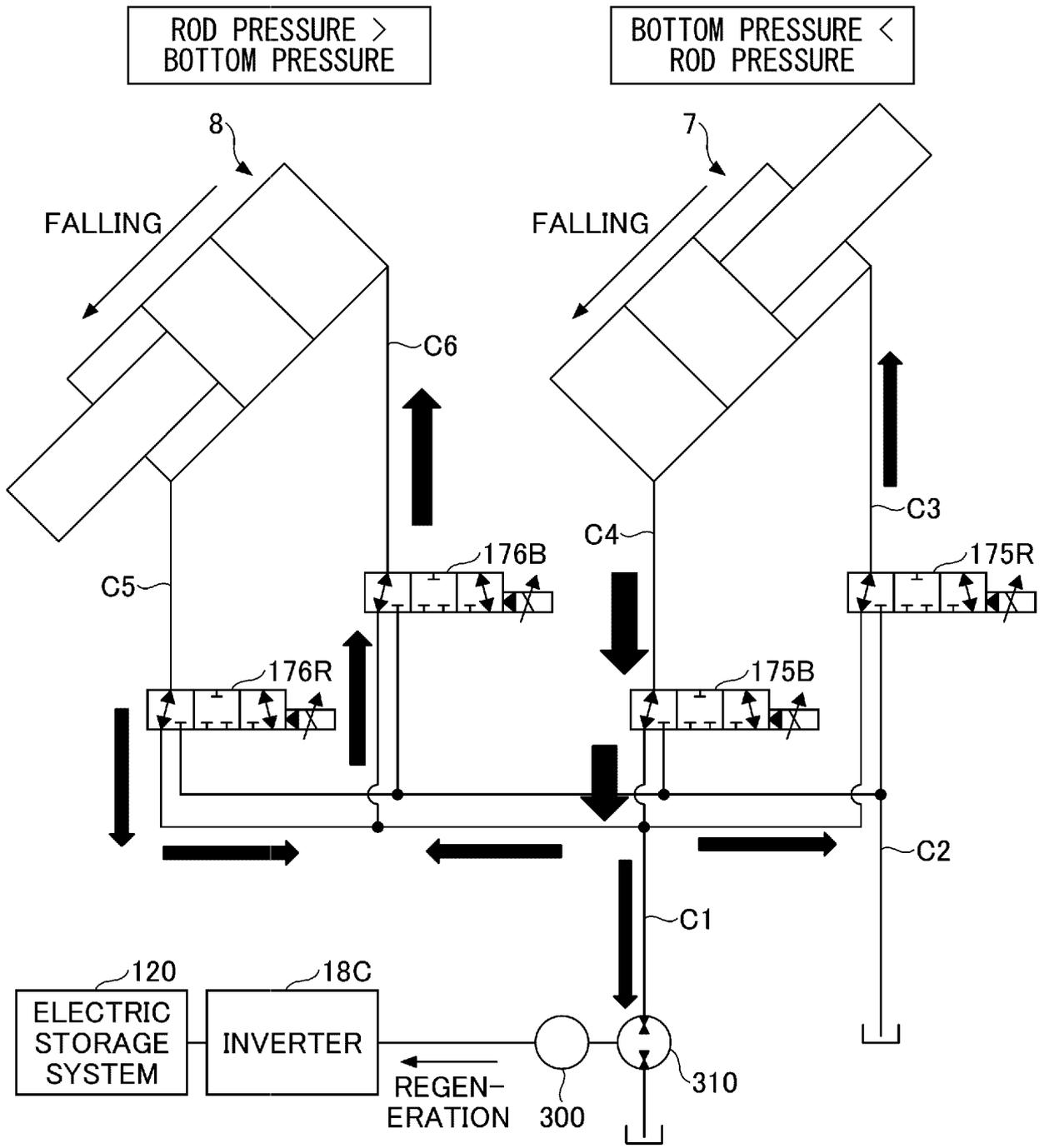


FIG.9

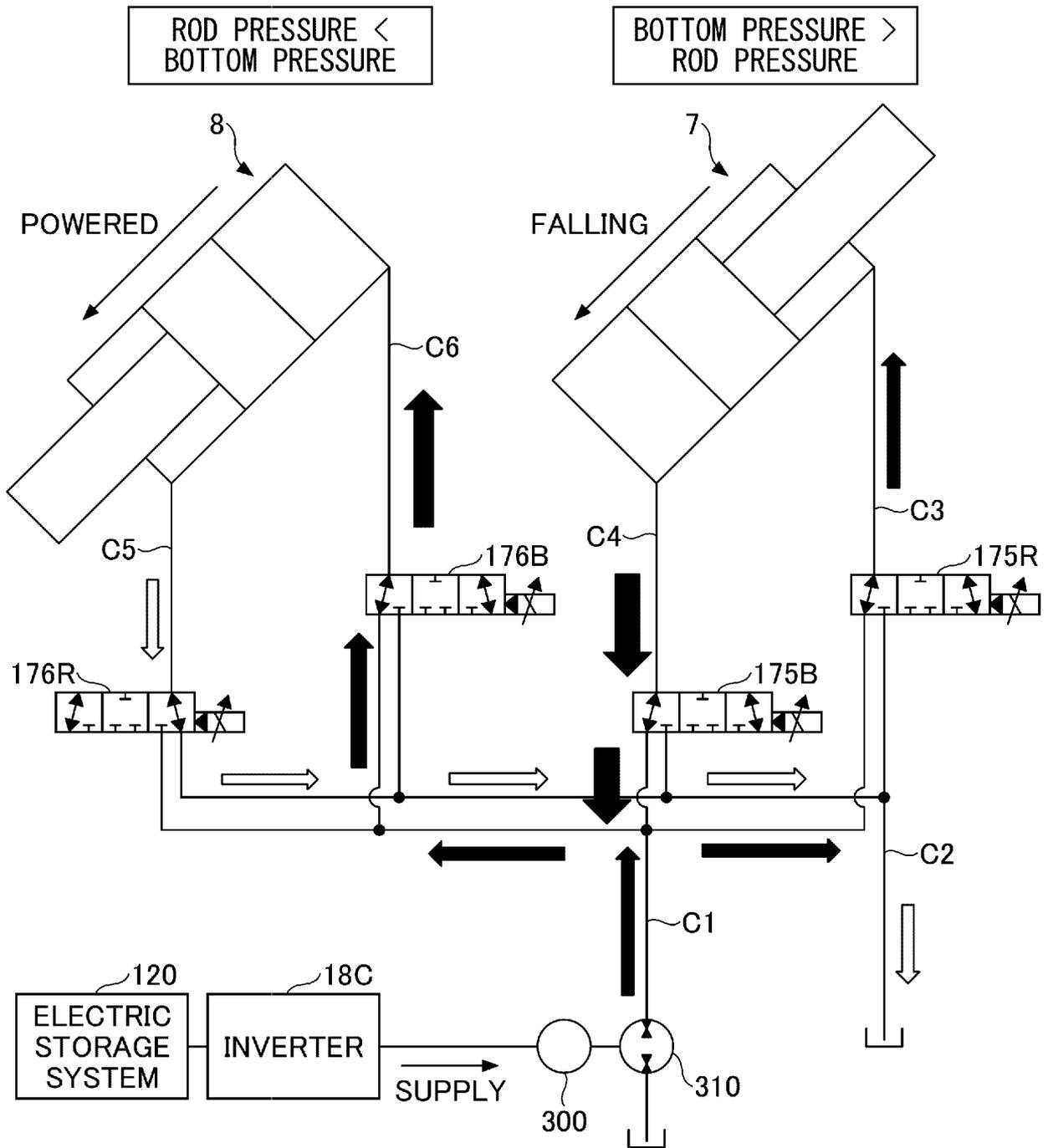


FIG.10

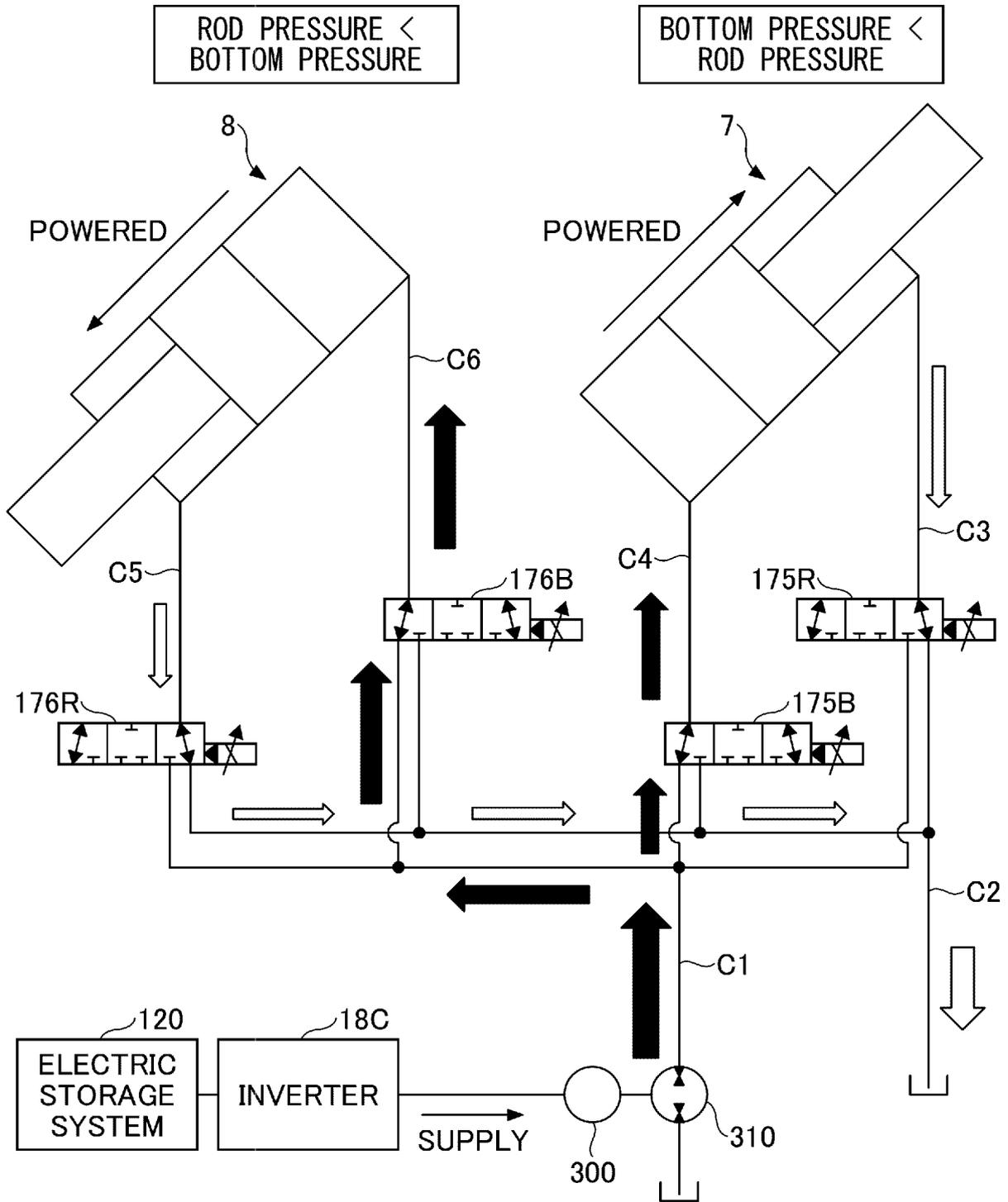


FIG.11

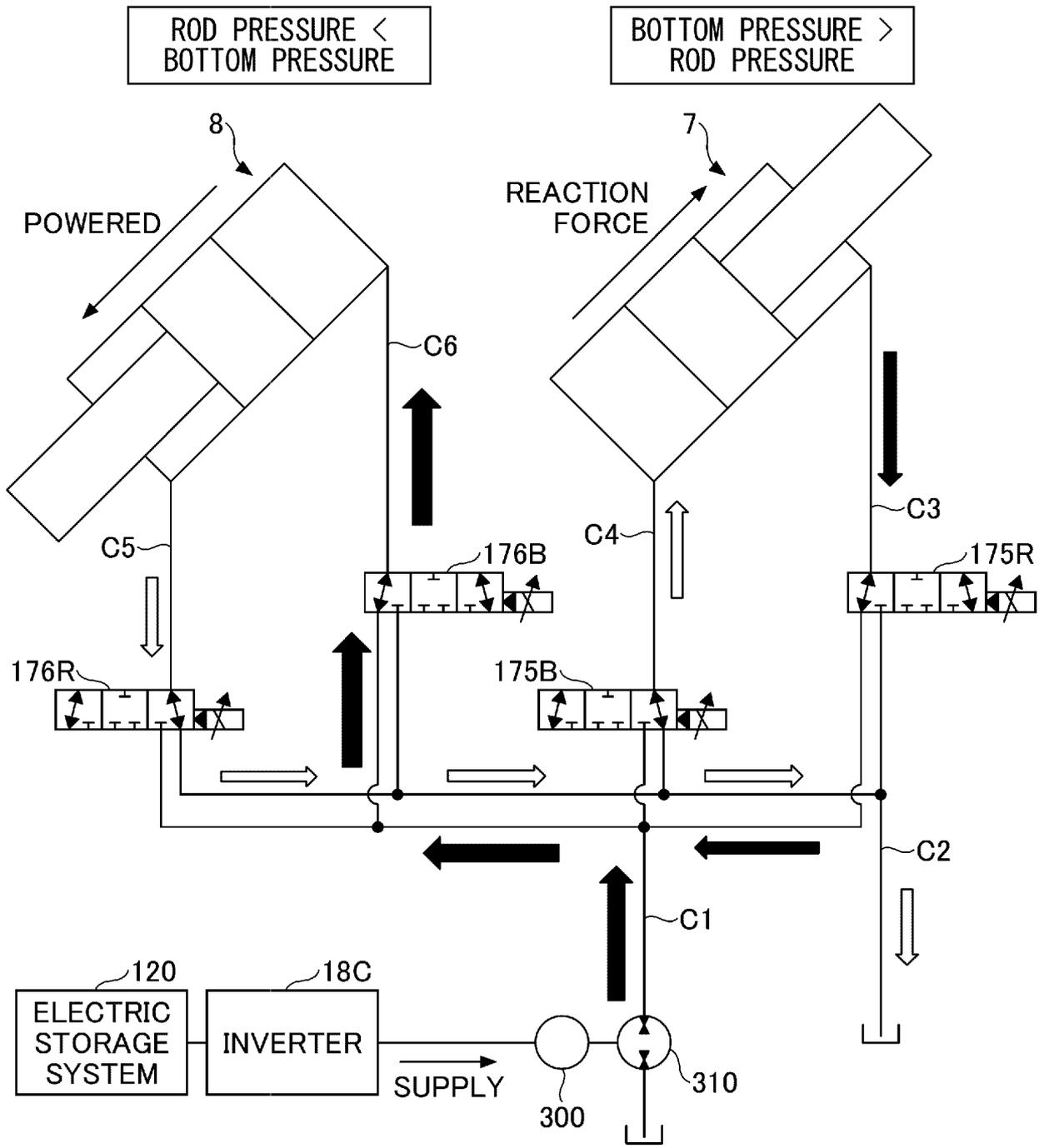
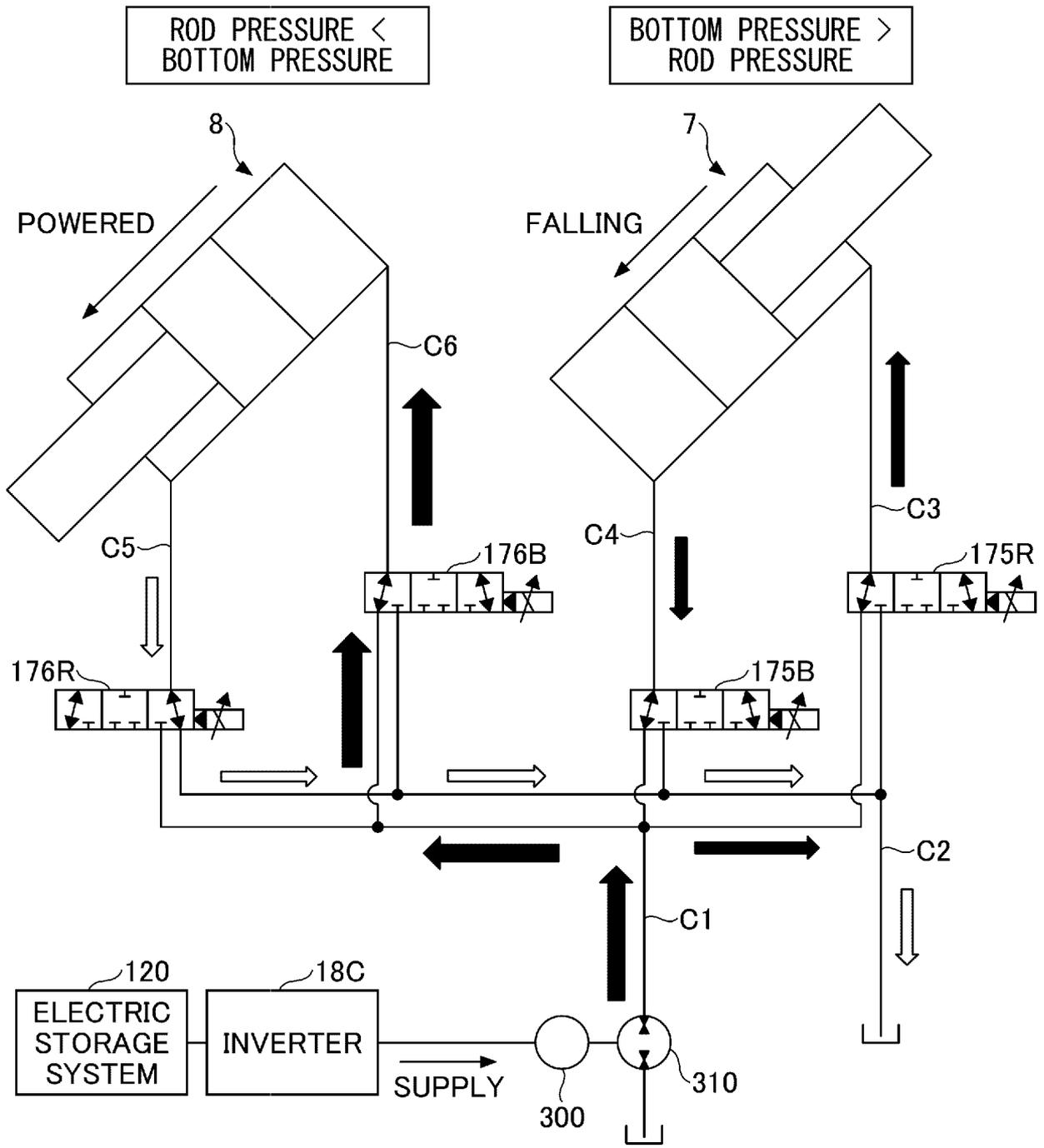


FIG.12



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2020/014184

A. CLASSIFICATION OF SUBJECT MATTER

E02F 9/20(2006.01)i; E02F 9/22(2006.01)i; F15B 11/042(2006.01)i; F15B 11/044(2006.01)i; F15B 11/08(2006.01)i; F15B 21/14(2006.01)i
 FI: E02F9/22 M; E02F9/20 Z; F15B11/042; F15B11/044; F15B21/14 A;
 F15B11/08 A

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)

E02F9/20; E02F9/22; F15B11/042; F15B11/044; F15B11/08; F15B21/14

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	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

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	JP 2011-069432 A (CATERPILLAR SARL) 07.04.2011 (2011-04-07) fig. 1, 2, paragraphs [0022], [0034]-[0037]	1
A	fig. 1, 2, paragraphs [0022], [0034]-[0037]	2-7
T	JP 2018-048698 A (KAWASAKI HEAVY INDUSTRIES, LTD.) 29.03.2018 (2018-03-29) fig. 8, paragraphs [0003]-[0006]	1
A	fig. 8, paragraphs [0003]-[0006]	2-7
A	WO 2019/054365 A1 (KAWASAKI HEAVY INDUSTRIES, LTD.) 21.03.2019 (2019-03-21) fig. 1, paragraphs [0046]-[0047], [0056]	1-7

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
15 June 2020 (15.06.2020)Date of mailing of the international search report
23 June 2020 (23.06.2020)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/014184

5
10
15
20
25
30
35
40
45
50
55

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 2017-125537 A (KYB CORPORATION) 20.07.2017 (2017-07-20) fig. 1, paragraphs [0055], [0060]	1-7
A	JP 2014-190433 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 06.10.2014 (2014-10-06) fig. 2, paragraph [0031]	1-7

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2020/014184

5
10
15
20
25
30
35
40
45
50
55

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP 2011-069432 A	07 Apr. 2011	(Family: none)	
JP 2018-048698 A	29 Mar. 2018	US 2018/0080196 A1 fig. 8, paragraphs [0003]-[0005] CN 107859087 A	
WO 2019/054365 A1	21 Mar. 2019	(Family: none)	
JP 2017-125537 A	20 Jul. 2017	(Family: none)	
JP 2014-190433 A	06 Oct. 2014	(Family: none)	

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2015172393 A [0003]
- JP 2019065019 A [0087]