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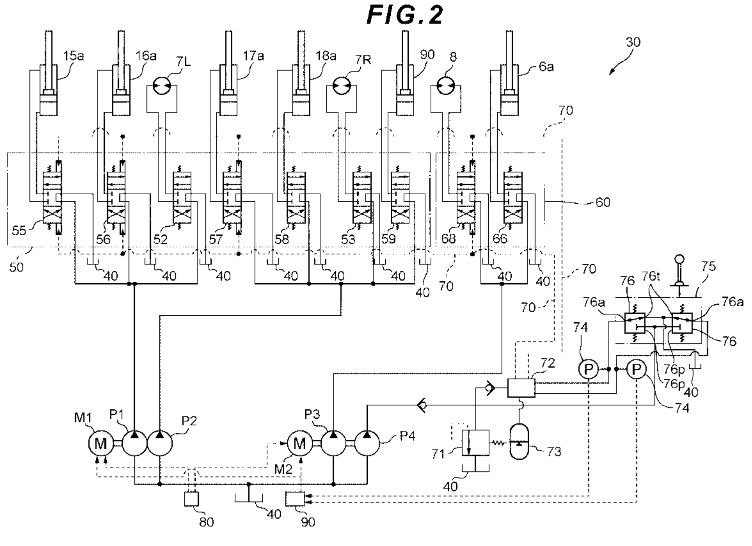
(54) HYDRAULIC CONTROL DEVICE FOR CONSTRUCTION MACHINE

(57) To provide a hydraulic control device for a construction machine, wherein the amount of drive of an electric motor is reduced in order to minimize cost and conserve energy, and wasteful energy consumption can be minimized. The hydraulic control device for a construction machine comprises a hydraulically actuated primary actuator group and a secondary actuator group which is used less frequently than the primary actuator group. The hydraulic control device also comprises primary pumps (P1, P2) for supplying operating oil to the primary actuator group; secondary pumps (P3, P4) for supplying the operating oil to the secondary actuator group; actuator operating means; a remote control valve group (75) and a pilot valve (72) for outputting pilot pressures according to the operated amount of the actuator operation means; a primary control valve group (50) and a secondary control valve group (60), which are driven by the pilot pressures and which control the flow rate of the operating oil supplied to the hydraulic actuators; a first electric motor (M1) for driving the primary pumps (P1, P2); and a second electric motor (M2) for driving the secondary pumps (P3, P4).

FIG.2



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Description

TECHNICAL FIELD

[0001] The present invention relates to a construction machine configured so as to use hydraulic pressure to actuate an actuator, and further relates to a hydraulic control device for a construction machine in which this hydraulic pressure is supplied from a hydraulic pump driven by an electric motor.

TECHNICAL BACKGROUND

[0002] An electric power shovel is an example of an electric construction machine having a configuration in which a hydraulic pump is activated by an electric motor, and operating oil supplied from the hydraulic pump is used to actuate a hydraulic actuator. Possible examples of the hydraulic actuator include a hydraulic motor, a hydraulic cylinder, and the like, and by actuating these hydraulic actuators, the cylinder of a travel device, a revolving device, a boom, an arm, a bucket, or another component is actuated to perform various operations such as traveling and excavating. In addition to traveling and excavating, a power shovel is also capable of performing operations such as revolving a vehicle and moving earth.

[0003] In a construction machine such as a power shovel, usually the hydraulic actuator is designed so that it can be actuated at a speed corresponding to the amount an operating device (e.g., an operating lever) is operated. Specifically, the actuated speed of the hydraulic actuator can be variably adjusted, but this is made possible, for example, by using a pilot pressure drive system for the control valve which controls the supply of hydraulic pressure to the hydraulic actuator, and continuously varying the flow rate of operating oil by adjusting the amount of the pilot pressure being supplied. Such a control valve could be a proportional solenoid valve, for example, wherein the flow rate of operating oil to the control valve is continuously varied by varying the electric current being supplied, or it could be a mechanical lever.

[0004] In a construction machine that uses a pilot pressure drive system as described above, in addition to the hydraulic pump for supplying operating oil to the hydraulic actuator, a pilot hydraulic pump for supplying pilot pressure is also required, and a construction machine has been proposed (see Patent Document 1, for example) wherein these hydraulic pumps are driven by electric devices (electric motors). This construction machine comprises an electric device for activating a hydraulic pump, electric device control means for controlling the electric device, an operating lever or another operating mechanism, and notification means for electrically notifying that operation of the operating mechanism has stopped. The construction machine is configured so that the electric device can be stopped immediately via the notification means when operation of the operating mechanism has been stopped, and is designed so that energy consumption can be minimized during a standby time when operation has been stopped.

[0005] An example of a conventional hydraulic control device 200 provided to such an electrically driven construction machine is shown in FIG. 11. This hydraulic control device 200 is configured comprising hydraulically driven primary pumps P21, P22 and secondary pumps P23, P24, a hydraulic actuator group 210 configured from a plurality of hydraulic cylinders and hydraulic motors, an operating oil tank 240, a control valve group 250, a power source unit 280, an electric motor M, and other components. Furthermore, the hydraulic control device 200 is provided with a pilot valve 260 for supplying pilot pressure to the control valve group 250 via a pilot oil passage 270, the actuating of the control valve group 250 is controlled by this pilot pressure, and the amount of operating oil passing through here and other factors are controlled to supply the oil to the hydraulic actuator group 210.

[0006] In such an electrically driven construction machine, two objects are to reduce the amount of power used by the electric motor or other electrical device and to prolong battery life. In view of this, there are known machines in which a plurality of electric devices and a plurality of inverters are provided, also provided are electricity control means for performing control for reducing the amount of electricity output to any of the plurality of electric devices to minimize the total electricity used when the amount of remaining electricity in the battery (hereinbelow referred to as remaining battery power) supplying electricity to the electric devices and inverters has decreased to a predetermined value or lower, and the electricity control means detects the remaining battery power and reduces the amount of electricity used along with the decrease in the remaining battery power (see Patent Document 2, for example). In such a construction machine, since the actuating rate of the hydraulic actuator is reduced by reducing the amount of electricity output to an electric device, the amount of electricity used can be reduced and an operator can confirm the decrease in remaining battery power.

PRIOR ARTS LIST

PATENT DOCUMENTS

[0007]

Patent Document 1: Japanese Laid-open Patent Publication No. 2008-214970(A)

Patent Document 2: Japanese Laid-open Patent Publication No. 2008-63902(A)

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0008] In the conventional hydraulic control device configured as shown in FIG. 11, a single electric motor

M actuates the traveling of the construction machine, the driving and revolving of the power shovel mechanism, the supply of pilot pressure, and the like. Therefore, there are problems in that it is not possible to set or control factors such as an amount of operating oil suited to the desired drive amount of each hydraulic actuator, operating oil is supplied to the hydraulic pumps needlessly, and the electric motors consume energy needlessly.

[0009] A problem with the electrically driven construction machine disclosed in Patent Document 2 described above is that although the amount of electricity used can be reduced, a plurality of inverters are still needed and cost rises. Another problem is that the space occupied by the devices increases, such as the need to ensure new space for installing the devices because the number of devices increases, and the structure becomes complicated.

[0010] Because of such problems, an object of the present invention is to provide a hydraulic control device for a construction machine wherein the drive rate of an electric motor can be reduced in order to minimize cost and conserve energy, and needless energy consumption can be minimized.

MEANS TO SOLVE THE PROBLEMS

[0011] To resolve the problems described above, the hydraulic control device for a construction machine according to the present invention is part of a construction machine comprising a hydraulically actuated first hydraulic actuator group (e.g., the boom cylinder 15a, arm cylinder 16a, and bucket cylinder 17a in the embodiments) and a hydraulically actuated second hydraulic actuator group (e.g., the revolution motor 8 in the embodiments) used less frequently than the first hydraulic actuator group, and having mechanisms driven by the first hydraulic actuator group and the second hydraulic actuator group, the hydraulic control device comprising a first hydraulic pump (e.g., the primary pumps P1, P2 in the embodiments) for supplying the first hydraulic actuator group with operating oil for actuating the first hydraulic actuator group, a first electric motor for driving the first hydraulic pump, a second hydraulic pump (e.g., the secondary pumps P3, P4 in the embodiments) for supplying the second hydraulic actuator group with operating oil for actuating the second hydraulic actuator group, the second hydraulic pump having a lower volume than the first hydraulic pump, a second electric motor for driving the second hydraulic pump, first hydraulic actuator operating means (e.g., the boom operation lever, arm operation lever, and bucket operation lever of the operating means 20 in the embodiments) operated in order to perform actuation control on the first hydraulic actuator group, second hydraulic actuator operating means (e.g., the revolution operation lever of the operating means 20 in the embodiments) operated in order to perform actuation control on the second hydraulic actuator group, pilot pressure output means (e.g., the pilot valve 72 and the remote control valve group 75 in the embodiments) which uses operating oil supplied by the second hydraulic pump to output a pilot pressure according to the operation of the first hydraulic actuator operating means and the second hydraulic actuator operating means, a first operating oil control valve (e.g., the primary control valve group 50 in the embodiments) which is driven by a first pilot pressure outputted by the pilot pressure output means in accordance with the operation of the first hydraulic actuator operating means, and which performs flow rate control on the operating oil supplied from the first hydraulic pump to the first hydraulic actuator group so that the flow rate of the operating oil reaches a rate corresponding to the first pilot pressure, and a second operating oil control valve (e.g., the secondary control valve group 60 in the embodiments) which is driven by a second pilot pressure outputted by the pilot pressure output means in accordance with the operation of the second hydraulic actuator operating means, and which performs flow rate control on the operating oil supplied from the second hydraulic pump to the second hydraulic actuator group so that the flow rate of the operating oil reaches a rate corresponding to the second pilot pressure.

[0012] The pilot pressure output means preferably has an accumulator which stores operating oil supplied by the second hydraulic pump and which can output this stored operating oil with a steady oil pressure.

[0013] The hydraulic control device for a construction machine preferably further comprises pilot pressure detection means (e.g., the pressure sensor 74 in the embodiments) for detecting a value of the pilot pressure outputted by the pilot pressure output means, and motor control means (e.g., the control device 90) for detecting the pilot pressure value detected by the pilot pressure detection means and causing the second electric motor to be driven when the pilot pressure value is equal to or less than a predetermined value.

[0014] Furthermore, the first electric motor is preferably selected based on a frequency distribution of actuating torque for the first hydraulic actuator group, and the second electric motor is preferably selected based on a frequency distribution of actuating torque for the secondary actuator group.

[0015] In the hydraulic control device for a construction machine of the above configuration, the first hydraulic pump may be configured from a variable-volume hydraulic pump, and the hydraulic control device may comprise volume-varying means (e.g., the volumetric cylinder 137 in the embodiments) for varying the maximum permissible volume of the first hydraulic pump, a battery for supplying the first electric motor with electricity for driving the first electric motor, and a controller which detects remaining battery power of the battery and performs a control for actuating the volume-varying means and reducing the maximum permissible volume of the first hydraulic pump in accordance with a decrease in the remaining battery power.

[0016] In this case, a switch (e.g., the energy-saving mode switch 20a in the embodiments) is preferably provided which can switch the controller between performing and not performing the control for reducing the maximum permissible volume of the first hydraulic pump.

[0017] Furthermore, preferably, the second hydraulic pump is configured from a variable-volume hydraulic pump, the hydraulic control device comprises second volume-varying means for varying the maximum permissible volume of the second hydraulic pump, electricity for driving the second electric motor is supplied to the second electric motor from the battery, and the hydraulic control device is configured so that the controller detects the remaining battery power of the battery and performs a control for actuating the second volume-varying means and reducing the maximum permissible volume of the second hydraulic pump in accordance with the decrease in the remaining battery power. In this case, a second switch is preferably provided which can switch the controller between performing and not performing the control for reducing the maximum permissible volume of the second hydraulic pump.

ADVANTAGEOUS EFFECTS OF THE INVENTION

[0018] As described above, in the hydraulic control device for a construction machine according to the present invention, first and second electric motors are provided respectively to the first hydraulic pump for supplying operating oil to the first hydraulic actuator group and the second hydraulic pump for supplying operating oil to the second hydraulic actuator group. Consequently, it is possible, for example, to use the first electric motor for travel and for driving the power shovel mechanism and to use the second electric motor for revolving and for actuating the blade. The second hydraulic pump can therefore be activated at low rotation during travel, there is no need to uselessly activate the electric motors, and energy can therefore be conserved.

[0019] In the hydraulic control device for a construction machine according to the present invention, when an accumulator is provided, the operating oil for supplying pilot pressure can be stored and oil pressure maintained, and it is therefore possible to actuate the first hydraulic actuator group while the second hydraulic pump has been stopped rather than activated. Furthermore, providing the motor control means makes it possible to activate the electric motors solely when pilot pressure is needed, and the activation of the electric motors can therefore be further minimized.

[0020] Furthermore, in the hydraulic control device for a construction machine according to the present invention, the first and second electric motors are selected based on the respective frequency distributions of the actuating torques of the first and second hydraulic actuators, whereby the motor efficiency of the first electric motor and second electric motor can be improved.

[0021] The hydraulic pumps are variable volume models, and the controller detects the remaining battery power performs a control for causing the volume-varying means to reduce the maximum volumes of the hydraulic pumps in accordance with the decrease in the detected remaining battery power, whereby it is possible to reduce the amount of electricity used and extend the life of the battery while minimizing cost and the space occupied by the machinery and maintaining a simple configuration. Furthermore, due to the hydraulic pumps being volume variable models, even when the load suddenly increases, the pumps' own pressures are fed back to prevent the absorption torques of the hydraulic pumps from increasing, and the maximum electric current therefore ceases to flow from the battery as shown in FIG. 10B. Therefore, it is possible to prevent the above-described sudden drops in voltage, the output of voltage drop errors, and stopping of the construction machine.

[0022] By providing the controller with a switch that enables selection of either reducing the maximum volumes of the hydraulic pumps or not reducing the maximum volumes, it is possible to make the controller not reduce the maximum volumes in cases such as when work must be performed quickly.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023]

FIG. 1 is a side view of a power shovel showing an example of a construction machine in which the hydraulic control device according to the present invention is applied;

FIG. 2 is a hydraulic circuit showing a hydraulic control device for performing actuating control of a hydraulic actuator of the power shovel;

FIG. 3 shows graphs comparing cases in which two electric motors are used and one electric motor is used in the hydraulic control device, wherein FIGS. 3A and 3B show the frequency distribution of torque in a case in which four hydraulic pumps are activated by one electric motor and a case in which two hydraulic pumps are activated (two primary pumps in FIG. 3A and two secondary pumps in FIG. 3B), and FIG. 3C is a graph showing the torque characteristics of two electric motors;

FIG. 4 contains graphs showing the relationship between pilot pressure and secondary pump rotational speed in the hydraulic control device;

FIG. 5 is a hydraulic circuit showing a second hydraulic control device according to the second embodiment;

FIG. 6 is a graph showing the P-Q characteristics of the hydraulic pumps before and after the maximum volume of the hydraulic pumps is reduced in the second hydraulic control device;

FIG. 7 contains views showing the relationship between the oil pressure and the electric current outputted by the battery and the relationship between the oil pressure and the rotational speed of the electric motor in the hydraulic control device, wherein FIG. 7A is a graph showing the relationship between oil pressure and electric current in normal mode or energy-saving mode and FIG. 7B is a graph showing the relationship between oil pressure and the rotational speed of the electric motor;

FIG. 8A and FIG.8B contain graphs showing the relationship between the volume (discharge volume) of the hydraulic pumps and the remaining battery power in the hydraulic control device;

FIG. 9A is a view of the hydraulic control device showing a modification of the configuration of the controller and volumetric cylinder periphery, FIG. 9B is a graph showing the relationship between discharge volume and discharge pressure in the case of no elastic member in the volumetric cylinder in this modification, FIG. 9C is a graph showing the relationship between discharge volume and discharge pressure in the case of an elastic member in the volumetric cylinder in this modification;

FIG. 10A and FIG.10B contain graphs showing the variations in voltage and electric current caused by varying the pump pressure as well as their relationship with time, wherein FIG. 10A is a graph of a case in which a fixed volume hydraulic pump is used and FIG. 10B is a graph of a case in which a variable volume hydraulic pump is used; and

FIG. 11 is a hydraulic circuit diagram showing an example of a conventional hydraulic control device.

DESCRIPTION OF THE EMBODIMENTS

[0024] Preferred embodiments of the present invention are described hereinbelow with reference to FIG. 1. A crawler-type power shovel 1 (hereinbelow referred to as a power shovel 1) is described as an example of the construction machine according to the present invention. The power shovel 1 described herein is an electrically driven construction machine which actuates using electricity, and, having the same essential configuration as the conventional example, is configured from a travel device 2 having a pair of left and right crawler travel mechanisms, a revolving mechanism 3 provided to the top of the travel device 2, a driver cabin 4 provided to the top of the revolving mechanism 3 and capable of horizontal revolution, a power shovel mechanism 5 attached to the front of the driver cabin 4 and capable of horizontal revolution, a blade 6 (an earth-moving plate) provided to be free to swing o the rear of the driver cabin 4, and other components.

[0025] The travel device 2 is configured from crawler mechanisms provided to the left and right sides of a travel frame 2d, the crawler mechanisms being composed of drive wheels 2a, driven wheels 2b, and crawler belts 2c wrapped around the drive wheels 2a and driven wheels 2b. These mechanisms are configured so that the drive wheel 2a provided to the right side is driven by a right travel hydraulic motor 7R (see FIG. 2), and the drive wheel 2a provided to the left side is driven by a left travel hydraulic motor 7L (see FIG. 2). The revolving mechanism 3 is provided to the center top part of the travel frame 2d, and the revolving mechanism 3 is designed so that by tilting a revolution operating lever of an operating device 20 described hereinafter, the driving of a revolution motor 8 (see FIG. 2) described hereinafter can be controlled to revolvably drive the driver cabin 4.

[0026] A vehicle body frame 9 is provided in the bottom of the driver cabin 4, a hydraulic control device 30, described hereinafter, is mounted in the top of the vehicle body frame 9 and in the rear of the driver cabin 4, and the hydraulic control device 30 is covered by a cover member 13. The driver cabin 4 is provided with an operator seat 11 in which the operator can ride and the operating device 20 for operating the various actions of the power shovel 1 as shown in FIG. 1, and by riding in the operator seat 11 and operating the operating device 20, the operator can operate the actions of the power shovel 1.

[0027] The power shovel mechanism 5 is configured from a boom 15 which is pivotally connected so as to be free to horizontally revolve or swing on a main body pivotally connecting part 14 formed protruding toward the front of the vehicle body frame 9, an arm 16 pivotally connected to the distal end of the boom 15 so as to be capable of swinging up and down in the same vertical plane, and a bucket 17 pivotally connected to the distal end of the arm 16 so as to be capable of swinging up and down in the same vertical plane. A swing-side pivotally connected part 18 and a swinging cylinder 18a are provided to the front of the vehicle body frame 9, and the swing-side pivotally connected part 18 can be swung by the reciprocating action of the swinging cylinder 18a. A boom cylinder 15a which causes the boom 15 to swing up and down is provided as a connection between the swing-side pivotally connected part 18 and the boom 15, an arm cylinder 16a which causes the arm 16 to swing up and down is provided as a connection between the boom 15 and the arm 16, and a bucket cylinder 17a and link 17b which cause the bucket 17 to swing up and down are provided as a connection between the arm 16 and the bucket 17. The blade 6 is designed so that it can be swung by the reciprocating action of a blade cylinder 6a.

[0028] The power shovel 1 also comprises a quick hitch mechanism (not shown) for disengaging a chip breaker, an auger device, and other various attachments at the distal end of the arm 16; and a quick hitch cylinder 90 (see FIG. 2) described hereinafter for actuating the attachments engaged by the quick hitch mechanism. The supplied amount and supply direction of operating oil supplied to the quick hitch cylinder 90 can be controlled and the actuating of the attachments attached to the quick hitch mechanism can be controlled by the hydraulic control device 30 described hereinafter.

[0029] The hydraulic actuators described above (the left and right travel hydraulic motors 7L, 7R, the boom cylinder 15a, the arm cylinder 16a, the bucket cylinder

17a, the swinging cylinder 18a, the blade cylinder 6a, the revolution motor 8, the quick hitch cylinder 90) are actuated by the supply of operating oil (oil pressure), and the hydraulic control device 30 (see FIG. 2) controls the amount and direction of operating oil supplied to the hydraulic actuators in accordance with the operation of the operating device 20 by the operator, thereby causing the power shovel 1 to travel, the power shovel mechanism 5 to actuate, the driver cabin 4 to revolve, etc.; and enabling traveling, excavating, revolving, and other operations. The operating device 20 is configured from a travel operation lever for operating the travel of the power shovel 1, a revolving operation lever for operating the revolution of the driver cabin 4, a boom operation lever for performing operations of the boom, arm, bucket, and other components, an arm operation lever, a bucket operation lever, and the like.

[0030] The operations performed by the power shovel 1 described above are mostly excavating (the actuating of the power shovel mechanism 5) and traveling (these are referred to as the main operations hereinbelow). Operations such as the revolving of the driver cabin 4 and the reciprocating of the blade 6 (hereinbelow referred to as the sub-operations) are supplementary to the main operations, and are therefore used less frequently than the main operations. Specifically, when these operations are performed, eight tenths of the total operating oil being supplied to the hydraulic actuators is supplied for the actuating of the boom, arm, and bucket, i.e. for excavating (actuating the power shovel mechanism 5), while the other two tenths is supplied for traveling, revolving the driver cabin 4, and the like. Thus, while excavating (actuating the power shovel mechanism 5) requires a large amount of operating oil, the other operations require only a small amount of operating oil in comparison with actuating the power shovel mechanism 5.

[0031] The conventional hydraulic control device is configured from a control valve for controlling factors such as the amount of operating oil supplied to the hydraulic actuators, a hydraulic pump for discharging operating oil, an electric motor for activating the hydraulic pump, an operating oil tank for storing operating oil, and other components, but the conventional hydraulic control device is often provided with only one electric motor. In such a hydraulic control device, since the actuating of all of the hydraulic actuators is performed by one electric motor, a problem occurs in that the electric motor is driven at the same drive rate as operations requiring a large amount of operating oil even when performing operations that do not require a large amount of operating oil, operating oil is repeatedly supplied and relieved needlessly, and energy is consumed needlessly.

[0032] In view of this, in the present embodiment, the travel motors 7L, 7R, the boom cylinder 15a, the arm cylinder 16a, the bucket cylinder 17a, and the swinging cylinder 18a for performing the main operations such as traveling and excavating are designated as the primary actuator group, the revolution motor 8 and the blade cylinder 6a for performing the sub-operations are designated as the secondary actuator group, and different electric motors and hydraulic pumps are used for the primary actuator group and the secondary actuator group. Specifically, the operating oil supplied to the primary actuator group is supplied by the first and second hydraulic pumps P1, P2 (hereinbelow referred to as the primary pumps P1, P2), and the primary pumps P1, P2 are driven by a first electric motor M1, as shown in FIG. 2. The operating oil supplied to the secondary actuator group and a hereinafter-described pilot oil passage 70 is supplied by the third and fourth hydraulic pumps P3, P4 (hereinbelow referred to as the secondary pumps P3, P4, and the secondary pumps P3, P4 are driven by a second electric motor M2. The first and second electric motors M1, M2 receive AC voltage from a power source unit 80 configured from a battery and an inverter, whereby the motors are driven. The power shovel 1 in the present embodiment uses a so-called manual system (link system), and when the power shovel 1 is traveling, revolving and other actions are not performed, nor are the secondary pumps P3, P4 activated. Therefore, traveling is categorized as a main operation and the driving thereof is achieved by the supply of operating oil from the primary pumps P1, P2.

[0033] Thus, a total of two electric motors are provided, one for the supply of operating oil to the primary actuator group and one for the supply of operating oil to the secondary actuator group, thereby making it possible to reduce the amount of operating oil supplied during the sub-operations (revolving and blade reciprocating) which do not require a large amount of operating oil, and also to prevent needless energy consumption.

[0034] The hydraulic control device 30 is configured comprising a primary control valve group 50, a secondary control valve group 60, the above-described primary pumps P1, P2 and secondary pumps P3, P4, the first and second electric motors M1, M2, and an operating oil tank 40, as shown in FIG. 2. The primary control valve group 50 is configured from left and right travel control valves 52, 53, a boom control valve 55, an arm control valve 56, a bucket control valve 57, a swing control valve 58, and a quick hitch control valve 59 which respectively control the operating oil supplied to the travel motors 7L, 7R, the boom cylinder 15a, the arm cylinder 16a, the bucket cylinder 17a, the swinging cylinder 18a, and the quick hitch cylinder 90. The secondary control valve group 60 is configured comprising a blade control valve 66 and a revolving control valve 68 for controlling the operating oil supplied to the blade cylinder 6a and the revolution motor 8.

[0035] The boom control valve 55, the arm control valve 56, the bucket control valve 57, and the revolving control valve 68 are each configured comprising a spool, and are also configured so that the spools move according to the pilot pressure of the operating oil supplied through a remote control valve group 75 (described in detail hereinafter) and a pilot valve 72 (described in detail hereinafter), which are opened and closed by the secondary pump P4 according to the amount the operating device 20 is operated. The operating oil is supplied from the pilot valve 72 through the pilot oil passage 70 to the boom control valve 55, the arm control valve 56, the bucket control valve 57, and the revolving control valve 68, and the supply of operating oil to the boom cylinder 15a, the arm cylinder 16a, the bucket cylinder 17a, and the revolution motor 8 can be controlled by the movement of the spools. In addition to the aforementioned remote control valve group 75 and pilot valve 72, the pilot oil passage 70 is also provided with a relief valve 71, an accumulator 73, a pressure sensor 74, and other components.

[0036] The relief valve 71 is a valve for relieving the operating oil tank 40 of operating oil when the pilot pressure has risen above a predetermined set value, and is provided between the pilot valve 72 and the operating oil tank 40. This pilot pressure is detected by the pressure sensor 74 which is provided between the pilot valve 72 and the remote control valve group 75, and the detected pilot pressure is transmitted to a control device 90. The control device 90 is designed to be capable of controlling the activation (rotational speed) of the secondary pumps P3, P4 on the basis of the detected value.

[0037] The remote control valve group 75 is configured from a revolution motor remote control valve 76, a boom cylinder actuation remote control valve, an arm cylinder actuation remote control valve, and a bucket cylinder actuation remote control valve, which are driven respectively by a revolving operation lever, a boom operation lever, an arm operation lever, and a bucket operation lever. Since the revolution motor remote control valve 76, the boom cylinder actuation remote control valve, the arm cylinder actuation remote control valve, and the bucket cylinder actuation remote control valve all have the same configuration, only the revolution motor remote control valve 76 is described hereinbelow, and only the revolution motor remote control valve 76 is shown in FIG. 2.

[0038] The revolution motor remote control valve 76 has a P port (a pump port) 76p, a T port (a tank port) 76t, and an A port 76a; and the secondary pump P4 is connected to the P port 76p, the operating oil tank 40 is connected to the T port 76t, and the pilot valve 72 is connected to the A port 76a. The P port 76p is usually blocked, but when the revolving operation lever is operated, the P port 76p is communicated with the A port 76a, operating oil from the secondary pump P4 is supplied to the pilot oil passage 70, and the pilot pressure (remote control pressure) thereof is outputted to the revolving control valve 68 via the pilot oil passage 70.

[0039] The accumulator 73 is provided as being connected to the pilot valve 72, and is capable of storing up the operating oil discharged from the secondary pump P4. When the supply of operating oil from the secondary pump P4 is stopped, the accumulator 73 is capable of releasing the stored up operating oil to the pilot oil passage 70, and oil pressure can be maintained by this storing up and releasing of operating oil. Since the power shovel 1 uses a manual system (a link system) as described above, providing this accumulator 73 makes it possible to temporarily completely stop the secondary pump P4 supplying the pilot pressure while the power shovel 1 is traveling. Specifically, even when the secondary pump P4 is stopped, the pilot pressure can be supplied from the pilot valve 72 to the hydraulic actuators (described in detail hereinafter) by the release of operating oil from the accumulator 73.

[0040] In the hydraulic control device 30 configured as described above, the needless supply of operating oil can be reduced by providing respective electric motors (the first and second electric motors M1, M2) to the primary actuator group and the secondary actuator group, and the reasons for this are described while referring to FIG.3. FIGS. 3A and B show the respective torque frequency distributions in a case in which the primary pumps P1, P2 and the secondary pumps P3, P4 are activated using only one electric motor M, and a case in which the first and second electric motors M1, M2 are used, wherein the primary pumps P1, P2 are activated by the first electric motor M1 and the secondary pumps P3, P4 are activated by the second electric motor M2. In the graphs of FIGS. 3A and B, the dashed lines show a torque frequency distribution in a case of one electric motor M and the solid lines show a torque frequency distribution in a case of two electric motors (M1, M2). FIG. 3A shows the torque frequency distribution of the first electric motor M1, and FIG. 3B shows the torque frequency distribution of the second electric motor M2.

[0041] When these torque frequency distributions are compared, in the case of using one electric motor as shown in FIG. 3A, the torque frequency distribution remains substantially uniform between 0 and 50 (Nm). In the case of using two electric motors, the actuator connected to the first electric motor M1 is different from the actuator connected to the second electric motor M2, and the torque frequency distributions of the first electric motor M1 and the second electric motor M2 therefore concentrate at different values. Therefore, the electric motors can be efficiently utilized by selecting motors with similar frequency distributions and torque characteristics as the first and second electric motors M1, M2. For example, in a case in which the torque frequency distribution of the first electric motor M1 concentrates at 25 Nm as shown in FIG. 3A, the energy of the electric motor can be efficiently utilized by selecting a motor 102 having characteristics such that the torque frequency distribution concentrates at 25 Nm as shown in FIG. 3C as the first electric motor M1.

[0042] FIG. 4 is referenced to describe the relationship between the pilot pressure when the power shovel 1 is traveling and the rotational speed of the secondary pump P4 whose maximum rotational speed is 3800 rpm, for example, in the hydraulic control device 30. First, the pilot pressure at time 0 is 3.5 MPa, and the accumulation of pressure in the accumulator 73 is complete at this time. After the secondary pump P4 has been stopped in this state, if the excavating operation is performed by the various operation levers of the operating device 20, the excavating operation can be continued by the pilot pressure of the operating oil because the operating oil whose pressure has accumulated in the accumulator 73 is released. When the operating oil proceeds to be released by the accumulator 73, the pilot pressure begins to gradually decrease, and when the control device 90 has detected that the pilot pressure has decreased to 1.0 MPa, for example, the control device 90 activates the secondary pump P4 at approximately 1000 rpm, far lower than the maximum rotational speed. After the secondary pump P4 has been activated, the pilot pressure begins to rise and the accumulator 73 again begins to accumulate pressure. The control device 90 then again stops the secondary pump P4 upon detecting that the pilot pressure has risen to 3.5 MPa, for example.

[0043] Thus, the operations of the power shovel 1 can be continued even if the secondary pump P4 has been temporarily completely stopped. Furthermore, even when the pilot pressure has decreased, there is no need to rotate the secondary pump P4 at the maximum rotational speed (3800 rpm), and pilot pressure can still be supplied even if the secondary pump P4 is activated at a lower rotation. The aforementioned pilot pressure upper limit (3.5 MPa) and lower limit (1.0 MPa) and the rotational speed (1000 rpm) of the secondary pump P4 are not limited to the aforementioned values and can be varied as desired.

[0044] The hydraulic control device in the embodiment described above is provided with a total of two electric motors, one for the primary actuator group and one for the secondary actuator group, whereby the supply of needless energy by the electric motors can be reduced. Providing the accumulator 73 makes it possible to reduce or temporarily stop the rotational speed of the secondary pump P4, and an energy conservation effect can be achieved.

[0045] The present invention should not be interpreted as being limited to the embodiment described above, and suitable improvements can be made within a range that does not deviate from the scope of the present invention. For example, in the embodiment described above, an example was described in which the accumulator 73 was provided and the rotational speed of the secondary pump P4 was reduced or temporarily stopped, but the rotational speeds of the primary pumps P1, P2 can also be reduced or temporarily stopped by providing the same accumulators to the oil passages for operating oil supplied from the primary pumps P1, P2.

[0046] In the embodiment described above, an example was described in which the first and second electric motors M1, M2 were provided respectively to the primary pumps P1, P2 and the secondary pumps P3, P4, thereby allowing different torque frequency distributions to be obtained and the energy of the electric motors to be efficiently utilized, but the method of disposing electric motors is not limited to this example, and electric motors may also be provided respectively to the first hydraulic pump P1 and the second hydraulic pump P2, for example. Different torque frequency distributions can be obtained and the energy of the electric motors can be more efficiently utilized even when the electric motors are provided in this manner.

[0047] Next, a second preferred embodiment according to the present invention will be described. In this embodiment as well, a crawler-type power shovel 1 having the same configuration as described above is used as the construction machine according to the present invention. Structural components identical to those of the power shovel 1 are denoted by the same numbers and are not described.

[0048] This embodiment has a description of the primary actuator group for performing the above-described main operations (the left and right travel motors 7L, 7R, the boom cylinder 15a, the arm cylinder 16a, the bucket cylinder 17a, and the swinging cylinder 18a), and the configuration for controlling the supply of operating oil (oil pressure) to the main operation actuator group. In this embodiment, a hydraulic control device 110 is provided for performing operating oil supply control for the main operation actuator group. This hydraulic control device 110 is configured as shown in FIG. 5, and the amount and direction of operating oil supplied to the hydraulic actuators are controlled according to the operation of the operating device 20 by the operator, thereby enabling traveling, excavating, and other operations of the power shovel 1.

[0049] The hydraulic control device 110 is configured comprising first and second control valve groups 120, 130, first and second hydraulic pumps P1, P2, an electric motor M, an inverter 136, a volumetric cylinder 137, first and second pressure sensors 138, 139, an operating oil tank 140, a controller 150, a battery 160, and other components, as shown in FIG. 5. The first control valve group 120 is configured comprising a left travel control valve 121, a boom travel control valve 122, and a bucket control valve 132 for performing controls such as the amount of operating oil supplied to the left travel motor 7L, the boom cylinder 15a, and the bucket cylinder 17a, respectively. The second control valve group 130 is configured comprising a right travel control valve 131, an arm control valve 123, and a swing control valve 133 for performing controls such as the amount of operating oil supplied to the right travel motor 7R, the arm cylinder 16a, and the swinging cylinder 18a, respectively. The boom travel control valve 122, the arm control valve 123, and the bucket control valve 132 each house a spool, and the spools can be moved by pilot pressure supplied from a pilot valve (not shown). Factors such as the amount of operating oil supplied to the boom cylinder 15a, the arm cylinder 16a, and the bucket cylinder 17a can be controlled by this spool movement.

[0050] The first and second hydraulic pumps P1, P2 are provided in order to perform the traveling and excavating of the power shovel 1 (the actuating of the power shovel mechanism 5), connected with the output shaft (not shown) of the electric motor M, and configured so as to both discharge operating oil obtained from the operating oil tank 140 along with the driving of the electric motor M. The first and second hydraulic pumps P1, P2 are so-called swash plate piston pumps having swash plates (not shown), wherein the angles of the swash plates can be varied. The amount of operating oil discharged (discharge amount) can be varied by varying these angles.

[0051] In the first and second hydraulic pumps P1, P2 in the present embodiment, the discharge volume is not controlled (feedback control) based on the pressure of the discharged operating oil (the detected values of the first and second pressure sensors 138, 139 described hereinafter). Therefore, the discharge volumes of the first and second hydraulic pumps P1, P2 do not fluctuate even if the load torque of the electric motor M increases and the discharge pressure fluctuates, as shown in FIG. 6. The electric motor M is driven by a supply of AC electricity which has a predetermined voltage and frequency and which has been converted via the inverter 136 from DC electricity supplied from the battery 160 described hereinafter.

[0052] The first and second pressure sensors 138, 139 are provided so as to be connected to the oil passages of the operating oil supplied from the first and second hydraulic pumps P1, P2 respectively, and the first pressure sensor 138 detects the pressure of operating oil discharged from the first hydraulic pump P1, while the second pressure sensor 139 detects the pressure of operating oil discharged from the second hydraulic pump P2. The oil pressures detected by the first and second pressure sensors 138, 139 are both outputted to the controller 150.

[0053] The controller 150 is capable of detecting the remaining battery power from the value of the electric current supplied from the battery 160 described hereinafter, and the controller 150 outputs a volume variation signal to the volumetric cylinder 137 in accordance with the detected remaining battery power. The volumetric cylinder 137 is configured to be free to reciprocate, and is designed so as to reciprocate according to the volume variation signal. The angles of the swash plates of the first and second hydraulic pumps P1, P2 can be varied according to this reciprocation, and the volumetric cylinder 137 can vary the maximum volumes of the first and second hydraulic pumps P1, P2 by varying the angles of the swash plates.

[0054] The battery 160 is provided in order to supply DC electricity to the inverter 136 and the controller 150, and the maximum value of the battery's output electric current is 30 A in this embodiment. The pressure of the operating oil discharged from the first and second hydraulic pumps P1, P2 increases in proportion to this output electric current. Both the relationship between the size of the electric current supplied from the battery 160 and the pressure (oil pressure) of the operating oil discharged from the first and second hydraulic pumps P1, P2, and the relationship between the rotational speed of the electric motor M and the oil pressure, are such that when the load torque of the electric motor M increases, the rotational speed of the electric motor M is maintained at a constant value as shown in FIGS. 7A and B, and the oil pressure and electric current supplied from the battery 160 therefore increase as well. When the load torque reaches a certain constant value or greater, the electric current reaches an upper limit of 30 A and does not increase any further, and the rotational speed of the electric motor M decreases. The output of the electric motor M is 7 kW in the present embodiment.

[0055] The operating device 20 is configured from a travel operating lever for operating the travel of the power shovel 1; and a boom operating lever, an arm operating lever, a bucket operating lever, and the like for operating a boom, an arm, a bucket, and other components. The operating device 20 is provided with an energy-saving mode switch 20a, the energy-saving mode switch 20a is capable of being turned on and off, and the energy-saving mode switch 20a can switch to an energy-saving mode when turned on and switched to a normal mode when turned off. When the energy-saving mode switch 20a is turned on to switch to energy-saving mode, the controller 150 performs a control for reducing the maximum volume of the first and second hydraulic pumps P1, P2 in accordance with the decrease in remaining battery power of the battery 160. Specifically, when the maximum volume of the first and second hydraulic pumps P1, P2 is lowered as shown by the arrow and dashed line in FIG. 6, the discharge volumes do not exceed the maximum volume even if the discharge pressure decreases, and the amount of electricity output by the battery 160 can therefore be minimized. Thus, in energy-saving mode, the amount of electricity can be minimized by reducing the maximum volume and the battery 160 can be used over a longer period of time. In normal mode, on the other hand, the controller 150 is not made to reduce the maximum volume of the first and second hydraulic pumps P1, P2, and the controller 150 can be made to actuate the hydraulic actuators quickly.

[0056] In the hydraulic control device 110 configured as described above, by providing energy-saving mode and making the controller 150 perform control so that the maximum volume of the first and second hydraulic pumps P1, P2 is reduced according to the decrease in the remaining battery power, the electricity consumed by the battery 160 is minimized and the active time duration can be extended. The operating speed also decreases when energy-saving mode is activated and the volume of the first and second hydraulic pumps P1, P2 is reduced, but it is also possible to not lower oil pressure (power), and the operator can be made aware from this speed decrease that the remaining battery power has decreased. Specifically, when the first and second hydraulic pumps P1, P2 are activated at a point in time when the remaining battery power is 100%, during which the maximum volume of the first and second hydraulic pumps P1, P2 is 4.5 cc/rev, for example, the remaining battery power gradually decreases from 100% as shown in FIG. 8. When the controller 150 then detects that the remaining battery power has decreased to 50%, the controller outputs a volume variation signal to the volumetric cylinder 137, and the volumetric cylinder 137 varies the angles of the swash plates of the first and second hydraulic pumps P1, P2 to reduce the maximum volume. At this time, the speeds of the hydraulic actuators decrease, and the operator can perceive that the remaining battery power is low. The maximum volume is designed to decrease to 3.0 cc/rev when the remaining battery power reaches 0%.

[0057] As described above, since the hydraulic control device 110 in the above-described embodiment is capable of reducing the maximum volume of the first and second hydraulic pumps P1, P2 in accordance with the decrease in the remaining battery power, the active time duration of the battery 160 can be extended. During energy-saving mode in which the maximum volume of the first and second hydraulic pumps P1, P2 is reduced in accordance with the decrease in remaining battery power, the electric current output from the battery 160 can be reduced in comparison with normal mode in which the maximum volume is not varied, as shown in FIG. 7A.

[0058] In the embodiment described above, an example was described in which the first and second pressure sensors 138, 139 detect the pressures of operating oil discharged from the first and second hydraulic pumps P1, P2 respectively, the detected values are output to the controller 150, and the controller 150 outputs a volume variation signal to the volumetric cylinder 137 to vary the volume of the first and second hydraulic pumps P1, P2, but the configurations of the controller and volumetric cylinder are not limited to this example.

[0059] For example, in the hydraulic control device 110 having a configuration such as the one shown in FIG. 5, signal conversion means (not shown) for converting electric signals to oil pressure signals, such as a proportional valve, must be provided between the controller 150 and the volumetric cylinder 137. In view of this, this type of configuration may be modified and an ON-OFF valve 145, which communicates with the oil passages of operating oil discharged from the first and second hydraulic pumps P1, P2, may be provided between the oil passages and the volumetric cylinder 137 as shown in FIG. 9A. With this type of configuration, the first and second pressure sensors 138, 139 can be omitted, the ON-OFF valve 145 and the controller 150 can be less expensive models than the proportional valve and the controller described above, and the overall cost of the hydraulic control device can therefore be lowered.

[0060] The volumetric cylinder 137 in the configuration shown in FIG. 9A can have a spring or another elastic member attached, and the relationship between discharge volume and pressure of the first and second hydraulic pumps P1, P2 in the case of no elastic member is shown in FIG. 9B, while the relationship in the case of the elastic member is shown in FIG. 9C. Specifically, in the case of no elastic member, the first and second hydraulic pumps P1, P2 are configured to vary their volumes based on their own pressures, and the discharge volume in energy-saving mode (refer to the dashed line in FIG. 9B) is therefore the same as the discharge volume during normal mode (refer to the solid line in FIG. 9B) when the discharge pressure is 0, but the discharge volume decreases progressively as the pressure increases from 0, and after decreasing to a certain extent, the discharge volume remains constant even if the pressure is then increased. In the case of an elastic member, on the other hand, the discharge volume in energy-saving mode (refer to the dashed line in FIG. 9C) is the same as the discharge volume during normal mode (refer to the solid line in FIG. 9C) even if the discharge pressure is increased to a certain extent from 0, but the pressure gradually decreases upon reaching a predetermined value or greater. This predetermined value can be varied by using an elastic member of a different elastic force as the elastic member of the volumetric cylinder 137.

[0061] Thus, with a configuration such as the one shown in FIG. 9A, cost can be lowered, and the relationship between the discharge volume and discharge pressure of the pumps can be varied as shown in FIGS. 9B and C, for example, by attaching and detaching the elastic member to and from the volumetric cylinder 137 and by varying the elastic force of the elastic member. Furthermore, the discharge volume can be reduced incrementally according to the increase in discharge pressure, and so-called two-stage control can be performed in which the discharge pressure is varied in two stages.

[0062] The present invention should not be interpreted to be limited to the above embodiments, and suitable improvements can be made within a range that does not deviate from the scope of the present invention. For example, in the present embodiment, an example was described in which two hydraulic pumps were provided, but the number of hydraulic pumps is not limited to two, and the present invention can still be applied even if one, three, or more pumps are provided. The output of the electric motor M (7.0 kW), the maximum volumes of the first and second hydraulic pumps P1, P2 (4.5 cc/rev and 3.0 cc/rev), and the maximum output electric current of the battery 160 (30 A) are not limited to these values and can be varied as desired.

[0063] Furthermore, in the embodiments described above, an example was described in which a crawler-type power shovel 1 was used as an example of the construction machine, but the present invention is not limited to a power shovel and can also be applied to a shovel loader, a hydraulic crane, and other construction machines, for example.

EXPLANATION OF NUMERALS AND CHARACTERS

[0064]

P1, P2: first and second hydraulic pumps (primary pumps)
P3, P4: third and fourth hydraulic pumps (secondary pumps)
M1: first electric motor
M2: second electric motor
1: power shovel (construction machine)
8: revolving motor (secondary actuator group)
15a: boom cylinder (primary actuator group)
16a: arm cylinder (primary actuator group)
17a: bucket cylinder (primary actuator group)
20: operating device (actuator operating means)
30: hydraulic control device
50: primary control valve group (operating oil control valves)
60: secondary control valve group (operating oil control valves)
72: pilot valve (pilot pressure output means)
73: accumulator
74: pressure sensor
75: remote control valve group (pilot pressure output means)
90: control device (motor control means)

Claims

1. A hydraulic control device for a construction machine comprising a hydraulically actuated first hydraulic actuator group and a hydraulically actuated second hydraulic actuator group used less frequently than the first hydraulic actuator group, and also having a mechanism driven by the first hydraulic actuator group and the second hydraulic actuator group, the hydraulic control device comprising:

a first hydraulic pump for supplying the first hydraulic actuator group with operating oil for actuating the first hydraulic actuator group;
a first electric motor for driving the first hydraulic pump;
a second hydraulic pump for supplying the second hydraulic actuator group with operating oil for actuating the second hydraulic actuator group, the second hydraulic pump having a lower volume than the first hydraulic pump;
a second electric motor for driving the second hydraulic pump;
first hydraulic actuator operating means operated in order to perform actuation control on the first hydraulic actuator group;
second hydraulic actuator operating means operated in order to perform actuation control on the second hydraulic actuator group;
pilot pressure output means which uses operating oil supplied by the second hydraulic pump to output a pilot pressure according to the operation of the first hydraulic actuator operating means and the second hydraulic actuator operating means;
a first operating oil control valve which is driven by a first pilot pressure outputted by the pilot pressure output means in accordance with the operation of the first hydraulic actuator operating means, and which performs flow rate control on the operating oil supplied from the first hydraulic pump to the first hydraulic actuator group so that the flow rate of the operating oil reaches a rate corresponding to the first pilot pressure; and
a second operating oil control valve which is driven by a second pilot pressure outputted by the pilot pressure output means in accordance with the operation of the second hydraulic actuator operating means, and which performs flow rate control on the operating oil supplied from the second hydraulic pump to the second hydraulic actuator group so that the flow rate of the operating oil reaches a rate corresponding to the second pilot pressure.

2. The hydraulic control device for a construction machine according to claim 1, **characterized in that** the pilot pressure output means has an accumulator which stores operating oil supplied by the second hydraulic pump and which can output this stored operating oil with a steady oil pressure.

3. The hydraulic control device for a construction machine according to claim 1 or 2, further comprising:

pilot pressure detection means for detecting a value of the pilot pressure outputted by the pilot pressure output means; and
motor control means for detecting the pilot pressure value detected by the pilot pressure detection means and causing the second electric motor to be driven when the pilot pressure value is equal to or less than a predetermined value.

4. The hydraulic control device for a construction machine according to any of claims 1 through 3, **characterized in that** the first electric motor is selected based on a frequency distribution of actuating torque for the first hydraulic actuator group, and the second electric motor is selected based on a frequency distribution of actuating torque for the secondary actuator group.

5. The hydraulic control device for a construction machine according to any of claims 1 through 4, **characterized in that**:

the first hydraulic pump is configured from a variable-volume hydraulic pump;
the hydraulic control device further comprising:

volume-varying means for varying a maximum permissible volume of the first hydraulic pump;
a battery for supplying the first electric motor with electricity for driving the first electric motor; and
a controller which detects remaining battery power of the battery and performs a control for actuating the volume-varying means and reducing the maximum permissible volume of the first hydraulic pump in accordance with a decrease in the remaining battery power.

6. The hydraulic control device for a construction machine according to claim 5, **characterized in** being provided with a switch capable of switching the controller between performing and not performing the control for reducing the maximum permissible volume of the first hydraulic pump.

7. The hydraulic control device for a construction machine according to claim 5 or 6, **characterized in that**:

the second hydraulic pump is configured from a variable-volume hydraulic pump;
the hydraulic control device comprises second volume-varying means for varying the maximum permissible volume of the second hydraulic pump;
electricity for driving the second electric motor is supplied to the second electric motor from the battery; and
the hydraulic control device is configured so that the controller detects the remaining battery power of the battery and performs a control for actuating the second volume-varying means and reducing the maximum permissible volume of the second hydraulic pump in accordance with the decrease in the remaining battery power.

8. The hydraulic control device for a construction machine according to claim 7, **characterized in** being provided with a second switch capable of switching the controller between performing and not performing the control for reducing the maximum permissible volume of the second hydraulic pump.

FIG.1

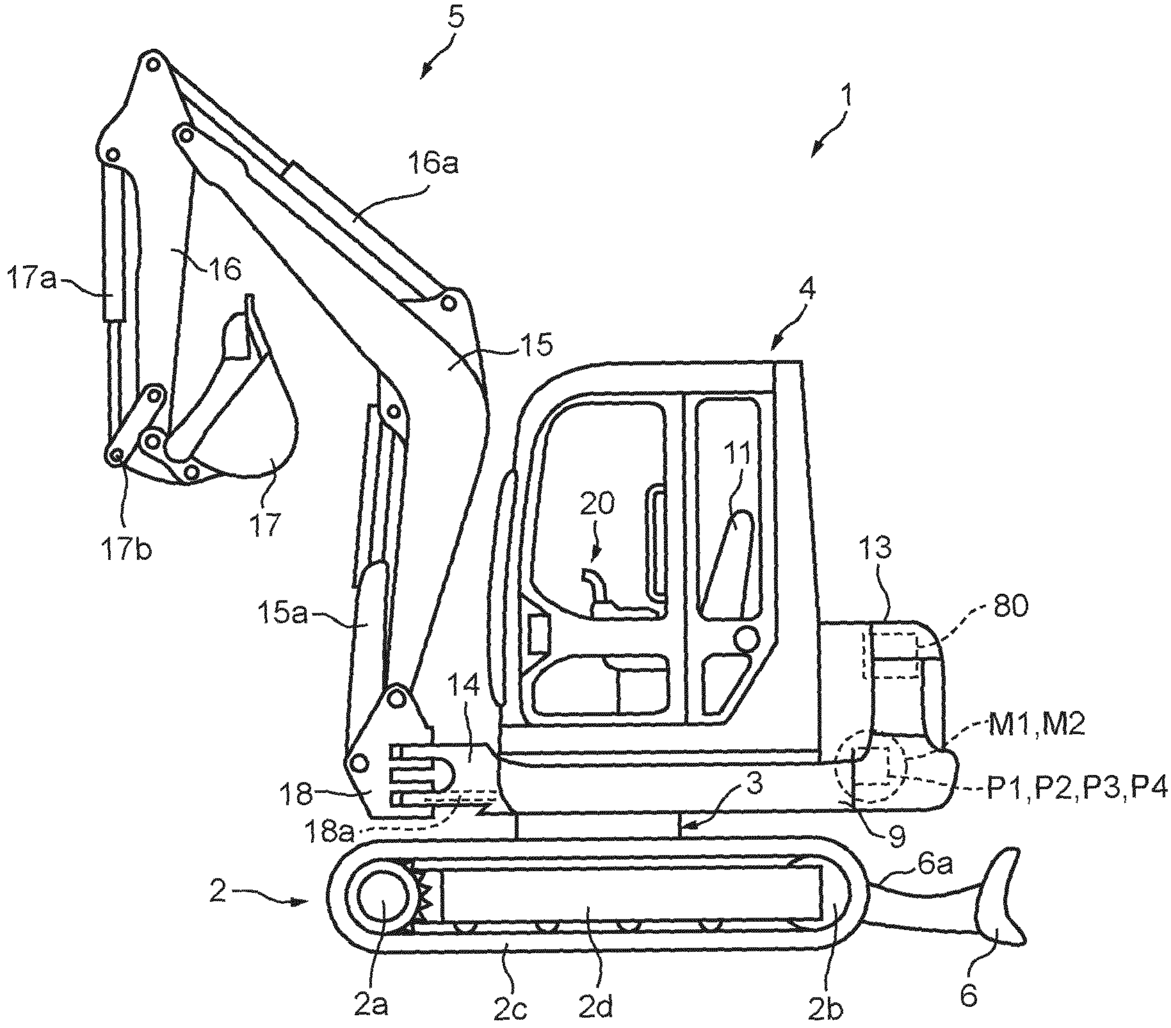

5
1
16a
17a
16
4
15
11
20
17
17b
13
80
15a
14
M1,M2
3
P1,P2,P3,P4
18
18a
9
6a
2
2a
2c
2d
2b
6

FIG. 2

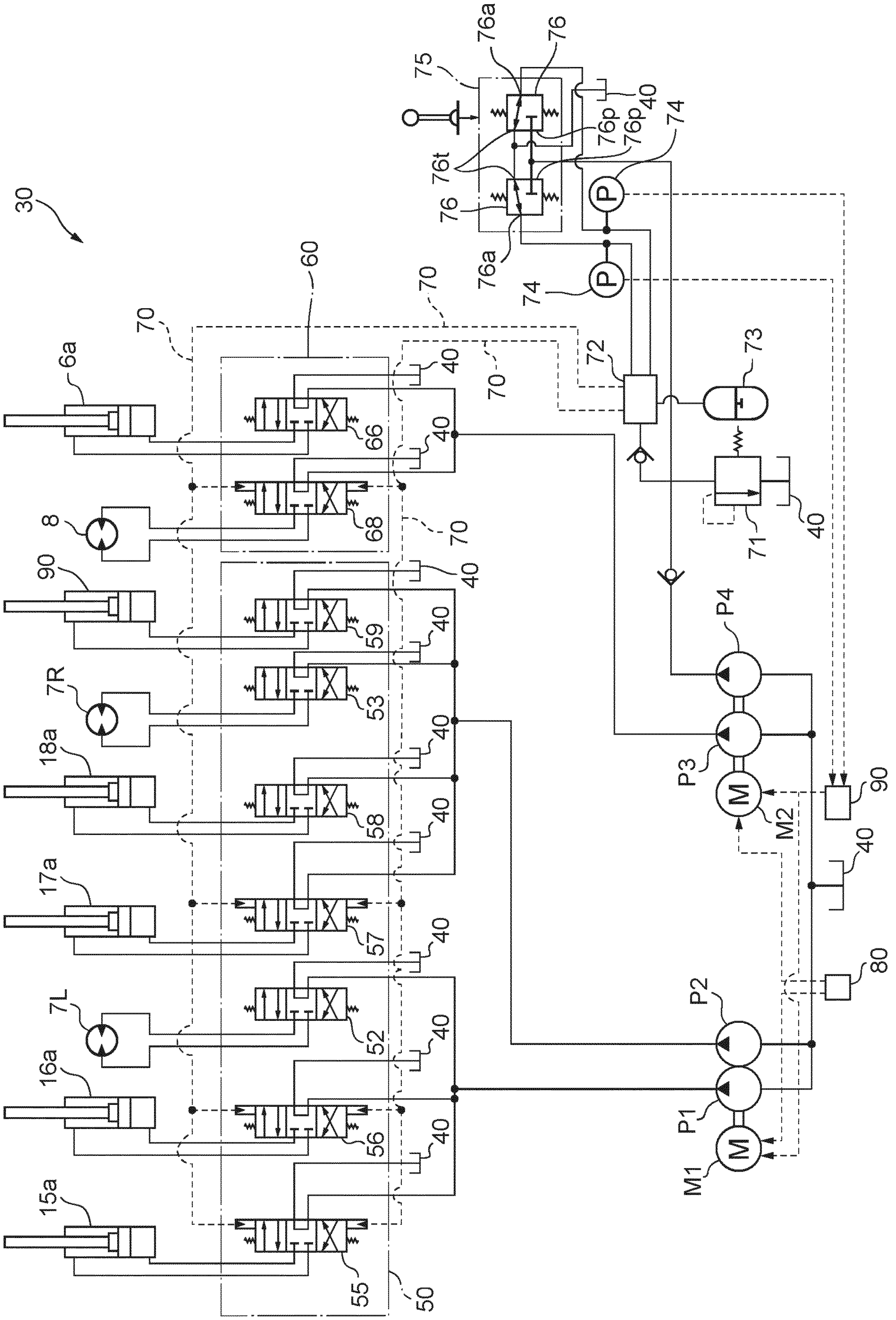

30
60
70
6a
8
90
7R
18a
17a
7L
16a
15a
66
68
59
53
58
57
52
56
55
50
40
72
73
71
74
P
75
76
76a
76t
76p
P1
P2
P3
P4
M
M1
M2
80

FIG.3A

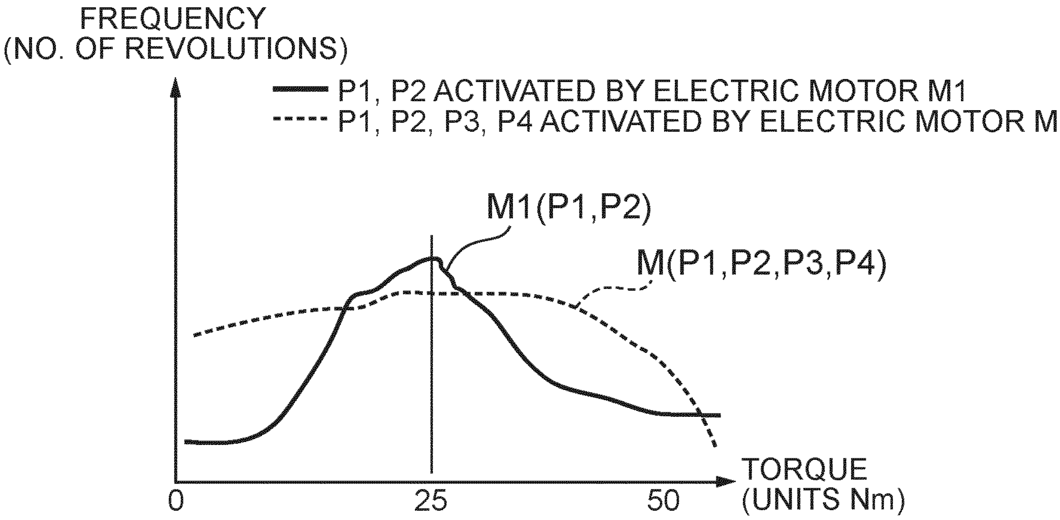


FIG.3B

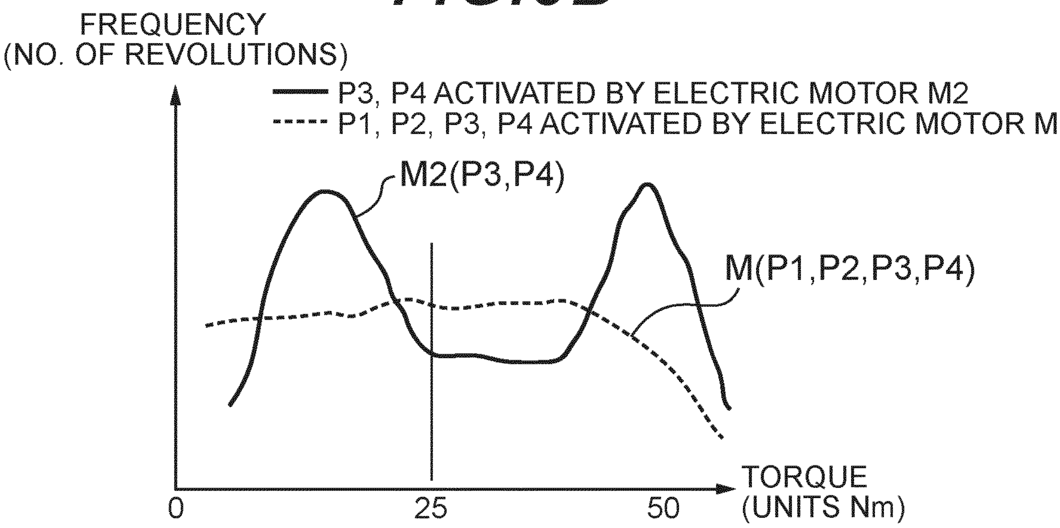


FIG.3C

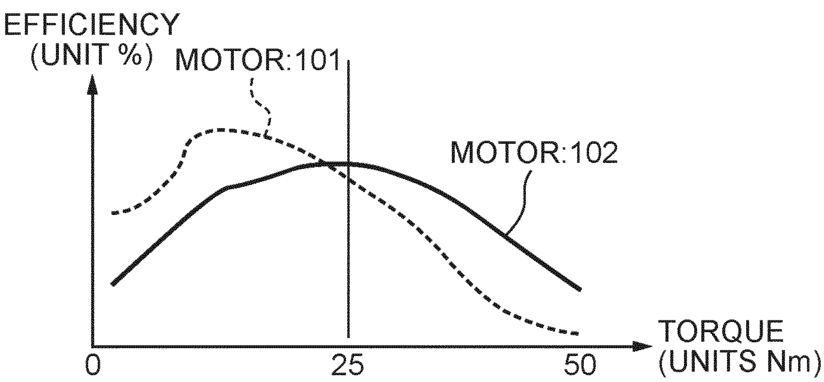


FIG.4

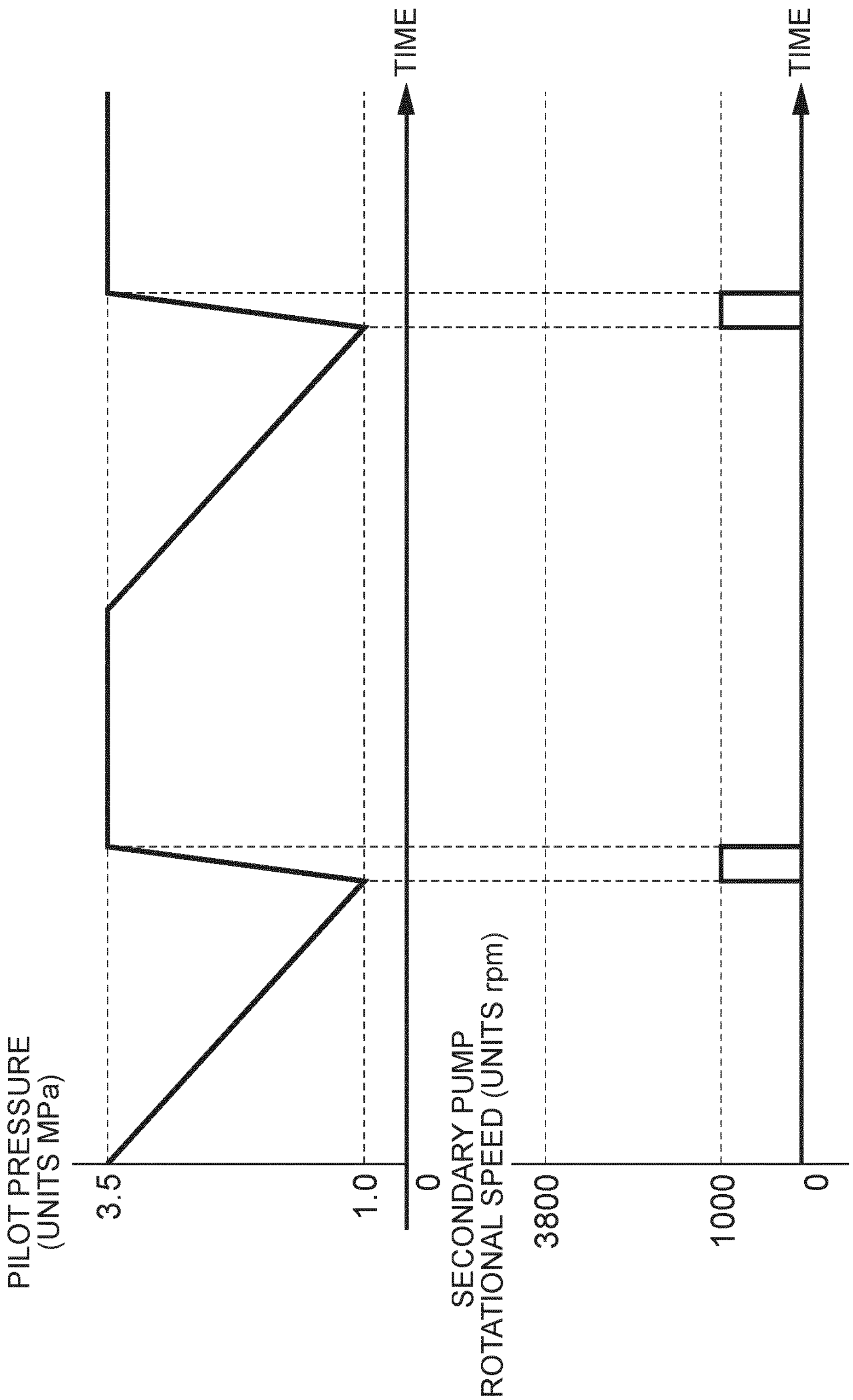
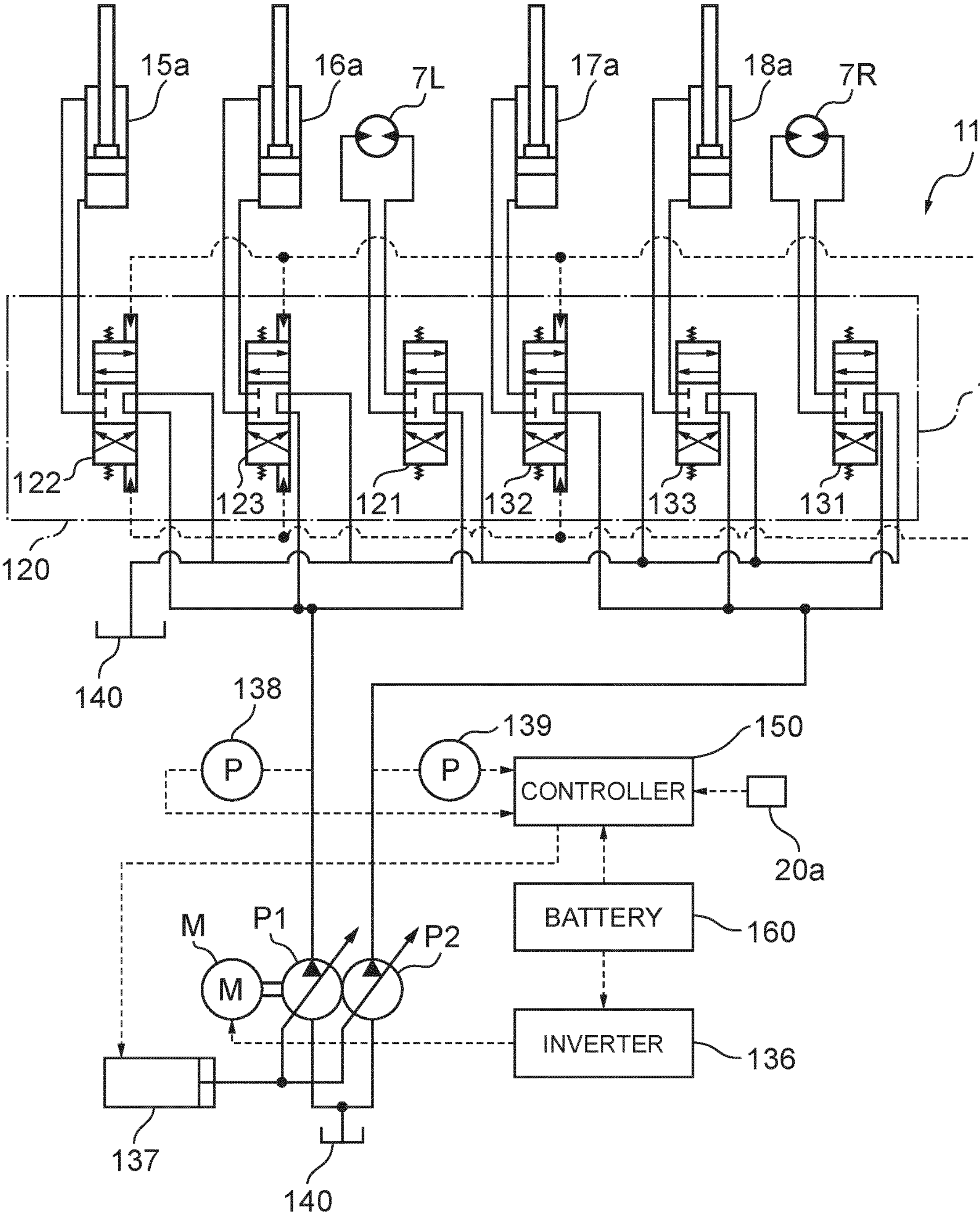

PILOT PRESSURE
(UNITS MPa)
3.5
1.0
0
TIME
SECONDARY PUMP
ROTATIONAL SPEED (UNITS rpm)
3800
1000
0
TIME

FIG. 5



15a
16a
7L
17a
18a
7R
110
130
122
123
121
132
133
131
120
140
138
139
150
P
P
CONTROLLER
20a
BATTERY
160
M
P1
P2
M
INVERTER
136
137
140

FIG. 6

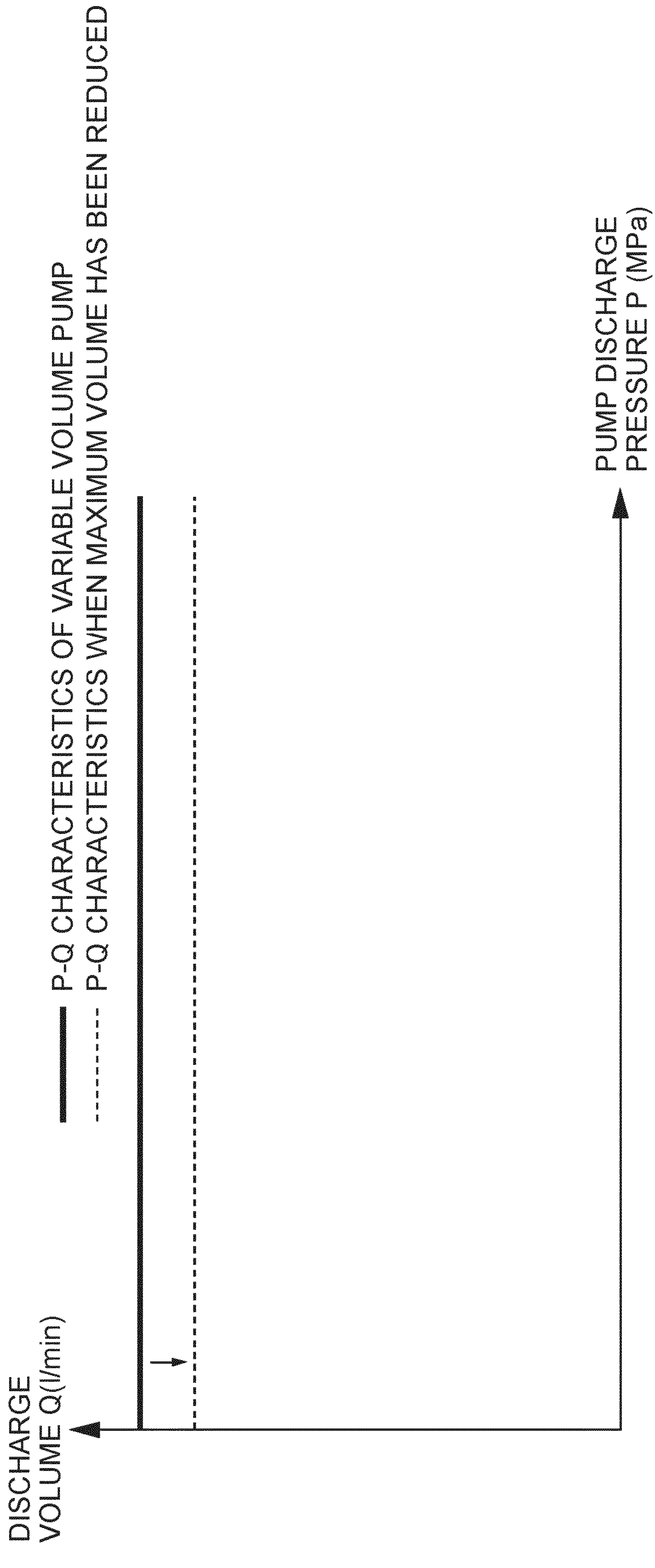

P-Q CHARACTERISTICS OF VARIABLE VOLUME PUMP
P-Q CHARACTERISTICS WHEN MAXIMUM VOLUME HAS BEEN REDUCED
DISCHARGE VOLUME Q(l/min)
PUMP DISCHARGE PRESSURE P (MPa)

FIG.7A

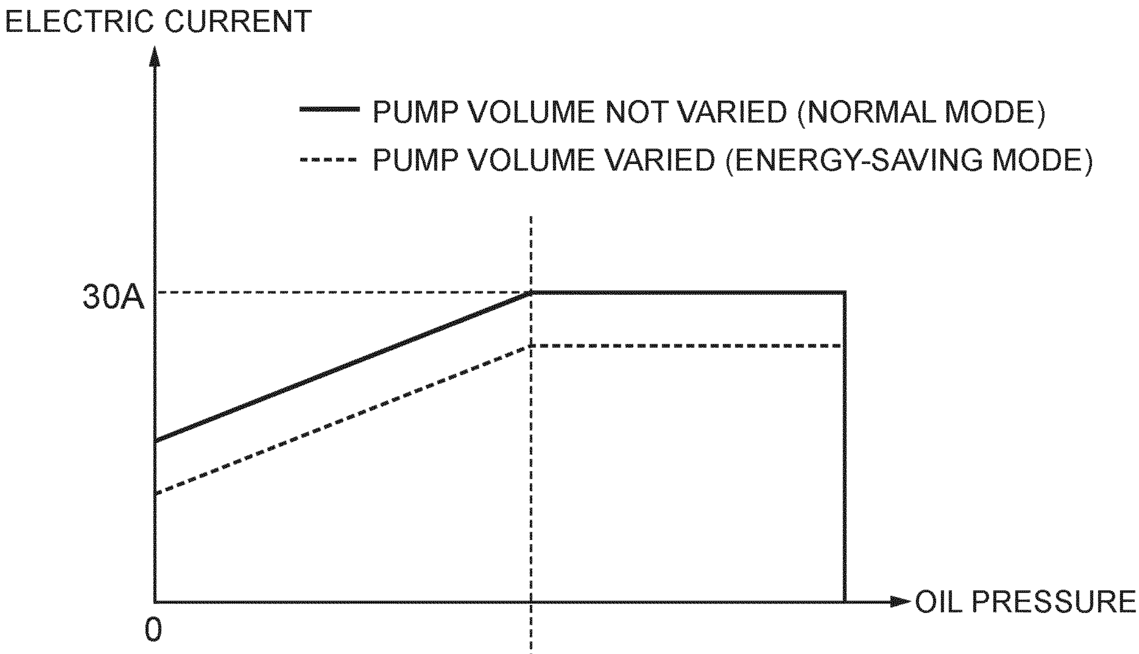

ELECTRIC CURRENT
PUMP VOLUME NOT VARIED (NORMAL MODE)
PUMP VOLUME VARIED (ENERGY-SAVING MODE)
30A
0
OIL PRESSURE

FIG.7B

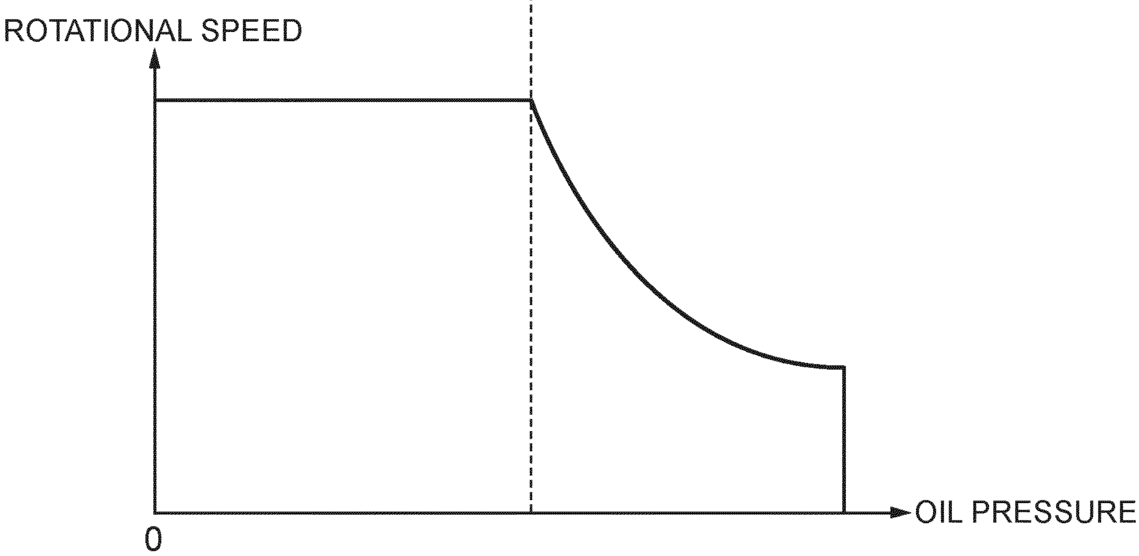

ROTATIONAL SPEED
0
OIL PRESSURE

FIG. 8A

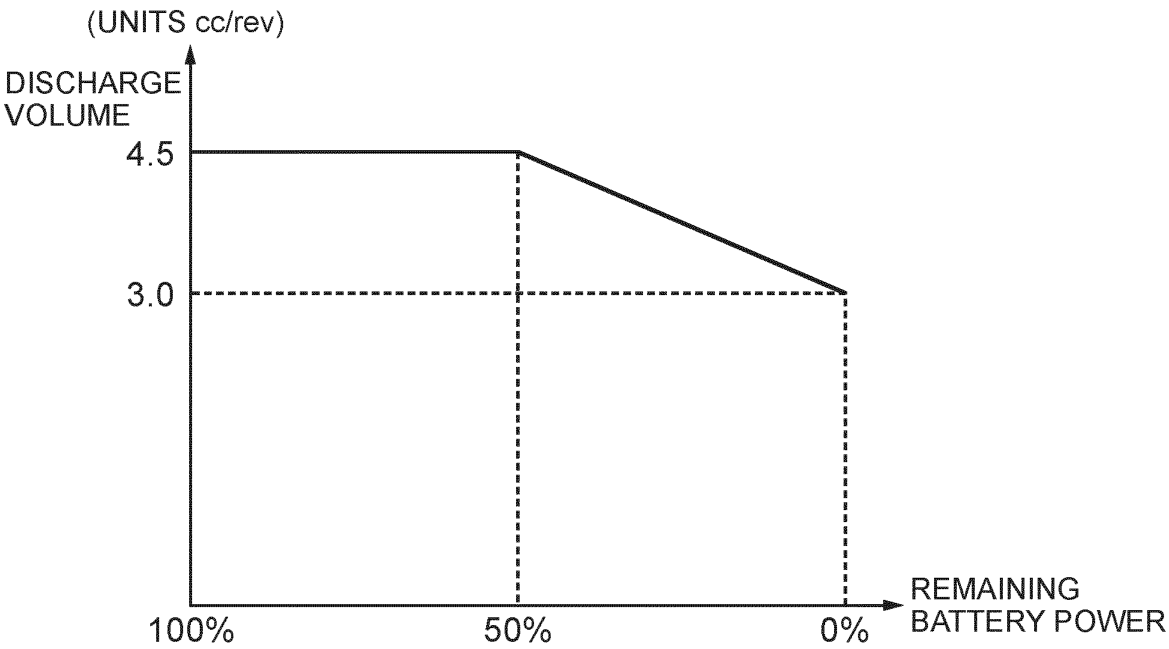

(UNITS cc/rev)
DISCHARGE VOLUME
4.5
3.0
100%
50%
0%
REMAINING BATTERY POWER

FIG. 8B

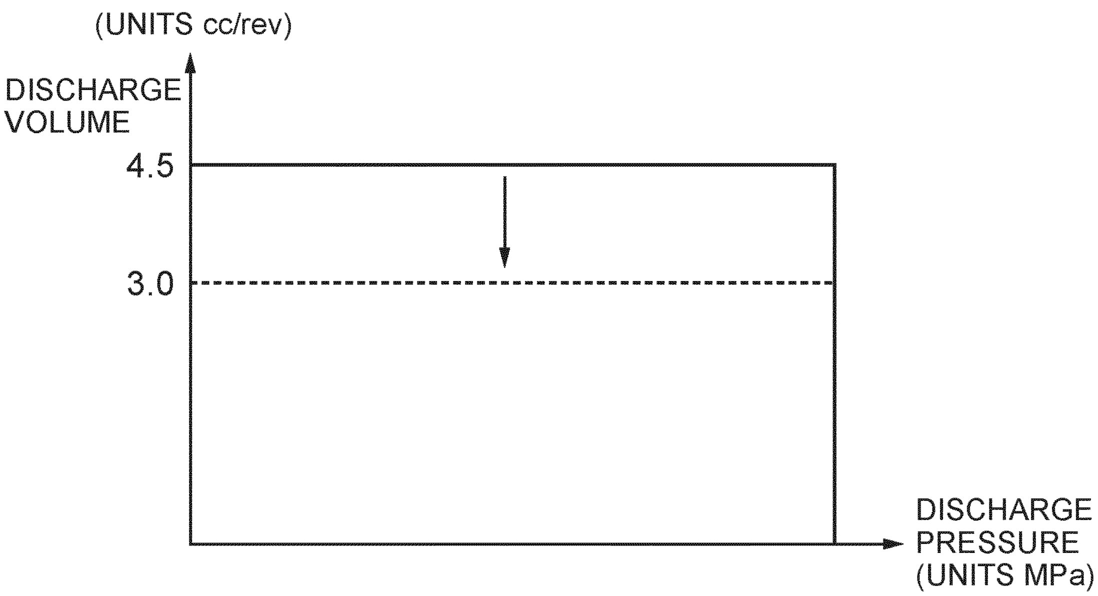

(UNITS cc/rev)
DISCHARGE VOLUME
4.5
3.0
DISCHARGE PRESSURE (UNITS MPa)

FIG.9A

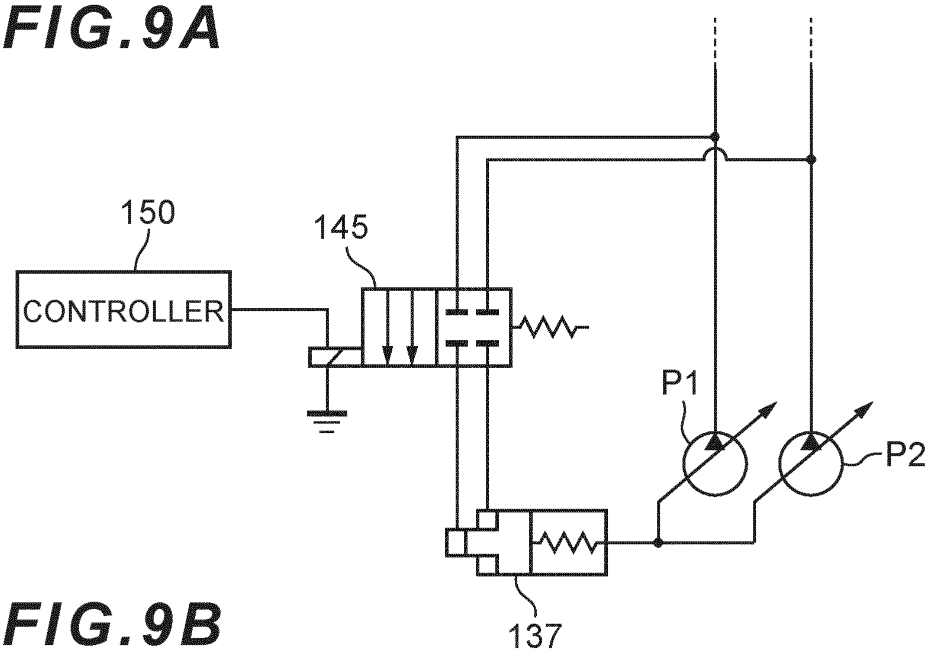


FIG.9B

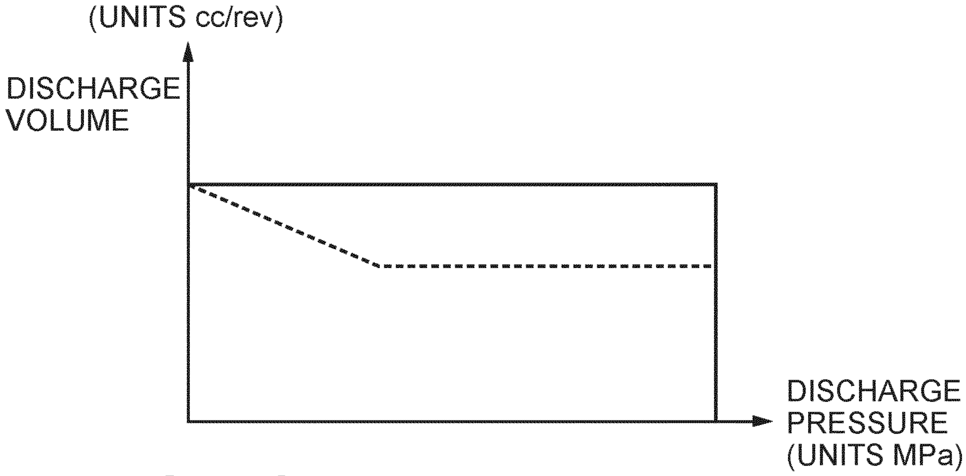


FIG.9C

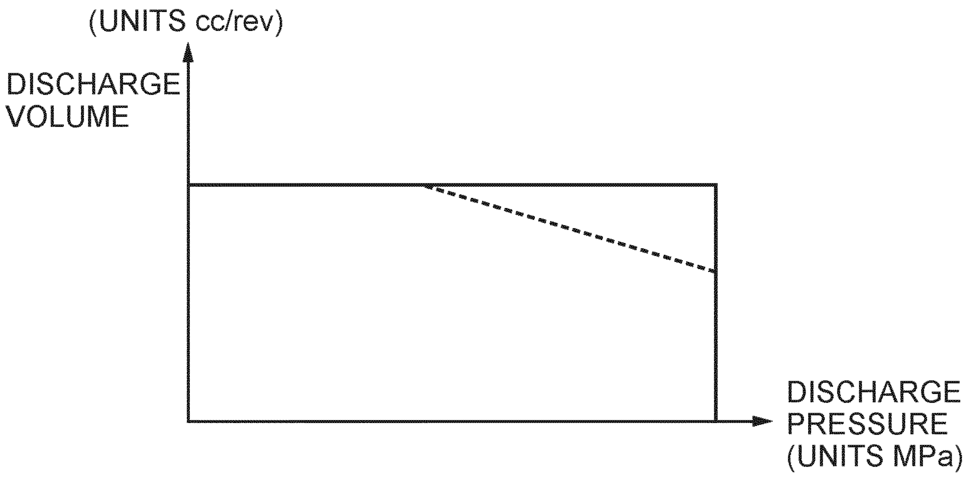


FIG.10A

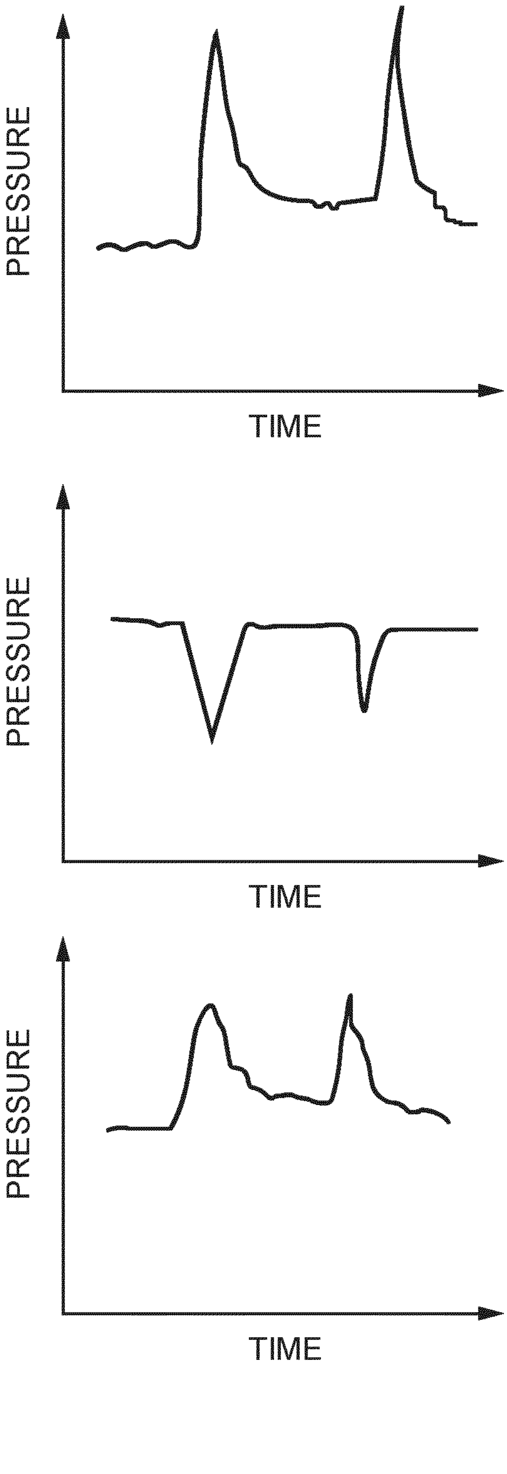


FIG.10B

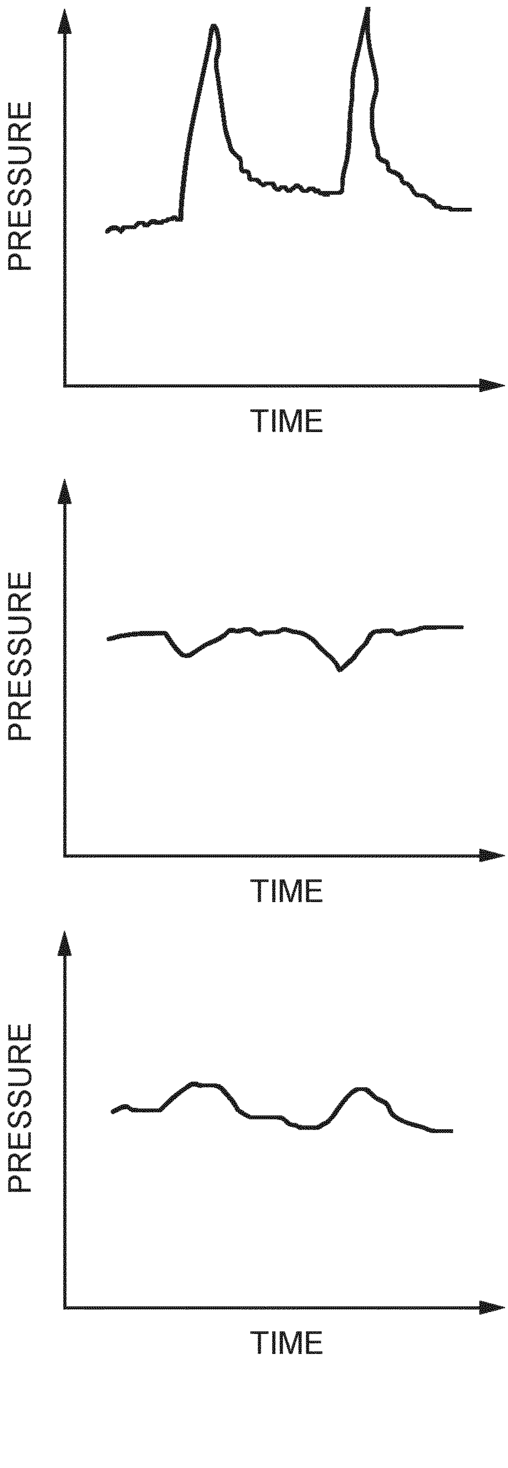
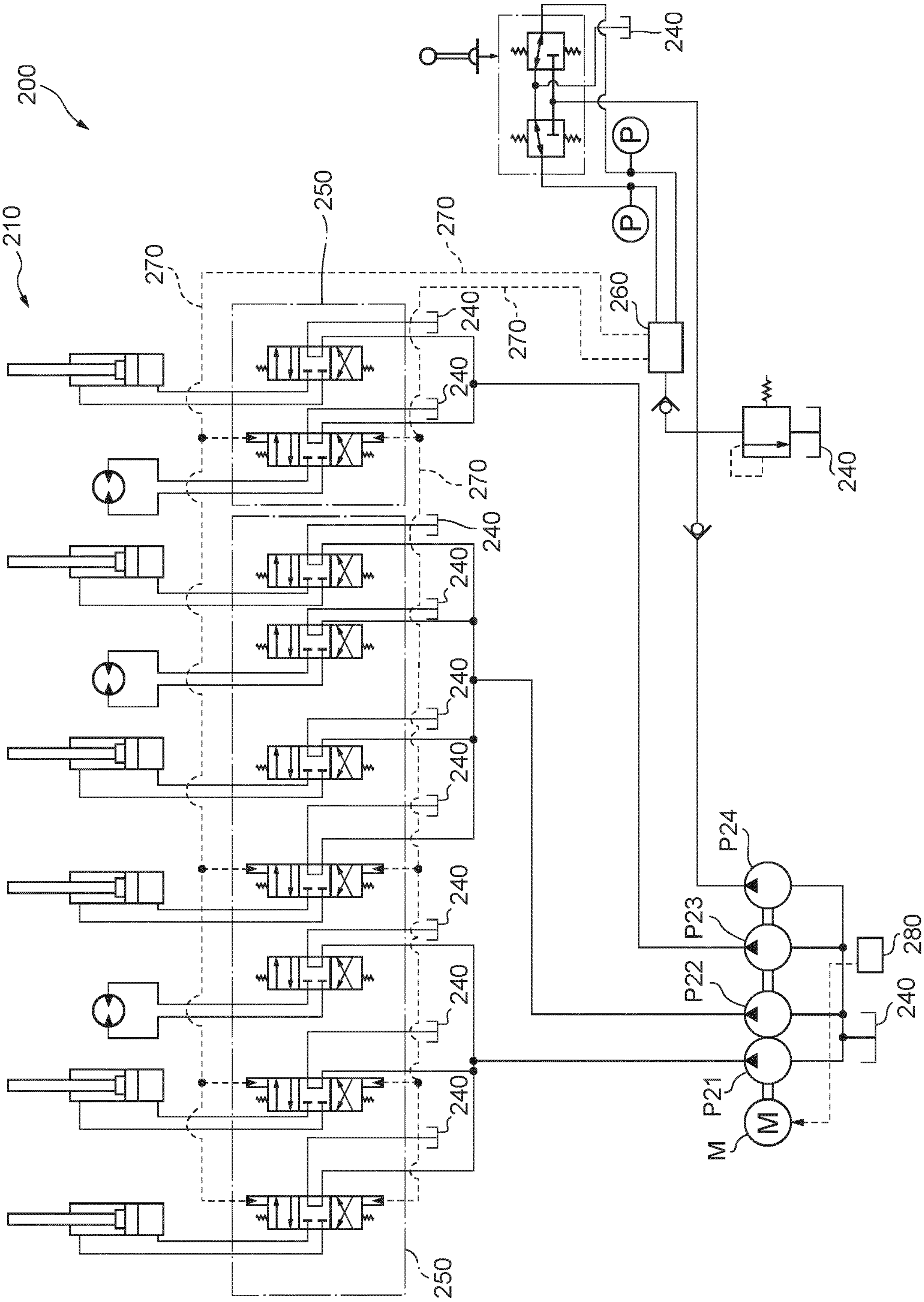


FIG. 11



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/004052

A. CLASSIFICATION OF SUBJECT MATTER
E02F9/22(2006.01)i, *E02F9/00*(2006.01)i, *E02F9/20*(2006.01)i, *F15B11/00*(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)
E02F9/22, E02F9/00, E02F9/20, F15B11/00

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2010
Kokai Jitsuyo Shinan Koho	1971-2010	Toroku Jitsuyo Shinan Koho	1994-2010

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 2003-155760 A (Kobelco Construction Machinery Co., Ltd.), 30 May 2003 (30.05.2003), paragraphs [0033] to [0036], [0049]; fig. 2 & US 2005/0001567 A1 & EP 1455439 A1 & WO 2003/044940 A1	1-3 5,6 4
Y A	JP 11-107320 A (Yutani Heavy Industries, Ltd., Shinko Electric Co., Ltd., Kobe Steel, Ltd.), 20 April 1999 (20.04.1999), paragraphs [0021], [0024], [0031], [0032]; fig. 3 (Family: none)	5,6 4

☐ 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 08 September, 2010 (08.09.10)	Date of mailing of the international search report 21 September, 2010 (21.09.10)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/004052

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 7, 8
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
It is set forth in claim 7 that the control for decreasing the maximum allowable capacity of a second hydraulic pump is carried out, and in claim 8 that a switch, which is capable of switching of such a control between performance or non-performance, is provided. (continued to extra sheet)

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/004052

Continuation of Box No.II-2 of continuation of first sheet(2)

However, disclosed in the meaning of PCT Article 5 is only the control for a first hydraulic pump set forth in the description, and consequently, claims 7, 8 are lack in the support in the meaning of PCT Article 6.

Form PCT/ISA/210 (extra sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2008214970 A **[0007]**
- JP 2008063902 A **[0007]**