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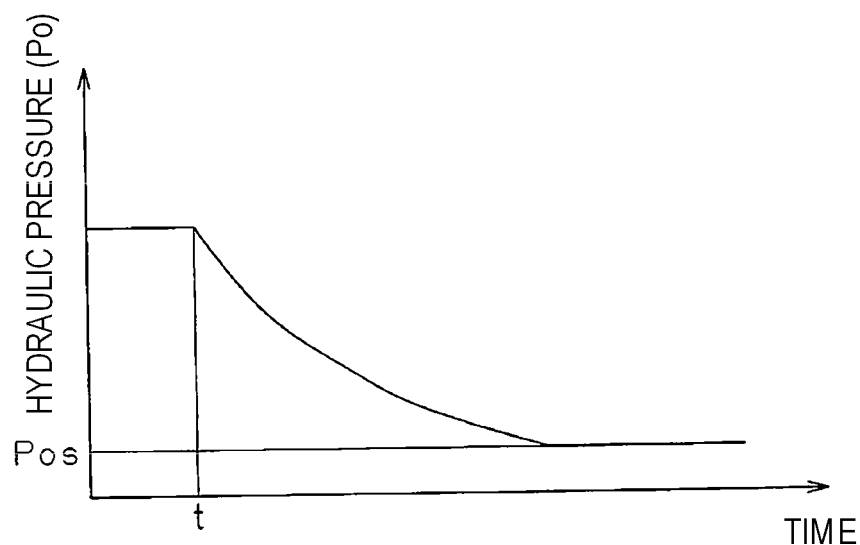
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(54) **ELECTRIC PUMP DEVICE**

(57) There is provided an electric pump device that
can suppress the generation of vibration or noise.
When reducing hydraulic pressure P_o supplied from

an oil pump with the increase of hydraulic pressure supplied from a main pump driven by an engine, an EOP ECU performs a pressure reducing control gradually reducing the hydraulic pressure P_o .

Fig. 3



EP 2 662 567 A1

Description

Technical Field

[0001] The present invention relates to an electric pump device.

Background Art

[0002] Conventionally, hydraulic pressure has been supplied to a hydraulic operating device such as a transmission by a main pump, which is driven by an engine, and an electric pump device, which uses a motor as a driving source, in a vehicle having a so-called idle stop function of automatically stopping an engine at the time of the temporary stop of a vehicle (for example, see PTL 1). Specifically, the main pump and an oil pump of the electric pump device are connected to a common hydraulic circuit that is used to supply hydraulic pressure to the hydraulic operating device. Further, when the engine is driven, hydraulic pressure is supplied to the hydraulic operating device by the main pump and the electric pump device generally stops. Meanwhile, since the main pump stops at the time of the stop of an engine such as idle stop, the supply of hydraulic pressure to the hydraulic operating device is ensured by the electric pump device.

Citation List

Patent Literature

[0003] [PTL 1] JP-A-2010-78088

Summary of Invention

Technical Problem

[0004] Incidentally, when the engine is restarted after idle stop and the supply of hydraulic pressure to the hydraulic operating device is switched to the main pump from the electric pump device, if the electric pump device gets stopped immediately, then the hydraulic pressure supplied from the electric pump device (oil pump) is suddenly changed. As a result, the sudden fluctuation of hydraulic pressure occurs in the hydraulic circuit. For this reason, there has been a concern that vibration or noise is generated.

[0005] The invention has been made to solve the above-mentioned problem, and an object of the invention is to provide an electric pump device that can suppress the generation of vibration or noise.

Solution to Problem

[0006] In order to achieve the object, according to a first aspect of the invention, there is provided an electric pump device that includes an oil pump generating hy-

draulic pressure, a motor driving the oil pump, and a controller controlling the operation of the oil pump through the supply of drive power to the motor, and is provided in a hydraulic circuit supplying operating oil to a hydraulic operating device together with another oil pump. The controller operates the oil pump to complement the supply of hydraulic pressure to the hydraulic operating device when the supply of hydraulic pressure to the hydraulic operating device performed by the another oil pump is stopped. The controller performs a pressure reducing control gradually reducing hydraulic pressure supplied from the oil pump when the supply of hydraulic pressure to the hydraulic operating device is switched to the another oil pump from the oil pump.

[0007] According to the above-mentioned structure, when the supply of hydraulic pressure to the hydraulic operating device is switched to the another oil pump from the oil pump of the electric pump device, the pressure reducing control is performed, so that hydraulic pressure supplied from the oil pump is gradually reduced. Accordingly, the occurrence of the sudden fluctuation of hydraulic pressure in the hydraulic circuit is suppressed unlike when the electric pump device is immediately stopped. Therefore, the supply of hydraulic pressure to the hydraulic operating device is smoothly switched to the another oil pump from the electric pump device, so that it is possible to suppress the generation of vibration or noise.

[0008] According to a second aspect of the invention, in the electric pump device according to the first aspect, the motor may be formed of a sensorless type brushless motor, the controller may estimate the rotational position of a rotor on the basis of induced voltages generated at motor coils, and the controller may maintain a motor angular velocity at which the rotational position can be detected on the basis of the induced voltages while hydraulic pressure is supplied to the hydraulic operating device by the another oil pump.

[0009] That is, while the rotor stops, the induced voltages are not generated. Accordingly, the rotor is forcibly rotated by the switching (forcible commutation) of the directions and phases of current supplied to the respective motor coils in a predetermined order regardless of the rotational position of the rotor, so that the sensorless type brushless motor is started. Further, since the motor angular velocity (the rotation speed of the rotor) is increased and it is possible to detect the rotational position of the rotor on the basis of the induced voltages generated at the motor coils, it is possible to control hydraulic pressure. For this reason, if the motor is completely stopped, it takes time before hydraulic pressure can be supplied from the electric pump device. In this regard, according to the above-mentioned structure, even while hydraulic pressure is supplied to the hydraulic operating device by the another oil pump, the motor angular velocity is maintained at angular velocity at which the rotational position of the rotor can be detected on the basis of the induced voltages. Accordingly, when the supply of hydraulic pres-

sure to the hydraulic operating device from the another oil pump is reduced, it is possible to promptly supply hydraulic pressure from the oil pump of the electric pump device.

[0010] Furthermore, hydraulic pressure corresponding to the angular velocity at which the rotational position of the rotor can be detected on the basis of the induced voltages continues to be supplied from the oil pump. Accordingly, as compared to a case where hydraulic pressure supplied from the oil pump is zero, it is possible to suppress the occurrence of the fluctuation of hydraulic pressure when the supply of hydraulic pressure to the hydraulic operating device is switched to the another oil pump from the electric pump device.

Advantageous Effects of Invention

[0011] According to the invention, it is possible to provide an electric pump device that can suppress the generation of vibration or noise.

Brief Description of Drawings

[0012]

Fig. 1 is a schematic view showing the configuration of a hydraulic circuit that supplies hydraulic pressure to a transmission mechanism.

Fig. 2 is a block diagram showing the electrical configuration of an electric pump device.

Fig. 3 is a view showing that hydraulic pressure to be supplied from an oil pump of this embodiment is reduced.

Fig. 4 is a view showing that hydraulic pressure to be supplied from another oil pump is reduced.

Fig. 5 is a view showing that hydraulic pressure to be supplied from another oil pump is reduced.

Description of Embodiment

[0013] An embodiment of the invention will be described with reference to the drawings.

An electric pump device 1 shown in Fig. 1 is mounted on a vehicle (not shown) having a so-called idle stop function of automatically stopping an engine 2 at the time of the temporary stop of a vehicle. The electric pump device 1 is provided in a hydraulic circuit 5 supplying hydraulic pressure (operating oil) to a transmission mechanism 4 (a continuously variable transmission in this embodiment) that is a hydraulic operating device, together with a main pump 3 as the other oil pump that is driven by the engine 2. Further, the electric pump device 1 supplies hydraulic pressure to the transmission mechanism 4 instead of the main pump 3, at the time of the stop of the engine 2 such as idling stop.

[0014] In detail, the main pump 3 is connected to the engine 2 so as to be driven by the engine 2, and sucks operating oil from an oil pan 11 by the drive of the engine

2 and supplies hydraulic pressure to the transmission mechanism 4. Meanwhile, the electric pump device 1 includes an oil pump 12 that generates hydraulic pressure, an electric motor 13 that drives the oil pump 12, and an EOP (electric oil pump) ECU 14 as a controller that controls the operation of the electric motor 13. Further, when the oil pump 12 is driven by the electric motor 13, the electric pump device 1 sucks operating oil from the oil pan 11 and supplies hydraulic pressure to the transmission mechanism 4. Meanwhile, a check valve 16, which prevent the operating oil from flowing backward at the time of the stop of the electric motor 13, is provided on an outlet oil passage 15 of the oil pump 12.

[0015] A host ECU 18 is connected to the engine 2. Various sensor values, such as vehicle speed and an accelerator opening, are input to the host ECU 18, and the host ECU 18 controls the operation of the engine 2 and the transmission mechanism 4 on the basis of these respective state quantities. For example, the host ECU 18 stops the engine 2 when a predetermined stop condition is satisfied, and performs an idle-stop control restarting the engine 2 when a predetermined restart condition is satisfied.

[0016] Further, the EOP ECU 14 is connected to the host ECU 18. Furthermore, the EOP ECU 14 is adapted to supply hydraulic pressure to the transmission mechanism 4 from the oil pump 12 by driving the electric motor 13 at the time of idle stop on the basis of a control signal output from the host ECU 18.

[0017] Next, the electrical configuration of the electric pump device will be described.

As shown in Fig. 2, the EOP ECU 14 includes a drive circuit 21 that supplies three-phase drive power to the electric motor 13, and a microcomputer 22 that drives the electric motor 13 by outputting motor control signals to the drive circuit 21. Meanwhile, in this embodiment, the EOP ECU 14 supplies drive power to the electric motor 13 by 120°-rectangular wave current supply where a current supply phase and a current supply direction are switched for every 120° (electrical angle). Further, a sensorless type brushless motor, which does not include a rotation sensor detecting the rotational position of a rotor 24, is employed as the electric motor 13, and the microcomputer 22 estimates the rotational position of the rotor 24 on the basis of induced voltages that are generated at motor coils 25u, 25v, and 25w of the respective phases.

[0018] In detail, a well-known PWM inverter, in which three switching arms corresponding to the motor coils 25u, 25v, and 25w of the respective phases are connected in parallel while a pair of switching elements connected in series are used as a basic unit (switching arm), is employed as the drive circuit 21. That is, the motor control signals output from the microcomputer 22 define the on/off-states of the switching elements of the respective phases that form the drive circuit 21 (duty ratios of the switching arms of the respective phases). Moreover, the drive circuit 21 is adapted so that drive power based on the current supply phase, the current supply direction,

and the duty ratio corresponding to a switching pattern thereof is output to the electric motor 13.

[0019] Voltage sensors 26u, 26v, and 26w, which detect terminal voltages Vu, Vv, and Vw of the motor coils 25u, 25v, and 25w, are connected to the microcomputer 22. The microcomputer 22 estimates the rotational position (rotational angle) of the rotor 24 on the basis of induced voltages (back-electromotive forces) of the respective motor coils 25u, 25v, and 25w that are detected by the voltage sensors 26u, 26v, and 26w. Specifically, the microcomputer 22 estimates the rotational position of the rotor 24 by a well-known method of detecting a point of time (zero-cross point) where an induced voltage corresponds to a reference potential. Further, the microcomputer 22 determines a switching pattern according to the estimated rotational position of the rotor 24.

[0020] Further, a current sensor 27, which detects an actual current value I of current supplied to the electric motor 13, and the host ECU 18 are connected to the microcomputer 22. The microcomputer 22 determines a duty ratio, which corresponds to a deviation between a current command value I* and the actual current value I, by performing a feedback control making the actual current value I follow the current command value I* that is included in the control signal output from the host ECU 18. Furthermore, the microcomputer 22 outputs motor control signals, which represent the switching pattern and the duty ratio determined in this way, to the drive circuit 21. Accordingly, three-phase drive power is supplied to the electric motor 13 from the drive circuit 21 and the electric motor 13 is driven, so that hydraulic pressure is supplied from the oil pump 12.

[0021] Next, the switching of the pump that supplies hydraulic pressure to the transmission mechanism 4 of this embodiment will be described.

Since the engine 2 stops at the time of idle stop and hydraulic pressure is not supplied from the main pump 3, a control signal supplying hydraulic pressure to the transmission mechanism 4 from the host ECU 18 by the oil pump 12 is output to the EOP ECU 14. Moreover, the EOP ECU 14 supplies hydraulic pressure Po by driving the electric motor 13 on the basis of the control signal (current command value I*). Meanwhile, when the engine 2 is restarted and hydraulic pressure Pm supplied from the main pump 3 exceeds a predetermined value, a control signal stopping the supply of hydraulic pressure performed by the oil pump 12 is output to the EOP ECU 14 from the host ECU 18 and the supply of hydraulic pressure to the transmission mechanism 4 is switched to the main pump 3 from the electric pump device 1.

[0022] Here, when the electric pump device 1 (oil pump 12) receives a control signal output from the host ECU and immediately stops, hydraulic pressure supplied by the electric pump device 1 is suddenly reduced, so that the sudden fluctuation of hydraulic pressure occurs in the hydraulic circuit 5. For this reason, there is a concern that vibration or noise is generated.

[0023] On the basis of this, the EOP ECU 14 performs

a pressure reducing control gradually reducing hydraulic pressure Po supplied from the oil pump 12 without immediately stopping the operation of the electric motor 13 even though a control signal stopping the electric motor 13 is input from the host ECU 18. Specifically, in the pressure reducing control of this embodiment, the EOP ECU 14 reduces the hydraulic pressure Po while continuously changing the reduction rate of the hydraulic pressure Po supplied from the oil pump 12. Further, while supplying hydraulic pressure to the transmission mechanism 4 by the main pump 3, the EOP ECU 14 is adapted to maintain a motor angular velocity ω (the rotation speed of the rotor 24) at a standby angular velocity ω_s at which the position of the rotor can be detected on the basis of induced voltages generated at the motor coils 25u, 25v, and 25w.

[0024] In the electric pump device 1 having this structure, as shown in Fig. 3, the pressure reducing control is performed when the control signal stopping the supply of hydraulic pressure performed by the oil pump 12 is input to the EOP ECU 14 from the host ECU 18 at a time t. Accordingly, the hydraulic pressure Po supplied from the oil pump 12 is gradually reduced. Furthermore, when hydraulic pressure is reduced to standby hydraulic pressure Pos that is supplied from the oil pump 12 by the electric motor 13 rotating at the standby angular velocity ω_s , hydraulic pressure is maintained at the standby hydraulic pressure Pos.

[0025] As described above, according to this embodiment, it is possible to obtain the following functional effects.

- (1) The EOP ECU 14 performs a pressure reducing control gradually reducing the hydraulic pressure Po supplied from the oil pump 12 when the supply of hydraulic pressure to the transmission mechanism 4 is switched to the main pump 3 that is driven by the engine 2 from the oil pump 12.

[0026] According to the above-mentioned structure, the pressure reducing control is performed, so that the hydraulic pressure Po supplied from the oil pump 12 of the electric pump device 1 is gradually reduced. Accordingly, the occurrence of the sudden fluctuation of hydraulic pressure in the hydraulic circuit 5 is suppressed unlike when the electric pump device 1 is immediately stopped. Therefore, the supply of hydraulic pressure to the transmission mechanism 4 is smoothly switched to the main pump 3 from the electric pump device 1, so that it is possible to suppress the generation of vibration or noise.

[0027]

- (2) The electric motor 13 has been formed of a sensorless type brushless motor. Further, the EOP ECU 14 has been adapted to maintain the motor angular velocity ω at the standby angular velocity ω_s at which the rotational position of the rotor 24 can be detected on the basis of the induced voltages generated at the motor coils 25u, 25v, and 25w.

[0028] That is, while the rotor 24 stops, the induced voltages are not generated. Accordingly, the rotor 24 is forcibly rotated by the switching (forcible commutation) of the directions and phases of current supplied to the respective motor coils 25u, 25v, and 25w in a predetermined order regardless of the rotational position of the rotor 24, so that the sensorless type brushless motor is started. Further, since the motor angular velocity ω is increased and it is possible to detect the rotational position of the rotor 24 on the basis of the induced voltages generated at the motor coils 25u, 25v, and 25w, it is possible to control hydraulic pressure. For this reason, if the electric motor 13 is completely stopped, time is taken until hydraulic pressure can be supplied from the electric pump device 1. In this regard, according to the above-mentioned structure, even while hydraulic pressure is supplied to the transmission mechanism 4 by the main pump 3, the motor angular velocity ω is maintained at the standby angular velocity ω_s at which the rotational position of the rotor 24 can be detected on the basis of the induced voltages. Accordingly, when the supply of hydraulic pressure to the transmission mechanism 4 from the main pump 3 is reduced, it is possible to promptly supply hydraulic pressure from the electric pump device 1.

[0029] Furthermore, the standby hydraulic pressure P_{os} corresponding to the standby angular velocity ω_s continues to be supplied from the oil pump 12. Accordingly, compared to a case where the hydraulic pressure P_o supplied from the oil pump 12 is zero, it is possible to suppress the occurrence of the fluctuation of hydraulic pressure when the supply of hydraulic pressure to the transmission mechanism 4 is switched to the main pump 3 from the electric pump device 1.

[0030]

(3) Since the EOP ECU 14 continuously changes the reduction rate of the hydraulic pressure P_o supplied from the oil pump 12, it is possible to suitably suppress the fluctuation of hydraulic pressure. Meanwhile, the above-mentioned embodiment may be embodied in the following aspect that is obtained by appropriately modifying the embodiment.

[0031] In the above-mentioned embodiment, the hydraulic pressure P_o has been reduced while the reduction rate of the hydraulic pressure P_o supplied from the oil pump 12 is continuously changed. However, the invention is not limited thereto, and the hydraulic pressure P_o may be reduced to the standby hydraulic pressure P_{os} at a constant reduction rate and the standby hydraulic pressure P_{os} may be maintained. Further, as long as the hydraulic pressure P_o is gradually reduced, the pressure reducing control may be performed in any aspect.

[0032] For example, as shown in Fig. 4, hydraulic pressure may be temporarily maintained at a predetermined hydraulic pressure during the reduction of the hydraulic pressure P_o supplied from the oil pump 12. Furthermore,

a plurality of predetermined hydraulic pressures may be set so that hydraulic pressure is reduced stepwise. It is possible to reliably suppress the occurrence of the sudden fluctuation of hydraulic pressure in the hydraulic circuit 5 by reducing the hydraulic pressure stepwise while temporarily maintaining hydraulic pressure during the reduction of the hydraulic pressure P_o in this way.

[0033] Moreover, for example, as shown in Fig. 5, the hydraulic pressure P_o supplied from the oil pump 12 may be reduced after being increased once. According to this structure, even though the hydraulic pressure P_m supplied from the main pump 3 is higher than the hydraulic pressure P_o , it is possible to make these hydraulic pressures P_o and P_m be close to each other when pressure reducing control is performed. Accordingly, it is possible to suitably suppress the fluctuation of hydraulic pressure.

[0034] In addition, for example, similar to a case where the hydraulic pressure P_o supplied from the oil pump 12 is reduced stepwise after being increased once, the reduction aspects of the hydraulic pressure P_o shown in Figs. 3 to 5 may be combined.

In the above-mentioned embodiment, the EOP ECU 14 has maintained the motor angular velocity ω at the standby angular velocity ω_s even when hydraulic pressure is supplied to the transmission mechanism 4 by the main pump 3. However, the invention is not limited thereto, and the electric motor 13 may be completely stopped.

[0035] In the above-mentioned embodiment, the motor angular velocity ω has been maintained at the standby angular velocity ω_s after the pressure reducing control is performed. However, the invention is not limited thereto, and the electric motor 13 may be controlled so as to make the motor angular velocity ω immediately become the standby angular velocity ω_s and the motor angular velocity ω (standby hydraulic pressure P_{os}) may be maintained when the supply of hydraulic pressure to the transmission mechanism 4 is switched to the main pump 3 from the oil pump 12. Even in this structure, it is possible to obtain the functional effect according to (2) of the above-mentioned embodiment.

[0036] In the above-mentioned embodiment, the invention has been applied to the electric pump device 1 that is connected to the hydraulic circuit 5 together with the main pump 3 driven by the engine 2. However, the invention is not limited thereto, and may be applied to the electric pump device that is connected to a hydraulic circuit together with a pump except for the main pump 3. Further, the hydraulic circuit 5 may be provided with a plurality of pumps except for the electric pump device 1.

[0037] Next, a technical idea, which can be grasped from the above-mentioned embodiment and another example, will be additionally described below together with the effects of these.

(A) The electric pump device according to claim 1 or 2 changes the reduction rate of hydraulic pressure supplied from the oil pump in the pressure reducing control. According to the above-mentioned structure,

it is possible to suitably suppress the fluctuation of hydraulic pressure.

[0038]

(B) In the pressure reducing control, the electric pump device according to any one of claims 1 and 2 and (A) reduces hydraulic pressure stepwise while temporarily maintaining the hydraulic pressure supplied from the oil pump. According to the above-mentioned structure, it is possible to reliably suppress the occurrence of the sudden fluctuation of hydraulic pressure in the hydraulic circuit.

[0039]

(C) In the pressure reducing control, the electric pump device according to any one of claims 1 and 2, (A), and (B) increases hydraulic pressure once before reducing the hydraulic pressure supplied from the oil pump. According to the above-mentioned structure, even though hydraulic pressure supplied from another oil pump is higher than hydraulic pressure supplied from the oil pump of the electric pump device, it is possible to make the hydraulic pressures supplied from the respective pumps be close to each other when reducing the hydraulic pressure supplied from the oil pump. Accordingly, it is possible to suitably suppress the fluctuation of hydraulic pressure.

[0040]

(D) An electric pump device includes an oil pump that generates hydraulic pressure, a motor that drives the oil pump, and a controller that controls the operation of the oil pump through the supply of drive power to the motor; and is provided in a hydraulic circuit that supplies operating oil to a hydraulic operating device together with another oil pump. The controller operates the oil pump to complement the supply of hydraulic pressure to the hydraulic operating device when the supply of hydraulic pressure to the hydraulic operating device performed by the another oil pump is stopped. The motor is formed of a sensorless type brushless motor, and the controller estimates the rotational position of a rotor on the basis of induced voltages generated at motor coils and maintains a motor angular velocity at which the rotational position can be detected on the basis of the induced voltages while hydraulic pressure is supplied to the hydraulic operating device by the other oil pump. According to the above-mentioned structure, it is possible to obtain the same functional effect as the claim 2.

[0041] This application is based on Japanese Patent Application No. 2011-000125, filed on January 4, 2011, the content of which is incorporated herein by reference.

Industrial Applicability

[0042] According to the invention, it is possible to provide an electric pump device that can suppress the generation of vibration or noise.

Reference Signs List

[0043]

- 1: electric pump device
- 2: engine
- 3: main pump
- 4: transmission mechanism
- 5: hydraulic circuit
- 12: oil pump
- 13: electric motor
- 14: EOPECU
- 16: check valve
- 18: host ECU
- 21: drive circuit
- 22: microcomputer
- 24: rotor
- 25u, 25v, 25w: motor coil
- Pm, Po: hydraulic pressure
- Pos: standby hydraulic pressure
- ω : motor angular velocity
- ω s: standby angular velocity

Claims

1. An electric pump device that includes an oil pump generating hydraulic pressure, a motor driving the oil pump, and a controller controlling an operation of the oil pump through a supply of drive power to the motor, and is provided in a hydraulic circuit supplying operating oil to a hydraulic operating device together with another oil pump, wherein the controller operates the oil pump to complement a supply of hydraulic pressure to the hydraulic operating device when the supply of hydraulic pressure to the hydraulic operating device performed by the another oil pump is stopped, and the controller performs a pressure reducing control gradually reducing hydraulic pressure supplied from the oil pump when the supply of hydraulic pressure to the hydraulic operating device is switched to the another oil pump from the oil pump.
2. The electric pump device according to claim 1, wherein the motor is formed of a sensorless type brushless motor, the controller estimates a rotational position of a rotor based on induced voltages generated at motor coils, and the controller maintains a motor angular velocity at which the rotational position can be detected based

on the induced voltages, in a state where hydraulic pressure is supplied to the hydraulic operating device by the another oil pump.

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Amended claims under Art. 19.1 PCT

1. An electric pump device that includes an oil pump generating hydraulic pressure, a motor driving the oil pump, and a controller controlling an operation of the oil pump through a supply of drive power to the motor, and is provided in a hydraulic circuit supplying operating oil to a hydraulic operating device together with another oil pump, wherein the controller operates the oil pump to complement a supply of hydraulic pressure to the hydraulic operating device when the supply of hydraulic pressure to the hydraulic operating device performed by the another oil pump is stopped, and the controller performs a pressure reducing control gradually reducing hydraulic pressure supplied from the oil pump when the supply of hydraulic pressure to the hydraulic operating device is switched to the another oil pump from the oil pump.

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2. The electric pump device according to claim 1, wherein the motor is formed of a sensorless type brushless motor, the controller estimates a rotational position of a rotor based on induced voltages generated at motor coils, and the controller maintains a motor angular velocity at which the rotational position can be detected based on the induced voltages, in a state where hydraulic pressure is supplied to the hydraulic operating device by the another oil pump.

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3. [NEW] The electric pump device according to claim 2, wherein the controller changes a reduction rate of hydraulic pressure supplied from the oil pump in the pressure reducing control.

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4. [NEW] The electric pump device according to claim 2, wherein the controller reduces the hydraulic pressure stepwise while temporarily maintaining the hydraulic pressure supplied from the oil pump in the pressure reducing control.

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5. [NEW] The electric pump device according to claim 2, wherein The controller increases the hydraulic pressure once before reducing the hydraulic pressure supplied from the oil pump in the pressure reducing control.

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Fig. 1

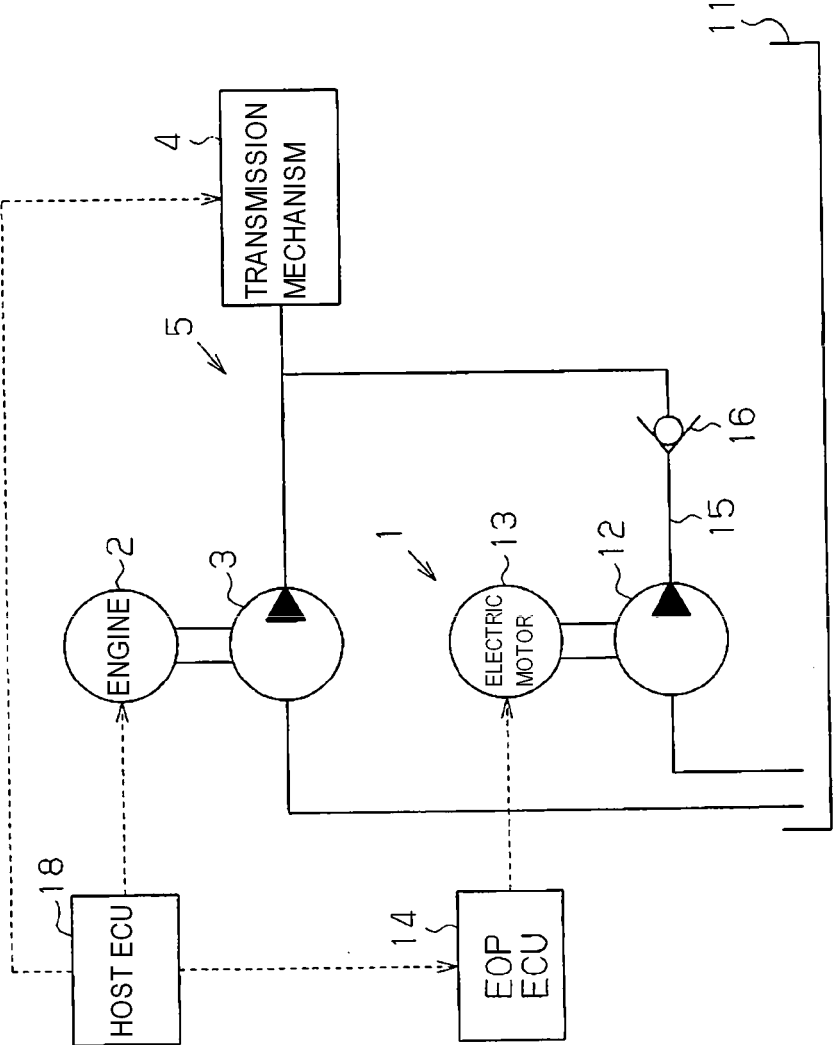


Fig. 2

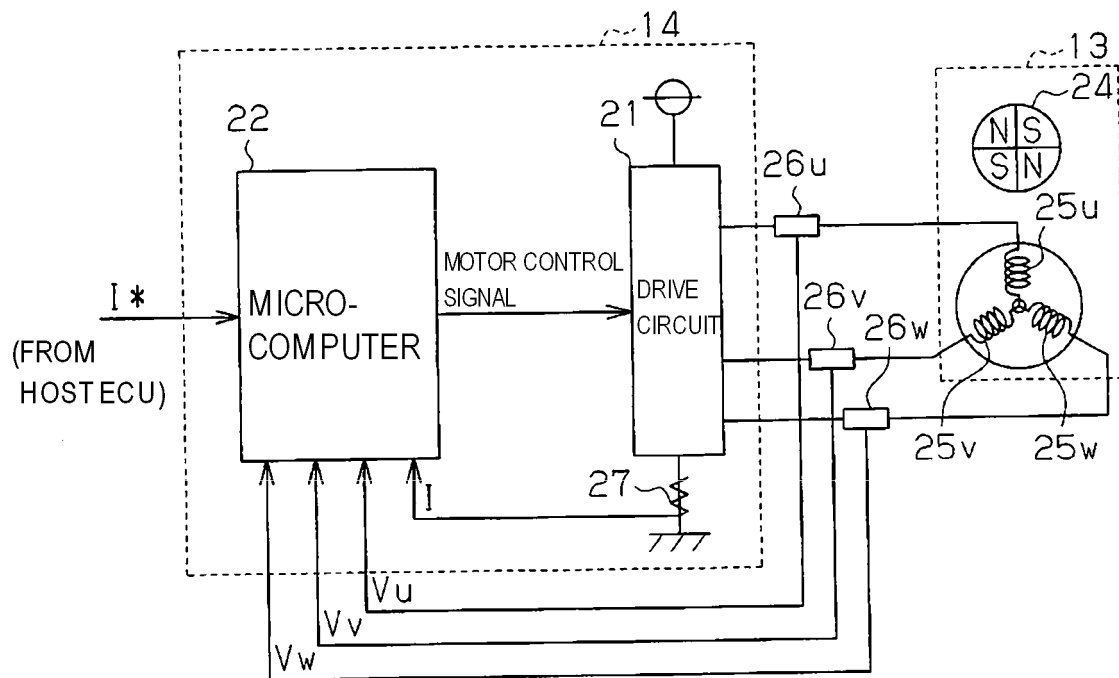


Fig. 3

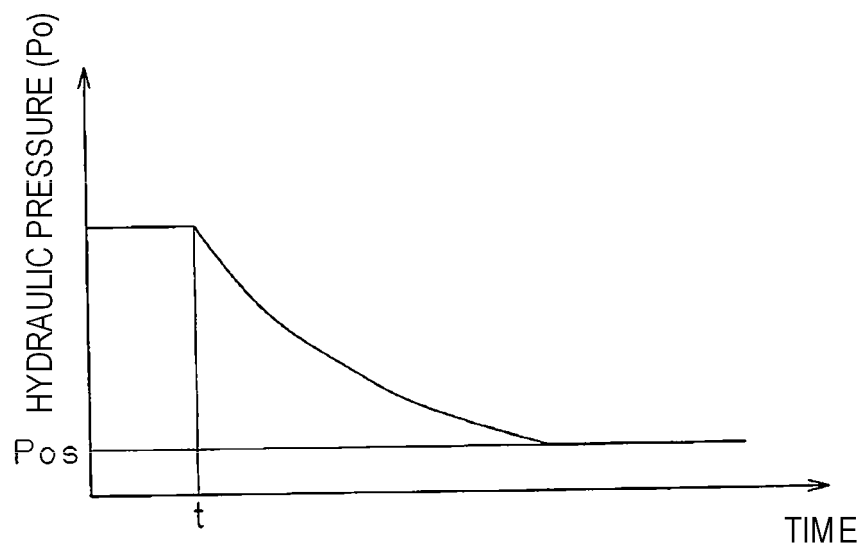


Fig. 4

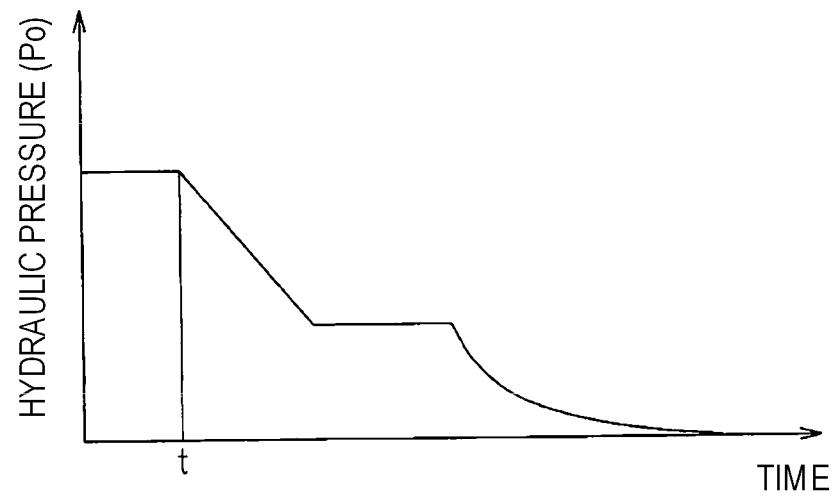
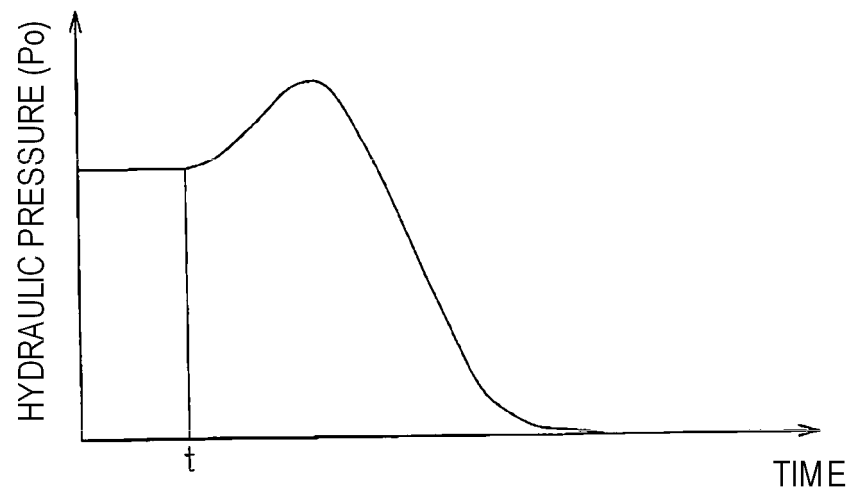


Fig. 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/050034

A. CLASSIFICATION OF SUBJECT MATTER

F04B49/06(2006.01)i, F04B49/02(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)

F04B49/06, F04B49/02, F16H61/00, H02P6/18

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	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

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.
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Y	JP 5-180159 A (Ebara Densan Ltd.), 20 July 1993 (20.07.1993), paragraphs [0004], [0009] to [0011]; fig. 2 (Family: none)	1-2
Y	JP 2002-31064 A (Tsurumi Manufacturing Co., Ltd.), 31 January 2002 (31.01.2002), paragraphs [0004], [0008] (Family: none)	1-2

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

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Date of the actual completion of the international search
29 March, 2012 (29.03.12)Date of mailing of the international search report
10 April, 2012 (10.04.12)Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/050034

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	JP 64-43224 A (Hitachi, Ltd.), 15 February 1989 (15.02.1989), page 1, lower right column, line 17 to page 2, upper right column, line 17; page 3, upper right column, line 11 to lower left column, line 8 (Family: none)	2
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Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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