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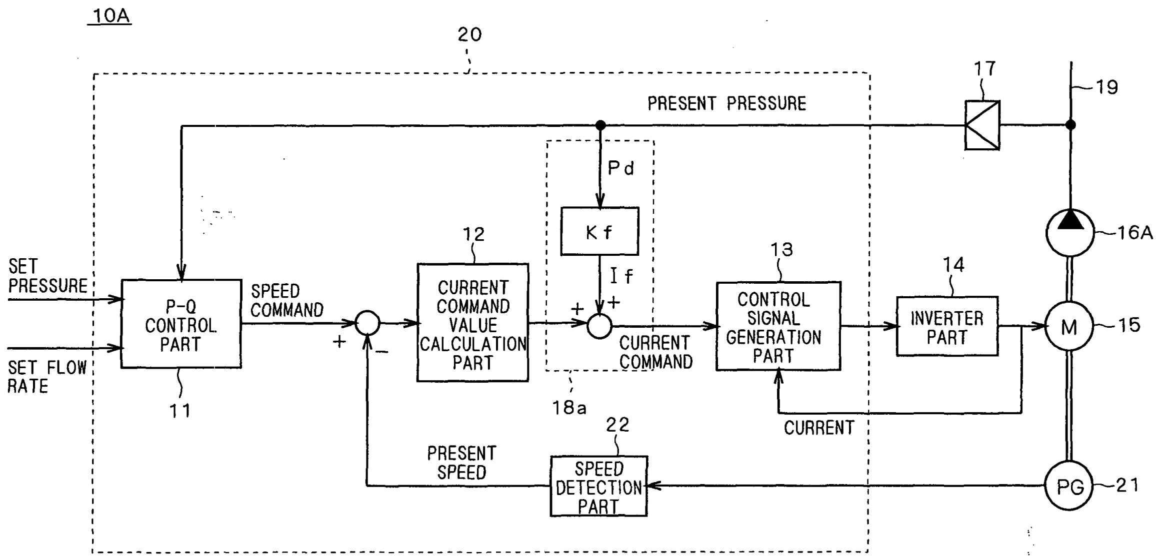
(54) HYDRAULIC UNIT AND METHOD OF CONTROLLING SPEED OF MOTOR IN HYDRAULIC UNIT

(57) In the present invention, an oil pressure unit includes an inverter 14 for supplying electric power to a motor 15; a load sensor 17 for detecting a load of the oil pressure pump 16A; a rotation sensor 19 for detecting a rotation speed of the motor 15; a current command value calculation means 12 for calculating a current command value so that a deviation between a speed command value representing a target rotation speed of the motor 15 and a rotation speed of the motor 15 converges to zero; a correction means 18A for correcting the current command value based on the load of the oil pressure pump 16A; and a control signal generation means for outputting a control signal to the inverter 14 based on a corrected current command value.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to an oil pressure unit for driving an oil pressure pump with a motor.

BACKGROUND ART

[0002] Conventionally, in an oil pressure unit having an oil pressure pump directly connected to a motor as a drive source, a speed control (PI control) calculation is executed to calculate a current command value through comparison of a speed command value of the motor and a current rotation speed, and a current control based on the current command value is realized by an inverter. The motor controlled by the inverter is then driven so that pressure oil is discharged from the oil pressure pump (e.g., patent document 1).

[0003] Patent document 1: Japanese Laid-Open Patent Publication No. 2004-162860

DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

[0004] In such oil pressure unit, the pressure of oil (oil pressure) becomes larger as a total amount of the oil discharged from the oil pressure pump by a drive of the oil pressure pump increases. An increase in the oil pressure leads to an increase in a load of the oil pressure pump in discharge, and causes a load torque of the motor to become larger.

[0005] Thus, in such oil pressure unit, in a case where a stepwise speed command value is provided, if a rotation speed of the motor drastically rises in response to the speed command value, the load of the oil pressure pump drastically increases and the load torque of the motor drastically becomes large. If the load torque of the motor drastically becomes large, the speed control constituted by the PI control cannot follow, and the rotation speed of the motor might lower.

[0006] A method of preventing lowering of the rotation speed of the motor includes a method of improving a response of the control by shortening a control period of the PI control by improving a processing speed of a microcomputer that performs the PI control. However, a cost of the microcomputer increases if such method is adopted. Furthermore, since the improvement of the processing speed of the microcomputer has physical limitations, lowering in the rotation speed of the motor cannot be effectively prevented with such method.

[0007] Another method includes a method using the load torque for the speed control in which the load torque is estimated from acceleration information obtained by differentiating the rotation speed of the motor. However, since the rotation speed is discrete information, a noise component increases by differentiation. Thus, there is a possibility a behavior will become unstable if the speed control is executed using the load torque.

[0008] Moreover, if a gain of the speed control is increased to improve a response to the load variation, an oscillation might occur when the stepwise speed command value is provided.

[0009] In view of the above problems, it is an object of the present invention to provide a technique capable of improving a followability of the rotation speed of the motor with respect to the variation of the load of the oil pressure pump. Means for Solving the Problems

[0010] A first aspect of an oil pressure unit according to the present invention relates to the oil pressure unit for supplying oil to an actuator by driving an oil pressure pump (16A) with a motor (15), characterized in that it comprises an inverter (14) for supplying power to the motor (15), a load sensor (17) for detecting a load of the oil pressure pump (16A), a rotation sensor (21) for detecting a rotation speed of the motor (15), a current command value calculation means (12) for calculating a current command value so that a deviation between a speed command value representing a target rotation speed of the motor (15) and a rotation speed of the motor (15) converges to zero, a correction means (18A; ⋯ ; 18D) for correcting the current command value based on the load of the oil pressure pump (16A), and a control signal generation means (13) for outputting a control signal to the inverter (14) based on a corrected current command value.

[0011] According to a second aspect of the oil pressure unit, in the first aspect, it is characterized in that said correction means (18A; ⋯ ; 18D) corrects the current command value to raise the rotation speed of said motor (15) with an increase in the load of said oil pressure pump (16A).

[0012] According to a third aspect of the oil pressure unit, in the first or the second aspect, it is characterized in that said correction means (18A; ⋯ ; 18D) increases the current command value with an increase in the load of said oil pressure pump (16A).

[0013] According to a fourth aspect of the oil pressure unit, in any one of the first to the third aspects, it is characterized in that said correction means (18A) acquires a correction value (If) using a correction coefficient (Kf) set in advance, and adds said correction value (If) to said current command value.

[0014] According to a fifth aspect of the oil pressure unit, in any one of the first to the third aspects, it is characterized in that said correction means (18B; 18C; 18D) acquires a correction value (If) using a data table DT acquired in advance, and adds said correction value (If) to said current command value.

[0015] According to a sixth aspect of the oil pressure unit, in any one of the first to the fifth aspects, it is characterized in that said load sensor (17) is a pressure sensor (17) for detecting a pressure of oil in a discharge line (19) of said oil pressure pump (16A).

[0016] A seventh aspect of the oil pressure unit relates to a speed control method of a motor (15) in the oil pressure unit for supplying oil to an actuator by driving an oil pressure pump (16A) with the motor (15) controlled by an inverter (14) and, characterized in that it comprises the steps of: a) detecting a load of said oil pressure pump (16A); b) detecting a rotation speed of said motor (15); c) calculating a current command value so that a deviation between a speed command value representing a target rotation speed of said motor (15) and a rotation speed of said motor (15) converges to zero; d) correcting the current command value based on the load of said oil pressure pump (16A); and e) outputting a control signal to said inverter (14) based on the corrected current command value.

The Effect of the Invention

[0017] According to the first aspect to the seventh aspect of the oil pressure unit of the present invention, the followability of the rotation speed of the motor with respect to the variation of the load (load oil pressure) of the oil pressure pump can be improved since the current command value is corrected based on the load of the oil pressure pump.

[0018] In particular, according to the second aspect of the oil pressure unit of the present invention, lowering in rotation speed of the motor involved in an increase of the load of the oil pressure pump can be prevented since the current command value is corrected to raise the rotation speed of the motor with an increase in the load of the oil pressure pump.

[0019] The objects, features, aspects, and advantages of the present invention will become apparent from the following detailed description and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

[FIG. 1] It is a schematic view showing a configuration of an oil pressure unit according to an embodiment.

[FIG. 2] It is a schematic view showing a configuration of an oil pressure unit without a correction part.

[FIG. 3] It is a view showing a state of an operation when a stepwise speed command is provided in the oil pressure unit according to the embodiment.

[FIG. 4] It is a view showing a state of an operation when a stepwise speed command is provided in the oil pressure unit oil pressure unit not including a correction part.

[FIG. 5] It is a schematic view showing an oil pressure unit including a correction part capable of acquiring a correction value using a data table.

[FIG. 6] It is a schematic view showing an oil pressure unit in which two oil pressure pumps are driven with one motor.

[FIG. 7] It is a schematic view showing an oil pressure unit in which two oil pressure pumps are connected in series.

BEST MODE FOR CARRYING OUT THE INVENTION

[0021] An embodiment of the present invention will now be described with reference to the drawings.

<Configuration>

[0022] FIG. 1 is a schematic view showing a configuration of an oil pressure unit 10A according to the embodiment of the present invention. The oil pressure unit 10A is connected to a molding machine etc., and supplies oil as working fluid to an actuator (not shown) having the oil pressure as the power source.

[0023] As shown in FIG. 1, the oil pressure unit 10A includes a controller 20, an inverter unit 14, a motor 15, an oil pressure pump 16A, a pressure sensor 17, and a pulse generator 21. In the oil pressure unit 10A having such configuration, the oil is taken in from a tank (not shown) by the oil pressure pump 16A driven by the motor 15, and the oil is discharged. The discharged oil is supplied to the actuator such as an oil pressure cylinder or an oil pressure motor through a discharge line 19.

[0024] The pressure sensor 17 serves as a load sensor for detecting the load of the oil pressure pump. The pressure sensor 17 also detects the pressure (also referred to as "present pressure" or "load oil pressure") of the oil in the discharge line 19 of the oil pressure pump.

[0025] The pulse generator 21 serves as a rotation sensor for outputting a pulse signal for detecting the rotation speed of the motor to the controller 20 (speed detection part 22).

[0026] The inverter unit 14 controls the rotation number of the motor 15 by performing switching based on a control signal from the controller 20.

[0027] The controller 20 includes a P-Q control part 11, a current command value calculation part 12, a correction part 18A, a control signal generation part 13, and a speed detection part 22. The controller 20 outputs a control signal for driving the inverter.

[0028] The P-Q control part 11 generates discharge pressure-discharge flow rate characteristics (P-Q characteristics) based on a set pressure and a set flow rate from a higher level system such as a molding machine. The P-Q control part 11 outputs a speed command value based on the present pressure from the pressure sensor 17 as an input.

[0029] The current command value calculation part (also referred to as "PI control part") 12 performs a proportional-integral (PI) control with the speed command value and the current speed as inputs, and outputs a current command value. More specifically, the PI control part 12 calculates the current command value so that the deviation between speed command value representing the target rotation speed of the motor 15 and the rotation speed of the motor 15 converges to zero.

[0030] The correction part 18A corrects the current command value based on the present pressure from the pressure sensor 17. The details will be hereinafter described.

[0031] The control signal generation part 13 generates a control signal for controlling the inverter part 14 based on the corrected current command value.

<Correction unit>

[0032] The correction part 18A will now be described in detail.

[0033] FIG. 2 is a schematic view showing a configuration of a general oil pressure unit 10B. The oil pressure unit 10B has the same configuration as the oil pressure unit 10A other than that the correction part 18A is not equipped.

[0034] A high response is demanded on the molding machine to which the oil pressure unit 10B is connected from the standpoint of mass production. Thus, in the oil pressure unit 10B for driving the molding machine, a stepwise speed command is provided in a short cycle.

[0035] As the total amount of the oil discharged from the oil pressure pump 16A increases, the oil pressure (load oil pressure) in the discharge line 19 of the oil pressure pump 16A becomes larger. As the load oil pressure becomes larger, the load of the oil pressure pump 16A in discharge increases. That is, the load oil pressure and the load torque of the motor 15 are more or less in a proportional relationship, where the load torque of the motor 15 becomes larger as the mad oil pressure becomes larger.

[0036] Therefore, in the oil pressure unit 10B, when the stepwise speed command is provided, the rotation speed of the motor 15 drastically rises in response to the speed command value. The load oil pressure drastically increases with rise in rotation speed of the motor 15. The load torque drastically becomes larger with an increase in the load oil pressure. Thus, the speed control by the PI control cannot be followed, and the rotation speed of the motor 15 lowers.

[0037] In order to prevent the lowering in the rotation speed of the motor 15 by an increase in load torque, the generated torque of the motor 15 needs to become larger with the increase in load torque. The generated torque of the motor 15 and the motor current are in proportional relationship, and thus the motor current, that is, the current command value merely needs to become large for the generated torque of the motor 15 to become large.

[0038] In brief, the followability of the rotation speed of the motor 15 with respect to variation of the load oil pressure can be improved by changing the current command value with variation of the load oil pressure. Furthermore, the lowering in the rotation speed of the motor 15 can be prevented by increasing the current command value with the increase in load oil pressure.

[0039] In the oil pressure unit 10A according to the present embodiment, the correction part 18A for correcting the current command value based on the load oil pressure is equipped. In the correction part 18A, the correction value (current correction value) If is acquired using the present pressure (pressure detected value) Pd detected by the pressure sensor 17 and a correction coefficient Kf acquired in advance. The correction value If is added to the current command value output from the current command value calculation part 12.

[0040] According to the correction part 18A, the current command value is corrected based on the load of the oil pressure pump 16A, that is, the pressure (load oil pressure) of the oil in the discharge line 19. Therefore, the followability of the rotation speed of the motor 15 with respect to the variation of the load (load oil pressure) of the oil pressure pump 16A can be enhanced (improved).

[0041] The coefficient acquired through tests in advance is used as the correction coefficient Kf. Specifically, the correction coefficient Kf is set so that the current command value necessary for preventing lowering in the rotation speed of the motor 15 and following the speed command can be acquired in the correction part 18A. The correction coefficient Kf can also be represented as being set so that the lack of current command value necessary for preventing lowering in the rotation speed of the motor 15 and following the speed command can be acquired as the correction value.

[0042] Through the use of the correction coefficient Kf set so that the lack of the current command value can be acquired as the correction value, the rotation speed of the motor 15 can be controlled to the rotation speed given by the speed command value.

[0043] The correction value If acquired using the correction coefficient Kf becomes larger with rise in load oil pressure. Thus, in the correction part 18A, the current command value can be corrected so as to raise the rotation speed of the motor 15 with the increase in load oil pressure, and lowering in rotation speed of the motor 15 involved in rise of the load oil pressure is prevented.

[0044] The operation in a case where a stepwise speed command SC is provided in the oil pressure unit 10A will now be specifically described. FIG. 3 is a view showing a state of an operation when a stepwise speed command SC is provided in the oil pressure unit 10A according to the present embodiment.

[0045] As shown in FIG. 3(a), when the stepwise speed command SC is provided in the oil pressure unit 10A, the rotation speed Rs1 of the motor 15 drastically rises in response to the speed command SC. The pressure Pd1 of the oil discharged from the oil pressure pump 16A then drastically increases, and the load torque of the motor 15 becomes larger.

[0046] However, in the oil pressure unit 10A, the correction value If which value becomes larger with the increase in the load oil pressure Pd1 is acquired in the correction part 18A. The correction value If is added to the output from the current command value calculation part 12, and the corrected current command value Ic1 is acquired (see FIG. 3(b)). The current command value Ic1 becomes larger following the increase in the load oil pressure Pd1, and thus the lowering in the rotation speed Rs1 of the motor 15 by the increase in load torque is prevented. The rotation speed Rs1 of the motor 15 thus can follow the rotation speed given by the speed command SC.

[0047] There will be compared the operation in a case where the stepwise speed command SC is provided in the oil pressure unit 10A with the operation in a case where the stepwise speed command SC is provided in the oil pressure unit 10B not including the correction part 18A. FIG. 4 is a view showing a state of an operation when the stepwise speed command SC is provided in the oil pressure unit 10B.

[0048] As shown in FIG. 4(a), when the stepwise speed command SC is provided in the oil pressure unit 10B, the rotation speed Rs2 of the motor 15 lowers by influence of an increase in the load oil pressure Pd2 due to drastic rise in the rotation speed Rs2 of the motor 15.

[0049] Comparing FIG. 3(b) with FIG. 4(b), the magnitude of the current command value is different in zone BT. The difference in magnitude of the current command value indicates that the appropriate current command value necessary for following the rotation speed of the motor 15 to the speed command SC is not acquired (calculated) in the oil pressure unit 10B (FIG. 4(b)).

[0050] Therefore, when the rapid speed command like the stepwise speed command SC is provided, the rotation speed of the motor 15 cannot be followed to such speed command with only the speed control constituted by the PI control.

[0051] In the present embodiment, the correction value If that becomes larger with the increase in the load oil pressure Pd is acquired using the load oil pressure Pd detected by the pressure sensor 17 and the correction coefficient Kf previously acquired in the correction part 18A. The relevant correction value If is added to the current command value output from the current command value calculation part 12.

[0052] As described above, the current command value Ic1 can be increased following the increase in the load oil pressure Pd1 by adding the correction value If acquired based on the load oil pressure Pd1 to the current command value output from the current command value calculation part 12 in a feedforward manner. The lowering in the rotation speed Rs1 of the motor 15 by the increase in load torque thus can be prevented.

<Modification>

[0053] The embodiment of the present invention has been described, but the present invention is not limited to the content described above.

[0054] For instance, in the above embodiments, the correction value If is acquired using the correction coefficient Kf previously acquired in the correction part 18A, but is not limited thereto. FIG. 5 is a schematic view showing an oil pressure unit 10C including a correction part 18B capable of acquiring the correction value If using a data table DT.

[0055] Specifically, the correction value If may be acquired (calculated) using a data table DT showing a relationship between the load oil pressure (pressure detected value) Pd acquired in advance and the correction value If in the correction part 18B, as shown in FIG. 5.

[0056] An appropriate correction value If thus can be acquired with respect to the load pressure Pd from the pressure sensor 17 even if the load pressure and the correction value necessary for following the speed command are not in a proportional relationship.

[0057] Furthermore, the oil pressure unit 10A is driven using one oil pressure pump 16A in the above embodiment, but is not limited thereto.

[0058] Specifically, the oil pressure unit may be driven using a plurality of oil pressure pumps. FIG. 6 is a schematic view showing an oil pressure unit 10D in which two oil pressure pumps 16A, 16B are driven with one motor.

[0059] For instance, as shown in FIG. 6, information (pump drive information) indicating which oil pressure pump is being driven is output to the correction part 18C from the P-Q control part 11 according to the switching of the pump when configuring the oil pressure unit 10D with two oil pressure pumps 16A, 16B. In the correction part 18C, the data table for acquiring the correction value If is switched according to the pump drive information, and the correction value If corresponding to the driven pump is acquired.

[0060] When simultaneously driving the two oil pressure pumps 16A, 16B, the data table showing a relationship between the load oil pressure (pressure detected value) Pd and the correction value If in a case where the two oil pressure pumps 16A, 16B are simultaneously driven is used to acquire the correction value If.

[0061] The two oil pressure pumps 16A, 16B do not need be connected in parallel. FIG. 7 is a schematic view showing an oil pressure unit in which two oil pressure pumps are connected in series. As shown in FIG. 7, when the two oil pressure pumps are connected in series such that the oil discharged from one oil pressure pump 16B is taken in by the other oil pressure pump 16A, the pressure of the oil discharged form the oil pressure pump 16A on the downstream side is detected by the pressure sensor (17). The current command value is corrected based on the oil pressure discharged by the oil pressure pump 16A on the downstream side.

[0062] Although the present invention has been described in detail above, the above description is merely illustrative in all aspects and the present invention should not be limited by the description. It should be recognized that an infinite number of modifications that are not illustrated can be contrived without deviating from the scope of the invention.

Claims

1. An oil pressure unit for supplying oil to an actuator by driving an oil pressure pump (16A) with a motor (15), the oil pressure unit **characterized in that** it comprises:

   an inverter (14) for supplying electric power to said motor (15);
   a load sensor (17) for detecting a load of said oil pressure pump (16A);
   a rotation sensor (21) for detecting a rotation speed of said motor (15);
   a current command value calculation means (12) for calculating a current command value so that a deviation between a speed command value representing a target rotation speed of said motor (15) and a rotation speed of said motor (15) converges to zero;
   a correction means (18A; ··· ; 18D) for correcting said current command value based on the load of said oil pressure pump; and
   a control signal generation means (13) for outputting a control signal to said inverter (14) based on a corrected current command value.

2. The oil pressure unit according to claim 1, **characterized in that** said correction means (18A; ··· , 18D) corrects said current command value to raise the rotation speed of said motor (15) with an increase in the load of said oil pressure pump (16A).

3. The oil pressure unit according to claim 1 or 2, **characterized in that** said correction means (18A; ··· ; 18D) increases said current command value with an increase in the load of said oil pressure pump (16A).

4. The oil pressure unit according to claim 1 or 2, **characterized in that** said correction means (18A) acquires a correction value (If) using a correction coefficient (Kf) set in advance, and adds said correction value (If) to said current command value.

5. The oil pressure unit according to claim 3, **characterized in that** said correction means (18A) acquires a correction value (If) using a correction coefficient (Kf) set in advance, and adds said correction value (If) to said current command value.

6. The oil pressure unit according to claim 1 or 2, **characterized in that** said correction means (18B; 18C; 18D) acquires a correction value (If) using a data table DT acquired in advance, and adds said correction value (If) to said current command value.

7. The oil pressure unit according to claim 3, **characterized in that** said correction means (18B; 18C; 18D) acquires a correction value (If) using a data table DT acquired in advance, and adds said correction value (If) to said current command value.

8. The oil pressure unit according to claim 1 or 2, **characterized in that** said load sensor (17) is a pressure sensor (17) for detecting a pressure of oil in a discharge line (19) of said oil pressure pump (16A).

9. The oil pressure unit according to claim 3, **characterized in that** said load sensor (17) is a pressure sensor (17) for detecting a pressure of oil in a discharge line (19) of said oil pressure pump (16A).

10. The oil pressure unit according to claim 4, **characterized in that** said load sensor (17) is a pressure sensor (17) for detecting a pressure of oil in a discharge line (19) of said oil pressure pump (16A).

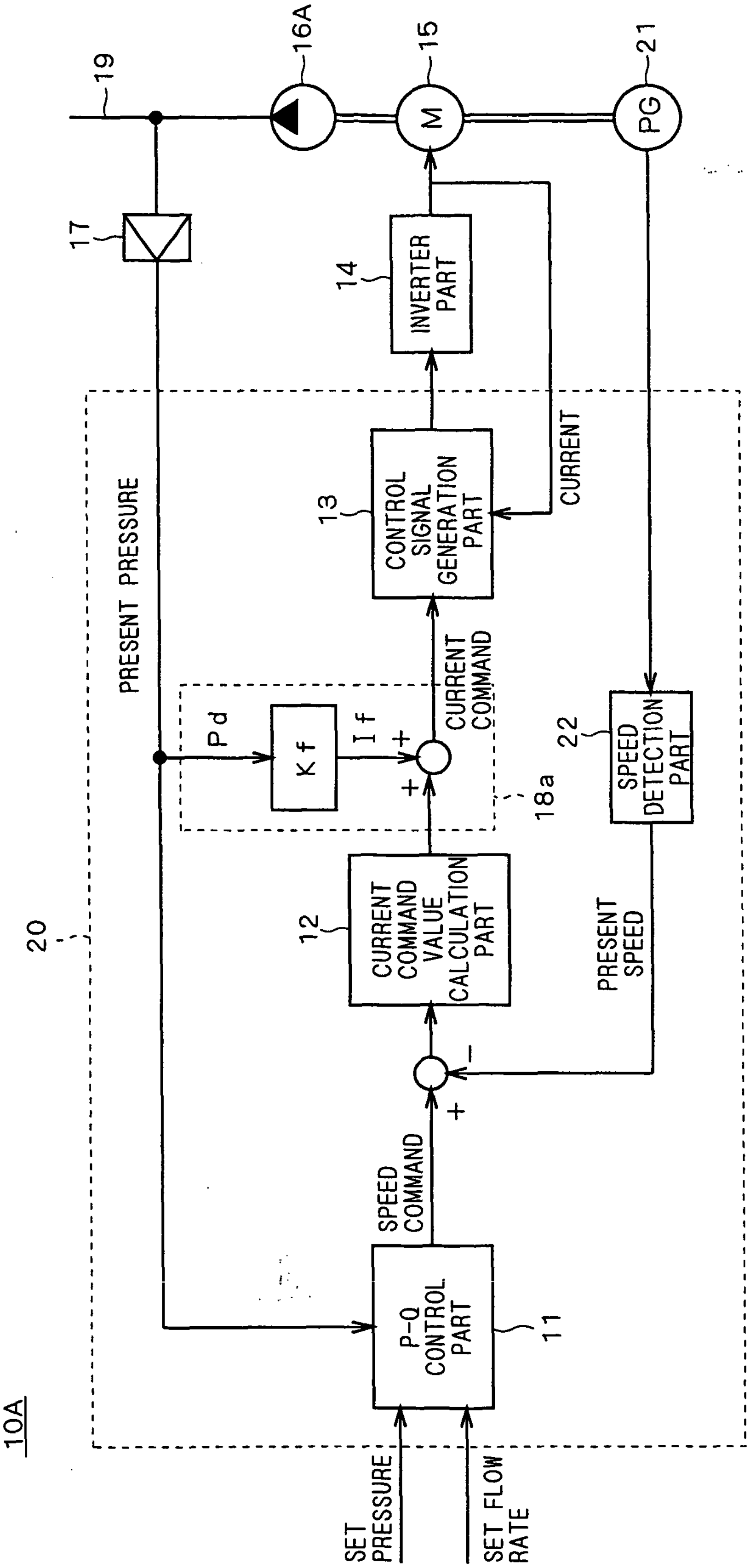
11. The oil pressure unit according to claim 5 or 7, **characterized in that** said load sensor (17) is a pressure sensor (17) for detecting a pressure of oil in a discharge line (19) of said oil pressure pump (16A).

12. The oil pressure unit according to claim 6, **characterized in that** said load sensor (17) is a pressure sensor (17) for detecting a pressure of oil in a discharge line (19) of said oil pressure pump (16A).

13. A speed control method of a motor (15) in an oil pressure unit for supplying oil to an actuator by driving an oil pressure pump (16A) with said motor (15) controlled by an inverter (14), the speed control method **characterized in that** it comprises the steps of:

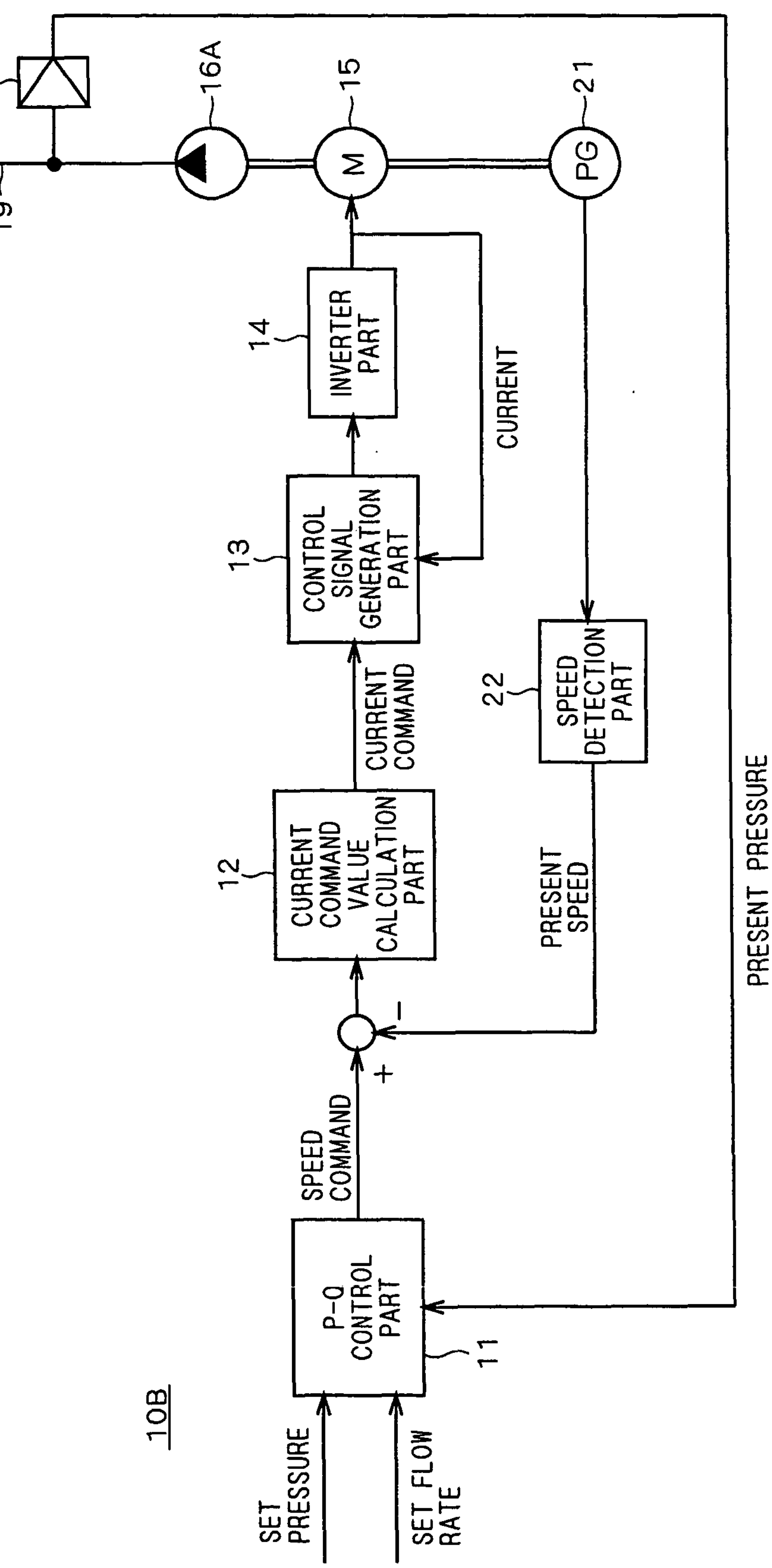
   a) detecting a load of said oil pressure pump (16A);
   b) detecting a rotation speed of said motor (15);
   c) calculating a current command value so that a deviation between a speed command value representing a target rotation speed of said motor (15) and a rotation speed of said motor (15) converges to zero;
   d) correcting said current command value based on the load of said oil pressure pump (16A); and
   e) outputting a control signal to said inverter (14) based on a corrected current command value.

FIG. 1

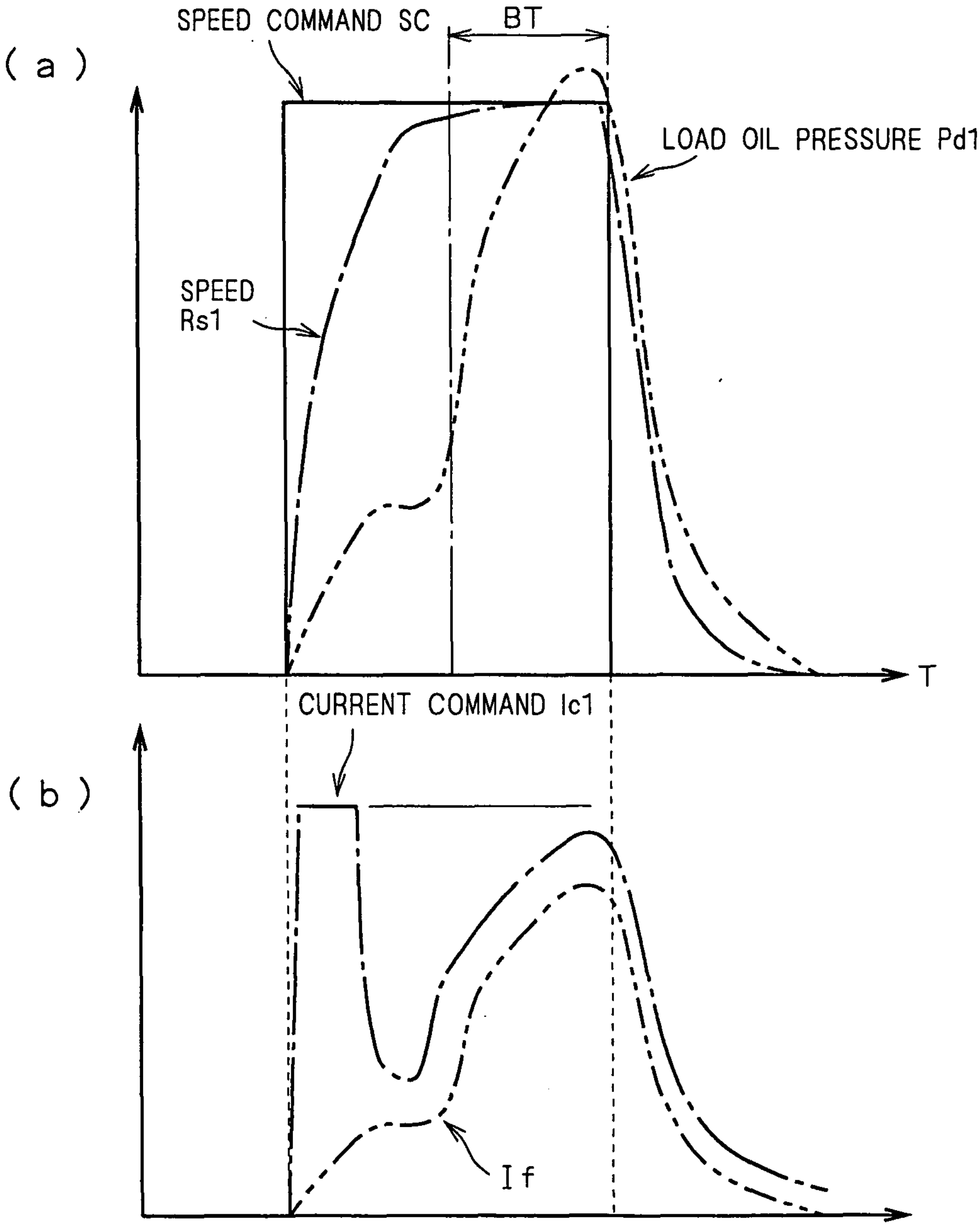


10A
20
SET PRESSURE
SET FLOW RATE
P-Q CONTROL PART
11
SPEED COMMAND
+
−
CURRENT COMMAND VALUE CALCULATION PART
12
PRESENT SPEED
SPEED DETECTION PART
22
Pd
Kf
If
+
+
18a
CURRENT COMMAND
CONTROL SIGNAL GENERATION PART
13
CURRENT
INVERTER PART
14
PRESENT PRESSURE
17
19
16A
M
15
PG
21

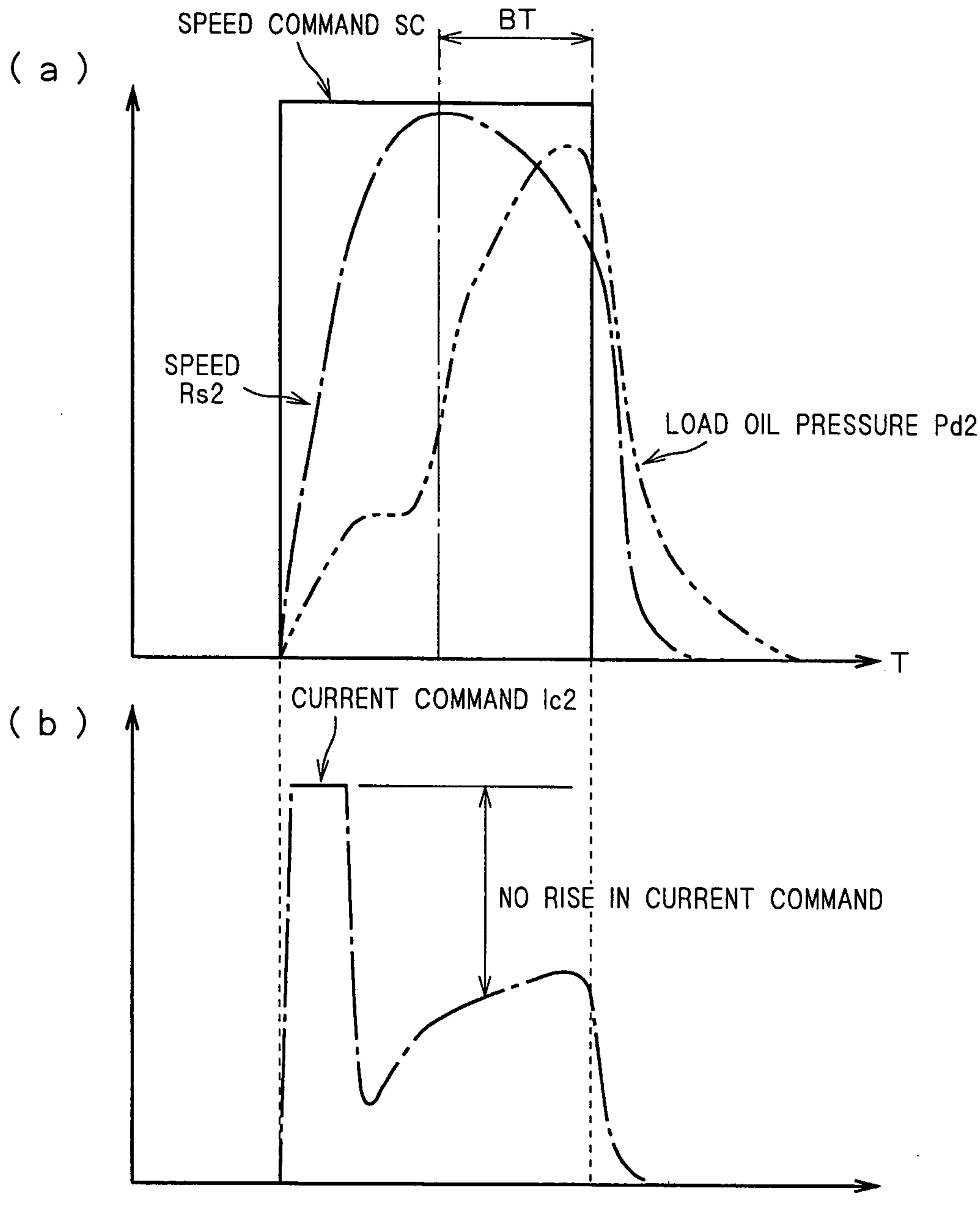
F I G . 2


10B
SET PRESSURE
SET FLOW RATE
P-Q CONTROL PART
11
SPEED COMMAND
+
−
CURRENT COMMAND VALUE CALCULATION PART
12
CURRENT COMMAND
CONTROL SIGNAL GENERATION PART
13
INVERTER PART
14
CURRENT
M
15
16A
17
19
PG
21
SPEED DETECTION PART
22
PRESENT SPEED
PRESENT PRESSURE

F I G . 3


(a)
SPEED COMMAND SC
BT
LOAD OIL PRESSURE Pd1
SPEED
Rs1
T
CURRENT COMMAND Ic1
(b)
If

F I G . 4



(a)
SPEED COMMAND SC
BT
SPEED
Rs2
LOAD OIL PRESSURE Pd2
T
(b)
CURRENT COMMAND Ic2
NO RISE IN CURRENT COMMAND

FIG. 5

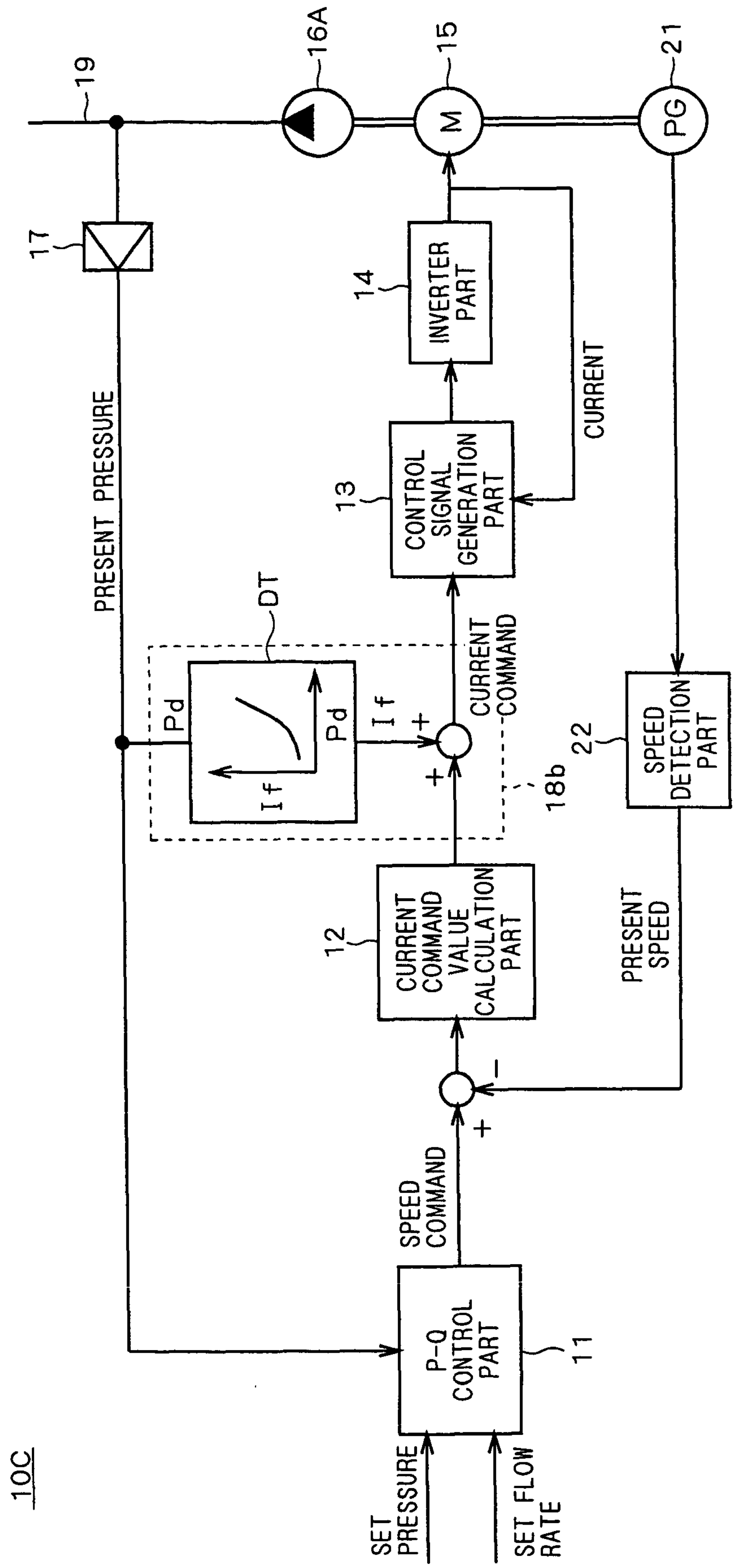

10C
SET PRESSURE
SET FLOW RATE
P-Q CONTROL PART
11
SPEED COMMAND
+
−
CURRENT COMMAND VALUE CALCULATION PART
12
PRESENT SPEED
SPEED DETECTION PART
22
18b
DT
Pd
If
+
CURRENT COMMAND
CONTROL SIGNAL GENERATION PART
13
CURRENT
INVERTER PART
14
PRESENT PRESSURE
17
19
16A
M
15
PG
21

FIG. 6

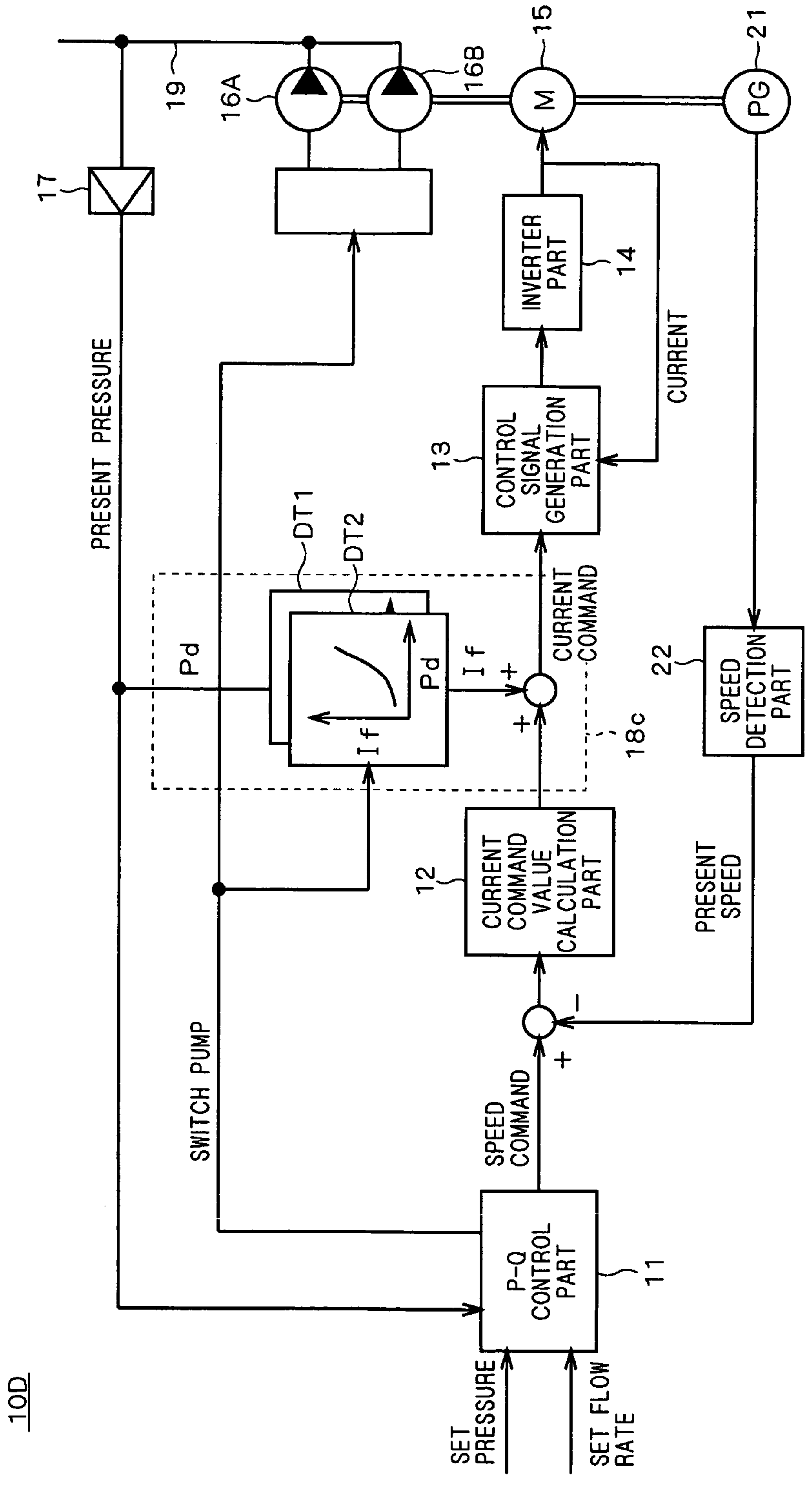
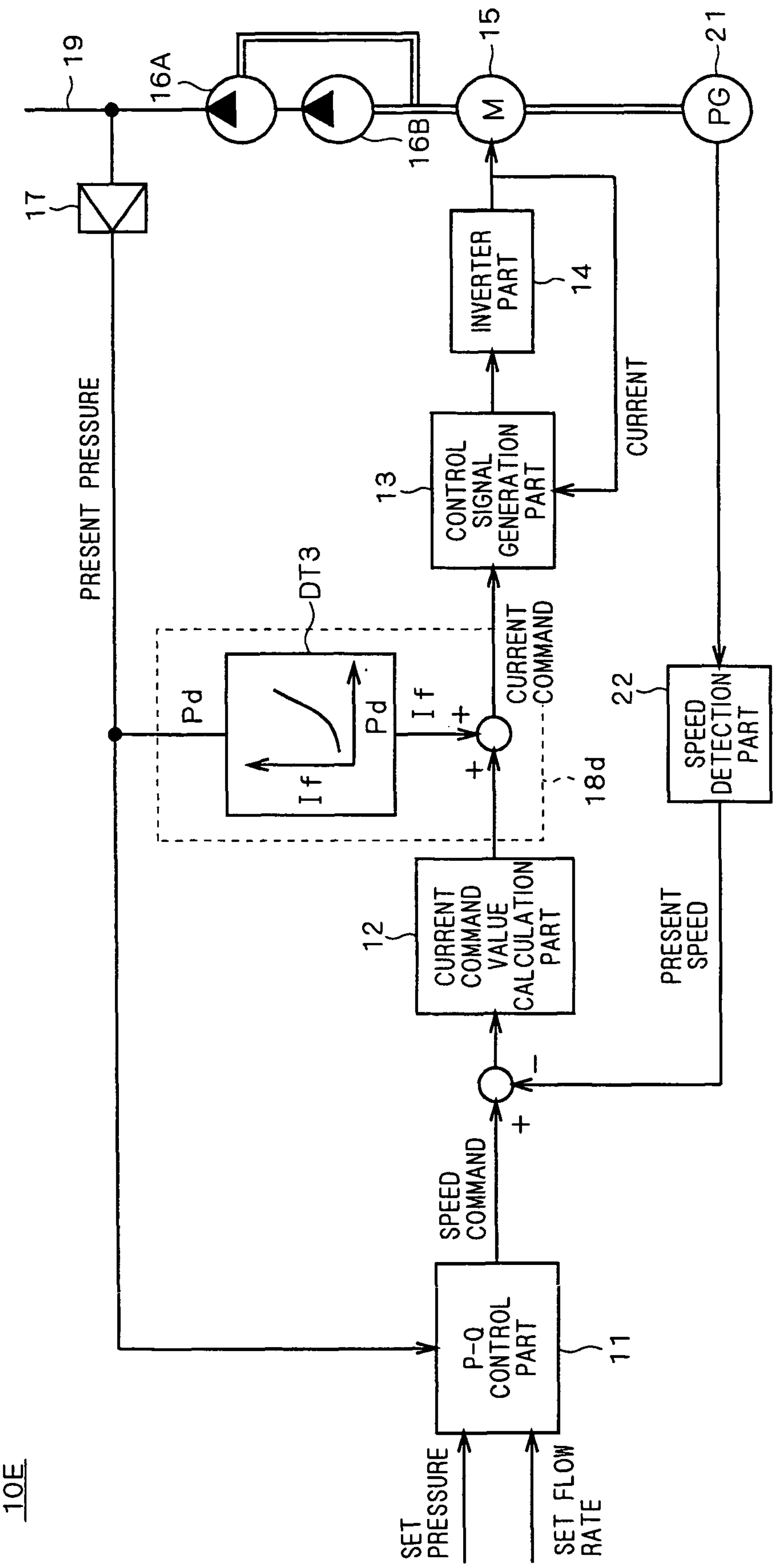

10D
SET PRESSURE
SET FLOW RATE
P-Q CONTROL PART
11
SWITCH PUMP
PRESENT PRESSURE
SPEED COMMAND
CURRENT COMMAND VALUE CALCULATION PART
12
CURRENT COMMAND
CONTROL SIGNAL GENERATION PART
13
INVERTER PART
14
CURRENT
M
15
16A
16B
17
19
PG
21
SPEED DETECTION PART
22
PRESENT SPEED
DT1
DT2
Pd
I f
18c
+
-

FIG. 7


10E
SET PRESSURE
SET FLOW RATE
P-Q CONTROL PART
11
SPEED COMMAND
+
-
PRESENT SPEED
CURRENT COMMAND VALUE CALCULATION PART
12
+
+
Pd
If
Pd
If
DT3
18d
CURRENT COMMAND
CONTROL SIGNAL GENERATION PART
13
CURRENT
INVERTER PART
14
SPEED DETECTION PART
22
PRESENT PRESSURE
17
19
16A
16B
M
15
PG
21

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/066559

A. CLASSIFICATION OF SUBJECT MATTER
F15B11/00(2006.01)i, *F04B49/00*(2006.01)i, *H02P27/06*(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)
F15B11/00, F04B49/06, H02P27/06

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	1996-2007
Kokai Jitsuyo Shinan Koho	1971-2007	Toroku Jitsuyo Shinan Koho	1994-2007

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.
X	JP 2001-248566 A (Tokimec Inc.), 14 September, 2001 (14.09.01), Par. Nos. [0030] to [0037] (Family: none)	1-13
A	JP 2004-162860 A (Daikin Industries, Ltd.), 10 June, 2004 (10.06.04), Full text & WO 2004/046562 A & EP 1574723 A & CA 2505753 A & US 2006/0150621 A1	1-13

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

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- "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
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- "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	Date of mailing of the international search report
12 September, 2007 (12.09.07)	25 September, 2007 (25.09.07)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (April 2005)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2004162860 A **[0003]**