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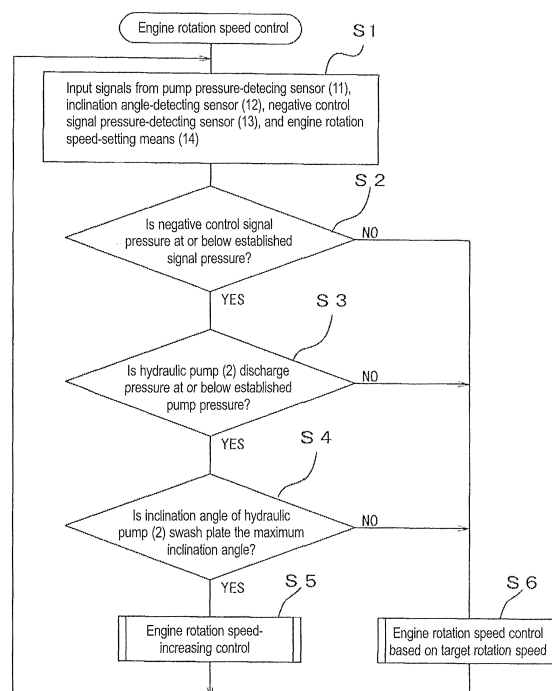
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(54) **HYDRAULIC MACHINERY**

(57) The invention addresses the problem of avoiding insufficient flow being supplied to the hydraulic actuator and speed becoming insufficient during light loads in hydraulic machinery such as hydraulic shovels when the engine rotation speed is set low during normal work. The solution is to increase the discharge flow of the hydraulic pump (2) by increasing the rotation speed of the engine (1) above the target rotation speed set by the engine rotation speed-setting means (14) when the hydraulic pump (2) discharge pressure is at the light load pump discharge pressure, the hydraulic pump (2) inclination angle is at the maximum inclination angle, and the negative control signal pressure is at the signal pressure when the hydraulic actuator-operating means (7) is at full operation.

Fig. 2



EP 2 792 888 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to the technical field of a hydraulic work machine such as a hydraulic shovel.

BACKGROUND ART

[0002] Generally, hydraulic work machines, such as hydraulic shovels, are configured to drive a hydraulic pump by an engine to operate various hydraulic actuators (a hydraulic motor and a hydraulic cylinder) that use the hydraulic pump as a hydraulic pressure supply source, and thus perform various operations such as traveling and excavation. In recent years, improvements in fuel efficiency and reductions of exhaust gases in these hydraulic work machines have been in progress. One studied method of achieving the objects is setting the engine rotation speed to be low during normal operation. However, when the engine rotation speed is thus set to be low, the rotation speed of the hydraulic pump, driven by the engine, is also lowered. Thus, the maximum flow rate that can be supplied from the hydraulic pump to the hydraulic actuator is reduced. As a result, a problem arises in that a sufficient speed cannot be obtained when the hydraulic actuator is to be operated at a high speed in a light load state.

[0003] A technique of controlling the engine rotation speed in accordance with the load pressure to improve fuel efficiency in the light load state, is known (see, for example, Patent Document 1). Here, when the load on the hydraulic actuator is light and the discharge pressure of the hydraulic pump is low, a desired discharge flow rate is obtained by lowering the engine rotation speed and increasing the capacity of the hydraulic pump.

[0004] Patent Document 1: Japanese Patent Application Laid-open No. H6-81802

DISCLOSURE OF THE INVENTION

[0005] However, when the engine rotation speed is set to be low during normal operation, in an attempt to achieve lower fuel consumption, in the technique described in Patent Document 1 described above, the engine rotation speed, at the time when the load on the hydraulic actuator is light, is even lower than that during the normal operation. Thus, the flow rate from the hydraulic pump to the hydraulic actuator is not increased with the increased capacity of the hydraulic pump. As a result, the problem of the insufficient speed, when the hydraulic actuator is to be operated at a high speed in the light load state, cannot be solved. Thus, an object of the present invention is to solve this problem.

[0006] With the foregoing in view, the present invention is made to solve the problems and an invention of claim 1 is a hydraulic work machine including: an engine; a

variable capacity hydraulic pump driven by the engine; a hydraulic actuator that operates using the hydraulic pump as a hydraulic pressure supply source; a control valve that is displaced in accordance with an operation amount of a hydraulic actuator operation means so as to control a pressure oil supply flow rate from the hydraulic pump to the hydraulic actuator; a negative control circuit that outputs a negative control signal pressure to capacity varying means of the hydraulic pump to increase or decrease a discharge flow rate of the hydraulic pump in accordance with a displacement amount of the control valve; an engine rotation speed setting means operated to set a target rotation speed of the engine; and an engine control device that controls a rotation speed of the engine based on the target rotation speed set with the engine rotation speed setting means. The hydraulic work machine further includes pump pressure detection means for detecting a discharge pressure of the hydraulic pump, pump capacity detection means for detecting a capacity of the hydraulic pump, and negative control signal pressure detection means for detecting the negative control signal pressure. The engine control device performs engine rotation speed increasing control for increasing the engine rotation speed to be higher than the target rotation speed set with the engine rotation speed setting means, when the discharge pressure of the hydraulic pump detected by the pump pressure detection means is not larger than a set pump pressure set in advance as a pump discharge pressure in a light load state, the pump capacity detected by the pump capacity detection means is at a maximum capacity of the hydraulic pump, and the negative control signal pressure detected by the negative control signal pressure detection means is not larger than a set signal pressure set in advance as a negative control signal pressure in a fully operated state of the hydraulic actuator operation means.

[0007] With the invention of claim 1, even in the case where the engine rotation speed is set to be low during normal operation to achieve lower fuel consumption, the engine rotation speed increases when the engine rotation speed increasing control is performed, and thus the discharge flow rate of the hydraulic pump can be increased. This can prevent insufficient speed due to an insufficient supply flow rate to the hydraulic actuator in the case where an operation requiring high speed at a light load is performed, whereby excellent operability is guaranteed and an attempt to improve work efficiency is largely facilitated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Fig. 1 is a hydraulic pressure control circuit diagram of a hydraulic shovel.

Fig. 2 is a flowchart of engine rotation speed control.

BEST MODE FOR CARRYING OUT THE INVENTION

[0009] An embodiment of the present invention is described below by referring to the drawings.

[0010] A hydraulic pressure control circuit provided to a hydraulic shovel, as an example of a hydraulic work machine, is illustrated in Fig. 1, in which 1 denotes an engine, 2 denotes a variable capacity hydraulic pump driven by the engine 1, 2a denotes capacity varying means of the hydraulic pump 2, 3 denotes an oil tank, and A denotes hydraulic actuators that operate using the hydraulic pump 2 as a hydraulic pressure supply source. In this embodiment, the hydraulic shovel includes, as the hydraulic actuators A, left and right drive motors, a swing motor, a boom cylinder, an arm cylinder, and a bucket cylinder. In this embodiment, an axial piston pump, in which a capacity changes in accordance with a inclination angle of a swash plate, is used as the hydraulic pump 2.

[0011] Furthermore, 4 denotes control valves that perform oil supply/discharge control for the respective hydraulic actuators A. The control valve 4 is configured to be positioned at a neutral position N in which pressure oil is not supplied to the hydraulic actuator A, in a state where no pilot pressure is supplied to pilot ports 4a and 4b, and is configured to be displaced when the pilot pressure is supplied to the pilot ports 4a and 4b and to be switched to an operation position X or Y in which a discharged oil from the hydraulic pump 2 is supplied to the hydraulic actuator A. Here, a control is performed in such a manner that the displacement amount (movement stroke) of the control valve 4 increases/decreases in accordance with the increase/decrease of the pilot pressure input to the pilot ports 4a and 4b, and a pressure oil supply flow rate to the hydraulic actuator A increases when a displacement amount of the control valve 4 increases. A center bypass valve path 4c to be connected to a center bypass oil path 5, described later, is formed in each control valve 4. The opening amount of the center bypass valve path 4c is at the maximum when the control valve 4 is at the neutral position N, and reduces as the displacement amount of the control valve 4 increases.

[0012] Furthermore, 6 denotes a pilot valve. The pilot valve 6 outputs the pilot pressure to each of the pilot ports 4a and 4b of the control valve 4, based on an operation on a hydraulic actuator operation device (operation devices respectively for left and right traveling, swing, the boom, the arm, and the bucket, in this embodiment) 7. Here, the pilot pressure output from the pilot valve 6 increases/decreases in accordance with the operation amount on the hydraulic actuator operation means 7. In Fig. 1, only the pilot valve 6 that outputs the pilot pressure to the control valve 4 at the right end is illustrated, and the pilot valves 6 that output the pilot pressure to other control valves 4 are omitted because the pilot valves are the same as the right end one.

[0013] The center bypass oil path 5 is an oil path that is formed to extend from the hydraulic pump 2, sequentially pass through the center bypass valve paths 4c

formed in the respective control valves 4, and then pass through a negative control orifice 8 to reach the oil tank 3. The pressure on the upstream side of the negative control orifice 8 in the center bypass oil path 5 is input, as a negative control signal pressure, to the capacity varying means 2a of the hydraulic pump 2, through a signal circuit 9. The negative control signal pressure is high when the opening amount of the center bypass valve path 4c of the control valve 4 is maximum, that is, when the control valve 4 is positioned at the neutral position N, while the negative control signal pressure becomes lower as the opening amount of the center bypass valve path 4c becomes smaller, that is, as the displacement amount of the control valve 4 becomes larger. The capacity varying means 2a of the hydraulic pump 2 controls the discharge flow rate of the hydraulic pump 2, in such a manner that the negative control signal pressure at a higher pressure leads to a smaller discharge flow rate of the hydraulic pump 2, and the negative control signal pressure at a lower pressure leads to a larger discharge flow rate of the hydraulic pump 2. The center bypass valve path 4c of the control valve 4, the center bypass oil path 5, the negative control orifice 8, and the signal circuit 9 form a negative control circuit of the present invention.

[0014] Furthermore, 10 denotes an engine control device that controls the rotation speed of the engine 1. The engine control device 10 receives a signal from each of a pump pressure detection sensor (corresponding to pump pressure detection means of the present invention) 11 that detects the discharge pressure of the hydraulic pump 2, a inclination angle detection sensor (corresponding to pump capacity detection means of the present invention) 12 that detects the inclination angle of the swash plate of the hydraulic pump 2, a negative control signal pressure detection sensor (corresponding to negative control signal pressure detection means of the present invention) 13 that detects the negative control signal pressure, and an engine rotation speed setting means (such as an accelerator dial and an accelerator lever) 14. The engine control device 10 controls the rotation speed of the engine 1, based on the input signals.

[0015] Here, the engine rotation speed setting means 14 is an operation means used by an operator to set the target rotation speed of the engine 1 as desired. In this embodiment, the operator can set the engine rotation speed to a plurality of levels by using the engine rotation speed setting means 14. The engine rotation speed setting means 14 may enable the engine rotation speed to be set in a stepless manner.

[0016] Next, an engine rotation speed control performed by the engine control device 10 will be described by referring to the flowchart in Fig. 2.

[0017] First, the engine control device 10 receives signals from the pump pressure detection sensor 11, the inclination angle detection sensor 12, a negative control signal pressure detection sensor 13, and the engine rotation speed setting means 14 (step S1).

[0018] Then, the engine control device 10 determines

whether a negative control signal pressure P_n , detected by the negative control signal pressure detection sensor 13, is not larger than a set signal pressure P_{nS} (1.8 Mpa, for example) ($P_n \leq P_{nS}$?), the set signal pressure P_{nS} being set in advance as a negative control signal pressure when at least one hydraulic actuator operation means 7 is in a fully operated state (at least one control valve 4 is displaced by the maximum displacement amount) (step S2).

[0019] When "YES" is determined in step S2 described above, that is, when the negative control signal pressure P_n is not larger than the set signal pressure P_{nS} ($P_n \leq P_{nS}$), it is further determined whether the discharge pressure P_p of the hydraulic pump 2 detected by the pump pressure detection sensor 11 is not larger than a set pump pressure P_{pS} (20 MPa for example) ($P_p \leq P_{pS}$?), the set pump pressure P_{pS} being set in advance as a pump discharge pressure in the light load state (step S3).

[0020] When "YES" is determined in step S3 described above, that is, when the discharge pressure P_p of the hydraulic pump 2 is not larger than the set pump pressure P_{pS} ($P_p \leq P_{pS}$), whether the inclination angle $S\theta$ of the swash plate of the hydraulic pump 2, detected by the inclination angle detection sensor 12, is at the maximum inclination angle $S\theta_m$ at which the capacity of the hydraulic pump 2 ($S\theta = S\theta_m$?) is maximum, is further determined (step S4).

[0021] When "YES" is determined in step S4 described above, that is, when the inclination angle $S\theta$ of the swash plate of the hydraulic pump 2 is at the maximum inclination angle $S\theta_m$ ($S\theta = S\theta_m$), the engine control device 10 performs an engine rotation speed increasing control for increasing the engine rotation speed up to a light-load state rotation speed that is higher than the target rotation speed set with the engine rotation speed setting means 14 (step S5). Here, the light-load state rotation speed is higher than the target rotation speed set with the engine rotation speed setting means 14, by a predetermined rotation speed (200 rps, for example), and is set for each target rotation speed.

[0022] The engine rotation speed increasing control for increasing the engine rotation speed up to the light-load state rotation speed that is higher than the target rotation speed set with the engine rotation speed setting means 14 is performed, when "YES" is determined in all of steps S2, S3, and S4 described above, that is, when the negative control signal pressure P_n is not larger than the set signal pressure P_{nS} (the hydraulic actuator operation means 7 is in the fully operated state), the discharge pressure P_p of the hydraulic pump 2 is not larger than the set pump pressure P_{pS} (in the light load state), and the inclination angle $S\theta$ of the swash plate of the hydraulic pump 2 is at the maximum inclination angle $S\theta_m$ (the capacity of the hydraulic pump 2 is at the maximum). Thus, the rotation speed of the hydraulic pump 2, driven by the engine 1, is increased by performing the engine rotation speed increasing control, whereby the discharge flow rate of the hydraulic pump 2 can be increased.

[0023] On the other hand, when "NO" is determined in any one of steps S2, S3, and S4 described above, that is, when the negative control signal pressure exceeds the set signal pressure ($P_n > P_{nS}$), when the discharge pressure of the hydraulic pump 2 exceeds the set pump pressure ($P_p > P_{pS}$), or when the inclination angle of the swash plate of the hydraulic pump 2 is not at the maximum inclination angle ($S\theta \neq S\theta_m$), the engine control device 10 controls the engine rotation speed so that the target rotation speed set with the engine rotation speed setting means 14 is achieved (step S6).

[0024] In this embodiment configured as described above, the hydraulic shovel includes: the engine 1; the variable capacity hydraulic pump 2 driven by the engine 1; the hydraulic actuator A that operates using the hydraulic pump 2 as a hydraulic pressure supply source; the control valve 4 that is displaced in accordance with an operation amount of a hydraulic actuator operation means 7 so as to control a pressure oil supply flow rate from the hydraulic pump 2 to the hydraulic actuator A; the negative control circuit (the center bypass valve path 4c of the control valve 4, the center bypass oil path 5, the negative control orifice 8, and the signal circuit 9) that outputs the negative control signal pressure to the capacity varying means 2a of the hydraulic pump 2 to increase or decrease a discharge flow rate of the hydraulic pump 2 in accordance with a displacement amount of the control valve 4; the engine rotation speed setting means 14 operated to set the target rotation speed of the engine 1; and the engine control device 10 that controls a rotation speed of the engine 1 based on the target rotation speed set with the engine rotation speed setting means 14. The hydraulic shovel further includes the pump pressure detection sensor 11 for detecting a discharge pressure of the hydraulic pump 2, the inclination angle detection sensor 12 for detecting the inclination angle of the hydraulic pump 2, and the negative control signal pressure detection sensor 13 for detecting the negative control signal pressure. The engine control device 10 performs engine rotation speed increasing control for increasing the rotation speed of the engine 1 up to the light-load state rotation speed higher than the target rotation speed set with the engine rotation speed setting means 14, when the discharge pressure of the hydraulic pump 2 detected by the pump pressure detection sensor 11 is not larger than a set pump pressure set in advance as a pump discharge pressure in the light load state, the inclination angle of the swash plate of the hydraulic pump 2 detected by the inclination angle detection sensor 12 is at the maximum inclination angle (the pump capacity is at the maximum capacity), and the negative control signal pressure detected by the negative control signal pressure detection sensor 13 is not larger than the set signal pressure set in advance as the negative control signal pressure in the fully operated state of the hydraulic actuator operation means 7.

[0025] When, in the light load state, the capacity of the hydraulic pump 2 is at the maximum capacity, and the

hydraulic actuator operation means 7 is in the fully operated state, the engine rotation speed increasing control is performed for increasing the engine rotation speed up to the light-load state rotation speed higher than the target rotation speed set with the engine rotation speed setting means 14. Thus, the rotation speed of the hydraulic pump 2 also increases. As a result, by setting a low target rotation speed with the engine rotation speed setting means 14 and performing an operation with the low target rotation speed during normal operation, a lower fuel consumption can be achieved, and the discharge flow rate of the hydraulic pump 2 can be increased by the engine rotation speed increasing control in the light load state. Thus, for example, when an operation such as dumping or return operation during truck loading, requiring a high speed with a light load, is performed, an insufficient speed due to an insufficient supply flow rate to the hydraulic actuator A can be prevented, whereby an excellent operability is guaranteed, and an attempt to improve the work efficiency is largely facilitated.

INDUSTRIAL APPLICABILITY

[0026] The present invention can be used for various hydraulic work machines such as a hydraulic shovel, including a hydraulic pump driven by an engine and a hydraulic actuator that operates using the hydraulic pump as a hydraulic pressure supply source.

EXPLANATION OF REFERENCE NUMERALS

[0027]

1	Engine	
2	Hydraulic pump	35
2a	Capacity varying means	
4	Control valve	
4c	Center bypass valve path	
5	Center bypass oil path	
7	Hydraulic actuator operation means	40
8	Negative control orifice	
9	Signal circuit	
10	Engine control device	
11	Pump pressure detection sensor	
12	Inclination angle detection sensor	45
13	Negative control signal pressure detection sensor	
14	Engine rotation speed setting means	

Claims 50

1. A hydraulic work machine comprising:

- an engine;
- a variable capacity hydraulic pump driven by the engine;
- a hydraulic actuator that operates using the hydraulic pump as a hydraulic pressure supply

source;

a control valve that is displaced in accordance with an operation amount of a hydraulic actuator operation means so as to control a pressure oil supply flow rate from the hydraulic pump to the hydraulic actuator;

a negative control circuit that outputs a negative control signal pressure to capacity varying means of the hydraulic pump to increase or decrease a discharge flow rate of the hydraulic pump in accordance with a displacement amount of the control valve;

an engine rotation speed setting means operated to set a target rotation speed of the engine; and

an engine control device that controls a rotation speed of the engine based on the target rotation speed set with the engine rotation speed setting means,

the hydraulic work machine further comprising:

pump pressure detection means for detecting a discharge pressure of the hydraulic pump;

pump capacity detection means for detecting a capacity of the hydraulic pump; and negative control signal pressure detection means for detecting the negative control signal pressure,

wherein the engine control device performs engine rotation speed increasing control for increasing the engine rotation speed to be higher than the target rotation speed set with the engine rotation speed setting means, when the discharge pressure of the hydraulic pump detected by the pump pressure detection means is not larger than a set pump pressure set in advance as a pump discharge pressure in a light load state, the pump capacity detected by the pump capacity detection means is at a maximum capacity of the hydraulic pump, and the negative control signal pressure detected by the negative control signal pressure detection means is not larger than a set signal pressure set in advance as a negative control signal pressure in a fully operated state of the hydraulic actuator operation means.

Fig. 1

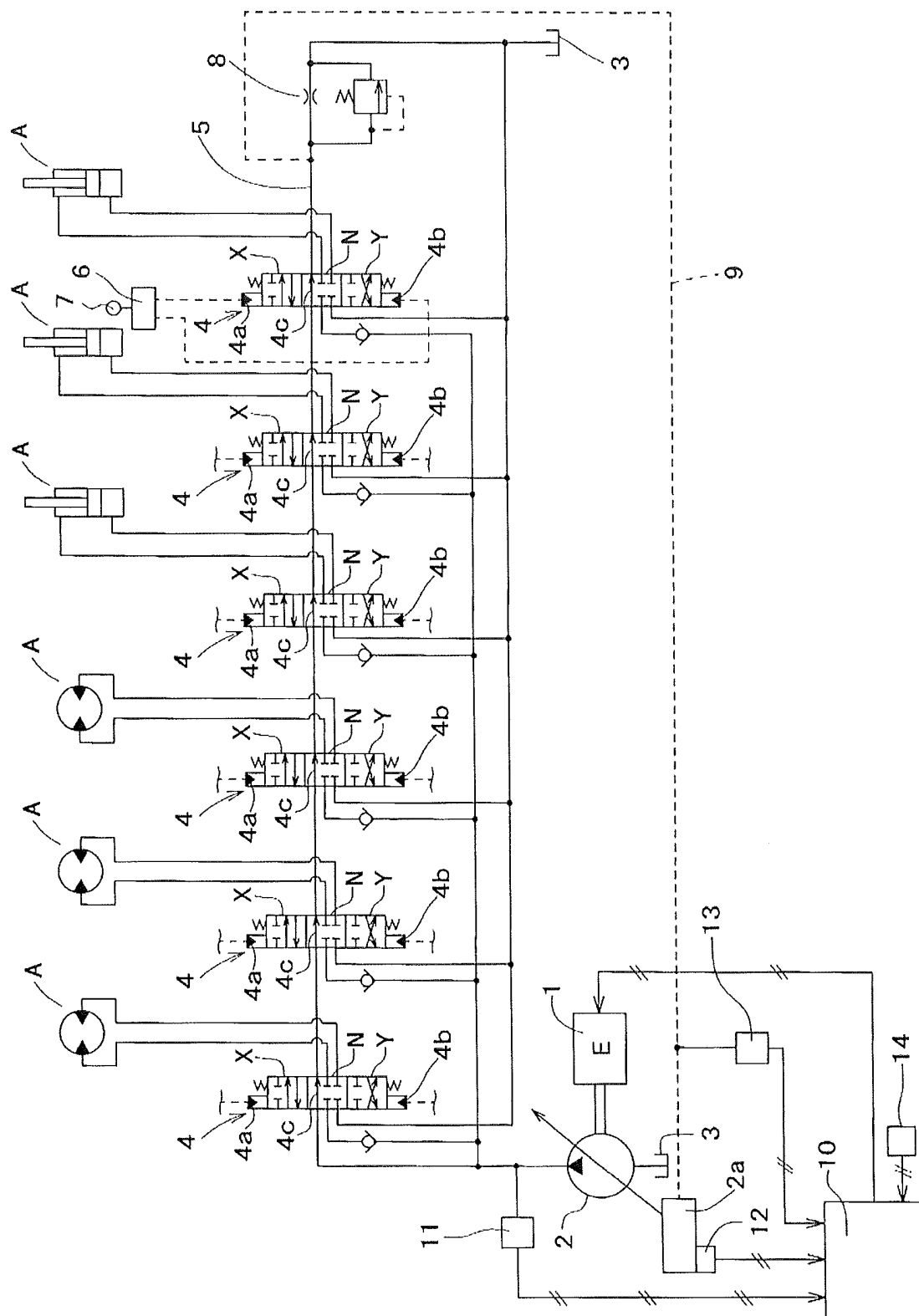
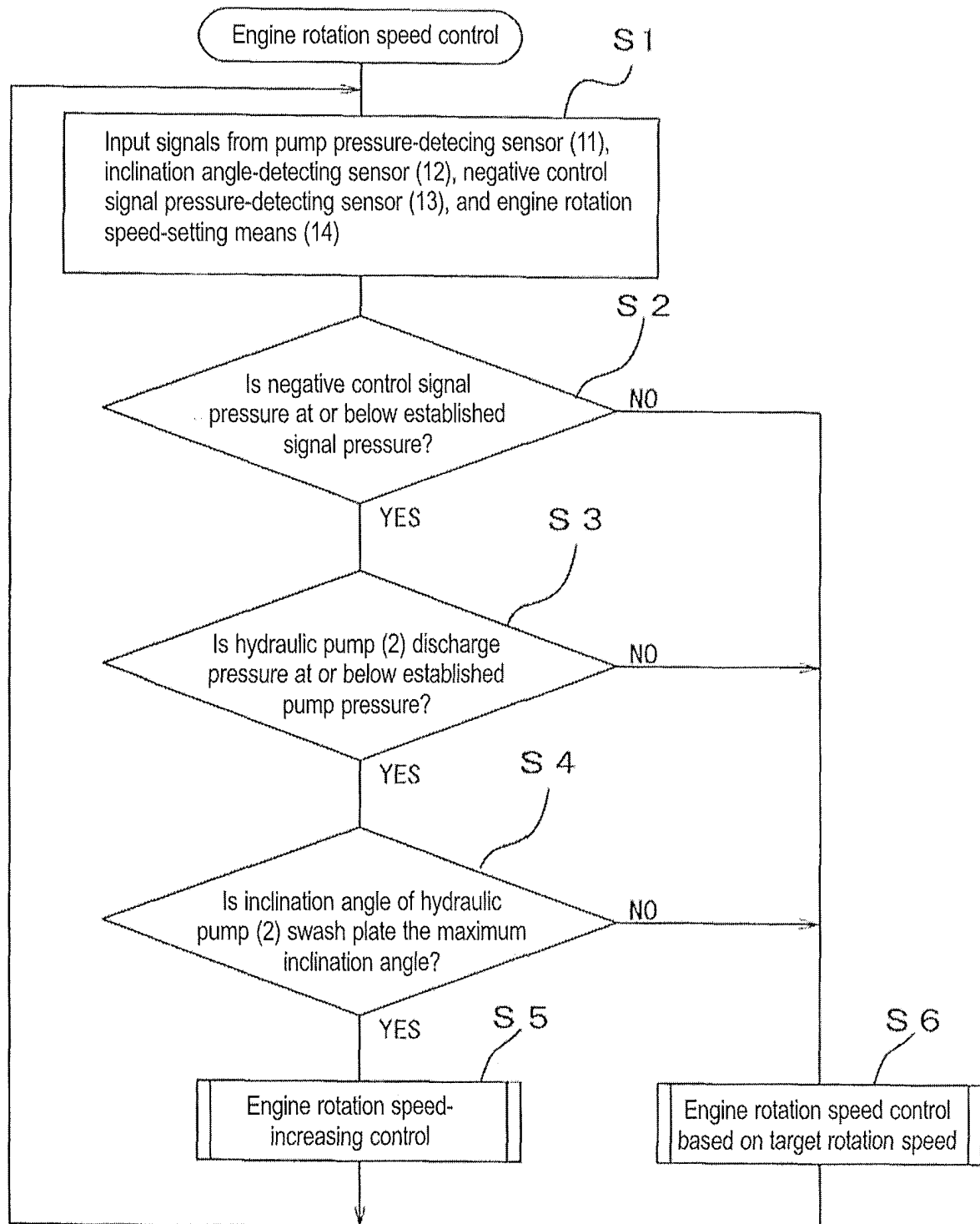


Fig. 2



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/082494

A. CLASSIFICATION OF SUBJECT MATTER

F15B11/00(2006.01) i, E02F9/22(2006.01) i, F02D29/04(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, E02F9/22, F02D29/04

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	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

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.
A	JP 2009-281149 A (Kobelco Construction Machinery Co., Ltd.), 03 December 2009 (03.12.2009), entire text; all drawings (Family: none)	1
A	JP 61-81587 A (Komatsu Ltd.), 25 April 1986 (25.04.1986), entire text; all drawings (Family: none)	1
A	JP 62-94622 A (Komatsu Ltd.), 01 May 1987 (01.05.1987), entire text; all drawings (Family: none)	1

☒ 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
15 February, 2013 (15.02.13)Date of mailing of the international search report
26 February, 2013 (26.02.13)Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/082494

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2008-190694 A (Komatsu Ltd.), 21 August 2008 (21.08.2008), entire text; all drawings (Family: none)	1
A	JP 4-258505 A (Hitachi Construction Machinery Co., Ltd.), 14 September 1992 (14.09.1992), entire text; all drawings (Family: none)	1

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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