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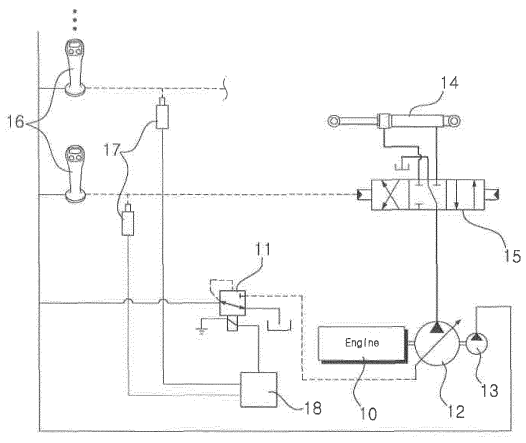
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(54) FLOW RATE CONTROL DEVICE FOR VARIABLE DISPLACEMENT TYPE HYDRAULIC PUMP FOR CONSTRUCTION EQUIPMENT

(57) The present invention pertains to a hydraulic pressure control device of a variable displacement type hydraulic pump for construction equipment, wherein operable sections of operation systems are formed in a wide manner while the hydraulic pump discharges a relatively small flow rate compared with the operation amount of the respective operation systems in the case of complex operations, so as to improve the pressure loss and the fuel ratio of the hydraulic pump. The device includes a flow rate controller, which is preferably connected to an operation amount detecting means and a swash plate control device, and receives operation signals from the operation system of a control device that are detected by the operation amount detecting means so as to control the discharge flow rate of the hydraulic pump. In the case of the complex operations, the flow rate controller predetermines the required flow rate of an actuator for the respective operation systems via the operation signals of the operation systems and subsequently operates the square root of the sum of the squares of the respective required flow rates so as to determine the discharge flow rate of the hydraulic pump, thereby controlling the swash plate control device.

[Fig. 3]



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Description

[Field of the Invention]

[0001] The present invention relates to a flow rate control apparatus of a variable displacement hydraulic pump for a construction machine including an excavator. More particularly, the present invention relates to an improved flow rate control apparatus of a variable displacement hydraulic pump for a construction machine, in which an opening area of a hydraulic pump is controlled to be large by a controller that pre-determines a flow rate required by a plurality of actuators during a combined operation of work apparatuses for a construction machine so that a pressure loss of the hydraulic pump can be reduced and fuel efficiency can be improved, and in which during a combined operation, a hydraulic pump discharges a relatively small amount of hydraulic fluid in comparison to a manipulation amount of respective work apparatuses to make wide a manipulation period range of a manipulation device.

[Background of the Invention]

[0002] A construction machine including an excavator or a hydraulic shovel is provided with a hydraulic circuit configured so that a work apparatus including a boom, an arm, a bucket and a swing motor is driven by the pressure of a hydraulic fluid discharged from a hydraulic pump.

[0003] Referring to Fig. 1, a hydraulic excavator 1 includes a crawler-type lower traveling structure 2, an upper swing structure 3 swingably supported on the lower traveling structure 2, and a work apparatus mounted on the upper swing structure 3. The work apparatus generally includes a boom 5 configured so that its base is ascendably and descendably supported on the upper swing structure 3, an arm 6 provided at an end of the boom 5, a bucket 7 mounted at a front end of the boom 5, and a swing motor (not shown) configured to provide power during the swing operation of the upper swing structure 3.

[0004] Depending on a specification of the equipment, one variable displacement hydraulic pump is frequently used to supply a hydraulic pressure to the work apparatus, and the sum of the required flow rates spent by the actuators for work apparatuses during a combined operation in which a plurality of actuators 14 is controlled by a manipulation device including a manipulation lever or a joystick is controlled to be a discharge flow rate of the hydraulic pump.

[0005] That is, during the combined operation, the discharge flow rate of the variable displacement hydraulic pump is determined by the flow rate required by the respective actuators for work apparatuses, which is controlled by the following equation:

"Hydraulic Pump Discharge Flow Rate = Required flow rate of first actuator + Required flow rate of second actuator + Required flow rate of third actuator".

[0006] In the above equation, it can be understood that the first actuator is a boom actuator 14a, the second actuator is a bucket actuator 14c, and the third actuator is swing motor (not shown). It is of course to be noted that a work apparatus can be additionally provided to the hydraulic construction machine.

[0007] The control method of the discharge flow rate of the conventional hydraulic pump using the above-mentioned equation entails a problem in that a relatively large amount of hydraulic fluid is discharged from an opening area of a pump flow path, leading to a great increase in a pressure loss, which influences the fuel efficiency and thus increases fuel consumption.

[0008] In addition, during the combined operation, the maximum discharge flow rate of the hydraulic pump is reached rapidly and thus the control range of the discharge flow rate of the hydraulic pump according to a pilot pressure of the manipulation device is narrowed, resulting in a deterioration of manipulability.

[0009] Meanwhile, Korean Patent Laid-Open Publication No. 2001-0033699 discloses a flow rate control apparatus for allowing an output flow rate of the hydraulic pump to be controlled to be a distributed flow rate that is preset in each hydraulic actuator in view of a problem involved in a flow rate control apparatus for a hydraulic shovel in that manipulability is deteriorated during a combined operation.

[0010] During the combined operation, the flow rate control apparatus calculates the sum of the absolute values of the required flow rates of the hydraulic actuators to obtain the required flow rates of the hydraulic actuators, and uses the calculated sum of the absolute values in a control method of the pump required flow rate. Thus, it is possible to prevent the sum of the required flow rates of the hydraulic actuators from exceeding the maximum discharge flow rate of the hydraulic pump and control the sum of the required flow rates of the hydraulic actuators to be a distributed flow rate according to actuators for work apparatuses during the combined operation.

[0011] Such a flow rate control method using the sum of the absolute values of the required flow rates of the hydraulic

actuators can also avoid a shortcoming in that the distributed flow rate is larger than the required flow rate needed by the manipulation of a manipulation device such as a manipulation lever or a joystick. However, this flow rate control method still does not suggest a solution to problems in that a pressure loss occurs during the combined operation and in that during the combined operation, the maximum discharge flow rate of the hydraulic pump is reached rapidly and thus the control range of the discharge flow rate of the hydraulic pump by the manipulation device is narrowed, resulting in a deterioration of manipulability.

[Detailed Description of the Invention]

[Technical Problems]

[0012] Accordingly, the present invention was made to solve the aforementioned problem occurring in the prior art, and it is an object of the present invention to provide a flow rate control apparatus of a variable displacement hydraulic pump for a construction machine, in which the discharge flow rate of a hydraulic pump is controlled to show an effect of making wide an opening area of the hydraulic pump according to the matching condition of the actuators for work apparatuses, thereby reducing a pressure loss and improving fuel efficiency.

[Technical Solution]

[0013] To accomplish the above object, in accordance with the present invention, there is provided a flow rate control apparatus of a variable displacement hydraulic pump for a construction machine including: an engine; at least one variable displacement hydraulic pump having a swash plate control device for controlling an opening area thereof and configured to be pumped by the engine to provide hydraulic pressure; a plurality of actuators for work apparatuses including a boom actuator or an arm actuator, a bucket actuator, and a swing motor; a work apparatus control valve connected and installed between the hydraulic pump and the actuators for work apparatuses, and configured to control the hydraulic pressure discharged from the hydraulic pump to perform a start, a stop, and a swing operation of the actuators for the work apparatuses and the swing motor during the spool shift; a manipulation amount detection means configured to detect a manipulation amount of a manipulation device to drive the actuators for work apparatuses; and a flow rate controller connected to the manipulation amount detection means and the swash plate control device, and configured to receive a work apparatus manipulation signal of the manipulation device, which is detected by the manipulation amount detection means and to control a discharge flow rate of the hydraulic pump, wherein the flow rate controller pre-determines the required flow rates of the respective actuators for work apparatuses through the work apparatus manipulation signal during a combined operation, and then controls the swash plate control device by calculating the square root of the sum of squares of the respective required flow rates to determine the discharge flow rate of the hydraulic pump.

[Advantageous Effect]

[0014] The flow rate control apparatus of a variable displacement hydraulic pump for a construction machine according to the present invention has an advantage in that it controls an opening area of the hydraulic pump based on the calculated the square root of the sum of squares of the required flow rates to drive the respective actuators for work apparatuses, so that the plurality of actuators for work apparatuses can be simultaneously manipulated or the opening area of the hydraulic pump, which is relatively large as compared to the prior art, can be secured during a combined operation (this means that the discharge flow rate of hydraulic pump is relatively small), thereby reducing a pressure loss of the hydraulic pump and improving the operation efficiency and fuel efficiency.

[0015] In addition, the flow rate control apparatus of a variable displacement hydraulic pump for a construction machine according to the present invention has another advantage in that the hydraulic pump discharges a relatively small amount of hydraulic fluid in the same period range in comparison with the prior art in the manipulation of the manipulation device and the control of the discharge flow rate of the hydraulic pump according to the manipulation of the manipulation device to perform a combined operation, and the manipulation period range of the manipulation device is made relatively wide so that manipulability of the equipment can be improved.

[Brief Description of the Invention]

[0016] The above objects, other features and advantages of the present invention will become more apparent by describing the preferred embodiments thereof with reference to the accompanying drawings, in which:

Fig. 1 is a schematic perspective view showing an excavator for a construction machine according to the prior art;

Fig. 2 is a flow chart for controlling the discharge flow rate of a hydraulic pump according to the prior art;
Fig. 3 is a block diagram schematically showing the construction of a flow rate control apparatus according to an embodiment of the present invention;
Fig. 4 is a flow chart for controlling the discharge flow rate of a hydraulic pump according to the present invention;
Fig. 5 is a graph showing the flow rate characteristics of the hydraulic pump according to the present invention.

[Preferred Embodiments of the Invention]

[0017] Now, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings. The matters defined in the description, such as the detailed construction and elements, are nothing but specific details provided to assist those of ordinary skill in the art in a comprehensive understanding of the invention, and the present invention is not limited to the embodiments disclosed hereinafter.

[0018] Here, the terminology or words used in the specification and the claims of the present invention should not be interpreted as typical meanings or lexical meanings, and they should be interpreted as the meaning and concept conforming to the technological idea of the present invention on the basis of the idea that the inventor can define the concept of the words appropriately in order to illustrate his invention in the best manner.

[0019] Hereinafter, a preferred embodiment of the present invention will be described in more detail with reference to the accompanying drawings.

[0020] Referring to Figs. 3 and 4, the flow rate control apparatus of a variable displacement hydraulic pump for a construction machine according to the present invention includes:

an engine 10;
at least one variable displacement hydraulic pump 12 having a swash plate control device 11 for controlling an opening area thereof and configured to be pumped by the engine 10 to provide hydraulic pressure;
a plurality of actuators 14 for work apparatuses including a boom actuator or an arm actuator, a bucket actuator, and a swing motor;
a work apparatus control valve 15 connected and installed between the hydraulic pump 12 and the actuators 14 for work apparatuses, and configured to control the hydraulic pressure discharged from the hydraulic pump to perform a start, a stop, and a swing operation of the actuators for the work apparatuses and the swing motor during the spool shift;
a manipulation amount detection means 17 configured to detect a manipulation amount of a manipulation device 16 to drive the actuators 14 for work apparatuses; and
a flow rate controller 18 connected to the manipulation amount detection means 17 and the swash plate control device 11, and configured to receive a work apparatus manipulation signal of the manipulation device 16, which is detected by the manipulation amount detection means 17 and to control a discharge flow rate of the hydraulic pump 12.

[0021] The flow rate controller 18 pre-determines the required flow rates of the respective actuators 15 for work apparatuses through the work apparatus manipulation signal during a combined operation, and then controls the swash plate control device 11 by calculating the square root of the sum of squares of the respective required flow rates to determine the discharge flow rate of the hydraulic pump 12.

[0022] In addition, the manipulation amount detection means 17 is constructed as a pilot pressure detection sensor, and the swash plate control device 11 is constructed as an electro proportional pressure reducing valve.

[0023] The operation principle of the flow rate control apparatus of a variable displacement hydraulic pump for a construction machine according to an embodiment of the present invention will be described in further detail with reference to Figs. 3 to 5.

[0024] In an embodiment of the present invention, the hydraulic excavator 1 includes a crawler-type lower traveling structure 2, an upper swing structure 3 swingably supported on the lower traveling structure 2, and a work apparatus mounted on the upper swing structure 3. The work apparatus generally includes a boom 5 configured so that its base is ascendably and descendably supported on the upper swing structure 3, an arm 6 provided at an end of the boom 5, a bucket 7 mounted at a front end of the boom 5, and a swing motor (not shown) configured to provide power during the swing operation of the upper swing structure 3 as in the prior art.

[0025] In addition, the boom 5, the arm 6 and the bucket 7 are operated by respective actuators 14 that are expanded and contacted by hydraulic pressure.

[0026] Particularly, in the flow rate control apparatus of a variable displacement hydraulic pump for a construction machine according to an embodiment of the present invention, when an operator manipulates a manipulation device 16, for example, a manipulation lever or a joystick to drive the actuators 14 for work apparatuses, the manipulation amount of a work apparatus manipulation signal including a pilot pressure or an electric signal is detected by the manipulation amount detection means 17.

[0027] The flow rate controller 18 is connected to the manipulation amount detection means 17 and the swash plate control device 11, and receives a work apparatus manipulation signal of the manipulation device 16, which is detected by the manipulation amount detection means 17 and controls a discharge flow rate of the hydraulic pump 12.

[0028] Preferably, the flow rate controller 18 pre-determines the required flow rates of the respective actuators 15 for work apparatuses through the work apparatus manipulation signal during a combined operation, and then controls the swash plate control device 11 by calculating the square root of the sum of squares of the respective required flow rates to determine the discharge flow rate of the hydraulic pump 12.

[0029] The manipulation device 16 is installed at a pilot pump 13, and the manipulation amount of the manipulation device 16 is detected by a pilot pressure detection sensor of the manipulation amount detection means 17.

[0030] According to an embodiment of the present invention, the discharge flow rate of the hydraulic pump 12 is determined by performing a step S100 of detecting the manipulation amount of the manipulation device 16 to calculate the required flow rates of the respective actuators 14, a step S200 of calculating the square root of the sum of squares of the required flow rates of the respective actuators 14 calculated in the step S100, and a step S300 of outputting a control signal corresponding to a result determined at the step S200 to control the swash plate control device 11.

[0031] More specifically, the flow rate controller 18 according to the present invention merely does not calculate the sum of the required flow rates of the respective actuators 14 for work apparatuses when a hydraulic pump discharge flow rate is set unlike the conventional flow rate control method. Instead, the flow rate controller 18 calculates the square root of the sum of squares of the respective required flow rates of the actuators 14 for work apparatuses according to a work apparatus manipulation signal of the manipulation device 16 detected by the manipulation amount detection means 17 and determines the calculated square root value to be the discharge flow rate of the hydraulic pump 12.

[0032] In other words, the discharge flow rate of the hydraulic pump determined by the flow rate controller 18 can be defined by the following equation:

$$\textit{The sum of squares of the required flow rates of the actuators for work apparatuses} = \textit{(required flow rate of first actuator)}^2 + \textit{(required flow rate of second actuator)}^2 + \textit{(required flow rate of third actuator)}^2 \ldots.$$

[0033] Here, the flow rate controller 18 controls the discharge flow rate of the hydraulic pump by calculating the square root of the sum of squares of the required flow rates of the actuators for work apparatuses as defined above and using an output signal of the swash plate control device 11 corresponding to a result of the calculation. The discharge flow rate of the hydraulic pump can be defined by the following equation:

$$\textit{Hydraulic Pump Discharge Flow Rate} = (\textit{(Required flow rate of first actuator)}^2 + \textit{(Required flow rate of second actuator)}^2 + \textit{(Rrequired flow rate of third actuator)}^2 \ldots.)^{1/2}$$

[0034] In order to compare the characteristics of the discharge flow rate of the hydraulic pump controlled by the flow rate controller 18 according to the present invention, during the combined operation of two actuators for work apparatuses, for example, the boom actuator and the bucket actuator, a comparison of the flow rate characteristics is made between the conventional flow rate control method of simply adding the required flow rates of the actuators and the inventive flow rate control method. A result of the comparison shows that the inventive flow rate control method controls the maximum flow rate of the hydraulic pump in a relatively delayed period in comparison with the conventional flow rate control method.

[0035] That is, as shown in Fig. 5, when the maximum discharge flow rate performance of the hydraulic pump 12 is set to be constant, the discharge flow rate control characteristic line B of the hydraulic pump 12 according to the present invention has a relatively small gradient and shows a relatively long delay period to reach the maximum flow rate in comparison with the discharge flow rate control characteristic line A of the hydraulic pump 12 according to the prior art.

[0036] This means that when one actuator 14 is manipulated alone, there is no difference in control characteristics between the inventive flow rate control method and the conventional flow rate control method. In addition, the flow rate control apparatus of a variable displacement hydraulic pump for a construction machine according to the present invention has the characteristics that when two or more actuators 14 are manipulated simultaneously or a combined operation is performed, the opening area of the hydraulic pump is controlled such that the hydraulic pump discharges a relatively small amount of hydraulic fluid in comparison to the prior art.

[0037] Additionally, a relatively large opening area can be secured with respect to the same discharge flow rate of the hydraulic pump 12, and thus a pressure loss can be greatly reduced as well as the operation efficiency of the hydraulic pump 12 and the fuel efficiency can be improved.

[0038] In the meantime, the flow rate control apparatus of a variable displacement hydraulic pump for a construction machine according to the present invention has the characteristics that when the manipulation amount of the manipulation device 16 is maintained constantly during a combined operation, the hydraulic pump 12 discharges a relatively small amount of hydraulic fluid in comparison to the prior art and a relatively large manipulation amount as compared to the prior art is required to discharge the same amount of hydraulic fluid as that in the prior art in terms of the control of the manipulation device 16.

[0039] By virtue of such characteristics, the flow rate control apparatus of a variable displacement hydraulic pump for a construction machine according to the present invention provides an operator with a relatively wide manipulation period range as compared to the prior art in the manipulation of the manipulation device 16 including a manipulation lever or a joystick so that manipulability can be maintained smoothly and stably.

[Industrial Applicability]

[0040] As described above, the present invention is very useful in a the flow rate control apparatus of a variable displacement hydraulic pump for a construction machine, in which the hydraulic pump discharges a relatively small amount of hydraulic fluid in the same period range in comparison with the prior art in the manipulation of the manipulation device and the control of the discharge flow rate of the hydraulic pump according to the manipulation of the manipulation device to perform a combined operation, and the manipulation period range of the manipulation device is made relatively wide so that manipulability can be improved and a pressure loss of the hydraulic pump can be reduced.

Claims

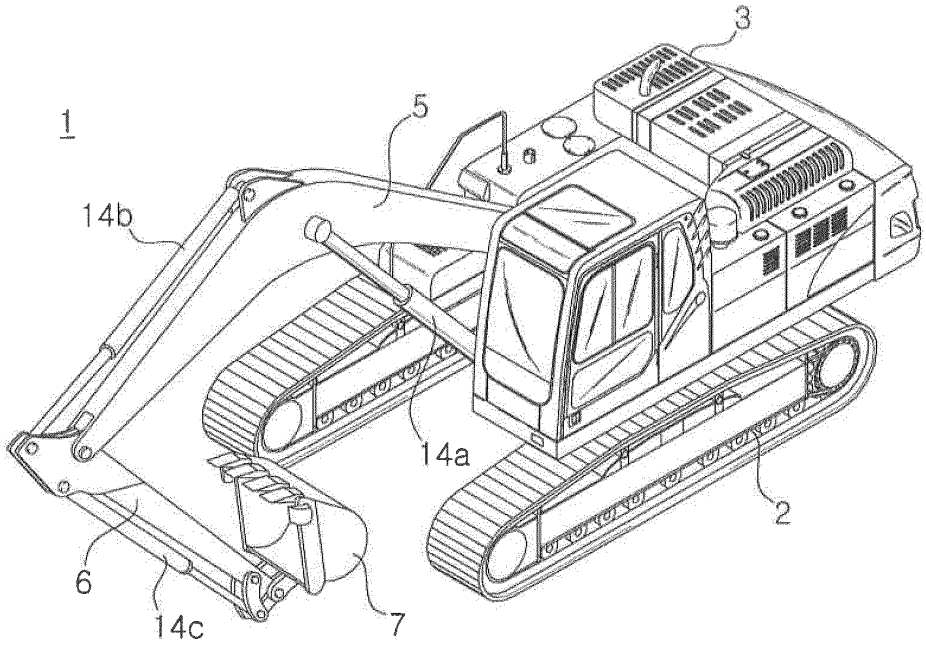
1. A flow rate control apparatus of a variable displacement hydraulic pump for a construction machine comprising:

an engine;
at least one variable displacement hydraulic pump having a swash plate control device for controlling an opening area thereof and configured to be pumped by the engine to provide hydraulic pressure;
a plurality of actuators for work apparatuses including a boom actuator or an arm actuator, a bucket actuator, and a swing motor;
a work apparatus control valve connected and installed between the hydraulic pump and the actuators for work apparatuses, and configured to control the hydraulic pressure discharged from the hydraulic pump to perform a start, a stop, and a swing operation of the actuators for the work apparatuses and the swing motor during the spool shift;
a manipulation amount detection means configured to detect a manipulation amount of a manipulation device to drive the actuators for work apparatuses; and
a flow rate controller connected to the manipulation amount detection means and the swash plate control device, and configured to receive a work apparatus manipulation signal of the manipulation device, which is detected by the manipulation amount detection means and to control a discharge flow rate of the hydraulic pump,
wherein the flow rate controller pre-determines the required flow rates of the respective actuators for work apparatuses through the work apparatus manipulation signal during a combined operation, and then controls the swash plate control device by calculating the square root of the sum of squares of the respective required flow rates to determine the discharge flow rate of the hydraulic pump.

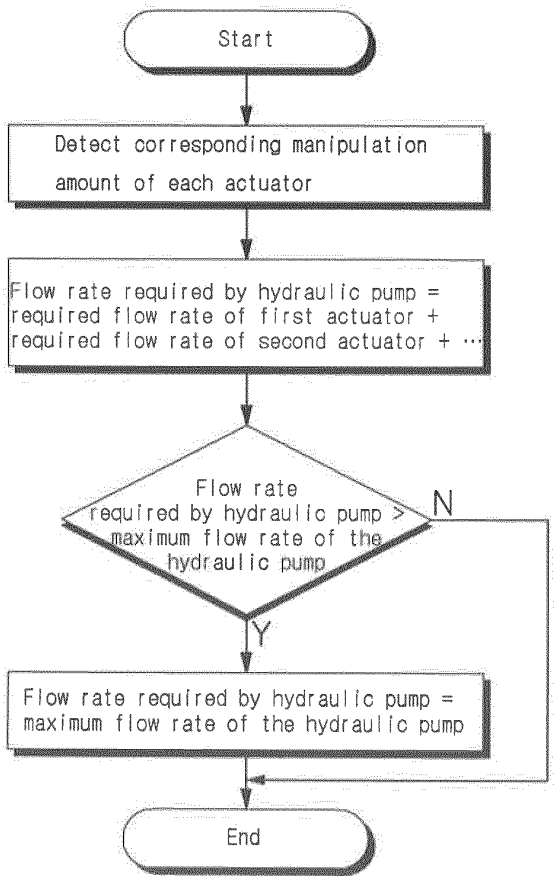
2. The flow rate control apparatus of a variable displacement hydraulic pump according to claim 1, wherein the manipulation amount detection means is constructed as a pilot pressure detection sensor.

3. The flow rate control apparatus of a variable displacement hydraulic pump according to claim 1, wherein the swash plate control device is constructed as an electro proportional pressure reducing valve.

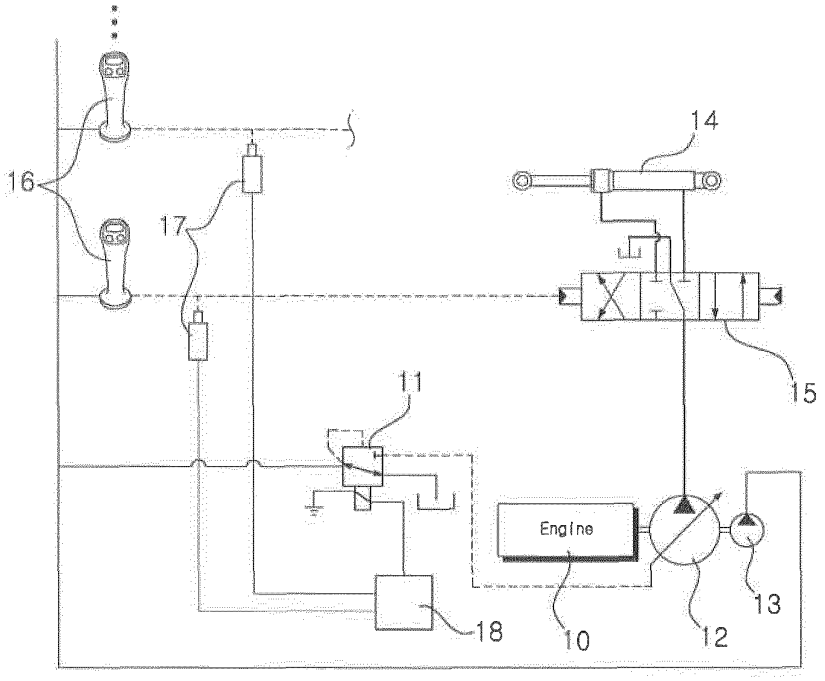
[Fig. 1]


1
3
5
14b
14a
2
6
14c
7

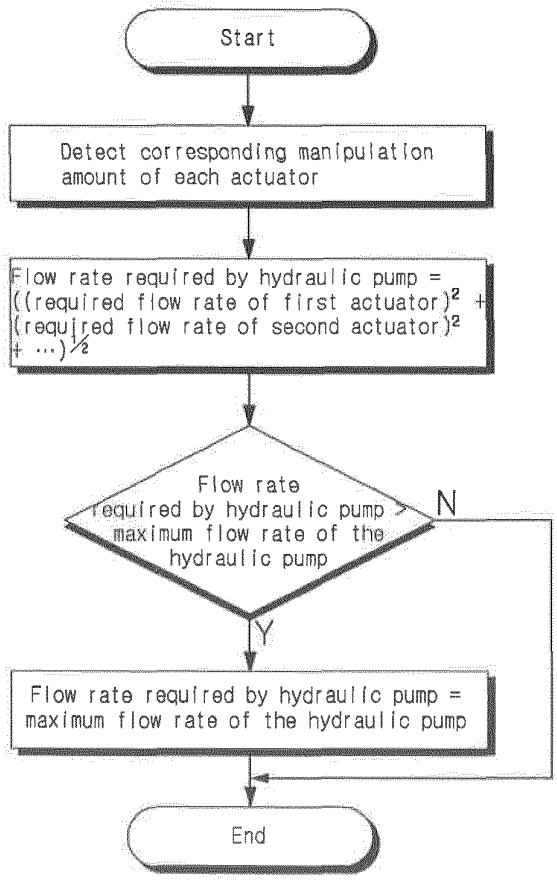
[Fig. 2]


Start
Detect corresponding manipulation amount of each actuator
Flow rate required by hydraulic pump = required flow rate of first actuator + required flow rate of second actuator + ···
Flow rate required by hydraulic pump > maximum flow rate of the hydraulic pump
N
Y
Flow rate required by hydraulic pump = maximum flow rate of the hydraulic pump
End

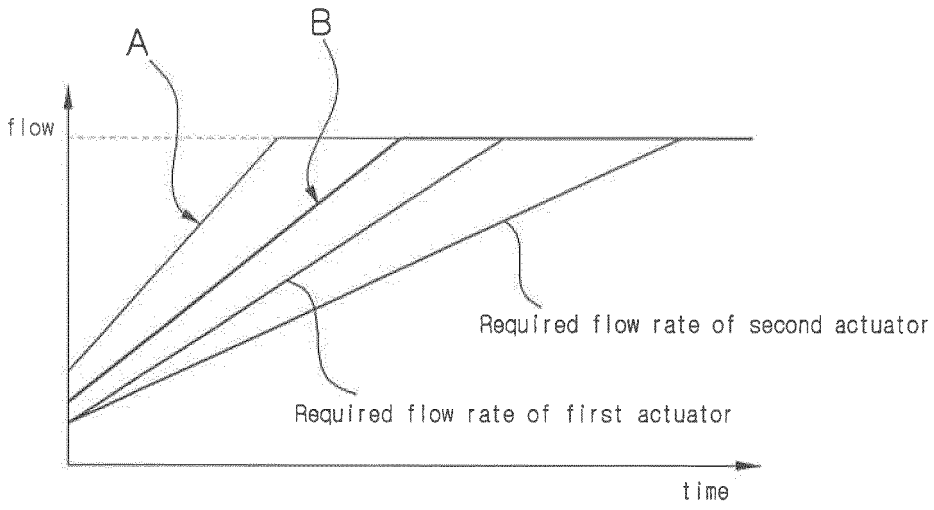
[Fig. 3]


16
17
14
15
11
Engine
18
10
12
13

[Fig. 4]


Start
Detect corresponding manipulation amount of each actuator
Flow rate required by hydraulic pump = ((required flow rate of first actuator)² + (required flow rate of second actuator)² + ···)½
Flow rate required by hydraulic pump > maximum flow rate of the hydraulic pump
N
Y
Flow rate required by hydraulic pump = maximum flow rate of the hydraulic pump
End

[Fig. 5]


A
B
flow
Required flow rate of second actuator
Required flow rate of first actuator
time

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2010/005742

A. CLASSIFICATION OF SUBJECT MATTER

F15B 13/043(2006.01)i, F15B 13/02(2006.01)i, E02F 9/22(2006.01)i, F15B 21/08(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)

F15B; E02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

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

eKOMPASS (KIPO internal) & Keywords: "engine", "hydraulic pump", "actuator", "manipulated quantity", "detection", "sensor", "flow rate", "control", "controller", "wobble plate", "demand", "discharge", "calculation", "square"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2000-027803 A (UCHIDA HYDRAULICS CO., LTD.) 25 January 2000 See paragraph 0004 to paragraph 0029 and figures 1 to 4.	1-3
A	JP 06-159319 A (HITACHI CONSTR. MACH. CO., LTD.) 07 June 1994 See claims 1 to 5 and figures 1 to 3.	1-3
A	JP 2007-205464 A (BOSCH REXROTH CORP.) 16 August 2007 See claims 1 to 9 and figures 1 to 8.	1-3
A	KR 10-0637675 B1 (HANIL HYDRAULICS CO., LTD.) 25 October 2006 See claims 1 to 10 and figures 1 to 8.	1-3
A	KR 10-2009-0059188 A (VOLVO CONSTRUCTION EQUIPMENT HOLDING SWEDEN AB) 11 June 2009 See claims 1 to 2 and figures 1 to 5.	1-3

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 MAY 2011 (26.05.2011)	**27 MAY 2011 (27.05.2011)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon, 139 Seonsa-ro, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer Telephone No.

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2010/005742

Patent document cited in search report	Publication date	Patent family member	Publication date
JP 2000-027803 A	25.01.2000	JP 3471620 B2	02.12.2003
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JP 2007-205464 A	16.08.2007	NONE	
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KR 10-2009-0059188 A	11.06.2009	NONE	

Form PCT/ISA/210 (patent family annex) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- KR 20010033699 **[0009]**