(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 821 299 A1

(12) EUROPEAN PATENT APPLICATION

published in accordance with Art. 158(3) EPC

(43) Date of publication:
28.01.1998 Bulletin 1998/05

(21) Application number: **96909331.9**

(22) Date of filing: **10.04.1996**

(51) Int. Cl.[6]: **G05G 7/00**, G05G 9/047, B66C 13/56, B66C 13/22, B66D 1/28

(86) International application number:
PCT/JP96/00983

(87) International publication number:
WO 96/32670 (17.10.1996 Gazette 1996/46)

(84) Designated Contracting States:
DE

(30) Priority: **10.04.1995 JP 84069/95**

(71) Applicant: **KOMATSU LTD.**
Minato-ku Tokyo 107 (JP)

(72) Inventors:
- **IKEDA, Masahiro**
  Kenkyusho of Komatsu Ltd.
  Kanagawa 254 (JP)
- **MIYATA, Keisuke**
  Kenkyusho of Komatsu Ltd.
  Kanagawa 254 (JP)
- **HAYAKAWA, Nobuyoshi**
  Kenkyusho of Komatsu Ltd.
  Kanagawa 254 (JP)
- **IDEURA, Yoshie**
  Kenkyusho of Komatsu Ltd.
  Kanagawa 254 (JP)

(74) Representative: **Fiener, Josef**
Postfach 12 49
87712 Mindelheim (DE)

(54) OPERATIONAL REACTION FORCE CONTROL DEVICE FOR AN OPERATING LEVER OF A WORKING MACHINE

(57) An operation for effectively preventing the swing of load is made possible by imparting to an operating lever (1) an operational reaction force F that becomes greater as an acceleration α detected by an acceleration detecting means (14) becomes greater, and moreover the operator can be relieved of fatigue.

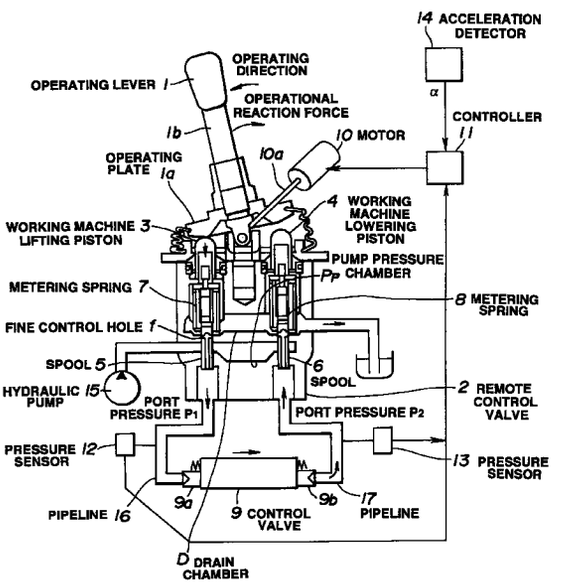


FIG.1

EP 0 821 299 A1

Description

TECHNICAL FIELD

The invention relates to a device for controlling an operational reaction force to be imparted to an operating lever for actuating a working machine, e.g., a boom, of machinery such as a crane.

BACKGROUND ART

In connection with the hoisting work by a crane, it is known to use an operational reaction force control device for imparting an operational reaction force to an operating lever for actuating a winch of crane in order to improve operability of the operating lever.

For example, Japanese Utility Model Publication No. 62-14077 discloses a control device for varying an operational reaction force to a level proportional to the weight of a lifted load.

And, Japanese Patent Publication No. 5-5755 improves operability of a winch operating lever by generating an operational reaction force in accordance with a manipulated variable (a lifting speed) of the lever as well as the weight of a lifted load and imparting the generated operational reaction force to the lever.

Such existing related technologies are effective in the hoisting work but if they are applied to turning work of the crane or luffing work of the working machine (boom), they are not necessarily effective.

Specifically, when a boom 21 of a crane 20 is luffed in directions indicated by arrows A, B as shown in Fig. 5, the operator cannot know an acceleration of the boom 21 to grasp a possible motion of the boom 21. Therefore, it is hard to make delicate control of the boom 21 through the operating lever, and a lifted load 22 suffers from a vibrating relative motion to swing in directions indicated by arrows C, D.

And, when an upper rotary body 23 is turned, the lifted load 22 is also swung in the turning direction.

In view of above, it is necessary to impart an operational reaction force to the operating lever to prevent effectively the lifted load from being swung. But, the above-described related art could not achieve it by imparting the operational reaction force based on information such as the weight of the lifted load or the manipulated variable of the lever.

Besides, if prior art which imparts the operational reaction force proportional to the weight of a lifted load is applied to operate a working machine to handle a heavy load for a long time or to operate a working machine at a high and constant speed for a long time, a large operational reaction force acts on the operating lever for a long time. As a result, the operator is exhausted.

The invention was achieved in view of the above circumstances and aims to provide an operational reaction force control device which can be operated easily to prevent effectively the swing of load and can relieve the operator from getting fatigue.

DISCLOSURE OF THE INVENTION

The invention relates to an operational reaction force control device for an operating lever of a working machine, in which an operational reaction force is imparted to the operating lever for actuating the working machine in a direction opposite to an operating direction, characterized by comprising acceleration detecting means for detecting an acceleration of the working machine; and operational reaction force imparting means for imparting the operational reaction force, which increases as the acceleration detected by the acceleration detecting means increases, to the operating lever.

By configuring as described above, the operational reaction force which increases as the acceleration detected by the acceleration detecting means increases is imparted to the operating lever.

Specifically, if the operating machine suffers from the swing of load, namely the load 22 which is hung by the working machine 21 is swung in the direction that the working machine is moving (in the rotating direction of the working machine 23 when the working machine is turned, and direction C or D when it is luffing) as shown in Fig. 5, the working machine 21 or 23 is required to be accelerated or decelerated to suppress the swing of load.

Therefore, by varying the operational reaction force so to increase as the acceleration of the working machine increases, the accelerating or decelerating condition of the working machine can be known based on the operational reaction force. As a result, an operation of preventing the swing of load by accelerating or decelerating the working machine (controlling the relative motion of the load with respect to the working machine) can be made with ease by referring to the operational reaction force, and the swing of load can be prevented effectively.

And, since a large operational reaction force does not act on the operating lever at a constant speed excepting the accelerating and decelerating states, a large operational reaction force is not imparted to the operating lever for a long time even when the working machine is operated against a heavy load for a long time or the working machine is operated at a high and constant speed for a long time, and the operator can be relieved of fatigue remarkably.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram showing the structure of an embodiment of the operational reaction force control device for an operating lever of a working machine according to the invention.

Fig. 2 is a control characteristic diagram showing

the relationship between an acceleration of the working machine and an operational reaction force.

Fig. 3 is a diagram showing another embodiment of the invention.

Fig. 4 is a diagram showing another embodiment of the invention.

Fig. 5 is a side view of a truck crane applied to the embodiments.

BEST MODE FOR CARRYING OUT THE INVENTION

Embodiments of the operational reaction force control device for an operating lever of a working machine according to the invention will be described with reference to the accompanying drawings.

As shown in Fig. 3, an embodiment will be described on the assumption that an operational reaction force, which is imparted to an operating lever for operating a boom 21 as working machine of a crane 20, is controlled to raise or lower the boom 21.

Fig. 1 is a diagram showing a structure of the device for controlling an operational reaction force of an operating lever 1 which is disposed in the operator cab of the crane 20 shown in Fig. 3.

Specifically, when the operating lever 1 is operated in the direction indicated by an arrow (in the direction to raise the boom 21), one of a piston 3 for lifting and a piston 4 for lowering the working machine which are in a remote control valve 2, namely the piston 3 corresponding to the direction that the operating lever 1 is operated, is pushed down through an operating plate 1a. When the operating lever 1 is operated in the opposite direction (in the direction that the boom 21 is lowered), the piston 4 is pushed down in the same way.

Beneath these pistons 3, 4 are disposed a spool 5 for raising the working machine and a spool 6 for lowering the working machine. And, the spool 5 or 6 which corresponds to the lowered piston is pushed down by a metering spring 7 or 8. Since the piston 3 is pushed down in this case, the spool 5 is moved downward.

As a result, a pump pressure chamber Pp which is communicated with a discharge port of a hydraulic pump 15 is repeatedly connected with or cut off from a drain chamber D through a fine control hole f. And, a port pressure P1 or P2 of a pipeline 16 or 17 on the side of the pushed-down piston is raised to a level corresponding to a force (proportional to a stroke of the lever 1) for shrinking the metering spring 7 or 8, and they are balanced between the drain hole D and the pump pressure chamber Pp.

Specifically, the port pressure P1 or P2 increases to a level proportional to the stroke of the operating lever 1 and acts with its magnitude on a pilot port 9a or 9b of a control valve 9. More specifically, since the operating lever 1 is operated in the direction to raise the boom, the port pressure P1 proportional to the stroke of the lever 1 acts on the pilot port 9a of the control valve 9. As a result, the control valve 9 is actuated to drive a hydraulic cylinder for driving the boom 21 at a speed corresponding to its valve opening, thereby raising the boom 21. When the port pressure P2 is exerted on the pilot port 9b of the control valve 9, the control valve 9 is moved in the opposite direction, and the boom 21 is lowered through the hydraulic cylinder.

To the root of a shaft 1b of the operating lever 1 is connected a rotating shaft 10a of a motor 10, so that the operating lever 1 is tilted to its operated direction or the direction opposite to its operated direction according as the motor 10 rotates.

The motor 10 has its rotation direction and rotation torque varied according to an electrical command signal (voltage) from a controller 11.

Pressure sensors 12, 13 are respectively disposed on the pipelines 16, 17 in order to detect the pipeline inner pressures P1, P2 as manipulated variable P1 of the lever to raise the boom and as manipulated variable P2 of the lever to lower the boom. And, detected pressures P1, P2 of the pressure sensors 12, 13 as lever manipulated variable detecting means are outputted to the controller 11.

An acceleration detector 14 is a detector for detecting an acceleration of the boom 21 which is rising or lowering. For example, it is comprised of a speed sensor (e.g., a rotary encoder or a laser speed sensor is used) and a differentiation circuit which differentiates output from the speed sensor and outputs an acceleration α. A servo-type acceleration sensor may be used as the acceleration detector 14. The acceleration α detected by the acceleration detector 14 is outputted to the controller 11.

The functions of the differentiation circuit may be incorporated into the controller 11.

And, a potentiometer or the like which detects a manipulated variable of the operating lever 1 as rotated quantity may be used instead of the pressure sensors 12, 13 as the lever manipulated variable detecting means.

The lever manipulated variable may also be detected as speed of the boom 21, and where the acceleration detector 14 is comprised of the speed sensor and the differentiation circuit as described above, a value detected by the speed sensor can be used as it is as lever manipulated variable detected value. And, it is not necessary to separately dispose a lever manipulated variable detecting means, and the cost as a whole can be reduced.

And, to detect the acceleration α of the boom 21, the pressures P1, P2 may be determined as speed of the boom 21 and differentiated.

Based on the boom acceleration α detected by the acceleration detector 14 and the lever manipulated variables P1, P2 detected by the pressure sensors 12, 13, the controller 11 determines an operational reaction force F (see Fig. 1) to be imparted in the direction opposite to the operated direction of the operating lever 1 as described afterward, generates an electrical command

signal corresponding to the operational reaction force F, and outputs it to the motor 10.

Fig. 2 is a graph showing the control characteristics in controlling a reaction force. The relationship among the boom acceleration α, the lever manipulated values P1, P2 and the lever operational reaction force F is indicated as control characteristic L (L1-LM-L2). And, this relationship is stored in a memory of the controller 11.

It is apparent from Fig. 2 that the control characteristic L is determined so that the operational reaction force F increases gradually as the acceleration α of the boom 21 increases.

And, the control characteristics L1-LM-L2 are determined so to increase gradually the operational reaction force F with the control characteristics varied in the order of L1, LM and L2 as the lever manipulated variables P1, P2 are increased.

More specifically, it is determined as follows:

* When the boom acceleration α is negative, the operational reaction force F is set to a low value close to zero in order to prevent the operational reaction force from being inverted while the boom is decelerated (the speed direction of the boom 21 by operating the lever is opposite to the direction of accelerating).
* In a range that the lever manipulated variable is small and the lever 1 is often required to be operated delicately than the swing of load is prevented, it is necessary to reduce the operational reaction force F to make it easy to control the boom 21 delicately. Accordingly, it is designed that the control characteristics are varied in the order of L2, LM and L1 sequentially so that the operational reaction force F becomes smaller as the lever manipulated variable becomes small.
* And, when the acceleration α of the boom 21 is extremely high, it is necessary to make the operational reaction force F high to prevent the boom 21 from moving suddenly due to an error in operation. Therefore, the operational reaction force F is varied nonlinearly so that the control characteristic L has a higher inclination in a range in that the boom acceleration α is high than in a range in which the boom acceleration is low.

When the present lever manipulated variables P1, P2 become equal to or below a predetermined first threshold, the controller 11 selects the control characteristic L1. And, when the lever manipulated variables P1, P2 become equal to or higher than a second threshold which is determined to be higher than the first threshold, the control characteristic L2 is selected. When the lever manipulated variables P1, P2 become higher than the first threshold but smaller than the second threshold, the control characteristic LM is selected so that the operational reaction force F increases as the manipulated variable increases in the range L1-L2 as indicated by the arrow.

Furthermore, the operational reaction force F corresponding to the present boom acceleration α is determined on the basis of the selected control characteristic L, and an electrical command signal corresponding to the operational reaction force F is generated and outputted to the motor 10. Accordingly, the motor M is actuated, and the operational reaction force F is imparted to the operating lever 1.

As a result, based on the operational reaction force F imparted to the operating lever 1, the operator can know the state of acceleration or deceleration of the boom 21 as the working machine and can operate with ease to prevent the swing of load by accelerating or decelerating the boom 21 with reference to the operational reaction force F. Thus, the swing of load can be prevented effectively.

And, at a constant speed excepting the accelerating and decelerating states, a high operational reaction force F does not act on the operating lever 1. Therefore, even when the boom 21 is operated to move a heavy load for a long time or operated at a high and constant speed for a long time, a high operational reaction force F is not imparted to the operating lever 1 for a long time, and the operator is relieved of fatigue remarkably.

The control characteristic L shown in Fig. 2 is just an example and can be set to various patterns according to the working conditions.

For example, the control characteristic L is varied according to the lever manipulated variable in the embodiment, but the control characteristic L can be determined constant (e.g., L1) regardless of the lever manipulated variable.

Fig. 3 and Fig. 4 show another embodiment of the invention.

In this embodiment, the detector for detecting an acceleration of the boom which is luffing is disposed at the boom top end so that the operator can know the luffing motion of the boom top end accurately. Since the acceleration sensor is expensive, a sensor for detecting a boom angle or a boom position is adopted as the detector for detecting the acceleration of the boom in the luffing motion. And, the value detected by such a sensor is second order differentiated to calculate a boom acceleration.

Specifically, the crane operator can presume the position of the boom top end in the lengthwise direction from a luffing angle θ of the boom (see Fig. 3) and a length L of the boom. However, the boom top end suffers from complicated motions because the boom is warped, vibrated or moved by wind.

Therefore, when it is configured that the accelerometer described above is mounted on a luffing cylinder 30 for luffing the boom to measure a luffing acceleration of the boom and a torque corresponding to the measured value is imparted as the operational reaction force, the crane operator is hard to know the motion of the crane top end accurately. And, since the luffing cylinder 30

and the boom 21 are linked mutually, the relationship between an extension speed of the luffing cylinder 30 and a boom luffing angle speed does not become linear. Therefore, the configuration that the accelerometer is mounted on the luffing cylinder 30 is not helpful for the crane operator in knowing the motion of the boom top end.

In this embodiment, a boom angle detector 25 for detecting a boom angle θ is mounted on the leading end of the boom 21 as shown in Fig. 3.

As shown in Fig. 4, output from the angle detector 25 is inputted in the controller 11.

The controller 11 calculates component $\cos\theta$ in the lengthwise direction (properly speaking, the lengthwise direction of the boom 21 and not in the lengthwise direction of the crane body) of the boom angle θ entered from the angle detector 25. The calculated value $\cos\theta$ is second order differentiated to determine component $-\cos\theta$ in the lengthwise direction of the acceleration of the boom top end. And, based on the component $-\cos\theta$ thus obtained in the lengthwise direction of the acceleration of the boom top end and the lever manipulated variables P1, P2 detected by the pressure sensors 12, 13, the controller 11 determines in the same way as in the former embodiment the operational reaction force F to be imparted in the direction opposite to the operated direction of the operating lever 1 in view of the relationship shown in Fig. 2, generates an electrical command signal corresponding to the operational reaction force F, and outputs it to the motor 10. Thus, the motor is actuated, and the operational reaction force F proportional to the component - $\cos\theta$ in the lengthwise direction of the acceleration of the boom top end is imparted to the operating lever 1.

Thus, in this embodiment, a torque proportional to the acceleration in the lengthwise direction of the boom top end is imparted as a reaction force to the luffing operating lever. Therefore, the crane operator can feel the motion (acceleration) in the lengthwise direction of the boom top end while operating the luffing operating lever and can also presume the motion (position and speed) of the boom top end. And, when a hung load is moved, the boom can be operated so that the hung load is hardly swung. At the time of luffing the boom, the boom top end is desirably positioned just above the hung load to stop a swing motion of the hung load, and this embodiment is also effective to do so. Besides, this embodiment has an inexpensive boom angle sensor as the sensor for detecting the acceleration of the boom top end, and output from the sensor is second order differentiated to calculate the acceleration of the boom top end, so that the device cost can also be reduced.

The acceleration in the lengthwise direction of the boom top end was determined in the above embodiment, but the acceleration in the vertical direction of the boom top end may be determined to impart as the operational reaction force a force proportional to the obtained acceleration to the luffing lever.

And, the boom angle sensor for detecting the boom angle of the boom top end was used in the above embodiment, but a position sensor may be disposed to determine the position of the boom top end, and the output from the position sensor second order differentiated to determine the acceleration of the boom top end.

The boom of a crane was assumed as the working machine in the above embodiments, but any working machines which are actuated to prevent the swing of load can be applied to a desired working machine.

INDUSTRIAL APPLICABILITY

As described above, the invention can easily make an operation to effectively prevent the swing of load. And, the operator operating the lever can be relieved of fatigue remarkably.

Claims

1. An operational reaction force control device for an operating lever of a working machine, in which an operational reaction force is imparted to the operating lever for actuating the working machine in a direction opposite to an operating direction, characterized in that the device comprises:

   acceleration detecting means for detecting an acceleration of the working machine; and
   operational reaction force imparting means for imparting to the operating lever the operational reaction force that becomes greater as the acceleration detected by the acceleration detecting means becomes greater.

2. The operational reaction force control device as set forth in claim 1, wherein the acceleration detecting means is mounted on a leading end of the working machine.

3. The operational reaction force control device as set forth in claim 1 or claim 2, wherein the acceleration detecting means detects an acceleration in a lengthwise direction of the working machine.

4. The operational reaction force control device as set forth in claim 1, further comprising manipulated variable detecting means for detecting a manipulated variable of the operating lever, wherein the operational reaction force imparting means imparts to the operating lever the operational reaction force that becomes greater as the manipulated variable detected by the manipulated variable detecting means becomes greater.

5. The operational reaction force control device as set forth in claim 1, wherein the acceleration detecting means comprises:

working machine angle detecting means for detecting an angle of the working machine; and
acceleration calculating means for calculating the acceleration of the working machine by second order differentiating the angle detected by the working machine angle detecting means.

6. The operational reaction force control device as set forth in claim 5, wherein the working machine angle detecting means is mounted on a leading end of the working machine.

7. The operational reaction force control device as set forth in claim 5 or claim 6, further comprising manipulated variable detecting means for detecting a manipulated variable of the operating lever, wherein the operational reaction force imparting means imparts to the operating lever the operational reaction force that becomes greater as the manipulated variable detected by the manipulated variable detecting means becomes greater.

8. The operational reaction force control device as set forth in claim 1, wherein the acceleration detecting means comprises:

working machine position detecting means for detecting a position of the working machine; and
acceleration calculating means for calculating the acceleration of the working machine by second order differentiating the working machine position detected by the working machine position detecting means.

9. The operational reaction force control device as set forth in claim 8, wherein the working machine position detecting means is mounted on a leading end of the working machine.

10. An operational reaction force control method for an operating lever of a working machine, in which an operational reaction force is imparted to the operating lever for actuating the working machine in a direction opposite to an operating direction, characterized in that the method comprises the steps of:

detecting an acceleration of the working machine; and
imparting to the operating lever the operational reaction force that becomes greater as the acceleration detected becomes greater.

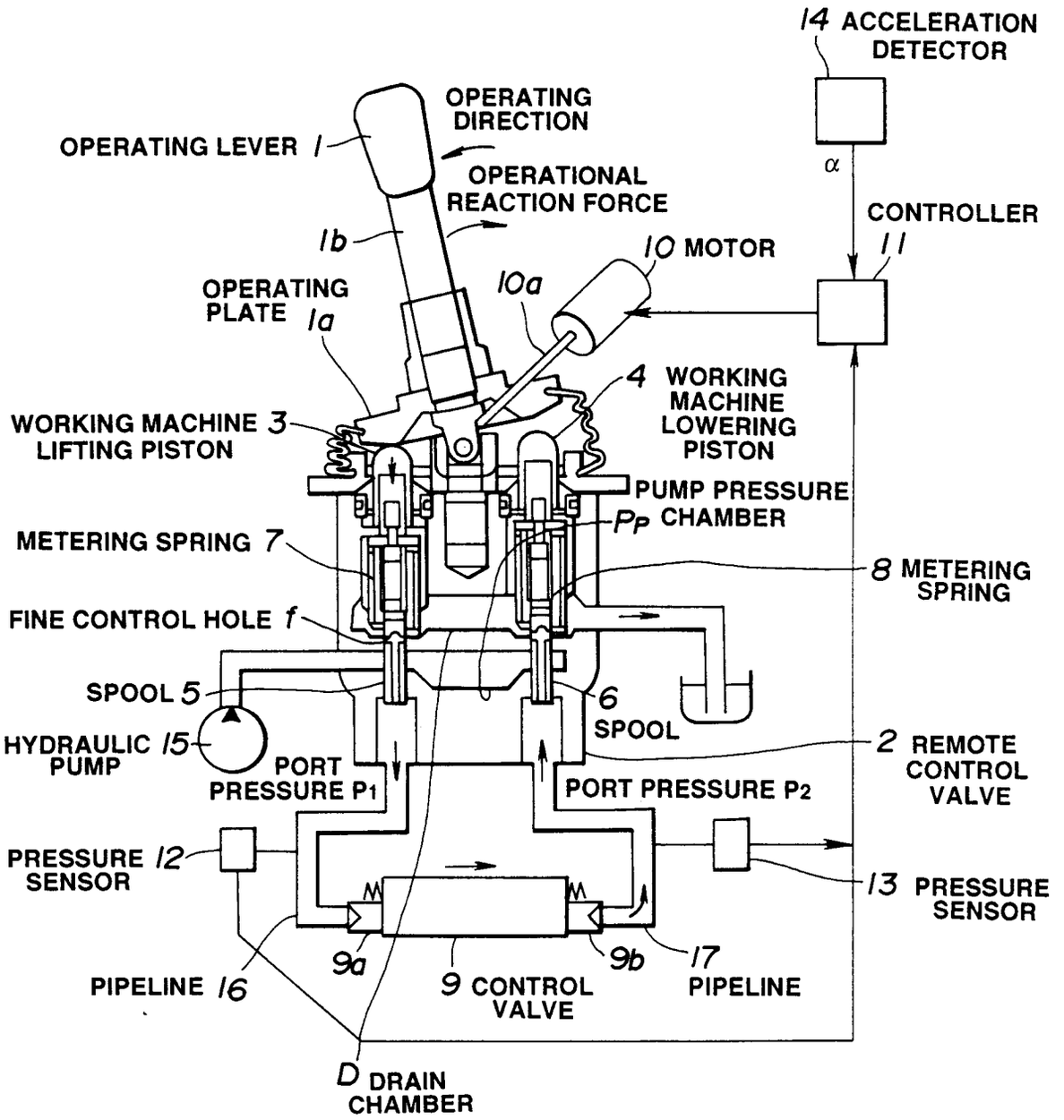

14 ACCELERATION DETECTOR
OPERATING DIRECTION
OPERATING LEVER 1
OPERATIONAL REACTION FORCE
α
CONTROLLER
11
1b
10 MOTOR
10a
OPERATING PLATE 1a
4 WORKING MACHINE LOWERING PISTON
WORKING MACHINE 3 LIFTING PISTON
PUMP PRESSURE
Pp CHAMBER
METERING SPRING 7
8 METERING SPRING
FINE CONTROL HOLE f
SPOOL 5
6 SPOOL
HYDRAULIC 15 PUMP
2 REMOTE CONTROL VALVE
PORT PRESSURE P1
PORT PRESSURE P2
PRESSURE 12 SENSOR
13 PRESSURE SENSOR
9a
9b
17 PIPELINE
PIPELINE 16
9 CONTROL VALVE
D DRAIN CHAMBER

FIG.1

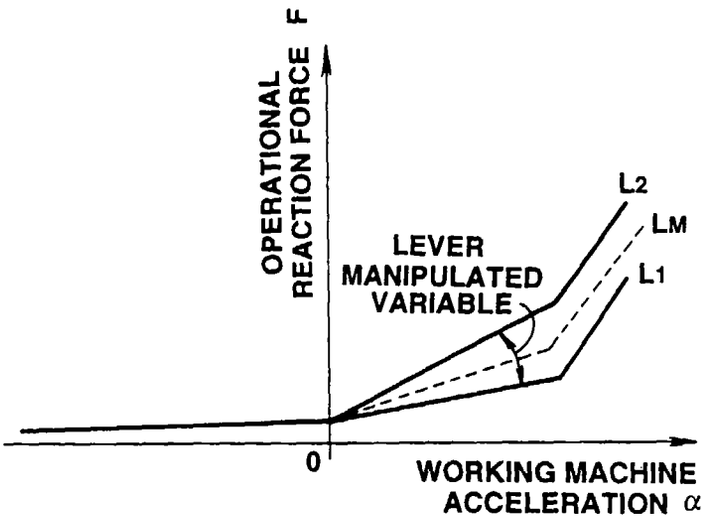

OPERATIONAL REACTION FORCE F
L2
LM
L1
LEVER MANIPULATED VARIABLE
0
WORKING MACHINE ACCELERATION α

FIG.2

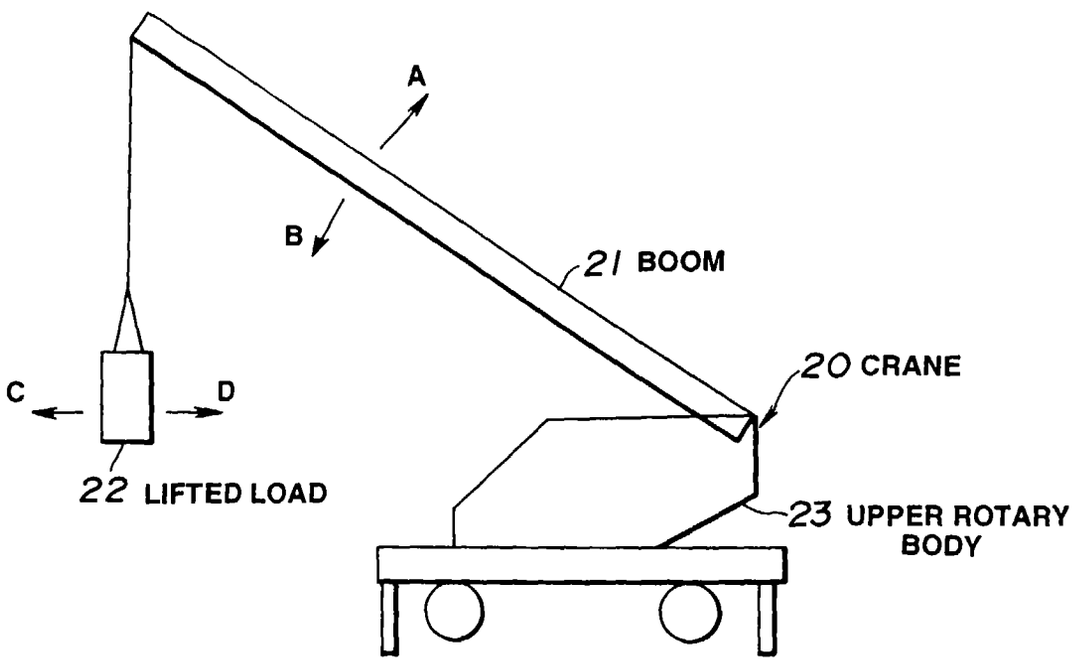

A
B
21 BOOM
20 CRANE
C
D
22 LIFTED LOAD
23 UPPER ROTARY BODY

FIG.5

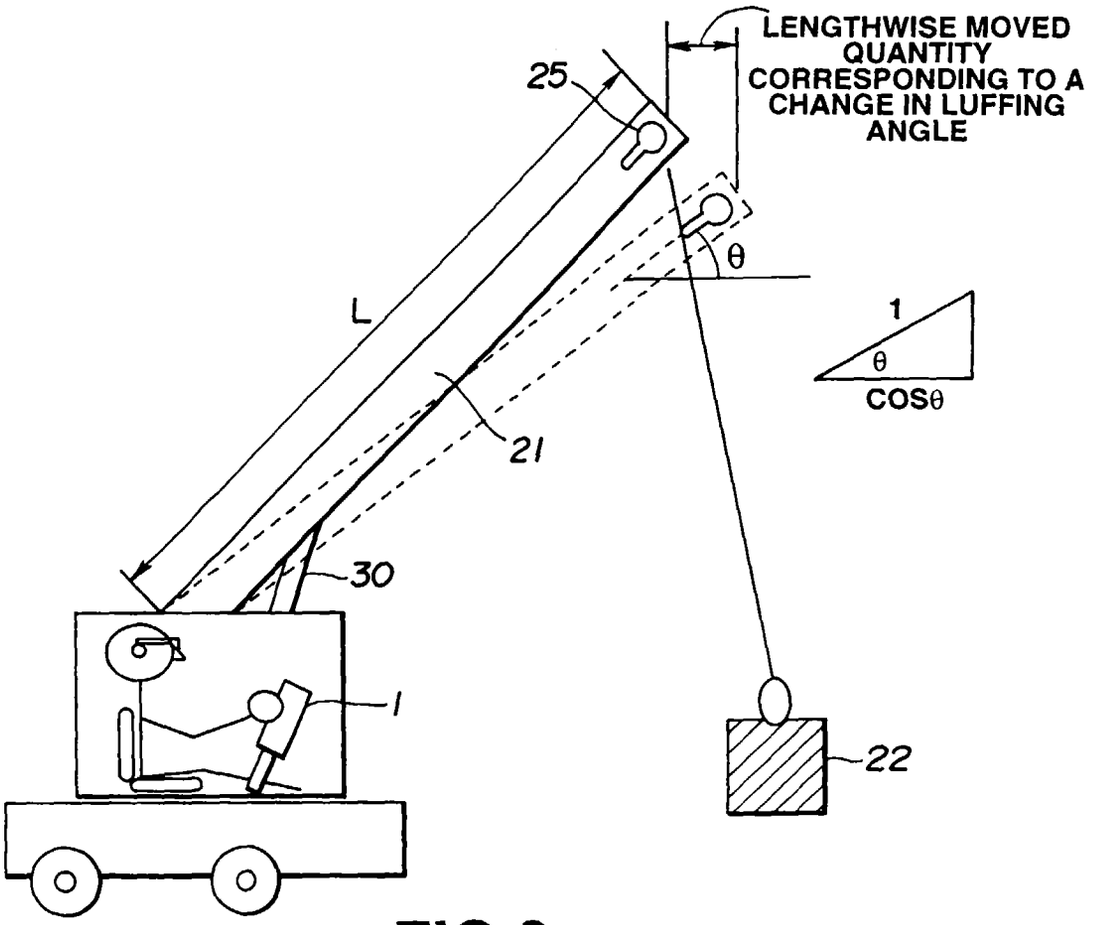

LENGTHWISE MOVED QUANTITY CORRESPONDING TO A CHANGE IN LUFFING ANGLE
25
θ
L
1
θ
COSθ
21
30
1
22

FIG.3

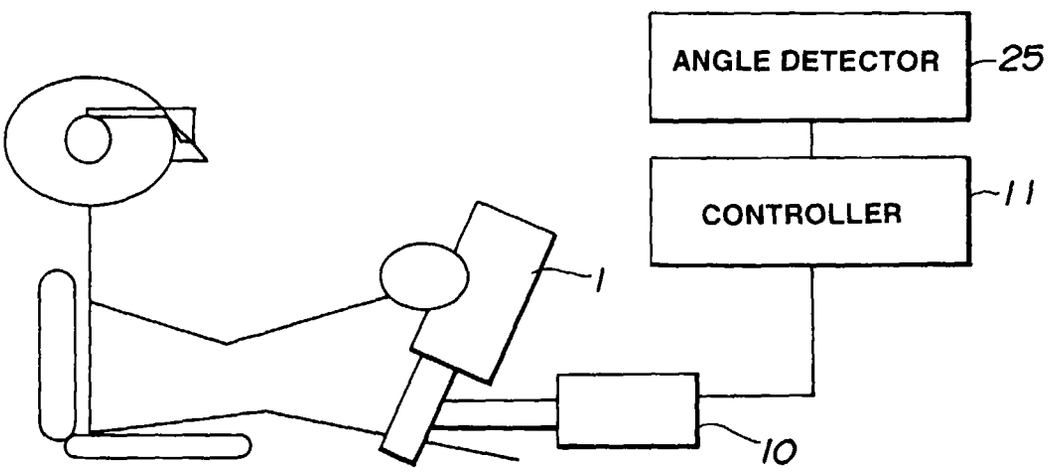

ANGLE DETECTOR
25
CONTROLLER
11
1
10

FIG.4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP96/00983

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl^6 G05G7/00, 9/047, B66C13/56, 13/22, B66D1/28

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)
Int. Cl^6 G05G7/00, 9/047, B66C13/56, 13/22, B66D1/28

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1926 - 1996
Kokai Jitsuyo Shinan Koho 1971 - 1996

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.
Y	JP, 5-5755, B2 (Kobe Steel, Ltd.), January 25, 1993 (25. 01. 93), Liens 6 to 19, column 3 (Family: none)	1-4, 10
Y	JP, 62-23285, U (Shinko Electric Co., Ltd.), February 12, 1987 (12. 02. 87), Line 2, left column to line 1, right column, page 1 (Family: none)	1-4, 10
A	JP, 60-17510, A (Sumitomo Electric Industries, Ltd.), January 29, 1985 (29. 01. 85), Line 4, upper left column to line 2, lower left column, page 3 (Family: none)	1 - 10
A	JP, 2-254098, A (Aerospatical Societe Nationale Industrielle), October 12, 1990 (12. 10. 90), Line 20, lower right column, page 4 to line 6, upper left column, page 5, line 16, upper left column to line 2, upper right column, page 4	1, 4, 10

[X] 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 document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
July 9, 1996 (09. 07. 96)	July 23, 1996 (23. 07. 96)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP96/00983

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	& EP, 384806, A	

Form PCT/ISA/210 (continuation of second sheet) (July 1992)