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(54) BOOM STORING AND EXTENDING DEVICE FOR CRANE

(57) A device for improving safety during operations of storing or extending a boom of a crane. A corresponding relationship between a boom hoisting angle (θ) and a length of rope (s) is beforehand set when an attitude of a boom (4) shifts from a working attitude (A) to a working attitude (B). Means (14) for detecting a boom hoisting angle detects a current boom hoisting angle (θ), and means (18) for detecting a current length of rope detects a length of rope (s). On the basis of the current boom hoisting angle detected by the boom hoisting angle detecting means (14), and the current length of rope (s) detected by the rope length detecting means (18), a boom drive device and a winch drive device are drivingly controlled so that a boom hoisting angle and a length of rope are equal to the set boom hoisting angle (θ_p) and a length of rope (s_p), respectively.

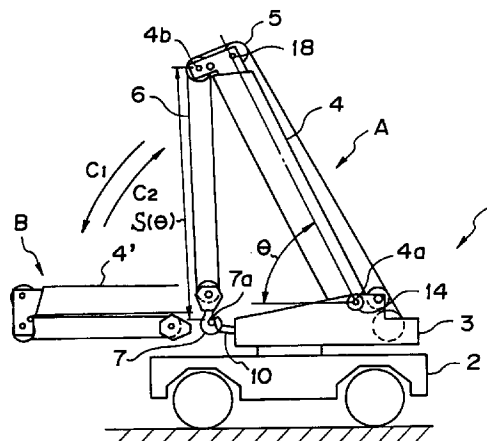


Fig. 1

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Description

TECHNICAL FIELD

The present invention relates to a boom storing and extending device for a crane, which stores the boom of a crane so that the boom attitude changes from a working attitude to a traveling attitude, or extends the boom so that the boom attitude changes from a traveling attitude to a working attitude.

BACKGROUND ART

As illustrated in Fig. 1, for a mobile crane, for instance a rough terrain crane, to travel, it is necessary that the boom 4, in its shortest state, be set to a traveling attitude B as indicated by the arrow C1, and that the boom 4 be stored so that the hook 7 does not swing around by attaching the hook 7 to an anchoring member 10 such as a link or wire ring mounted to a revolving frame 3, which is the revolving superstructure.

Producing such a stored state of the boom manually is not easy.

In manual storing operations, first, the boom 4 is shortened to its minimum length and raised sufficiently, and the hook 7 is lowered to a position where it can be anchored to the wire ring 10. Then, the hook 7 is attached to the wire ring 10, and in that state, the wire 6 is raised up by the winch while lowering the boom 4, all the while maintaining fixed tension on the hoisting rope 6. These operations are performed manually.

To perform this kind of storing operations, the operator is required to carry out two precision operations simultaneously, the lowering of the boom and the hoisting of the winch. For this reason, expert skills are needed to perform the operation, and even highly-skilled operators make mistakes and create problems that lead to a dangerous situation.

Specifically, if an error occurs while carrying out the two simultaneous precision operations described above, the hook 7 can crash into the frame of the crane, causing damage, or dangerous situations may likely occur, in which too much tension is applied to the hoisting rope 6, tearing off the wire ring 1 that anchors the hook 7 and allowing the hook 7 to fly up.

These problems are not limited to storing operations alone, and an extending operation, whereby the boom 4 is extended from a traveling attitude to a working attitude, leads to the same problems.

As described above, in the past, there have been problems with safety during boom storing operations or boom extending operations.

DISCLOSURE OF THE INVENTION

An object of the present invention is to make it possible for the two simultaneous operations involving a boom driving device and a winch driving device to be performed easily and accurately without the need for

expert skills, thereby improving safety during boom storing operations or boom extending operations.

Therefore, the main invention of the present invention is a boom storing and extending device for a crane, which stores a boom by changing the attitude of the boom from a working attitude to a traveling attitude, or which extends the boom by changing the attitude of the boom from a traveling attitude to a working attitude by using a boom driving device to change a boom hoisting angle and a winch driving device to change the length of a hoisting rope from tip of the boom to a hook provided at fore end of the hoisting rope, while anchoring the hook to an anchoring member mounted to a revolving superstructure, the boom storing and extending device comprising setting means for setting beforehand a corresponding relationship between a boom hoisting angle and a length of the rope when the boom shifts its attitude from the working attitude to the traveling attitude; boom hoisting angle detecting means for detecting current boom hoisting angle; rope length detecting means for detecting current rope length; and control means for controlling the boom driving device and the winch driving device so that the boom hoisting angle and the rope length of the rope are equal to the boom hoisting angle and length of the rope set by the setting means based on the current boom hoisting angle detected by the boom hoisting angle detecting means and the current rope length detected by the rope length detecting means.

With this configuration, as shown in Fig. 6, the corresponding relationship between the boom hoisting angle θ and the length of the rope s is set beforehand for the attitude of the boom 4 as it shifts from a working attitude A See Fig. 1 to a traveling attitude B. The current boom hoisting angle θ is detected by the boom hoisting angle detecting means 14 (See Fig. 1), and the current length of the rope s is detected by the rope length detecting means 18 (See Fig. 1).

Therefore, based on the current boom hoisting angle θ detected by the boom hoisting angle detecting means 14, and the current length of the rope s detected by the rope length detecting means 18, the boom driving device 13 and the winch driving device 17 See Fig. 5 are controlled so that the boom hoisting angle and length of the rope are equal to the boom hoisting angle θ_p and length of the rope s_p set as described above.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side view of a crane used in an embodiment of the boom storing and extending device for a crane according to the present invention; Fig. 2 is a graph depicting as a target locus the corresponding relationship of the boom hoisting angle and the length of the rope during a boom storing operation for the crane of the embodiment; Fig. 3 is a block diagram depicting the configuration of the controller of the embodiment; Fig. 4 is a block diagram depicting another configu-

ration of the controller of the embodiment;

Fig. 5 is a block diagram depicting yet another configuration of the controller of the embodiment;

Fig. 6 is a graph used to explain the operations performed by the controller depicted in Fig. 5; and

Fig. 7(a) is a circuit diagram depicting the configuration of the boom driver of the embodiment; and

Fig. 7(b) is a circuit diagram depicting the configuration of the winch driver of the embodiment.

BEST MODE FOR CARRYING OUT THE INVENTION

The following describes an embodiment of the boom storing and extending device for a crane according to the present invention in reference to the figures.

Fig. 1 is a side view of the outside of the crane 1 used in the embodiment, and, as shown in the figure, the crane is assumed to travel via a wheeled lower mechanism 2.

On the upper portion of the lower mechanism 2, a revolving superstructure 3, which is a revolving frame, is mounted revolvably, and on the revolving superstructure 3 a boom 4 is rotatably supported by a shaft via a boom rotation pin 4a, enabling this boom to move up and down as depicted by the arrows C1 and C2. The hoisting angle θ of the boom 4 is detected by a specified hoisting angle sensor 14, which detects the variable resistance provided by the rotation pin 4a, the output from a rotary encoder and the like. The configuration of the boom driver 13 that drives the boom 4 is described later (See Fig. 7(a)). A hoisting rope 6, at one end of which is attached a hook 7, is installed on the boom 4 to freely hoist and lower the hook 7 via a plurality of guide sheaves, including a guide sheave 5 mounted at the top of the boom 4. Here, the distance between the location at the tip 4b of the boom 4 and the location 7a at the center of the hook 7, which is below that, is defined as the length of the rope s.

The length of the rope s is detected by a specified rope length sensor 18, such as a rotary encoder that outputs the length of the rope s by detecting the number of revolutions of the guide sheave 5. The configuration of the winch driver 17 that hoists up and lowers down the hoisting rope 6 is described later (See Fig. 7(b)).

In order to perform storing operations of the boom 4, as described above, first, the boom 4 is shortened to its minimum length and raised sufficiently, and the hook 7 is lowered to a position where it can be anchored to a wire ring 10. Then, so as to maintain the state whereby the hook 7 is anchored at a fixed tension to the wire ring 10, the boom driver 13 drives the boom 4, causing the hoisting angle θ to change so that the hoisting angle θ gradually decreases, and the winch driver 17 hoists the hoisting rope 6 causing the length of the rope s to change so that the length of the rope s gradually becomes shorter. In this way, the attitude of the boom 4 changes from a working attitude A to a traveling attitude B as depicted by the arrow C1, and the boom 4 is stored.

Fig. 3 is a block diagram depicting the configuration of a controller 11 which performs the above-described storing operation.

This controller 11 controls the boom hoisting angle manually, and controls the length of the rope automatically.

An electric lever 12 comprises an operating lever 12a mounted in the operating compartment and operated by the operator to manually change the boom hoisting angle θ , and a velocity command output component 12b that outputs to the boom drive 13 as a boom hoisting angle velocity command $\theta \cdot R$ a voltage proportional to the manipulated variable of the operating lever 12a configured by a variable resistor, etc. The " $\cdot$ " depicted in the above-mentioned " $\theta \cdot R$ " is defined as that which hereafter expresses a "one-level differential".

The boom driver 13 drives the boom 4 so that the hoisting angle θ changes at the $\theta \cdot R$ velocity specified by the input velocity command $\theta \cdot R$.

More specifically, as indicated in Fig. 7(a), the velocity command is applied to an electrical proportional control EPC valve driver 22, and this driver 22 outputs to an EPC valve 23 an electric current E proportional to the input velocity command. The EPC valve 23 generates a pilot pressure PT, which is a secondary pressure proportional to the input electric current E, and applies this to a pilot port 24a or 24b of the flow control valve 24, changing the valve location of the flow control valve 24 in accordance with the pressure PT. An hydraulic pump 21 supplies discharge pressure oil to the flow control valve 24, and the pressure oil of the flow determined by the above-mentioned valve location is supplied from the flow control valve 24 to an hydraulic cylinder 25 for driving the boom 4.

As described above, the hoisting angle θ of the boom 4 is changed at the $\theta \cdot R$ velocity dictated by the velocity command. The successive hoisting angles θ of the boom 4 by the driving of the boom 4 are detected by the hoisting angle sensor 14.

In the meantime, as indicated in Fig. 2, the corresponding relationship D between the boom hoisting angle θ and the length of the rope s as the boom 4 shifts from a working attitude A to a traveling attitude B is stored in the memory component 15. This corresponding relationship D is the target locus of θ and s that enables storing to be performed accurately in a state wherein the hook 7 remains anchored to the wire ring 10 at a fixed tension when θ and s change along the locus D. The target locus D can be found beforehand via tests conducted using an actual crane, or via simulations.

Thus, the length of the rope Sr that corresponds to the hoisting angle θ detected by the hoisting angle sensor 14 is read out from the memory component 15.

That is, as shown in Fig. 2, if the current hoisting angle is θ_1 , a point P1 can be found on the target locus D that corresponds to the hoisting angle θ_1 as indicated by the arrow, and the length of the rope sR1 indicated by this point P1 can be found and output from memory 15.

The length of the rope s_r output from memory 15 is added to a subtractor 16 as the target value of the winch drive control system. Meanwhile, the current rope length s is detected by the rope length sensor 18, and this detected value s is fed back to the subtractor 16 as a feedback amount.

As a result, the subtractor 16 outputs the deviation Δs_r between the target value s_r and the feedback amount s , and this deviation Δs_r is added to the winch driver 17.

The winch driver 17 is configured similarly to the above-described boom driver 13. As shown in Fig. 7(b), the deviation command Δs_r is applied to the EPC valve driver 22, and the driver 22 outputs to an EPC valve 23 an electric current E proportional to the input deviation command. The EPC valve 23 generates a pilot pressure PT proportional to the input electric current E , and applies this to a pilot port 26a or 26b of the flow control valve 26, changing the valve location of the flow control valve 26 in accordance with the pressure PT . A hydraulic pump 21 supplies discharge pressure oil to the flow control valve 26, and the pressure oil of the flow determined by the above-mentioned valve location is supplied from the flow control valve 26 to an hydraulic motor 27 for driving the winch.

As described above, the length of the rope s is changed so that the deviation Δs_r becomes equal to zero. The winch drive control system need not be a feedback control system, but can also be configured as an open loop control system. When this is the case, a rope length sensor 18 need not be installed.

As the above control operation progresses, the hoisting angle θ and length of the rope s change along the target locus D , enabling the storing operation to be performed accurately. With this approach, the operator need only be concerned with manipulating the operating lever 12a for driving the boom 4 so that the operations can be easily performed without the need for expert skills.

Fig. 4 is a block diagram depicting another example of a configuration for a controller that performs the storing operation.

This controller 11', contrary to the one depicted in Fig. 3, controls the length of the rope manually, and controls the hoisting angle automatically.

The electric lever 19 is a lever for driving the winch, and is configured the same as electric lever 12, and when the operating lever 19a is manipulated, a voltage proportional to the manipulated variable of the operating lever 19a is output from the velocity command output component 19b to the winch driver 17 as a winch velocity command $s \cdot R$.

The winch driver 17 drives the winch so that the length of the rope s changes at the $s \cdot R$ velocity specified by the velocity command $s \cdot R$. The length of the rope s changes in line with the driving of the winch, and the successive rope lengths s are detected by the rope length sensor 18.

Then, a hoisting angle θ_R that corresponds to the

length of the rope s detected by the above-described rope length sensor 18 is read out from the memory component 15.

That is, as shown in Fig. 2, supposing that the current rope length is s_2 , a point P_2 can be found on the target locus D that corresponds to the length of the rope s_2 as indicated by the arrow, and the hoisting angle θ_{R2} indicated by this point P_2 can be found and output from the memory 15.

The hoisting angle θ_{R2} output from the memory 15 is added to a subtractor 16 as the target value of the boom drive control system. Meanwhile, the current hoisting angle θ is detected by the hoisting angle sensor 14, and this detected value θ is fed back to the subtractor 16 as feedback.

As a result of this, the subtractor 16 outputs the deviation $\Delta \theta_R$ between the target value θ_{R2} and the feedback θ , and this deviation $\Delta \theta_R$ is added to the boom driver 17.

The boom drive control system need not be a feedback control system, but can also be configured as an open loop control system. When this is the case, a hoisting angle sensor 14 need not be installed.

As the above control operation progresses, the hoisting angle θ and length of the rope s change along the target locus D , enabling a storing operation to be performed accurately. With this approach, the operator need only be concerned with manipulating the operating lever 19a for driving the winch so that the storing operations can be made easily without the need for expert skills.

Fig. 5 is a block diagram depicting yet another example of a configuration for a controller that performs the above-described storing operation.

This controller 11" automatically controls both the boom hoisting angle and the length of the rope.

A boom hoisting angle velocity command $\theta \cdot R$ proportional to the manipulated variable of the operating lever 12a is output from the velocity command output component 12b of the electric lever 12 for driving the boom. The boom driver 13 drives the boom 4 so that the hoisting angle θ changes in accordance with the input command. The successive hoisting angles θ of the boom 4, which change in line with the driving of the boom 4, are detected by the hoisting angle sensor 14 and added to an arithmetic unit 20.

In the meantime, a winch velocity command $s \cdot R$ proportional to the manipulated variable of the operating lever 19a is output from the velocity command output component 19b of the electric lever 19 for driving the winch. The winch driver 17 drives the winch so that the length of the rope s changes in accordance with the input command. The successive changes in rope length s in line with the driving of the winch are detected by the rope length sensor 18 and added to the arithmetic unit 20.

Then, the arithmetic unit 20 calculates the deviation $\Delta \theta$ between the hoisting angle θ detected by the hoisting angle sensor 14 and the target hoisting angle θ_p on

the target locus D, and calculates the deviation Δs between the length of the rope s detected by the rope length sensor 18 and the target rope length s_p on the target locus D, and then outputs these results.

Specifically, as indicated in Fig. 6, the current hoisting angle θ and the current length of the rope s are expressed as coordinate location $Q(\theta, s)$ of the θ - s coordinate system. Then, coordinate location $P(\theta_p, s_p)$ on the locus D, which manifests the shortest distance between this coordinate location Q and a coordinate location on the target locus D, can be found. The vector directed from coordinate location Q to coordinate location P at this time is labeled L . As a result, it is possible to find both the deviation $\Delta\theta$ between the hoisting angle θ detected by the hoisting angle sensor 14 and the target hoisting angle θ_p on the target locus D, and the deviation Δs between the length of the rope s detected by the rope length sensor 18 and the target rope length s_p on the target locus D, in which the direction of vector L is indicated by plus or minus polarity, and the scalar quantity of vector L is an absolute value.

The deviations $\Delta\theta, \Delta s$ output from the arithmetic unit 20 are added to the respective velocity commands $\theta \cdot R, s \cdot R$ mentioned above, and these commands $\theta \cdot R + \Delta\theta, s \cdot R + \Delta s$ are then added to the boom driver 13 and winch driver 17, respectively.

With this operation, the boom 4 is driven by the boom driver 13 so that the deviation $\Delta\theta$ becomes equal to zero, and the winch is driven by the winch driver 17 so that the deviation Δs becomes equal to zero.

As a result, the hoisting angle θ and the length of the rope s change along the target locus D, making it possible to automatically perform a storing operation with excellent accuracy.

In the above-described embodiments, the control processes for performing a storing operation of the boom are described. However, similar control operations can be applied when performing an extending operation of the boom.

INDUSTRIAL APPLICABILITY

As explained above, the present invention makes it possible to easily and with good accuracy perform the two operations for driving a boom and driving a winch simultaneously without the need for expert skills. As a result, the safety of boom storing and extending operations for a crane are dramatically improved. Further, the application of the present invention to equipment other than cranes which require that working machinery be stored and extended can dramatically improve the safety of that equipment.

Claims

1. A boom storing and extending device for a crane, which stores a boom by changing the attitude of the boom from a working attitude to a traveling attitude, or which extends the boom by changing the attitude

of the boom from a traveling attitude to a working attitude by using a boom driving device to change a boom hoisting angle and a winch driving device to change the length of a hoisting rope from tip of the boom to a hook provided at fore end of the hoisting rope, while anchoring the hook to an anchoring member mounted to a revolving superstructure, the boom storing and extending device comprising:

setting means for setting beforehand a corresponding relationship between a boom hoisting angle and a length of the rope when the boom shifts its attitude from the working attitude to the traveling attitude;

boom hoisting angle detecting means for detecting current boom hoisting angle;

rope length detecting means for detecting current rope length; and

control means for controlling the boom driving device and the winch driving device so that the boom hoisting angle and the rope length of the rope are equal to the boom hoisting angle and length of the rope set by the setting means based on the current boom hoisting angle detected by the boom hoisting angle detecting means and the current rope length detected by the rope length detecting means.

2. A boom storing and extending device for a crane, which stores a boom by changing the attitude of the boom from a working attitude to a traveling attitude, or which extends the boom by changing the attitude of the boom from a traveling attitude to a working attitude by using a boom driving device to change a boom hoisting angle and a winch driving device to change the length of a hoisting rope from tip of the boom to a hook provided at fore end of the hoisting rope, while anchoring the hook to an anchoring member mounted to a revolving superstructure, the boom storing and extending device comprising:

setting means for setting beforehand a corresponding relationship between a boom hoisting angle and a length of the rope when the boom shifts its attitude from the working attitude to the traveling attitude;

boom hoisting angle detecting means for detecting current boom hoisting angle; and

control means, when the boom driving device is manually controlled and while the boom hoisting angle which changes in line with the manual control is detected by the boom hoisting angle detecting means and a rope length corresponding to the detected value of the boom hoisting angle is read out from the setting contents of the setting means, for automatically controlling the winch driving device so that the read-out rope length can be achieved.

3. The boom storing and extending device for a crane as set forth in Claim 2, further comprising rope length detecting means for detecting current length of the rope, wherein the control means controls the winch driving device so that the difference between the rope length read out from the setting means and the value of the rope length detected by the rope length detecting means is equal to zero. 5
4. A boom storing and extending device for a crane, which stores a boom by changing the attitude of the boom from a working attitude to a traveling attitude, or which extends the boom by changing the attitude of the boom from a traveling attitude to a working attitude by using a boom driving device to change a boom hoisting angle and a winch driving device to change the length of a hoisting rope from tip of the boom to a hook provided at fore end of the hoisting rope, while anchoring the hook to an anchoring member mounted to a revolving superstructure, the boom storing and extending device comprising: 10
- setting means for setting beforehand a corresponding relationship between a boom hoisting angle and a length of the rope when the boom shifts its attitude from the working attitude to the traveling attitude; 25
- rope length detecting means for detecting current length of the rope; and
- control means, when the winch driving device is manually controlled while the rope length which changes in line with the manual control is detected by the rope length detecting means and a boom hoisting angle corresponding to the detected value of the rope length is read out from the setting contents of the setting means, for automatically controlling the boom driving device so that the read-out boom hoisting angle can be achieved. 30
5. The boom storing and extending device for a crane as set forth in Claim 4, further comprising boom hoisting angle detecting means for detecting current boom hoisting angle, wherein the control means controls the boom driving device so that the difference between the boom hoisting angle read out from the setting means and the value of the boom hoisting angle detected by the boom hoisting angle detecting means is equal to zero. 35
6. A boom storing and extending device for a crane, which stores a boom by changing the attitude of the boom from a working attitude to a traveling attitude, or which extends the boom by changing the attitude of the boom from a traveling attitude to a working attitude by using a boom driving device to change a boom hoisting angle and a winch driving device to change the length of a hoisting rope from tip of the boom to a hook provided at fore end of the hoisting 40

rope, while anchoring the hook to an anchoring member mounted to a revolving superstructure, the boom storing and extending device comprising:

setting means for setting beforehand a corresponding relationship between a boom hoisting angle and a length of the rope when the boom shifts its attitude from the working attitude to the traveling attitude;

boom hoisting angle detecting means for detecting current boom hoisting angle;

rope length detecting means for detecting current rope length; and

control means, when the boom driving device and the winch driving device are manually controlled while the boom hoisting angle and the rope length which change in line with the manual control are respectively detected by the boom hoisting angle detecting means and the rope length detecting means, for calculating deviation between the detected value of the boom hoisting angle and the boom hoisting angle set by the setting means, and deviation between the detected value of the rope length and the rope length set by the setting means, and for automatically controlling the boom driving device and the winch driving device so that both the boom hoisting angle deviation and rope length deviation are equal to zero. 45

7. The boom storing and extending device for a crane as set forth in Claim 6, wherein the setting means sets corresponding relationship between the boom hoisting angle and the rope length as a locus on a two-dimensional coordinate system with the boom hoisting angle as one coordinate axis and the rope length as another coordinate axis, and wherein the control means finds the coordinate locations on the locus so that the distance between the coordinate location on the two-dimensional coordinate system indicated by the boom hoisting angle detected value and rope length detected value and the coordinate location on the locus becomes minimum, and calculates the deviation between the boom hoisting angle specified by the coordinate locations on the locus and the detected value of the boom hoisting angle, and the deviation between the rope length specified by the coordinate locations on the locus and the detected value of the rope length. 50

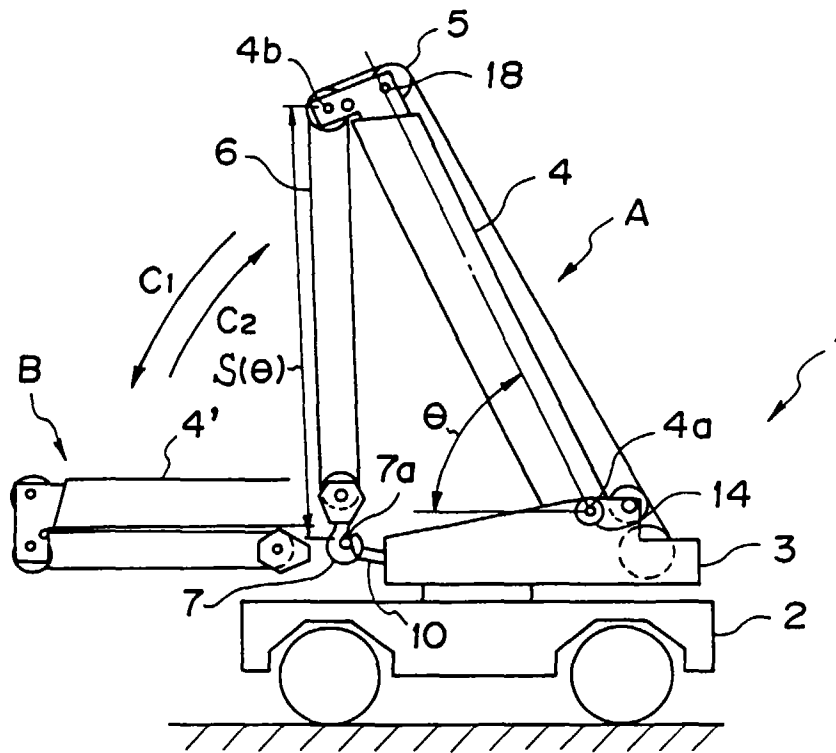


Fig. 1

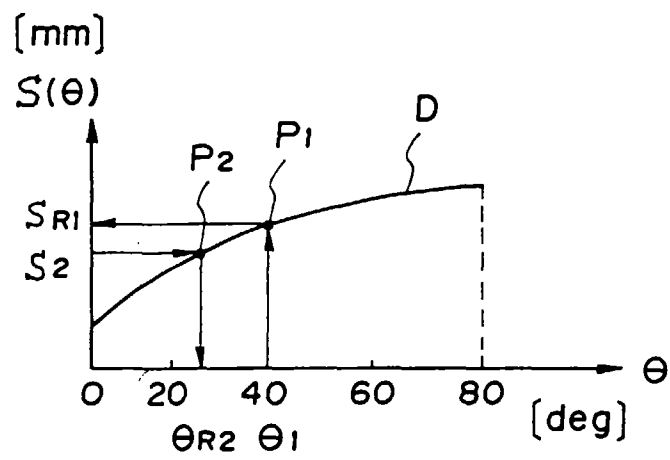


Fig. 2

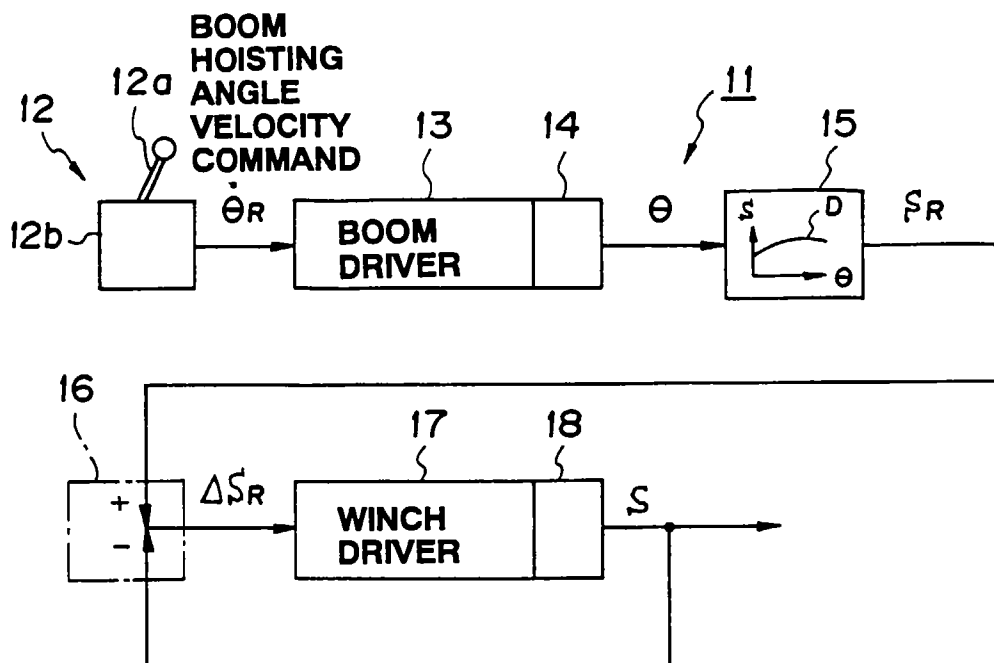


Fig. 3

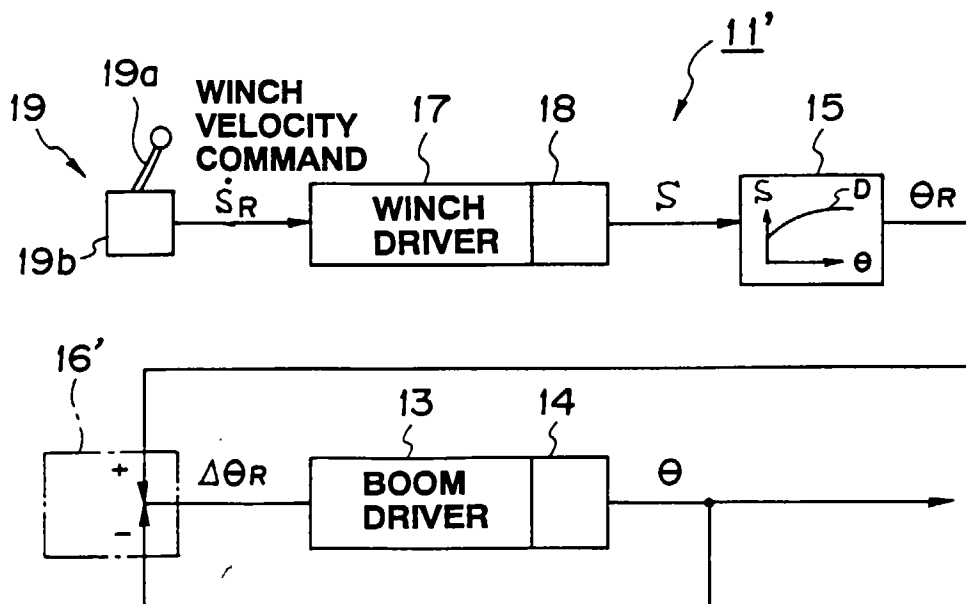


Fig. 4

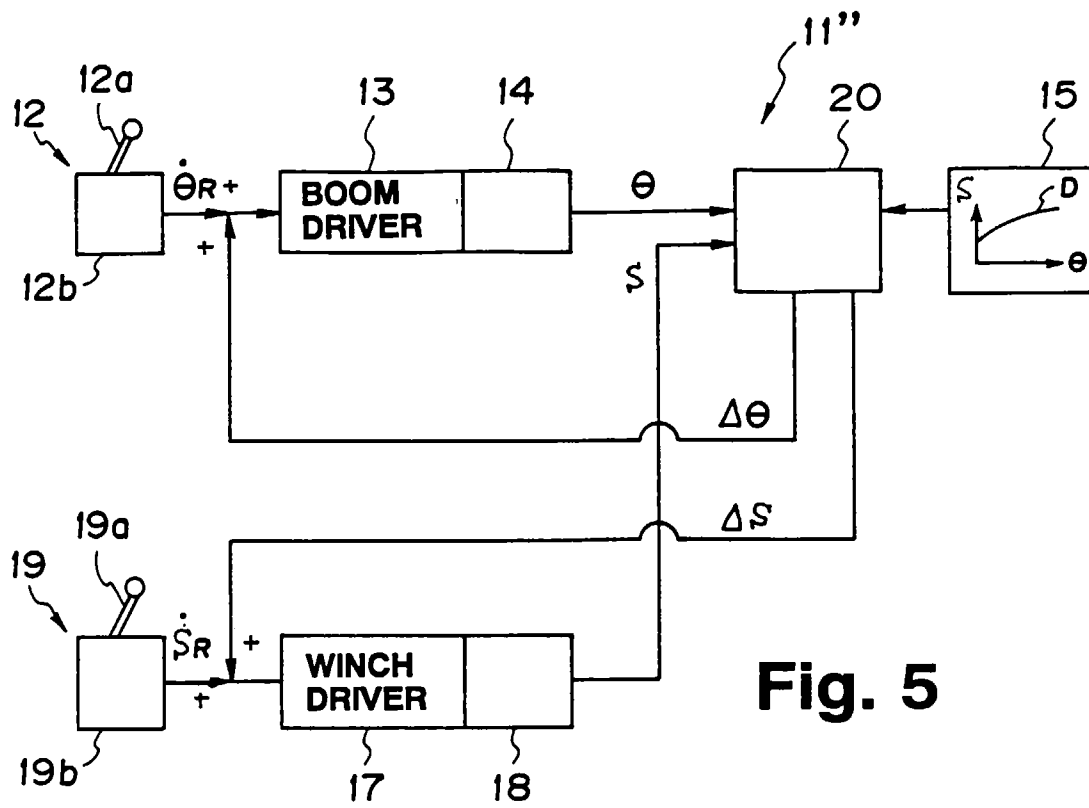


Fig. 5

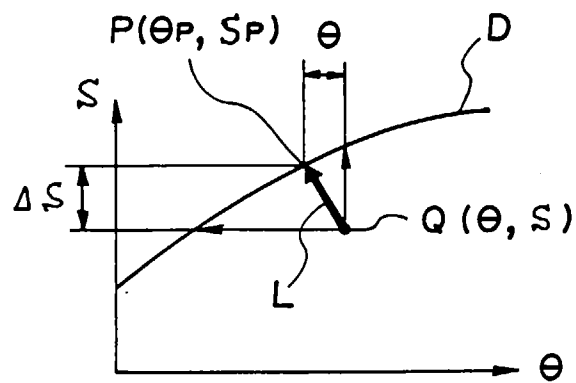


Fig. 6

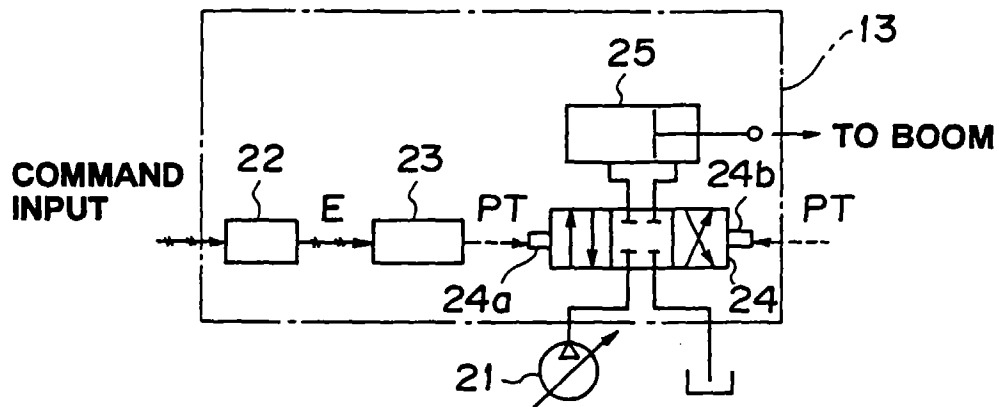


Fig. 7(a)

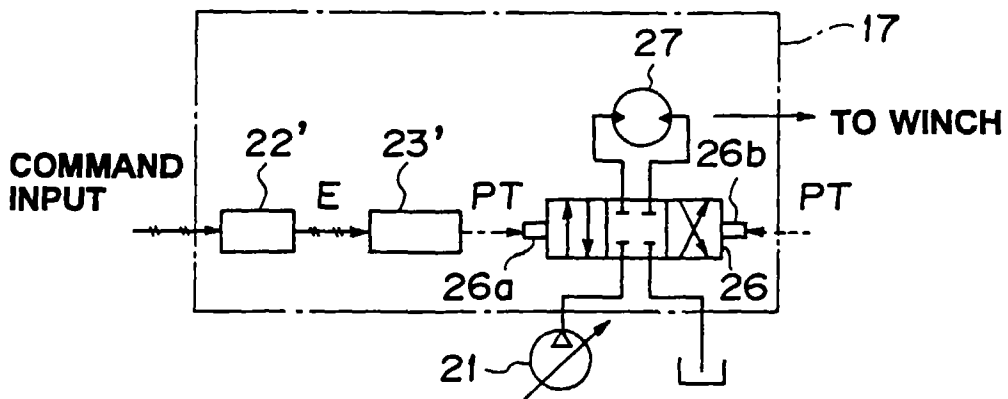


Fig. 7(b)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP95/00335

A. CLASSIFICATION OF SUBJECT MATTER		
Int. Cl ⁶ B66C23/00, 23/26, 23/82, 23/88		
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 B66C23/00, 23/26, 23/82, 23/88		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Jitsuyo Shinan Koho 1926 - 1995		
Kokai Jitsuyo Shinan Koho 1971 - 1995		
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, 55-17751, Y2 (Tadano Ltd.), April 24, 1980 (24. 04. 80) (Family: none)	1 - 7
A	Microfilm of the specification and drawings annexed to the written application of Japanese Utility Model Application No. 125396/1979 (Laid-open No. 43892/1981) (Aichi Sharyo K.K.), April 21, 1981 (21. 04. 81) (Family: none)	1 - 7
A	Microfilm of the specification and drawings annexed to the written application of Japanese Utility Model Application No. 83652/1986 (Laid-open No. 166590/1988) (Sumitomo Heavy Industries, Ltd.), October 31, 1988 (31. 10. 88) (Family: none)	1 - 7
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Date of the actual completion of the international search May 15, 1995 (15. 05. 95)		Date of mailing of the international search report June 6, 1995 (06. 06. 95)
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