



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
06.02.2013 Bulletin 2013/06

(51) Int Cl.:
B21B 37/38 (2006.01) B21B 13/14 (2006.01)
B21B 29/00 (2006.01)

(21) Application number: **11762311.6**

(86) International application number:
PCT/JP2011/050785

(22) Date of filing: **12.01.2011**

(87) International publication number:
WO 2011/122070 (06.10.2011 Gazette 2011/40)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

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(30) Priority: **31.03.2010 JP 2010084054**

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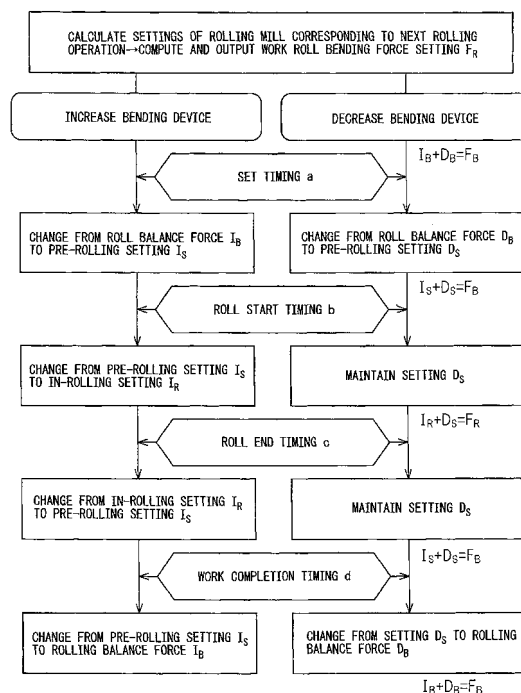
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(54) **ROLLING OF METAL STRIP**

(57) The present invention has as its task to be able to impart a high response crown/shape control function to a rolling mill with a response of decrease bending devices inferior to increase bending devices even under conditions causing a decrease roll bending force to act.

To achieve this task, before the start of rolling, both the increase bending force and the decrease bending force are made to act and the composite force constituted by a roll bending force which corresponds to the roll balance force is made to act on a work roll chock. At the time of the start of rolling, the decrease bending force is held at a constant value while the increase bending force is made to change and a composite force constituted by a predetermined roll bending force (decrease bending force) is made to act on the work roll chock for rolling. At the time of the end of rolling, the increase bending force is returned to the state before the start of rolling and a composite force with the decrease bending force constituted by the roll bending force corresponding to the roll balance force is made to act on the work roll chock. In that state, the rolling is ended.

Fig.2



Description

Citations List

Technical Field

Patent Literature

[0001] The present invention relates to a rolling mill of a metal flat-rolled product which has a high response and can impart a powerful roll bending force. In particular, it relates to a rolling method which can provide a high response crown/shape control function even in the case of a multiple-high rolling mill with a response of decrease bending devices lower than a response of increase bending devices.

5 **[0005]**

PLT 1: Japanese Patent Publication No. 6-55207 A1
PLT 2: Japanese Patent Publication No. 8-215730 A1

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Summary of Invention

Background Art

Technical Problem

[0002] As the methods of control when performing crown/shape controlled rolling in a four-high rolling mill, a six-high rolling mill, or other multiple-high rolling mill, there are roll bending which imparts a bending force to the work roll chocks, roll shift which causes a roll to displace in a roll axial direction, roll cross which imparts a cross angle to a roll, etc.

15 **[0006]** However, the response of a roll bending device is not determined by just the piping length from the servo valve to the hydraulic cylinder.

[0003] Among these control methods, with roll shift and roll cross, it is difficult to change the settings quickly during rolling. Therefore, these are not suitable for crown/shape control rolling where control during rolling is demanded. As opposed to this, roll bending devices can be changed in roll bending force during rolling by control of the hydraulic pressure, so are suitable for crown/shape control rolling.

For example, the rolling mill which is shown in FIG. 1 is a four-high rolling mill which is provided with a pair of upper and lower work rolls 1-1 and 1-2 and a pair of upper and lower backup rolls 2-1 and 2-2 which support the same. Increase bending devices 6-1 to 6-4 are built into project blocks 5-1 and 5-2, while decrease bending devices 7-1 to 7-4 are built into upper and lower backup roll chocks 4-1 and 4-2 in this type of rolling mill. In this type of rolling mill, the response of the decrease bending devices is slower compared with the response of the increase bending devices.

PLT 1 describes a method of continuously rolling a rolled material comprised of steel materials differing in width, thickness, steel type, etc. joined together by using a hot final rolling mill which has a roll bending mechanism and a roll shift mechanism. However, compared with the speed of change of the roll bending force, the speed of change of the roll shift position is extremely slow, so during rolling, the roll shift position is fixed and only the high response roll bending force is used for crown control.

For this reason, when making an increase bending force act on a work roll for crown/shape control, high response control is possible, but when making a decrease bending force act on it, it is not possible to change the settings quickly during rolling. Therefore, it is not possible to eliminate external factors which fluctuate during rolling such as entry side thickness of the rolled material and the temperature of the rolled material. Sometimes this caused a drop in the product quality and yield.

[0004] In this case, the crown/shape control is regulated by the speed of control of the roll bending devices. High response has been desired from roll bending devices since the past.

[0007] Further, the decrease bending devices cannot be made high in response also because fixed piping cannot be used. That is, the work rolls are more easily worn than backup rolls due to rolling operations, so the rolls have to be periodically replaced. However, the rolling mill which is shown in FIG. 1 has the increase bending devices built into the project blocks, so there is no need to detach and reattach the hydraulic piping of the increase bending devices each time replacing a roll. It is possible to connect to hydraulic control valves through fixed piping. Due to this, it is possible to employ servo valves for high response hydraulic control. As opposed to this, the decrease bending devices of the rolling mill of FIG. 1 are built into the upper and lower backup roll chocks, so each time replacing the rolls, the hydraulic piping of the decrease bending devices has to be detached and reattached. There is a high possibility of minute foreign matter entering the hydraulic piping at the time of detachment and reattachment, so it is not possible to employ servo valves for high response hydraulic control. Further, it is necessary to use flexible structure, freely detachable hy-

PLT 2 describes that the response of a roll bending device is determined by the secondary piping length of the servo valve (see PLT 2, paragraph [0014] and FIG. 1). Therefore, the bending force is controlled by servo valves which control the difference between the increase side and decrease side. To secure a high response, these servo valves are provided at the side surfaces of housing posts at a total of four locations of the inlet sides and exit sides of the drive side and work side of the rolling mill housing. The lengths of piping from the servo valves to the hydraulic cylinder are made within 2 meters.

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draulic piping such as flexible piping etc. to connect to the hydraulic control valves, so sometimes fluctuations in the hydraulic pressure to be transmitted ended up being absorbed and eased.

That is, whether it is possible to connect to hydraulic control valves through fixed hydraulic piping or whether it is necessary to connect to hydraulic control valves through flexible structure, freely detachable hydraulic piping such as flexible piping is the biggest cause for the response of the decrease bending devices becoming lower than the response of the increase bending devices.

[0008] Further, since the decrease bending devices cannot be controlled with a high response, the rolling becomes unstable at the time of application and release of the decrease bending force at the time of the start of rolling and the time of the end of rolling. This causes the product quality to deteriorate and the productivity to fall. That is, the decrease bending force cannot be applied at the time of idling when no rolling load is being applied. For this reason, when starting rolling, it is necessary to quickly apply a decrease bending force. On the other hand, at the time of end of the rolling, it is necessary to quickly return to the roll balance state. Therefore, if changing the roll bending force by control by inferior response decrease bending devices, the predetermined decrease bending force will not be applied at the tip and tail ends of the rolled material and the parts with defective shapes will become longer.

That is, a second discovery is that when causing a decrease bending force to act in a rolling mill of the type which is shown in FIG. 1, it is difficult to quickly change the settings during rolling, so it is not possible to eliminate external factors which fluctuate during rolling such as inlet side thickness of the rolled material and the temperature of the rolled material. This caused a drop in the product quality and yield.

[0009] The technical problem of the present invention is to provide a rolling method of a metal flat-rolled product which can impart to a rolling mill with a response of the decrease bending devices lower than the response of the increase bending devices a high response crown/shape control function even when making a decrease bending force act.

Solution to Problem

[0010] The inventors engaged in intensive studies to solve the above problem and as a result discovered that by setting the bending force by the composite force of two types of bending devices in a rolling mill with a response of decrease bending devices lower than a response of increase bending devices and performing control during rolling by only the high response increase bending devices, high response crown/shape control becomes possible, and thereby completed the present invention.

That is, this is a rolling method which changes the roll bending force at the time of the start of rolling and the

time of the end of rolling by using the high response increase bending devices in the case of causing a decrease bending force to act as the work roll bending force for the purpose of crown/shape control. The high response increase bending devices can compensate (cover for) the response of the decrease bending devices. Furthermore, even in the face of external factors which fluctuate during rolling such as inlet side thickness of the rolled material and the temperature of the rolled material, by using the high response increase bending devices for control, good crown/shape can be built in and the product quality and the productivity can be remarkably improved.

[0011] For example, the rolling mill which is shown in FIG. 1 is a rolling mill of a structure which employs flexible structure, easily detachable hydraulic piping for the hydraulic piping of the decrease bending devices due to the ease of detachment and reattachment of the piping at the time of roll replacement. As a result, this is a rolling mill which has the property that the response of the decrease bending devices has to be lower than the response of the increase bending device. However, this rolling mill is structured with the increase bending devices provided at the project blocks, so it is possible to provide large capacity increase bending devices at the project blocks and possible to connect to the hydraulic control valves through fixed hydraulic piping, so the rolling mill also has the superior property of enabling high response increase bending devices. For this reason, the above high response roll bending force control becomes possible.

[0012] Based on these above discoveries, the inventors perfected an invention of a method of rolling a metal flat-rolled material which can impart a high response crown/shape control function even in a rolling mill with a response of the decrease bending devices lower than the response of the increase bending devices. The gist is as follows.

[0013] (1) A rolling method of a metal flat-rolled product which is performed using a rolling mill which has increase bending devices which generate an increase bending force and decrease bending devices which generate a decrease bending force and where the decrease bending devices are lower in response compared with the increase bending devices, the rolling method of a metal flat-rolled product characterized by comprising, before the start of rolling, causing both an increase bending force and a decrease bending force to act and causing, as a composite force, a roll bending force corresponding to a roll balance force to act on work roll chocks. After that, causing the decrease bending force to change to become a predetermined in-rolling decrease bending force while causing the increase bending force to change so that the composite force of the decrease bending force and the increase bending force maintains the roll balance force. This step can be eliminated if from the start making the decrease bending force a predetermined in-rolling decrease bending force and making the increase bending force act on the work roll chocks so that the composite

force of the decrease bending force and the increase bending force becomes the roll balance force. After that, at the time of rolling start, continuing control for holding the decrease bending force at the predetermined in-rolling decrease bending force while making the increase bending force change and making the predetermined in-rolling work roll bending force act on the work roll chocks as the composite force. During the rolling, performing the rolling so as to maintain the predetermined in-rolling work roll bending force by controlling the increase bending force, after that, at the time of rolling end, making the increase bending force change, making a roll bending force which corresponds to the roll balance force act on the work roll chocks as a composite force with the decrease bending force, and ending the rolling of the metal flat-rolled product in that state. After that, to maintain the composite force constituted by the roll balance force, reducing the decrease bending force and increase bending force. This step as well can be omitted if maintaining the decrease bending force at a predetermined in-rolling decrease bending force and if making the increase bending force act on the work roll chocks so that the composite force of the decrease bending force and the increase bending force becomes the roll balance force.

(2) A rolling method of a metal flat-rolled material as set forth in (1), characterized by being performed using a rolling mill,

wherein the rolling mill has a pair of upper and lower work rolls and a pair of upper and lower backup rolls which respectively support the same, has a structure where increase hydraulic cylinders which form the increase bending devices for the upper and lower work rolls are connected to hydraulic control valves through fixed hydraulic piping and are built into project blocks which project to the inside of the rolling mill housing, and, further, has a structure where decrease hydraulic cylinders which form the decrease bending devices for at least the upper work roll are connected to hydraulic control valves through flexible structure, freely detachable hydraulic piping and are built into the upper backup roll chock.

[0014] (3) A rolling method of a metal flat-rolled material as set forth in (2), characterized by measuring a hydraulic pressure inside of a decrease hydraulic cylinder or inside of hydraulic piping which leads to the cylinder and using the measured value as the basis to control the increase bending force so that the roll bending force which acts on the work roll chock becomes a predetermined value.

Here, the "predetermined value of the roll bending force" is the value of the roll bending force which is found in advance from the rolling conditions etc. Further, the roll bending force which acts on a work roll chock becomes a composite force of the increase bending force and decrease bending force.

Advantageous Effects of Invention

[0015] The rolling method according to the present in-

vention changes the roll bending force at the time of the start of rolling and the time of the end of rolling by using the high response increase bending devices. Therefore, even in a rolling mill in which the response of the decrease bending devices is lower than the response of the increase bending devices due to the employing of flexible structure, freely detachable hydraulic piping for the hydraulic piping of the decrease bending devices due to the ease of detachment and reattachment of piping at the time of roll replacement, the high response increase bending devices can compensate for the response of the decrease bending devices and thereby impart a high response, powerful crown/shape control function.

Therefore, according to the rolling method according to the present invention, it is possible to build in an excellent crown/shape even in the face of external factors which fluctuate during rolling such as inlet side thickness of the rolled material and the temperature of the rolled material and possible to greatly improve the product quality and yield.

Brief Description of Drawings

[0016]

FIG. 1 is a side view which shows an example of the structure of a rolling mill covered by the present invention.

FIG. 2 is a view which shows an example of a flow of operation of a rolling method according to the present invention.

FIG. 3 is a view which shows changes along with time in a roll bending force etc. accompanying the flow of operation of FIG. 2.

FIG. 4 is a view which shows changes along with time in a roll bending force etc. in the case where a response of decrease bending devices is low.

FIG. 5 is a view which shows another example of a flow of operation of the rolling method according to the present invention.

FIG. 6 is a view which shows changes along with time in a roll bending force etc. accompanying the flow of operation of FIG. 5.

FIG. 7 is a side view which shows another example of the structure of a rolling mill covered by the present invention.

FIG. 8 is a side view which shows another example of the structure of a rolling mill covered by the present invention.

Description of Embodiments

[0017] Below, referring to FIGS. 1 to 8, a rolling method according to the present invention will be explained.

FIG. 1 is a side view which shows one example of the structure of a rolling mill covered by the present invention. This rolling mill will be explained as an example. As shown in this figure, the rolling mill which is covered by

the present invention is a multiple high rolling mill which is provided with a pair of upper and lower work rolls 1-1 and 1-2 and a pair of upper and lower backup rolls 2-1 and 2-2 which support the work rolls.

Note that the rolling mill which is shown in this figure is a four-high rolling mill of the type which is employed for final tandem rolling mills of steel sheet/strip, but the invention is not limited to this. It may also be a six-high rolling mill.

[0018] Further, in this the rolling mill, upper increase bending devices 6-1 and 6-2 which apply increase bending force to the upper work roll 1-1 and lower increase bending devices 6-3 and 6-4 which apply increase bending force to the lower work roll 1-2 are installed in project blocks 5-1 and 5-2 which project to the inside of the housing 9.

The work rolls 1-1 and 1-2 have to be periodically replaced due to the wear caused by rolling operations. However, the rolling mill of FIG. 1 does not require detachment and reattachment of the hydraulic piping of the increase bending devices with each roll replacement operation. The increase bending devices 6-1 to 6-4 can be connected to respective hydraulic control valves through fixed hydraulic piping. Due to this, it is possible to employ servo valves for high response hydraulic control. Therefore, they can be made high response increase bending devices.

[0019] On the other hand, the upper decrease bending devices 7-1 and 7-2 which apply the decrease bending force to the upper work roll 1-1 are built into the upper backup roll chock 4-1, while the lower decrease bending devices 7-3 and 7-4 which apply the decrease bending force to the lower work roll 1-2 are built into the lower backup roll chock 4-2.

The backup rolls 2-1 and 2-2 as well, while not to the extent of the work rolls, are worn by the rolling operations, so have to be periodically replaced. Due to this, this rolling mill requires detachment and reattachment of the hydraulic piping of decrease bending devices 7-1 to 7-4 at each roll replacement operation. At the time of detachment and reattachment, the possibility of minute foreign matter entering the hydraulic piping becomes high. For this reason, it is difficult to employ servo valves for high response hydraulic control for the decrease bending devices 7-1 to 7-4. Further, when it is necessary to connect to hydraulic control valves through flexible piping and other flexible structure, freely detachable hydraulic piping so as to facilitate detachment and reattachment of piping, sometimes the flexible structure results in fluctuations in hydraulic pressure ending up being absorbed and eased.

[0020] Therefore, when not employing servo valves, but employing flexible piping for hydraulic piping of the decrease bending devices 7-1 to 7-4 due to the ease of detachment and reattachment of the piping at the time of roll replacement, the response of the decrease bending devices ends up becoming lower than the response of the increase bending devices.

For this reason, when causing the decrease bending

force to act as the work roll bending force for the purpose of crown/shape control, it becomes difficult to quickly change the settings during rolling. For this reason, due to the entry side thickness of the rolled material, the temperature of the rolled material, and other external factors which fluctuate during rolling, suitable roll bending control is not possible and sometimes the product quality and yield are caused to fall.

[0021] On the other hand, the decrease bending force cannot be applied at the time of idling when no rolling load is being applied. When applying a decrease bending force, it is necessary to quickly switch to the decrease bending force at the time of starting rolling from the roll balance state at the time of idling and further to quickly return to the roll balance state at the time of rolling end. Therefore, if changing the roll bending force by control by inferior response decrease bending devices, there is a possibility that the predetermined decrease bending force will not be applied at the tip and tail ends of the rolled material and the parts with defective shapes will become longer.

[0022] Here, in the roll bending device which is described in PLT 2, the response of a roll bending device is determined by the length of the secondary piping of the servo valve. That is, by shortening the length of the piping from each servo valve to the hydraulic cylinder to within 2 meters and controlling the pressure difference between the increase side hydraulic pressure and the decrease side hydraulic pressure through the servo valve, it is possible to secure a high response of the bending force. However, the work rolls and the backup rolls have to be periodically replaced, so it is impractical to make both the increase side and the decrease side fixed hydraulic piping. Therefore, it is not possible to sufficiently raise the response when causing decrease bending to act - the object of the present invention.

[0023] The rolling method according to the present invention solves the problem of PLT 2.

Note that, an "increase bending device" means a hydraulic device which gives a force in a direction increasing the roll gap to a work roll chock. "Increase bending device" is a general term for a device including an actuator comprised of a hydraulic cylinder. In the present invention, for simplification of the explanation, an "increase bending device" will, unless otherwise stated, indicate the actuator comprised of a hydraulic cylinder. Further, the force which is applied to a work roll by an increase bending device is referred to as the "increase bending force". On the other hand, a hydraulic device which gives a force in a direction reducing the roll gap to a work roll chock is a "decrease bending device" and a force applied to a work roll due to this is called a "decrease bending force". Further, "decrease bending device" is a general term for a device including an actuator comprised of a hydraulic cylinder. However, in the present invention, for simplification of the explanation, "decrease bending device" will, unless otherwise stated, indicate the actuator comprised of a hydraulic cylinder.

[0024] FIG. 2 is a view which shows one example of the flow of operation of the rolling method according to present invention. More specifically, it is a view which shows the flow of operation of a high response increase bending device and a somewhat lower response decrease bending device compared with that.

Further, FIG. 3 shows the changes along with time in the roll bending force etc. accompanying a rolling operation on a single rolled material in the case of following this rolling method. FIG. 3 shows, from the top, the changes along with time in the rolling load, output of an increase bending device, output of a decrease bending device, and the composite force of the same, that is, the work roll bending force. Below, this will be explained based on FIGS. 2 and 3.

[0025] First, before the start of rolling, the set value F_R of the work roll bending force corresponding to the rolled material to be next rolled is calculated and output. Here, assume that F_R is calculated as a negative value, that is, a decrease bending force. Note that, in the present invention, in the roll bending force, an increase bending force (force in increase direction (direction opening up rolls)) is defined as a positive value, while a decrease bending force (force in decrease direction (direction pressing rolls)) is defined as a negative value.

[0026] Before the start of rolling, both the increase bending force and decrease bending force are made to act and the composite force constituted by the increase side roll bending force corresponding to the roll balance force (F_B) acts on the work roll chock.

That is, at the timing of idling before rolling, the increase bending device output is made I_B (>0), the decrease bending device output is made D_B (<0), and $I_B + D_B$ acts as the roll balance force F_B (>0).

Note that the roll balance force F_B is determined as the force by which the work roll which is driven by the electric motor and the backup roll which is driven by that roll do not slip even at the time of the idling state. Further, D_B should be set by the minimum hydraulic pressure of an extent where the actuator of the decrease bending device does not end up separating from the work roll chock.

[0027] Further, at a certain timing right before the start of rolling (point a on time axis), a predetermined in-rolling decrease bending device output D_S sufficient for making the in-rolling work roll bending force F_R act is calculated by $D_S = F_R - I_R$. Further, D_S and I_S are simultaneously output so that the roll balance force (F_B) becomes constant. Here, I_R is the increase bending device output during rolling. A value close to the minimum value of possible control is determined in advance so that the absolute value of D_S does not become excessive. I_S is the increase bending device output which becomes $I_S + D_S = F_B$.

Therefore, at the set timing, the composite force constituted by the work roll bending force remains at F_B and does not substantially change.

[0028] Next, right after rolling start, control is continued to hold the decrease bending force at a constant value while the increase bending force is lowered and the com-

posite force constituted by the predetermined decrease side roll bending force F_R acts on the work roll chock. Rolling is performed in that state. That is, at the time of rolling start (point b on the time axis), the increase bending device output is changed from I_S to I_R . By doing this, the slow response decrease bending device output is left as D_S while the fast response increase bending device can be controlled to quickly switch the composite force constituted by the work roll bending force from the roll balance force F_B (>0) to the decrease bending force F_R (<0).

Note that, "the time of rolling start (b)" indicates the point of time of start of rolling. This may be detected for example by the method of finding the time when the load which is detected by a load cell for measurement of the rolling load of a rolling mill exceeds for example 30% of a rolling load calculated by prediction by calculation of the settings. This value is preferably set between 10 to 30%. This is so that it can be differentiated from fluctuations in the roll balance force and so that the start of rolling can be quickly detected.

[0029] Further, at the time of rolling end, the roll bending force is returned to the state before the start of rolling, an increase side roll bending force which corresponds to the composite force constituted by the roll balance force is made to act on the work roll chock, and the rolling of the metal flat-rolled material is ended in that state.

That is, at the time of rolling end (point c on time axis), the decrease bending device output is left as D_S while the fast response increase bending device output is returned from I_R to I_S . By doing this, the composite force constituted by the work roll bending force can be quickly switched from the decrease bending force F_R (<0) to the roll balance force F_B (>0).

Note that, "the time of rolling end (point c on time axis)" indicates the point of time of ending the rolling end. This may be detected for example by the method of finding the time when the load which is detected by a load cell for measurement of the rolling load of a rolling mill falls under for example 50% of a value of the measured rolling load during rolling averaged over time. This value can be freely set, but is preferably set to between 50 to 80%. This is so that it can be differentiated from fluctuations in the roll bending force and so that the end of rolling can be quickly detected.

[0030] Further, the point of time after the elapse of for example 1 to 3 seconds from the time of rolling end is made the timing of work completion d . At this timing, the increase bending device output is made I_B and the decrease bending device output is made D_B . Even with this change, the composite force constituted by the work roll bending force is maintained at substantially the roll balance force F_B .

[0031] As shown in FIGS. 2 and 3, in the rolling method according to present invention, at the time of rolling start and at the time of rolling end, the roll bending force is changed by using high response increase bending devices. For this reason, even if decrease bending devices

with responses lower than the increase bending devices have to be provided, they are compensated for by the high response increase bending devices, so a high response and powerful crown/shape control function can be imparted.

Further, even when various factors (outside disturbances) cause the rolling force to change during rolling, quick control to make the high response increase bending devices maintain the optimal work roll bending force is possible.

That is, according to the rolling method according to present invention, even when the rolled material entry side thickness or the rolled material temperature or other parameters fluctuate during rolling, a good crown/shape can be built in despite these external disturbances. Due to this, the product quality and yield can be greatly improved.

[0032] FIG. 4 is a view which shows the changes along with time in the rolling bending force etc. in the case of a low response of the decrease bending device (in particular, in the case of having hydraulic pressure characteristics whereby if the reaction force is withdrawn, the pressure ends up falling). In the same way as FIG. 3, this shows the changes along with time in the roll bending force etc. which accompany a rolling operation on a single rolled material in accordance with the flow of operation of the increase bending device and the decrease bending device which is shown in FIG. 2. That is, compared with the case of FIGS. 2 and 3, the example of a case of a slow speed of response of the decrease bending device is shown.

[0033] In the case where the response of the decrease bending device is low such as in this example, at the timings b and c , the output of the high response increase bending device rapidly changes, so the output of the poor response decrease bending device fluctuates. As a result, the composite force constituted by the work roll bending force is slow to reach F_R at the timing b and is slow to reach F_B at the timing c . The rolling method which is shown in FIG. 5 solves this problem.

[0034] FIG. 5 is a view which shows another example of the flow of operation of the rolling method according to the present invention and shows the flow of operation of a high response increase bending device and a decrease bending device with a low response compared with the case of FIGS. 2 and 3. Below, this will be explained based on the drawings.

The rolling method which is shown in FIG. 5 measures the hydraulic pressure in hydraulic piping which leads to a decrease bending device and uses the found decrease bending force, or uses the decrease bending force which is measured by a load cell which is provided at the device, as the basis to control an increase bending devices. That is, the output of the increase bending device is controlled in accordance with the decrease bending force or the hydraulic pressure of the decrease bending device so that before and after rolling, the work roll bending force becomes the roll balance force F_B and so that during

rolling, the work roll bending force becomes F_R . Note that the rest of the control is similar to the rolling method which is shown in FIG. 2.

By using the rolling method which is shown in FIG. 5 for rolling, as shown in FIG. 6, it is possible to compensate for fluctuations in the output of the decrease bending devices by the increase bending devices and realize high response control of the work roll bending force.

Further, even without measuring the decrease bending force during rolling or feedback control by measurement of the hydraulic pressure, it is possible to obtain similar effects by predicting in advance the fluctuations in output of a decrease bending device and setting the output of an increase bending device to compensate for this.

[0035] FIG. 7 and FIG. 8 are side views which show other examples of the structure of a rolling mill which is covered by the present invention. These rolling mills are improved so as to enable the roll gap to be enlarged by having the rolling direction force which is applied to the barrel of the upper work roll 1-1 received not at the project blocks 5-1 and 5-2, but the housing window 12. Among these, the rolling mill which is shown in FIG. 7 is a rolling mill which provides the lower decrease bending devices 7-3 and 7-4 which apply decrease bending force to the lower work roll 1-2 at the lower backup roll chock 4-2. The rolling mill which is shown in FIG. 8 is a rolling mill which provides the lower decrease bending devices 7-3 and 7-4 at special project blocks 5-3 and 5-4 which are positioned below the project blocks 5-1 and 5-2.

The rolling method according to the present invention can also be applied to these rolling mills. Due to this, it is possible to build in a good crown/shape even in the face of external factors which fluctuate during rolling such as inlet side thickness of the rolled material and the temperature of the rolled material and possible to greatly improve the product quality and yield.

Industrial Applicability

[0036] The present invention can be utilized for rolling of steel plate, in particular for reverse rolling mills which require particularly large gaps etc.

Reference Signs List

[0037]

- 1-1. upper work roll
- 1-2. lower work roll
- 2-1. upper backup roll
- 2-2. lower backup roll
- 3-1. upper work roll chock
- 3-2. lower work roll chock
- 4-1. upper backup roll chock
- 4-2. lower backup roll chock
- 5-1. entry side project block
- 5-2. exit side project block
- 5-3. entry side lower project block

- 5-4. exit side lower project block
- 6-1. entry side upper increase bending device
- 6-2. exit side upper increase bending device
- 6-3. entry side lower increase bending device
- 6-4. exit side lower increase bending device 5
- 7-1. entry side upper decrease bending device
- 7-2. exit side upper decrease bending device
- 7-3. entry side lower decrease bending device
- 7-4. exit side lower decrease bending device
- 8-1. entry side backup roll balancing device 10
- 8-2. exit side backup roll balancing device
- 9. housing
- 10. rolled material
- 11. reduction device
- 12. housing window 15

Claims

1. A rolling method of a metal flat-rolled product which is performed using a rolling mill which has increase bending devices which generate an increase bending force and decrease bending devices which generate a decrease bending force and where said decrease bending devices are lower in response compared with said increase bending devices, the rolling method of a metal flat-rolled product **characterized by:**
 - before the start of rolling, causing both an increase bending force and a decrease bending force to act and causing, as a composite force, a roll bending force corresponding to a roll balance force to act on work roll chocks; 30
 - after that, at the time of rolling start, holding the decrease bending force at said predetermined in-rolling decrease bending force while making the increase bending force change and making the predetermined in-rolling work roll bending force act on the work roll chocks as the composite force; 35 40
 - during the rolling, performing the rolling so as to maintain said predetermined in-rolling work roll bending force by control of the increase bending force; and 45
 - after that, at the time of rolling end, making the increase bending force change, making a roll bending force which corresponds to the roll balance force act on the work roll chocks as a composite force with the decrease bending force, and ending the rolling of the metal flat-rolled product in that state. 50
2. A rolling method of a metal flat-rolled material as set forth in claim 1, **characterized by** being performed using a rolling mill, 55

wherein the rolling mill further has a pair of upper

and lower work rolls and a pair of upper and lower backup rolls which respectively support the same,

has a structure where increase hydraulic cylinders which form said increase bending devices for the upper and lower work rolls are built into project blocks which project to the inside of the rolling mill housing and fixed hydraulic piping is connected to hydraulic control valves of the increase hydraulic cylinders, and, further, has a structure where decrease hydraulic cylinders which form said decrease bending devices for the upper work roll are built into the upper backup roll chock and flexible structure, freely detachable hydraulic piping are connected to hydraulic control valves of the decrease hydraulic cylinders.

3. A rolling method of a metal flat-rolled material as set forth in claim 2, **characterized by** measuring a hydraulic pressure inside of a decrease hydraulic cylinder or inside of hydraulic piping which leads to said cylinder and using the measured value as the basis to control the increase bending force so that the roll bending force which acts on the work roll chock becomes a predetermined value.

Fig.1

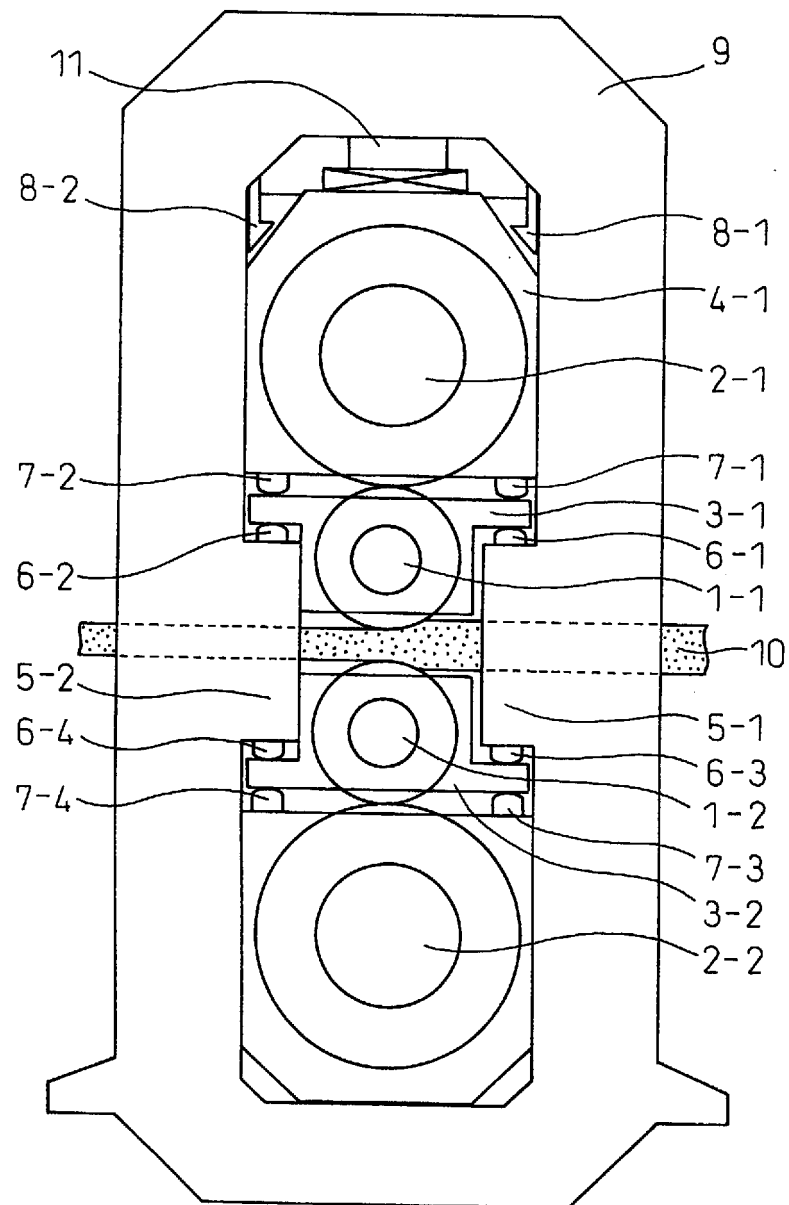


Fig.2

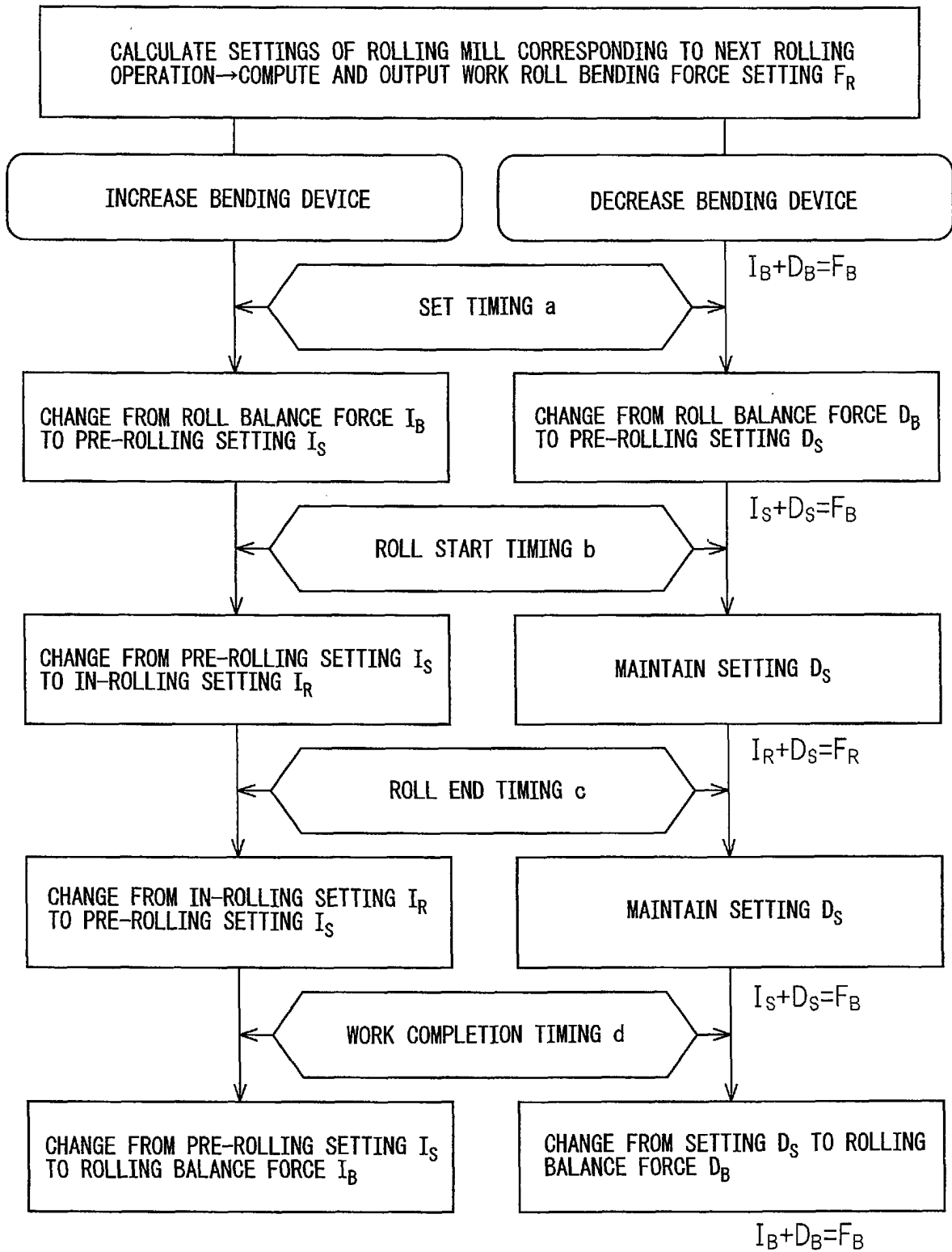


Fig.3

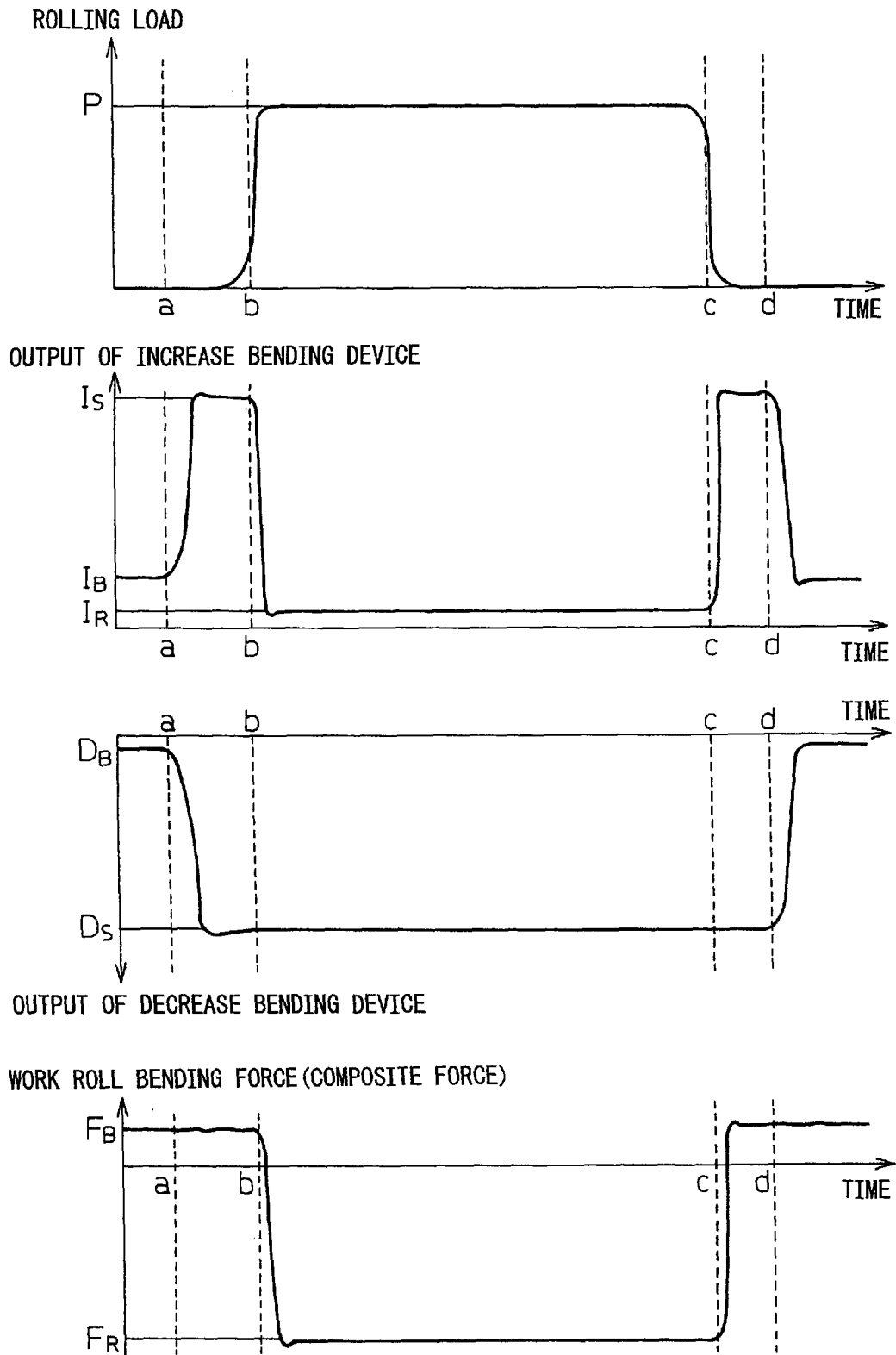


Fig.4

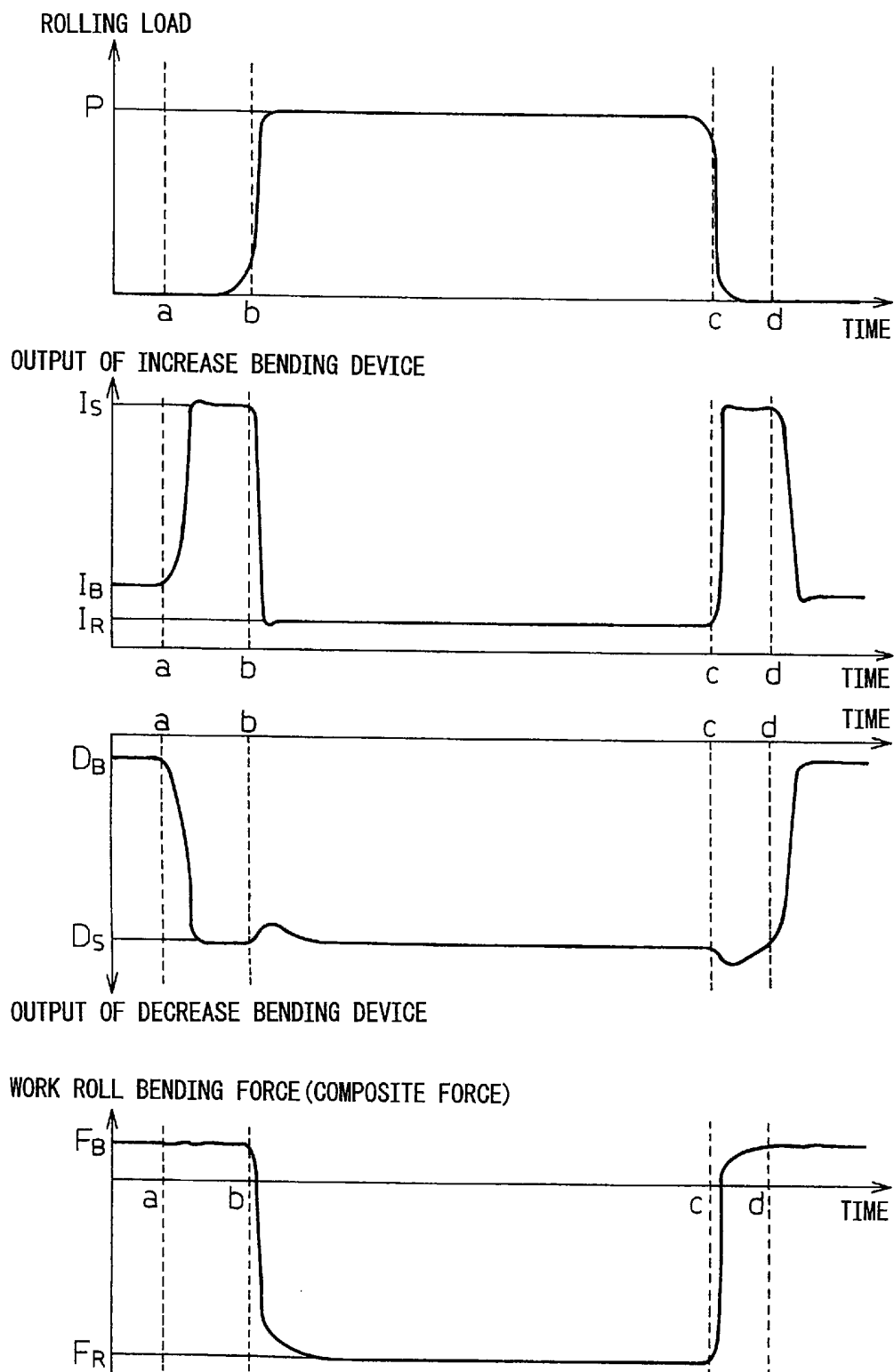


Fig.5

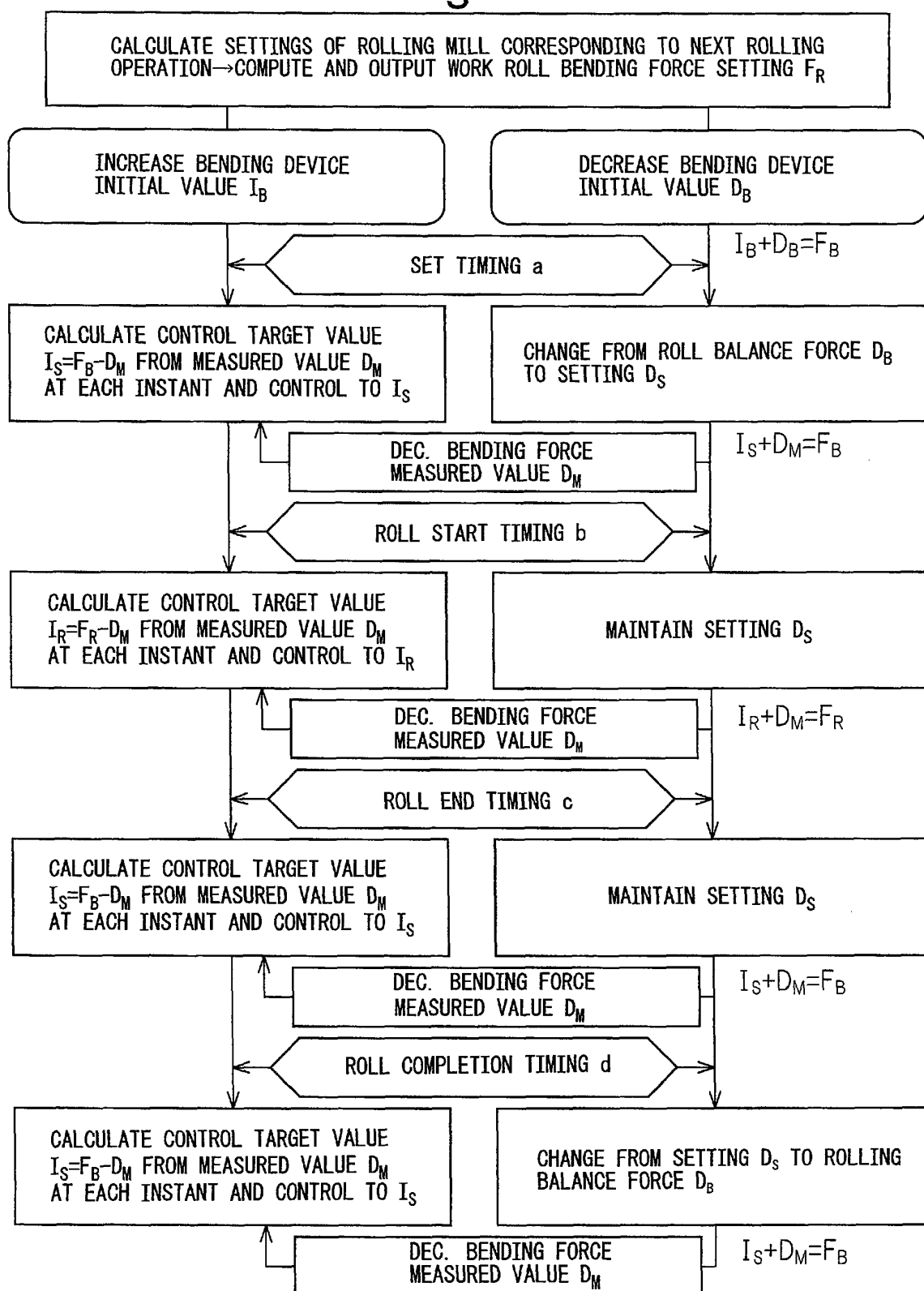


Fig.6

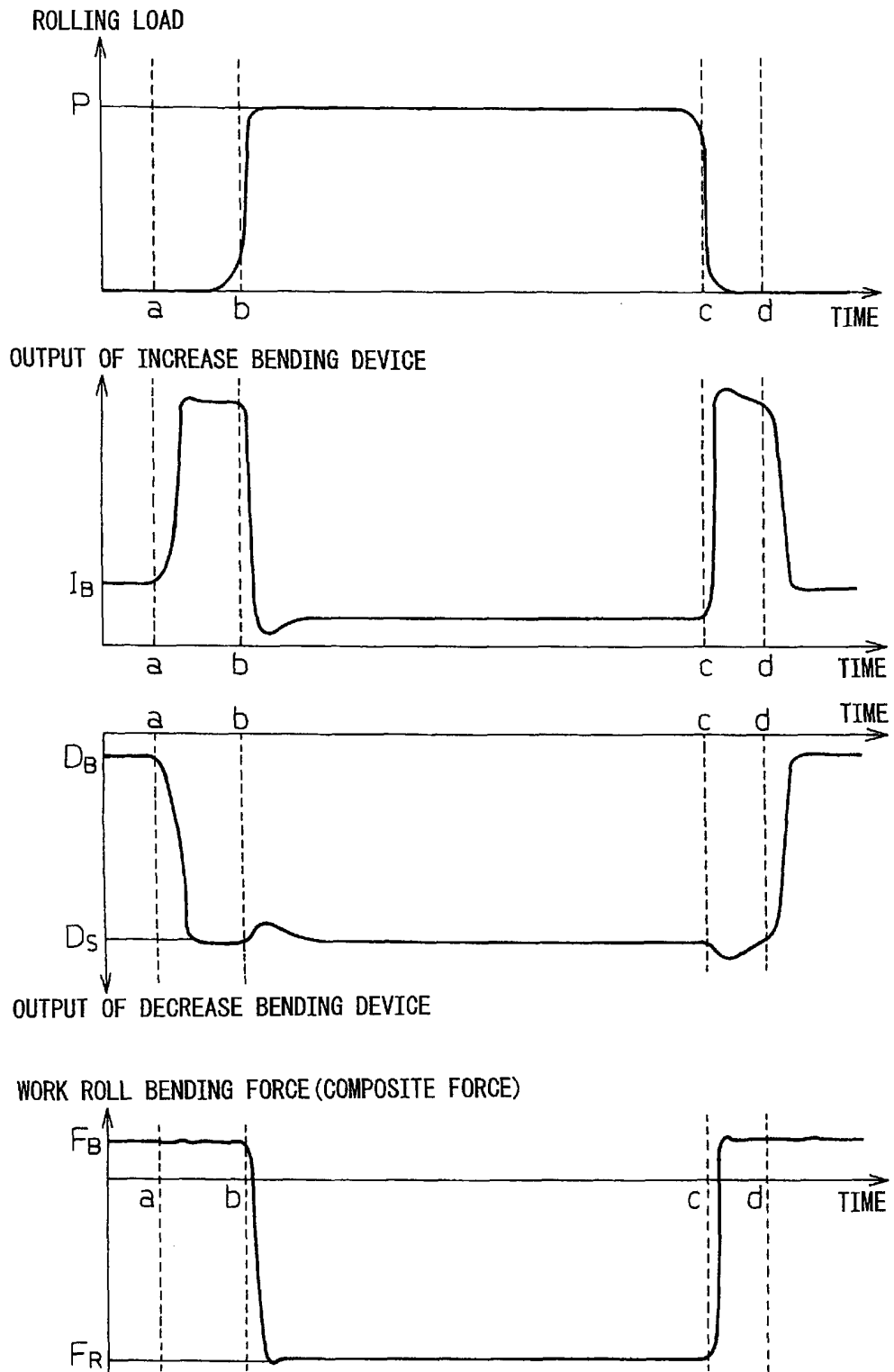


Fig.7

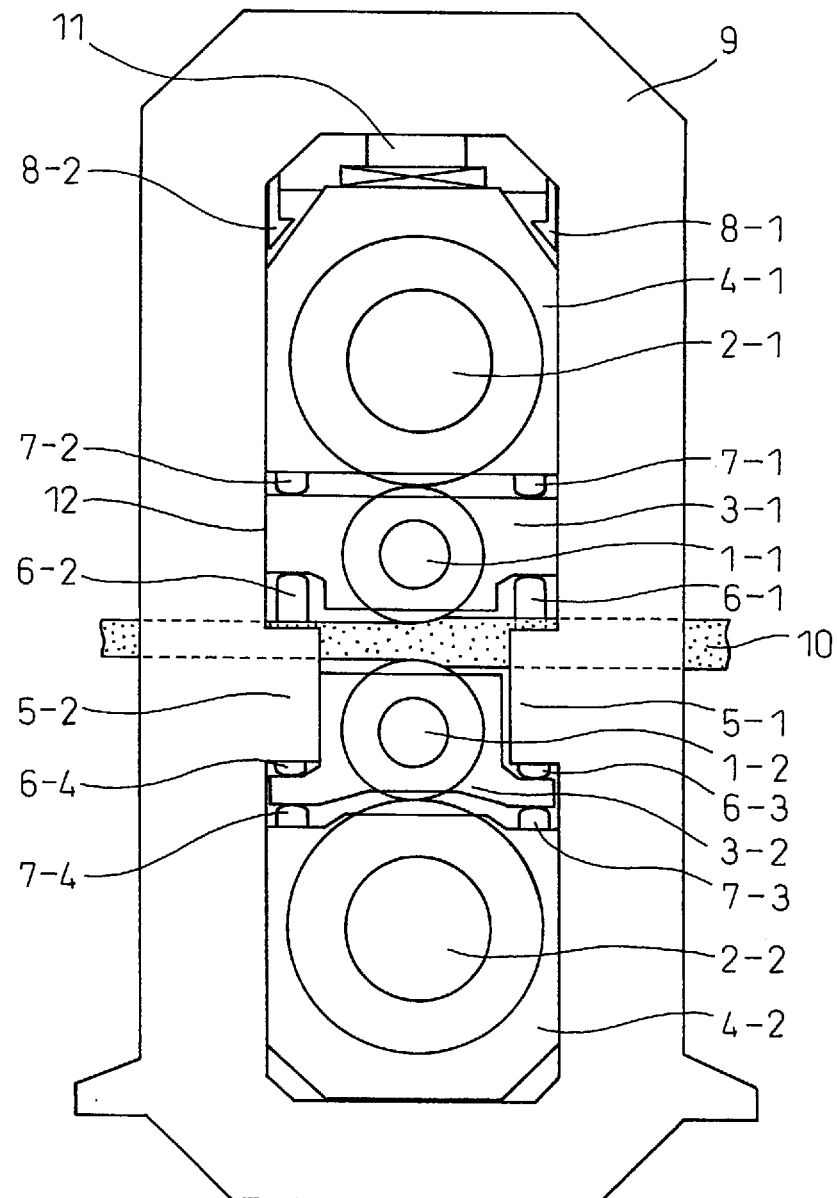
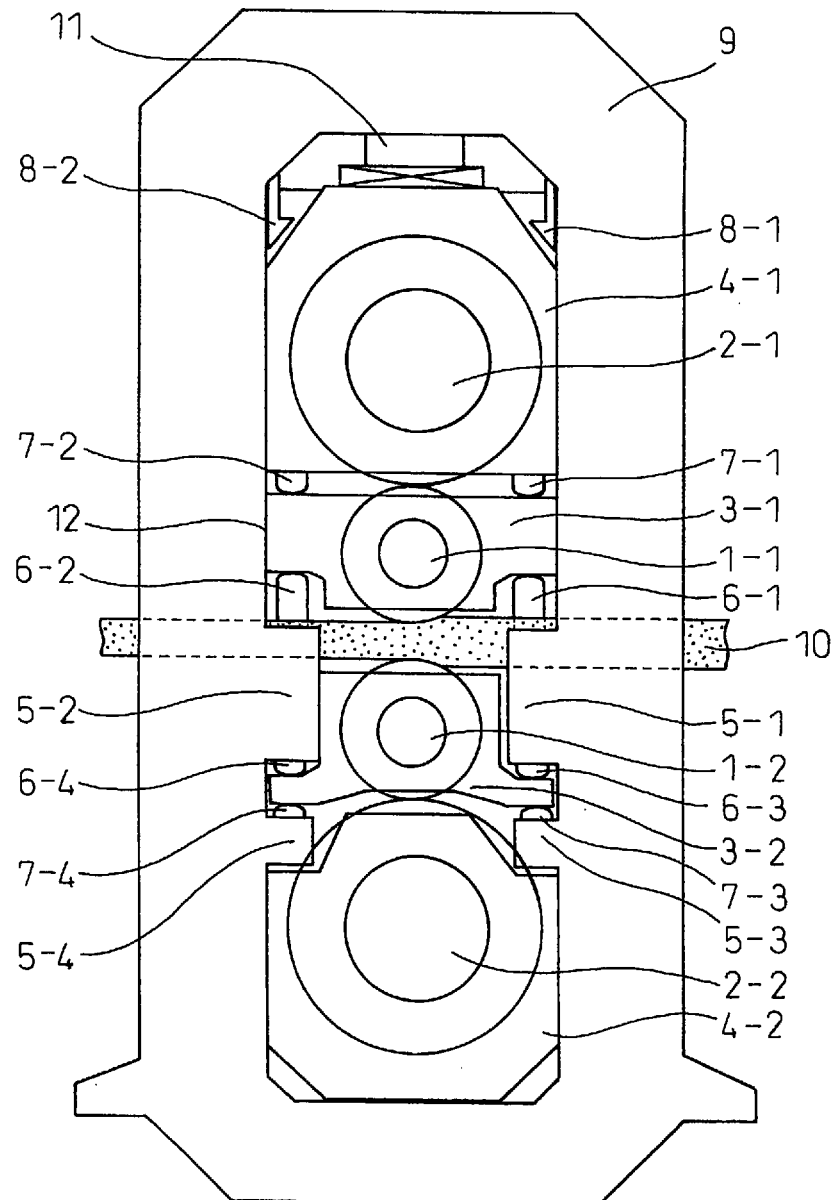


Fig.8



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/050785

A. CLASSIFICATION OF SUBJECT MATTER

B21B37/38 (2006.01) i, B21B13/14 (2006.01) i, B21B29/00 (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)

B21B37/38, B21B13/14, B21B29/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2011

Kokai Jitsuyo Shinan Koho 1971-2011 Toroku Jitsuyo Shinan Koho 1994-2011

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 63-199006 A (Nippon Steel Corp.), 17 August 1988 (17.08.1988), fig. 2 (Family: none)	1-3
A	JP 11-267728 A (Kawasaki Steel Corp.), 05 October 1999 (05.10.1999), fig. 2, 4 (Family: none)	1-3

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

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Date of the actual completion of the international search
09 February, 2011 (09.02.11)Date of mailing of the international search report
22 February, 2011 (22.02.11)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

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Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/050785

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 27384/1986 (Laid-open No. 142403/1987) (Hitachi, Ltd.), 08 September 1987 (08.09.1987), drawings (Family: none)	1-3
A	JP 2-280910 A (Kawasaki Steel Corp.), 16 November 1990 (16.11.1990), drawings (Family: none)	1-3
A	JP 8-215730 A (Nippon Steel Corp.), 27 August 1996 (27.08.1996), fig. 2 to 5 (Family: none)	1-3

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 6055207 A [0005]
- JP 8215730 A [0005]