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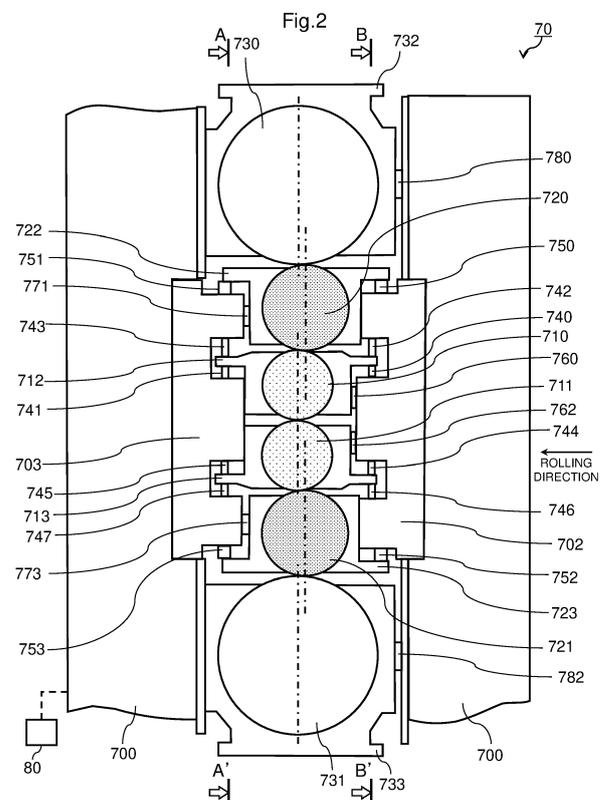
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(54) **ROLLING MILL AND ROLLING METHOD**

(57) To provide a rolling mill and a rolling method capable of reducing offset loads on bearings even with a simple structure as compared to conventional technologies.

Two or more first cylinders 740, 741, 744, 745, are provided on each of the entry side and the exit side in the rolling direction, the two or more first cylinders being aligned in the axial direction, and a controller 80 is configured to be able to choose to drive one first cylinder on the entry side and one first cylinder on the exit side such that resultant force thereof acts on a central portion of a bearing when the roll performs bending and when at least the center of the bearing is arranged between the axially outermost first cylinder and the axially innermost first cylinder in the first cylinders.



EP 3 812 057 A1

Description

BACKGROUND OF THE INVENTION

5 1. Field of the Invention

[0001] The present invention relates to a rolling mill and a rolling method.

10 2. Description of the Related Art

[0002] JP-1988-055369-B describes one example of rolling mills that can prevent occurrence of extreme offset loads on bearings and that makes it possible to extend the service life of the bearing, increase the roll shift amount, and additionally improve the capability of correcting the shape of a rolled material. In order for the resultant force of bending force that acts on a bearing of a rolling roll to always act on the lengthwise center position of the bearing, each pressure of a plurality of bending cylinders arranged along the roll-axis direction is made adjustable. That is, for example, the hydraulic pressure of a cylinder in proximity to the lengthwise-center side of the bearing is set high, and the hydraulic pressure of a cylinder not in proximity to the lengthwise center of the bearing is set low. Thereby, the resultant force of the bending force is caused to act on the bearing at the lengthwise center of the bearing even if the acting positions of the bending force are different.

20 SUMMARY OF THE INVENTION

[0003] There is a known rolling mill that has a shift function of moving rolling rolls in the roll-axis direction, and a bending function of causing pressurizing force to act on bearings of the rolls in a direction perpendicular to the axes and controls the shape of a rolled material by controlling related action between movements of the rolls, and bending force on the rolls.

[0004] In such a rolling mill, if an offset load acts on a bearing as a result of changes of the positions of the bearing and bending cylinders depending on the position of a shifting roll, the lifetime of the bearing becomes shorter in some cases, and this is particularly noticeable in a case in which the shift amount of the roll is large.

30 **[0005]** JP-1988-055369-B describes one example of technologies for suppressing offset loads that act on bearings, and extending the lifetime of the bearings. In the configuration described in JP-1988-055369-B, each cylinder pressure can be adjusted such that the resultant force of bending force acting on a bearing acts on a middle portion of the bearing in the roll-axis direction.

[0006] However, a rolling mill with a configuration like the one described in JP-1988-055369-B requires a large number of bending cylinders according to the shift of a roll and furthermore requires a large number of mechanisms for adjusting the pressing force of individual cylinders, leading to an increase in the number of parts and to complexity of control. Accordingly, there is room for improvement in terms of the simplification of structures and control.

[0007] The present invention provides a rolling mill and a rolling method capable of reducing offset loads on bearings even with a simple structure as compared to conventional technologies.

40 **[0008]** The present invention includes a plurality of means for solving the problem described above and by way of example, includes: a roll that is shifted in an axial direction; a bearing and four or more first cylinders that are provided on each of a drive side and a work side, the bearing being configured to be shifted in the axial direction of the roll along with the roll and to receive a load from the roll, the four or more first cylinders being configured to apply bending force vertically to the bearing and to cause the roll to perform bending; and a controller that drives the first cylinders, in which, 45 on each of the drive side and the work side, two or more first cylinders in the first cylinders are provided on each of an entry side and an exit side in a rolling direction, the two or more first cylinders being aligned in the axial direction, and the controller is configured to be able to choose to drive one first cylinder on the entry side and one first cylinder on the exit side such that resultant force thereof acts on a central portion of the bearing when the roll performs bending and when at least a center of the bearing is arranged between an axially outermost first cylinder and an axially innermost first cylinder in the first cylinders.

50 **[0009]** According to the present invention, offset loads on bearings can be reduced even with a simple structure as compared to conventional technologies. Problems, configurations and effects other than those described above become apparent from the following explanation of embodiments.

55 BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

FIG. 1 is a figure illustrating an overview of a rolling facility including a rolling mill of a first or second embodiment of the present invention;

FIG. 2 is a front view for explaining an overview of the rolling mill of the first or second embodiment;

FIG. 3 is a figure illustrating part of a cross-sectional view taken along A-A' in FIG. 2;

5 FIG. 4 is a figure illustrating part of a cross-sectional view taken along B-B' in FIG. 2;

FIG. 5 is a plan view for explaining details of a work-roll portion of the rolling mill of the first embodiment;

FIG. 6 is a plan view for explaining details of another form of the work-roll portion of the rolling mill of the first embodiment; and

10 FIG. 7 is a plan view for explaining details of another form of the work-roll portion of the rolling mill of the second embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

15 **[0011]** A first or second embodiment of a rolling mill and a rolling method of the present invention is explained by using FIG. 1 to FIG. 7. FIG. 1 is a figure illustrating an overview of a rolling facility including a rolling mill of a first or second embodiment. FIG. 2 is a front view for explaining an overview of the rolling mill. FIG. 3 is a figure illustrating part of a cross-sectional view taken along A-A' in FIG. 2. FIG. 4 is a figure illustrating part of a cross-sectional view taken along B-B' in FIG. 2. FIG. 5, FIG. 6, and FIG. 7 are plan views for explaining details of a work-roll portion of the rolling mill.

20 <First Embodiment

[0012] First, an overview of the rolling facility including the rolling mill of the present embodiment is explained by using FIG. 1.

25 **[0013]** As illustrated in FIG. 1, a rolling facility 1 includes: a plurality of rolling mills that perform hot rolling of a rolled material 5 into a strip; and a controller 80. The rolling mills include seven stands, which are a first stand 10, a second stand 20, a third stand 30, a fourth stand 40, a fifth stand 50, a sixth stand 60, and a seventh stand 70, from an entry side of the rolled material 5. Among them, each of the first stand 10, the second stand 20, the third stand 30, the fourth stand 40, the fifth stand 50, the sixth stand 60, and the seventh stand 70, and a part of the controller 80 that controls the stands correspond to what is called a rolling mill in the present invention.

30 **[0014]** Note that the rolling facility 1 is not limited to one including seven stands like the one illustrated in FIG. 1, but can be one including at least two stands.

[0015] Next, part of the overview of the rolling mill of the present invention is explained by using FIG. 2. Note that, although the seventh stand 70 illustrated in FIG. 1 is explained as an example in FIG. 2, the rolling mill of the present invention can be applied to any stand of the first stand 10, the second stand 20, the third stand 30, the fourth stand 40, 35 the fifth stand 50, and the sixth stand 60 illustrated in FIG. 1.

[0016] In FIG. 2, the seventh stand 70 which is a rolling mill of the present embodiment is a rolling mill including six rolls that roll the rolled material 5, and has a housing 700, the controller 80 and a hydraulic device (illustration omitted).

40 **[0017]** The housing 700 includes: an upper work roll 710 and a lower work roll 711; and an upper intermediate roll 720 and a lower intermediate roll 721 that support the upper work roll 710 and the lower work roll 711 by being in contact with the upper work roll 710 and the lower work roll 711, respectively. Furthermore, the housing 700 includes an upper backup roll 730 and a lower backup roll 731 that support the upper intermediate roll 720 and the lower intermediate roll 721 by being in contact with the upper intermediate roll 720 and the lower intermediate roll 721, respectively.

45 **[0018]** Among the rolls, the upper work roll 710 has, at its axial end parts on both the drive side and the work side, bearings 790 (see FIG. 5) that are shifted in the roll-axis direction together with the upper work roll 710 and that receive loads from the roll, and these bearings are supported by upper-work-roll bearing housings 712 and 712A. Similarly, the lower work roll 711 also has bearings (omitted for the convenience of illustration) at its axial end parts on both the drive side and the work side, and these bearings are supported by lower-work-roll bearing housings 713 and 713A.

50 **[0019]** In the present embodiment, a shift cylinder 715 illustrated in FIG. 3 is driven via the work-side upper-work-roll bearing housing 712, and accordingly, the upper work roll 710 is configured to be able to be shifted in the roll-axis direction via a shift mechanism 715A. Similarly, the lower work roll 711 also is configured to be able to be shifted in the roll-axis direction by a shift cylinder 716 illustrated in FIG. 3 via the work-side lower-work-roll bearing housing 713.

55 **[0020]** The upper intermediate roll 720 has bearings (illustration omitted) at its axial end parts on both the drive side and the work side, and these bearings are supported by upper-intermediate-roll bearing housings 722A and 722, respectively. The lower intermediate roll 721 also has bearings (illustration omitted) at its axial end parts on both the drive side and the work side, and these respective bearings are supported by lower-intermediate-roll bearing housings 723A and 723.

[0021] In addition, the upper intermediate roll 720 is configured to be able to be shifted in the roll-axis direction by a shift cylinder 725 illustrated in FIG. 3 via the drive-side upper-intermediate-roll bearing housing 722A. Similarly, the lower

intermediate roll 721 is also configured to be able to be shifted in the roll-axis direction by a shift cylinder 726 illustrated in FIG. 3 via the drive-side lower-intermediate-roll bearing housing 723A.

[0022] Returning to FIG. 2, an entry-side fixation member 702 is fixed to the housing 700 on the entry side of the rolled material 5, and an exit-side fixation member 703 is fixed to the housing 700 on an exit side of the housing 700 opposite to the entry-side fixation member 702 on an exit side of the rolled material 5.

[0023] In the seventh stand 70, as illustrated in FIG. 2 and FIG. 4, on each of the work side and the drive side, upper-work-roll bending cylinders 740 provided to a work-roll bending block part 714 of the entry-side fixation member 702, an upper-work-roll bending cylinder 742 provided to an upper-intermediate-roll bending block part 727, and upper-work-roll bending cylinders 741 and 743 provided to the exit-side fixation member 703 support the upper-work-roll bearing housings 712 and 712A, and by driving these cylinders as appropriate, it is possible to apply bending force vertically to the bearing of the upper work roll 710 and to thereby cause the upper work roll 710 to perform bending.

[0024] Similarly, as illustrated in FIG. 2 and FIG. 4, on each of the work side and the drive side, lower-work-roll bending cylinders 744 provided to the entry-side fixation member 702, a lower-work-roll bending cylinder 746 provided to a lower-intermediate-roll bending block part 728, and lower-work-roll bending cylinders 745 and 747 provided to the exit-side fixation member 703 support the lower-work-roll bearing housings 713 and 713A, and by driving these cylinders as appropriate, it is possible to apply bending force vertically to the bearing of the lower work roll 711 and to thereby cause to the lower work roll 711 to perform bending.

[0025] Regarding the upper intermediate roll 720, on each of the work side and the drive side, upper-intermediate-roll bending cylinders 750 provided to the upper-intermediate-roll bending block part 727 of the entry-side fixation member 702, and upper-intermediate-roll bending cylinders 751 provided to the upper-intermediate-roll bending block part 727 of the exit-side fixation member 703 support the upper-intermediate-roll bearing housings 722 and 722A, and by driving these cylinders as appropriate, it is possible to apply bending force vertically to the bearing and to thereby cause the upper intermediate roll 720 to perform bending. In addition, the upper-intermediate-roll bending block part 727 is provided with the upper-work-roll bending cylinders 742 and 743 on the entry side and the exit side, respectively, and by driving these cylinders as appropriate, it is possible to cause the upper work roll 710 to perform bending.

[0026] Regarding the lower intermediate roll 721 also, on each of the work side and the drive side, a lower-intermediate-roll bending cylinder 752 provided to the lower-intermediate-roll bending block part 728 of the entry-side fixation member 702, and a lower-intermediate-roll bending cylinder 753 provided to the lower-intermediate-roll bending block part 728 of the exit-side fixation member 703 support the lower-intermediate-roll bearing housings 723 and 723A, and by driving these cylinders as appropriate, it is possible to apply bending force vertically to the bearing and to thereby cause the lower intermediate roll 721 to perform bending. In addition, the lower-intermediate-roll bending block part 728 is provided with the lower-work-roll bending cylinders 746 and 747 on the entry side and the exit side, respectively, and by driving these cylinders as appropriate, it is possible to cause the lower work roll 711 to perform bending.

[0027] Among these cylinders, the upper-work-roll bending cylinders 740 and 741 are arranged such that bending force is applied to the bearings of the upper work roll 710 that contacts the rolled material 5 in a direction toward the vertical increase-side (away from the rolled material) to cause the roll to perform bending (first cylinders). In addition, the upper-work-roll bending cylinders 742 and 743 are arranged such that bending force is applied to the bearings in a direction toward the vertical decrease-side (toward the rolled material), which is the opposite direction to the bending force applied by the upper-work-roll bending cylinders 740 and 741 to cause the upper work roll 710 to perform bending.

[0028] Similarly, the lower-work-roll bending cylinders 744 and 745 are arranged such that bending force is applied to the bearings of the lower work roll 711 that contacts the rolled material 5 in the direction toward the vertical increase-side to cause the roll to perform bending (first cylinders). In addition, the lower-work-roll bending cylinders 746 and 747 are arranged such that bending force is applied to the bearings in the direction toward the decrease-side, which is the opposite direction to the lower-work-roll bending cylinders 744 and 745 to cause the lower work roll 711 to perform bending.

[0029] The upper-intermediate-roll bending cylinders 750 and 751 are arranged such that bending force is applied to the bearings of the upper intermediate roll 720 in the direction toward the vertical increase-side, and the roll performs bending (first cylinders).

[0030] The lower-intermediate-roll bending cylinders 752 and 753 are arranged such that bending force is applied to the bearings of the lower intermediate roll 721 in the direction toward the vertical increase-side to cause the roll to perform bending (first cylinder).

[0031] As illustrated in FIG. 2, FIG. 3 and FIG. 4, for the purpose of preventing backlashes, the entry-side fixation member 702 on the entry side of the rolled material 5 is provided with upper-work-roll bearing-housing backlash elimination cylinders 760 (second cylinders) such that horizontal force, specifically pressing force in the rolling direction, is applied to the upper work roll 710 via liners (illustration omitted) of the upper-work-roll bearing housings 712 and 712A. Similarly, the entry-side fixation member 702 is provided with lower-work-roll bearing-housing backlash elimination cylinders 762 (second cylinders) such that pressing force is applied to the lower work roll 711 in the rolling direction via liners of the lower-work-roll bearing housings 713 and 713A. Thereby, desired force can be applied to the work roll or the like in the direction orthogonal to the roll-axis direction.

[0032] In addition, as illustrated in FIG. 2, FIG. 3 and FIG. 4, for the purpose of preventing backlashes, the exit-side fixation member 703 on the exit side of the rolled material 5 is provided with upper-intermediate-roll bearing-housing backlash elimination cylinders 771 (second cylinders) such that horizontal force, that is, pressing force in the direction opposite to the rolling direction, is applied to the upper intermediate roll 720 via liners of the upper-intermediate-roll bearing housings 722A and 722. Similarly, the exit-side fixation member 703 is provided with lower-intermediate-roll bearing-housing backlash elimination cylinders 773 (second cylinders) such that pressing force is applied to the lower intermediate roll 721 in the direction opposite to the rolling direction via liners of the lower-intermediate-roll bearing housings 723A and 723.

[0033] Returning to FIG. 2, the upper backup roll 730 has bearings (illustration omitted) at its axial end portions on both the drive side and the work side, and these bearing are supported by upper-backup-roll bearing housings 732. Similarly, the lower backup roll 731 also has bearings (illustration omitted) at its axial end portions on both the drive side and the work side, and these bearings are supported by lower-backup-roll bearing housings 733.

[0034] In addition, as illustrated in FIG. 2, on the entry side, the housing 700 is provided with upper-backup-roll bearing-housing backlash elimination cylinders 780 such that horizontal force is applied to the upper backup roll 730 via the upper-backup-roll bearing housings 732. Similarly, on the entry side, the housing 700 is provided with lower-backup-roll bearing-housing backlash elimination cylinders 782 such that horizontal force is applied to the lower backup roll 731 via the lower-backup-roll bearing housings 733.

[0035] The hydraulic device is connected to hydraulic cylinders such as the bending cylinders, backlash elimination cylinders, or shift cylinders that are mentioned above, or rolling cylinders (illustration omitted) that apply rolling force for rolling the rolled material 5 to the upper work roll 710 and the lower work roll 711. This hydraulic device is connected to the controller 80.

[0036] The controller 80 performs actuation control of the hydraulic device, and supplies and discharges a hydraulic fluid to the bending cylinders and the like mentioned above, to thereby perform drive control of those cylinders.

[0037] Next, configurations related to the upper work roll 710 in the rolls are explained by using FIG. 5. Note that the upper intermediate roll 720, the lower work roll 711, and the lower intermediate roll 721 also can have configurations equivalent to those of the upper work roll 710. Their detailed configurations are approximately the same as those of the upper work roll 710, and accordingly, explanation thereof is omitted.

[0038] The present invention is suitably applied to the upper work roll 710 illustrated in FIG. 5 or the lower work roll 711.

[0039] In the form illustrated in FIG. 5, on the entry side of the rolled material 5 on each of the drive side and the work side of the upper work roll 710, two upper-work-roll bending cylinders 740 are provided in the roll-axis direction. In addition, on the exit side of the rolled material 5, two upper-work-roll bending cylinders 741 are provided, and two first cylinders are provided being aligned in the axial direction on each of the entry side and the exit side in the rolling direction. The two upper-work-roll bending cylinders 740 provided on the entry side of the rolled material 5, and the two upper-work-roll bending cylinders 741 provided on the exit side of the rolled material 5 are arranged such that they overlap each other when seen in the rolling direction.

[0040] In addition, in the present embodiment, an upper-work-roll bearing-housing backlash elimination cylinder 760 arranged on the entry side of the rolled material 5 is arranged at an axially intermediate position between two upper-work-roll bending cylinders 740 provided on the same entry side when seen in the rolling direction.

[0041] Furthermore, desirably, acting positions of the exit force of the two upper-work-roll bending cylinders 740 and 741 to be driven, and the acting position of the exit force of the one upper-work-roll bearing-housing backlash elimination cylinder 760 to be driven are set such that each of them is kept within $L_B/4$ on the axially outer side from the axial center of the bearing 790, and $L_B/4$ on the axially inner side from the axial center of the bearing 790, that is, within $L_B/2$ from the axial center of the bearing 790, when it is assumed that the axial length of the bearing 790 is set to L_B , or the exit force is controlled in such a manner.

[0042] Next, details of drive control of the upper-work-roll bending cylinders 740 and 741, and the upper-work-roll bearing-housing backlash elimination cylinders 760 of the present embodiment are explained with reference to FIG. 5 and TABLE 1. The drive control of these is executed by the controller 80 that performs drive control of the hydraulic device.

[0043] Here, it is assumed that the shift amount of the upper work roll 710, that is, the shift amount of the axial center of the bearing 790 is L_S (it is assumed that the shift amount in the direction toward the drive direction is a positive amount).

[TABLE 1]

	section	C	B	A
5	target to be actuated			
	drive-side entry side bending cylinder (inner side)	OFF	ON(OFF)	ON
10	drive-side entry side bending cylinder (outer side)	ON	OFF(ON)	OFF
15	drive-side exit side bending cylinder (inner side)	OFF	OFF(ON)	ON
20	drive-side exit side bending cylinder (outer side)	ON	ON(OFF)	OFF
25	work-side entry side bending cylinder (inner side)	ON	ON(OFF)	OFF
30	work-side entry side bending cylinder (outer side)	OFF	OFF(ON)	ON
35	work-side exit side bending cylinder (inner side)	ON	OFF(ON)	OFF
40	work-side exit side bending cylinder (outer side)	OFF	ON(OFF)	ON
	drive-side backlash elimination cylinder	ON	ON	ON
	work-side backlash elimination cylinder	ON	ON	ON

[0044] When the work roll is shifted such that the axial center of the bearing is shifted between L_s , the bearing center is in any of sections A, B, and C illustrated in FIG. 5. When the bearing center is in the section C, on the drive side, axially inner cylinders in both the entry-side upper-work-roll bending cylinders 740 and the exit-side upper-work-roll bending cylinders 741 are not driven, but axially outer cylinders in both the entry-side upper-work-roll bending cylinders 740 and the exit-side upper-work-roll bending cylinders 741 are driven. The total exit force of the driven cylinders on the entry side and the exit side acts on the portion near the intersection between the roll-axis line and a line linking the driven cylinders. The acting position of the total exit force of the cylinders is arranged such that it is kept within $L_B/4$ on the axially outer side from the axial center of the bearing 790, and $L_B/4$ on the axially inner side from the axial center of the bearing 790, that is, within $L_B/2$ from the axial center of the bearing 790.

[0045] Accordingly, the boundary between the section A and the section B is present at a position within $L_B/4$ on the axially outer side from the intersection between the roll-axis line and a straight line linking the axially outer entry-side upper-work-roll bending cylinder 740 and the axially inner exit-side upper-work-roll bending cylinder 741 (or a straight line linking the axially inner entry-side upper-work-roll bending cylinder 740 and the axially outer exit-side upper-work-roll bending cylinder 741). In addition, the boundary between the section B and the section C is present at a position within $L_B/4$ on the axially inner side from the intersection described above.

[0046] On the work side, axially outer cylinders in both the entry-side upper-work-roll bending cylinders 740 and the exit-side upper-work-roll bending cylinders 741 are not driven, but axially inner cylinders in both the entry-side upper-work-roll bending cylinders 740 and the exit-side upper-work-roll bending cylinders 741 are driven.

5 **[0047]** When the bearing center is in the section A, on the drive side, axially outer cylinders in both the entry-side upper-work-roll bending cylinders 740 and the exit-side upper-work-roll bending cylinders 741 are not driven, but axially inner cylinders in both the entry-side upper-work-roll bending cylinders 740 and the exit-side upper-work-roll bending cylinders 741 are driven.

10 **[0048]** On the work side, axially inner cylinders in both the entry-side upper-work-roll bending cylinders 740 and the exit-side upper-work-roll bending cylinders 741 are not driven, but axially outer cylinders in both the entry-side upper-work-roll bending cylinders 740 and the exit-side upper-work-roll bending cylinders 741 are driven.

15 **[0049]** In this configuration, when the bearing center is in the section B, that is, the center of the bearing 790 is arranged between the axially outer first cylinder and the axially inner first cylinder in the first cylinders, and the bearing center is apart from the acting position of the resultant force of the first cylinders that overlap each other on the entry side and the exit side when seen in the rolling direction, one first cylinder on the entry side and one first cylinder on the exit side are driven such that the resultant force acts on a central portion of the bearing 790.

20 **[0050]** In this case, the controller 80 drives the first cylinder adjacent to the first cylinders that overlap each other when seen in the rolling direction. More specifically, in this configuration, the axially inner first cylinder in the two first cylinders provided on one of the entry side or the exit side is driven, and the axially outer first cylinder in the two first cylinders provided on the other of the entry side or the exit side is driven.

25 **[0051]** Detailed drive patterns are classified into the following two patterns.

30 **[0052]** In the first pattern, on the drive side, the axially outer cylinder in the entry-side upper-work-roll bending cylinders 740 is not driven, but the axially inner cylinder in the entry-side upper-work-roll bending cylinders 740 is driven. The axially inner cylinder in the exit-side upper-work-roll bending cylinders 741 is not driven, but the axially outer cylinder in the exit-side upper-work-roll bending cylinders 741 is driven.

35 **[0053]** On the work side also, the axially outer cylinder in the entry-side upper-work-roll bending cylinders 740 is not driven, but the axially inner cylinder in the entry-side upper-work-roll bending cylinders 740 is driven. The axially inner cylinder in the exit-side upper-work-roll bending cylinders 741 is not driven, but the axially outer cylinder in the exit-side upper-work-roll bending cylinders 741 is driven (items without parentheses in the section B in TABLE 1).

40 **[0054]** In the second pattern, on the drive side, the axially inner cylinder in the entry-side upper-work-roll bending cylinders 740 is not driven, but the axially outer cylinder in the entry-side upper-work-roll bending cylinders 740 is driven. The axially outer cylinder in the exit-side upper-work-roll bending cylinders 741 is not driven, but the axially inner cylinder in the exit-side upper-work-roll bending cylinders 741 is driven.

45 **[0055]** On the work side also, the axially inner cylinder in the entry-side upper-work-roll bending cylinders 740 is not driven, but the axially outer cylinder in the entry-side upper-work-roll bending cylinders 740 is driven. The axially outer cylinder in the exit-side upper-work-roll bending cylinders 741 is not driven, but the axially inner cylinder in the exit-side upper-work-roll bending cylinders 741 is driven (items with parentheses in the section B in TABLE 1).

[0056] The upper-work-roll bearing-housing backlash elimination cylinders 760 are driven no matter which of the sections A, B and C the bearing center is in as illustrated by TABLE 1.

50 **[0057]** Although the exit force of the upper-work-roll bending cylinders 740 and 741 and the exit force of the upper-work-roll bearing-housing backlash elimination cylinders 760 have only two states, ON and OFF, in the example described above, by more finely and individually adjusting the exit force of each upper-work-roll bending cylinder 740 or 741 and the exit force of each upper-work-roll bearing-housing backlash elimination cylinder 760, it is possible to cause the bending force to act on the axial center of the bearing 790 more accurately.

55 **[0058]** Although the case in which two upper-work-roll bending cylinders 740 are provided in the roll-axis direction on the entry side of the rolled material 5 and two upper-work-roll bending cylinders 741 are provided in the roll-axis direction on the exit side of the rolled material 5 is explained with reference to FIG. 5, the number of cylinders to be provided on each of the entry side and the exit side only has to be two or larger and is not particularly limited.

[0059] In the following, a case in which three upper-work-roll bending cylinders are provided on each of the entry side and the exit side is explained by using FIG. 6 and TABLE 2.

[TABLE 2]

	section	C	B	A
5	target to be actuated			
	drive-side entry side bending cylinder (inner side)	OFF	OFF	ON(OFF)
	drive-side entry side bending cylinder (middle)	OFF(ON)	ON	OFF(ON)
10	drive-side entry side bending cylinder (outer side)	ON(OFF)	OFF	OFF
	drive-side exit side bending cylinder (inner side)	OFF	OFF	OFF(ON)
15	drive-side exit side bending cylinder (middle)	ON(OFF)	ON	ON(OFF)
	drive-side exit side bending cylinder (outer side)	OFF(ON)	OFF	OFF
	work-side entry side bending cylinder (inner side)	ON(OFF)	OFF	OFF

	work-side entry side bending cylinder (middle)	OFF(ON)	ON	OFF(ON)
25	work-side entry side bending cylinder (outer side)	OFF	OFF	ON(OFF)
	work-side exit side bending cylinder (inner side)	OFF(ON)	OFF	OFF
	work-side exit side bending cylinder (middle)	ON(OFF)	ON	ON(OFF)
30	work-side exit side bending cylinder (outer side)	OFF	OFF	OFF(ON)
	drive-side backlash elimination cylinder (inner side)	OFF	ON	ON
	drive-side backlash elimination cylinder (outer side)	ON	OFF	OFF
35	work-side backlash elimination cylinder (inner side)	ON	OFF	OFF
	work-side backlash elimination cylinder (outer side)	OFF	ON	ON

40 **[0060]** In the form illustrated in FIG. 6, on the entry side of the rolled material 5, three upper-work-roll bending cylinders 740A are provided in the roll-axis direction. In addition, on the exit side of the rolled material 5, three upper-work-roll bending cylinders 741A are provided, and three first cylinders are provided being aligned in the axial direction on each of the entry side and the exit side in the rolling direction. The three upper-work-roll bending cylinders 740A provided on the entry side of the rolled material 5, and the three upper-work-roll bending cylinders 741A provided on the exit side of the rolled material 5 are arranged such that all of them overlap each other when seen in the rolling direction. On both the work side and the drive side, upper-work-roll bearing-housing backlash elimination cylinders 760 are added between the entry-side upper-work-roll bending cylinders 740 in FIG. 5 and the entry-side upper-work-roll bending cylinders 740A in FIG. 6.

50 **[0061]** Next, details of drive control of the upper-work-roll bending cylinders 740A and 741A, and the upper-work-roll bearing-housing backlash elimination cylinders 760 of the present embodiment are explained with reference to FIG. 6 and TABLE 2. The drive control of these is executed by the controller 80 that performs drive control of the hydraulic device.

[0062] When the work roll is shifted such that the axial center of the bearing is shifted between L_s , the bearing center is present in any of the sections A, B, and C illustrated in FIG. 6. When the bearing center is in the section C, on the drive side, only the axially outer cylinder in the entry-side upper-work-roll bending cylinders 740A is driven, and only the axially middle cylinder in the exit-side upper-work-roll bending cylinders 741A is driven. On the work side, only the axially inner cylinder in the entry-side upper-work-roll bending cylinders 740A is driven, and only the axially middle cylinder in the exit-side upper-work-roll bending cylinders 741A is driven (items without parentheses in the section C in TABLE 2).

[0063] Alternatively, on the contrary, on the drive side, only the axially middle cylinder in the entry-side upper-work-

roll bending cylinders 740A is driven, and only the axially outer cylinder in the exit-side upper-work-roll bending cylinders 741A is driven. On the work side also, only the axially middle cylinder in the entry-side upper-work-roll bending cylinders 740A is driven, and only the axially inner cylinder in the exit-side upper-work-roll bending cylinders 741A is driven (items with parentheses in the section C in TABLE 2).

5 **[0064]** Next, when the bearing center is in the section B, on both the drive side and the work side, only the axially middle cylinders in the entry-side upper-work-roll bending cylinders 740A and the exit-side upper-work-roll bending cylinders 741A are driven.

10 **[0065]** Next, when the bearing center is in the section A, on the drive side, only the axially inner cylinder in the entry-side upper-work-roll bending cylinders 740A is driven, and only the axially middle cylinder in the exit-side upper-work-roll bending cylinders 741A is driven. On the work side also, only the axially outer cylinder in the entry-side upper-work-roll bending cylinders 740A is driven, and only the axially middle cylinder in the exit-side upper-work-roll bending cylinders 741A is driven (items without parentheses in the section A in TABLE 2).

15 **[0066]** Alternatively, on the contrary, on the drive side, only the axially middle cylinder in the entry-side upper-work-roll bending cylinders 740A is driven, and only the axially inner cylinder in the exit-side upper-work-roll bending cylinders 741A is driven. On the work side also, only the axially middle cylinder in the entry-side upper-work-roll bending cylinders 740A is driven, and only the axially outer cylinder in the exit-side upper-work-roll bending cylinders 741A is driven (items with parentheses in the section A in TABLE 2).

20 **[0067]** As mentioned above, in the form illustrated in FIG. 6, when the center of the bearing 790 is arranged between the axially outermost first cylinder in the first cylinders and the axially innermost first cylinder in the first cylinders, and when the acting position of the resultant force of the first cylinders that overlap each other on the entry side and the exit side when seen in the rolling direction is apart from the bearing-center position, first cylinders are driven such that a line linking driven cylinders on the entry side and the exit side on the drive side, and a line linking driven cylinders on the entry side and the exit side on the work side do not become parallel with each other, but cross at a position on the entry side or exit side of the rolled material 5, that is, become diagonal to each other, except when the axial center of the bearing 790 has not been shifted to between the axially middle upper-work-roll bending cylinders 740A and 741A on the drive side.

25 **[0068]** The upper-work-roll bearing-housing backlash elimination cylinders 760 are driven no matter which of the sections A, B, and C the bearing center is in as illustrated by TABLE 2. The driving and pressures of two cylinders that are arrayed in the axial direction are adjusted such that the acting position is not apart from each bearing-center position in the sections A, B, and C as much as possible.

30 **[0069]** Although the case in which the exit force of the upper-work-roll bending cylinders 740A and 741A and the exit force of the upper-work-roll bearing-housing backlash elimination cylinders 760 have only two states, ON and OFF, are explained in the example illustrated in FIG. 6 described above, by more finely and individually adjusting the exit force of each upper-work-roll bending cylinder 740A or 741A and the exit force of each upper-work-roll bearing-housing backlash elimination cylinder 760, it is possible to cause the bending force to act on the axial center of the bearing 790 more accurately.

35 **[0070]** Next, effects of the present embodiment are explained.

40 **[0071]** The rolling mill of the present embodiment mentioned above includes: the roll that is shifted in the axial direction; the bearing 790 and the four or more first cylinders that are provided on each of the drive side and the work side, the bearing 790 being configured to be shifted in the axial direction of the roll along with the roll and to receive a load from the roll, the four or more first cylinders being configured to apply bending force vertically to the bearing 790 and to cause the roll to perform bending; and the controller 80 that drives the first cylinders. On each of the drive side and the work side, two or more first cylinders in the first cylinders are provided on each of the entry side and the exit side in the rolling direction, the two or more first cylinders being aligned in the axial direction, and the controller 80 is configured to be able to choose to drive one first cylinder on the entry side and one first cylinder on the exit side such that the resultant force thereof acts on a central portion of the bearing 790 when the roll performs bending and when at least the center of the bearing 790 is arranged between the axially outermost first cylinder and the axially innermost first cylinder in the first cylinders.

45 **[0072]** Therefore, in a case in which the bearing center is arranged between first cylinders, it is not necessary to drive all of the four or more first cylinders provided per bearing, but it is possible to cause the resultant bending force of two first cylinders to act on the portion near a lengthwise middle portion of the bearing. Accordingly, it is not necessary to provide a large number of mechanisms for adjusting the pressing force of each cylinder for the purpose of reducing the offset load on the bearing, the control can be performed simply, and thus, the configuration can be simplified as compared to conventional rolling mills.

50 **[0073]** In addition, the entry side first cylinders and the exit side first cylinders are arranged overlapping each other when seen in the rolling direction. Accordingly, it is possible to more simply cause the resultant bending force of two first cylinders to act on the portion near a lengthwise middle portion of the bearing.

55 **[0074]** Furthermore, the rolling mill further includes the entry-side fixation member 702 and/or the exit-side fixation

member 703 that is/are fixed to at least either of the entry side and the exit side of the housing of the rolling mill in the rolling direction and that is/are provided with the first cylinders; and the second cylinders that are disposed on either of the entry side and the exit side at the exit-side fixation member 703 or the entry-side fixation member 702 and that apply pressing force to the bearings 790 in the rolling direction or in a direction opposite to the rolling direction. Thereby, it is possible to prevent the bearings and the first cylinders from being moved in the rolling direction when the top of the rolled material 5 is drawn in. Thereby, an effect of preventing bending acting positions from being unintentionally moved can be attained. That is, it is possible to suppress the movement of the bearings in the rolling direction in a state that the bending force is acting thereon. Accordingly, a slip does not occur at portions that are pressed by the first cylinders, and it is possible to suppress damages to the first cylinder and wear on the pressed side, and to keep high precision of bending.

[0075] In addition, the controller 80 is configured to drive the first cylinder adjacent to the first cylinders that overlap each other when seen in the rolling direction, for example, in a case in which there are four first cylinders, to drive the axially inner first cylinder in two first cylinders provided on one of the entry side and the exit side, and drive the axially outer first cylinder in two first cylinders provided on the other of the entry side and the exit side. Thereby, the controller 80 can cause the resultant bending force to act on the portion near a lengthwise middle portion of the bearing with the two first cylinders more accurately and simply. Accordingly, it is possible to reduce the offset load on the bearing with a simple configuration not being provided with a large number of mechanisms for adjusting pressing force of each cylinder.

<Second Embodiment

[0076] The rolling mill of a second embodiment in the present invention is explained by using FIG. 7 and TABLE 3.

[TABLE 3]

type	position		acting force		section where bearing axial center is present	
					B	A
bending force	entry side	e1	Pe1	1 × Pbe	0 × Pbe	
		e2	Pe2	0 × Pbe	1 × Pbe	
		total = Pe1 + Pe2		Pbe	Pbe	
	exit side	d1	Pd1	αd1 × Pbd	αd1 × Pbd	
		d2	Pd2	αd2 × Pbd	αd2 × Pbd	
		total = Pd1 + Pd2		Pbd	Pbd	
	total				Pbe + Pbd	Pbe + Pbd
backlash elimination pressing force	axial direction	g1	Pg1	Pg1	Pg1	

[0077] Differences of FIG. 7 from FIG. 5 are explained. In the present embodiment, the shift amount Ls is divided into the sections A and B. TABLE 3 indicates a relation between the bearing-center position and the state of driving of each cylinder. The intersection position between the roll-axis line and the line linking e1 and d2 is the boundary between the section B and the section A. No matter which of the sections A and B the bearing center is present in, both the two exit-side upper-work-roll bending cylinders 741 are driven.

[0078] In a case in which the axial center of the bearing 790 is present in the section B, the axially inner upper-work-roll bending cylinder 740, e1, the upper-work-roll bending cylinder 741, d1 and the upper-work-roll bending cylinder 741, d2 are driven with the exit force of the upper-work-roll bending cylinder 741, d1 being set to a value obtained by multiplying required exit-side bending force Pbd by a predetermined coefficient αd1, and the exit force of the upper-work-roll bending cylinder 741, d2 being set to a value obtained by multiplying the required exit-side bending force Pbd by a predetermined coefficient αd2.

[0079] In a case in which the axial center of the bearing 790 is present in the section A, the axially outer upper-work-roll bending cylinder 740, e2, the upper-work-roll bending cylinder 741, d1 and the upper-work-roll bending cylinder 741, d2 are driven with the exit force of the upper-work-roll bending cylinder 741, d1 being set to a value obtained by multiplying the required exit-side bending force Pbd by the predetermined coefficient αd1, and the exit force of the upper-work-roll bending cylinder 741, d2 being set to a value obtained by multiplying the required exit-side bending force Pbd by the predetermined coefficient αd2.

[0080] That is, it is chosen to drive all of the exit side first cylinders and to drive only one entry side first cylinder. In

addition, it may be chosen to drive all of the entry side first cylinders and to drive only one exit side first cylinder. Note that the second cylinders provided on the entry side in FIG. 7 may be provided on the exit side.

[0081] The upper-work-roll bearing-housing backlash elimination cylinders 760 are driven no matter which of the sections A and B the bearing center is in.

[0082] Therefore, in a case in which the bearing center is arranged between first cylinders, it is not necessary to drive all of the four first cylinders provided per bearing, but it is possible to cause the resultant bending force of three first cylinders to act on the portion near a lengthwise middle portion of the bearing. Accordingly, it is not necessary to provide a large number of mechanisms for adjusting the pressing force of each cylinder for the purpose of reducing the offset load on the bearing, the control can be performed simply, and thus, the configuration can be simplified as compared to conventional rolling mills. Furthermore, because non-stepwise adjustments of the resultant bending force of the first cylinders are possible, it becomes easy to cause the bearing center and the acting position of the resultant bending force to match no matter which position in the section the bearing center is in.

<Others>

[0083] Note that the present invention is not limited to the embodiments described above, but a variety of modifications and applications are possible. The embodiments mentioned above are explained in detail in order to explain the present invention in an easy-to-understand manner, and the present invention is not necessarily limited to those including all the configurations explained.

Claims

1. A rolling mill (10, 20, 30, 40, 50, 60, 70) comprising:

a roll (710, 711, 720, 721) that is shifted in an axial direction;
 a bearing (790) and four or more first cylinders (740, 740A, 741, 741A, 744, 745, 750, 751, 752, 753) that are provided on each of a drive side and a work side, the bearing being configured to be shifted in the axial direction of the roll along with the roll and to receive a load from the roll, the four or more first cylinders being configured to apply bending force vertically to the bearing and to cause the roll to perform bending; and
 a controller (80) that drives the first cylinders, wherein
 on each of the drive side and the work side,

two or more first cylinders in the first cylinders are provided on each of an entry side and an exit side in a rolling direction, the two or more first cylinders being aligned in the axial direction, **characterized in that** the controller is configured to be able to choose to drive one first cylinder on the entry side and one first cylinder on the exit side such that resultant force thereof acts on a central portion of the bearing when the roll performs bending and when at least a center of the bearing is arranged between an axially outermost first cylinder and an axially innermost first cylinder in the first cylinders.

2. The rolling mill according to claim 1, wherein

the controller is configured to be able to choose to further drive any of remaining first cylinders on the entry side or remaining first cylinders on the exit side.

3. The rolling mill according to claim 1 or 2, further comprising:

a fixation member (702, 703) that is fixed to at least either of the entry side or the exit side of a housing (700) of the rolling mill in the rolling direction, and is provided with the first cylinders; and
 second cylinders (760, 762, 771, 773) that are provided to the fixation member on either of the entry side or the exit side and to apply pressing force to the bearings in the rolling direction or in a direction opposite to the rolling direction.

4. The rolling mill according to any one of claims 1 to 3, wherein

the controller is able to choose to drive the first cylinder adjacent to the first cylinders that overlap each other when seen in the rolling direction.

5. The rolling mill according to any one of claims 1 to 4, wherein

in a case in which the first cylinders are four, the axially inner first cylinder in two of the first cylinders provided on

one of the entry side or the exit side is driven, and the axially outer first cylinder in two of the first cylinders provided on the other of the entry side or the exit side is driven.

- 5
6. A rolling method for a rolling mill (10, 20, 30, 40, 50, 60, 70) including:

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a roll (710, 711, 720, 721) that is shifted in an axial direction;
a bearing (790) and four or more first cylinders (740, 740A, 741, 741A, 744, 745, 750, 751, 752, 753) that are provided on each of a drive side and a work side, the bearing being configured to be shifted in the axial direction of the roll along with the roll and to receive a load from the roll, the four or more first cylinders being configured to apply bending force vertically to the bearing and to cause the roll to perform bending; and
a controller (80) that drives the first cylinders, wherein
on each of the drive side and the work side,

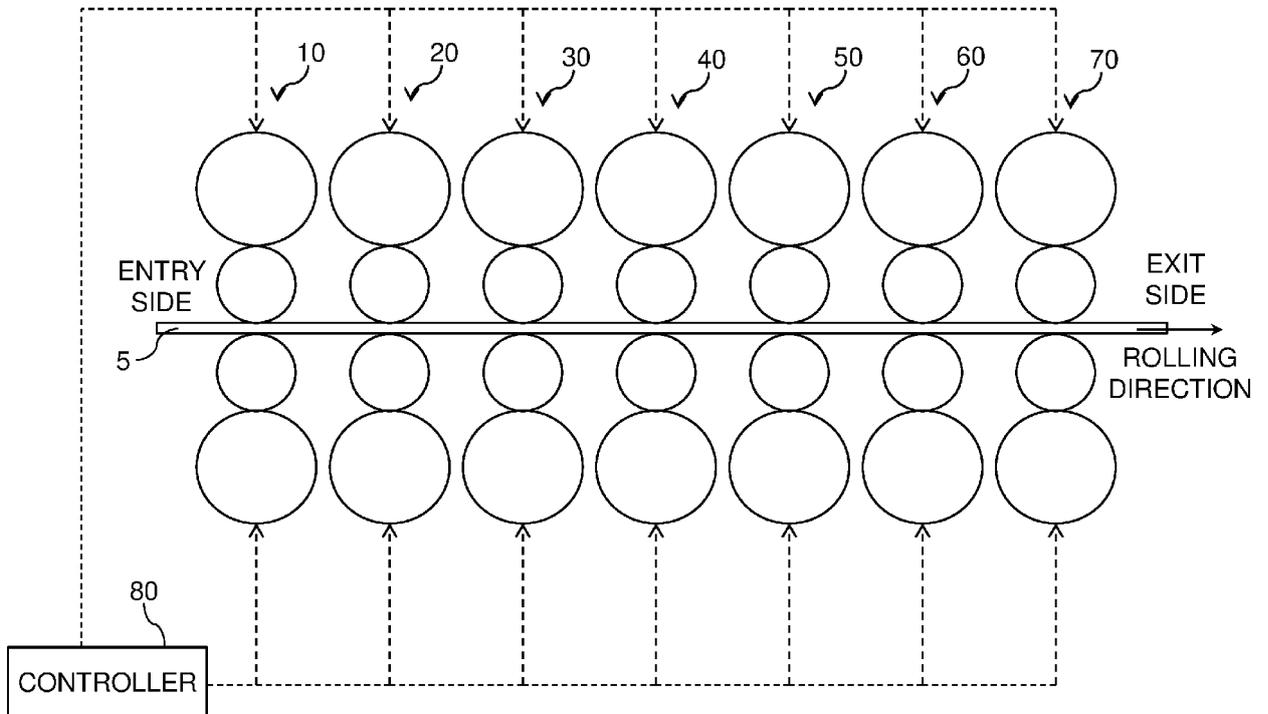
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two of the first cylinders are provided on each of an entry side or an exit side in the axial direction on each of an entry side and an exit side in a rolling direction, **characterized in that**
when at least a center of the bearing is arranged between the two first cylinders provided in the axial direction and when the roll performs bending, it is possible to choose to drive the axially inner first cylinder in the two first cylinders provided on one of the entry side or the exit side and to drive an axially outer first cylinder in the two first cylinders provided on the other of the entry side or the exit side.

- 20
7. The rolling method according to claim 6, wherein the rolling mill further includes:

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a fixation member (702, 703) that is fixed to at least either of the entry side or the exit side of a housing (700) of the rolling mill in the rolling direction, and is provided with the first cylinders; and
second cylinders (760, 762, 771, 773) that are provided to the fixation member on either of the entry side or the exit side and to apply pressing force to the bearings in the rolling direction or in a direction opposite to the rolling direction.

Fig.1

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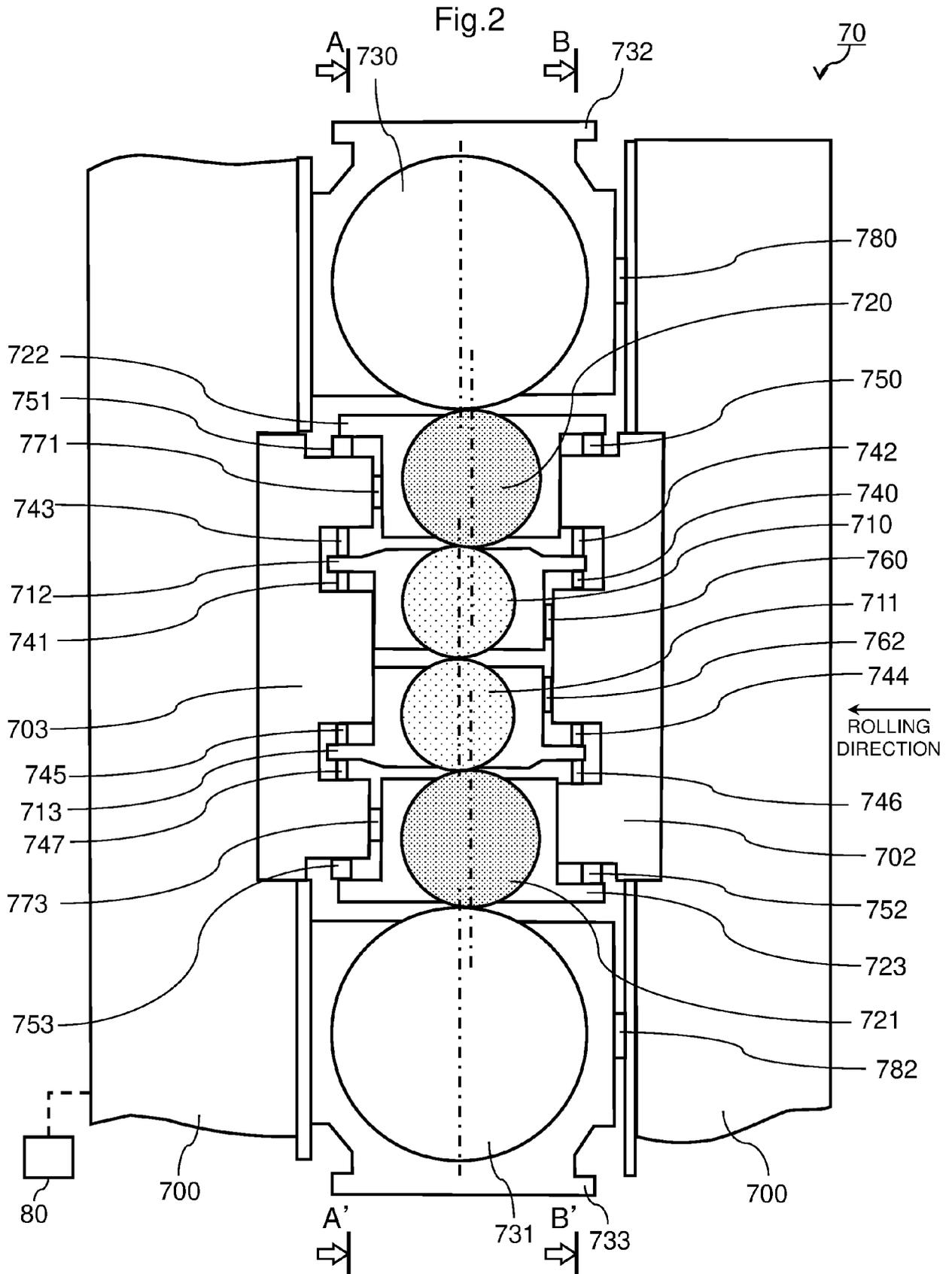


Fig.4

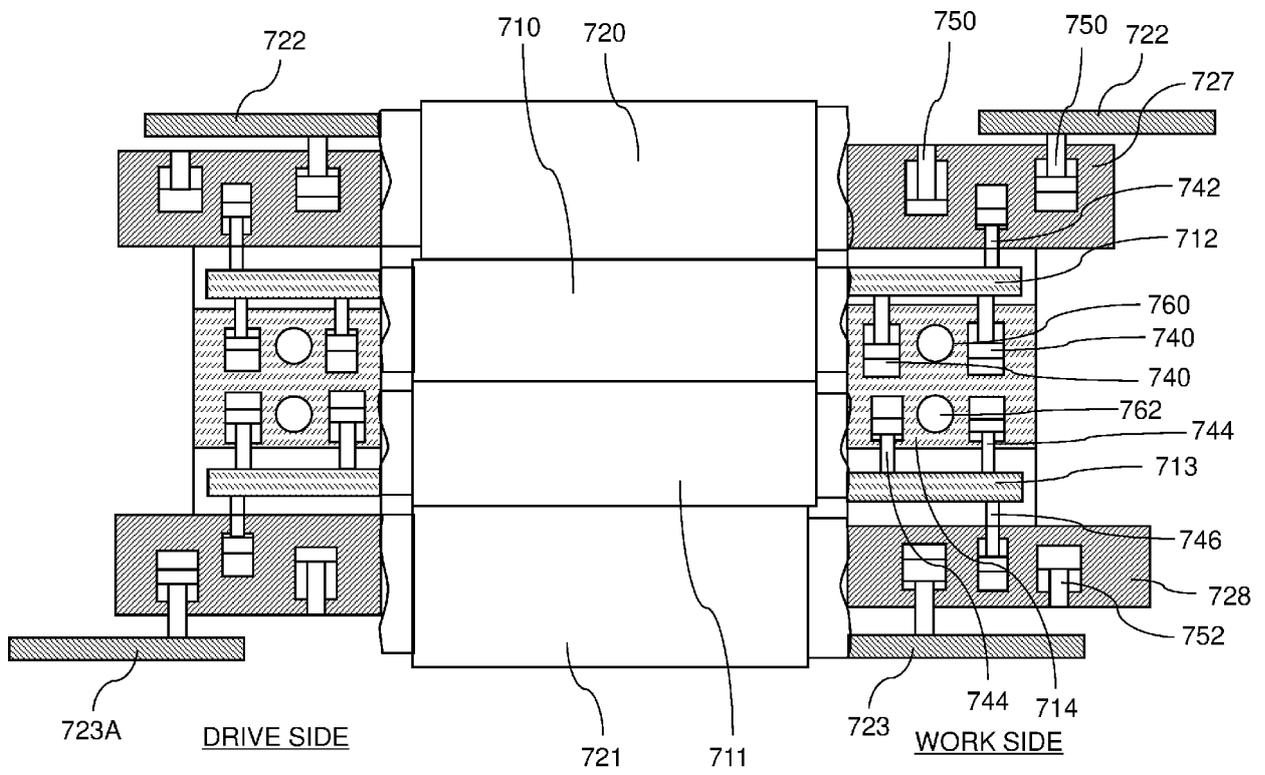


Fig.5

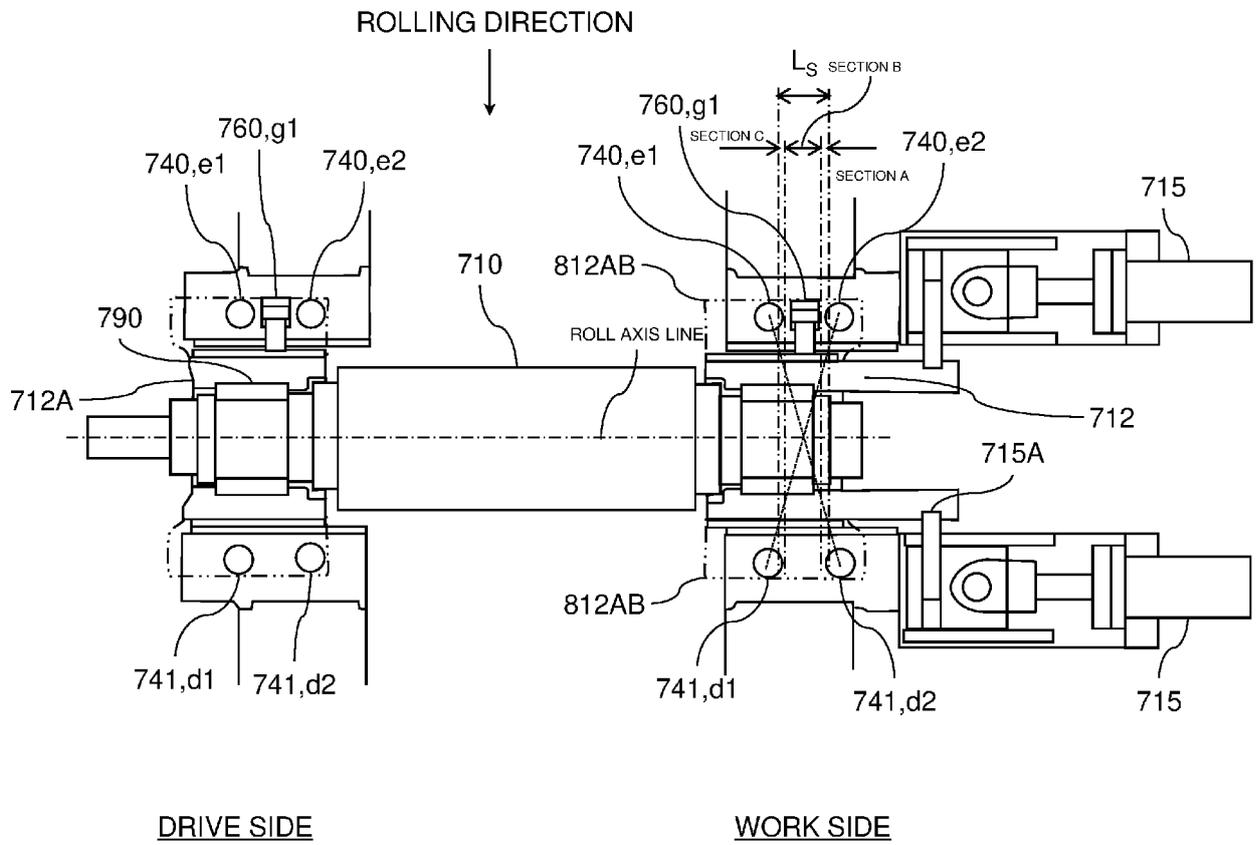


Fig.6

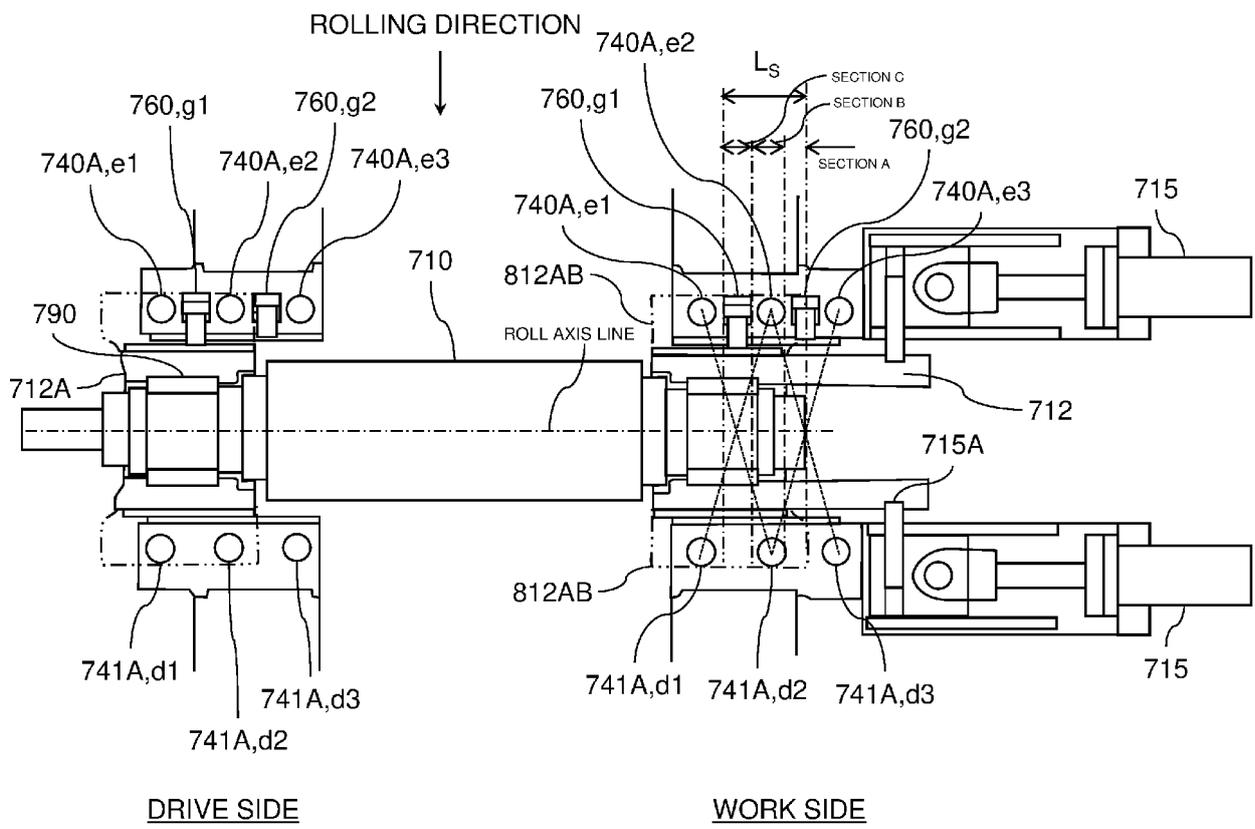
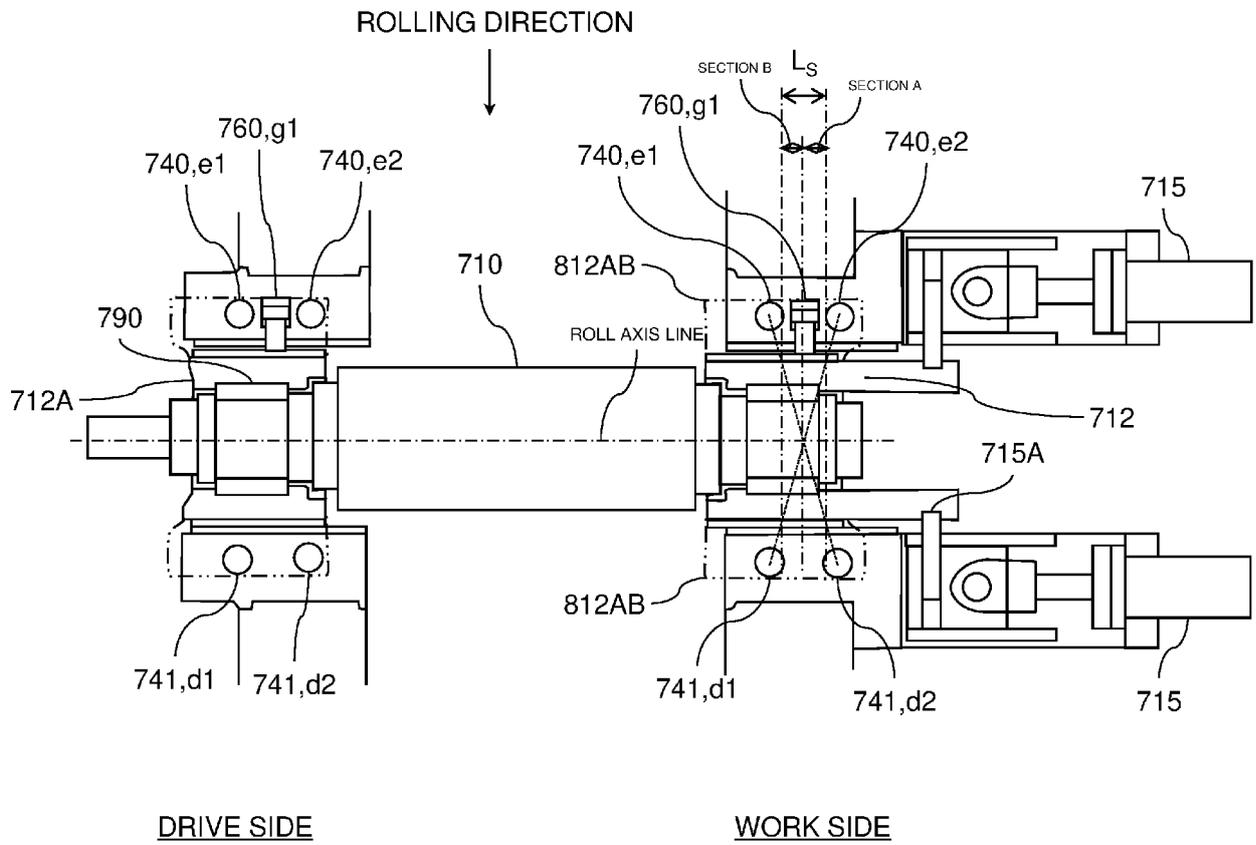


Fig.7





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