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(71) Applicant: **Mitsubishi-Hitachi Metals Machinery, Inc.**
Tokyo 108-0014 (JP)

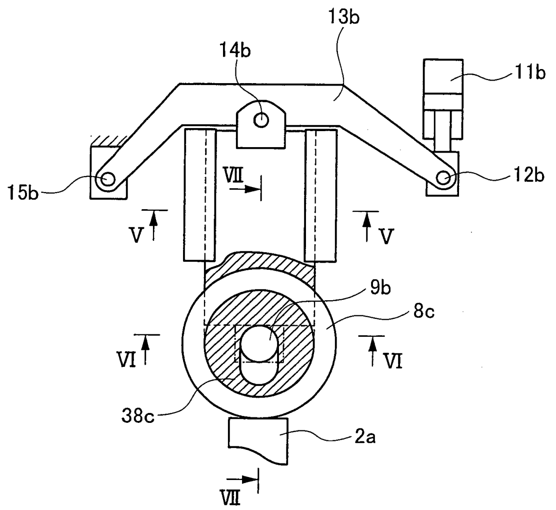
(72) Inventors:
- **Norikura, Takashi**
  Tokyo, 108-0014 (JP)
- **Shimaya, Fumihisa**
  Hiroshima-shi, Hiroshima (JP)

(74) Representative: **Strehl Schübel-Hopf & Partner**
Maximilianstrasse 54
80538 München (DE)

(54) **Multi-high rolling mill equipped with work roll shift function**

(57) A multi-high rolling mill equipped with a work roll shift function where thrust bearings are effectively installed so that the shifting function of small-diameter work rolls can be achieved with a simple mechanism is provided. A pair of upper and lower work rolls (2a, 2b) are provided with tapered portions (22a, 22b) in upper and lower positions in point symmetry; end faces of the respective work rolls are supported by two upper and lower thrust bearings (8a to 8d) on each of an operation side and a drive side; long holes (38a to 38d) are formed in inner-race side shafts (37a to 37d) of bearing boxes (10a to 10d) pivotally supporting the respective thrust bearings, respectively, such that the respective thrust bearings are movable individually together with the respective bearing boxes in roll axial directions; coupling bars (9a, 9b) each penetrating the corresponding long holes to restrict vertical displacements of the corresponding two upper and lower thrust bearings are provided between the respective bearing boxes; first roll shift devices (13a to 13d, 11a to 11d) connected to the respective bearing boxes to shift the respective work rolls in the roll axial directions are provided; and taper start positions SP of the tapered portions of the respective work rolls are shifted to vicinities of insides of strip widthwise ends or vicinities of outsides of strip widthwise ends.

Fig.4



Description

{Technical Field}

[0001] The present invention relates to a multi-high rolling mill having small-diameter work rolls for performing rolling of a hard material, such as a stainless steel strip or an electrical steel strip, the rolling mill being equipped with a work roll shift function to shift the work rolls tapered at one ends in the axial directions, thereby controlling edge drop of a material to be rolled or controlling a strip shape.

{Background Art}

[0002] Generally, when rolling is performed with straight (not tapered at one end) work rolls, in strip widthwise distribution of strip thickness in the material to be rolled, the strip thickness becomes extremely thin in the vicinity of strip widthwise ends compared to a strip central portion, because of Hertzian flattening of the work roll. A so-called edge drop phenomenon occurs. If the amount of this edge drop is large, the amount of edge trimming in the following process increases, and the yield decreases accordingly. Therefore, a technique to reduce this amount of edge drop has been demanded.

[0003] Further, since a strip shape varies depending on a speed-load correlation during rolling speed acceleration or deceleration, smooth acceleration or deceleration cannot be performed, which also results in such a problem that production efficiency is not improved. Therefore, a technique to make it possible to reduce the strip shape variation during the acceleration or deceleration has also been demanded strongly.

{Citation List}

{Patent Literature}

[0004]

{Patent Literature 1} Japanese Patent No. 3640162
{Patent Literature 2} Japanese Patent Application Laid-Open No. S59-61511
{Patent Literature 3} Japanese Patent Application Laid-Open No. 2010-066255

{Summary of Invention}

{Technical Problem}

[0005] By the way, conventionally, the structure of a thrust bearing of a work roll of a six-high rolling mill or a 12-high or 20-high cluster-type rolling mill using small-diameter work rolls, as shown in Figs. 20 and 21, is such that end faces of one ends of an upper work roll 100a and a lower work roll 100b are supported by a single vertically-barrel thrust bearing 101a or 101b on each of an operation side and a drive side, because of limited installation space. The thrust bearings 101a and 101b are rotatably supported by brackets 102a and 102b, each formed in a groove shape in cross section, via vertical shafts 103a and 103b.

[0006] It should be noted that Figs. 20 and 21 show an example where a metal strip W, which is a material to be rolled, is rolled by the pair of upper and lower work rolls 100a and 100b of a 20-high cluster-type rolling mill. In the example, the pair of upper and lower work rolls 100a and 100b are supported in contact with two upper and two lower first intermediate rolls 104a and 104b. These two upper and two lower first intermediate rolls 104a and 104b are supported in contact with three upper and three lower second intermediate rolls 105a and 105b. These three upper and three lower second intermediate rolls 105a and 105b are supported in contact with four upper and four lower backing bearing shafts formed of backing bearings 106a and 106b, shafts 107a and 107b, and saddles 108a and 108b, respectively.

[0007] Then, in a case where separate upper and lower thrust bearings are provided for the purpose of application of a shift function to shift a roll shoulder position of the work roll having a tapered roll shoulder (known from the patent literature 1, the patent literature 2, etc.) to the vicinity of the inside of the strip widthwise end in order to reduce the edge drop described above, there is the problem that thrust bearings having a required bearing capacity cannot be disposed because the work rolls are of small diameter, and because an installation space cannot be secured due to the cluster roll structure. In short, it is impossible to install thrust bearings effectively to achieve the shift function of the small-diameter work rolls.

[0008] Furthermore, in the six-high rolling mill or the 12-high or 20-high cluster-type rolling mill using small-diameter work rolls, there is no space to install the thrust bearings in a linear cylinder generally used, and thus it is difficult to introduce a mechanism to shift the work roll in the axial direction. Moreover, there is also a problem that it is impossible to cause the tapered roll shoulder positions of the work rolls to coincide with the vicinities of the insides of the positions of the strip widthwise ends or the vicinities of the outsides of the positions of the strip widthwise ends correctly if correct positions of the strip widthwise ends cannot be determined when a steel strip meanders during rolling.

[0009] In view of the above-described circumstances, an object of the present invention is to provide a multi-high rolling mill equipped with a work roll shift function where thrust bearings are effectively installed so that the shifting function of small-diameter work rolls can be achieved with a simple mechanism.

{Solution to Problem}

[0010] A multi-high rolling mill equipped with a work roll shift function according to an first aspect of the present invention for solving the above problems is a rolling mill including a pair of upper and lower work rolls for rolling a metal strip, and one or a plurality of upper support rolls and one or a plurality of lower support rolls supporting the work rolls, characterized in that

the pair of upper and lower work rolls are provided with tapered portions in upper and lower positions in point symmetry;

end faces of the respective work rolls are supported by two upper and two lower thrust bearings on each of an operation side and a drive side;

long holes are formed in inner-race side shafts of bearing boxes pivotally supporting the respective thrust bearings, the long holes allowing the thrust bearings to be individually movable together with the respective bearing boxes in roll axial directions;

coupling bars penetrating the corresponding long holes to restrict vertical displacements of the two upper and two lower thrust bearings are provided between the corresponding bearing boxes;

first roll shift devices connected to the respective bearing boxes to shift the corresponding work rolls in the roll axial directions are provided; and

taper start positions of the tapered portions of the respective work rolls are shifted to vicinities of insides of strip widthwise ends or vicinities of outsides of strip widthwise ends.

[0011] Moreover,

the multi-high rolling mill equipped with a work roll shift function according to a second aspect of the present invention is characterized in that a ratio DB (D: bearing outer diameter, B: bearing width) of an outer diameter of the thrust bearings to a width of the thrust bearings is set to a range between 5.0 to 12.

[0012] Moreover,

the multi-high rolling mill equipped with a work roll shift function according to a third aspect of the present invention is characterized in that guides are provided for guiding the respective bearing boxes, on the opposite side to the thrust bearings, slidably in the roll axial directions and collectively while restricting the respective bearing boxes in vertical, entry-side and delivery-side Passing directions.

[0013] Moreover

the multi-high rolling mill equipped with a work roll shift function according to a fourth aspect of the present invention is characterized in that each of the first roll shift devices comprises: an arm joined at a middle portion thereof to the corresponding bearing box via a pin, and a shift cylinder for applying shift force to one end of the arm using a hinge coupled to the other ends of the arms as a fulcrum.

[0014] Moreover,

the multi-high rolling mill equipped with a work roll shift function according to a fifth aspect of the present invention is characterized in that a strip widthwise end position detector for a metal strip is provided on an entry side or a delivery side of the rolling mill, and a control means for performing shift controls of the first roll shift devices is provided to cause the taper start positions of the tapered portions of the upper and lower work rolls to coincide with the vicinities of the insides of the strip widthwise ends or the vicinities of the outsides of the strip widthwise ends detected by the strip widthwise end position detector independently for the upper side and the lower side.

[0015] Moreover,

the multi-high rolling mill equipped with a work roll shift function according to a sixth aspect of the present invention is characterized in that a strip widthwise end thickness meter for measuring thicknesses of the strip widthwise ends of a metal strip is provided on a delivery side of the rolling mill, and a control means for performing shift controls of the first roll shift devices is provided in order to adjust the taper start positions of the tapered portions of the upper and lower work rolls in the vicinities of the insides of the strip widthwise ends individually for the upper side and the lower side such that the thicknesses of the strip widthwise ends measured on the operation side and on the drive side become predetermined thicknesses.

[0016] Moreover,

the multi-high rolling mill equipped with a work roll shift function according to a seventh aspect of the present invention is characterized in that second roll shift devices are further provided for shifting the one or plurality of upper support rolls and the one or plurality of lower support rolls in the roll axial directions, and the control means performs shift controls of the second roll shift devices to shift-control the one or plurality of upper support rolls and the one or plurality of lower support rolls asymmetrically on the operation side and on the drive side.

{Advantageous Effects of Invention}

[0017] According to the configuration of the present invention, since the two upper and lower thrust bearings have the long-hole structures allowing the respective thrust bearings to move individually in the roll axial directions at the inner-race side shafts, and the coupling bars for restricting vertical displacements of the respective thrust bearings are provided. Therefore, the bearing stiffness of the thrust bearings can be increased. Further, the ratio D/B (D: thrust bearing outer diameter, B: thrust bearing width) of each of the thrust bearings of the work rolls has been changed from a conventional ratio (D/B: 2.0 to 3.0) to a ratio of 2.5 to 4.0 times (D/B: 5.0 to 12) the conventional ratio. Therefore, even if the thrust bearing width B is narrower, a bearing life equal to or longer than a conventional bearing life can be obtained. Furthermore, since the guides are provided for guiding the bearing boxes, on the opposite side to the thrust bearings, slidably in the roll axial directions and collectively under restriction in vertical and entry and delivery directions, the stiffness of this part can be raised. As a result, this configuration makes it possible to withstand large external force at the time of strip cutting, and also prevent chattering due to vibration from occurring.

[0018] In addition, the first roll shift devices include the arms joined at middle portions thereof to the bearing boxes via the pins, and the shift cylinders for applying shift force to one ends of the arms using the hinges coupled to the other ends of the arms as fulcrums. Therefore, even if the capacities of the cylinders are smaller than those of cylinders having a linear structure, the arm ratio makes it possible to secure a predetermined shift force, and consequently the cylinders can be installed even in narrow spaces.

[0019] In addition, it becomes possible to shift the taper start positions of the tapered portions of the respective work rolls to the vicinities of the insides of the strip widthwise ends, a reduction (edge drop) in the strip thickness of the strip widthwise ends after rolling is also suppressed by clearances of the tapered portions, the amount of edge trimming in the following process is reduced, and the yield is improved accordingly.

[0020] In addition, by causing the taper start positions of the tapered portions of the respective work rolls to coincide with the vicinities of the outsides of the strip widthwise ends, harmful contact linear pressure from the outside of the strip width to the work rolls from the intermediate rolls that are the support rolls is reduced, and therefore shape stability (small shape variation relative to load variation) is significantly improved, stable rolling becomes possible, and production efficiency is improved.

[0021] In case of meandering of the metal strip during rolling, by detecting actual strip widthwise end positions using the strip widthwise end position detector and causing the taper start positions of the tapered portions of the respective work rolls to coincide with the vicinities of the insides of the strip widthwise ends of the actual strip widthwise ends independently for the upper side and the lower side, the amount of edge drop, which is a reduction in the strip thickness of the strip widthwise end, can be reduced more effectively. Therefore, the amount of edge trimming in the following process is reduced, and the yield is improved.

[0022] In addition, by causing the taper start positions of the tapered portions of the respective work rolls to coincide with the vicinities of the outsides of the strip widthwise ends from actual strip widthwise ends detected by the strip widthwise end detector, harmful contact linear pressure from the outside of the strip width to the work roll from the intermediate roll that is the support roll is reduced, and therefore shape stability (small shape variation relative to load variation) is significantly improved, and stable rolling becomes possible.

[0023] In addition, by shifting the taper start positions of the tapered portions of the respective work rolls to the vicinities of the insides of the strip widthwise ends independently for the upper side and the lower side such that the thicknesses of the strip widthwise ends measured by the strip widthwise end thickness meter are predetermined thicknesses on the operation side and on the drive side, the amount of edge drop, which is a reduction in the strip thickness of the strip widthwise end, can be reduced more effectively, and consequently the edge trimming amount in the following process is reduced, and the yield is improved.

[0024] In addition, though the meandering causes the strip shape to be asymmetrical on the operation side and on the drive side, by shift-controlling the pair of or the plurality of pairs of upper and lower support rolls asymmetrically on the operation side and on the drive side by the second roll shift devices, rolling into a symmetrical shape on the operation side and on the drive side is made possible, and therefore stable rolling can be realized.

{Brief Description of Drawings}

[0025]

{Fig. 1} Fig. 1 is a front view of a 20-high cluster-type rolling mill according to a first example of the present invention.
{Fig. 2} Fig. 2 is an arrow sectional view taken along the lines II-II of Fig. 1.

{Fig. 3} Fig. 3 is an arrow sectional view taken along the lines III-III of Fig. 2.
{Fig. 4} Fig. 4 is an arrow sectional view taken along the lines IV-IV of Fig. 1.
{Fig. 5} Fig. 5 is an arrow sectional view taken along the lines V-V of Fig. 4.
{Fig. 6} Fig. 6 is an arrow sectional view taken along the lines VI-VI of Fig. 4.
{Fig. 7} Fig. 7 is an arrow sectional view taken along the lines VII-VII of Fig. 4.
{Figs. 8A and 8B} Figs. 8A and 8B are graphs of results of comparison of strip shape variation relative to load variation, Fig. 8A being a graph showing a calculation result of strip shape variation relative to load variation in a conventional technique, Fig. 8B being a graph showing a calculation result of strip shape variation relative to load variation in the present invention.
{Fig. 9} Fig. 9 is a front view of a 20-high cluster-type rolling mill according to a second example of the present invention.
{Fig. 10} Fig. 10 is a descriptive view of strip meandering according to the second example.
{Figs. 11A and 11B} Figs. 11A and 11B are descriptive views showing the necessity of an asymmetrical control means in case of strip meandering, Fig. 11A being a descriptive view of a linear pressure distribution in material, Fig. 11B being a descriptive view of a strip shape.
{Fig. 12} Fig. 12 is a side view showing an example of application of the second example to a tandem rolling mill.
{Fig. 13} Fig. 13 is a front view showing an example of application of a third example of the present invention to a 20-high cluster-type rolling mill.
{Fig. 14} Fig. 14 is a side view showing an example of application of the third example to a tandem rolling mill.
{Fig. 15} Fig. 15 is a front view of a 20-high cluster-type rolling mill according to a fourth example of the present invention.
{Fig. 16} Fig. 16 is a front view of a 20-high cluster-type rolling mill according to a fifth example of the present invention.
{Fig. 17} Fig. 17 is a front view of a 12-high cluster-type rolling mill according to a sixth example of the present invention.
{Fig. 18} Fig. 18 is a front view of a six-high rolling mill having side support rolls according to a seventh example of the present invention.
{Fig. 19} Fig. 19 is a front view of a six-high rolling mill according to an eighth example of the present invention.
{Fig. 20} Fig. 20 is a front view of a conventional 20-high cluster-type rolling mill.
{Fig. 21} Fig. 21 is a sectional view taken along the lines IIXI-IIXI of Fig. 20.

{Description of Embodiments}

[0026] Hereinafter, examples of a multi-high rolling mill equipped with a work roll shift function according to the present invention will be described in detail by using the drawings.

{First Example}

[0027] Fig. 1 is a front view of a 20-high cluster-type rolling mill according to a first example, Fig. 2 is an arrow sectional view taken along the lines II-II of Fig. 1, Fig. 3 is an arrow sectional view taken along the lines III-III of Fig. 2, Fig. 4 is an arrow sectional view taken along the lines IV-IV of Fig. 1, Fig. 5 is an arrow sectional view taken along the lines V-V of Fig. 4, Fig. 6 is an arrow sectional view taken along the lines VI-VI of Fig. 4, Fig. 7 is an arrow sectional view taken along the lines VII-VII of Fig. 4, and Figs 8A and 8B are graphs of results of comparison of strip shape variation relative to load variation, Fig. 8A is a graph showing a calculation result of strip shape variation relative to load variation in a conventional technique, and Fig. 8B is a graph showing a calculation result of strip shape variation relative to load variation in the present invention.

[0028] A rolling mill of the first example is a 20-high cluster-type rolling mill as shown in Figs. 1 to 3, and a metal strip (hereinafter simply called strip) W, which is a material to be rolled, is rolled by a pair of upper and lower work rolls 2a and 2b.

[0029] This pair of upper and lower work rolls 2a and 2b are supported in contact with two upper and two lower first intermediate rolls 3a and 3b, respectively. These two upper and two lower first intermediate rolls 3a and 3b are supported in contact with three upper and three lower second intermediate rolls 4a and 4b, respectively. These three upper and three lower second intermediate rolls 4a and 4b are supported in contact with four upper and four lower backing bearing shafts formed of backing bearings 5a and 5b, shafts 6a and 6b, and saddles 7a and 7b. The four upper backing bearing shafts are supported at the saddles 7a by a top inner housing 17a. The top inner housing 17a is supported on lower faces of upper beams of outer housings 20a and 20b provided respectively on an operation side and on a drive side via pass line adjusters 18a and 18b, such as a worm jack or a taper wedge and a stepped rocker plate.

[0030] Here, the pass line adjusters 18a and 18b may incorporate load cells to measure rolling loads. In addition, the four lower backing bearing shafts are supported at the saddles 7b by a bottom inner housing 17b. The bottom inner housing 17b is supported on upper faces of lower beams of the outer housings 20a and 20b via push-up cylinders 19a and 19b. These push-up cylinders 19a and 19b generate a rolling load. In addition, the two upper and two lower first intermediate rolls 3a and 3b have tapered portions (see taper start positions SP) located in upper and lower positions in point symmetry and on the opposite sides respectively to tapered portions 22a and 22b of the work rolls 2a and 2b which are in contact with the first intermediate rolls 3a and 3b, and can be shifted in roll axial directions by unillustrated second roll shift devices.

[0031] Here, the pair of upper and lower work rolls 2a and 2b are provided with the tapered portions 22a and 22b at upper and lower positions in point symmetry, and besides, operation-side end faces and drive side end faces of these upper and lower work rolls 2a and 2b are supported by two upper and lower thrust bearings 8a and 8b and two upper and lower thrust bearings 8c and 8d.

[0032] As to these thrust bearings 8a, 8b, 8c, and 8d, as shown in Figs. 4 to 7, inner-race side shafts 37a, 37b, 37c, and 37d of bearing boxes 10a, 10b, 10c, and 10d, which pivotally support the respective thrust bearings 8a, 8b, 8c, and 8d, have long holes 38a, 38b, 38c, and 38d formed therein allowing the respective thrust bearings 8a, 8b, 8c, and 8d to move individually together with the respective bearing boxes 10a, 10b, 10c, and 10d in the roll axial directions. In addition, coupling bars 9a and 9b are provided between the bearing boxes 10a and 10b and between the bearing boxes 10c and 10d, respectively. The coupling bars 9a and 9b each penetrate the corresponding long holes 38a and 38b or 38c and 38d, to restrict vertical displacements of the corresponding two upper and lower thrust bearings 8a and 8b or 8c and 8d.

[0033] In addition, the ratio D/B (D: bearing outer diameter, B: bearing width) of the outer diameter of each thrust bearing 8a, 8b, 8c, 8d to the width of the thrust bearing 8a, 8b, 8c, 8d is set between 5.0 and 12 (see Fig. 6). In addition, guides 16a, 16b, 16c, and 16d are provided for guiding the respective bearing boxes 10a, 10b, 10c, and 10d, on the opposite side to the thrust bearings 8a, 8b, 8c, 8d, slidably in the roll axial directions and collectively while restricting the bearing boxes 10a, 10b, 10c, and 10d in vertical and entry/delivery directions (see Fig. 5). It should be noted that these guides may be guide rods or bush structures.

[0034] Furthermore, first roll shift devices connected to the respective bearing boxes 10a, 10b, 10c, and 10d to shift the respective work rolls 2a and 2b in the roll axial directions are provided. These first roll shift devices are formed of arms 13a, 13b, 13c, and 13d and shift cylinders 11a, 11b, 11c, and 11d. The arms 13a, 13b, 13c, and 13 are joined at middle portions thereof to the bearing boxes 10a, 10b, 10c, and 10d via pins 14a, 14b, 14c, and 14d, and the shift cylinders 11a, 11b, 11c, and 11d are joined to one ends of the arms 13a, 13b, 13c, and 13d via pins 12a, 12b, 12c, and 12d for applying shift force thereto using hinges 15a, 15b, 15c, and 15d coupled to the other ends of the arms 13a, 13b, 13c, and 13d as fulcrums (see Fig. 4).

[0035] Then, in the first example, the first roll shift devices shift taper start positions SP of the tapered portions 22a and 22b of the respective work rolls 2a and 2b to an inner vicinity of strip widthwise ends or an outer vicinity of the strip widthwise ends.

[0036] In the first example thus configured, first, the two, upper and lower, thrust bearings 8a and 8b, and the two, upper and lower, thrust bearings 8c and 8d have the long-hole 38a, 38b, 38c and 38d structures allowing the respective thrust bearings 8a, 8b, 8c, and 8d to move individually in the roll axial directions at the inner-race side shafts 37a and 37b, 37c and 37d, and are provided with the coupling bars 9a and 9b restricting displacements of the thrust bearings 8a, 8b, 8c, and 8d in the vertical direction of the bearing boxes 10a, 10b, 10c, and 10d of the respective thrust bearings 8a, 8b, 8c, and 8d. Therefore, the bearing stiffness of the thrust bearings can be increased.

[0037] Furthermore, the ratio D/B (D: thrust bearing outer diameter, B: thrust bearing width) of each thrust bearing 8a, 8b, 8c, 8d has been changed from a conventional ratio (D/B: 2.0 to 3.0) to a ratio of 2.5 to 4.0 times (D/B: 5.0 to 12) the conventional ratio. Therefore, even if the thrust bearing width B is narrower, a bearing life equal to or longer than a conventional bearing life can be obtained. Furthermore, since the guides 16a, 16b, 16c, and 16d are provided for guiding the respective bearing boxes 10a, 10b, 10c, and 10d, on the opposite side to the thrust bearings 8a to 8d, slidably in the roll axial directions and collectively while restricting the bearing boxes 10a, 10b, 10c, and 10d vertical and entry and delivery directions, the stiffness of this part can be raised.

[0038] As a result, this configuration makes it possible to withstand large external force at the time of strip breakage, and also prevent chattering due to vibration from occurring.

[0039] In addition, the first roll shift devices are formed of the arms 13a, 13b, 13c, and 13d joined at middle portions thereof to the respective bearing boxes 10a, 10b, 10c, and 10d via the pins 14a, 14b, 14c, and 14d, and the shift cylinders 11a, 11b, 11c, and 11d for applying shift force to one ends of the arms 13a, 13b, 13c, and 13d using the hinges 15a, 15b, 15c, and 15d coupled to the other ends of the arms 13a, 13b, 13c, and 13d as fulcrums. Therefore, even if the capacities of the cylinders are smaller than those of cylinders having a linear structure, the arm ratio makes it possible to secure a predetermined shift force, and consequently the cylinders can be installed even in narrow spaces.

[0040] Thus, the thrust bearings 8a, 8b, 8c, and 8d are effectively incorporated, so that the shifting functions of the small-diameter work rolls 2a and 2b can be achieved by the roll shift devices having simple structures.

[0041] In addition, in the first example, the taper start positions SP of the tapered portions 22a and 22b, disposed in upper and lower positions in point symmetry, of the pair of upper and lower work rolls 2a and 2b can be shifted to the vicinities of the insides of the strip widthwise ends.

[0042] This causes the strip widthwise ends to be thicker by clearances (see δW and δd in Fig. 2) of the tapered portions 22a and 22b than the strip central portion. Consequently, a reduction in the strip thickness of the strip widthwise ends after rolling (edge drop) is also suppressed, the amount of edge trimming in the following process is reduced, and the yield is improved accordingly.

[0043] On the other hand, when the taper start positions SP of the tapered portions 22a and 22b of the work rolls 2a and 2b are shifted to the vicinities of the outsides of the strip widthwise ends (in the example shown in Fig. 2, taper start positions SP of tapered portions of the first intermediate rolls 3a and 3b are also shifted to the vicinities of the outsides of the strip widthwise ends), undesirable contact linear pressure from the outside of the strip width to the work rolls 2a and 2b, caused by the first intermediate rolls 3a and 3b, is reduced, so that shape stability (small shape variation relative to load variation) is improved.

[0044] Here, the shape stability (small shape variation relative to load variation) will be described by using Figs. 8A and 8B as to a case where the taper start positions SP of the tapered portions 22a and 22b of the work rolls 2a and 2b have been shifted so as to coincide with the vicinities of the outsides of the strip widthwise ends.

[0045] Fig. 8A shows a case of the conventional straight work rolls 100a shown in Fig. 21. In this case, when the load changes by 2.1 times from 400 tons to 820 tons, the shape changes by 250 I-units. On the other hand, Fig. 8B shows a case where the taper start positions SP of the tapered portions 22a and 22b of the work rolls 2a and 2b have been caused to coincide with the vicinities of the outsides of the strip widthwise ends. In this case, similarly, when the load changes by 2.1 times from 400 tons to 820 tons, the shape changes by 140 I-units, and the change amount has been reduced to 56% (= 140/250). This means that shape variation is small relative to load variation during acceleration or deceleration, and indicates that the shape stability has been significantly improved accordingly in the present invention.

{Second Example}

[0046] Fig. 9 is a front view of a 20-high cluster-type rolling mill according to a second example of the present invention, Fig. 10 is a descriptive view of strip meandering according to the second example, Figs. 11A and 11B are descriptive views showing the necessity of an asymmetrical control means in case of strip meandering, Fig. 11A is a descriptive view of a linear pressure distribution in material, Fig. 11B is a descriptive view of a strip shape, and Fig. 12 is a side view showing an example of application of the second example to a tandem rolling mill.

[0047] The second example is an example where a strip widthwise end position detector 35 for a strip W is provided on the entry side (or the delivery side) of a 20-high cluster-type rolling mill, and a controller (control means) 40 is provided to perform shift controls of the first roll shift devices for the work rolls 2a and 2b of the first example to cause the taper start positions SP of the upper and lower work rolls 2a and 2b of the first example to coincide with the vicinities of the insides of the strip widthwise ends or the vicinities of the outsides of the strip widthwise ends detected by the strip widthwise end position detector 35 independently for the upper side and the lower side.

[0048] According to the second example, by causing the taper start positions SP of the work rolls 2a and 2b to coincide with the vicinities of the insides of the strip widthwise ends from actual strip widthwise ends detected by the strip widthwise end position detector 35, the amount of edge drop, which is a reduction in strip thickness of the strip widthwise end, can be reduced more effectively against meandering of a strip 1 during rolling.

[0049] On the other hand, by causing the taper start positions SP of the work rolls 2a and 2b to coincide with the vicinities of the outsides of the strip widthwise ends from actual strip widthwise ends detected by the strip widthwise end position detector 35, the undesirable contact linear pressure from the outsides of the strip width to the work rolls 2a and 2b from the first intermediate rolls 3a and 3b are reduced more effectively against meandering of the strip W during rolling, and therefore the shape stability (small shape variation relative to load variation) is significantly improved.

[0050] During the meandering, however, the strip shape becomes asymmetrical on the operation side and on the drive side. This shape asymmetry caused during the meandering of the strip W will be described by using Fig. 10 and Figs. 11A and 11B.

[0051] First, when a strip center O1 has meandered by "e" from a mill center 02 toward the drive side, the taper start positions SP of the work rolls 2a and 2b are shifted by an amount corresponding to the meandering accordingly. This makes it possible to set the taper start positions SP in the vicinities of the insides of the strip widthwise ends or the vicinities of the outsides of the strip widthwise ends of actual strip widthwise ends. However, since the strip center O1 has been offset by "e" from the mill center 02 toward the drive side, the linear pressure distribution in material of the work rolls 2a and 2b and the strip W is such that, as shown by the vertical straight arrows in Fig. 11A, the linear pressure is low on the drive side and high on the operation side. As a result, the shape of the strip W takes a strip shape where edge waves T occur on the operation side, as shown in Fig. 11B.

[0052] Therefore, as an operation side-drive side asymmetrical shape control means, upper-lower asymmetrical shifting of the two upper and two lower first intermediate rolls 3a and 3b is performed. Specifically, in this case, the taper start position SP of each upper first intermediate roll 3a is shifted toward the drive side, and the taper start position SP of each lower first intermediate roll 3b is also shifted toward the drive side (see the horizontal straight arrows in Fig. 11A) by the second roll shift devices.

[0053] This makes it possible to roll the strip W into a shape symmetrical on the operation side and the drive side, so that stable rolling can be realized. Similarly, a crown adjuster called AS-U installed in an upper backing bearing shaft formed of the backing bearing 5a, the shaft 6a, and the saddle 7a may be caused to operate asymmetrically on the operation side and on the drive side. In addition, similarly, bender force of roll benders of the work rolls 2a and 2b and/or the first intermediate rolls 3a and 3b may be made larger on the operation side than on the drive side.

[0054] In addition, as shown in Fig. 12, it is preferred that the rolling mill of the second example be installed in at least one stand of a tandem rolling mill including, for example, No. 1 to No. 5 stands (for example, in the No. 5 stand in the example shown in Fig. 12), and that the strip widthwise end position detector 35 be installed on the entry side (or the delivery side) of this at least one stand (the No. 5 stand in the example shown in Fig. 12). According to this configuration, also in a tandem rolling mill, the amount of edge drop can be reduced with the inexpensive strip widthwise end position detector 35.

{Third Example}

[0055] Fig. 13 is a front view showing an example of application of a third example of the present invention to a 20-high cluster-type rolling mill, and Fig. 14 is a side view showing an example of application of the third example to a tandem rolling mill.

[0056] The third example is an example where a strip widthwise end thickness meter 36 to measure the thicknesses of strip widthwise ends of the strip W is provided on the delivery side of the 20-high cluster-type rolling mill, and a controller (control means) 41 is provided to perform shift control of the first roll shift devices for the work rolls 2a and 2b of the first example to cause the taper start positions SP of the upper and lower work rolls 2a and 2b to coincide with the vicinities of the insides of the strip widthwise ends individually for the upper side and lower side, such that the thicknesses of the strip widthwise ends measured on the operation side and the drive side become predetermined thicknesses.

[0057] First, a method of reducing edge drop by roll shift of the work rolls 2a and 2b having taper start positions SP will be described below. The pair of upper and lower work rolls 2a and 2b are provided with the taper start positions SP in upper and lower positions in point symmetry, and distances between the taper start positions SP and the strip widthwise ends are represented as δw and δd. In addition, the strip widthwise end thickness meter 36 measures a strip thickness or strip thicknesses at a single point or a plurality of points in the vicinities of the strip widthwise ends, on the operation side and the drive side, on the delivery side of the rolling mill. If the strip thickness or the strip thicknesses measured at the single point or the plurality of points in the vicinities of the strip widthwise end on the operation side is or are thinner than a predetermined strip thickness, the upper work roll 2a is shifted in a roll axial narrowing direction. In other words, the upper work roll 2a is shifted in a direction in which the distance δw increases. On the other hand, if the strip thickness or the strip thicknesses measured close to the strip widthwise ends is or are thicker than the predetermined strip thickness, the upper work roll 2a is shifted in a roll axial widening direction. In other words, the upper work roll 2a is shifted in a direction in which the distance δw decreases. In addition, if the strip thickness or the strip thicknesses measured at the single point or the plurality of points in the vicinities of the strip widthwise end on the drive side is or are different from the predetermined strip thickness, the lower work roll 2b is similarly shifted such that the predetermined strip thickness can be obtained.

[0058] According to the third example, the amount of edge drop, which is a reduction in the strip thickness of the strip widthwise end, can be reduced more effectively As a result, the amount of edge trimming in the following process is reduced, and therefore the yield is improved.

[0059] In addition, as shown in Fig. 14, it is preferred that the rolling mill of the third example be installed in at least one stand of a tandem rolling mill including, for example, No. 1 to No. 5 stands (in the No. 5 stand in the example shown in Fig. 14) and the strip widthwise end thickness meter 36 be installed on the delivery side of the at least one stand (the No. 5 stand in the example shown in Fig. 14).

[0060] According to this, though an expensive strip widthwise end thickness meter 36 using X-ray is used, the amount of edge drop can be reduced with high accuracy.

{Fourth Example}

[0061] Fig. 15 is a front view of a 20-high cluster-type rolling mill according to a fourth example of the present invention.

[0062] Fig. 15 shows a 20-high cluster-type rolling mill which is characterized in that a top inner housing 17a and a bottom inner housing 17b are supported by an entry-side outer housing 23a and a delivery-side outer housing 23b and is known from the patent literature 3. The fourth example has a configuration where this rolling mill is provided with the first roll shift devices in which the thrust bearings 8a to 8d are effectively installed in the same manner as in the first example. According to the fourth example, the advantage that the rolling mill is made compact is obtained.

{Fifth Example}

[0063] Fig. 16 is a front view of a 20-high cluster-type rolling mill according to a fifth example of the present invention.

[0064] The fifth example is a 20-high cluster-type rolling mill, where a strip W is rolled by a pair of upper and lower work rolls 2a and 2b. This pair of upper and lower work rolls 2a and 2b are supported in contact with two upper and two lower first intermediate rolls 3a and 3b. These two upper and two lower first intermediate rolls 3a and 3b are supported in contact with three upper and three lower second intermediate rolls 4a and 4b. These three upper and three lower second intermediate rolls 4a and 4b are supported in contact with four upper and four lower backing bearing shafts formed of backing bearings 5a and 5b, shafts 6a and 6b, and saddles 7a and 7b. The four upper and four lower backing bearing shafts are supported at the saddles 7a and 7b by a monoblock housing 24. The fifth example has a configuration where this rolling mill is provided with the first roll shift devices in which the thrust bearings 8a to 8d are effectively installed in the same manner as in the first example. According to the fifth example, the advantage that the rolling mill is made further compact is obtained.

{Sixth Example}

[0065] Fig. 17 is a front view of a 12-high cluster-type rolling mill according to a sixth example of the present invention.

[0066] The sixth example is a 12-high cluster-type rolling mill, where a strip W is rolled by a pair of upper and lower work rolls 2a and 2b. This pair of upper and lower work rolls 2a and 2b are supported in contact with two upper and two lower intermediate rolls 3a and 3b. These two upper and two lower intermediate rolls 3a and 3b are supported in contact with three upper and three lower backing bearing shafts formed of three upper and three lower backing bearings 25a and 25b, three upper and three lower shafts 26a and 26b, and three upper and three lower unillustrated saddles, respectively, and the three upper backing bearing shafts are supported at the saddles by unillustrated inner housing and outer housing. The sixth example has a configuration where this rolling mill is provided with the first roll shift devices in which the thrust bearings 8a to 8d are effectively installed in the same manner as in the first example.

{Seventh Example}

[0067] Fig. 18 is a front view of a six-high rolling mill having side support rolls according to a seventh example of the present invention.

[0068] The seventh example is a six-high rolling mill having side support rolls, where a strip W is rolled by a pair of upper and lower work rolls 2. This pair of upper and lower work rolls 2 are supported in contact with a pair of upper and lower intermediate rolls 3, respectively. This pair of upper and lower intermediate rolls 3 are supported in contact with a pair of upper and lower back-up rolls 27, respectively. This pair of upper and lower back-up rolls 27 are supported by housings 20a and 20b via bearing boxes 39 with a pass line adjuster 18a on the upper side and with a push-up cylinder 19a on the lower side, respectively. In addition, the pair of upper and lower work rolls 2 are supported, on the entry and delivery sides, by support rolls 28a, 28b, 28c, and 28d, and further by backing bearing shafts 29a, 29b, 29c, and 29d, and 30a, 30b, 30c, and 30d. The seventh example has a configuration where this rolling mill is provided with the first roll shift devices in which the thrust bearings 8a to 8d are effectively installed in the same manner as in the first example. In addition, the intermediate rolls 3 and the work rolls 2 may be provided with roll benders. These roll benders improve shape controllability, thereby making stable rolling possible.

{Eighth Example}

[0069] Fig. 19 is a front view of a six-high rolling mill according to an eighth example of the present invention.

[0070] The eighth example is a six-high rolling mill having side support rolls, where a strip W is rolled by a pair of upper and lower work rolls 2. This pair of upper and lower work rolls 2 are supported in contact with a pair of upper and lower intermediate rolls 3, respectively. This pair of upper and lower intermediate rolls 3 are supported in contact with a pair of upper and lower back-up rolls 27, respectively. This pair of upper and lower back-up rolls 27 are supported by housings 20a and 20b via bearing boxes 39a with a pass line adjuster 18a on the upper side and with a push-up cylinder 19a on the lower side, respectively. The eighth example has a configuration where this rolling mill is provided with the first roll shift devices in which the thrust bearings 8a to 8d are effectively installed in the same manner as in the first example. In addition, the intermediate rolls 3 and the work rolls 2 may be provided with roll benders. These roll benders improve shape controllability, thereby making stable rolling possible.

{Industrial Applicability}

[0071] Since the thrust bearings are effectively installed so that the shifting function of the work rolls can be achieved with a simple mechanism, the present invention is applicable to a rolling mill having small-diameter work rolls so that edge drop reduction and shape stability are achieved by shifting work rolls having tapered portions in roll axial directions.

{Reference Signs List}

{0072}

2a, 2b	WORK ROLL
3a, 3b	FIRST INTERMEDIATE ROLL
4a, 4b	SECOND INTERMEDIATE ROLL
5a, 5b	BACKING BEARING
6a, 6b	SHAFT
7a, 7b	SADDLE
8a to 8d	THRUST BEARING
9a, 9b	COUPLING BAR
10a to 10d	BEARING BOX
11a to 11d	SHIFT CYLINDER
12a to 12d	PIN
13a to 13d	ARM
14a to 14d	PIN
15a to 15d	HINGE
16a to 16d	GUIDE
17a	TOP INNER HOUSING
18a, 18b	PASS LINE ADJUSTER
19a, 19b	PUSH-UP CYLINDER
20a, 20b	OUTER HOUSING
22a, 22b	TAPERED PORTION OF WORK ROLL
23a	ENTRY-SIDE OUTER HOUSING
23b	DELIVERY-SIDE OUTER HOUSING
24	MONOBLOCK HOUSING
25a, 25b	BACKING BEARING
26a, 26b	SHAFT
27	BACK-UP ROLL
28a to 28d	SUPPORT ROLL
29a to 29d	BACKING BEARING SHAFT
30a to 30d	BACKING BEARING SHAFT
35	STRIP WIDTHWISE END POSITION DETECTOR
36	STRIP WIDTHWISE END THICKNESS METER
37a to 37d	INNER-RACE SIDE SHAFT
38a to 38d	LONG HOLE
39	BEARING BOX
40	CONTROLLER (CONTROL MEANS)
41	CONTROLLER (CONTROL MEANS)
B	BEARING WIDTH
D	BEARING OUTER DIAMETER
e	OFFSET AMOUNT OF STRIP CENTER
O1	STRIP CENTER
O2	MILL CENTER
SP	TAPER START POSITION OF TAPERED PORTION
T	EDGE WAVE
W	METAL STRIP (MATERIAL TO BE ROLLED)

Claims

1. A multi-high rolling mill equipped with a work roll shift function, including a pair of upper and lower work rolls (2a, 2b) for rolling a metal strip (W), and one or a plurality of upper support rolls and one or a plurality of lower support rolls (3a, 3b, 4a, 4b) supporting the work rolls (2a, 2b), **characterized in that**
the pair of upper and lower work rolls (2a, 2b) are provided with tapered portions (22a, 22b) in upper and lower positions in point symmetry,
end faces of the work rolls (2a, 2b) are supported by two upper and two lower thrust bearings (8a to 8d) on an operation side and a drive side,
long holes (38a to 38d) are formed in inner-race side shafts (37a to 37d) of bearing boxes (10a to 10d) pivotally supporting the respective thrust bearings (8a to 8d), the long holes (38a to 38d) allowing the thrust bearings (8a to 8d) to be individually movable together with the respective bearing boxes (10a to 10d) in roll axial directions,
coupling bars (9a, 9b) penetrating the corresponding long holes (38a to 38d) to restrict vertical displacements of the two upper and two lower thrust bearings (8a to 8d) are provided between the corresponding bearing boxes (10a to 10d),
first roll shift devices (13a to 13d, 11a to 11d) connected to the respective bearing boxes (10a to 10d) to shift the corresponding work rolls (2a, 2b) in the roll axial directions are provided, and
taper start positions (SP) of the tapered portions (22a, 22b) of the respective work rolls (2a, 2b) are shifted to vicinities of insides of strip widthwise ends or vicinities of outsides of strip widthwise ends.

2. The multi-high rolling mill equipped with a work roll shift function according to claim 1, **characterized in that** a ratio D/B (D: bearing outer diameter, B: bearing width) of an outer diameter of the thrust bearings (8a to 8d) to a width of the thrust bearings (8a to 8d) is set to a range between 5.0 to 12.

3. The multi-high rolling mill equipped with a work roll shift function according to claim 1 or 2, **characterized in that** guides (16a to 16d) are provided for guiding the respective bearing boxes (10a to 10d), on the opposite side to the thrust bearings (8a to 8d), slidably in the roll axial directions and collectively while restricting the respective bearing boxes (10a to 10d) in vertical, entry-side and delivery-side directions.

4. The multi-high rolling mill equipped with a work roll shift function according to claim 1, 2 or 3, **characterized in that** each of the first roll shift devices comprises: an arm (13a to 13d) joined at a middle portion thereof to the corresponding bearing box (10a to 10d) via a pin (14a to 14d); and a shift cylinder (11a to 11d) for applying shift force to one end of the arm (13a to 13d) using a hinge (15a to 15d) coupled to the other end of the arm (13a to 13d) as a fulcrum.

5. The multi-high rolling mill equipped with a work roll shift function according to any of claims 1 to 4, **characterized in that** a strip widthwise end position detector (35) for a metal strip is provided on an entry side or delivery side of the rolling mill, and a control means (40) for performing shift controls of the first roll shift devices is provided to cause the taper start positions (SP) of the tapered portions (22a, 22b) of the upper and lower work rolls (2a, 2b) to coincide with the vicinities of the insides of the strip widthwise ends or the vicinities of the outsides of the strip widthwise ends detected by the strip widthwise end position detector (35) independently for the upper side and the lower side.

6. The multi-high rolling mill equipped a work roll shift function according to any of claims 1 to 5, **characterized in that** a strip widthwise end thickness meter (36) for measuring thicknesses of the strip widthwise ends of a metal strip is provided on a delivery side of the rolling mill, and a control means (41) for performing shift controls of the first roll shift devices is provided to adjust the taper start positions (SP) of the tapered portions (22a, 22b) of the upper and lower work rolls (2a, 2b) in the vicinities of the insides of the strip widthwise ends individually for the upper side and the lower side, such that the thicknesses of the strip widthwise ends measured on the operation side and on the drive side become predetermined thicknesses.

7. The multi-high rolling mill equipped with a work roll shift function according to claim 5 or 6, **characterized in that** second roll shift devices are further provided for shifting the one or plurality of upper support rolls and the one or plurality of lower support rolls (3a, 3b, 4a, 4b) in the roll axial directions, and the control means (40) performs shift controls of the second roll shift devices to shift-control the one or plurality of upper support rolls and the one or plurality of lower support rolls (3a, 3b, 4a, 4b) asymmetrically on the operation side and on the drive side.

Fig.1

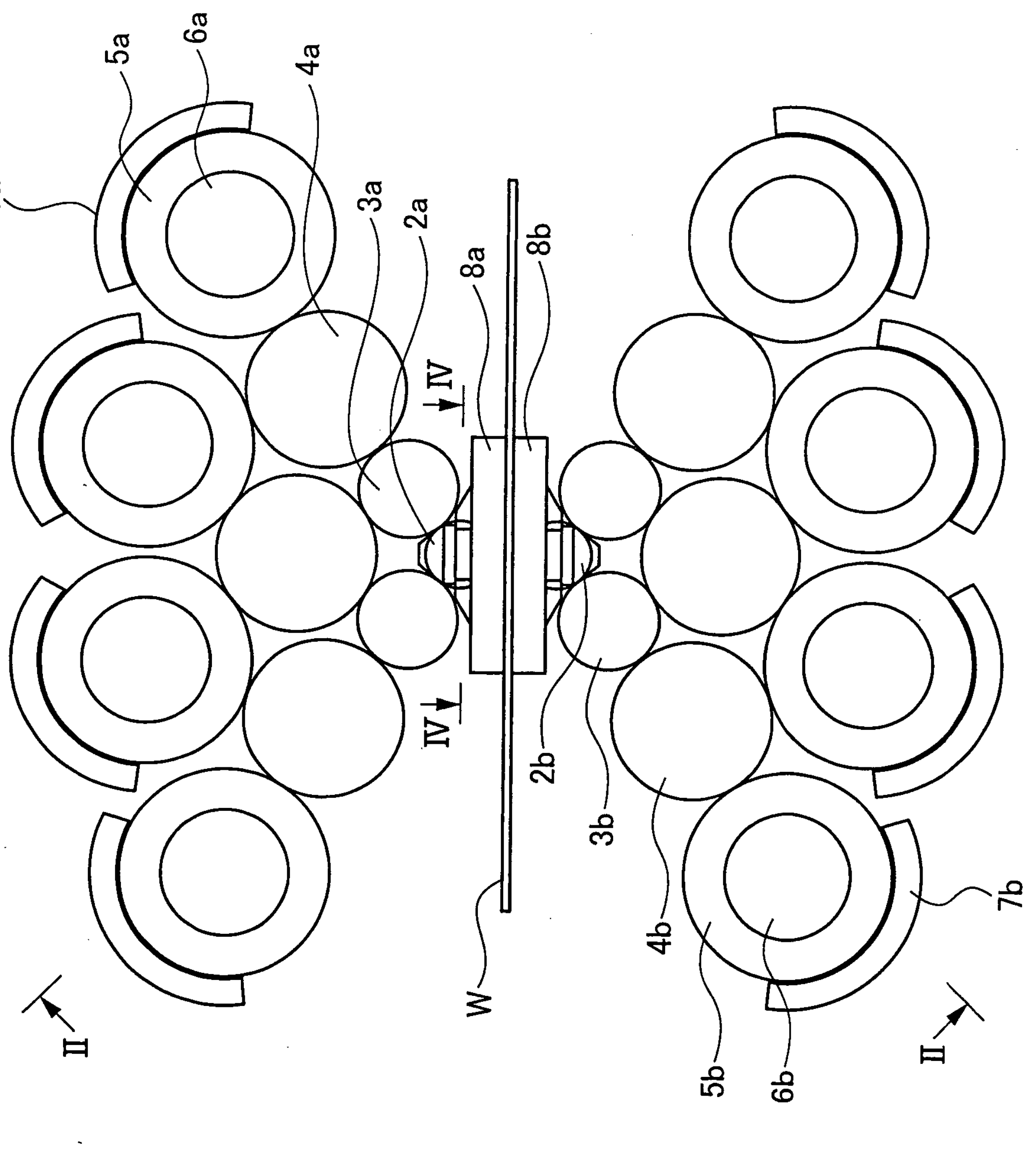


Fig.2

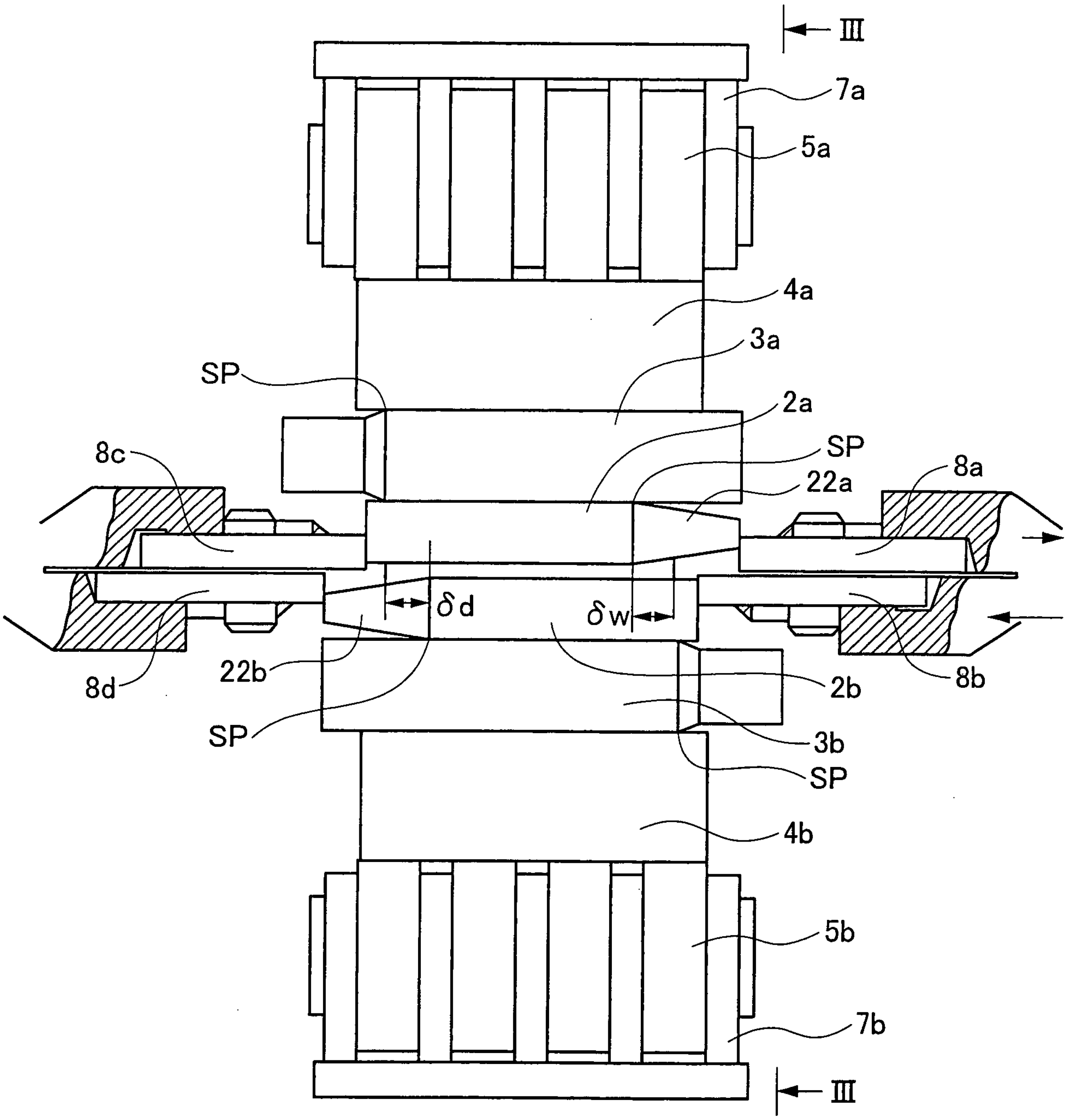

III
7a
5a
4a
3a
SP
2a
SP
8c
22a
8a
δd
δw
22b
8d
2b
8b
SP
3b
SP
4b
5b
7b
III

Fig.3

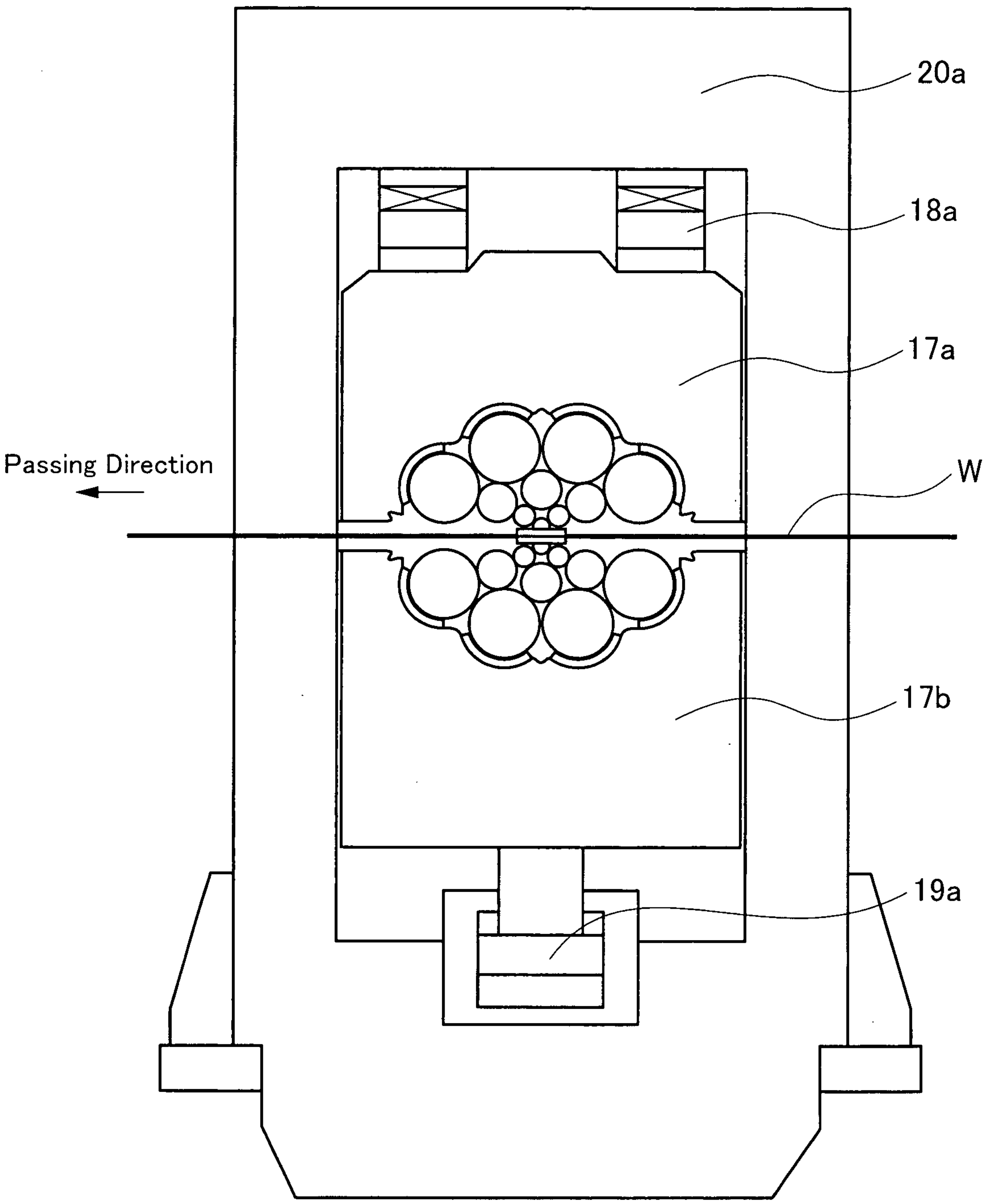


Fig.4

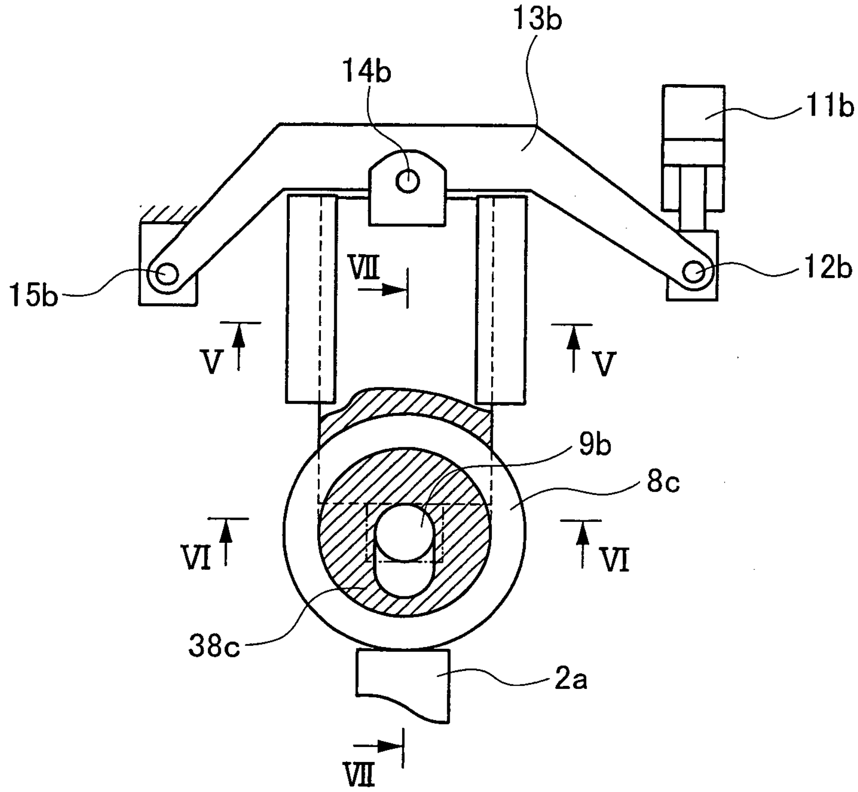


Fig.5

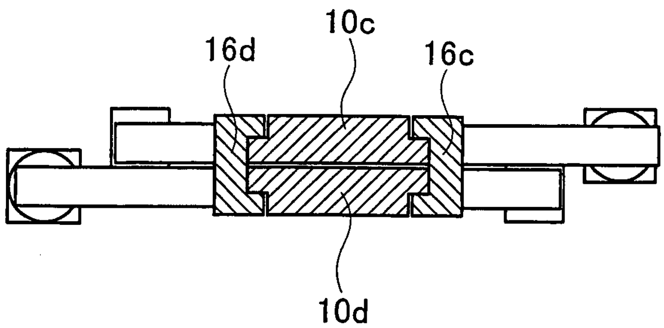


Fig.6

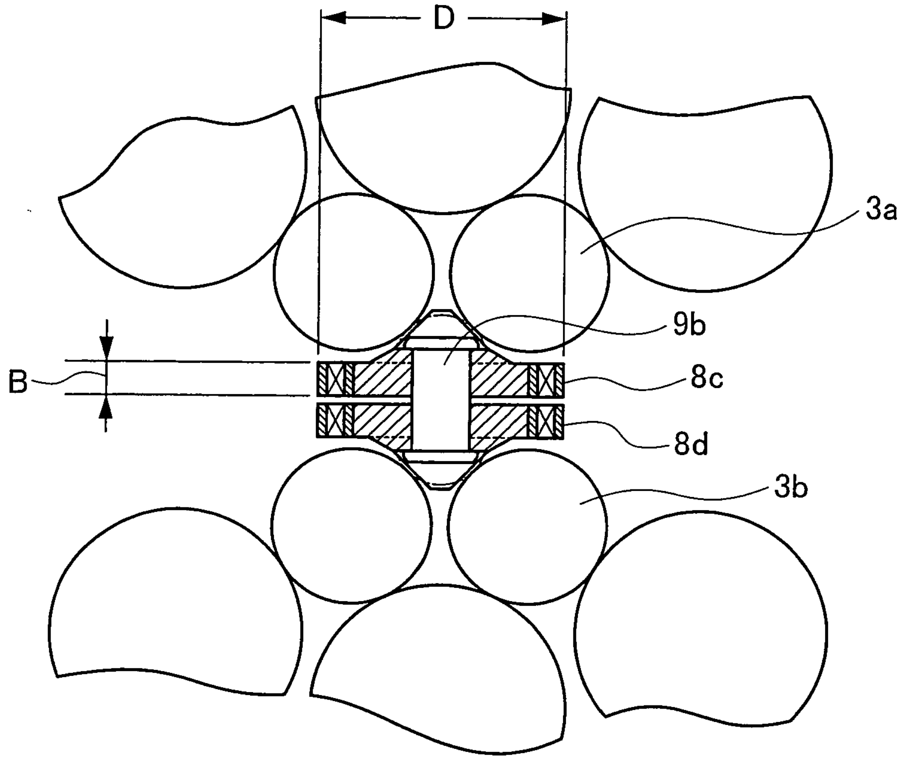


Fig.7

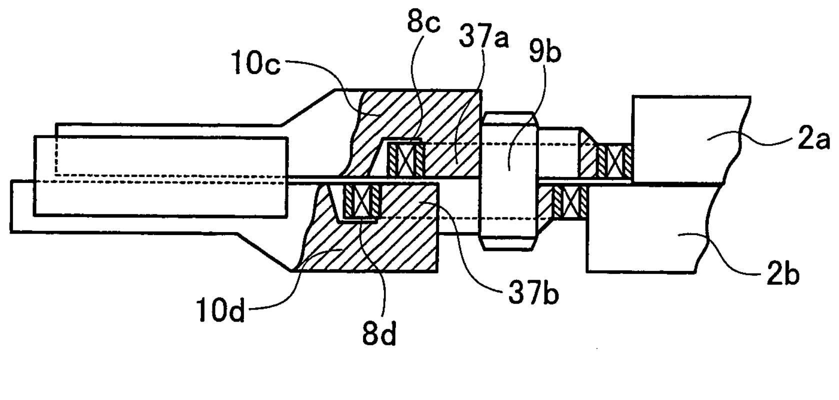


Fig.8A

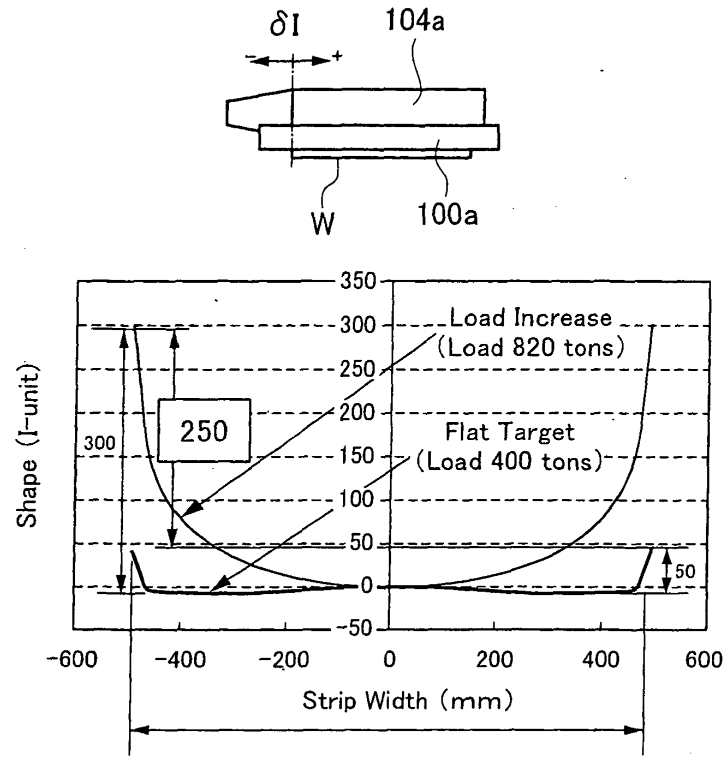

δI
104a
W
100a
Load Increase
(Load 820 tons)
Flat Target
(Load 400 tons)
250
300
50
Shape (I-unit)
Strip Width (mm)

Fig.8B

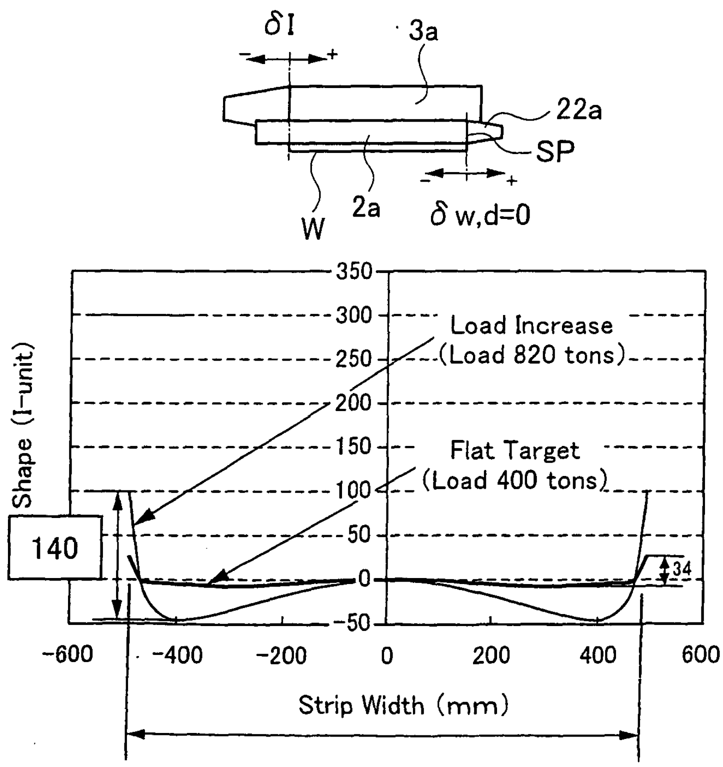

δI
3a
22a
SP
W
2a
δ w,d=0
Load Increase
(Load 820 tons)
Flat Target
(Load 400 tons)
140
34
Shape (I-unit)
Strip Width (mm)

Fig.9

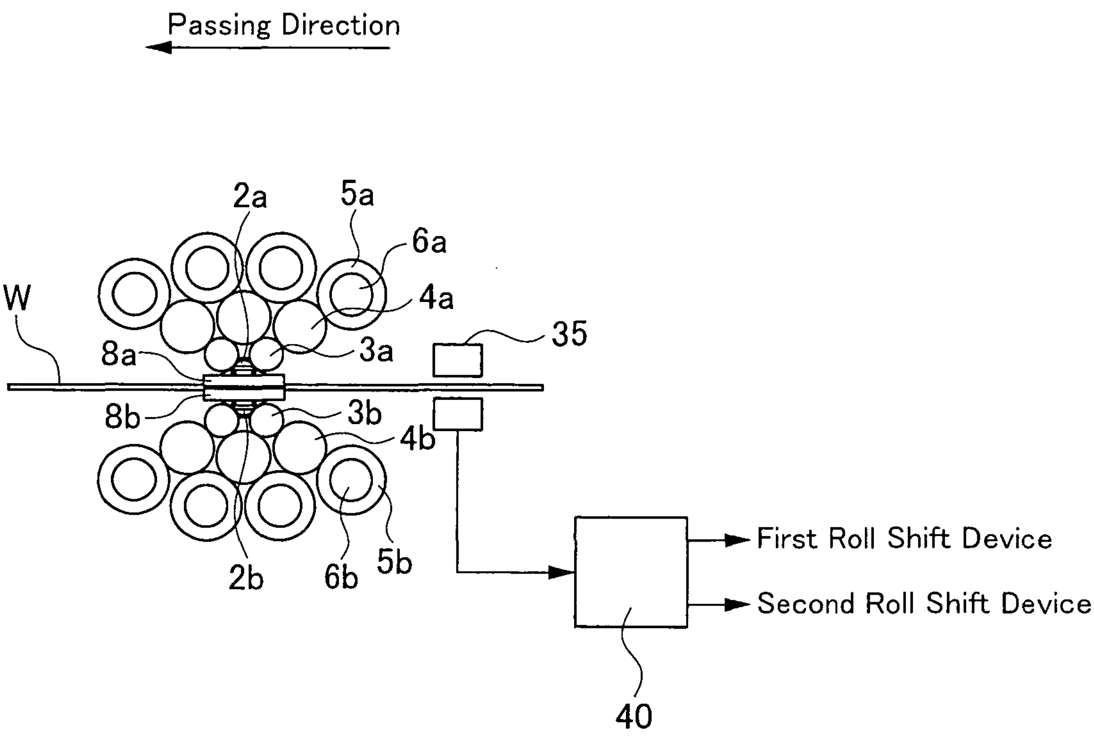

Passing Direction
2a
5a
6a
4a
W
35
8a
3a
8b
3b
4b
First Roll Shift Device
Second Roll Shift Device
2b
6b
5b
40

Fig.10

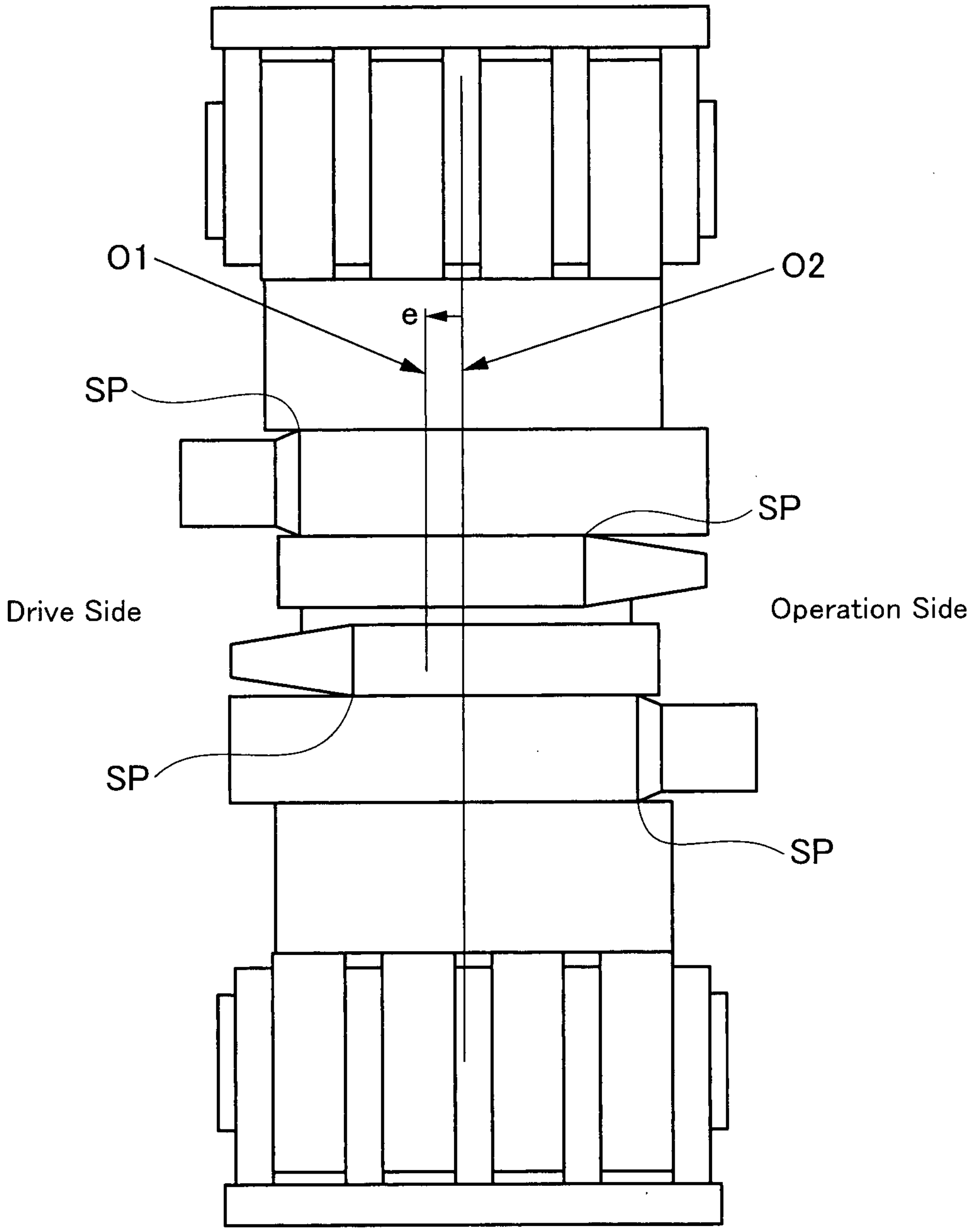


Fig.11A

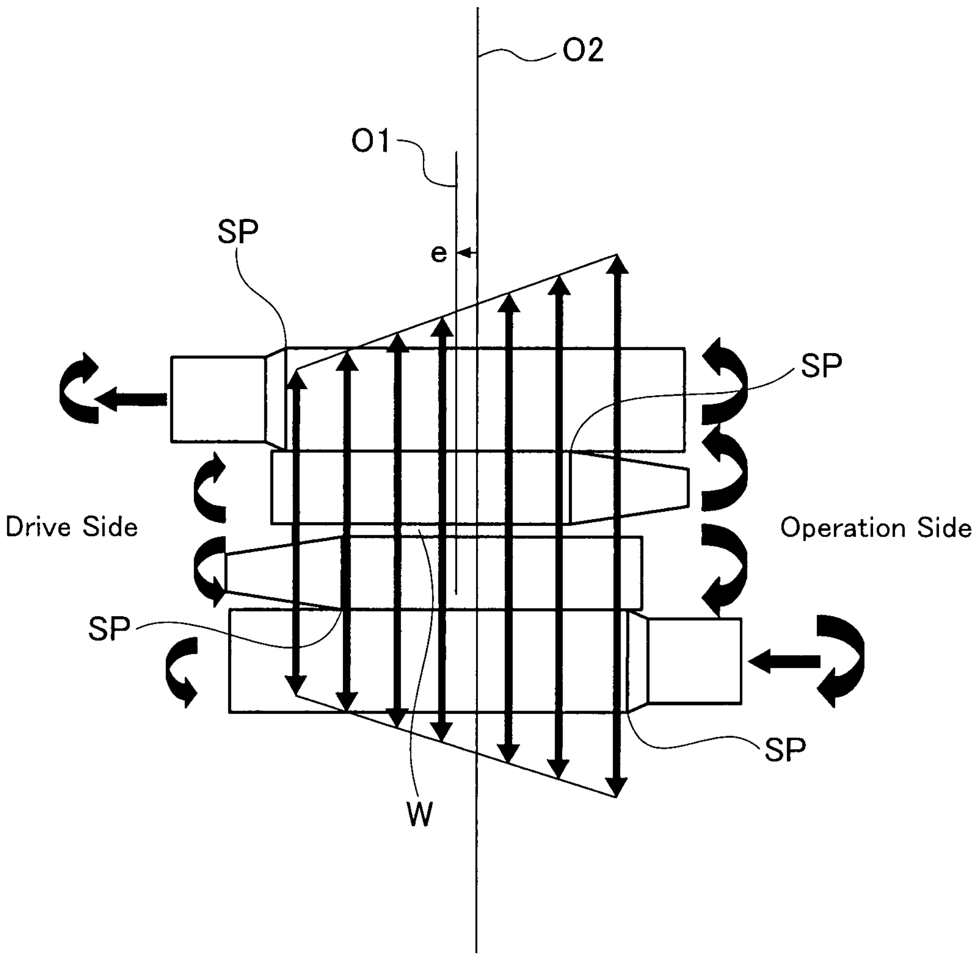


Fig.11B

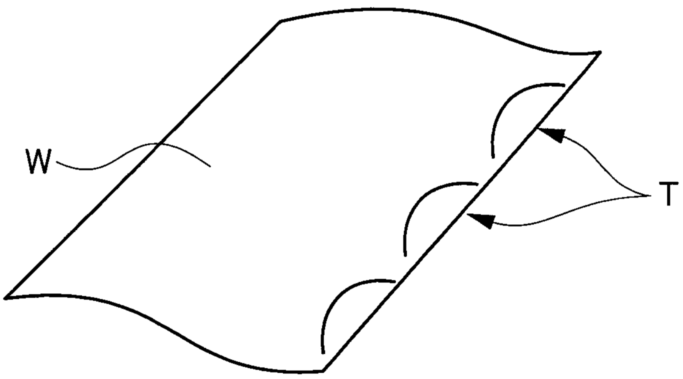


Fig.12

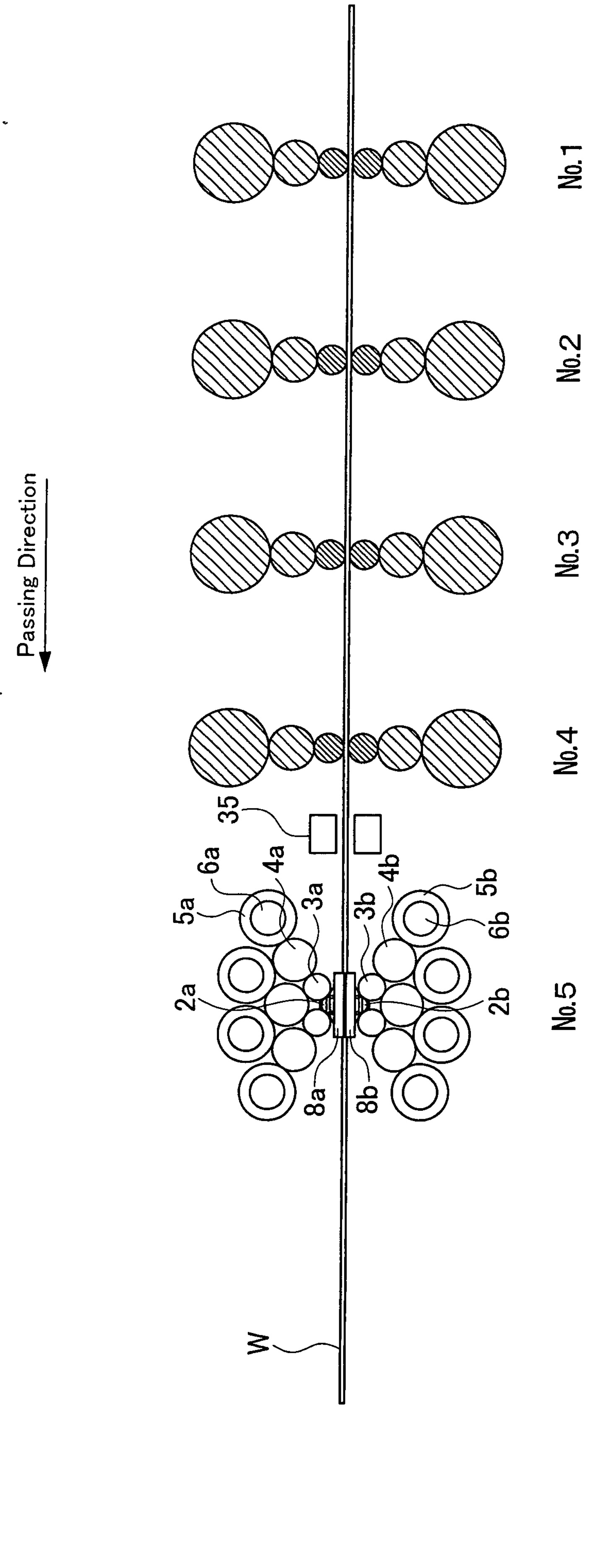

Passing Direction
No.1
No.2
No.3
No.4
No.5
35
6a
4a
5a
3a
3b
4b
5b
6b
2a
2b
8a
8b
W

Fig.13

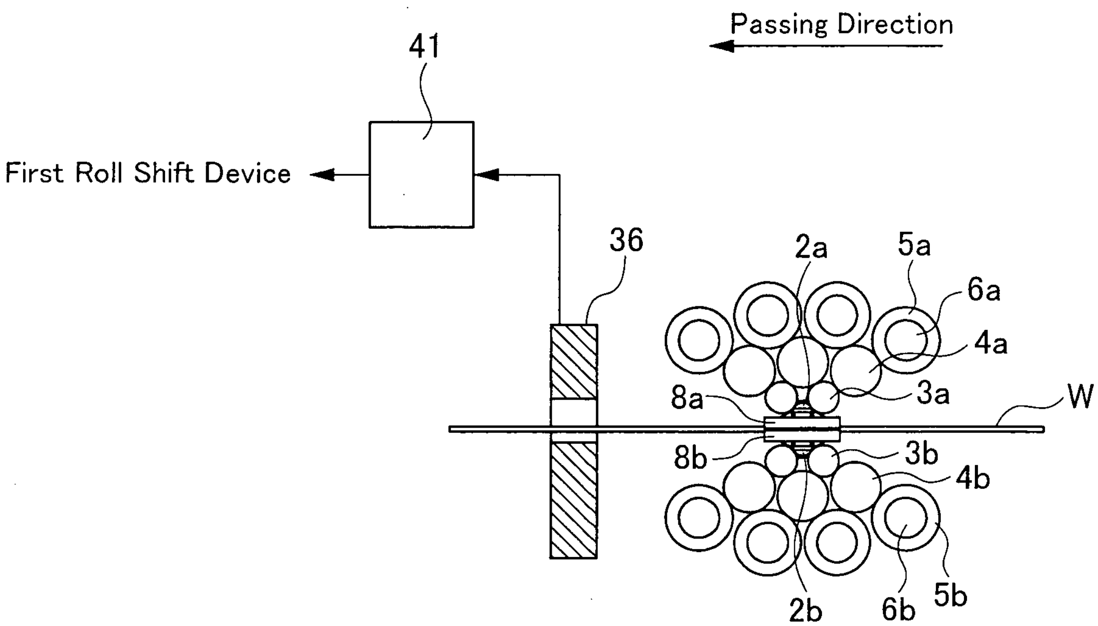

Passing Direction
41
First Roll Shift Device
36
2a
5a
6a
4a
3a
8a
W
8b
3b
4b
2b
6b
5b

Fig.14

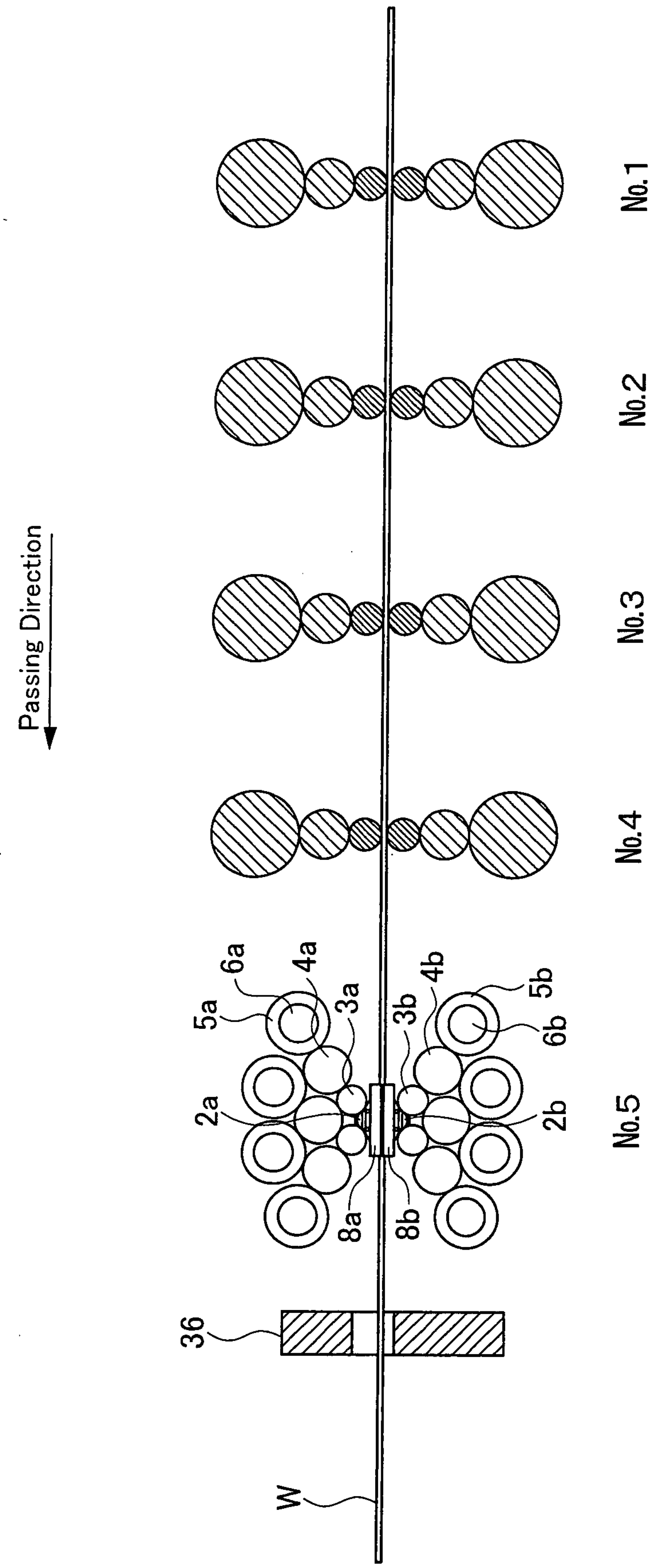

Passing Direction
No.1
No.2
No.3
No.4
No.5
5a
6a
4a
3a
2a
8a
3b
4b
5b
6b
2b
8b
36
W

Fig.15

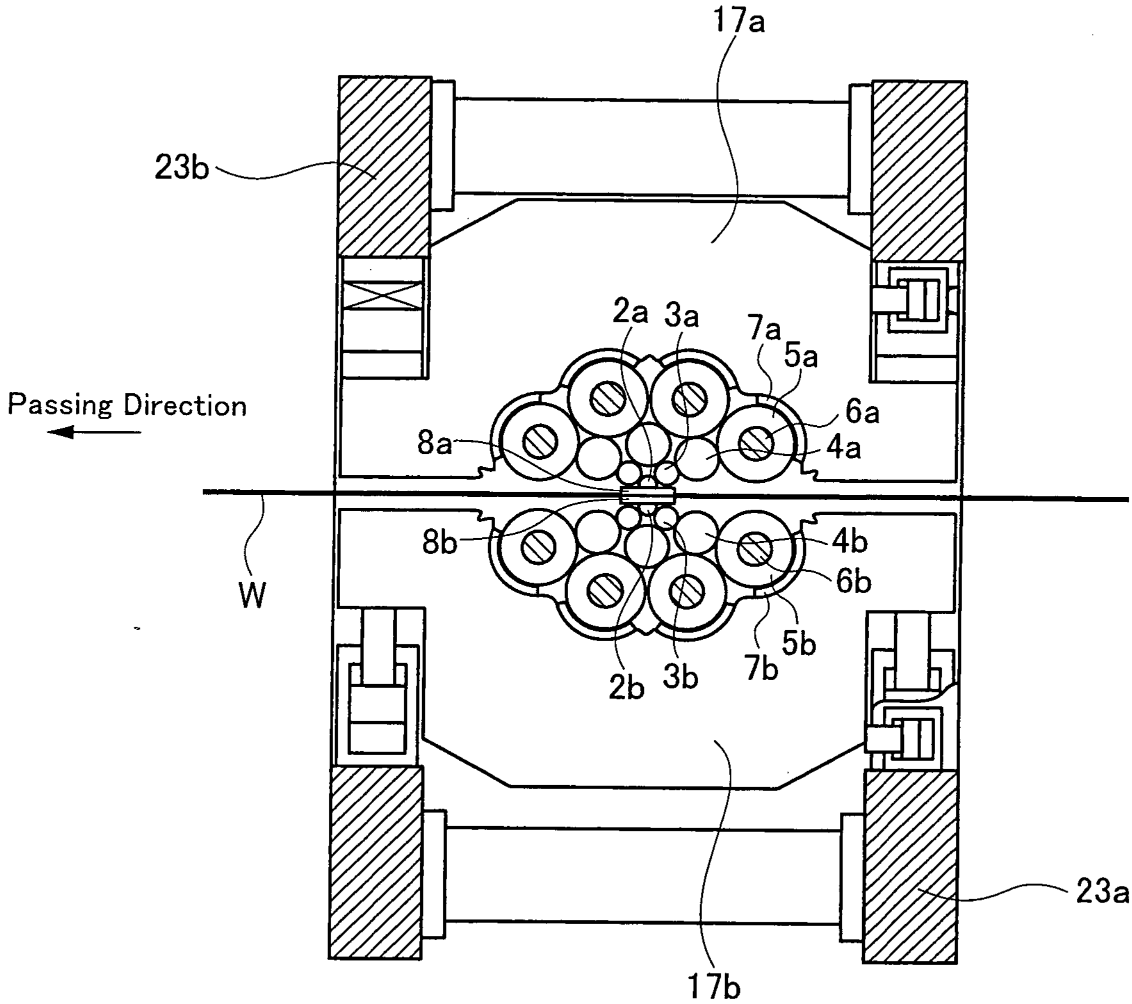

17a
23b
2a
3a
7a
5a
Passing Direction
6a
8a
4a
8b
4b
6b
W
5b
7b
2b
3b
17b
23a

Fig.16

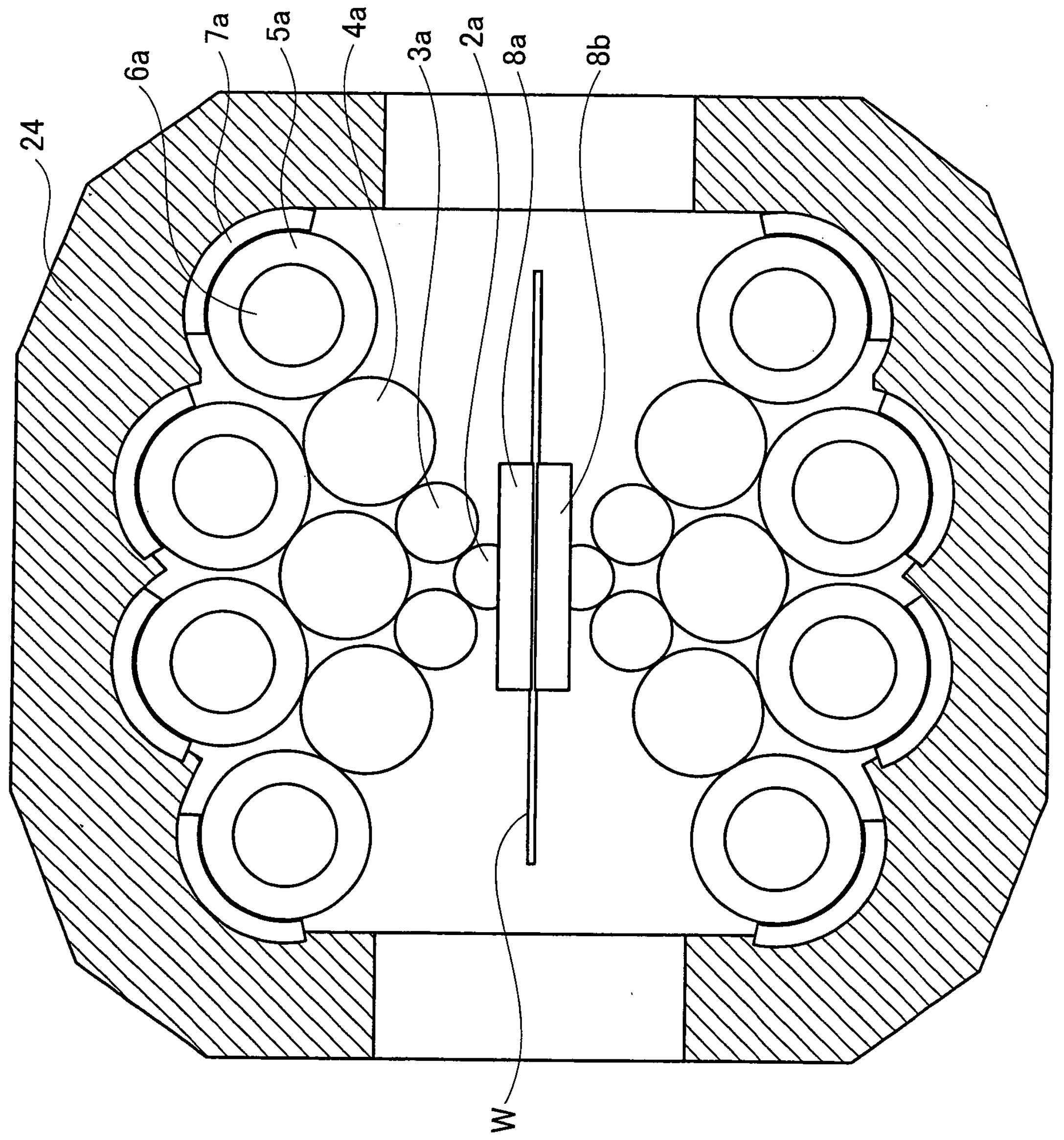


Fig.17

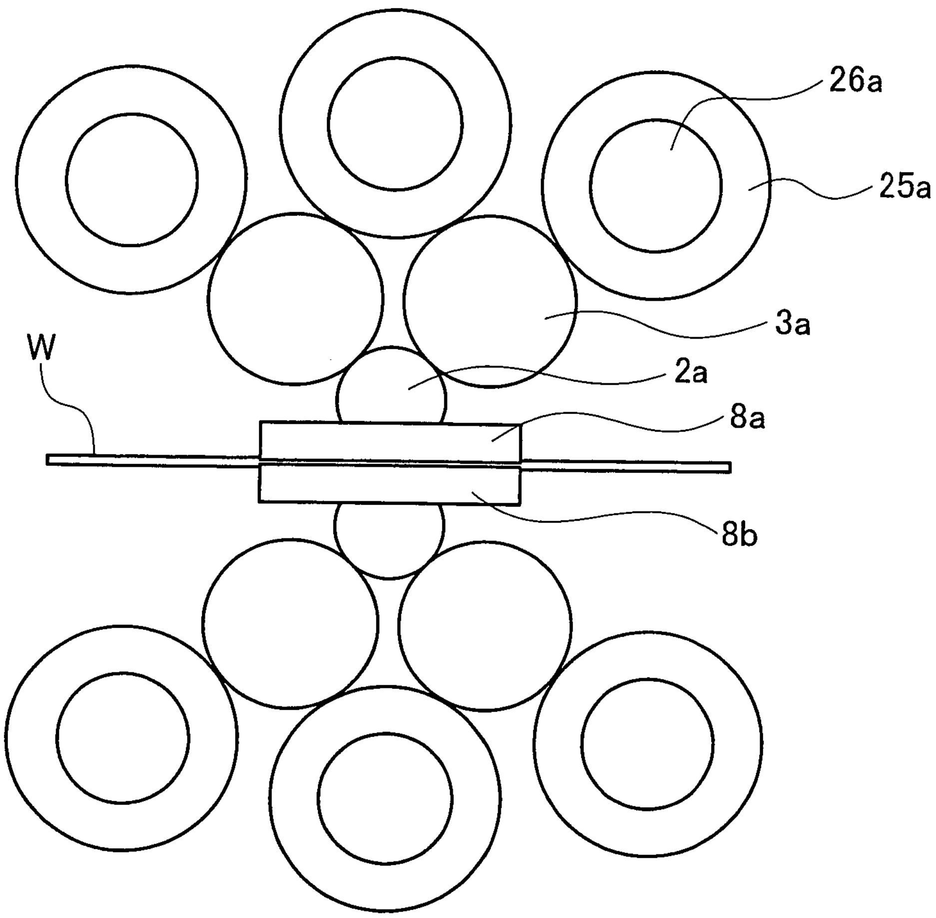


Fig.18

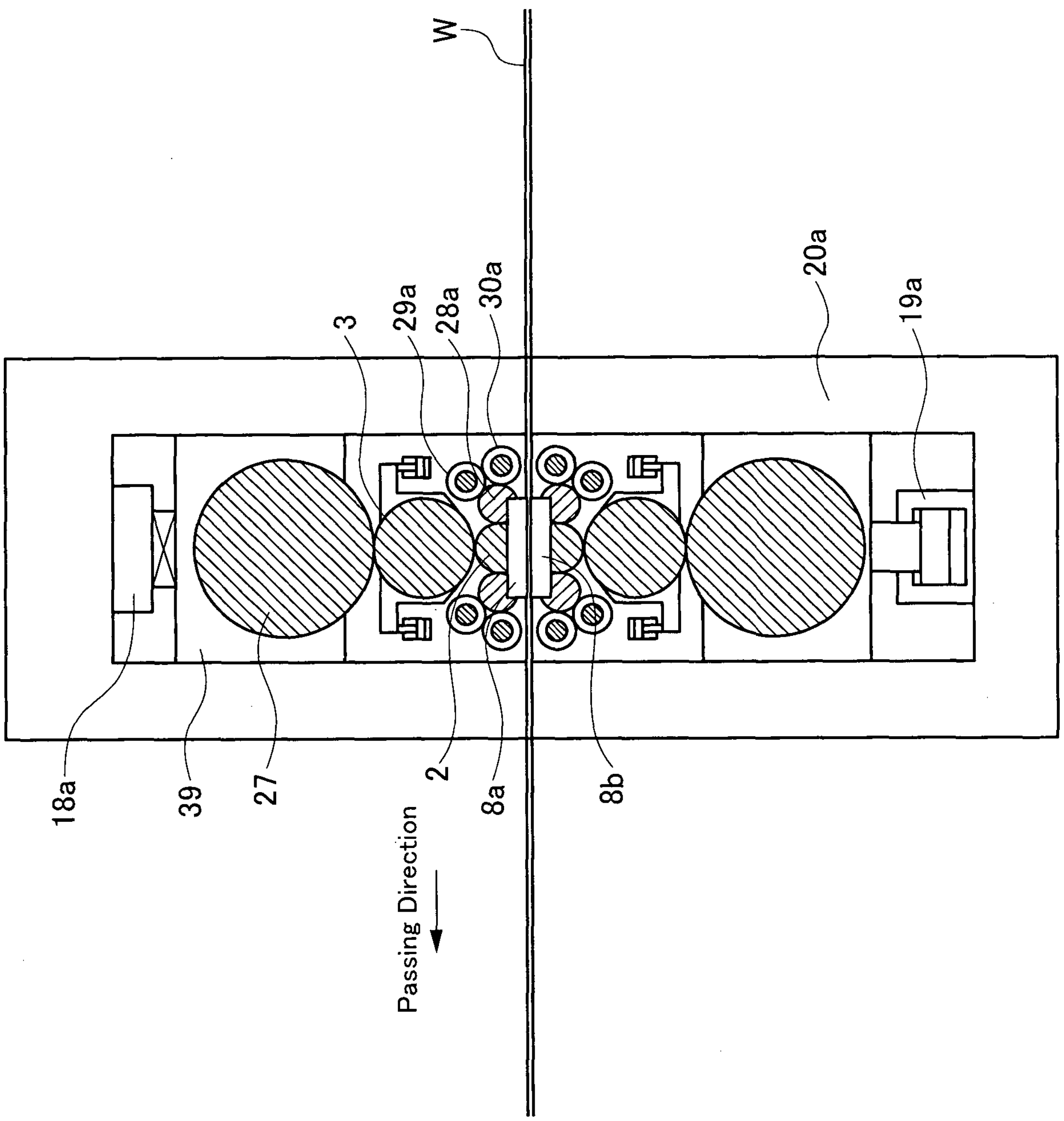


Fig.19

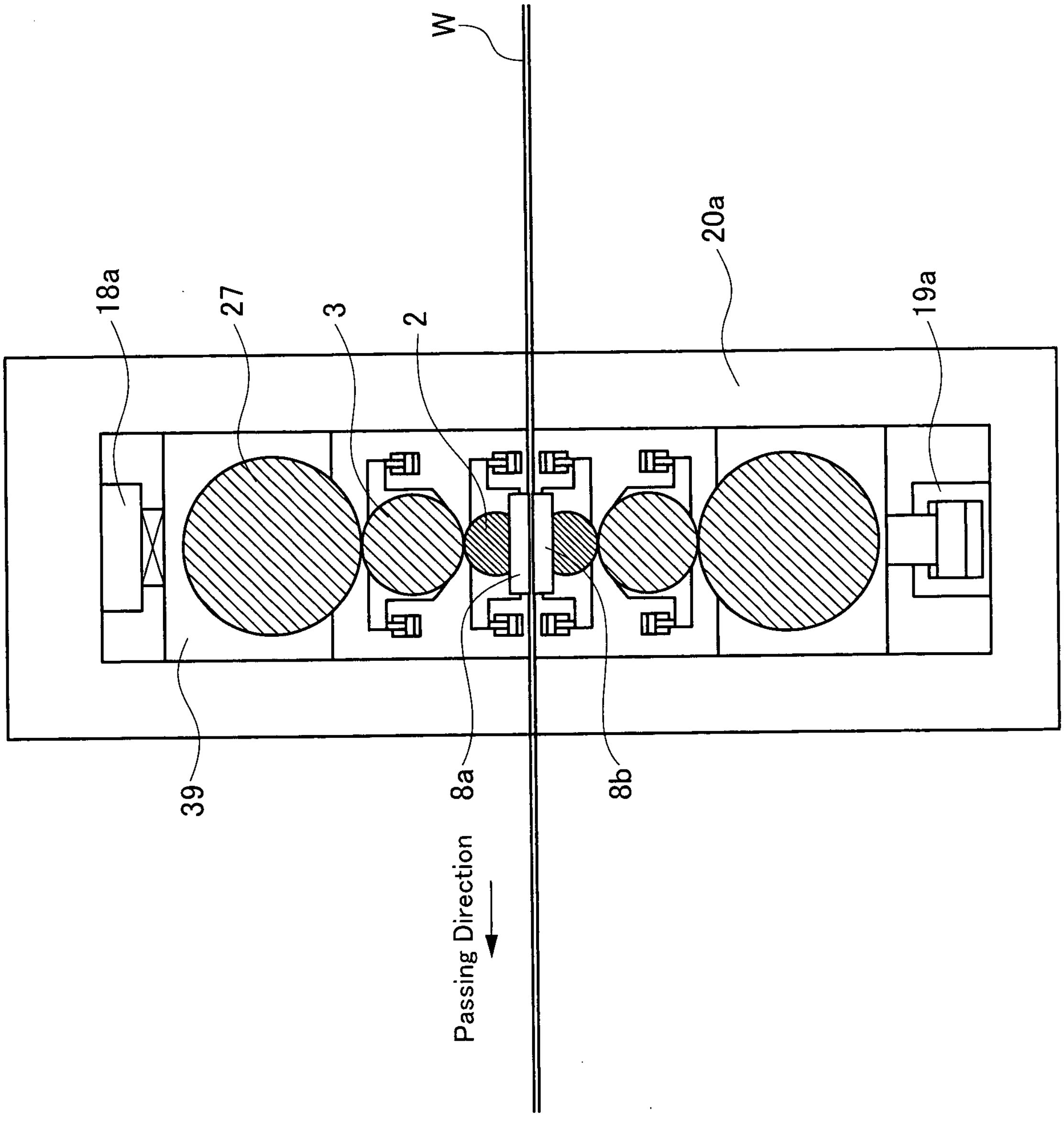


Fig.20

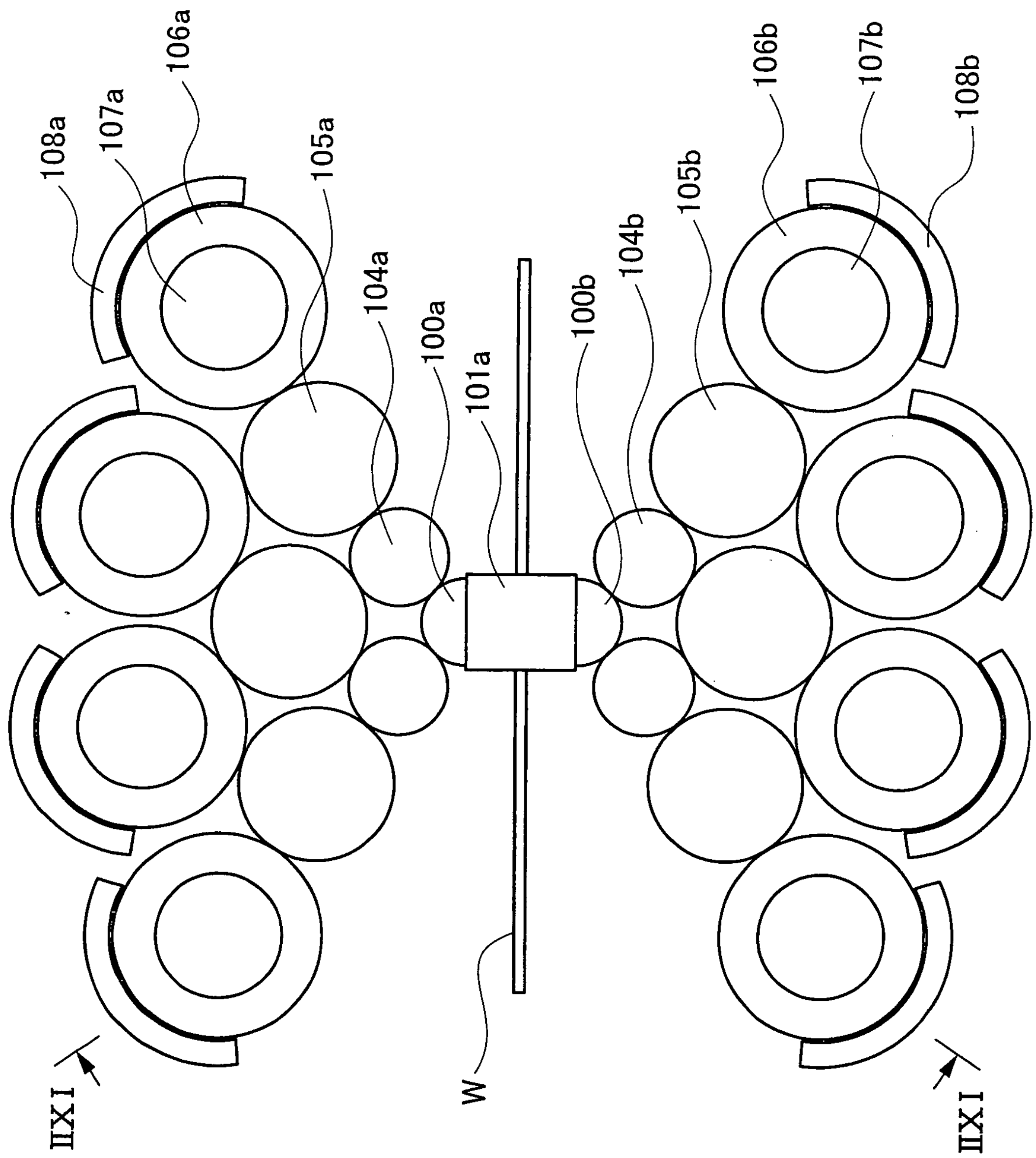
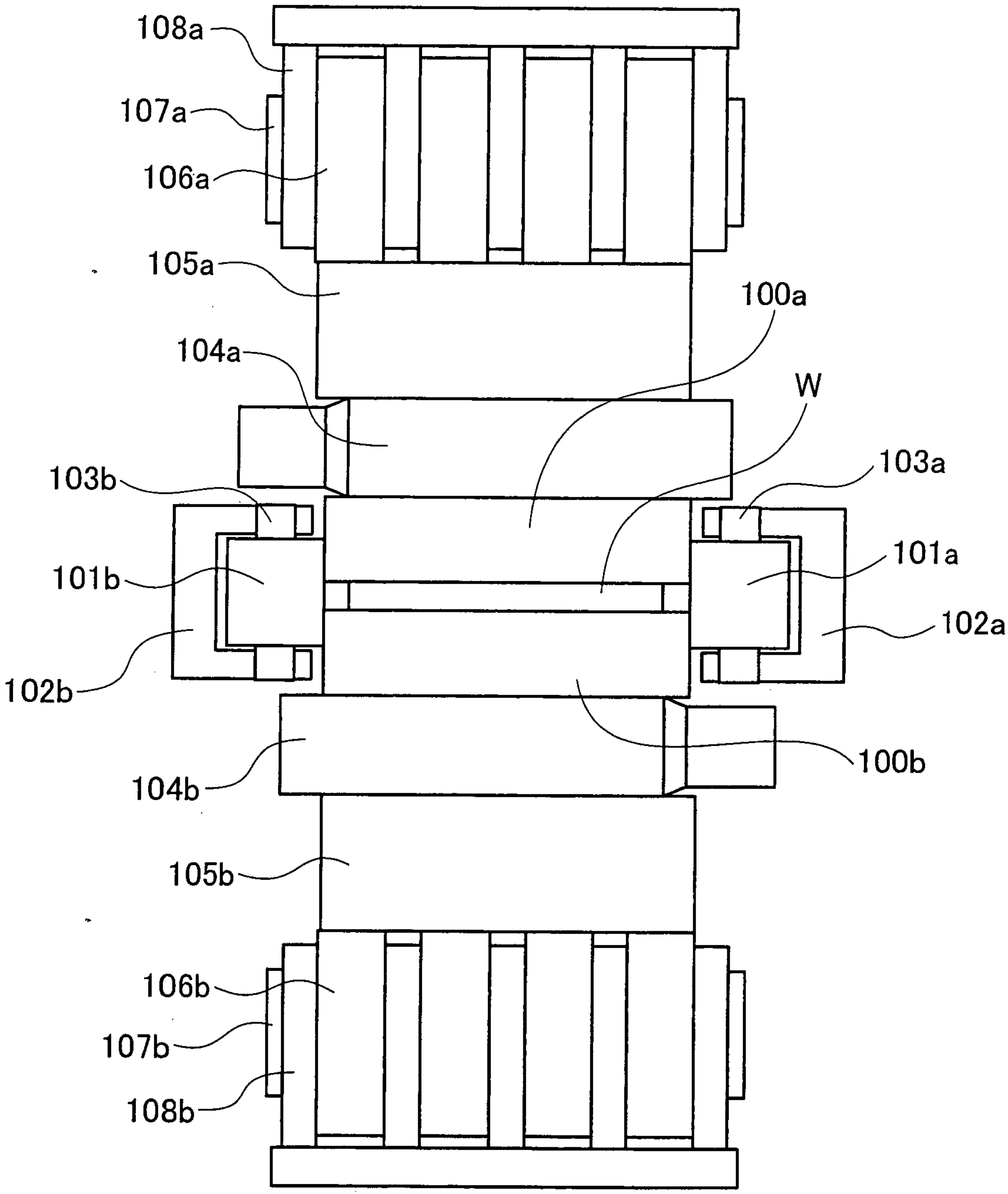

108a
107a
106a
105a
104a
100a
101a
100b
104b
105b
106b
107b
108b
W
ⅡXⅠ
ⅡXⅠ

Fig.21


108a
107a
106a
105a
100a
104a
W
103b
103a
101b
101a
102a
102b
100b
104b
105b
106b
107b
108b

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 13 00 2094

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 2 292 341 A2 (MITSUBISHI HITACHI METALS [JP]) 9 March 2011 (2011-03-09) * page 7, paragraph 50 - page 9, paragraph 79; figures 7-13 *	1-7	INV. B21B13/14
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