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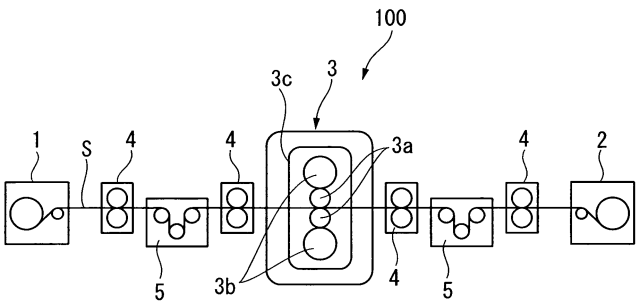
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(54) MAGNESIUM ALLOY HOT-ROLLING MILL

(57) In a magnesium alloy hot rolling apparatus (100) in which winders (1, 2) that are able to apply heat to and then maintain the temperature of a magnesium alloy sheet (S) while this sheet is in a coiled state are installed on both entry and exit sides of a rolling mill (3), and in which the magnesium alloy sheet undergoes a sequential thickness reduction via a plurality of reverse rollings, the rolling mill (3) is provided with working rollers (3a) and back-up rollers (3b) whose surface temperature can be heated to a particular fixed temperature and then maintained at this temperature. According to the present invention, it is possible to prevent any deterioration in the quality of a product which is caused by temperature variations during the hot rolling of the magnesium alloy sheet, and it is possible to improve the yield and increase productivity.

FIG. 1



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Description

[Technical Field]

[0001] The present invention relates to a magnesium alloy hot rolling apparatus.
Priority is claimed on Japanese Patent Application No. 2007-269057, filed October 16, 2007, the contents of which are incorporated herein by reference.

[Technical Background]

[0002] To manufacture a magnesium alloy sheet, a round bar-shaped billet having, for example, a diameter of approximately 300 to 400 mm and a length of approximately 500 to 600 mm is molded by hot extrusion molding into a thick plate having a thickness of, for example, 10 mm or less. This thick plate is then cut to a predetermined length (for example, 3 m) so as to form a cut plate material, and this cut plate material is then rolled to a thickness of approximately 1 mm by rough rolling.
This magnesium alloy coil which has a thickness of approximately 1 mm is then further rolled by finishing rolling so that a coil material having a thickness of approximately 0.2 to 0.5 mm or a coil having a thickness of 50 μm or less (for example, 30 to 40 μm) is manufactured.
[0003] Magnesium alloy not only requires a large amount of pressure if it is rolled at room temperature, but it also cracks easily. Accordingly, it is preferably rolled using hot rolling.
Conventional examples of apparatuses for the hot rolling of magnesium alloy are disclosed in FIG. 1 of patent document 1 and FIG. 1 of patent document 2.
The hot rolling apparatuses disclosed in these patent documents are provided with a rolling mill which reciprocatingly rolls the magnesium alloy, and with two heating furnaces which are located on the upstream side and the downstream side of the rolling mill. The magnesium alloy is heated to a predetermined temperature by these heating furnaces and is rolled in the rolling mill.

[Patent document 1] Japanese Patent Publication No. 3521863
[Patent document 2] Japanese Patent Publication No. 3821074

[Disclosure of the Invention]

[Problems to be Solved by the Invention]

[0004] However, in the hot rolling apparatuses disclosed in the aforementioned patent documents 1 and 2, the winder portion at the distal end portion of the coil and the unprocessed portion at the rear end thereof are not able to be heated and rolled with any stability. Because of this, they cannot be used for finished product coils. Furthermore, they cause the yield to drop and have other drawbacks such as not allowing the production volume to be increased.
[0005] The present invention was conceived in view of the above described circumstances and it is an object thereof to provide a magnesium alloy hot rolling apparatus which prevents any reduction in the quality of a product which is due to temperature variations during the hot rolling of a magnesium alloy, and which makes it possible to improve the yield and increase the production volume.

[Means for Solving the Problem]

[0006] In order to solve the above described problems, the following apparatuses are employed in the present invention.
As a first aspects of the present invention, in a magnesium alloy hot rolling apparatus in which winders that are able to apply heat to and then maintain the temperature of a magnesium alloy sheet while this sheet is in a coiled state are installed on both entry and exit sides of a rolling mill, and in which the magnesium alloy sheet undergoes a sequential thickness reduction via a plurality of reverse rollings, the rolling mill is provided with working rollers and back-up rollers whose surface temperature can be heated to a particular fixed temperature and then maintained at this temperature.
[0007] As a second aspects of the present invention, in the magnesium alloy hot rolling apparatus according to the above described first aspects of the present invention, it is also possible for the rolling mill to be a switchable stage rolling mill in which it is possible for small diameter working rollers which can be heated and then kept at a particular temperature to be installed.
[0008] As a third aspects of the present invention, in the magnesium alloy hot rolling apparatus according to the above described first aspects of the present invention, it is also possible for a plurality of pairs of pinch rollers which incorporate vertical rollers which can be heated and then kept at a particular temperature to be placed between the rolling mill and

each one of the pair winders so that stable transporting of the magnesium alloy coil is performed, and for tension adjustment apparatuses to be provided between the pinch rollers.

[Effects of the Invention]

[0009] According to the present invention, because working rollers and back-up rollers of a rolling mill enables to heat a magnesium alloy sheet and maintain the temperature thereof, it is possible to prevent any reduction in product quality which is due to temperature variations during the hot rolling of a magnesium alloy sheet. Furthermore, it is possible to improve the yield and increase the production capacity, and to maintain a superior quality in a sheet material or foil material.

[Brief description of the drawings]

[0010]

[FIG 1] FIG. 1 is a typical view showing the schematic structure of a hot rolling apparatus in an embodiment of the present invention.
[FIG 2] FIG 2 is a typical view showing the schematic structure of a temperature maintaining and heating winder in the aforementioned embodiment.
[FIG 3A] FIG 3A is a view showing an alteration of the setting of a rolling mill of the aforementioned embodiment.
[FIG 3B] FIG. 3B is a view showing an alteration of the setting of a rolling mill of the aforementioned embodiment.
[FIG 4A] FIG 4A is a view showing an example of a different number of rolling mill stages in the aforementioned embodiment.
[FIG 4B] FIG. 4B is a view showing an example of a different number of rolling mill stages in the aforementioned embodiment.
[FIG 5] FIG 5 is a view showing the schematic structure of a tension adjustment apparatus in the aforementioned embodiment.

[Description of the Reference Numerals]

[0011]

100	Hot rolling apparatus (Magnesium alloy hot rolling apparatus)
1	First temperature maintaining and heating winder (winder)
2	Second temperature maintaining and heating winder (winder)
1a, 2a	Winder portions
1b, 2b	Heating and a temperature maintaining furnaces
3	Rolling mill (switchable stage rolling mill)
3a	Working roller
3b	Back-up roller
4	Pinch roller
5	Tension adjustment apparatus
S .	Magnesium alloy sheet

[Best Embodiments for Implementing the Invention]

[0012] An embodiment of the present invention will now be described with reference made to the drawings.
FIG. 1 is a front view showing the structure of a hot rolling apparatus 100 in the present embodiment.
As is shown in FIG. 1, the hot rolling apparatus 100 (i.e., a magnesium alloy hot rolling apparatus) according to the present embodiment is provided with a first temperature maintaining and heating winder 1 (winder), a second temperature maintaining and heating winder 2 (winder), a rolling mill 3, a plurality of pairs of pinch rollers 4, and a tension adjustment apparatus 5.

[0013] FIG. 2 is a typical view showing the schematic structure of the first temperature maintaining and heating winder 1 and the second temperature maintaining and heating winder 2.
The two temperature maintaining and heating winders 1 and 2 are provided with winder portions 1a and 2a and with heating and a temperature maintaining furnaces 1b and 2b.
The heating and a temperature maintaining furnaces 1b and 2b have internal heaters H.

[0014] These temperature maintaining and heating winders 1 and 2 are installed on both the entry and exit sides of the rolling mill 3, and are able to heat up and then maintain the temperature of a magnesium alloy sheet while this sheet

is in a coiled state. They are also able to freely wind on or unwind both end portions in a longitudinal direction of a magnesium alloy sheet S in a coil shape using the winder portions 1a and 2a, and to heat the interiors of the heating and a temperature maintaining furnaces 1b and 2b to a predetermined temperature (a first temperature) using the heaters H and then maintain this temperature. As a result, the magnesium alloy sheet S which has been wound into a coil shape (i.e., a magnesium alloy coil) is maintained at the predetermined temperature.

The aforementioned (first temperature) is, for example, approximately 100 to 350 °C, and from 200 to 250 °C is preferable.

[0015] The description will now return to FIG. 1.

The rolling mill 3 (a rolling mill, a switchable stage rolling mill) has a pair of working rollers 3a that are placed between the aforementioned pair of temperature maintaining and heating winders 1 and 2 in parallel with and facing each other and that are able to apply heat and maintain the temperature, a pair of back-up rollers 3b that are provided in parallel with and facing the respective working rollers 3a and that are able to apply heat and maintain the temperature, a housing 3c which contains the two pairs of rollers 3a and 3b and supports them such that they are able to rotate freely, and a drive source (not shown) which drives the two pairs of rollers 3a and 3b to rotate.

[0016] The working rollers 3a and the back-up rollers 3b are heating rollers which can be heated so that the surface temperature thereof is raised to a fixed temperature and maintain the temperature thereof (a second temperature), and, while feeding the magnesium alloy sheet S in one direction between the working rollers 3a, are able to heat the magnesium alloy sheet S so as to raise the temperature thereof and roll it at the same time. Thereby, the thickness of the magnesium alloy sheet S is reduced. The working rollers 3a and the back-up rollers 3b have a structure in which, for example, a plurality of rod-shaped cartridge heaters are embedded at predetermined intervals in the axial direction at positions which are a predetermined depth from the surface.

The aforementioned (second temperature) is, for example, approximately 150 to 350 °C or less.

[0017] As a result of this, the rolling mill 3 stably reduces the thickness of the magnesium alloy sheet S so as to cause it to become elongated.

Moreover, the rolling mill 3 performs reciprocating rolling by reversing the feed direction of the magnesium alloy sheet S at a predetermined timing. By doing this, the rolling mill 3 causes the magnesium alloy sheet S to become elongated by reducing the thickness thereof from, for example, a thickness of approximately 1 mm to a thickness of approximately 0.2 to 0.5 mm or to 50 μm or less (for example, to 30 to 40 μm).

[0018] Here, the rolling mill 3 of the present embodiment is a switchable stage rolling mill in which it is also possible for small diameter working rollers to be installed. FIG. 3A shows a rolling mill 3 which has been set as a four-stage structure (i.e., the structure shown in FIG. 1), while FIG. 3B shows a rolling mill 3 which has been set as a ten-stage structure. This type of rolling mill 3 is normally set as the four-stage structure shown in FIG. 3A, however, for a thin material, for example, for a 50 μm foil material, as is shown in FIG. 3B, the rolling mill 3 can be altered to a ten-stage structure which has a pair of small-diameter working rollers 3d and two vertically aligned pairs of horizontal support rollers 3e provided on an intermediate path thereof.

[0019] FIG. 4 shows another structural example of this type of rolling mill 3. FIG. 4A shows a rolling mill 31 having a six-stage structure, while FIG 4B shows a rolling mill 32 having a ten-stage structure.

The rolling mill 31 has a pair of working rollers 3a and two pairs of back-up rollers 3b, while the rolling mill 32 has a pair of working rollers 3a and four pairs of back-up rollers 3b.

Here, of the four pairs of back-up rollers 3b of the rolling mill 32, the two pairs on the inner side (i.e., the ones in contact with the working rollers 3a) are known as intermediate rollers.

[0020] The description will now return to FIG 1.

Similar to the above described working rollers 3a and back-up rollers 3b, the pinch rollers 4 have a plurality of rod-shaped cartridge heaters embedded at predetermined intervals in the axial direction at positions which are a predetermined depth from the surface. These pinch rollers 4 are heating rollers whose surface temperature is raised to a suitable temperature and the temperature is maintained (for example, from 150 °C to 350 °C), and provide auxiliary transporting for the magnesium alloy sheet S which is traveling left or right in conjunction with the reciprocating rolling of the rolling mill 3. A plurality of sets of these pinch rollers 4 are provided respectively between the rolling mill 3 and the first temperature maintaining and heating winder 1, and between the rolling mill 3 and the second temperature maintaining and heating winder 2.

By adjusting the transporting speed, the pinch rollers 4 can be made to impart suitable tensile force to the magnesium alloy sheet S which is being rolled by the rolling mill 3.

[0021] The tension adjustment apparatuses 5 are sandwiched between two adjacent pairs of pinch rollers 4 and, as is shown in FIG. 5, are each provided with two fixed rollers 5a and one dancer roller 5b. The magnesium alloy sheet S is entrained such that the dancer roller 5b is suspended between the two fixed rollers 5a by the magnesium alloy sheet S, and the tension thereof is controlled by the vertical movement of the dancer roller 5b such that measurement values of a separately installed tension meter (not shown) stay constant.

[0022] In this type of structure, a hot rolling apparatus 100 performs finishing rolling on the magnesium alloy sheet S. Hereinafter, the operation of the hot rolling apparatus 100 will be described.

[0023] The magnesium alloy sheet S is rolled by the rolling mill 3 while being transported in one direction by being unwound from the first temperature maintaining and heating winder 1 and wound onto the second temperature maintaining and heating winder 2, or by being unwound from the second temperature maintaining and heating winder 1 and wound onto the first temperature maintaining and heating winder 2.
The temperature of the magnesium alloy sheet S drops somewhat between the first temperature maintaining and heating winder 1 and the second temperature maintaining and heating winder 2. However, because the working rollers 3a, the back-up rollers 3b and the pinch rollers 4 are heating rollers, there is little temperature drop or temperature variation in the material caused by the material contacting these rollers.

[0024] When the unwinding of the magnesium alloy sheet S from the first temperature maintaining and heating winder 1 (or the second temperature maintaining and heating winder 2) has finished, the hot rolling apparatus 100 reverses the rolling direction. The hot rolling apparatus 100 repeats this process so that the magnesium alloy sheet S is rolled reciprocatingly, and the thickness of the magnesium alloy sheet S is sequentially reduced. As a result, a sheet material having a thickness of approximately 0.2 to 0.5 mm, or a foil material having a thickness of 50 μm or less (for example, 30 to 40 μm) is manufactured.
Here, specific examples of pass schedules of finishing rolling performed by this hot rolling apparatus 100 are shown below in Table 1.

[0025]

[Table 1]

Pass No.	Entry side thickness (mm)	Reduction amount (mm)	Rolling temperature (°C)	Working roller diameter(mm)	Rolling speed (m/sec)	Rolling load (ton)
1	1.00	0.30	200	165	30	60
2	0.70	0.21	200	165	30	58
3	0.49	0.15	200	165	30	55
4	0.34	0.10	200	165	30	52
5	0.24	0.07	200	165	30	50
6	0.17	0.05	150	60	30	30
7	0.12	0.04	150	60	30	29
8	0.08	0.02	150	60	30	28
9	0.06	0.02	150	60	30	27
Final thickness 0.04 mm						

[0026] In the above pass schedule, the magnesium alloy sheet S is a coil material having a material quality of AZ31B, a thickness of 1.00 mm, and a width of 300 mm. The rolling mill 3 has four stages. The diameter of each roller of the working roller pairs 3a is 165 mm and the barrel length thereof is 500 mm, while the diameter of each of the back-up rollers 3b is 300 mm, and the diameter of each of the pinch rollers 4 is 150 mm.
Moreover, in the above described example, the temperature which the interiors of the two temperature maintaining and heating winders 1 and 2 are heated to and held at is 250 °C, while the working rollers 3a, the back-up rollers 3b, and the pinch rollers 4 are heating rollers having internal heaters and the surface temperature of these is set to 200 °C.
The rolling speed was set to a fixed speed of 30 m/ minute, and nine passes (i.e., four and a half reciprocations) of reciprocating rolling were performed resulting in a foil material having a final thickness of 0.04 mm being obtained. Moreover, on the sixth pass, the rolling mill was switched to a ten-stage small-diameter mill (i.e., to working rollers having a diameter of ϕ 60 mm), and this was subsequently used until the final pass (i.e., the ninth pass).

[0027] The magnesium alloy sheet S is soft during the rolling process due to the high temperature, and there is a possibility that pitting will remain if high pressure is also applied to areas other than those areas where the rolling mill 3 is used. However, in the hot rolling apparatus 100 of the present invention, because the magnesium alloy sheet S is nipped in a plurality of locations by a plurality of groups of pinch rollers 4, the force with which each pinch roller 4 nips the magnesium alloy sheet S is small as a result of being dispersed, and there is no concern that pitting from the pinch rollers 4 will remain.

[0028] Moreover, in this hot rolling apparatus 100, the tension of the magnesium alloy sheet S is kept constant from one pinch roller 4 to the next pinch roller 4 by the tension adjustment apparatus 5. As a result, any twisting or wrinkling

of the magnesium alloy sheet S is prevented, and stable rolling is guaranteed.

[0029] According to this type of hot rolling apparatus 100, because a magnesium alloy sheet S is rolled while substantially the entire length thereof is heated and held at a predetermined temperature, it is possible to suppress any drop in the temperature of the magnesium alloy sheet S, and it is possible to prevent any deterioration in the quality of a product which is caused by temperature variations during the hot rolling. Accordingly, it is possible to improve the yield and increase the production volume, and it is also possible to maintain a superior finished product, namely, a superior quality in the sheet material or foil material.

[0030] Note that in the present embodiment four-stage, six-stage, and ten-stage rolling mills are illustrated, however, the present embodiment is not limited to this.

[Industrial applicability]

[0031] Because the magnesium alloy hot rolling apparatus of the present invention is constructed such that working rollers and back-up rollers of the rolling mill are able to apply heat to a magnesium alloy sheet and to hold the temperature thereof, it is possible to prevent any deterioration in the quality of a product which is caused by temperature variations during the hot rolling of the magnesium alloy sheet. Furthermore, it is possible to improve the yield and increase productivity, and it is also possible to maintain a superior quality in the sheet material or foil material.

Claims

1. A magnesium alloy hot rolling apparatus in which winders that are able to apply heat to and then maintain the temperature of a magnesium alloy sheet while this sheet is in a coiled state are installed on both entry and exit sides of a rolling mill, and in which the magnesium alloy sheet undergoes a sequential thickness reduction via a plurality of reverse rollings, wherein
   the rolling mill is provided with working rollers and back-up rollers whose surface temperature can be heated to a particular fixed temperature and then maintained at this temperature.

2. The magnesium alloy hot rolling apparatus according to claim 1, wherein the rolling mill is a switchable stage rolling mill in which it is possible for small diameter working rollers which can be heated and then kept at a particular temperature to be installed.

3. The magnesium alloy hot rolling apparatus according to claim 1 or 2, wherein a plurality of pairs of pinch rollers which incorporate vertical rollers which can be heated and then kept at a particular temperature are placed between the rolling mill and each one of the pair winders so that stable transporting of the magnesium alloy coil is performed, and wherein tension adjustment apparatuses are provided between the pinch rollers.

FIG. 1

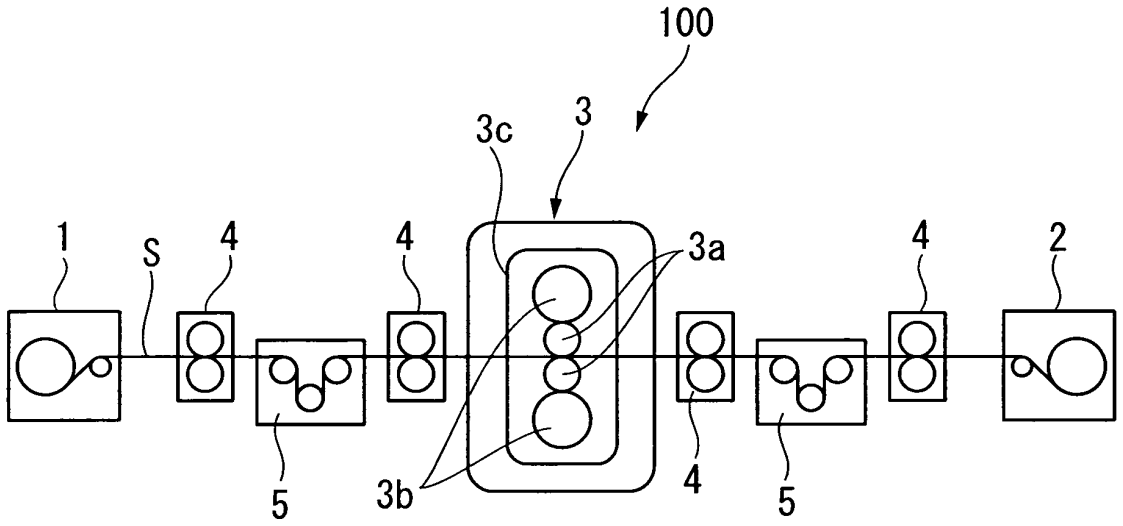


FIG. 2

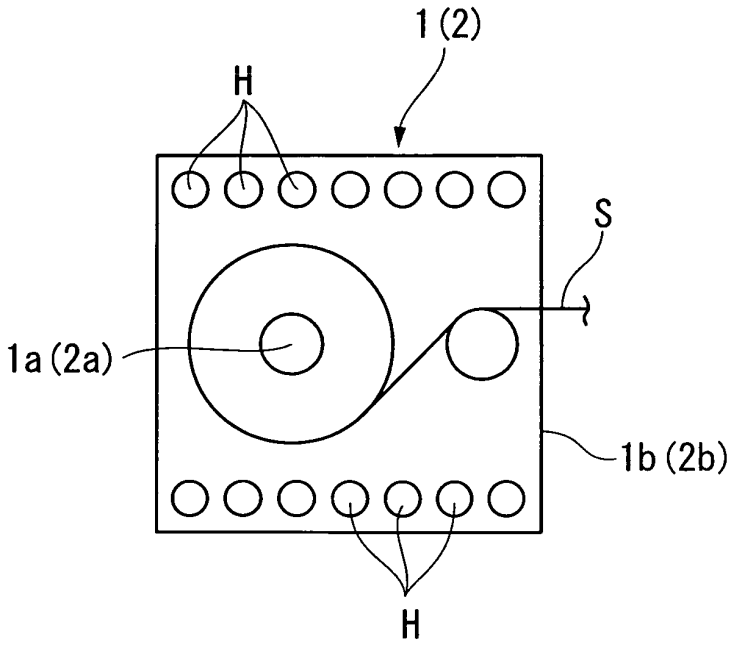


FIG. 3A

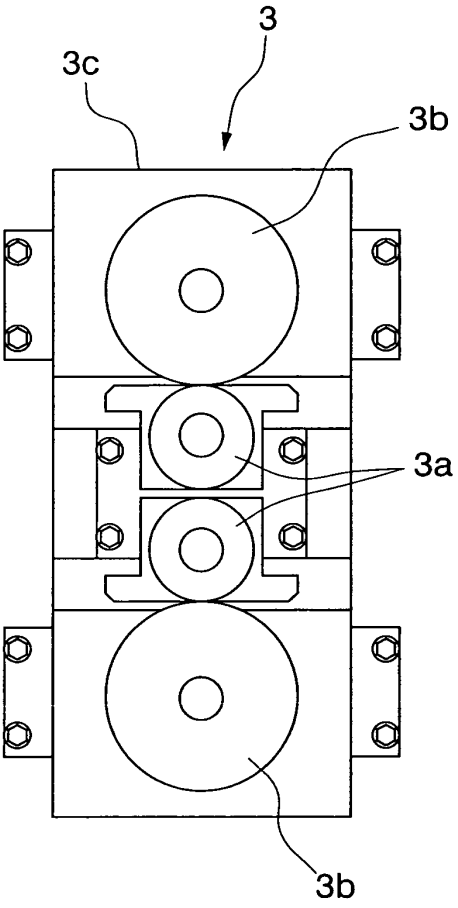


FIG. 3B

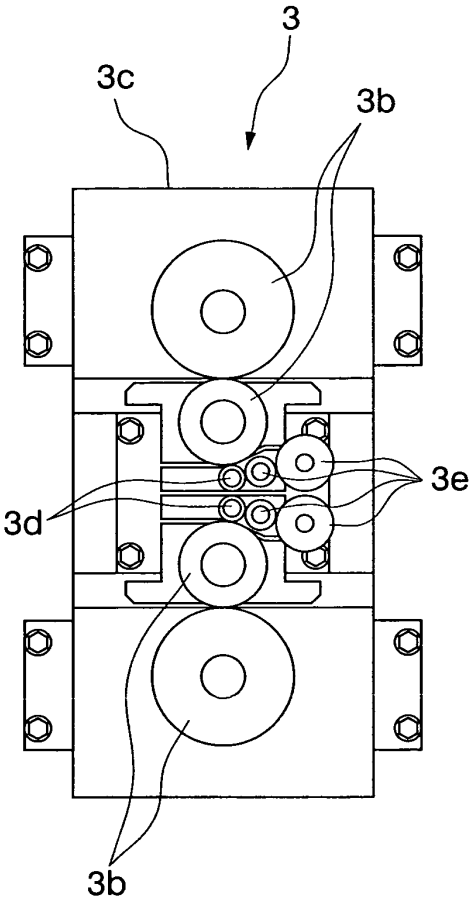


FIG. 4A

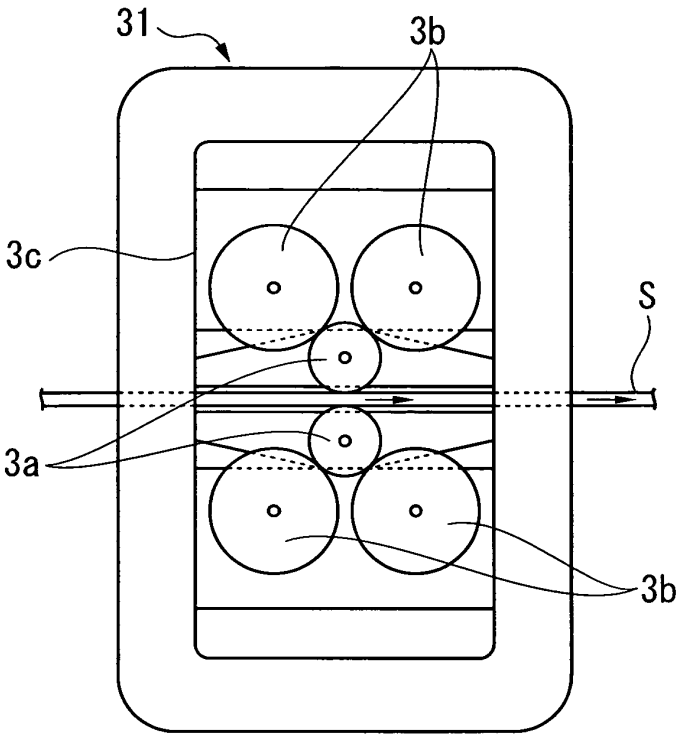


FIG. 4B

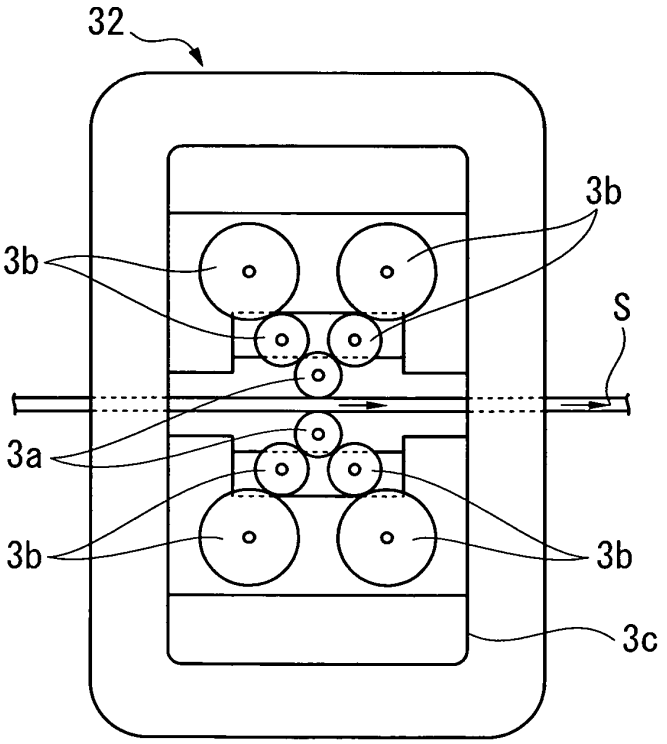
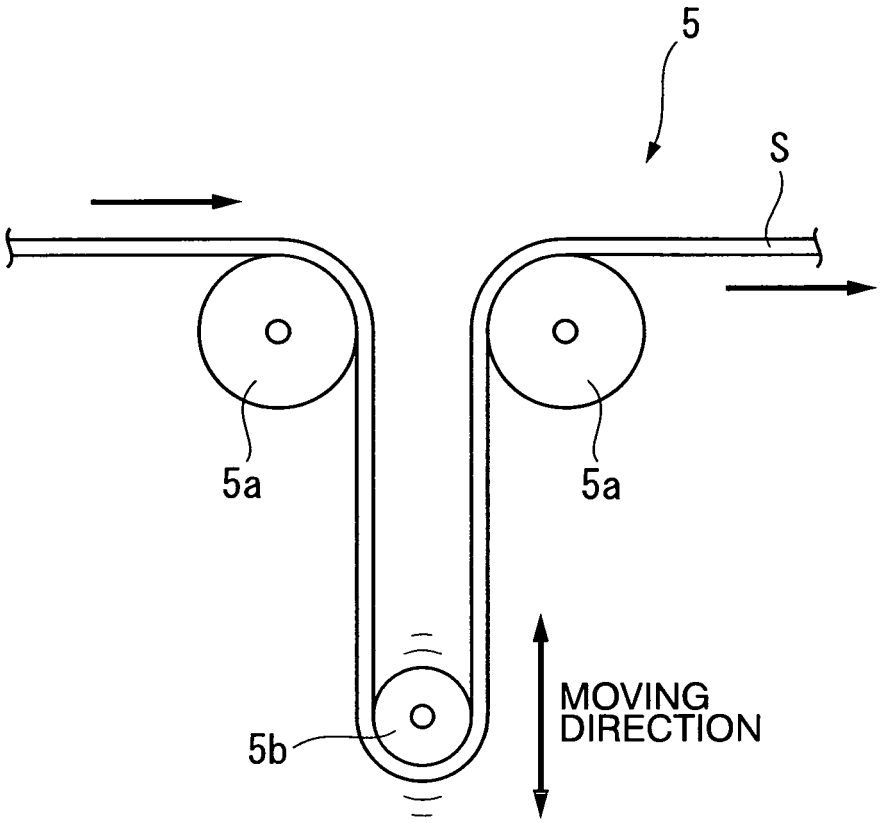


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/068745

A. CLASSIFICATION OF SUBJECT MATTER
B21B1/32(2006.01)i, *B21B3/00*(2006.01)i, *B21C47/00*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B21B1/32, B21B3/00, B21C47/00, B21B39/08, B21B45/00, B21B13/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2008
Kokai Jitsuyo Shinan Koho 1971-2008 Toroku Jitsuyo Shinan Koho 1994-2008

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2004-66302 A (Tadamasa FUJIMURA), 04 March, 2004 (04.03.04), Claims; Par. Nos. [0052] to [0054]; Fig. 1 (Family: none)	1 2,3
Y	JP 10-175002 A (Ishikawajima-Harima Heavy Industries Co., Ltd.), 30 June, 1998 (30.06.98), Claims (Family: none)	2,3
Y	JP 8-264261 A (Nippon Steel Corp.), 11 October, 1996 (11.10.96), Claims; Figs. 1, 2 (Family: none)	3

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

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
30 October, 2008 (30.10.08)	11 November, 2008 (11.11.08)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/068745

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2003/008121 A1 (Haruna Corp.), 30 January, 2003 (30.01.03), Fig. 1 (Family: none)	3
A	JP 9-327715 A (Nisshin Steel Co., Ltd.), 22 December, 1997 (22.12.97), Claims; Fig. 1 (Family: none)	1-3

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2007269057 A **[0001]**
- JP 3521863 B **[0003]**
- JP 3821074 B **[0003]**