



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

(43) Date of publication:
28.10.2015 Bulletin 2015/44

(51) Int Cl.:
B21C 47/28 ^(2006.01) **B21C 47/18** ^(2006.01)
B21C 47/14 ^(2006.01)

(21) Application number: **13868911.2**

(86) International application number:
PCT/KR2013/010522

(22) Date of filing: **20.11.2013**

(87) International publication number:
WO 2014/104578 (03.07.2014 Gazette 2014/27)

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

(30) Priority: **24.12.2012 KR 20120152582**
14.11.2013 KR 20130138645

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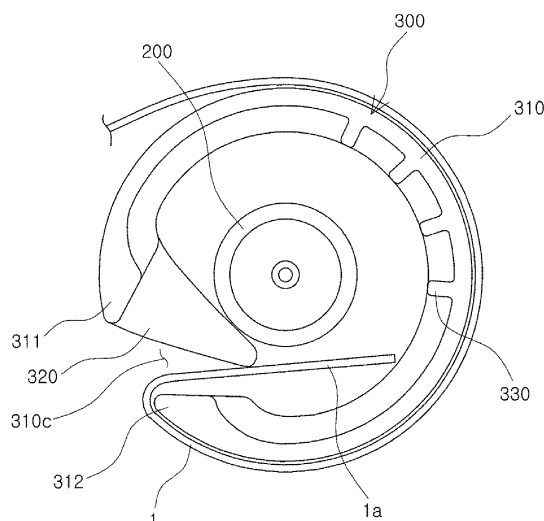
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(54) **MANDREL OF COIL BOX**

(57) A mandrel of a coil box, according to the present invention, comprises: a cylindrical mandrel body having a center shaft disposed therein and a slot into which a front end portion of a hot bar is inserted; and a guide part

which is arranged towards the inside of the mandrel body from a peripheral wall of one side of the slot so as to prevent the cooling and plastic deformation of the front end portion of the bar inserted through the slot.

【Figure 7】



Description

[Technical Field]

5 **[0001]** The present disclosure relates to a mandrel of a coil box, and more particularly, to a mandrel of a coil box for preventing cooling and plastic deformation of a leading end portion of a bar inserted through a slot in the mandrel and reducing the insertion length of the leading end portion.

[Background Art]

10 **[0002]** FIG. 1 is a view illustrating a rolling apparatus including a coil box 100 in the related art.

15 **[0003]** Referring to FIG. 1, a continuous casting process is performed using a ladle 5 filled with molten steel refined in a steel making process, a tundish 10 configured to receive the molten steel from the ladle 5 through an injection nozzle connected to the ladle 5 and temporarily store the molten steel, a mold 15 configured to receive the molten steel and initially solidify the molten steel in a predetermined shape, and a plurality of segments 20 disposed below the mold 15 to perform a series of operations for bending or stretching a non-solidified slab while cooling the slab.

20 **[0004]** In such a continuous casting process, a slab is cooled and reduced while passing through the segments 20. After passing through the segments 20, the slab may be subjected to rough rolling, shearing, and heating by a roughing mill 25, shears 30 and 35, and an inductive heater 40.

25 **[0005]** The slab may be formed as a bar 1 through such processes and fed to the coil box 100 so as to be coiled or uncoiled.

30 **[0006]** For example, if coiling or uncoiling in the coil box 100 is delayed, a bar 1, being continuously fed, may be processed as plate scrap by the shears 30 and 35.

35 **[0007]** A shear 45, a finishing mill 50, a run-out table 55, a final shear 60, and a coiler 70 may be sequentially arranged after the coil box 100 so that the bar 1 discharged from the coil box 100 may be continuously rolled, sheared, and coiled as a coil.

40 **[0008]** The above-explained processes are examples to which a coil box of the present disclosure may be applied. The coil box of the present disclosure may be used in various steel processing processes.

45 **[0009]** In a hot direct rolling process, the coil box 100 functions as a buffer to allow a continuous process. The coil box 100 will now be described in more detail with reference to FIGS. 2 to 5.

50 **[0010]** FIG. 2 is a perspective view illustrating the coil box 100 in the rolling apparatus illustrated in FIG. 1, FIG. 3 is another perspective view illustrating the coil box 100 of FIG. 2, FIG. 4 is a plan view illustrating the coil box 100 of FIG. 2, and FIG. 5 is a cross-sectional view taken along line I-I' of FIG. 4.

55 **[0011]** The coil box 100 may coil a roughly-rolled bar 1 and maintain the bar 1 at a constant temperature to reduce temperature and texture differences between the leading and trailing ends of the bar 1.

60 **[0012]** An introduction unit 112 is installed in front of the coil box 100, and a bar 1 is introduced to the coil box 100 through the introduction unit 112. A leveler 116 is installed behind the coil box 100, and the bar 1 is discharged through the leveler 116.

65 **[0013]** A carousel 130 may be disposed in the coil box 100 for coiling or uncoiling a bar 1. The carousel 130 may swing mandrels 132 to shift the positions of the mandrels 132. The carousel 130 may be connected to a driving unit 140.

70 **[0014]** The carousel 130 may include the mandrels 132 and rotating wheels 134.

75 **[0015]** The mandrels 132 are provided as a pair. One of the mandrels 132 (first mandrel 132) is used to coil a bar 1 introduced to the coil box 100, and the other of the mandrels 132 (second mandrel 132') is used to uncoil and discharge another bar 1, previously coiled.

80 **[0016]** After the first mandrel 132 coils a bar 1 and the second mandrel 132' uncoils a bar 1, the carousel 130 may rotate the rotating wheels 134 using the driving unit 140 to shift the positions of the first and second mandrels 132 and 132'. Then, the first mandrel 132 around which the bar 1 is coiled uncoils the bar 1, and the second mandrel 132' around which no bar 1 is coiled coils a newly-introduced bar 1.

85 **[0017]** In this manner, the carousel 130 shifts the positions of the first and second mandrels 132 and 132' to shift coiling and uncoiling and thus to allow for continuous processing.

90 **[0018]** Motors 136 may be connected to the first and second mandrels 132 and 132' to rotate the first and second mandrels 132 and 132', and decelerators 138 may be connected to the first and second mandrels 132 and 132' to control the rotating speeds thereof.

95 **[0019]** In the above-described coil box 100, a passage through which a leading end portion of a bar 1 is inserted into the mandrel 132 (hereinafter, the first and second mandrels 132 and 132' will be collectively referred to as a mandrel 132) for coiling may be precisely tracked and controlled so as to prevent coiling failure and perform a continuous process without interruption.

[Disclosure]

[Technical Problem]

5 **[0020]** An aspect of the present disclosure may provide a mandrel of a coil box, the mandrel including a guide part protruding from an edge wall of a slot of the mandrel into the mandrel to prevent a leading end portion of a bar inserted through the slot from making contact with a center shaft, thereby preventing cooling and plastic deformation of the leading end portion and reducing the insertion length of the leading end portion.

10 [Technical Solution]

[0021] According to an aspect of the present disclosure, a mandrel of a coil box includes: a cylindrical mandrel main body in which a center shaft is disposed, the mandrel main body including a slot to receive a leading end portion of a high-temperature bar; and a guide part formed from an edge wall of the slot toward an inner side of the mandrel main body so as to prevent cooling and plastic deformation of the leading end portion of the bar inserted through the slot.

15 **[0022]** The guide part may protrude from the edge wall of the slot to prevent the leading end portion of the bar from making contact with the center shaft when the leading end portion of the bar is inserted through the slot.

[0023] An inner end of the guide part may be spaced apart from an inner end of an opposite edge wall of the slot by 90 mm to 110 mm.

20 **[0024]** The guide part may be sloped in a manner such that an inner gap of the slot is smaller than an outer gap of the slot.

[0025] An outer end of the guide part may be spaced apart from an outer end of an opposite edge wall of the slot by 200 mm to 300 mm.

[0026] The guide part may be formed in one piece with the mandrel main body and may extend from the edge wall of the slot toward the inner side of the mandrel main body. The guide part may protrude from the edge wall of the slot and taper toward the inner side of the mandrel main body.

25 **[0027]** A counterweight may be provided on a side of the mandrel main body opposite to the guide part so as not to bias a center of gravity of the mandrel toward the guide part.

[Advantageous Effects]

30 **[0028]** As set forth above, according to exemplary embodiments of the present disclosure, the guide part protruding from the edge wall of the slot of the mandrel into the mandrel prevents a leading end portion of a bar inserted through the slot from making contact with the center shaft, thereby preventing cooling and plastic deformation of the leading end portion and reducing the insertion length of the leading end portion.

35 **[0029]** Therefore, during thin-plate rolling, a tail portion (corresponding to a leading end portion of a bar in mandrel coiling) may have a uniform temperature and thus may not be curled or tangled. Thus, work rolls may not be damaged by a curled or tangled bar, and product quality may not be deteriorated.

[0030] In addition, the length of a leading end portion of a bar inserted through the slot into the mandrel may be shortened, and when the bar is coiled around the mandrel, a portion of the bar making contact with the opposite edge wall of the slot may not be easily bent and plastically deformed. That is, deflection of the leading end portion of the bar may be prevented when the bar is coiled, and since the leading end portion is brought into contact with the guide part and supported on the guide part with an appropriate contact force therebetween, initial turns of the bar may be smoothly formed when the bar is coiled around the mandrel. Thus, the coiling process may not be suspended due to initial turn errors.

45 [Description of Drawings]

[0031]

FIG. 1 is a view illustrating a rolling apparatus including a coil box according to the related art;
 50 FIG. 2 is a perspective view illustrating the coil box of the rolling apparatus illustrated FIG. 1;
 FIG. 3 is another perspective view illustrating the coil box of FIG. 2;
 FIG. 4 is a plan view illustrating the coil box of FIG. 2;
 FIG. 5 is a cross-sectional view taken along line I-I' of FIG. 4;
 FIG. 6 is a view illustrating how the leading end portion of a bar is inserted into a slot of a mandrel and is coiled in the related art; and
 55 FIG. 7 is a view illustrating how the leading end portion of a bar is inserted into a slot of a mandrel of a coil box and is coiled according to an exemplary embodiment of the present disclosure.

[Best Mode]

[0032] First, with reference to FIG. 6, an explanation will be given of how a leading end portion 1a of a bar 1 is inserted into a slot 132a of a mandrel 132 and is coiled in the related art.

[0033] FIG. 6 is a view illustrating how the leading end portion 1a of the bar 1 is inserted into the slot 132a of the mandrel 132 and is coiled in the related art.

[0034] Referring to FIG. 6, the bar 1, heated to a high temperature and having a thickness of 16 mm to 23 mm, is coiled in the mandrel 132 as follows. The leading end portion 1a of the bar 1 is inserted into the mandrel 132 through the slot 132a (having a gap of 310 mm) by a length of about 800 mm to 1,000 mm. Then, the leading end portion 1a of the bar 1 is brought into contact with a center shaft 133 of the mandrel 132, and as the mandrel 132 rotates, the leading end portion 1a is brought into contact with an opposite edge wall 132c of the slot 132a. Then, the leading end portion 1a is bent at a position making contact with the opposite edge wall 132c and brought into contact with the outer surface of the mandrel 132. In this manner, an initial inner turn of the bar 1 is formed and the bar 1 is coiled.

[0035] The center shaft 133 is disposed in the mandrel 132 to support the mandrel 132 placed in a coil box having a high temperature (1,100°C), and coolant flows in the center shaft 133.

[0036] Although the center shaft 133 is coated with an insulator having a triple structure, the leading end portion 1a (about 800 mm to 1,000 mm) of the bar 1, inserted in the mandrel 132 and making contact with the center shaft 133, is inevitably cooled because temperature around the center shaft 133 is about 650°C due to the influence of coolant flowing in the center shaft 133.

[0037] Furthermore, during finishing rolling, a cooled portion of the bar 1 may be rolled at a temperature lower than an Ar3 transformation point to cause structural failures and texture errors, and during thin-plate rolling, a tail portion may have a non-uniform temperature and thus may be curled or tangled. Such failures or defects may damage work rolls to result in product quality deterioration and even workplace accidents such as roll breakage. The above-mentioned tail portion may correspond to the leading end portion 1a of the coiled bar 1. That is, during uncoiling, the leading end portion 1a becomes a tail portion.

[0038] In a finishing rolling process, it may be important to maintain the entire length and width of a hot-rolled coil at a uniform finishing mill delivery temperature (FDT) equal to or higher than an Ar3 transformation point (870°C).

[0039] However, when a bar 1 is processed by a finishing mill (FM), the tail of the bar 1 (a leading end portion in a mandrel coiling process) enters the FM in a state in which the tail has a temperature lower than that of the other normal part of the bar 1 by about 100°C because the structure of the mandrel 132 used to coil the bar 1. When the tail exits the FM, the tail has a temperature of 800°C or lower. Therefore, the bar 1 processed by the FM may not satisfy properties required of steel sheets.

[0040] So as not to deliver such defective products to customers, defective portions of the products are removed before packaging. However, this lowers the process yield.

[0041] Specific examples showing effects of such temperature decreases are listed in Table 1.

[Table 1]

	Standards	Sampling positions (skin-pass top portion)					Elongation range		FDT (minimum)
HS5282601	JS-SPHC	0m	5m	10m	15m	20m	Lower limit	Upper limit	822°C
Analysis results (3,lt)	TS	408	418	393	401	391	270	-	
	YP	322	321	290	291	279		-	
	EL	24	25	30	34	34	27	-	
[Sampling positions and texture test results] * FDT: Finishing Mill Delivery Temperature (temperature of bar 1 after finishing rolling).									

[0042] A relatively low-temperature portion of a coil corresponding to the tail of a bar 1 in a skin pass rolling process (the tail was a leading end portion in a mandrel coiling process) was sampled at intervals of 5 m, and mechanical properties of the samples were measured in a length direction thereof. Samples collected within 5 m from the end of the tail did not satisfy the lower limit of a target range of elongation. The results of texture defects are shown in Table 1.

[Structure analysis results for different sampling positions]

[0043] In addition, the structures of the samples were analyzed, and mixed-grain structures were observed until about

20 m. Therefore, in the related art, a leading end portion 1a (about 800 mm to 1,000 mm) of a bar 1 inserted in the mandrel 132 is cut off because the leading end portion 1a causes texture defects. For example, before collecting quality test samples from a coil, the sampling length is calculated based on the thickness of the coil so as to fully detect and remove defective portions.

[0044] Therefore, an intermediate inspector or an operator of a skin pass mill may be overburdened, and a skin pass rolling process may be additionally performed. In addition, the yield of the skin pass rolling process may be lowered because defective portions are cut off.

[0045] A bar 1 is coiled using the mandrel 132 as follows. A leading end portion 1a of the bar 1 is inserted into the mandrel 132 through the slot 132a of the mandrel 132, and then the leading end portion 1a is supported on the center shaft 133 and the opposite edge wall 312. Therefore, as the mandrel 132 is rotated, the leading end portion 1a is bent, and an initial turn of a coil is formed.

[0046] At this time, the bar 1 may receive a force (F) and torque expressed as follows: torque = force (F) x length (L) where the length (L) is a distance between a point of action and a rotation center. As the length (L) increases, the bar 1 may be bent by a smaller force. Therefore, the bar 1 may be easily bent and plastically deformed. That is, in the mandrel 132, the bar 1 may be plastically bent at a portion between the center shaft 133 and the opposite edge wall 312 of the slot 132a, and thus equilibrium of forces may collapse due to plastic deformation of the bar 1.

[0047] In the worst case, initial turns of a coil may be defectively formed due to deflection, and a coiling process may be frequently suspended. Therefore, a mandrel having an improved structure may be required.

[0048] A mandrel 300 of a coil box improved according to the present disclosure will now be described in comparison with the mandrel 132 of the related art shown in FIG. 6.

[0049] FIG. 7 is a view illustrating how a leading end portion 1a of a bar 1 is inserted into a slot 310c of the mandrel 300 and is coiled according to an exemplary embodiment of the present disclosure.

[0050] Referring to FIG. 7, the mandrel 300 includes a mandrel main body 310 in which the slot 310c is formed, and a guide part 320 formed on an edge wall 311 of the slot 310c of the mandrel main body 310.

[0051] A center shaft 200 is disposed in the mandrel main body 310, and the slot 310c is formed in the mandrel main body 310 to receive the leading end portion 1a of the bar 1. Coolant flows in the mandrel 300, and thus the temperature of the mandrel 300 is lower than the bar 1 having a high temperature.

[0052] The guide part 320 is formed from the edge wall 311 of the slot 310c toward an inner side of the mandrel main body 310 so as to prevent cooling and plastic deformation of the leading end portion 1a of the bar 1 inserted through the slot 310c.

[0053] The guide part 320 may protrude from the edge wall 311 of the slot 310c so as to prevent the leading end portion 1a of the bar 1 from making contact with the center shaft 200 when the leading end portion 1a of the bar 1 is inserted through the slot 310c.

[0054] Owing this structure, when the leading end portion 1a of the bar 1 is inserted, the leading end portion 1a is not brought into contact with the center shaft 200 having a relatively low temperature and thus is not cooled to a temperature lower than a proper temperature.

[0055] Therefore, during thin-plate rolling, a tail portion (corresponding to a leading end portion of a bar in mandrel coiling) may have a uniform temperature and thus may not be curled or tangled. Thus, work rolls may not be damaged, and product quality may not be deteriorated.

[0056] In addition, since the leading end portion 1a of the bar 1 is inserted through the slot 310c by a length of about 400 mm to about 500 mm shorter than an insertion length of about 800 mm to about 1,000 mm in the related art, and thus when the bar 1 is coiled around the mandrel 300, a portion of the bar 1 making contact with the opposite edge wall 312 of the slot 310c may not be easily bent and plastically deformed.

[0057] That is, when the bar 1 is coiled, the leading end portion 1a of the bar 1 inserted into the slot 310c may not undergo deflection but may make contact with the guide part 320 with an appropriate contact force therebetween. Therefore, initial inner turns of the bar 1 may be smoothly formed around the mandrel 300, and thus the coiling process may not be suspended due to defective initial inner turns.

[0058] For example, the inner end of the guide part 320 is spaced apart from the inner end of the opposite edge wall 312 of the slot 310c by a distance of 90 mm to 110 mm. Since the guide part 320 protrudes until the guide part 320 is spaced apart from the inner end of the opposite edge wall 312 by the distance, when the leading end portion 1a of the bar 1 is inserted in the slot 310c, the leading end portion 1a does not make contact with the center shaft 200. In addition, when the bar 1 is coiled around the mandrel 300, a portion of the bar 1 making contact with the opposite edge wall 312 may not be easily bent and plastically deformed.

[0059] The guide part 320 may be sloped in a manner such that an inner gap (inner width) of the slot 310c is smaller than an outer gap (outer width) of the slot 310c.

[0060] That is, since the outer gap of the slot 310c is greater than the inner gap of the slot 310c, the bar 1 may be easily inserted into the slot 310c, and the guide part 320 may stably guide the insertion of the bar 1 into the slot 310c.

[0061] In addition, since the guide part 320 is disposed in the mandrel main body 310 and narrows the inner gap of

the slot 310c, when the leading end portion 1a of the bar 1 is inserted, the leading end portion 1a may be prevented from making contact with the center shaft 200.

[0062] For example, the outer end of the guide part 320 may be spaced apart from the outer end of the opposite edge wall 312 by a distance of 200 mm to 300 mm, and in this case, the guide part 320 may more effectively function as an insertion guide.

[0063] In addition, the guide part 320 may be formed in one piece with the mandrel main body 310 and may extend from the edge wall 311 of the slot 310c into the mandrel main body 310.

[0064] The leading end portion 1a of the bar 1 inserted in the mandrel main body 310 may be cooled by the center shaft 200, close to the leading end portion 1a. However, since the guide part 320 formed in one piece with the mandrel main body 310 makes contact with the leading end portion 1a of the bar 1 in the mandrel main body 310, the leading end portion 1a may be maintained at an appropriate temperature in the mandrel main body 310.

[0065] That is, the leading end portion 1a of the bar 1 may receive heat from the other high-temperature portion of the bar 1 coiled around the mandrel main body 310 through the mandrel main body 310 and the guide part 320 formed in one piece, and thus the leading end portion 1a may be maintained at a high temperature.

[0066] For example, the guide part 320 may protrude from the edge wall 311 of the slot 310c and taper toward the inside of the mandrel main body 310. In this case, although the guide part 320 may transfer heat through a wide area thereof, the guide part 320 may not make contact with the center shaft 200.

[0067] In addition, counterweights 330 may be formed on a side of the mandrel main body 310 opposite to the guide part 320 so as not to bias the center of gravity of the mandrel 300 toward the guide part 320.

[0068] In FIG. 7, the counterweights 330 protrude from an inner side of the mandrel main body 310. However, the current embodiment is not limited thereto. That is, the number and shape of the counterweights 330 are not limited as long as the counterweights 330 cancel out the weight of the guide part 320.

[0069] The mandrel 300 of the embodiment of the present disclosure was applied to a production line, and as shown in a graph below, the finishing mill delivery temperature (FDT) of a leading end portion 1a of a bar 1 that had been inserted in the mandrel 300 and processed through a finishing rolling process was different as compared to an FDT measured in a product line of the related art. In the graph, the x-axis denotes a bar length, the y-axis denotes bar temperature (°C), FDT (before improvement) denotes FDT measured according to the related art, FDT (after improvement) denotes FDT measured according to the present disclosure.

[Temperature profile of bars after rolling]

[0070] As shown in the graph, the FDT of a leading end portion of a bar measured after improvement was higher than the FDT of the leading end portion of a bar measured before improvement by about 40°C to about 50°C, and the temperature of one or two inner turns of a coil making contact with the outer surface of the mandrel main body 310 was increased by about 10°C to about 20°C after improvement. Therefore, according to the present disclosure, a steel sheet or bar may be smoothly and stably rolled in a finishing rolling process.

[0071] Therefore, intermediate inspectors may be less burdened when inspecting for texture defects caused by a low temperature at the leading end of a bar, and operators may be less burdened when performing a skin pass rolling process for correcting defects. Furthermore, the yield of a skin pass rolling process may not be lowered due to removal of a defective portion.

[0072] In the embodiments of the present disclosure, numerical values of materials such as thickness values of bars are given as exemplary values. That is, the embodiments of the present disclosure are not limited thereto.

[0073] As described above, according to the embodiments of the present disclosure, in addition to productivity improvements by qualitative effects such as a decreased insertion length of a bar 1 into the mandrel 300, an increased temperature of inner turns of a bar 1 coiled around the mandrel 300, and an improvement in workpiece passing characteristics in a rolling process, other effects may be obtained such as an increase in the yield of a skin pass rolling process resulted from a decrease of scrap, and a decrease of overproduction by reducing defect rates in a test and a re-test.

[0074] Furthermore, since it is not necessary to cut a hot-final workpiece in a skin pass rolling process to remove a portion corresponding to a leading end portion 1a of a bar 1, costs necessary for the skin pass rolling process may be reduced, and thus manufacturing costs may be markedly reduced.

[0075] While exemplary embodiments have been shown and described above, it will be apparent to those skilled in the art that modifications and variations could be made without departing from the spirit and scope of the present disclosure as defined by the appended claims.

Claims

1. A mandrel (300) of a coil box, the mandrel (300) comprising:

a cylindrical mandrel main body (310) in which a center shaft (200) is disposed, the mandrel main body (310) comprising a slot (310c) to receive a leading end portion (1a) of a high-temperature bar (1); and a guide part (320) formed from an edge wall (311) of the slot (310c) toward an inner side of the mandrel main body (310) so as to prevent cooling and plastic deformation of the leading end portion (1a) of the bar (1) inserted through the slot (310c).

2. The mandrel (300) of claim 1, wherein the guide part (320) protrudes from the edge wall (311) of the slot (310c) to prevent the leading end portion (1a) of the bar (1) from making contact with the center shaft (200) when the leading end portion (1a) of the bar (1) is inserted through the slot (310c).

3. The mandrel (300) of claim 2, wherein an inner end of the guide part (320) is spaced apart from an inner end of an opposite edge wall (312) of the slot (310c) by 90 mm to 110 mm.

4. The mandrel (300) of claim 2, wherein the guide part (320) is sloped in a manner such that an inner gap of the slot (310c) is smaller than an outer gap of the slot (310c).

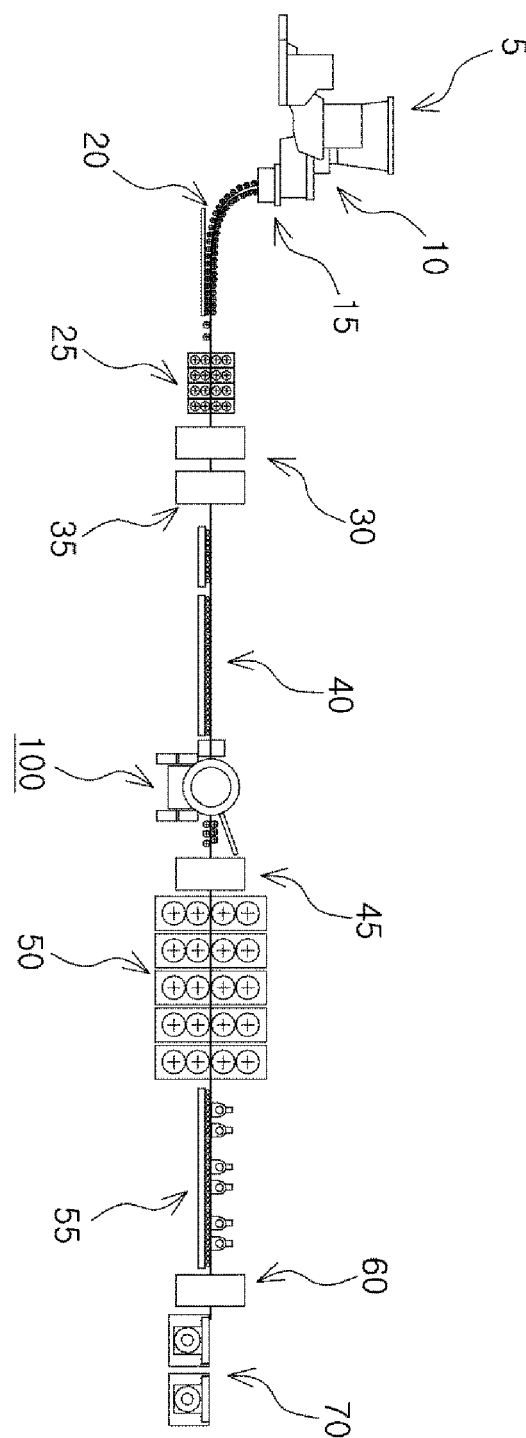
5. The mandrel (300) of claim 4, wherein an outer end of the guide part (320) is spaced apart from an outer end of an opposite edge wall (312) of the slot (310c) by 200 mm to 300 mm.

6. The mandrel (300) of any one of claims 1 to 5, wherein the guide part (320) is formed in one piece with the mandrel main body (310) and extends from the edge wall (311) of the slot (310c) toward the inner side of the mandrel main body (310).

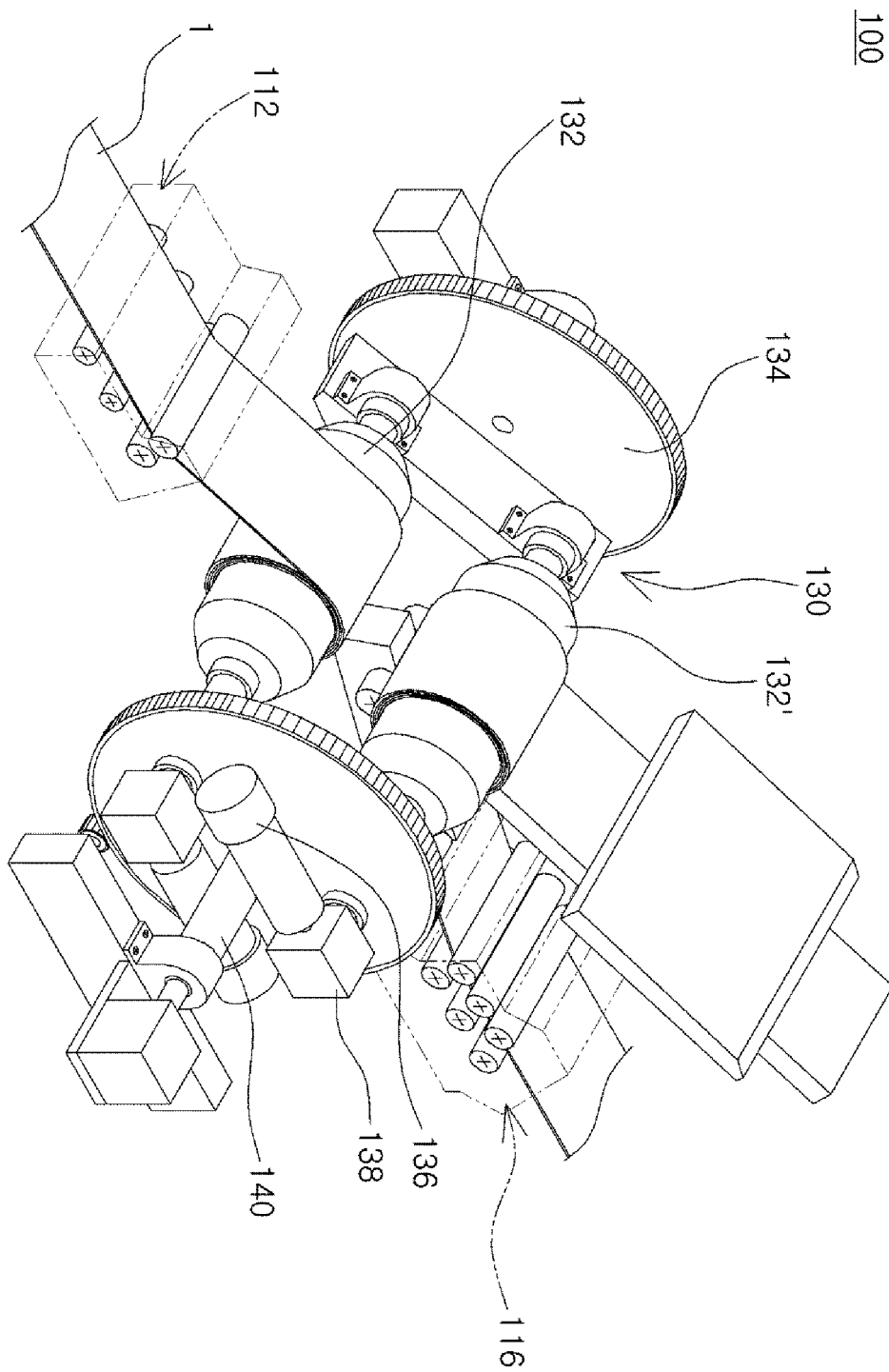
7. The mandrel (300) of any one of claims 1 to 5, wherein the guide part (320) protrudes from the edge wall (311) of the slot (310c) and tapers toward the inner side of the mandrel main body (310).

8. The mandrel (300) of any one of claims 1 to 5, wherein a counterweight (330) is provided on a side of the mandrel main body (310) opposite to the guide part (320) so as not to bias a center of gravity of the mandrel toward the guide part (320).

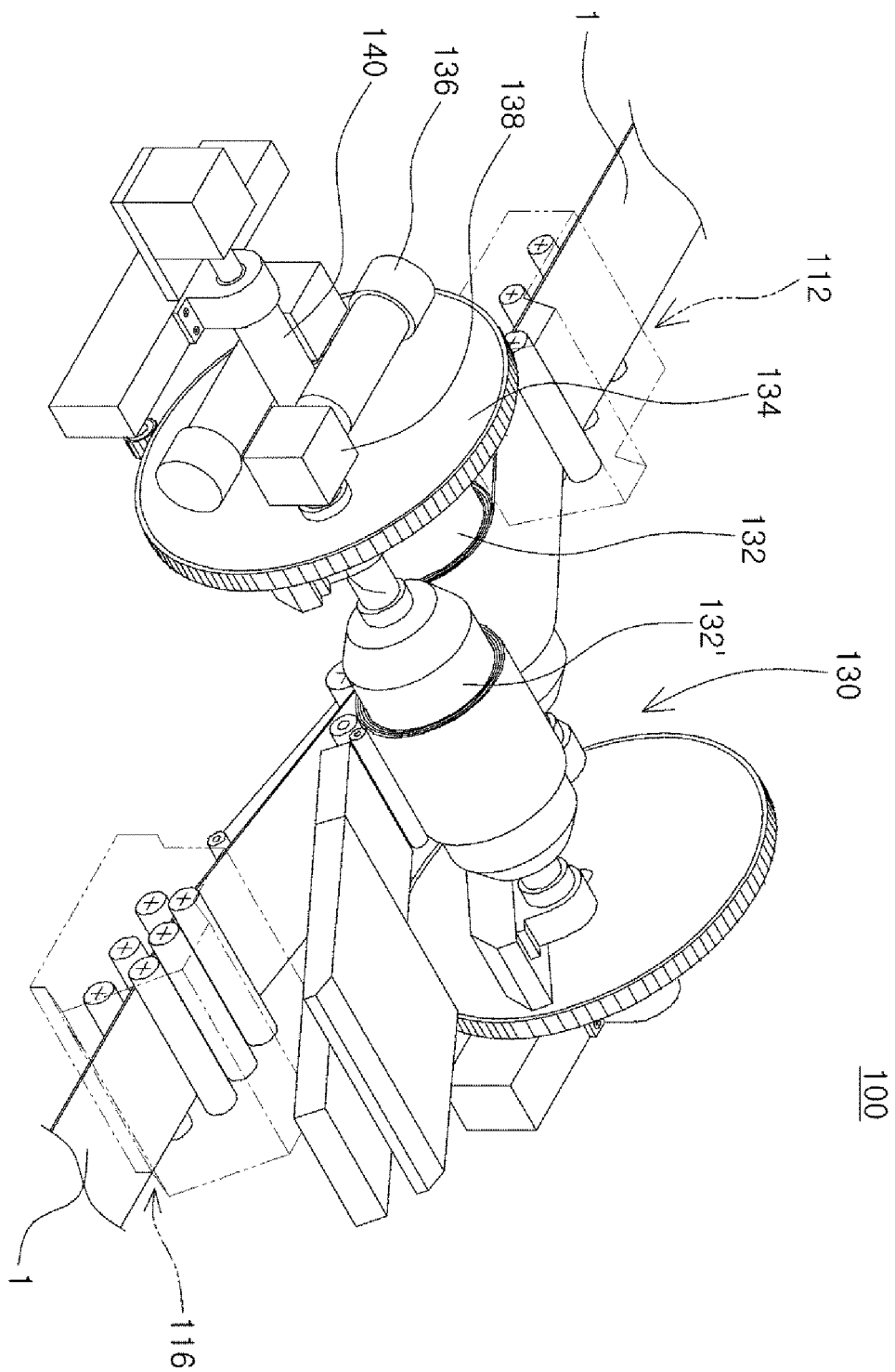
【Figure 1】



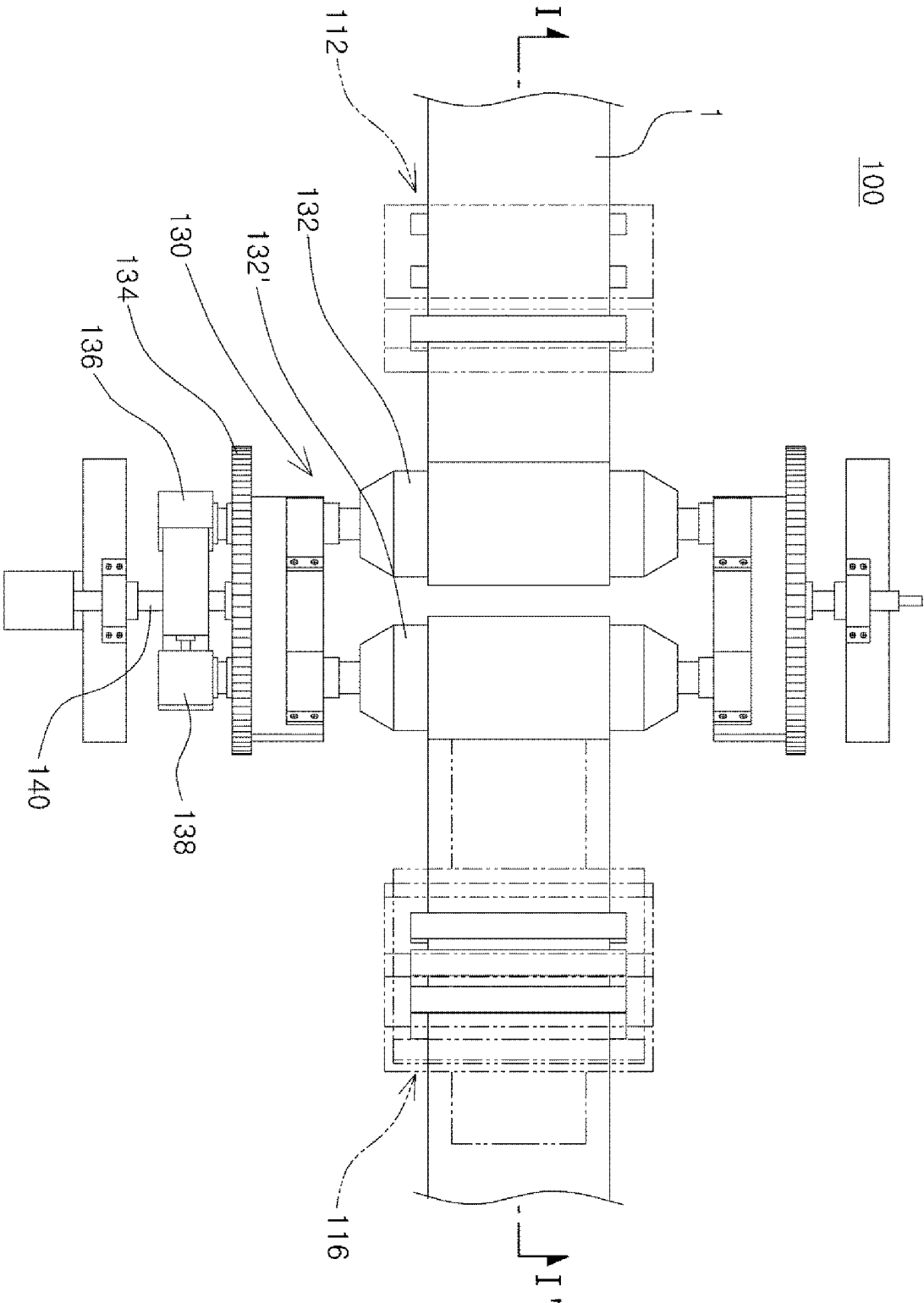
【Figure 2】



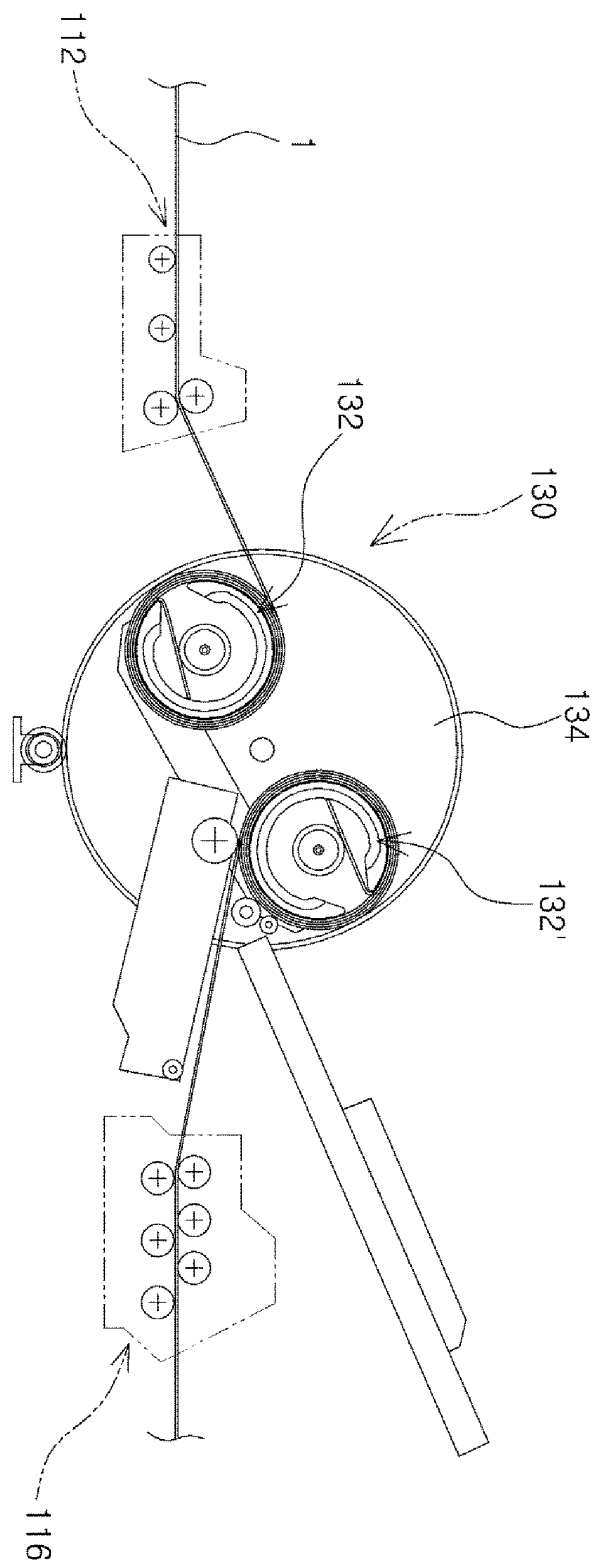
【Figure 3】



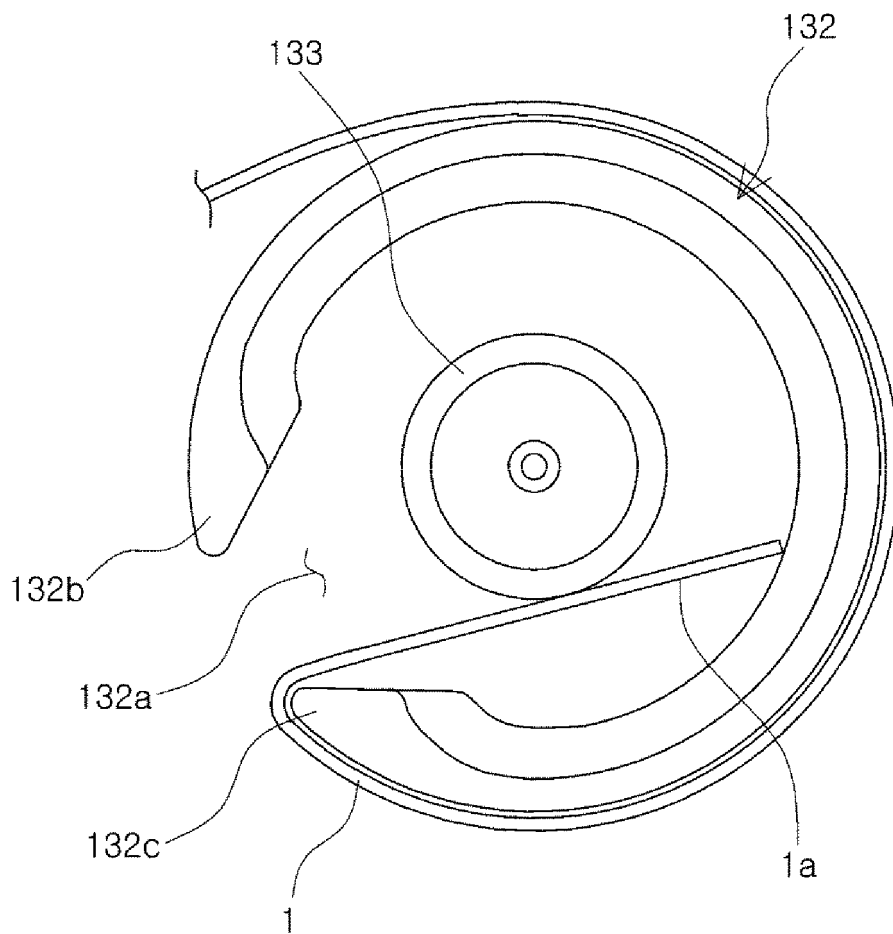
【Figure 4】



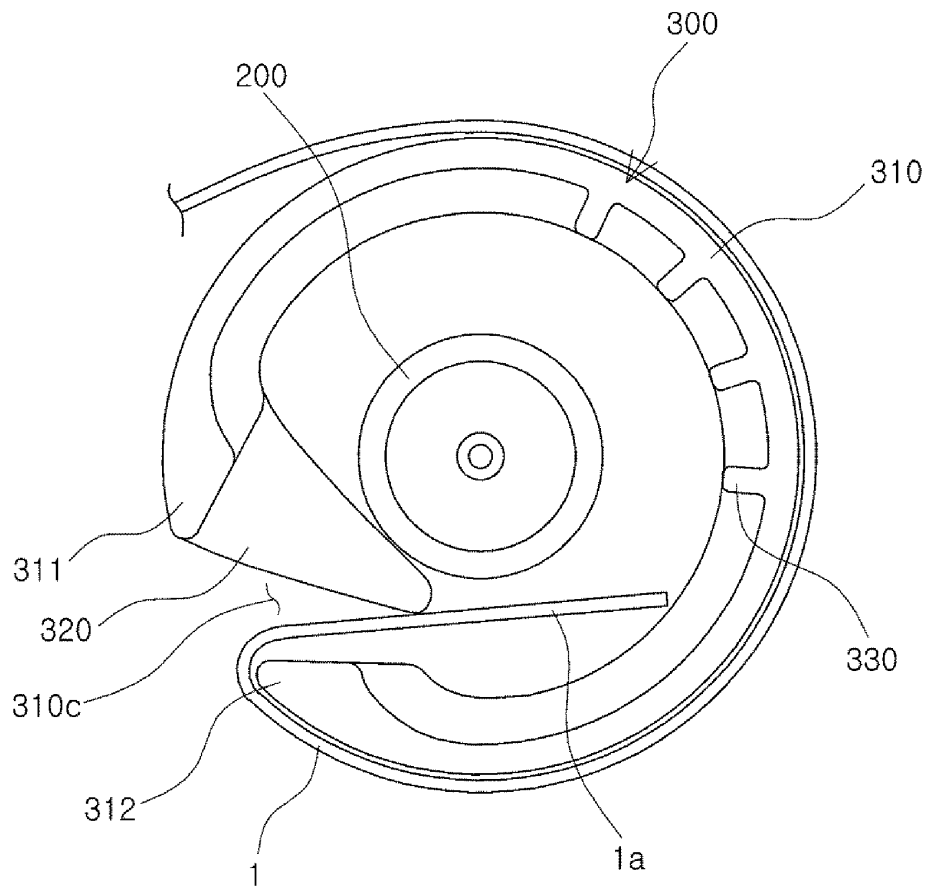
【Figure 5】



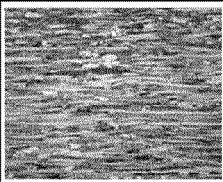
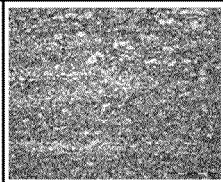
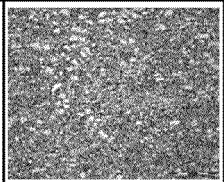
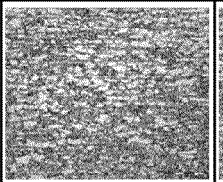
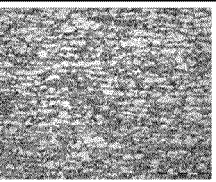
【Figure 6】



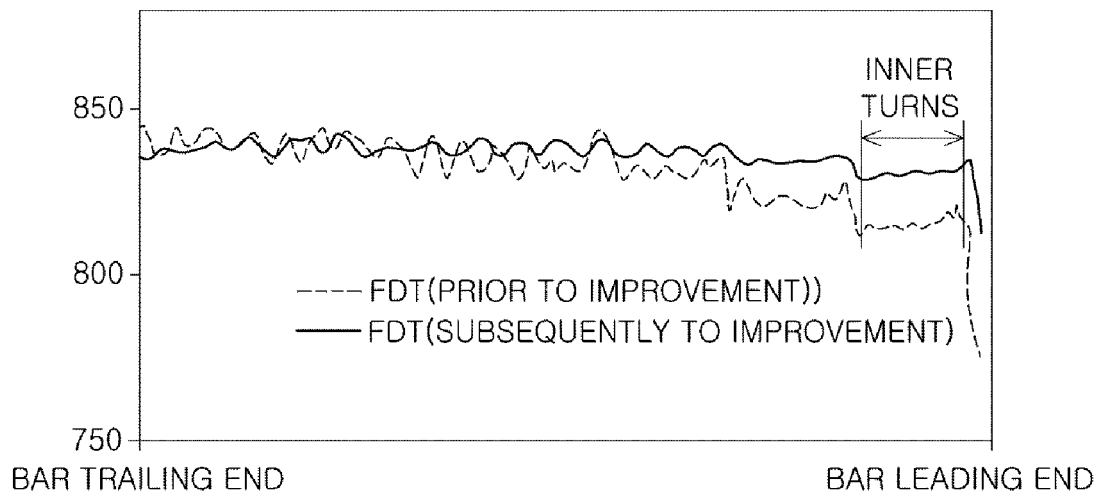
【Figure 7】



【Figure 8】

				
0m (DEFECTIVE STRUCTURE)	5m (NORMAL STRUCTURE)	10m (NORMAL STRUCTURE)	15m (MIXED GRAIN STRUCTURE)	20m (MIXED GRAIN STRUCTURE)

【Figure 9】



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2013/010522

A. CLASSIFICATION OF SUBJECT MATTER

B21C 47/28(2006.01)i, B21C 47/18(2006.01)i, B21C 47/14(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)

B21C 47/28; B21B 1/32; C21D 9/68; B21C 47/00; B21B 1/34; B21C 47/04; B21B 39/14; B21C 47/02; B21C 47/18; B21C 47/14

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

Korean Utility models and applications for Utility models: IPC as above

Japanese Utility models and applications for Utility models: IPC as above

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

eKOMPASS (KIPO internal) & Keywords: coil, winding, mandrel, slot, opening part

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 11-342420 A (HITACHI LTD.) 14 December 1999 See paragraphs [0013], [0023], [0028], [0031]; claim 1; and figures 1, 2.	1-8
A	US 2010-0101293 A1 (HOEN, Karl) 29 April 2010 See paragraphs [0032]-[0035] and figures 1-3.	1-8
A	KR 10-2009-0086400 A (SIEMENS VAI METALS TECHNOLOGIES GMBH) 12 August 2009 See paragraphs [0020], [0021] and figure 1.	1-8
A	KR 20-0255824 Y1 (POSCO) 13 December 2001 See page 2, line 69 - page 3, line 22 and figures 4-6.	1-8
A	KR 10-2004-0038505 A (POSCO) 08 May 2004 See page 4, lines 11-40 and figures 5a-5c.	1-8

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

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"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

Date of the actual completion of the international search

18 FEBRUARY 2014 (18.02.2014)

Date of mailing of the international search report

24 FEBRUARY 2014 (24.02.2014)

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR2013/010522

Patent document cited in search report	Publication date	Patent family member	Publication date
JP 11-342420 A	14/12/1999	JP 3419699 B2	23/06/2003
US 2010-0101293 A1	29/04/2010	CN 101501225 A	05/08/2009
		CN 101501225 B	03/08/2011
		DE 102006037962 A1	14/02/2008
		EP 2052090 A1	29/04/2009
		JP 2010-500176 A	07/01/2010
		JP 4937351 B2	23/05/2012
		RU 2391168 C1	10/06/2010
		WO 2008-019751 A1	21/02/2008
KR 10-2009-0086400 A	12/08/2009	CN 101522330 A	02/09/2009
		CN 101522330 B	06/07/2011
		EP 2073944 A1	01/07/2009
		EP 2073944 B1	20/07/2011
		US 2009-0320544 A1	31/12/2009
		US 8256256 B2	04/09/2012
		WO 2008-040431 A1	10/04/2008
KR 20-0255824 Y1	13/12/2001	NONE	
KR 10-2004-0038505 A	08/05/2004	NONE	

Form PCT/ISA/210 (patent family annex) (July 2009)