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(54) **COOLING ROLLERS FOR TWIN-ROLLER CASTING DEVICE**

(57) One of a pair of chilled rolls is a mid-thick roll 100a which has a longitudinal central diameter greater than longitudinal end diameters. The other of the chilled rolls is a mid-thin roll 200a which has a longitudinal central diameter shorter than longitudinal end diameters. A roll gap 3 is formed between the mid-thick and mid-thin rolls 100a and 200a such that the rolls are gradually made closer to each other from longitudinal roll centers to longitudinal roll ends.

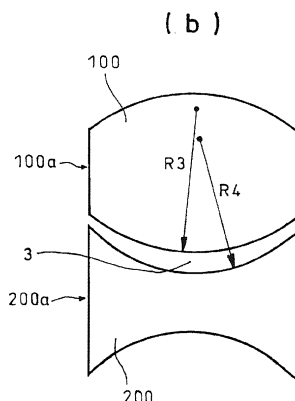
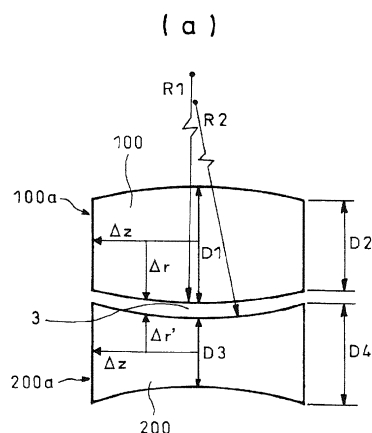


FIG. 3

Description

Technical Field

[0001] The present invention relates to chilled rolls for a twin roll caster.

Background Art

[0002] A twin roll caster comprises a pair of chilled rolls (casting rolls) for production of a thin sheet (strip) with a constant width. The chilled rolls are arranged horizontally in parallel with each other to have a predetermined gap (roll gap) therebetween. Side weirs abut on end surfaces of the chilled rolls to provide a molten metal pool defined by the side weirs and upper peripheries of the chilled rolls. The chilled rolls are counter-rotated such that the peripheries of the rolls which provide the roll gap are moved downward, molten metal being supplied to the molten metal pool from a tundish arranged above the rolls through a nozzle of the tundish. Thus, the molten metal in the molten metal pool is drawn out from the roll gap as a thin sheet cooled and solidified by the rotating chilled rolls. In the twin roll caster, the thin sheet with a constant width is continuously produced and is of the order of, for example, 1-6 mm in thickness and, for example, 1000-2000 mm in width. The thin sheet produced by the twin roll caster is usually made thinner by a rolling mill arranged downstream.

[0003] The chilled rolls in the twin roll caster serve as casting molds. In order to cool the molten metal into the thin sheet, coolant (cooling water) is forcedly passed through the rolls to drastically cool the same; however, during the casting, the chilled rolls are in contact with hot molten metal as high as, for example, 1600°C to receive great heat load (heat input), resulting in thermal deformation of the chilled rolls.

[0004] Thus, it has been carried out to preliminarily machine the rolls during cold into initial roll profiles so as to make the roll gap between the paired rolls uniform longitudinally of the rolls. However, it is known that, even having such initial roll profiles, the chilled rolls may have convexities called dog bones with increased roll diameters, by the heat load during the casting, at longitudinal end portions (at positions of the order of 130 mm from roll end surfaces) relative to that at a longitudinal central portion.

[0005] Thus, it has been carried out recently to preliminarily machine the rolls so as to have initial roll profiles in view of and compensable for the thermal deformation called dog bones and thus make the thin sheet with an intended thickness shape (thickness profile).

[0006] There exists, for example, Patent Literature 1 which discloses a twin roll caster with chilled rolls preliminarily machined to have initial roll profiles so as to have a thin sheet with an intended thickness profile. In the Patent Literature 1, the twin roll caster has the paired chilled rolls of the same shape each machined to have

the same initial roll profile.

Citation List

5 Patent Literature

[0007] [Patent Literature 1] JPH 07-323353A

Summary of Invention

Technical Problems

[0008] Fig. 1(a) shows shapes of conventional paired chilled rolls in a twin roll caster as in the Patent Literature 1. Each of the chilled rolls 1 and 2 has a hand-drum-shaped initial profile with a diameter d2 at longitudinal (lateral in Fig. 1(a)) ends machined to be greater than a diameter d1 at a longitudinal (lateral in Fig. 1(a)) center, so that a roll gap 3 between the rolls 1 and 2 is great at the longitudinal center and is small at the longitudinal ends. Thus, produced by the chilled rolls 1 and 2 in Fig. 1(a) is a thin sheet which has a mid-high thickness profile thicker at a widthwise center than at widthwise ends in accordance with the shape of the roll gap 3. Such thin sheet with the mid-high thickness profile can improve line controllability for prevention of the thin sheet from meandering upon rolling by a rolling mill downstream.

[0009] However, when the thin sheet is produced using the chilled rolls 1 and 2 with the hand-drum-shaped initial roll profiles shown in Fig. 1(a), the rolls 1 and 2 receive heat load (heat input) from molten metal and are thermally deformed as mentioned in the above to have thermal roll profiles as shown in Fig. 1(b) with convexities called dog bones 4 having increased roll diameters at positions of the order of 130 mm from roll end surfaces. When the dog bones 4 are produced, the thin sheet formed by the roll gap 3 between the chilled rolls 1 and 2 has changed thickness portions at widthwise ends where thickness is locally reduced by the dog bones 4, so that a thin sheet with an intended thickness profile cannot be produced due to such changed thickness portions.

[0010] Thus, as shown in Fig. 1(c), it has been carried out to machine the rolls 1 and 2 so as to have new initial roll profiles preliminarily formed with concavities 5 with depths and shapes compensable for the dog bones 4 at positions on the roll end portions where the dog bones 4 are to be produced.

[0011] According to the chilled rolls 1 and 2 having the initial roll profiles with such concavities 5, during casting of the thin sheet, the rolls 1 and 2 are thermally deformed to have favorable thermal roll profiles as shown in Fig. 1(d) to provide a roll gap 3 with an intended shape. Thus, with such roll gap 3, a thin sheet with an intended thickness profile can be produced.

[0012] However, it has been known that, during the casting, heat load (heat input) received by the chilled rolls 1 and 2 is totally or locally varied greatly depending on,

for example, temperature and/or components of molten metal, humidity of an atmosphere surrounding the molten metal pool and/or conditions of oxides on surfaces of the rolls cleaned by brushes.

[0013] Thus, with the heat input to the chilled rolls 1 and 2 being kept to a general normal value, favorable thermal roll profiles are obtained as shown in Fig. 1(d) so that a thin sheet with an intended thickness profile can be produced.

[0014] However, when the heat input is increased beyond the normal value, the chilled rolls 1 and 2 have reduced-diameter-end portions 6 on their peripheries at positions proximal to and of the order of 50 mm from roll end surfaces where the roll gap 3 is suddenly increased toward the roll end surface as shown in Fig. 1(e).

[0015] Fig. 2 shows results obtained by simulation on a relationship between longitudinal position on roll (abscissa) and roll gap (ordinate) upon casting by the chilled rolls 1 and 2 shown in Fig. 1(c) with the initial profiles having the concavities 5 compensable for the dog bones 4. Fig. 2 shows a case where the roll gap 3 at longitudinal central portions is 1.6 mm.

[0016] In Fig. 2, a curve A shows a roll gap 3 when an envisaged heat input is 12.5 MW upon setting of initial roll profiles. With the heat input being 12.5 MW, the roll gap 3 of about 1.6 mm at the longitudinal roll central portion is gradually reduced toward the roll end portion as shown in the curve A. Thus, a thin sheet with an intended thickness profile can be stably produced with the roll gap 3.

[0017] On the other hand, a curve B in Fig. 2 shows a case where the heat input is increased up to 15.5 MW. With the increased heat input as shown in the curve B, the roll gap of about 1.6 mm at the longitudinal roll central portion is gradually reduced toward the roll end portion; however, at a position proximal to and of the order of 50 mm from the roll end surface, an inflection point X occurs where the roll gap is changed into an increase, so that as shown in Fig. 1(e) reduced-diameter-end portions 6 are produced where the roll gap 3 is abruptly increased toward the roll end surface. Such production of the reduced-diameter-end portions 6 causes a phenomenon that pressure of material sandwiched at nips (narrowest portions of the roll gap between the chilled rolls 1 and 2) is abruptly increased to squeeze unsolidified molten steel from the inflection point X toward reduced-diameter-end portion 6. As a result, a thin sheet with insufficiently solidified widthwise ends is drawn out from the rolls, is heat-recuperated on its surface by heat inside, is re-fused into an untidy shape, and has locally thickened portions at the widthwise ends, resulting in failure of stable production of a thin sheet with an intended thickness profile.

[0018] In order to overcome this problem, it is conceivable to machine the rolls 1 and 2 during cold so as to have new initial roll profiles compensable for the reduced-diameter-end portions 6.

[0019] However, the conventional chilled rolls have a presupposition that the chilled rolls 1 and 2 of the same

shape are provided in pairs as shown in Fig. 1(a), so that it is extremely difficult to machine the rolls 1 and 2, which already have the concavities 5 machined on the end portions for prevention of dog bones 4 as shown in Fig. 1(c) from being produced, so as to prevent the reduced-diameter-end portions 6 from being produced. Specifically, with the roll gap being 1.6 mm, the chilled rolls 1 and 2 each have a halved nominal machinable range of 0.8 mm and are required to be prevented from being mutually contacted at their peripheries, so that the rolls each have an actual machinable range of, for example, about 0.6 mm at most. It is extremely difficult to machine the rolls with such minimal machinable range (grindable range) at their narrow roll end portions, not only for provision of the concavities 5 as shown in Fig. 1(c) to prevent the dog bones 4 shown in Fig. 1(b) from being produced but also for prevention of the reduced-diameter-end portions 6 shown in Fig. 1(e) from being produced.

[0020] Thus, it is impossible in the conventional chilled rolls 1 and 2 to prevent the reduced-diameter-end portions 6 on roll end portions from being produced.

[0021] The invention was made in view of the above and has its object to provide chilled rolls for a twin roll caster in which roll end portions are prevented from having reduced-diameter-end portions even if heat input for the chilled rolls is increased beyond a normal value.

Solution to Problems

[0022] The invention is directed to chilled rolls for a twin roll caster wherein molten metal from a tundish is received by the paired chilled rolls at a upper position of a roll gap between the rolls, a thin sheet being drawn out from said roll gap between the rolls while being cooled, wherein one of the paired chilled rolls is a mid-thick roll which has a longitudinal central portion with a diameter greater than that of longitudinal end portions, and the other of the paired chilled rolls is a mid-thin roll which has a longitudinal central portion with a diameter smaller than that of longitudinal end portions, the roll gap between the mid-thick and mid-thin rolls being such that the rolls are gradually made closer to each other from the longitudinal roll central portions to the longitudinal roll end portions.

[0023] It is preferable that in areas within 15% of roll length from the roll end surfaces, said mid-thick and mid-thin rolls have sudden approach portions which are made suddenly closer to each other than the longitudinal roll central portions.

[0024] In the above-mentioned chilled rolls for twin roll caster, said sudden approach portions may be provided by making a diameter increasing rate of said mid-thin roll at the longitudinal roll end portions greater than that at the longitudinal roll central portion.

[0025] In the above-mentioned chilled rolls for twin roll caster, said sudden approach portions may be provided by making a diameter decreasing rate of said mid-thick roll at the longitudinal roll end portions smaller than that

at the longitudinal roll central portion.

Advantageous Effects of Invention

[0026] The invention can exert an excellent effect that, even if the heat input to the chilled rolls is increased beyond a normal value, reduced-diameter-end portions can be prevented from being produced at the roll end portions.

Brief Description of Drawings

[0027]

Fig. 1(a) is a plan view showing shapes of conventional paired chilled rolls for a twin roll caster, Fig. 1(b) being a plan view showing shapes of dog bones produced during casting by the chilled rolls shown in Fig. 1(a), Fig. 1(c) being a plan view showing chilled rolls with concavities for prevention of dog bones shown in Fig. 1(b) from being produced, Fig. 1(d) being a plan view showing the chilled rolls in Fig. 1(c) thermally deformed into favorable thermal roll profiles, Fig. 1(e) being a plan view showing reduced-diameter-end portions formed at roll end portions when heat input to the chilled rolls of Fig. 1(c) is increased;

Fig. 2 is a diagram showing results obtained by simulation on a relationship between longitudinal position on roll and roll gap upon casting by conventional chilled rolls with concavities compensable for dog bones as shown in Fig. 1(c) in cases where the heat input is at a normal value and is increased beyond the normal value, respectively;

Fig. 3(a) is a plan view showing an embodiment of shapes of the paired chilled rolls, Fig. 3(b) being a plan view showing a further embodiment of shapes of the chilled rolls;

Fig. 4(a) is a plan view showing a still further embodiment of shapes of the chilled rolls, Fig. 4(b) being a plan view showing a still further embodiment of shapes of the chilled rolls;

Fig. 5 is a diagram showing results obtained by simulation on a relationship between longitudinal position on roll and roll gap during casting by the mid-thick and mid-thin rolls shown in Fig. 3(a) in cases where heat input is at a normal value and is increased beyond the normal value, respectively; and

Fig. 6 shows an overall structure of an example of a twin roll caster to which chilled rolls of the invention are applied.

Description of Embodiments

[0028] Embodiments of the invention will be described in conjunction with the drawings.

[0029] Fig. 6 shows an example of a twin roll caster to which chilled rolls of the invention are applied. A twin roll

caster 7 comprises two (paired) chilled rolls 100 and 200 (casting rolls) arranged horizontally and in parallel with each other to have a predetermined roll gap 3 therebetween. Further, side weirs 8 abut on roll end surfaces of the chilled rolls 100 and 200 to provide a molten metal pool 9 defined by the side weirs 8 and upper peripheries of the rolls 100 and 200.

[0030] Arranged above the chilled rolls 100 and 200 is a tundish 10 with molten metal therein fed via a slot-like nozzle 11 to the molten metal pool 9. The molten metal in the molten metal pool 9 is drawn out as a thin sheet 12 through the roll gap 3 while cooled and solidified by the chilled rolls 100 and 200 counter-rotated as shown by arrows. In the twin roll caster 7, the thin sheet 12 with a constant width is continuously produced and is of the order of, for example, 1-6 mm in thickness and, for example, 1000-2000 mm in width. The thin sheet 12 produced by the twin roll caster 7 is guided via pinch rolls 13 into a four-high rolling mill 14 where the sheet is made thinner; then, the sheet is guided via a deflector roll 15 to a coiler 16 where it is wound into a reel.

[0031] Fig. 3(a) is a plan view showing an embodiment of the paired chilled rolls 100 and 200. One 100 of the chilled rolls 100 and 200 is a barreled mid-thick roll 100a which has a longitudinal (lateral in Fig. 3(a)) central diameter D1 greater than longitudinal end diameters D2. The other chilled roll 200 is a hand-drum-shaped mid-thin roll 200a which has a longitudinal central diameter D3 smaller than longitudinal end diameters D4. The mid-thick roll 100a has roll diameters gradually decreased from the longitudinal roll central portion to the longitudinal roll end portions with a constant decreasing rate to provide a longitudinal contour with a radius R1. The mid-thin roll 200a has roll diameters gradually increased from the roll longitudinal central portion to the longitudinal end portions with a constant increasing rate to provide a longitudinal contour with a radius R2.

[0032] The increasing rate in the roll diameters of the mid-thin roll 200a increased toward the longitudinal roll end portion is greater than the decreasing rate in the roll diameters of the mid-thick roll 100a decreased toward the longitudinal roll end portions. Specifically, when a coordinate along a roll axis from the longitudinal roll central portion to the roll end portion is defined as Z-coordinate, the decreasing rate ($\Delta r/\Delta Z$) representing a degree of decrement Δr in roll radius r of the mid-thick roll 100a relative to increment Δz of Z and the increasing rate ($\Delta r'/\Delta z$) representing a degree of increment $\Delta r'$ in roll radius r' of the mid-thin roll 200a relative to increment Δz of Z have a relationship ($\Delta r/\Delta z < \Delta r'/\Delta z$). Thus, curvature of the arc with the radius R2 provided by the mid-thin roll 200a having the concave longitudinal central portion is greater than curvature of the arc with the radius R1 provided by the mid-thick roll 100a having the convex longitudinal central portion, and curvature radii R1 and R2 have a relationship $R1 > R2$. As a result, the roll gap 3 between the mid-thick and mid-thin rolls 100a and 200a has a shape wide at a longitudinal center and is gradually nar-

rowed toward longitudinal ends. According to such roll gap 3 wide at the longitudinal roll central portions and gradually narrowed toward the longitudinal roll end portions, the thin sheet 12 thick at a widthwise central portion and thin at lateral ends is produced, which improves line controllability for prevention of the sheet from meandering upon rolling by the rolling mill 14 downstream.

[0033] Fig. 3(b) is a plan view showing a further embodiment of shapes of the paired chilled rolls 100 and 200 in which the mid-thick and mid-thin rolls 100a and 200a have decrement and increment in roll diameters between the longitudinal roll central portions and the longitudinal roll end portions greater than those in Fig. 3(a) (curvature radii R3 and R4 of the arcs are smaller and have a relationship $R3 > R4$).

[0034] Next, the above-mentioned embodiments will be described.

[0035] As shown in Figs. 3(a) and 3(b), the mid-thick and mid-thin rolls 100a and 200a are arranged in combination in the twin roll caster 7 shown in Fig. 6 and are rotated as shown by the arrows while the molten metal in the tundish 10 is supplied via the nozzle 11 to the molten metal pool 9. The molten metal in the molten metal pool 9 is drawn out as the thin sheet 12 through the roll gap 3 while it is cooled and solidified by the mid-thick and mid-thin rolls 100a and 200a.

[0036] Formation of the roll gap 3 which is wide at the longitudinal roll central portions and is gradually narrowed toward the longitudinal roll end portions by the arcs of the radii R1 and R2 provided by the mid-thick and mid-thin rolls 100a and 200a shown in Fig. 3(a) or by the arcs of the radii R3 and R4 provided by the mid-thick and mid-thin rolls 100a and 200a shown in Fig. 3(b) could prevent the reduced-diameter-end portions 6 shown in Fig. 1(e), which are produced conventionally when heat input to the chilled rolls 1 and 2 is increased, from being produced. Thus, the thin sheet 12 with an intended thickness profile could be produced. In this manner, according to the twin roll caster 7 with the mid-thick and mid-thin rolls 100a and 200a in combination, a favorable roll gap 3 can be attained with no reduced-diameter-end portions 6 being produced, so that a thin sheet 12 with an intended thickness profile can be produced stably.

[0037] Fig. 5 shows results obtained by simulation on a relationship between longitudinal position on roll (abscissa) and roll gap (ordinate) upon casting by the mid-thick and mid-thin rolls 100a and 200a shown in Fig. 3(a) in cases A and B where heat input is at a normal value of 12.5 MW and is increased to 15.5 MW, respectively.

[0038] According to Fig. 5, it is noted that even when the heat input is increased as shown by B, the roll gap of about 1.6 mm at the longitudinal roll central portion is gradually reduced toward the roll end portion. That is, the problem of the inflection point X of the roll gap changed into an increase being produced at positions proximal to and of the order of 50 mm from the roll end surfaces as shown in Fig. 2 can be prevented and thus the problem of the reduced-diameter-end portions 6 be-

ing produced at the roll end portions as shown in Fig. 1(e) can be prevented.

[0039] It is considered that the fact that the conventional reduced-diameter-end portions 6 are prevented from being produced is due to the fact that combination of the mid-thick and mid-thin rolls 100a and 200a makes the change in roll diameters at the roll end portions moderate and great in comparison with the conventional art, which suppresses the thermal deformation at the roll end portions.

[0040] When the production of the dog bones 4 shown in Fig. 1(b) is problematic in the embodiments shown in Fig. 3, it suffices to preliminarily machine at least one of peripheries of the mid-thick and mid-thin rolls 100a and 200a to have concavities compensable for dog bones 4 so as to obtain an intended roll gap 3 in casting, thereby preventing the dog bones 4 from being produced.

[0041] Fig. 4(a) is a plan view showing a still further embodiment of shapes of the paired chilled rolls 100 and 200 in which, in areas within distance H or 15% of roll length of the mid-thin roll 200a from roll end surfaces, the roll diameter is suddenly increased by an increasing rate greater than that by which the roll diameter at the longitudinal roll central portion is gradually increased toward the longitudinal end portions with the arc of radius R2, thereby providing sudden approach portions 17, which suddenly approach the mid-thick roll 100a, at the roll end portions of the mid-thin roll 200a.

[0042] Further, Fig. 4(b) shows a still further embodiment in which, in areas within distance H or 15% of roll length of the mid-thick roll 100a from the roll end surfaces, the roll diameter is suddenly decreased by a decreasing rate smaller than that by which the roll diameter of the longitudinal roll central portion is gradually decreased toward the longitudinal end portions with the arc of radius R1, thereby providing sudden approach portions 17', which suddenly approach the mid-thin roll 200a, at the roll end portions of the mid-thick roll 100a.

[0043] In Fig. 4(a), the roll end portions of the mid-thin roll 200a are formed with the sudden approach portions 17 suddenly approaching the mid-thick roll 100a; in Fig. 4(b), the roll end portions of the mid-thick roll 100a is formed with the sudden approach portions 17' suddenly approaching the mid-thin roll 200a. Thus, the mid-thick and mid-thin rolls 100a and 200a rapidly approach to each other at the roll end portions. Such sudden approaching of the roll end portions each other can further reliably prevent the reduced-diameter-end portions 6 shown in Fig. 1(e) from being produced.

[0044] According to the above-mentioned embodiments of the invention, the combination of the mid-thick and mid-thin rolls 100a and 200a eliminates the need to make machining in narrow regions for providing concavities 5 shown in Fig. 1(c) to prevent the conventional dog bones from being produced and for preventing the reduced-diameter-end portions 6 shown in Fig. 1(e) from being produced, and an intended roll gap is attained by the simply shaped mid-thick and mid-thin rolls 100a and

200a.

[0045] It is to be understood that the chilled rolls for the twin roll caster according to the invention is not limited to the above embodiments and that various changes and modifications may be made without departing from the scope of the invention.

Reference Signs List

[0046]		10
3	roll gap	
7	twin roll caster	
10	tundish	
12	thin sheet	15
17	sudden approach portion	
17'	sudden approach portion	
100	chilled roll	
200	chilled roll	
100a	mid-thick roll	20
200a	mid-thin roll	
D1	diameter	
D2	diameter	
D3	diameter	
D4	diameter	25

Claims

1. Chilled rolls for a twin roll caster wherein molten metal from a tundish is received by the paired chilled rolls at a upper position of a roll gap between the rolls, a thin sheet being drawn out from said roll gap between the rolls while being cooled, wherein one of the paired chilled rolls is a mid-thick roll which has a longitudinal central portion with a diameter greater than that of longitudinal end portions, and the other of the paired chilled rolls is a mid-thin roll which has a longitudinal central portion with a diameter smaller than that of longitudinal end portions, the roll gap between the mid-thick and mid-thin rolls being such that the rolls are gradually made closer to each other from the longitudinal roll central portions to the longitudinal roll end portions. 30 35 40 45
2. The chilled rolls for the twin roll caster as claimed in claim 1 wherein, in areas within 15% of roll length from roll end surfaces, said mid-thick and mid-thin rolls have sudden approach portions which are made suddenly closer to each other than the longitudinal roll central portions. 50
3. The chilled rolls for the twin roll caster as claimed in claim 2 wherein said sudden approach portions are provided by making a diameter increasing rate of said mid-thin roll at the longitudinal roll end portions greater than that at the longitudinal roll central por- 55

tion.

4. The chilled rolls for the twin roll caster as claimed in claim 2 wherein said sudden approach portions are provided by making a diameter decreasing rate of said mid-thick roll at the longitudinal roll end portions smaller than that at the longitudinal roll central portion.

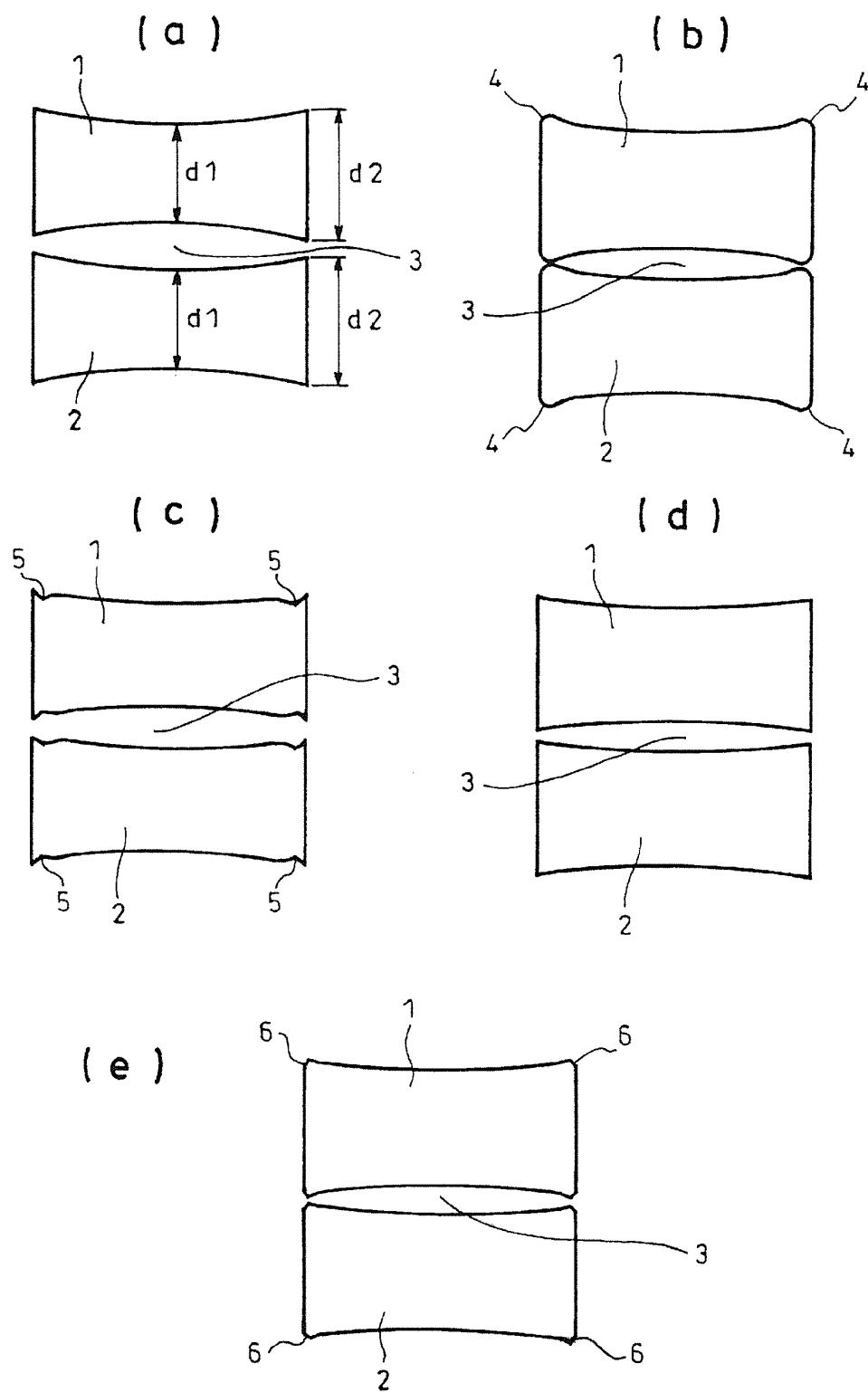


FIG. 1

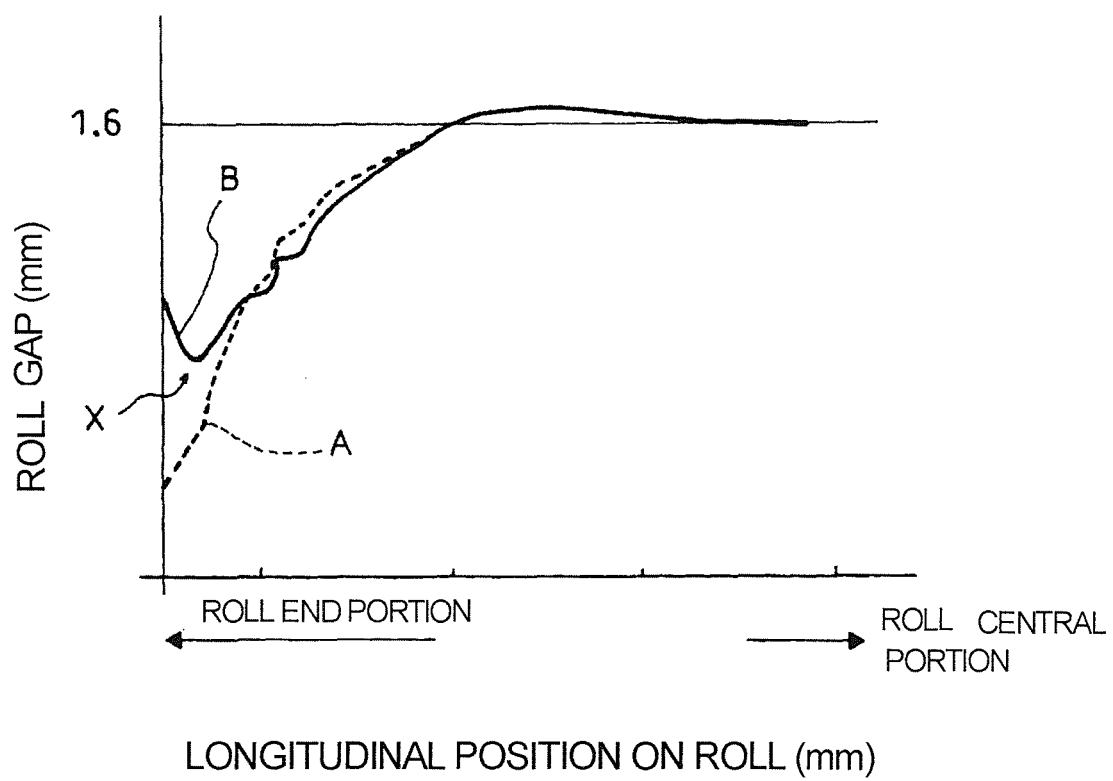
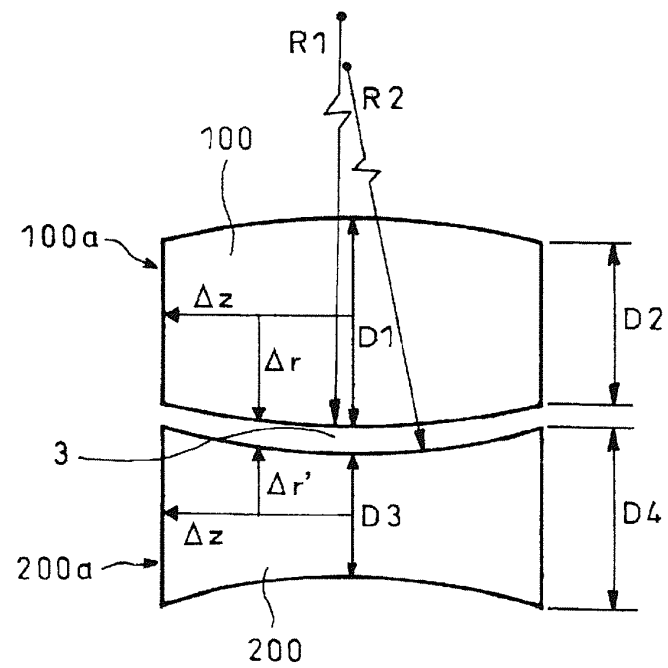


FIG. 2

(a)



(b)

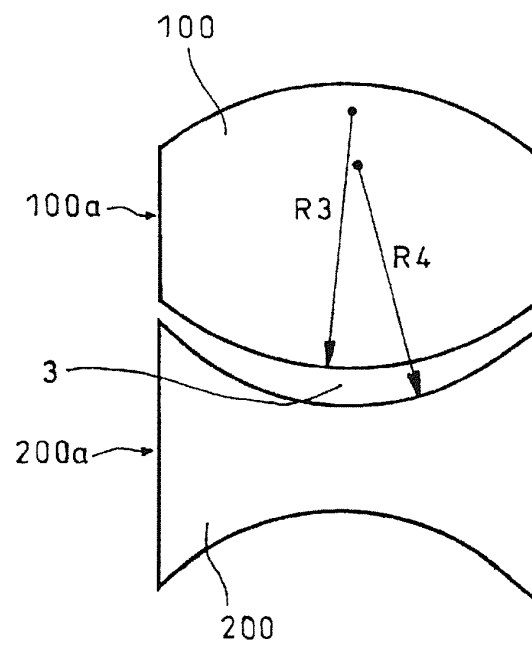
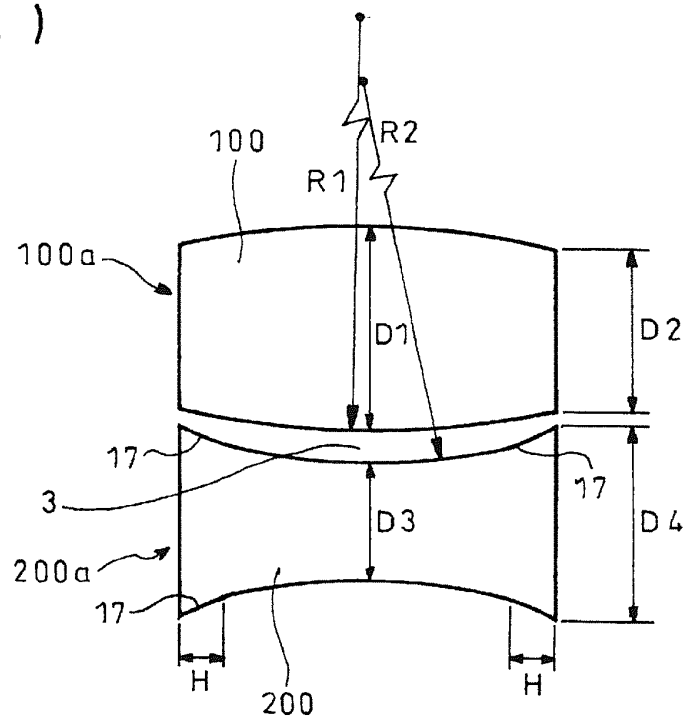


FIG. 3

(a)



(b)

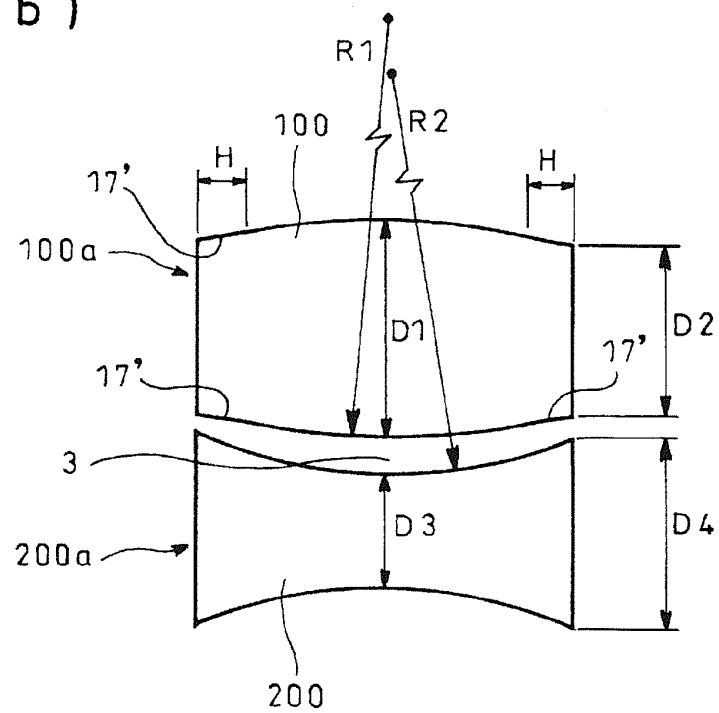


FIG. 4

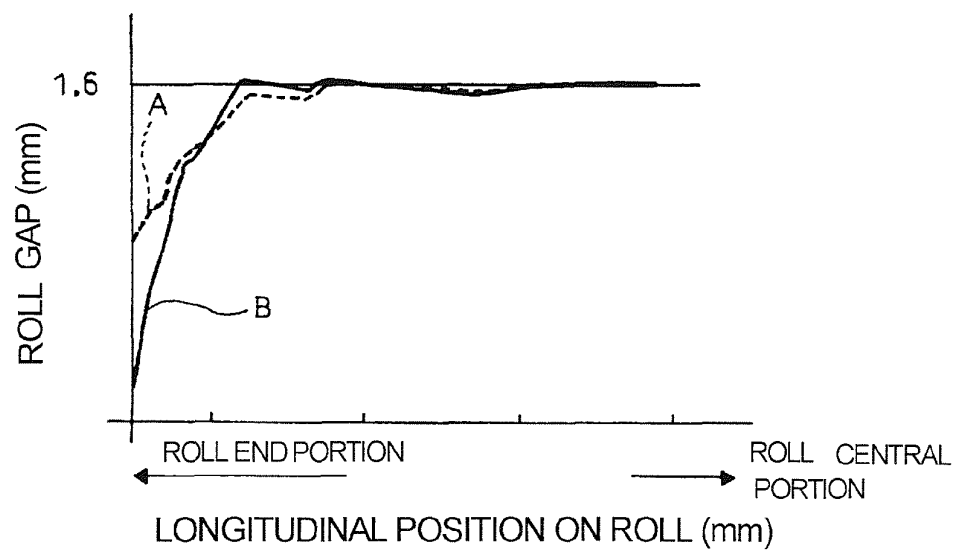


FIG. 5

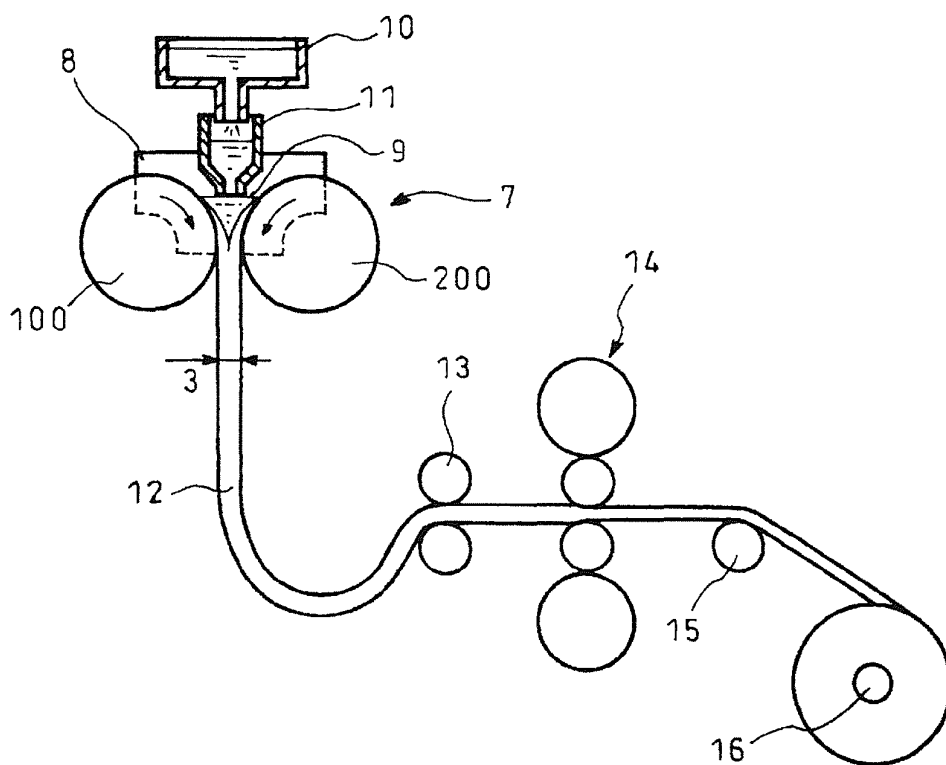


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/004332

A. CLASSIFICATION OF SUBJECT MATTER

B22D11/06(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)

B22D11/06

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 1996-2013

Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

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.
Y A	JP 2003-10948 A (Nippon Steel Corp.), 15 January 2003 (15.01.2003), claims; paragraphs [0002], [0003], [0016] to [0019]; fig. 3 to 5 (Family: none)	1 2-4
Y A	JP 7-323353 A (Danieli United, Inc.), 12 December 1995 (12.12.1995), paragraph [0013]; fig. 15 & US 5477911 A & EP 688620 A2	1 2-4



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
02 August, 2013 (02.08.13)Date of mailing of the international search report
13 August, 2013 (13.08.13)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

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