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(54) **Cooling apparatus for hot rolled steel strip, manufacturing method for hot rolled steel strip, and production line for hot rolled steel strip**

Kühlvorrichtung für heißgewalzte Stahlstreifen, Herstellungsverfahren für heißgewalzte Stahlstreifen und Produktionslinie für heißgewalzte Stahlstreifen

Appareil de refroidissement pour bande d'acier laminée à chaud, son procédé de fabrication et sa ligne de production

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- **PATENT ABSTRACTS OF JAPAN vol. 2000, no. 26, 1 July 2002 (2002-07-01) & JP 2001 246411 A (NKK CORP), 11 September 2001 (2001-09-11)**
- **PATENT ABSTRACTS OF JAPAN vol. 2000, no. 26, 1 July 2002 (2002-07-01) & JP 2001 246413 A (NKK CORP), 11 September 2001 (2001-09-11)**
- **PATENT ABSTRACTS OF JAPAN vol. 2000, no. 26, 1 July 2002 (2002-07-01) & JP 2001 246410 A (NKK CORP), 11 September 2001 (2001-09-11)**

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Description

TECHNICAL FIELD

[0001] The present invention relates to a cooling apparatus for hot rolled steel strip according to the preamble portion of claim 1, a manufacturing method for hot rolled steel strip and a production line for hot rolled steel strip using the cooling apparatus.

BACKGROUND ART

[0002] In general, a hot rolled steel strip is manufactured by heating a slab to a predetermined temperature in a reheating furnace, hot rolling the heated slab into a sheet bar having a predetermined thickness using a roughing mill, hot rolling the sheet bar into a steel strip having a predetermined thickness using a finishing mill having a plurality of rolling stands, transferring and cooling the hot rolled steel strip on a run-out table using a cooling apparatus, and then coiling the steel strip on a coiler. The run-out table is a transfer apparatus provided downstream of the finishing mill to transfer the hot rolled steel strip on a plurality of transfer rollers disposed at a suitable pitch.

[0003] A conventional cooling apparatus provided on the run-out table is so contrived as to mainly aim stable transfer of steel strip, as typically shown in Figs. 1A and 1B. Fig. 1A is a schematic view of such a cooling apparatus and Fig. 1B is a lateral view of the apparatus shown in Fig. 1A. As shown in Fig. 1A, the top surface cooling of a steel strip 9 is carried out by sprinkling laminar flow cooling water 32 from laminar flow cooling nozzles 31 in cylindrical pipes which are linearly provided directly above transfer rollers 7 in the width direction of the steel strip 9 in such a way that the steel strip 9 does not undulate on the transfer line due to water pressure. On the other hand, as shown in Fig. 1B, the bottom surface cooling of the steel strip 9 is carried out by intermittently jetting cooling water 34 from spray nozzles 33 provided between the transfer rollers 7 to the steel strip 9.

[0004] Recently, excellent workability, high strength with low carbon equivalent and the like have been required for a hot rolled steel strip. For these requirements, grain refining of steel strip is effective, and thus the steel strip need to be more rapidly cooled after hot rolling. In particular, the steel strip having low carbon equivalent such as an ultra low carbon steel strip should be cooled at a cooling rate exceeding 200°C/s because austenitic grains after hot rolling tend to become coarse due to recrystallization.

[0005] To conduct such rapid cooling, Japanese Unexamined Patent Application Publication No. 62-259610 discloses a method for increasing cooling capability for bottom surface of steel strip using a bottom surface cooling apparatus where cooling water jetting plates having a plurality of holes are disposed between transfer rollers and also function as a guide, and jetting cooling water toward the steel strip through the holes at different angles.

[0006] However, the method described in Japanese Unexamined Patent Application Publication No. 62-259610 causes various problems as follows.

(1) A hot rolled steel strip undulates vertically while being transferred on a run-out table when the leading end of the hot rolled steel strip lies between a finishing mill and a coiler, because the hot rolled steel strip is not under any tension. Cooling of such a tension free steel strip in this method causes further vertical waves. As a result, a sufficient volume of cooling water is not applied and it is impossible to cool, for example, a steel strip of 3mm in thickness at a cooling rate exceeding 200°C/s.

(2) This method does not enable the top and bottom surfaces of the steel strip to be cooled at the same cooling rate.

(3) This method presupposes cooling at a water flow rate of about 1,000L/min·m^2, but a higher water flow rate is required to cool a steel strip of, for example, about 3mm in thickness at a cooling rate exceeding 200°C/s. In the cooling apparatus used in this method, as shown schematically in Fig. 2A, a higher water flow rate causes jetted cooling water to remain in a narrow space between the cooling water jetting plate and the steel strip around the center in the width direction of the steel strip. Therefore, desired cooling is not performed because of a decrease in the flow velocity of the jetted cooling water. On the contrary, around the edge in the width direction of the steel strip, the cooling water flows down from the edge without remaining and therefore allows desired cooling. As a result, as shown in Fig. 2B, the temperature profile in the width direction of the steel strip shows an inverted-V shape, in which both edges are cooled to target temperature but the center is cooled to temperature higher than the target temperature. Thus, uniform cooling in the width direction is not performed.

Widening the space between the cooling water jetting plate and the steel strip, as shown in Fig. 3A, prevents cooling water from remaining at the center in the width direction of the steel strip, performing desired cooling. However, a large amount of cooling water is drained from the center toward the edges in the width direction of the steel strip after cooling, disrupting the cooling water flow at the edge in the width direction to lower cooling capability. As a result, as shown in Fig. 3B, the temperature profile in the width direction of the steel strip shows a V shape, in which both edges are cooled to temperature higher than target temperature and the center is cooled to the target temperature. Thus, uniform cooling in the width direction is not performed.

When the space between the cooling water jetting plate functioning also as a guide and the steel strip

is arranged properly, the temperature profile in the width direction of the steel strip after cooling shows an M shape which is the sum of the inverted-V shape in Fig. 2B and the V shape in Fig. 3B. Thus, uniform cooling in the width direction is not performed, either. (4) According to this method, when the cooling water is jetted toward the steel strip at different angles from a plurality of holes in the cooling water jetting plate functioning as nozzles, the distance that the cooling water travels varies depending on the nozzles. The cooling water jetted aslant to the steel strip travels a longer distance, thus greatly reducing the flow velocity to fail to efficiently cool the steel strip. As described in (3), cooling capability is greatly affected by the jetted cooling water, so it is more difficult to uniformly cool the steel strip in the width direction.

[0007] JP-A-2001246411 discloses a cooling apparatus for hot rolled steel strip with the features of the preamble portion of claim 1. The tips of the cooling water jetting nozzles in this apparatus are positioned above the respective protective member.

DISCLOSURE OF THE INVENTION

[0008] An object of the present invention is to provide a cooling apparatus for hot rolled steel strip which stably transfers a hot rolled steel strip and cools it rapidly and uniformly after hot rolling, a manufacturing method and a production line for hot rolled steel strip using such a cooling apparatus.

The above-mentioned object is accomplished by a cooling apparatus for hot rolled steel strip comprising the features of claim 1, by a manufacturing method as defined in claim 9 using such cooling apparatus, and by a production line as defined in claim 11 with such cooling apparatus. Preferred embodiments are defined in the dependent claims.

[0009] When such a cooling apparatus for hot rolled steel strip is provided on a run-out table in a production line for hot rolled steel strip, hot rolled steel strip can be transferred stably, and cooled rapidly and uniformly.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

Figs. 1A and 1B show an example of a conventional cooling apparatus for hot rolled steel strip installed on a run-out table.

Figs. 2A and 2B schematically show, respectively, behavior of cooling water and temperature profile in the width direction of steel strip when the cooling apparatus disclosed in Japanese Unexamined Patent Application Publication No. 62-259610 is applied.

Figs. 3A and 3B schematically show, respectively, behavior of cooling water and difference between target temperature and actual temperature in the width direction of steel strip when the space between cooling water jetting plate and steel strip in Figs. 2A and 2B is widened.

Fig. 4 shows an example of a production line for hot rolled steel strip provided with a cooling apparatus for hot rolled steel strip according to the present invention.

Figs. 5A and 5B show an example of a cooling apparatus for hot rolled steel strip according to the present invention.

Figs. 6A and 6B schematically show cylindrical laminar flow and non-laminar flow, respectively.

Figs. 7A, 7B, 7C and 7D show various protective members.

Figs. 8A and 8B show an example of cooling means provided with the protective member plate having cooling water passage slits shown in Fig. 7A.

Fig. 9 shows an example of positional relationship between protective member, cooling water header and cooling water jetting nozzles in bottom surface cooling means.

Fig. 10 shows another example of positional relationship between protective member, cooling water header and cooling water jetting nozzles in bottom surface cooling means.

Figs. 11A and 11B schematically show behavior of a leading end of steel strip during transfer.

Fig. 12 shows an example of positional relationship between protective member, cooling water header and cooling water jetting nozzles in top surface cooling means.

Fig. 13 shows another example of a cooling apparatus for hot rolled steel strip according to the present invention.

Fig. 14 shows a production line for hot rolled steel strip provided with the cooling apparatus shown in Fig. 13.

Fig. 15 shows a comparative example of a cooling apparatus for hot rolled steel strip.

Fig. 16 shows temperature profile in the width direction of steel strip.

EMBODIMENTS OF THE INVENTION

[0011] Fig. 4 shows an example of a production line for hot rolled steel strip provided with a cooling apparatus for hot rolled steel strip according to the present invention.

[0012] The production line includes a roughing mill 1 to roll a slab into a sheet bar 2, a finishing mill 3 including a plurality of rolling stands to roll the sheet bar 2 into a hot rolled steel strip 9 having a predetermined thickness, a run-out table 5 to transfer the hot rolled steel strip 9 after hot rolling on transfer rollers 7, and a coiler 6 to coil the hot rolled steel strip 9. The run-out table 5 is provided, just downstream of the finishing mill 3, with a cooling apparatus 4 according to the present invention to rapidly cool the hot rolled steel strip 9. In addition, the conven-

tional cooling apparatus 8 shown in Fig. 1A may also be provided downstream of the cooling apparatus 4.

[0013] Fig. 5A shows an example of a cooling apparatus for hot rolled steel strip according to the present invention. Fig. 5B is a partially magnified drawing of the cooling apparatus shown in Fig. 5A.

[0014] The cooling apparatus for hot rolled steel strip according to the present invention includes bottom surface cooling means 4a provided below a hot rolled steel strip 9 to cool the bottom surface of the hot rolled steel strip 9 and top surface cooling means 4b provided above the hot rolled steel strip 9 to cool the top surface of the hot rolled steel strip 9.

[0015] Each of the cooling means 4a and 4b is provided with protective member plates 10, consisting of bottom protective members 10a and top protective members 10b, disposed close and approximately parallel to the surface of the hot rolled steel strip 9, and cooling water headers 12, consisting of bottom surface cooling water headers 12a and top surface cooling water headers 12b, disposed to oppose the hot rolled steel strip 9 separated by the protective members 10a or 10b. Each of the cooling water headers 12a or 12b is provided with protruding cooling water jetting nozzles 15 at a suitable pitch in the width and longitudinal directions of a run-out table. The tips of the cooling water jetting nozzles 15 are disposed farther from the hot rolled steel strip 9 than the surfaces, opposing the hot rolled steel strip 9, of the protective members 10. Furthermore, each of the protective members 10 has a plurality of cooling water passage holes 11 to pass cooling water. Through the cooling water passage holes 11, each of the cooling water jetting nozzles 15 jets cooling water approximately vertically toward the surface of steel strip.

[0016] Two guide rollers 14 are provided above the hot rolled steel strip 9 approximately opposing the transfer rollers 7 provided under the hot rolled steel strip 9. The guide rollers 14 allow to transfer the hot rolled steel strip 9 more stably. Preferably, the guide rollers 14 are provided at at least one position above the hot rolled steel strip 9 approximately opposing the transfer rollers 7. The guide rollers 14 may be provided at all the positions approximately opposing the transfer rollers 7.

[0017] The top surface protective members 10b of the top surface cooling means 4b are disposed close to the surface of steel strip at positions other than where the guide rollers 14 are provided.

[0018] On the other hand, the bottom surface protective members 10a of the bottom surface cooling means 4a are disposed between the transfer rollers 7 provided in the longitudinal direction of the run-out table at a suitable pitch. Therefore, the cooling water jetting nozzles 15 of the bottom surface cooling water headers 12a are disposed between the transfer rollers 7. In Fig. 5A, the bottom surface cooling water headers 12a are provided between the transfer rollers 7, but the bottom surface cooling water headers 12a may be provided in such a way that they cover more than one of the transfer rollers 7 by passing below the conveying rollers 7. At least one bottom surface cooling water header 12a is provided between two adjacent transfer rollers 7, and preferably, a plurality of bottom surface cooling water headers 12a is separately provided in the longitudinal direction and/or the width direction of the run-out table. The cooling water headers 12 separately provided can minutely control the cooling of the hot rolled steel strip 9. When the cooling water headers 12 are separately provided in the longitudinal direction, for example, the cooling starting temperature of the steel strip 9 can be kept constant by minutely changing the cooling starting position of the cooling water headers 12 in response to the cooling starting point of the steel strip depending on the transfer speed of the steel strip. When the cooling water headers 12 are separately provided in the width direction, effective cooling is possible by selecting the cooling water headers 12 in response to various widths of the steel strips.

[0019] With regard to the top surface cooling water headers 12b, the same effect is achieved. Preferably, the top surface cooling water headers 12b are arranged to oppose the bottom surface cooling water headers 12a separated by the hot rolled steel strip 9. This provides the following advantages: The top and bottom cooling can be easily balanced; the positions of the headers to start cooling the top and bottom surfaces can be easily adjusted; the hot rolled steel strip 9 can be stably transferred due to the water pressure from the upside and downside.

[0020] Preferably, each of the cooling water jetting nozzles 15 of the top surface cooling means 4b protruding from each of the top cooling water headers 12 is arranged to approximately oppose each of the cooling water jetting nozzles 15 of the bottom surface cooling means 4a protruding from each of the bottom cooling water headers 12 separated by the hot rolled steel strip 9. This is effective to bring the cooling of the top and bottom surfaces and the water pressure thereof into balance.

[0021] As described above, each of the cooling water jetting nozzles 15 protrudes from each of the cooling water headers 12 and is disposed so as to jet cooling water approximately vertical to the surface of the steel strip. In other words, when nozzle installation surfaces of the cooling water headers 12 are parallel to the steel strip as shown in Fig. 5B, the cooling water jetting nozzles 15 vertically protrude from the cooling water headers 12. In this arrangement, cooling water being jetted from the nozzles is less affected by the jetted cooling water, as in the cooling apparatus disclosed in Japanese Unexamined Patent Application Publication No. 62-259610. Furthermore, the flow velocity of the cooling water, which is jetted from the nozzles and collides with the steel strip, is almost equal in all nozzles so as to conduct uniform cooling.

[0022] Laminar nozzles are generally used as the cooling water jetting nozzles 15. Since the cooling water jetting outlets of laminar nozzles are cylindrical, jetted water flow collides with the steel strip 9 as laminar flow without

divergence. Here, the cylindrical laminar flow is primarily laminar flow but it may contain some turbulent flow.

[0023] Figs. 6A and 6B, respectively, schematically show the cylindrical laminar flow and the non-laminar flow.

[0024] In the cylindrical laminar flow, the water flow reaches the steel strip without divergence to give good cooling efficiency, resulting in rapid cooling at a rate exceeding 200°C/s. On the other hand, in the non-laminar flow, since the flow velocity of the cooling water jetted from nozzles is reduced by cooling water remaining between the steel strip and the nozzles, even if the nozzles are disposed close to the steel strip, the cooling efficiency is low.

[0025] The conventional cooling apparatus uses laminar flow cooling nozzles for cooling the top surface of steel strip. However, since the main cooling is carried out by film boiling in which cooling water is poured over the entire steel strip to cover its surface with cooling water, the cooling rate is 100°C/s at highest. On the other hand, the cooling apparatus according to the present invention uses laminar nozzles as cooling water jetting nozzles as the conventional cooling apparatus, but the cooling apparatus according to the present invention can jet a large amount of cooling water at a water flow rate exceeding about 2,500L/min·m^2. As a result, the cooling water covers the entire steel strip and also the cooling water jetted from the nozzles is directly applied to the steel strip, making it possible to cool the steel strip of about 3mm in thickness at a cooling rate exceeding 200°C/s. The cooling rate depends on the thickness of steel strip and increases as the thickness becomes thinner. When a cooling condition such as the water flow rate is constant, the product of the strip thickness and the cooling rate is almost constant. Accordingly, even when the strip is thick, the desired cooling rate can be achieved, for example, by increasing the water flow rate.

[0026] The diameter of the cooling water jetting nozzles of the present invention is preferably 1 to 10mm. When the diameter is smaller than 1mm, it is difficult to generate the cylindrical laminar flow. Since the cooling using the cooling apparatus according to the present invention needs collision pressure, the flow velocity at nozzle outlets is constant and the amount of water increases with increasing diameter of jetting outlets. However, since cooling capability is saturated at a certain amount of water, the jetting outlet diameter should be 10mm or less from an economic standpoint.

[0027] The above-mentioned protective members disposed between cooling water headers and steel strip play two roles of stably transferring the steel strip and protecting the cooling water headers and the cooling water jetting nozzles from collision with the steel strip. The cooling water passage holes in the protective members function not only as jetting holes of cooling water and but as drain holes of jetted cooling water.

[0028] Each of the protective members provided with cooling water passage holes may be, for example, a flat plate having slits shown in Fig. 7A, a group of bars disposed in parallel shown in Fig. 7B, a grid shown in Fig. 7C, or an expanded metal shown in Fig. 7D. Since the protective members shown in Figs. 7B, 7C, and 7D make contact with the steel strip in a small area, the contact surface pressure increases. This readily causes seizing to the steel strip or indentation flaws on the steel strip. Thereby, flat plates, which have a minimum number of cooling water passage holes to pass the cooling water, provided with slits such as shown in Fig. 7A are preferable. Such protective members prevent flaws from generating on the steel strip.

[0029] When flat plates shown Fig. 7A are used as protective members, the plate thickness is preferably 5mm or more in view of strength, rigidity, or the like of the steel strip. When the plate thickness is less than 5mm, the plates may become damaged or deformed by collision with the transferred steel strip.

[0030] Figs. 8A and 8B show an example of cooling means which is provided with protective members having cooling water passage holes in a slit shape shown in Fig. 7A. Fig. 8A is a plan view of bottom surface cooling means. Fig. 8B is a cross sectional view taken along line A-A in Fig. 8A. Fig. 8B also shows top surface cooling means.

[0031] Each of the slit shaped cooling water passage holes 11 of the protective members 10 is provided with a plurality of cooling water jetting nozzles 15 to jet cooling water as the laminar flow 13. The orifices of the slit shaped cooling water passage holes 11 are preferably as large as possible to drain jetted cooling water, but larger orifices cause collision of the leading end of the steel strip 9 with the slit edge resulting in seizing and damage. Accordingly, the size of an orifice of the slit shaped cooling water passage holes 11 is preferably large enough to hold about two to ten cooling water jetting nozzles 15 in a line, as shown in Fig. 8A. Each of the slit shaped cooling water passage holes 11 may be provided with a plurality of nozzles being linearly disposed in a plurality of lines.

[0032] As shown in Fig. 8A, it is not necessary for all the cooling water passage holes 11 to be slit shaped, although the majority of the cooling water passage holes 11 should be slit shaped. If some of the cooling water passage holes 11 are not slit shaped, this does not disturb the passage of the cooling water. In particular, at the center and both edges in the width direction of steel strip, it is difficult to form slit shaped cooling water passage holes 11 due to restriction of the arrangement.

[0033] Preferably, the longitudinal direction of the slit shaped cooling water passage holes 11 inclines in the horizontal plane with respect to the transferring direction of the steel strip 9 in order to allow easy drainage to the outside of the cooling apparatus. When the longitudinal direction of the slit shaped cooling water passage holes 11 is perpendicular to the transferring direction of the steel strip 9, it may disturb the flow of the drainage or may cause collision of the leading end of the steel strip

9 with the slit shaped holes giving damage to the steel strip 9 and the cooling water passage holes 11. When the longitudinal direction of the slit shaped cooling water passage holes 11 is parallel to the transferring direction of the steel strip 9, the flow of the drainage is not smooth. As shown in Fig. 8A, the slit shaped cooling water passage holes 11 are disposed so as to be almost axisymmetric to the central line of the run-out table and the longitudinal direction of the cooling water passage holes 11 inclines in the horizontal plane to diverge toward the transferring direction of the steel strip 9. This is more preferable for the smooth flow of the drainage to the outside of the cooling apparatus.

[0034] Fig. 9 shows an example of positional relationship between protective member, cooling water header and cooling water jetting nozzles in bottom surface cooling means.

[0035] In this example, the thickness of the protective members 10a is small, and tips 16 of the cooling water jetting nozzles 15 are disposed below the bottom surface of the protective members 10a.

[0036] Fig. 10 shows another example of positional relationship between protective member, cooling water header and cooling water jetting nozzles in bottom surface cooling means.

[0037] In this example, the thickness of the protective members 10a is large, and tips 16 of the cooling water jetting nozzles 15 are disposed inside the cooling water passage holes 11 of the protective members 10a.

[0038] In the bottom surface cooling means shown in Fig. 9, the distance Xa from the tips 16 of the cooling water jetting nozzles to the surface of the steel strip 9, the distance Ya from the top surface of the protective members 10a to the surface of the steel strip, and the distance Za from the bottom surface of the protective members 10a to the cooling water headers 12a are determined as follows:

[0039] First, the impinging velocity of the laminar flow 13 of cooling water to the steel strip and the pitch between the cooling water jetting nozzles 15 are determined so as to achieve a desired cooling rate.

[0040] Then, the distance Xa from the tips 16 of the cooling water jetting nozzles to the surface of the steel strip is determined to secure the impinging velocity in view of the diameter of the cooling water jetting nozzles 15. It is preferable that the distance Xa from the tips 16 of the cooling water jetting nozzles to the surface of the steel strip be 100mm or less. When the cooling water used for cooling the steel strip 9 flows out from the space between the steel strip 9 and the protective members 10a, the cooling water prevents the laminar flow 13 of the cooling water jetted from the cooling water jetting nozzles 15 from colliding with the steel strip. In particular, when the distance Xa exceeds 100mm, the flow velocity of the laminar flow 13 of the cooling water significantly decreases. This further disturbs the collision of the cooling water with the steel strip, failing in rapid cooling. As described above, the tips 16 of the cooling water jetting nozzles are disposed farther from the steel strip 9 than the surface, opposing the steel strip 9, of the protective members 10a. In other words, the distance Xa from the tips 16 of the cooling water jetting nozzles to the surface of the steel strip is determined to be longer than the distance Ya, which will be described below, from the top surfaces of the protective members 10a to the surface of the steel strip.

[0041] The distance Ya from the top surfaces of the protective members 10a to the surface of the steel strip is determined in view of stably transferring the steel strip 9 above the top surfaces of the protective members 10a. When the protective members 10a are disposed at the lower positions, as shown in Fig. 11A, the leading end of the transferred steel strip 9 bends downward to collide with the transfer rollers 7 and be bounced upward. The leading end of the steel strip 9 further undulates vertically as the steel strip 9 is transferred, disturbing stable transferring. In the worst case, as shown in Fig. 11B, the steel strip 9 may bend several times and cannot be transferred. Such a phenomenon will readily occur when the Ya exceeds 50mm. On the other hand, when the Ya is smaller than 10mm, the steel strip 9 comes into contact with the protective members 10a, causing scratching in the steel strip and also bending of the steel strip described above. Consequently, the Ya is preferably 10 to 50mm.

[0042] The distance Za from the bottom surfaces of the protective members 10a to the cooling water headers 12a yields a necessary space for rapidly draining the cooling water jetted from the cooling water jetting nozzles 15, and thus the Za is preferably larger. However, when the Za is too large, the cooling water jetting nozzles 15 protruding from the cooling water headers 12a must be significantly long. On the other hand, the ratio of the diameter of the cooling water jetting nozzle to the length of a straight run of the cylindrical laminar nozzle used in the cooling water jetting nozzles 15 is preferably 5 to 20. The ratio over 20 increases the flow resistance, and thus the supply pressure of the cooling water should be increased, which is not economical. When the ratio is less than 5, the cooling water is jetted in non-laminar flow as shown in Fig. 6B, resulting in insufficient cooling capability. The distance Za is determined in view of the cooling water amount drained through the cooling water passage holes 11 of the protective members 10a. More specifically, the cooling water jetted from the cooling water jetting nozzles 15 to cool the steel strip 9 flows into the space having the distance Ya between the protective members 10a and the steel strip and is drained through the following three paths: (i) both edges in the width direction of the space between the protective members 10a and the steel strip 9; (ii) the space between the protective members 10a and the transfer rollers 7; and (iii) the cooling water passage holes 11 provided in the protective members 10a. The space between the protective members 10a and the transfer rollers 7 is usually, for example, 1mm or less so that the leading end of the steel strip 9 does not collide with the space. Consequently, the

amount of cooling water drained through the path (ii) is small. On the other hand, if the amount of cooling water flowing through the path (i) is large, the flow from the center to both edges in the width direction becomes strong causing a V-shaped temperature profile, as shown in Fig. 3B, in the width direction. Therefore, to reduce the flow from the center to both edges in the width direction as much as possible, the protective members 10a should be provided with the cooling water passage holes 11 to drain the cooling water through the path (iii). Thereby, the area dimension of the cooling water passage holes 11 is determined, the amount of cooling water drained through the cooling water passage holes 11, which is the amount of cooling water falling on the cooling water headers 12a, is calculated from the planar dimension, and then the distance Za from the bottom surfaces of the protective members 10a to the cooling water headers 12a is determined. The cooling water that has fallen on the cooling water headers 12a is drained through the space between the cooling water headers 12a and the transfer rollers 7. When the cooling water remains due to insufficient draining, it disturbs the laminar flow 13 of the cooling water jetted from the cooling water jetting nozzles 15, resulting in heterogeneous cooling of the steel strip in the width direction. Therefore, sufficient space is important for draining the cooling water.

[0043] Fig. 12 shows an example of positional relationship between protective member, cooling water header, and cooling water jetting nozzles in top surface cooling means.

[0044] The distance Xb from the tips 16 of the cooling water jetting nozzles to the surface of the steel strip 9, the distance Yb from the bottom surfaces of the protective members 10b to the surface of the steel strip, and the distance Zb from the top surfaces of the protective members 10b to the cooling water headers 12b are determined as follows.

[0045] The distance Xb from the tips 16 of the cooling water jetting nozzles to the surface of the steel strip in the top surface cooling means corresponds to the distance Xa in the bottom surface cooling means described above. In the top surface cooling means, since the cooling water remains on the steel strip 9, the distance is determined in additional view of the number and position of the guide rollers 14, the distance Yb between the bottom surfaces of the protective members 10b and the surface of the steel strip, and the thickness of the protective members 10b. Here, the distance Xb from the tips 16 of the cooling water jetting nozzles to the surface of the steel strip is preferably 100mm or less, similar to the distance Xa in the bottom surface cooling means.

[0046] The distance Yb from the bottom surfaces of the protective members 10b to the surface of the steel strip corresponds to the distance Ya in the bottom surface cooling means described above and is preferably 10 to 50mm, as in the bottom surface cooling means.

[0047] The distance Zb from the top surfaces of the protective members 10b to the cooling water headers 12b corresponds to the distance Za in the bottom surface cooling means and is determined in additional view of the number and position of the guide rollers 14 and the space between the guide rollers 14 and the steel strip 9. The area dimension of the cooling water passage holes 11 of the protective members 10b is also determined in view of the number and position of the guide rollers 14 and the space between the guide rollers 14 and the steel strip 9.

[0048] As shown in Fig. 12, the tips 16 of the cooling water jetting nozzles 15 in the top surface cooling means are preferably disposed inside the cooling water passage holes 11 of the protective members 10b. The reasons for this are as follows.

[0049] In the bottom surface cooling means, the cooling water jetted to the steel strip 9 flows down due to gravity through the cooling water passage holes 11 in the protective members 10a. On the other hand, in the top surface cooling means, the majority of the jetted cooling water is drained from both edges in the width direction. Therefore, the cooling water that is not drained from the space between the steel strip 9 and the protective members 10b flows into the space between the protective members 10b and the cooling water headers 12b from below the protective members 10b through the cooling water passage holes 11. Consequently, the tips 16 of the cooling water jetting nozzles 15 are preferably disposed inside the cooling water passage holes 11 so that the flow of the cooling water jetted from the cooling water jetting nozzles 15 is not affected by the drained water flowing toward both edges in the width direction in the space above the protective members 10b.

[0050] In the bottom surface cooling means, since the flow of the jetted cooling water may be affected by the drained water flowing toward both edges in the width direction in the space between the cooling water headers 12a and the protective members 10a depending on the amount of the drained water, the tips 16 of the cooling water jetting nozzles 15 are preferably disposed inside the cooling water passage holes 11 of the protective members 10b.

[0051] The guide rollers 14 provided above the transferred hot rolled steel strip 9 preferably has a gap about 5nm from the surface of the hot rolled steel strip 9, when no problems, such as jamming of the leading end of the steel strip 9 or looping of the steel strip 9, occur during transfer. When the above-mentioned problems occur during transfer, the gap between the guide rollers 14 and the steel strip 9 is broadened so as not to raise the loop and to send the leading and trailing ends of the steel strip out of the cooling means. When the broadened gap between the guide rollers 14 and the steel strip 9 disturbs the drainage, a pinch roll is preferably provided at at least one position of the entry side, the delivery side, or between both sides of the cooling means to forcibly pinch the steel strip 9 and send it into or out the cooling means.

[0052] The above-mentioned cooling apparatus for hot rolled steel strip according to the present invention can

almost uniformly jet the cooling water from above and below and rapidly cool the hot rolled steel strip while stable transfer of the steel strip is maintained by the protective members and the guide rollers. Since the cooling water jetted to the surface of the steel strip is properly drained and the influence of jetted cooling water flow is minimized to cool the hot rolled steel strip, rapid and uniform cooling in the width direction can be achieved.

[0053] As shown Fig. 4, when the cooling apparatus for hot rolled steel strip according to the present invention is provided on a run-out table in a production line for hot rolled steel strip, a steel strip can be stably and uniformly cooled at a cooling rate exceeding 200°C/s, and a hot rolled steel strip having excellent workability can be manufactured without fluctuation of properties nor degradation of shape.

Example

[0054] Using a production line for hot rolled steel strip shown in Fig. 14, which is provided with a cooling apparatus for hot rolled steel strip according to the present invention shown in Fig. 13, a sheet bar of carbon steel having a thickness of 30mm and a width of 1,000mm was rolled by a finishing mill having seven rolling stands at a transfer rate of 700 mpm and at a finishing temperature of 850°C into a steel strip having a thickness of 3mm. The steel strip was cooled to about 550°C at a cooling rate of 700°C/s, and then cooled to a coiling temperature of 500°C using a conventional cooling apparatus 8. The water flow rate was 7,500L/min·m^2 for a cooling rate of about 700°C/s.

[0055] As shown in Fig. 13, bottom surface cooling means 4a comprises a plurality of transfer rollers 7 having a diameter of 300mm which are disposed in the longitudinal direction at a pitch of 500mm, bottom surface protective member plates 10a having a thickness of 25mm which are disposed between the transfer rollers 7 close and parallel to the surface of the transferred hot rolled steel strip 9, a plurality of cooling water passage holes 11 in the bottom surface protective member plates 10a as passages for cooling water, cooling water jetting nozzles 15 having outlets with a diameter of 5mm, of which the tips are disposed at lower positions than the top surfaces of the protective member plates, and bottom surface cooling water headers 12a from which the cooling water jetting nozzles 15 protrude.

[0056] One bottom surface cooling water header 12a is disposed between two adjacent transfer rollers. The bottom surface cooling water headers 12a are provided with the cooling water jetting nozzles 15 used for jetting cooling water at the same pitch in both the width and the longitudinal directions. Laminar nozzles are used as the cooling water jetting nozzles 15.

[0057] The distance Xa between the surface of the steel strip and the tips 16 of the cooling water jetting nozzles is 25mm, the distance Ya between the surface of the steel strip and the top surfaces of the bottom surface protective member plates 10a is 10mm, and the distance Za between the bottom surface protective member plates 10a and the cooling water headers 12a is 30mm.

[0058] Top surface cooling means 4b comprises three guide rollers 14 which are disposed to oppose the transfer rollers 7 and have a space of 5mm from the steel strip 9, top surface protective member plates 10b having a thickness of 25mm which are disposed close and parallel to the surface of the transferred hot rolled steel strip 9, a plurality of cooling water passage holes 11 in the top surface protective member plates 10b as passages for cooling water, cooling water jetting nozzles 15 having outlets with a diameter of 5mm, of which the tips are disposed higher than the bottom surfaces of the protective member plates, and top surface cooling water headers 12b from which the cooling water jetting nozzles 15 protrude.

[0059] The top surface cooling water headers 12b are disposed to oppose the cooling water headers 12a of the bottom surface cooling means. The top surface cooling water headers 12b are provided with the cooling water jetting nozzles 15 used for jetting cooling water at a pitch of 30mm in the width direction and at a pitch of 30mm in the longitudinal direction. Laminar nozzles are used as the cooling water jetting nozzles 15.

[0060] The distance Xb between the surface of the steel strip and the tips 16 of the cooling water jetting nozzles is 30mm, the distance Yb between the surface of the steel strip and the bottom surfaces of the top surface protective member plates 10b is 15mm, and the distance Zb between the top surface protective member plates 10b and the top surface cooling water headers 12b is 30mm.

[0061] As a comparative example, a similar test was carried out using a production line provided with a cooling apparatus for hot rolled steel strip shown in Fig. 15.

[0062] The cooling apparatus used in the comparative example has almost the same constitution as the cooling apparatus of the present invention shown in Fig. 13 except that the cooling water jetting nozzles are mounted in the cooling water headers 22 and that the nozzle tips are disposed on the surface of the cooling water headers 22. In this regard, the distance X between the surface of the steel strip and the tips of the cooling water jetting nozzles is 60mm, the distance Y between the surface of the steel strip and the protective member plates 20 is 20mm, and the distance Z between the protective member plates 20 and the cooling water headers 22 is 15mm.

[0063] Fig. 16 shows temperature profile in the width direction of the steel strip.

[0064] When the cooling apparatus for hot rolled steel strip according to the present invention is used, the temperature profile in the width direction of the steel strip is around ±20°C, and almost uniform cooling in the width direction is achieved. In addition, the variation in strength of the hot rolled steel strip in the width direction is 20MPa.

[0065] In contrast, in the comparative example, the temperature profile in the width direction of the steel strip

is ±50°C or more and shows the V-shaped profile in the width direction. Because of high temperature at both edges in the width direction of the steel strip, the steel strip is deformed and is not coiled normally. The variation in strength of the hot rolled steel strip in the width direction is 80MPa.

[0066] When the protective member plates of the cooling apparatus used in the comparative example are disposed close to the steel strip, the temperature profile shows the inverted-V shape in the width direction of the steel strip.

Claims

1. A cooling apparatus for hot rolled steel strip (9) comprising:

top surface cooling means (4b) to be provided above a hot rolled steel strip (9) transferred with transfer rollers (7) after hot rolling to cool the top surface of the hot rolled steel strip (9); and
bottom surface cooling means (4a) to be provided below the hot rolled steel strip (9) to cool the bottom surface of the hot rolled steel strip (9),
each of the top surface cooling means (4b) and the bottom surface cooling means (4a) comprising:

a protective member (10a,10b) disposed close to the surface of the hot rolled steel strip (9), having at least one cooling water passage hole (11);
at least one cooling water header (12a,12b) opposing the hot rolled steel strip (9) separated by the protective member (10a,10b); and
cooling water jetting nozzles (15) protruding from the cooling water header (12a,12b) and adapted to jet cooling water approximately vertically toward the surface of the hot rolled steel strip (9) through the cooling water passage hole (11), wherein the tips (16) of the cooling water jetting nozzles (15) are disposed farther from the hot rolled steel strip (9) than the surface, opposing the hot rolled steel strip (9), of the protective member (10a,10b);

characterized in that
the cooling water passage hole (11) is slit shaped;
the longitudinal direction of the slit shaped cooling water passage hole (11) inclines in the horizontal plane with respect to the transferring direction of the hot rolled steel strip (9); and
cooling water is adapted to be jetted from a plurality of cooling water jetting nozzles (15) through the slit shaped cooling water passage hole (11).

2. The cooling apparatus for hot rolled steel strip (9) of claim 1, wherein the cooling water header (12b) of the top surface cooling means (4b) approximately opposes the cooling water header (12a) of the bottom surface cooling means (4a) separated by the hot rolled steel strip (9), and/or the cooling water jetting nozzles (15) of the top surface cooling means (4b) approximately oppose the cooling water jetting nozzles (15) of the bottom surface cooling means (4a) separated by the hot rolled steel strip (9).

3. The cooling apparatus for hot rolled steel strip (9) of claim 1 or 2, wherein the distance (Xa,Xb) between the surface of the hot rolled steel strip (9) and the tips (16) of the cooling water jetting nozzles (15) is 100mm or less.

4. The cooling apparatus for hot rolled steel strip (9) of any one of claims 1 to 3, wherein the distance (Ya, Yb) between the surface of the hot rolled steel strip (9) and the surface, opposing the hot rolled steel strip (9), of the protective member (10a,10b) is 10 to 50mm.

5. The cooling apparatus for hot rolled steel strip (9) of any one of claims 1 to 4, wherein a guide roller (14) is provided above the hot rolled steel strip (9) approximately opposing the transfer rollers (17) below the hot rolled steel strip (9) at at least one position.

6. The cooling apparatus for hot rolled steel strip (9) of any one of claims 1 to 5, wherein the tips (16) of the cooling water jetting nozzles (15) are disposed inside the cooling water passage hole (11).

7. The cooling apparatus for hot rolled steel strip (9) of any one of claims 1 to 6, wherein the size of an orifice of the slit shaped cooling water passage hole (11) is dimensioned such that it can hold two to ten cooling water jetting nozzles (15) in a line.

8. The cooling apparatus for hot rolled steel strip (9) of any one of claims 1 to 7, wherein the protective member (10a,10b) has a plurality of slit shaped cooling water passage holes (11) which are disposed so as to be almost axisymmetric to the central line of a run-out table (5) when installed in a production line, and such that the longitudinal direction of the slit shaped cooling water passage holes (11) inclines in the horizontal plane to diverge toward the transferring direction of the steel strip (9).

9. A method for manufacturing a hot rolled steel strip (9), comprising a step of cooling the hot rolled steel strip (9) after hot rolling with the cooling apparatus

(4) for hot rolled steel strip (9) according to any one of claims 1 to 8.

10. The method for manufacturing a hot rolled steel strip (9) according to claim 9, wherein the hot rolled steel strip (9) is cooled with a cylindrical laminar flow at a water flow rate exceeding 2,500L/min x m^2.

11. A production line comprising a run-out table (5) provided with a cooling apparatus (4) for hot rolled steel strip (9) of any one of claims 1 to 8.

Patentansprüche

1. Eine Kühlvorrichtung für warmgewalztes Stahlband (9), mit:

Oberseiten-Kühlmitteln (4b), die über einem warmgewalzten Stahlband (9) vorzusehen sind, welches mit Transfer-Walzen (7) nach dem Warmwalzen transportiert wird, um die obere Oberfläche des warmgewalzten Stahlbandes (9) zu kühlen, und
Unterseiten-Kühlmitteln (4a), die unter dem warmgewalzten Stahlband (9) vorzusehen sind, um die untere Oberfläche des warmgewalzten Stahlbands (9) zu kühlen,
wobei jedes der Oberseiten-Kühlmittel (4b) und der Unterseiten-Kühlmittel (4a) umfasst:

ein Schutzelement (10a,10b), das nahe der Oberfläche des warmgewalzten Stahlbandes (9) angeordnet ist und mindestens ein Kühlwasser-Durchgangsloch (11) besitzt,
mindestens ein Kühlwasser-Kopfteil (12a, 12b), das dem warmgewalzten Stahlband (9) unter Trennung durch das Schutzelement (10a,10b) gegenüberliegt, und
Kühlwasser-Ausstoßdüsen (15), die von dem Kühlwasser-Kopfteil (12a,12b) vorstehen und eingerichtet sind, Kühlwasser annähernd vertikal zu der Oberfläche des warmgewalzten Stahlbands (9) durch das Kühlwasser-Durchgangsloch (11) auszustoßen, wobei die Enden (16) der Kühlwasser-Ausstoßdüsen (15) weiter entfernt von dem warmgewalzten Stahlband (9) angeordnet sind als die dem warmgewalzten Stahlband (9) gegenüberliegende Oberfläche des Schutzelements (10a,10b),

dadurch gekennzeichnet, dass
das Kühlwasser-Durchgangsloch (11) schlitzförmig ist,
die Longitudinalrichtung des schlitzförmigen Kühlwasser-Durchgangslochs (11) in der Horizontalebene bezüglich der Transportrichtung des warmgewalzten Stahlbandes (9) geneigt ist bzw. schräg verläuft, und
Kühlwasser aus mehreren Kühlwasser-Ausstoßdüsen (15) durch das schlitzförmige Kühlwasser-Durchgangsloch (11) ausgestoßen werden kann.

2. Die Kühlvorrichtung für warmgewalztes Stahlband (9) gemäß Anspruch 1, wobei das Kühlwasser-Kopfteil (12b) des Oberseiten-Kühlmittels (4b) dem Kühlwasser-Kopfteil (12a) des Unterseiten-Kühlmittels (4a) getrennt durch das warmgewalzte Stahlband (9) annähernd gegenüberliegt, und/oder die Kühlwasser-Ausstoßdüsen (15) des Oberseiten-Kühlmittels (4b) den Kühlwasser-Ausstoßdüsen (15) des Unterseiten-Kühlmittels (4a) getrennt durch das warmgewalzte Stahlband (9) annähernd gegenüberliegen.

3. Die Kühlvorrichtung für warmgewalztes Stahlband (9) gemäß Anspruch 1 oder 2, wobei der Abstand (Xa,Xb) zwischen der Oberfläche des warmgewalzten Stahlbandes (9) und den Enden (16) der Kühlwasser-Ausstoßdüsen (15) auf 100mm oder weniger eingestellt ist.

4. Die Kühlvorrichtung für warmgewalztes Stahlband (9) gemäß einem der Ansprüche 1 bis 3, wobei der Abstand (Ya,Yb) zwischen der Oberfläche des warmgewalzten Stahlbandes (9) und der Oberfläche des Schutzelements (10a,10b) gegenüber dem warmgewalzten Stahlband (9) auf 10 bis 50mm eingestellt ist.

5. Die Kühlvorrichtung für warmgewalztes Stahlband (9) gemäß einem der Ansprüche 1 bis 4, wobei eine Leitwalze (14) über dem warmgewalzten Stahlband (9) annähernd gegenüber den Transportwalzen (17) unter dem warmgewalzten Stahlband (9) zumindest an einer Position vorgesehen ist.

6. Die Kühlvorrichtung für warmgewalztes Stahlband (9) gemäß einem der Ansprüche 1 bis 5, wobei die Enden (16) der Kühlwasser-Ausstoßdüsen (15) innerhalb des Kühlwasserdurchgangslochs (11) angeordnet sind.

7. Die Kühlvorrichtung für warmgewalztes Stahlband (9) gemäß einem der Ansprüche 1 bis 6, wobei die Größe einer Öffnung des schlitzförmigen Kühlwasser-Durchgangslochs (11) so dimensioniert ist, dass sie zwei bis zehn Kühlwasser-Ausstoßdüsen (15) in einer Reihe aufnehmen kann.

8. Die Kühlvorrichtung für warmgewalztes Stahlband (9) gemäß einem der Ansprüche 1 bis 7, wobei das Schutzelement (10a,10b) mehrere schlitzförmige Kühlwasser-Durchgangslöcher (11) besitzt, die, im Einbauzustand in einer Produktionsstraße, annä-

hernd achsensymmetrisch zu der Mittellinie eines Auslauftisches (5) angeordnet sind, und so, dass die Longitudinalrichtung der schlitzförmigen Kühlwasser-Durchgangslöcher (11) in der Horizontalebene zur Transportrichtung des warmgewalzten Stahlbandes (9) verlaufend geneigt ist bzw. schräg verläuft.

9. Ein Verfahren zum Herstellen eines warmgewalzten Stahlbandes (9) mit einem Schritt des Kühlens des warmgewalzten Stahlbandes (9) nach dem Warmwalzen mit der Kühlvorrichtung (4) für warmgewalztes Stahlband (9) gemäß einem der Ansprüche 1 bis 8.

10. Das Verfahren zum Herstellen eines warmgewalzten Stahlbandes (9) gemäß Anspruch 9, wobei das warmgewalzte Stahlband (9) mit einer zylindrischen laminaren Strömung bei einer Wasserströmungsrate von mehr 2500 L/min x m^2 gekühlt wird.

11. Eine Produktionsstraße mit einem Auslauftisch (5), der mit einer Kühlvorrichtung (4) für warmgewalztes Stahlband (9) gemäß einem der Ansprüche 1 bis 9 versehen ist.

Revendications

1. Dispositif de refroidissement d'une bande (9) d'acier laminée à chaud, comprenant:

des moyens (4b) de refroidissement de la surface du haut à mettre au-dessus d'une bande (9) d'acier laminée à chaud transférée par des rouleaux (7) de transfert après laminage à chaud, pour refroidir la surface du haut de la bande (9) d'acier laminée à chaud; et
des moyens (4a) de refroidissement de la surface du bas à mettre en dessous de la bande (9) d'acier laminée à chaud, pour refroidir la surface du bas de la bande (9) d'acier laminée à chaud,
chacun des moyens (4b) de refroidissement de la surface du haut et des moyens (4a) de refroidissement de la surface du bas comprenant:

un élément (10a, 10b) de protection disposé près de la surface de la bande (9) d'acier laminée à chaud et ayant au moins un trou (11) de passage d'eau de refroidissement;
au moins un collecteur (12a, 12b) d'eau de refroidissement opposé à la bande (9) d'acier laminée à chaud et séparé par l'élément (10a, 10b) de protection; et
des buses (15) de projection d'eau de refroidissement faisant saillie du collecteur (12a, 12b) d'eau de refroidissement et destinées à projeter de l'eau de refroidissement à peu près verticalement vers la surface de la bande (9) d'acier laminée à chaud en passant par le trou (11) de passage d'eau de refroidissement, les pointes (16) des buses (15) de projection d'eau de refroidissement étant disposées plus loin de la bande (9) d'acier laminée à chaud que la surface, opposée à la bande (9) d'acier laminée à chaud, de l'élément (10a, 10b) de protection;

caractérisé en ce que le trou (11) de passage d'eau de refroidissement est en forme de fente;
la direction longitudinale du trou (11) de passage d'eau de refroidissement conformé en fente s'incline dans le plan horizontal par rapport à la direction de transfert de la bande (9) d'acier laminée à chaud; et
de l'eau de refroidissement est destinée à être projetée d'une pluralité de buses (15) de projection d'eau de refroidissement par le trou (11) de passage d'eau de refroidissement conformé en fente.

2. Dispositif de refroidissement d'une bande (9) d'acier laminée à chaud suivant la revendication 1, dans lequel le collecteur (12b) d'eau de refroidissement des moyens (4b) de refroidissement de la surface du haut est à peu près opposé au collecteur (12a) d'eau de refroidissement des moyens (4a) de refroidissement de la surface du bas en étant séparé par la bande (9) d'acier laminée à chaud, et/ou les buses (15) de projection d'eau de refroidissement des moyens (4b) de refroidissement de la surface du haut sont à peu près opposées aux buses (15) de projection d'eau de refroidissement des moyens (4a) de refroidissement de la surface du bas en étant séparées par la bande (9) d'acier laminée à chaud.

3. Dispositif de refroidissement d'une bande (9) d'acier laminée à chaud suivant la revendication 1 ou 2, dans lequel la distance (Xa, Xb) entre la surface de la bande (9) d'acier laminée à chaud et les pointes (16) des buses (15) de projection d'eau de refroidissement soit inférieure ou égale à 100 mm.

4. Dispositif de refroidissement d'une bande (9) d'acier laminée à chaud suivant l'une quelconque des revendications 1 à 3, dans lequel la distance (Ya, Yb) entre la surface de la bande (9) d'acier laminée à chaud et la surface, opposée à la bande (9) d'acier laminée à chaud, de l'élément (10a, 10b) de protection soit comprise entre 10 et 50 mm.

5. Dispositif de refroidissement d'une bande (9) d'acier laminée à chaud suivant l'une quelconque des revendications 1 à 4, dans lequel un rouleau (14) de

guidage est prévu au-dessus de la bande (9) d'acier laminée à chaud à peu près de façon opposée aux rouleaux (17) de transfert en dessous de la bande (9) d'acier laminée à chaud en au moins une position.

6. Dispositif de refroidissement d'une bande (9) d'acier laminée à chaud suivant l'une quelconque des revendications 1 à 5, dans lequel les pointes (16) des buses (15) de projection d'eau de refroidissement sont disposées à l'intérieur du trou (11) de passage d'eau de refroidissement.

7. Dispositif de refroidissement d'une bande (9) d'acier laminée à chaud suivant l'une quelconque des revendications 1 à 6, dans lequel la taille d'un orifice du trou (11) de passage d'eau de refroidissement conformé en fente prend des dimensions au point d'être en mesure de retenir deux à dix buses (15) de projection d'eau de refroidissement dans une ligne.

8. Dispositif de refroidissement d'une bande (9) d'acier laminée à chaud suivant l'une quelconque des revendications 1 à 7, dans lequel l'élément (10a, 10b) de protection a une pluralité de trous (11) de passage d'eau de refroidissement conformés en fentes étant disposés d'une façon à peu prés axisymétrique à la ligne centrale de la table mobile (5) en cas d'installation dans une ligne de production et d'une façon que la direction longitudinale des trous (11) de passage d'eau de refroidissement conformés en fentes s'incline dans le plan horizontal à diverger vers la direction de transfert de la bande (9) d'acier.

9. Procédé de fabrication d'une bande (9) d'acier laminée à chaud, comprenant un stade de refroidissement de la bande (9) d'acier laminée à chaud après le laminage à chaud par le dispositif de refroidissement d'une bande (9) d'acier laminée à chaud suivant l'une quelconque des revendications 1 à 8.

10. Procédé de fabrication d'une bande (9) d'acier laminée à chaud suivant la revendication 9, dans lequel on refroidit la bande (9) d'acier laminée à chaud par un flux laminaire cylindrique à un débit d'eau dépassant 2500 litres/min x m^2.

11. Ligne de production comprenant une table mobile (5) munie d'un dispositif (4) de refroidissement d'une bande (9) d'acier laminée à chaud suivant l'une quelconque des revendications 1 à 8.

FIG. 1A

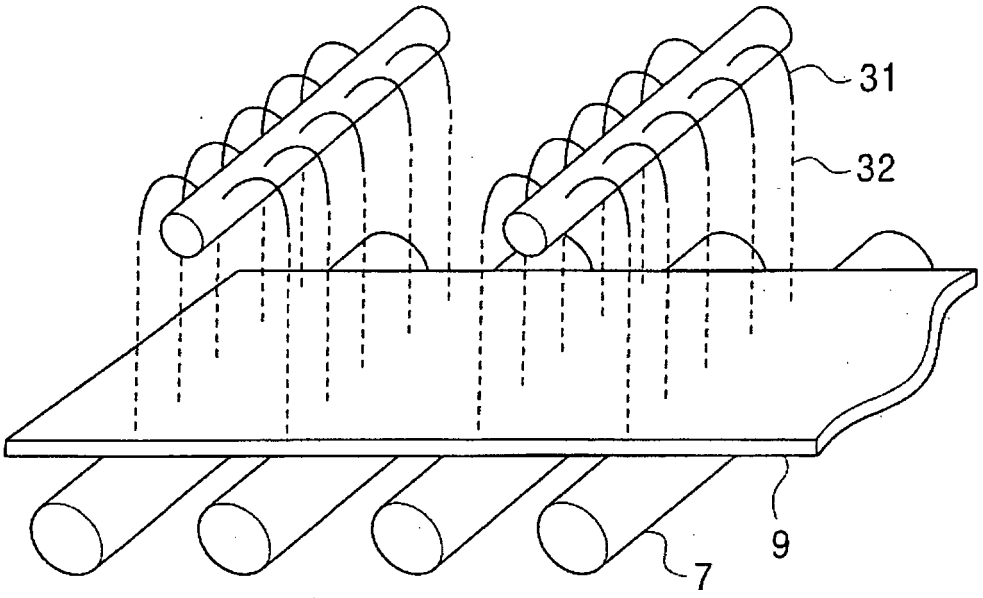


FIG. 1B

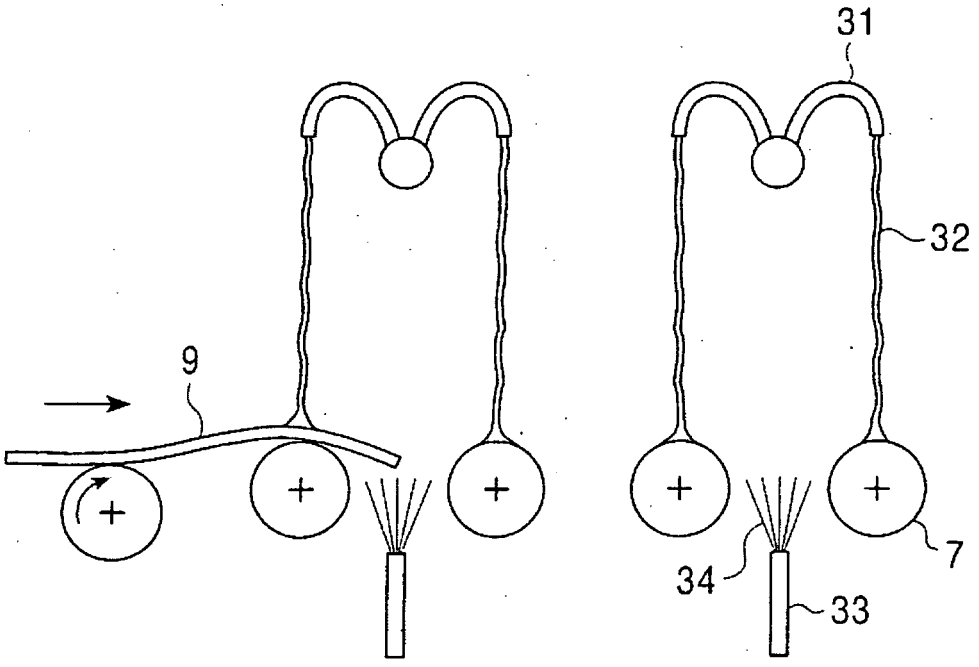


FIG. 2A

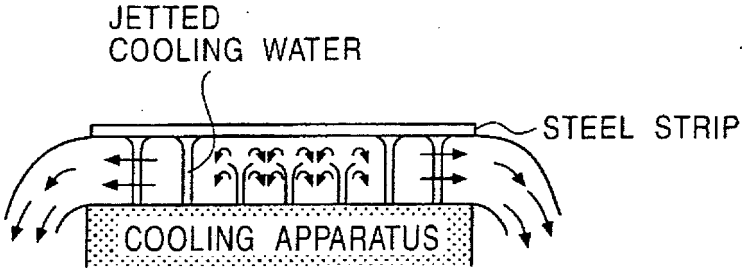

JETTED
COOLING WATER
STEEL STRIP
COOLING APPARATUS

FIG. 2B

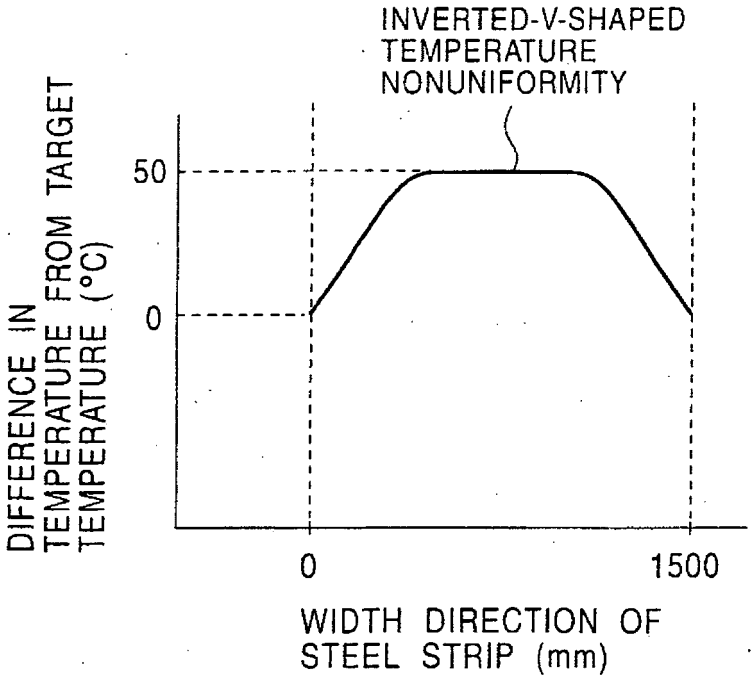

INVERTED-V-SHAPED
TEMPERATURE
NONUNIFORMITY
DIFFERENCE IN
TEMPERATURE FROM TARGET
TEMPERATURE (°C)
50
0
0
1500
WIDTH DIRECTION OF
STEEL STRIP (mm)

FIG. 3A

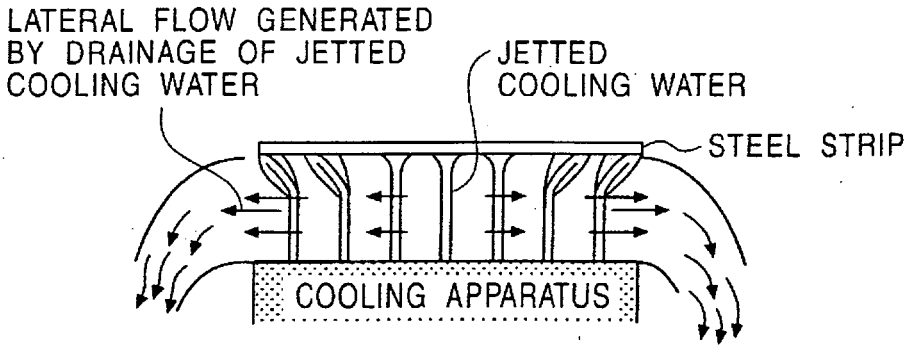

LATERAL FLOW GENERATED BY DRAINAGE OF JETTED COOLING WATER
JETTED COOLING WATER
STEEL STRIP
COOLING APPARATUS

FIG. 3B

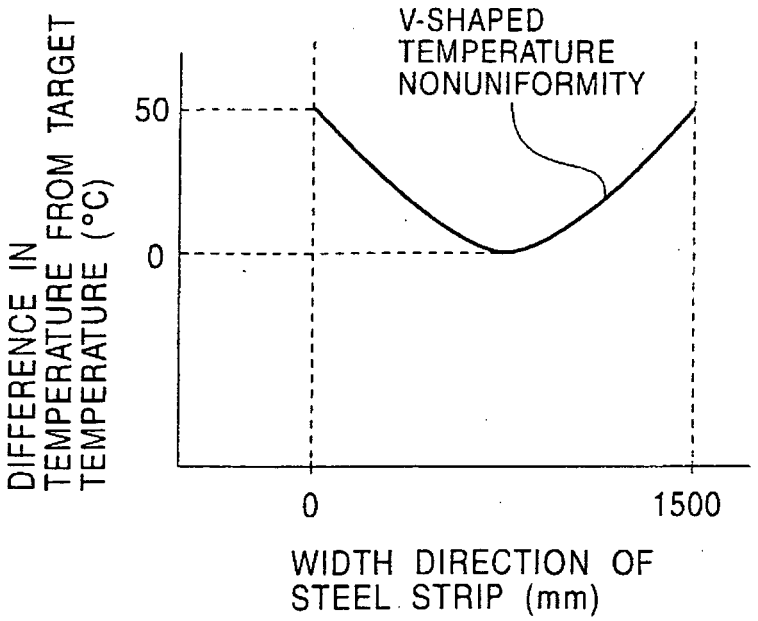

V-SHAPED TEMPERATURE NONUNIFORMITY
DIFFERENCE IN TEMPERATURE FROM TARGET TEMPERATURE (°C)
50
0
0
1500
WIDTH DIRECTION OF STEEL STRIP (mm)

FIG. 4

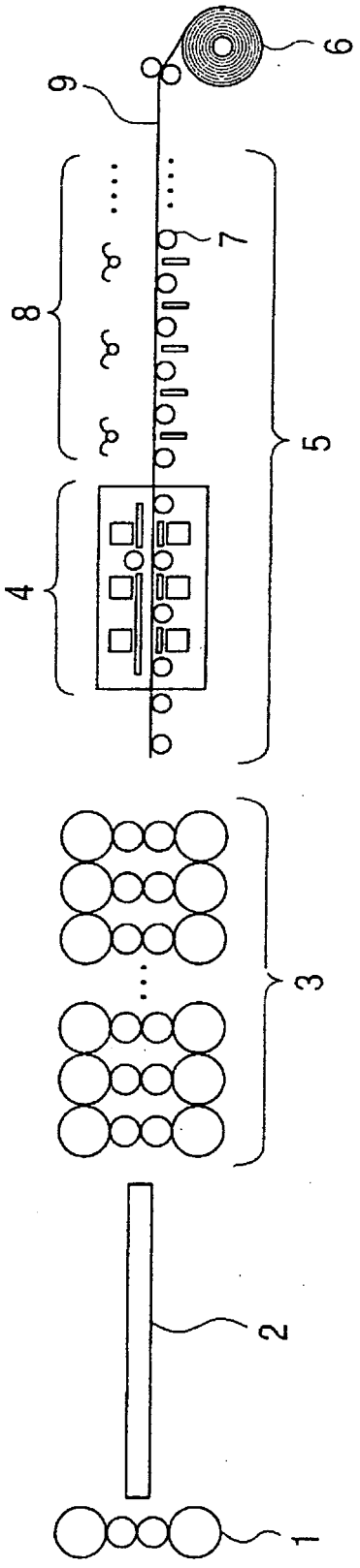


FIG. 5A

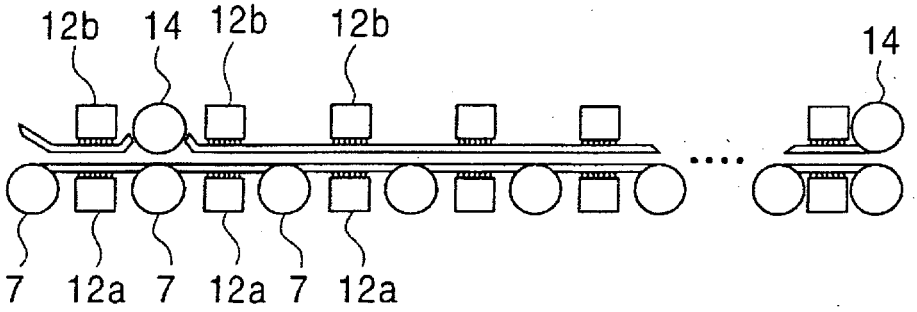

12b
14
12b
12b
14
7
12a
7
12a
7
12a

FIG. 5B

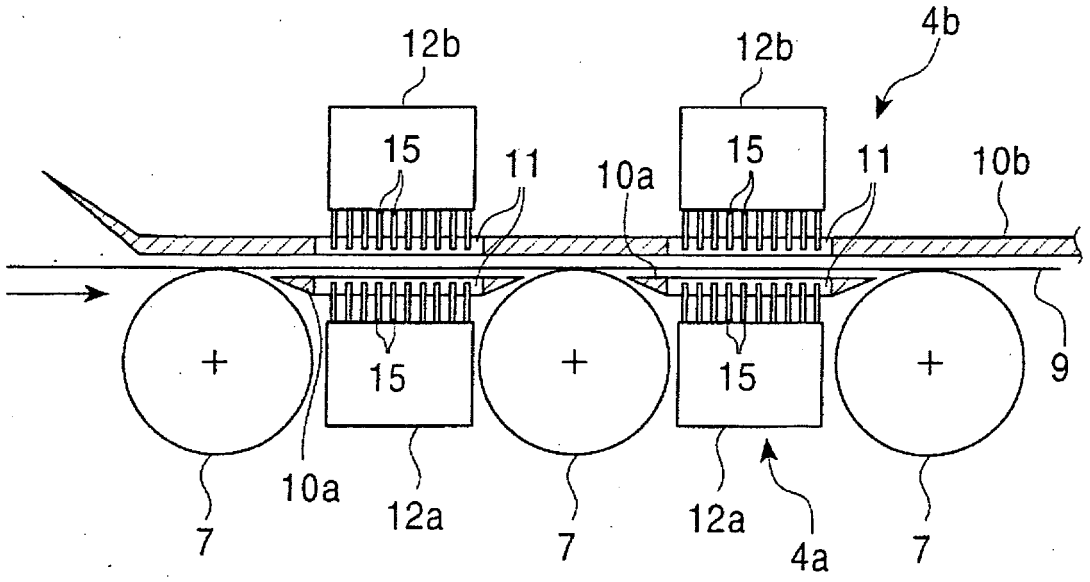

12b
12b
4b
15
11
10a
15
11
10b
15
15
9
10a
12a
7
7
12a
4a
7

FIG. 6A

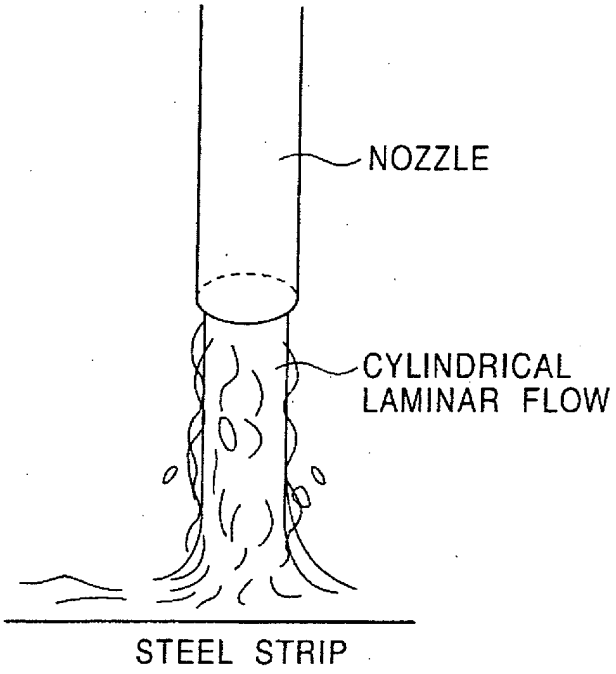

NOZZLE
CYLINDRICAL
LAMINAR FLOW
STEEL STRIP

FIG. 6B

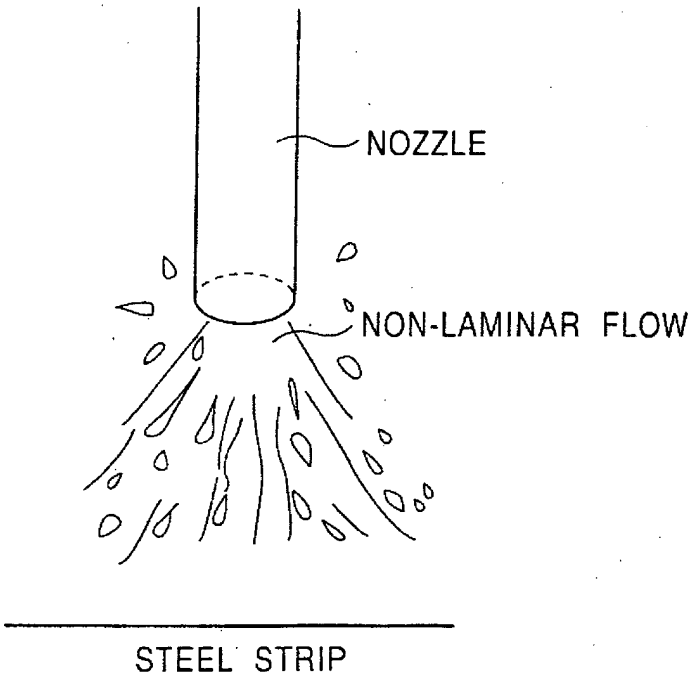

NOZZLE
NON-LAMINAR FLOW
STEEL STRIP

FIG. 7A

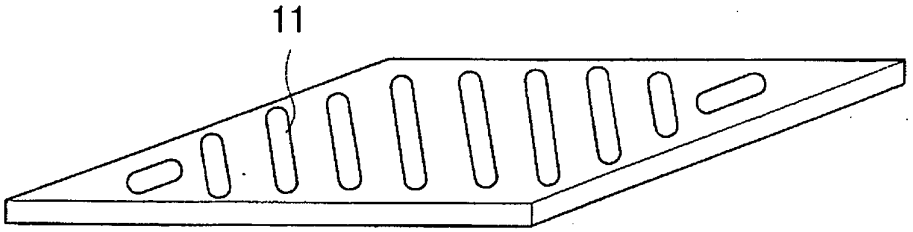


FIG. 7B

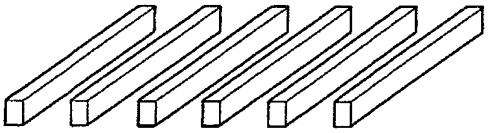


FIG. 7C

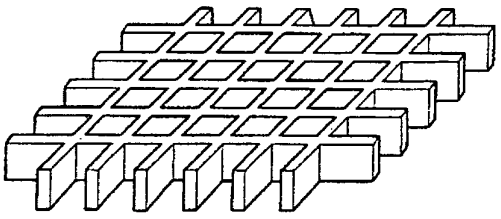


FIG. 7D

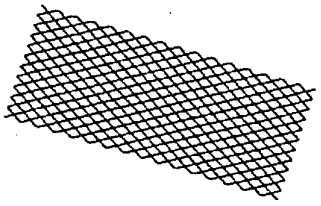


FIG. 8A

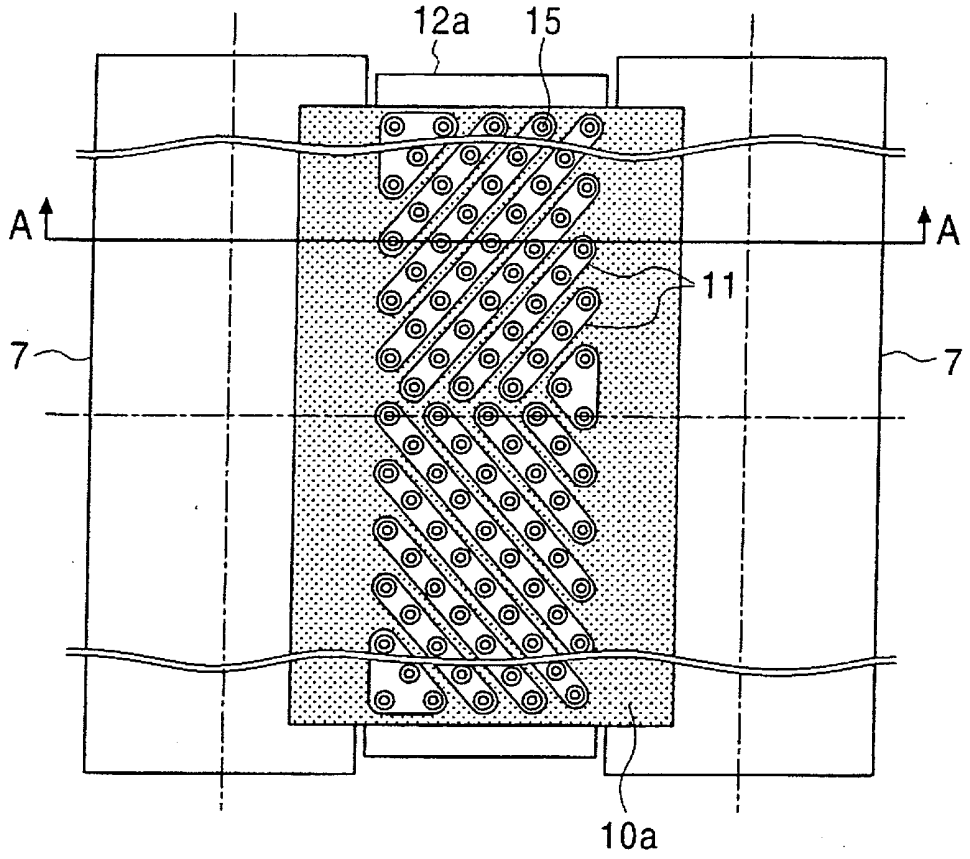


FIG. 8B

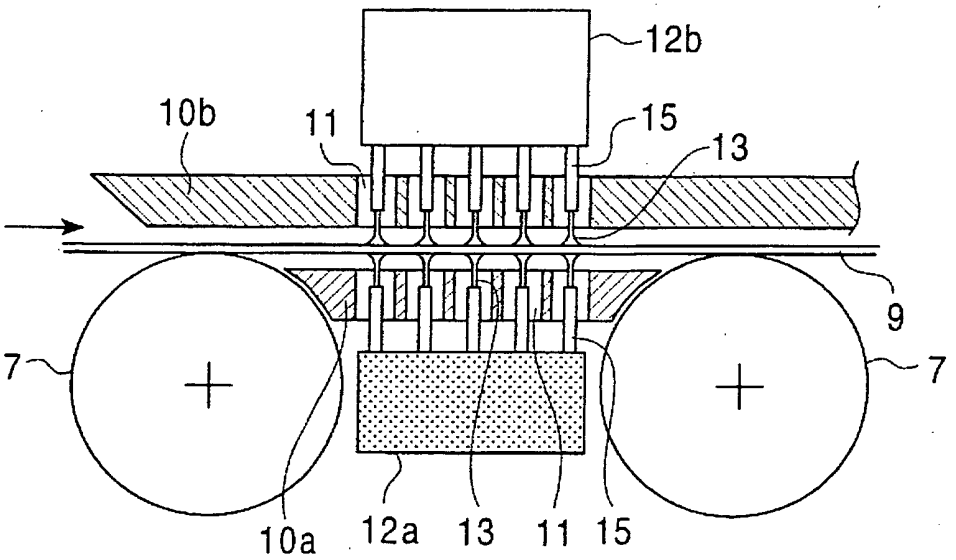


FIG. 9

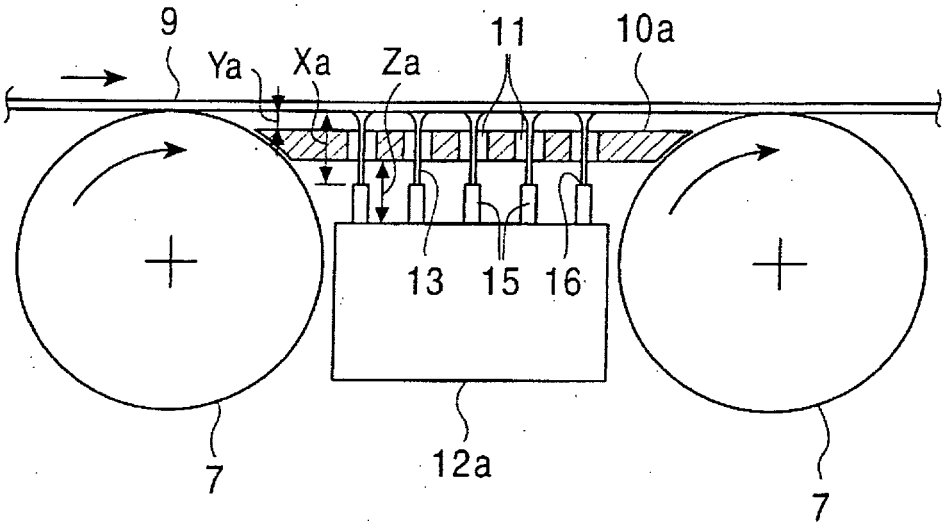


FIG. 10

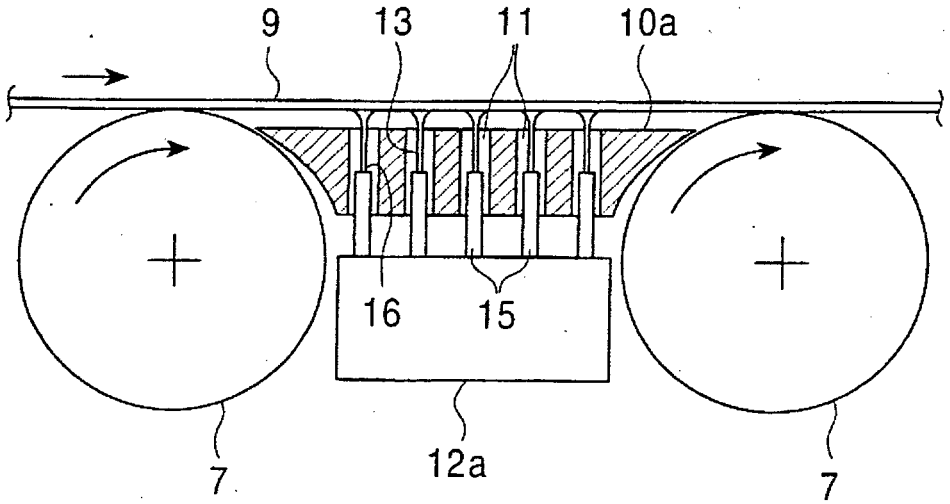


FIG. 11A

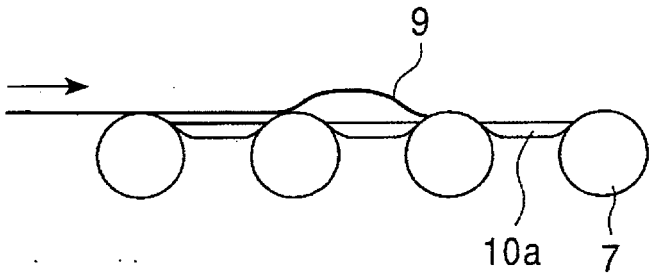


FIG. 11B

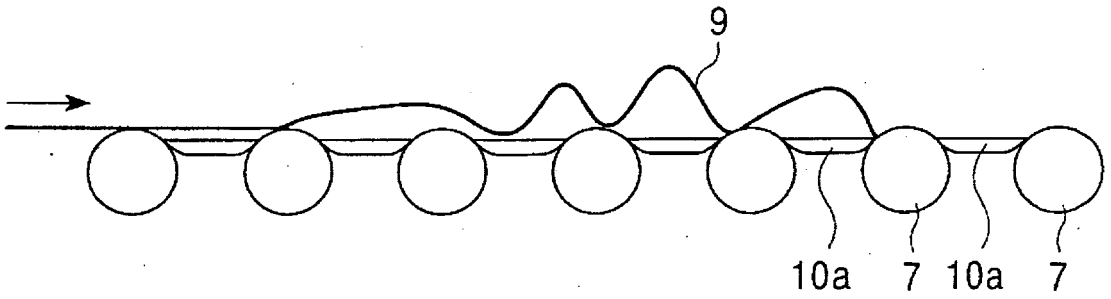


FIG. 12

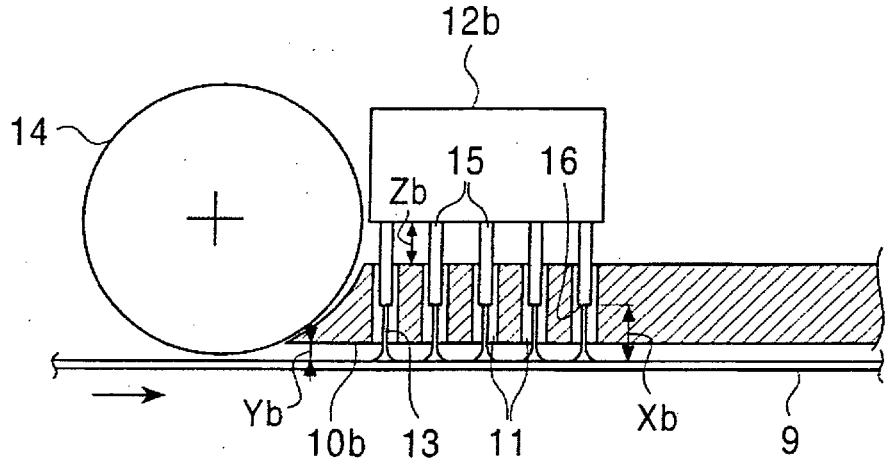

12b
14
15
16
Zb
Yb
10b
13
11
Xb
9

FIG. 13

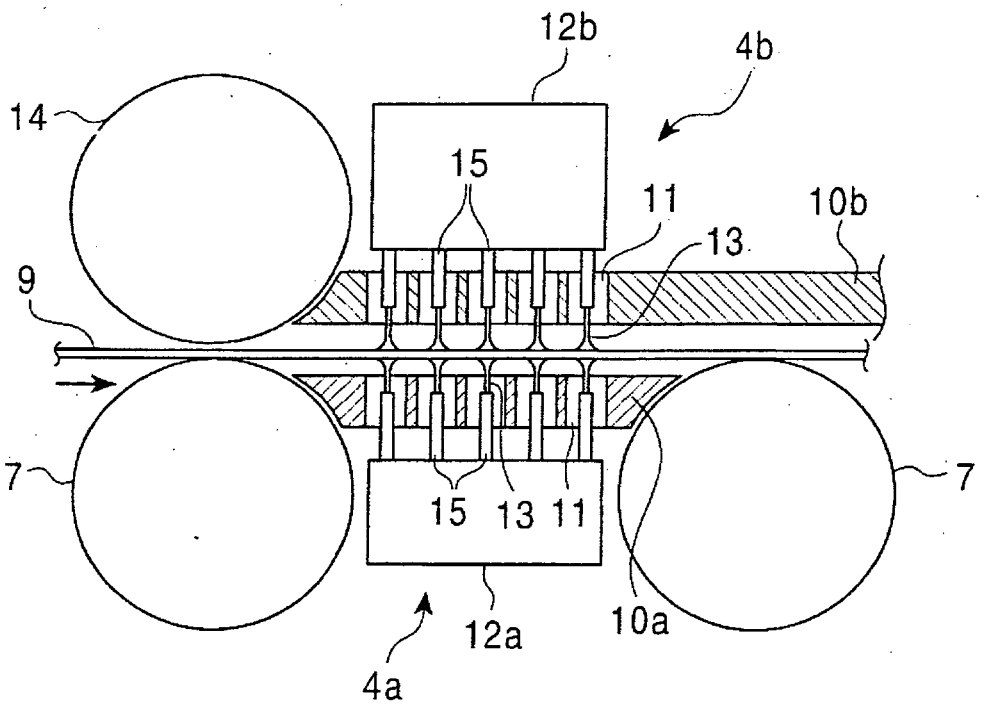

12b
4b
14
15
11
10b
13
9
7
15
13
11
7
12a
10a
4a

FIG. 14

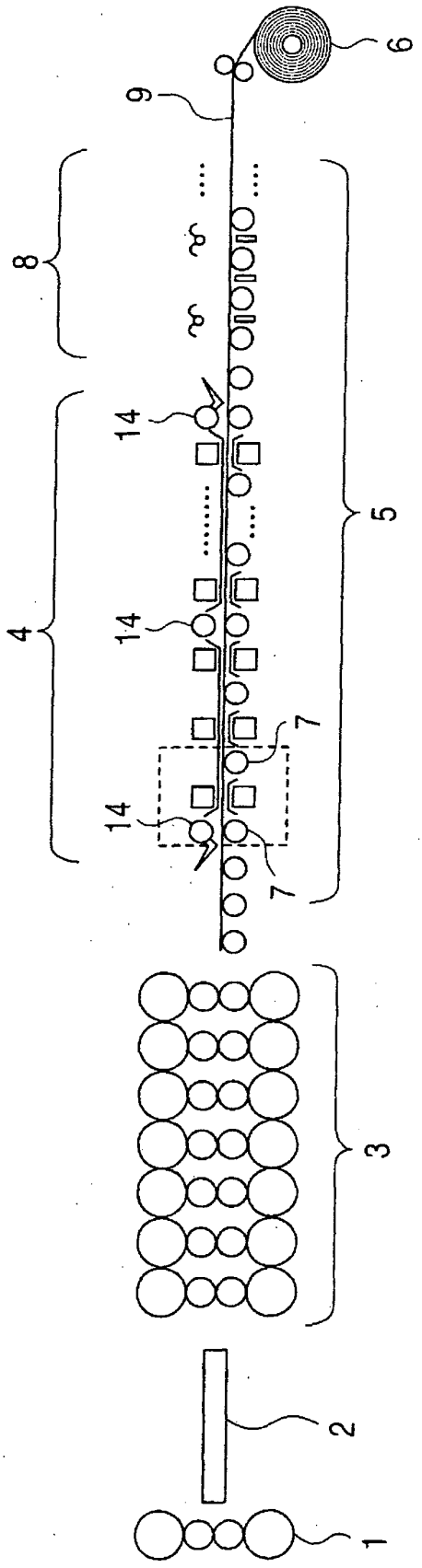


FIG. 15

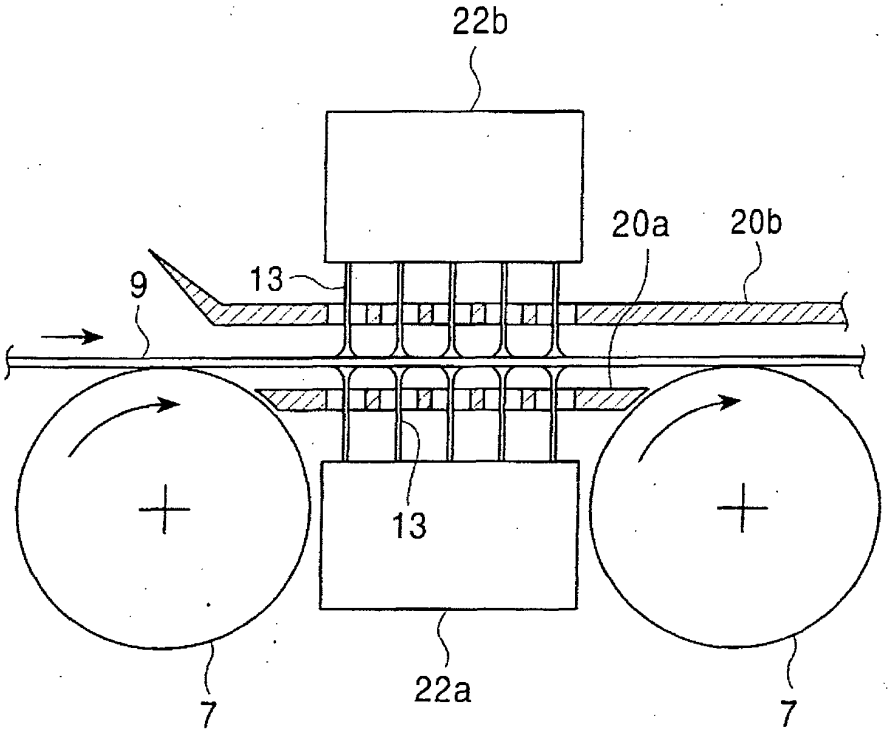
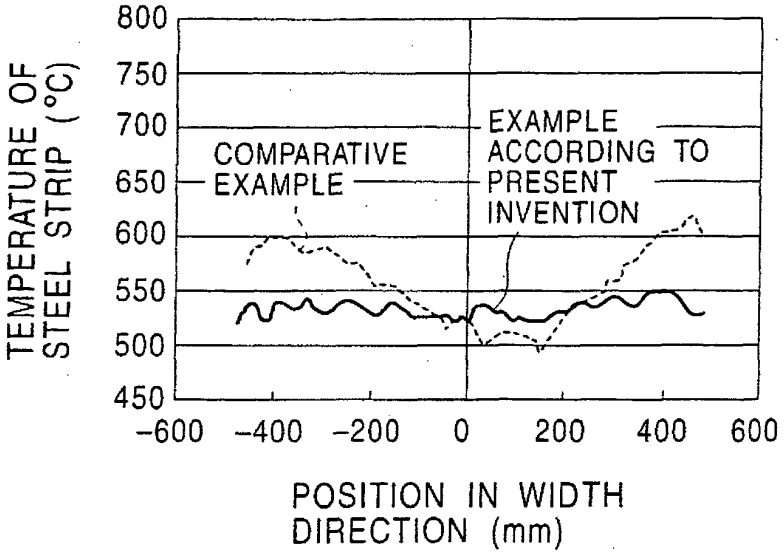

22b
20a
20b
9
13
13
7
22a
7

FIG. 16


800
750
700
650
600
550
500
450
TEMPERATURE OF STEEL STRIP (°C)
COMPARATIVE EXAMPLE
EXAMPLE ACCORDING TO PRESENT INVENTION
-600
-400
-200
0
200
400
600
POSITION IN WIDTH DIRECTION (mm)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 62259610 A **[0005] [0006] [0010] [0021]**
- JP 2001246411 A **[0007]**