(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 549 776 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
29.11.2006 Bulletin 2006/48

(21) Application number: **03798394.7**

(22) Date of filing: **09.09.2003**

(51) Int Cl.:
C21D 9/573 *(2006.01)*

(86) International application number:
PCT/JP2003/011522

(87) International publication number:
WO 2004/029305 (08.04.2004 Gazette 2004/15)

(54) COOLING DEVICE FOR STEEL STRIP

ABKÜHLVORRICHTUNG FÜR STAHLBAND

DISPOSITIF DE REFROIDISSEMENT POUR BANDE D'ACIER

(84) Designated Contracting States:
DE FR GB

(30) Priority: **27.09.2002 JP 2002284302**
17.06.2003 JP 2003172695

(43) Date of publication of application:
06.07.2005 Bulletin 2005/27

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- **PATENT ABSTRACTS OF JAPAN vol. 011, no. 332 (C-455), 29 October 1987 (1987-10-29) -& JP 62 116724 A (NIPPON STEEL CORP), 28 May 1987 (1987-05-28) cited in the application**

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Description

[0001] The present invention relates to a device for cooling a steel strip which is traveling continuously in, for example, a continuous annealing facility, a continuous hot dip galvanizing facility, a color coating line, a stainless steel pickling and annealing line, or the like, used for processing the steel strip.

[0002] It is well known that continuous annealing facilities perform the processes of heating, soaking, cooling and, as occasion demands, over-aging a steel strip continuously. Meanwhile, to obtain a steel strip having desired properties, it is important to cool the steel strip rapidly and evenly as well as to control a heating temperature and a soaking time. Various cooling mediums are presently employed as means for cooling a steel strip and the rate of cooling a steel strip varies with a cooling medium employed.

[0003] When water is selected from among various cooling mediums and employed as a cooling medium, and though a high cooling rate, up to an ultra-rapid cooling rate, is secured, the problem therein is that deformation called cooling-buckle of a steel strip occurs because of quench distortion. What is worse, an oxide film forms on the surface of a steel strip during the contact of the steel strip with water and, thus, a separate installation is required for removing the oxide film, and therefore water cooling is economically disadvantageous.

[0004] As a method for solving aforementioned problems, there is a roll cooling method wherein water or another cooling medium is introduced inside a roll and a steel strip is cooled while it is in contact with the surface of the cooled roll.

[0005] However, a roll cooling method has the following problem. A steel strip may not remain flat when it passes through a continuous annealing furnace.
Therefore, when a steel strip has contact with a cooling roll, some portions of the steel strip may not contact the cooling roll. In that case, the non-contacting portions make the cooling of the steel strip uneven along the width direction thereof and thus cause the shape of the steel strip to deform. To cope with this problem, a means is required for flattening a steel strip before it has contact with a cooling roll. However, the means causes the equipment cost to increase.

[0006] As another cooling means, a cooling method that uses gas as a cooling medium is put into practical use and achieves various results. In the method, though a cooling rate is lower in comparison with aforementioned water cooling and roll cooling methods, a steel strip can be cooled comparatively evenly along the width direction thereof. As means for raising the cooling rate, that is the utmost challenge of gas cooling, disclosed are the methods wherein: a cooling rate is raised by bringing the tips of nozzles for ejecting gas as close to a steel strip as possible and thus raising a heat transfer coefficient; and a cooling rate is raised by increasing the concentration of hydrogen gas as a cooling medium and thus raising a heat transfer coefficient.

[0007] As a method of raising a heat transfer coefficient by bringing the tips of nozzles for ejecting gas as close to a steel strip as possible, there is a technology disclosed in JP-A-62116724. In the technology, an efficient cooling is made possible by reducing distance between the tips of nozzles and a steel strip. To be more precise, the patent publication discloses that: the length of protruding nozzles being provided in a cooling gas chamber and protruding from the surface of the wall of the cooling gas chamber is adjusted to 100 mm - Z or longer; a space is provided from which gas being ejected from the protruding nozzles and hitting a steel strip escapes behind the wall; by so doing, the retention of ejected gas on the surface of the steel strip lessens; and thus the uniformity of cooling along the width direction of the steel strip improves. Here, Z indicates the distance between the tip of a nozzle and a steel strip.

[0008] The patent publication also discloses an experiment carried out for clarifying an optimum heat transfer coefficient with the protruding length of nozzles varied from 50 mm - Z to 200 mm - Z. Further, the patent publication proposes a cooling device that has an efficient cooling capacity on the basis of the experiment. By the cooling device, a heat transfer coefficient, that has usually been 100 kcal/m^{2}h°C, is improved to 400 kcal/m^{2}h°C.

[0009] However, a still higher cooling rate is required and an existing cooling device wherein an atmospheric gas containing about 95% N_2 and about 5% H_2 is used as the usual cooling medium has not been able to cope with the requirement. To solve the problem, the use of hydrogen gas as a cooling medium has been contrived. Though it has been known from the past that the employment of hydrogen gas improves cooling capacity, hydrogen gas has not been put into practical use because of the danger.

[0010] A technology wherein the concentration of hydrogen gas is raised and thus a steel strip is rapidly cooled is disclosed in Japanese Unexamined Patent Publication No. H9-235626. The technology is the one that secures a high cooling rate by blowing a cooling gas having a hydrogen concentration in the range from 30 to 60% onto a steel strip at a blowing rate in the range from 100 to 150 m/sec. In this manner, concrete technologies for adopting hydrogen gas are being developed and are ready to be put into practical use.

[0011] Generally, in the case of above technologies, as it is necessary to raise an H_2 concentration in comparison with the case of cooling by an atmospheric gas mainly composed of N_2 gas and to increase the flow rate of a gas ejected from nozzles up to a blowing rate in the range from 100 to 150 m/sec., the volume of the gas blown onto a steel strip is required to increase and also a gas pressure sufficient for ejecting the gas through nozzles at a blowing rate in the range from 100 to 150 m/sec. must also to be secured. As such a cooling device, generally adopted is a circulation-type cooling device wherein a cooling medium having been blown onto a steel strip is circulated through a duct and blown again onto the steel strip. In such a circulation-type cooling device, a cooling medium having been blown onto a steel strip is discharged into a furnace and sucked through a suction duct installed at the furnace body with a circulation blower. In front of the circulation blower, installed is a heat exchanger for cooling the cooling medium, that has been blown onto the steel strip and has been heated, to a blowing temperature so that the steel strip may be cooled with those devices while the cooling medium is circulated.

[0012] The highest pressure in such a circulation system is a pressure required when a cooling medium is ejected from nozzles and it has been desired to reduce the pressure drop, to the utmost, at the nozzles.

[0013] Thus, the problem above can be solved by the features defined in the appended claims.

[0014] The invention is described in detail in conjunction with the drawings, in which;

Fig. 1 is a sectional side view of cooling devices in continuous annealing facilities to which the present invention is applied,
Fig. 2 is a view taken on line A-A in Fig. 1,
Fig. 3 is a view showing the details of a nozzle according to the present invention,
Fig. 4 is a view showing a method for attaching a nozzle according to the present invention,
Fig. 5 is a graph showing resistance coefficients of nozzles,
Fig. 6 is a schematic illustration of a continuous coating line to which the present invention is applied,
Fig. 7 is a schematic illustration of a continuous hot dip galvanizing facility to which the present invention is applied,
Fig. 8 is a schematic illustration of another continuous hot dip galvanizing facility to which the present invention is applied, and
Fig. 9 is a schematic illustration of a stainless steel annealing and pickling facility to which the present invention is applied.

[0015] The present invention is hereunder explained in detail on the basis of examples shown in the figures. Fig. 1 is a sectional side view of cooling devices in continuous annealing facilities to which the present invention is applied, Fig. 2 a view taken on line A-A in Fig. 1, Fig. 3 a view showing the details of a nozzle according to the present invention, Fig. 4 a view showing knacks for attaching a nozzle according to the present invention, Fig. 5 a graph showing resistance coefficients of nozzles, Fig. 6 a schematic illustration showing an example of applying cooling devices according to the present invention to a continuous coating line, and Figs. 7 and 8 schematic illustrations each of which showing an example of applying the present invention to cooling devices for cooling a steel strip after being galvanized in continuous hot dip galvanizing facilities.

[0016] In Fig. 1, a pair of cooling devices 2 that eject gas are installed between upper and lower rolls 9 and 11, said rolls conveying a steel strip 12, so as to be opposed to the surfaces of said steel strip 12, and said paired cooling devices 2 are arranged at plural levels along the traveling direction of said steel strip 12. Further, holddown rolls 10 for preventing a flutter of said steel strip are provided above and under said paired cooling devices 2 so as to grasp said steel strip in between the rolls.

[0017] In Fig. 2, showing a view taken on line A-A in Fig. 1, a gas blown onto said steel strip 12 through said cooling devices 2 is reused as a cooling gas through a circulatory system. In the present invention, a cooling medium containing cooling gas is a mixed gas composed of N_2, H_2 and other inert gases and it is preferable that the concentration of H_2 is in the range from 0 to 100% with the balance consisting of N_2 and other inert gases. To be more precise, a blown gas is drawn in from a gas suction port provided at a furnace body 1, passes through an inlet duct 5, a heat exchanger 6, a circulation blower 7 and an outlet duct 8, and is blown again onto said steel strip 12 through nozzles provided at the surfaces of cooling chambers 3, the surfaces of said cooling chambers 3 being opposed to said steel strip 12, by using a circulatory system connected to said cooling chambers 3 in said furnace body. In this way, a gas blown onto a steel strip 12 in a furnace is circulated and reused.

[0018] A cooling device 2 is composed of a cooling chamber 3 and protruding nozzles 4 provided at the surface of said cooling chamber 3, the surface of said cooling chamber 3 being opposed to a steel strip 12. Each of the protruding nozzles 4 is selected so that the ratio (D/d) of the inner diameter at the nozzle foot B side D to the inner diameter at the nozzle tip A side d falls within the range from 1.5 to 3.0. Further, the protruding nozzles are arranged so that the total aperture area of the nozzle tips accounts for 2 to 4% of the surface area of a cooling chamber.

[0019] In Fig. 3 showing the shape of a nozzle according to the present invention, D is the inner diameter at the nozzle foot B side (here, the nozzle foot B side means the side at which a nozzle is attached to a cooling chamber 3), DO the outer diameter at the nozzle foot B side, d the inner diameter at the nozzle tip A side, L the total length of a nozzle, and DN the outer diameter of a nozzle at a position located in the range of (nozzle total length L) - (10 $\pm$ 3 mm), in other words, the range of 10 $\pm$ 3 mm away from a nozzle foot B side in the direction of the nozzle tip A side. A nozzle 4 is conical in shape and therefore made by rolling an SUS (stainless steel) plate. A nozzle may be made by drawing a tube, cutting, or casting. The experiment was carried out with nozzles having a total length of 200 mm and various ratios D/d. When the nozzle total length L is less than 200 mm, the minimum distance between the nozzle tip and the steel strip surface is limited to 50 mm. However, when the nozzle total length is not less than 200 mm, the minimum distance between the nozzle tip and the steel strip surface can be shortened to 30 mm.

[0020] In Fig. 4, showing the state of attaching a nozzle according to the present invention to a cooling chamber 3, a hole having a diameter DN is provided at a surface of a cooling chamber 3, the surface being opposed to a steel strip 12. The number of holes is determined so that the total aperture area may account for 2 to 4% of the surface area of the cooling chamber. The diameter DN is set so as to equal the diameter of the nozzle at a position located in the range of 10 $\pm$ 3 mm away from the nozzle foot B in the direction of the nozzle tip A side.

[0021] To be more precise, firstly, a hole of a diameter DN is drilled at the surface of a cooling chamber 3. A nozzle having an outer diameter DO at the nozzle foot B is inserted in the hole and attached to the hole of the cooling chamber 3 as shown in Fig. 4 with a punch (not shown in the figure). When the nozzle is attached to the hole, it should be ensured that the nozzle foot B does not protrude from the inner surface of the cooling chamber as shown in Fig. 4. In Fig. 4, the nozzle is inserted so that the nozzle foot B may be located 10 mm in depth from the inner surface of the cooling chamber 3. This is because that when the nozzle total length is less than 200 mm, the gas jetted from the nozzle stagnates on the steel strip surface and causes flattering. On the other hand, when the nozzle total length is more than 200 mm, the gas jetted from the nozzle flows easily away from the steel strip surface. As a result, flattering can be avoided. Thereafter, the nozzle foot inner diameter D is enlarged with a tube expander from the foot B side of the punched nozzle 4 and the nozzle is bonded by pressure to the inside of the hole having been provided at the cooling chamber 3 and having the diameter DN. By using a tube expander for the pressure bonding, the accuracy of attaching a nozzle 4 is improved more than in the conventional case of attaching a nozzle by welding. Here, the reason for limiting the position where the diameter DN is defined as described above is that: when the position exceeds the upper limit (10 + 3 mm), a nozzle is hard to insert; and, when the position is shorter than the lower limit, on the other hand, the accuracy of a nozzle attachment is inferior. In Fig. 4, the nozzle is fixed so that the tip of the nozzle foot side may be depressed in the hole from the inner surface of the cooling chamber 3 for the purpose of reducing the resistance coefficient of the nozzle. However, the tip of the nozzle foot side may be on the same surface as the inner surface of the cooling chamber 3 as long as the resistance coefficient of the nozzle is reduced. Then, the pressure losses of the nozzles made as described above were measured with an experimental apparatus and the resistance coefficient of each of the nozzles was calculated. The results are shown in Fig. 5. It has been clarified that the resistance coefficient is small when D/d is in the range from 1.5 to 3.0 and the smallest when D/d is 2.0 or so in comparison with the resistance coefficient obtained when D/d is 1.0, which is the case of a conventional straight nozzle. Therefore, the resistance coefficient of a nozzle according to the present invention decreases by about 30% from that of a conventional straight nozzle.

[0022] Fig. 6 shows the arrangement of a coater and a drying and baking furnace in a continuous coating line. The surface of a steel strip S1 is coated with paint in a coater 14 and then dried and baked with a prescribed temperature transition in a drying and baking furnace 15. Successively, the steel strip is cooled to a temperature close to room temperature in a cooling device assembly 16. In a conventional cooling device assembly 16, the surface quality of a coated paint is secured by employing air cooling at the former stage and a rapid cooling has been secured by employing water cooling at the latter stage. By using nozzles according to the present invention in a cooling device assembly 16, a facility configuration having a high cooling efficiency can be realized even when water cooling is not used.

[0023] Fig. 7 shows an example of applying a cooling device assembly in which nozzles according to the present invention are used in a cooling device assembly located at the rear of a plated layer alloying treatment apparatus in continuous hot dip galvanizing facilities. A steel strip S2 is introduced into a plating pot 19 through a turndown roll 18 provided in a turndown section 17. The steel strip S2 is pulled upward through a sink roll 20, and, after the thickness of the plated layer of the steel strip S2 is adjusted to a prescribed thickness in a plating apparatus 21, it is heated to an alloying treatment temperature in an alloying heater 22 and successively retained in a retention furnace 23. The steel strip S2 having been subjected to alloying treatment is cooled in a cooling device assembly 24 and another cooling device assembly 27 provided in the down pass, and is conveyed to a dip-cooling apparatus 28 for final cooling. By applying a cooling device assembly in which nozzles according to the present invention are used with the cooling device assemblies 24 and 27, not only cooling efficiency can be raised and thus the entire height of the alloying furnace can be lowered, but also a steel strip S2 can be rapidly cooled after being subjected to alloying treatment and thus a sound alloyed layer can be obtained.

[0024] Fig. 8 shows an example of applying a cooling device assembly in which tapered nozzles, each having a round aperture according to the present invention, are used in a cooling device assembly located at the rear of a plating apparatus likewise in a continuous hot dip galvanizing facility. A steel strip S2, after the thickness of the plating layer of the steel strip is adjusted to a prescribed thickness in a plating apparatus 21, is cooled in a cooling device assembly 24 and another cooling device assembly 27 provided in the down pass, and is conveyed to a dip-cooling apparatus 28 for final cooling. By applying a cooling device assembly in which nozzles according to the present invention are used to the cooling device assemblies 24 and 27, the cooling efficiency can be raised and thus the entire height of the alloying furnace can be lowered.

[0025] Fig. 9 shows an example of continuous annealing and pickling facilities for stainless steel strips. A stainless steel strip S3 is heated and soaked at a prescribed annealing temperature in a heating zone 29 and then is cooled at a prescribed cooling rate to a final temperature in a cooling zone 30. Successively, scales formed on the surfaces of the stainless steel strip S3 owing to rolls arranged on the upper and lower sides of the stainless steel strip S3 are removed in a descaling apparatus 31. Thereafter, the stainless steel strip S3 is introduced into a pickling tank 32. By applying a cooling device assembly in which nozzles according to the present invention are used with the cooling device assembly 30, cooling efficiency can be raised and thus a compact equipment configuration can be realized.

[0026] As explained above, the present invention: provides a cooling device for a steel strip, the cooling device allowing the ejection velocity of a nozzle to increase, the resistance coefficient of a nozzle to decrease and, thus, a high cooling rate to be secured, and, by so doing, a circulatory system to be downsized; and makes it possible to provide a cooling device for a steel strip, the cooling device enabling the distortion of nozzles caused by welding to be eliminated and fabrication accuracy to be improved by employing a pressure bonded structure instead of a conventional welded structure.

Claims

1. A cooling device (2) for a steel strip, said cooling device being equipped with a plurality of nozzle (4) protruding from the surfaces of a cooling chamber (3) and a traveling steel strip being cooled by ejecting a cooling medium through said nozzles, wherein the distance between the tips (A) of said nozzles and the surfaces of said steel strip is kept in the range from 50 to 100 mm **characterized in that**:

    said nozzle total length is less than 200 mm, and D/d of said blowing nozzles satisfies the expression $1.5 \leq D/d \leq 3.0$, wherein, d is the inner diameter at the tip (A) of a nozzle steel strip side and D is the inner diameter at the foot (B) of a nozzle cooling chamber side.

2. A cooling device (2) for a steel strip, said cooling device being equipped with a plurality of nozzles (4) protruding from the surfaces of a cooling chamber and a traveling steel strip being cooled by ejecting a cooling medium through said nozzles, wherein the distance between the tips (A) of said nozzles and the surfaces of said steel strip is kept in the range from 30 to 100 mm **characterized in that**:

    said nozzle total length is not less than 200 mm, and D/d of said blowing nozzles satisfies the expression $1.5 \leq D/d \leq 3.0$, wherein, d is the inner diameter at the tip (A) of a nozzle steel strip side and D is the inner diameter at the foot (B) of a nozzle cooling chamber side.

3. A cooling device for a steel strip according to claim 1 or 2, **characterized in that** said nozzles (4) are attached by fixing the feet (B) of said nozzles (4) in fitting holes provided at a cooling chamber (3) by means of tube expansion junction.

4. A cooling device for a steel strip according to any one of claims 1 to 3, **characterized in that** the diameters of said fitting holes provided at said cooling chamber (3) equal the outer diameters of said nozzles (4) at a position located in the range of (nozzle total length L - 10 mm (10 mm apart from the nozzle foot in the direction of the nozzle tip)) $\pm$ 3 mm.

5. A cooling device for a steel strip according to any one of claims 1 to 4, **characterized in that** said nozzles (4) are attached so that the feet of said nozzles may not protrude from the inner surfaces of said cooling chamber (3).

6. A cooling device for a steel strip according to any one of claims 1 to 5, **characterized in that** the cooling medium of said cooling device (2) is a mixed gas composed of N_2, H_2 and other inert gases and the concentration of H_2 is in the range from 0 to 100% with the balance consisting of N_2 or other inert gases.

Patentansprüche

1. Abkühlvorrichtung (2) für Stahlband, wobei die Abkühlvorrichtung mit mehreren Düsen (4) versehen ist, die von der Oberfläche der Kühlkammer (3) vorstehen, und ein durchlaufendes Stahlband durch Ausstoßen eines Kühlmittels durch die Düsen abgekühlt wird, wobei der Abstand zwischen den Spitzen der Düsen (A) und den Oberflächen des Stahlbandes im Bereich von 50 bis 100 mm gehalten wird, **dadurch gekennzeichnet, dass** die Gesamtdüsenlänge weniger als 200 mm beträgt, und D/d der Blasdüsen den Ausdruck $1{,}5 \leq D/d \leq 3{,}0$ erfüllt, wobei d den Innendurchmesser an einer Düsenspitze (A) auf der Stahlbandseite und D den Innendurchmesser an einem Düsenfuß (B) auf der Kühlkammerseite darstellt.

2. Abkühlvorrichtung (2) für Stahlband, wobei die Abkühlvorrichtung mit mehreren Düsen (4) versehen ist, die von der Oberfläche der Kühlkammern vorstehen, und ein durchlaufendes Stahlband durch Ausstoßen eines Kühlmittels durch die Düsen abgekühlt wird, wobei der Abstand zwischen den Spitzen der Düsen (A) und den Oberflächen des Stahlbandes im Bereich von 30 bis 100 mm gehalten wird, **dadurch gekennzeichnet, dass** die Gesamtdüsenlänge

nicht weniger als 200 mm beträgt, und D/d der Blasdüsen den Ausdruck $1{,}5 \leq D/d \leq 3{,}0$ erfüllt, wobei d den Innendurchmesser an einer Düsenspitze (A) auf der Stahlbandseite und D den Innendurchmesser an einem Düsenfuß (B) auf der Kühlkammerseite darstellt.

3. Abkühlvorrichtung für Stahlband gemäß Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** die Düsen (4) durch Befestigen der Füße (B) der Düsen (4), mittels Rohrdehnungverbindung, in Passlöcher angebracht sind, die in einer Kühlkammer (3) vorgesehen sind.

4. Abkühlvorrichtung für Stahlband gemäß einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** die Durchmesser der Passlöcher, die in der Kühlkammer (3) vorgesehen sind, den Außendurchmesser der Düsen (4) an einer Position im Bereich von (Gesamtdüsenlänge L - 10 mm (10 mm entfernt vom Düsenfuß in Richtung Düsenspitze)) ± 3 mm entsprechen.

5. Abkühlvorrichtung für Stahlband gemäß einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** die Düsen (4) so befestigt sind, dass der Fuß der Düsen nicht von der Innenfläche der Kühlkammer (3) vorsteht.

6. Abkühlvorrichtung für Stahlband gemäß einem der Ansprüche 1 bis 5, **dadurch gekennzeichnet, dass** das Kühlmittel der Abkühlvorrichtung (2) ein Mischgas, bestehend aus N_2, H_2, und anderen Inertgasen ist, und die H_2-Konzentration im Bereich von 0 bis 100 % liegt, Rest bestehend aus N_2 oder anderen Inertgasen.

Revendications

1. Dispositif de refroidissement (2) pour une bande d'acier, ledit dispositif de refroidissement étant muni d'une pluralité de buses (4) dépassant des surfaces d'une chambre de refroidissement (3) et une bande d'acier en déplacement étant refroidie en éjectant un fluide de refroidissement par l'intermédiaire desdites buses, dans lequel la distance entre les pointes (A) desdites buses et les surfaces de ladite bande d'acier est maintenue dans un intervalle de 50 à 100 mm, **caractérisé en ce que** la longueur totale desdites buses est inférieure à 200 mm et le rapport D/d desdites buses de soufflage respecte l'expression $1{,}5 \leq D/d \leq 3{,}0$, d étant le diamètre interne au niveau de la pointe (A) d'une buse du côté de la bande d'acier et D étant le diamètre interne au niveau de la base (B) d'une buse du côté de la chambre de refroidissement.

2. Dispositif de refroidissement (2) pour une bande d'acier, ledit dispositif de refroidissement étant muni d'une pluralité de buses (4) dépassant des surfaces d'une chambre de refroidissement et une bande d'acier en déplacement étant refroidie en éjectant un fluide de refroidissement par l'intermédiaire desdites buses, dans lequel la distance entre les pointes (A) desdites buses et les surfaces de ladite bande d'acier est maintenue dans un intervalle de 30 à 100 mm, **caractérisé en ce que** la longueur totale desdites buses n'est pas inférieure à 200 mm et le rapport D/d desdites buses de soufflage respecte l'expression $1{,}5 \leq D/d \leq 3{,}0$, d étant le diamètre interne au niveau de la pointe (A) d'une buse du côté de la bande d'acier et D étant le diamètre interne au niveau de la base (B) d'une buse du côté de la chambre de refroidissement.

3. Dispositif de refroidissement pour une bande d'acier selon la revendication 1 ou 2, **caractérisé en ce que** lesdites buses (4) sont attachées en fixant les bases (B) desdites buses (4) dans des trous de raccordement prévus dans une chambre de refroidissement (3) à l'aide d'une jonction de dilatation tubulaire.

4. Dispositif de refroidissement pour une bande d'acier selon l'une des revendications 1 à 3, **caractérisé en ce que** les diamètres desdits trous de raccordement prévus au niveau de ladite chambre de refroidissement (3) sont égaux aux diamètres externes desdites buses (4) au niveau d'une position située dans un intervalle de (longueur totale de la buse L - 10 mm (à 10 mm de la base de la buse dans la direction de la pointe de la buse)) ± 3 mm.

5. Dispositif de refroidissement pour une bande d'acier selon l'une des revendications 1 à 4, **caractérisé en ce que** lesdites buses (4) sont fixées de façon à ce que les bases desdites buses ne puissent pas dépasser des surfaces internes de ladite chambre de refroidissement (3).

6. Dispositif de refroidissement pour une bande d'acier selon l'une des revendications 1 à 5, **caractérisé en ce que** le fluide de refroidissement dudit dispositif de refroidissement (2) est un gaz mélangé constitué de N_2, de H_2 et d'autres gaz inertes et la concentration de H_2 est de l'ordre de 0 à 100%, le reste étant constitué de N_2 ou d'autres gaz inertes.

Fig.1

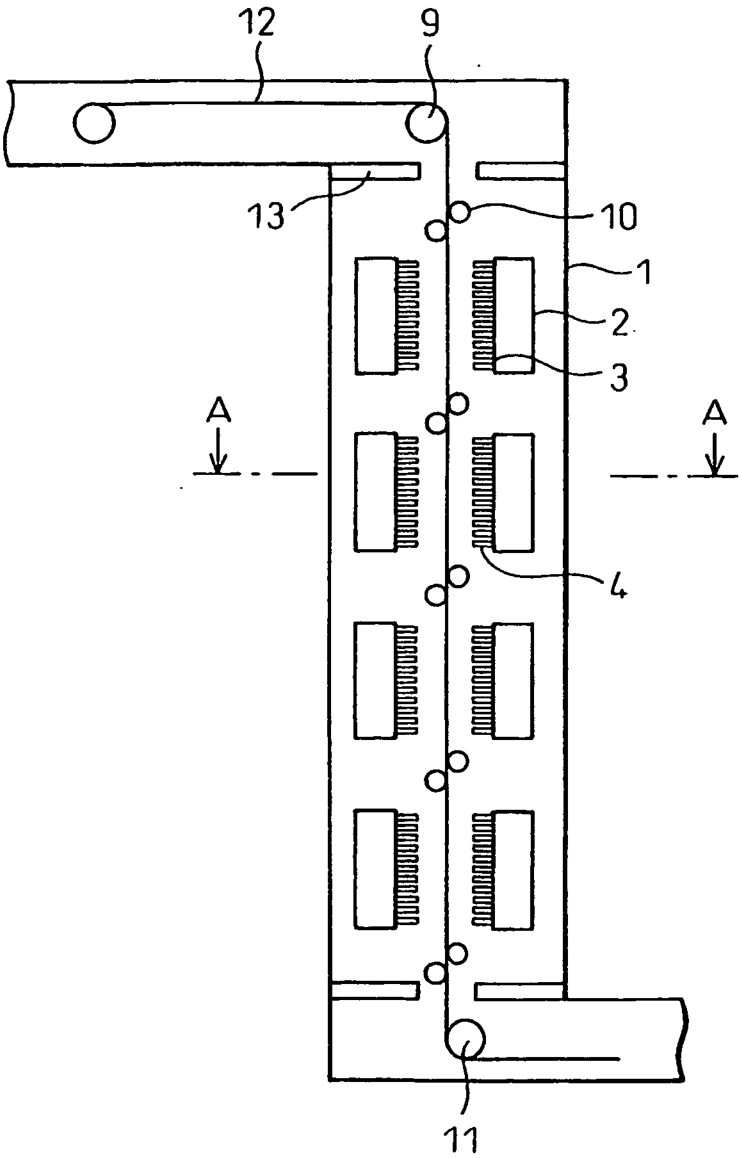

Fig. 2

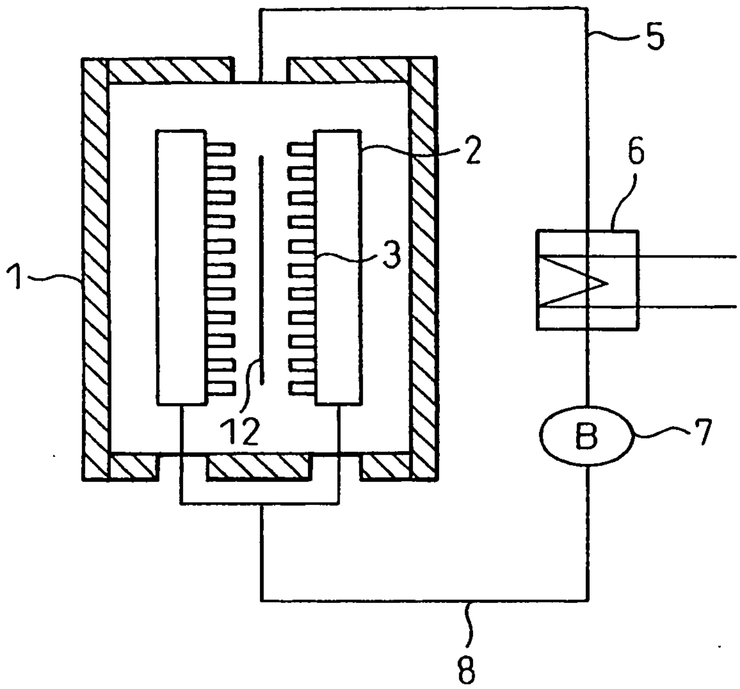

Fig. 3

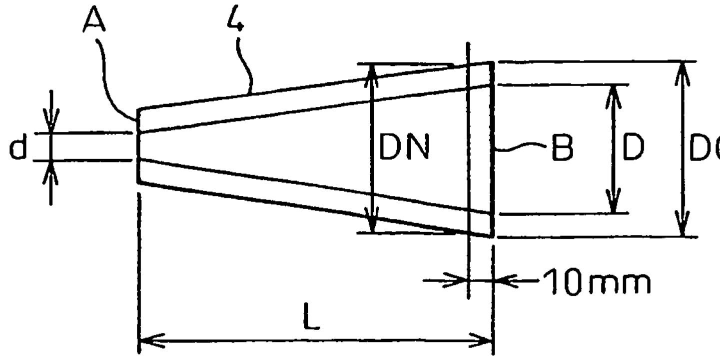

Fig.4

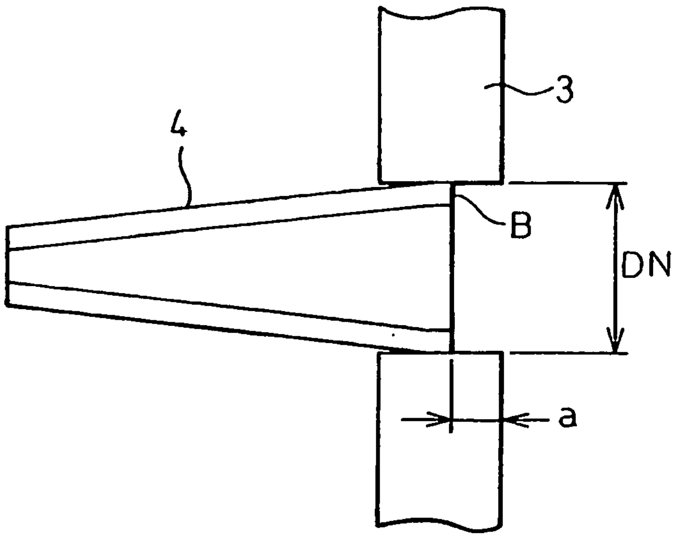

Fig.5

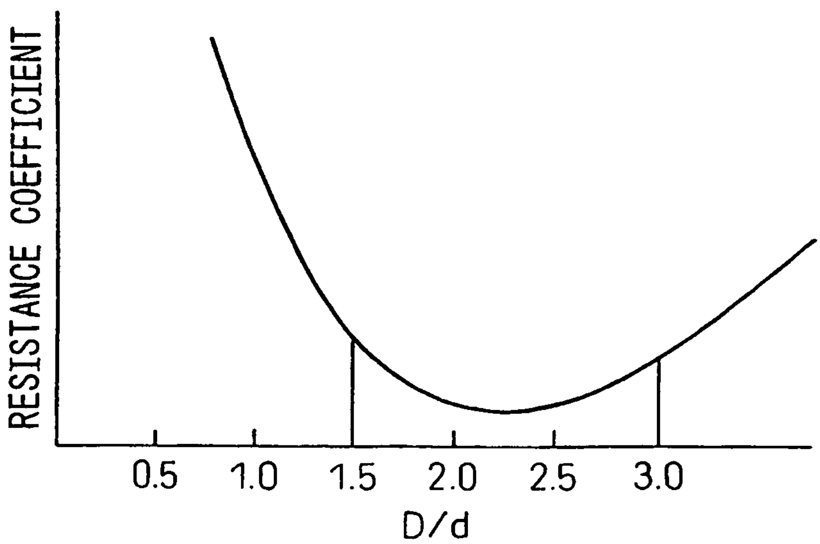

Fig.6

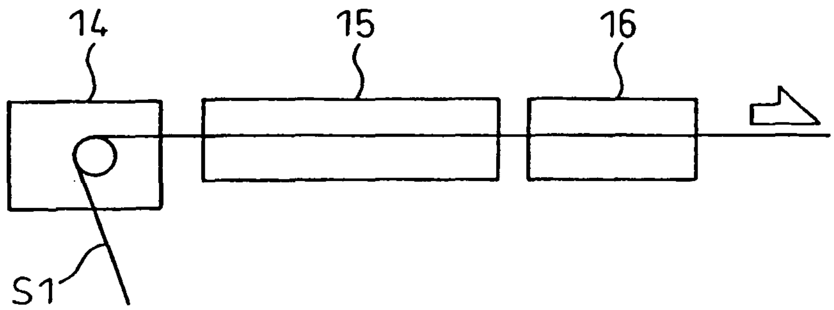

Fig.7

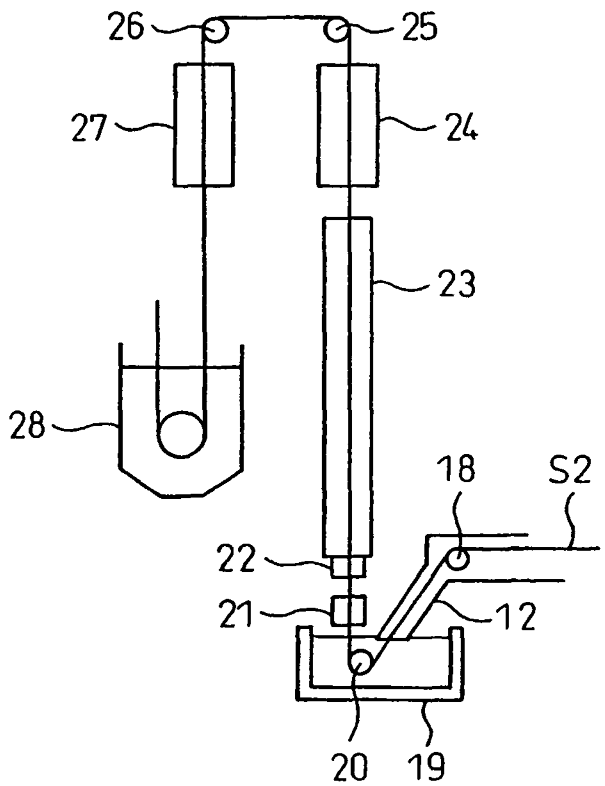

Fig.8

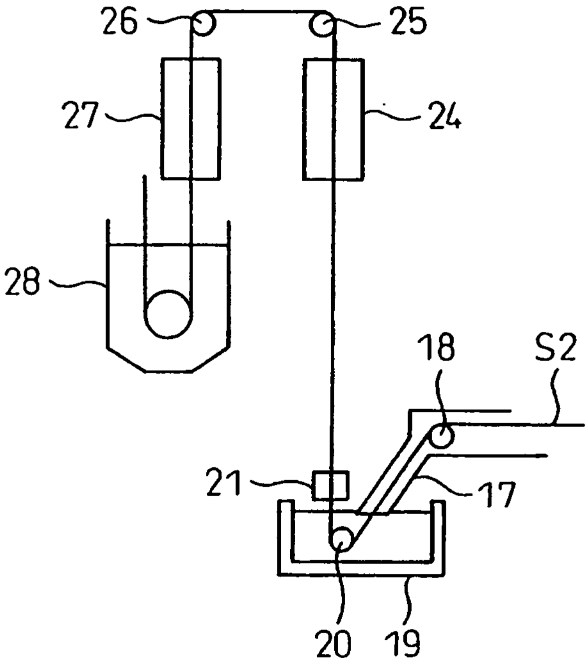

Fig.9