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(54) **METAL BAND COOLING APPARATUS AND COOLING METHOD THEREFOR**

KÜHLUNGSVORRICHTUNG UND -VERFAHREN FÜR METALLBAND

DISPOSITIF ET PROCÉDE DE REFROIDISSEMENT DE FEUILLARD

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Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to an equipment and a method for cooling metal strips in a heat treating line.

BACKGROUND OF THE INVENTION

10 **[0002]** As described e.g. in the document CA-A-2 047 793 a typical apparatus for cooling a metal strip may include a plurality of cooling rolls which are in contact with the metal strip continuously passing the rolls, each roll being displaceable toward the metal strip by a driving mechanism to control the contact area (wrapping length) between the surface of the metal strip and the surface of the respective cooling roll. The aforementioned document further discloses provision of a gas jet cooling equipment including gas blowing nozzles which are directed toward the rear side of the wrapped strip. The nozzles are provided at prescribed intervals in an arcuate nozzle header which is displaceable
15 toward the steel strip and is arranged stationarily or displaceably in the longitudinal direction of the respective cooling roll.

[0003] In gas jet cooling or roll quenching equipment in continuous annealing lines, there have often occurred non-uniform parts in temperature distributions in the width of the metal strip, so that problems such as non-uniform qualities, bucklings or form errors have arisen in the material qualities or strip travelling. Japanese Patent Laid Open No. 60-169524, therefore as seen in Fig.40 of the attached drawings, discloses an equipment of wrapping a metal strip X on a plurality of cooling rolls #1 to #4 for cooling the strip at its contacting faces thereof, composed of gas jetting equipment $\alpha 1$ to $\alpha 4$, gas flow control valves 84a to 84e, thermometers 90a to 90d, and strip temperature control systems 87a to 87d,
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25 said gas jetting equipment $\alpha 1$ to $\alpha 4$ opposite to the cooling rolls #1 to #4 being, as seen in Fig.41, divided into a plurality of parts 10a to 10e over the full width of the metal strip X, each of said gas flowing control valves 84a to 84e being furnished per each of said divisions, said thermometers 90a to 90d shown in the same being for detecting the temperature distributions in the width of the metal strip X and for calculating the strip temperature difference at respective points in the strip width with respect to an average temperature in the strip width, and when said difference exceeds an allowance limit, such a position in the strip width is detected, and
30 said strip temperature control systems 87a to 87d being for adjusting the gas flowing control valves 84a to 84e in response to said detected position.

35 **[0004]** The above mentioned components were applied to an actual installation for carrying out cooling experiments of the metal strips only depending upon the cooling rolls under conditions of the strip thickness: 0.5 to 2.3 mm, the strip width: 850 to 1575 mm, the strip temperature at the inlet of the cooling equipment: 550 to 680°C, and the strip temperature at the outlet of the same: 350 to 480°C. As a result, it was found in all cases as shown in Fig.42 that the temperatures at both edges and center parts of the strips were higher than the average temperatures in the strip widths, having W-shaped profiles of the strip temperature.
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[0005] Namely, a positive deviation of the strip temperature occurs within a certain range of the strip width with respect to the average temperature in the strip width, irrespective of the sizes of the metal strips and the cooling conditions in the center part thereof. At both edges of the same, the larger become the strip thickness, the speed or the amount of the strip temperature drop in the cooling equipment, the larger becomes the deviation of the strip temperature with respect to the average strip temperature in the width.
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[0006] Having made the experiments and analyses on occurring causes of those phenomena, the under stated matters were found. When the metal strip X was wrapped on the cooling roll #1, a stress distribution of tension/compression appeared in the strip thickness, and due to the deformation by Poisson's ratio by said stress, the stress distribution of compression/tension was reversely induced in the right angle direction thereto, i.e., in the strip width, so that a reverse bending deformation (called as "saddle shaped deformation" hereinafter) was caused in the right angle direction to a main bending as shown in Fig.43.
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[0007] Once the saddle shaped deformation occurs, bad contactings to the cooling roll are made around both strip edges, resulting in lacked cooling, and the positive deviation of the strip temperature occurs to the average strip temperature in the width. In the cooling only depending upon the cooling rolls, when the metal strip goes to a subsequent cooling roll, the bad contactings by the saddle shaped deformation are further added to bad contactings by differences in elongation in the strip length derived from the positive deviation of the strip temperature, and thus, they grow to a large positive deviation of the strip temperature.
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[0008] The non-contacting length L between the cooling roll and the metal strip at both edges wrapping on the cooling

roll as well as the strip displacement Z at both edges are expressed by the under mentioned formulae 11 and 12. For example, in case of the conditions of the strip thickness : 1.0 mm, the radius of the roll : 800 mm, and the strip temperature : 600°C, the non-contacting length L is about 15 mm and the strip displacement Z is about 0.1 mm.

[11]

$$L = \left\{ \sqrt{\left(\frac{Tb}{E \cdot \nu} \right)^2 \cdot R + \frac{(R \cdot t)^2}{3}} - \frac{Tb \cdot R^2}{E \cdot \nu} \right\}^{0.5}$$

[12]

$$Z = \left\{ \sqrt{\left(\frac{Tb}{E} \right)^2 \cdot R + \frac{(\nu \cdot t)^2}{3}} - \frac{Tb \cdot R}{E} \right\} / 2$$

L : Non contacting length between the strip and the roll

Z : Radial displacement (mm) at both strip edges

E : Young's modulus (kgf/mm²) of the metal strip

t : Thickness (mm) of the metal strip

ν : Poisson's ratio of the metal strip

Tb : Tension (kgf/mm²) of the strip passing line

R : Radius (mm) of the cooling roll

[0009] However, the cooling equipment of metal strips disclosed in Patent Laid Open No.60-169524 has disadvantages that it is necessary to largely increase the dividing number in the strip width of the gas jet equipment in order to respond to cooling the strip width in a large range with result of increasing the numbers of the gas flow adjusting valves and gas pipings, and heightening costs of the facilities.

[0010] If the dividing number in the strip width is around five sectioned as embodied in Fig.41 of said Publication, the width of the divided nozzles are large so that the gas flow rate grows, and not only the running cost is heightened, but also over-cooling is caused around both strip edges. As apparently from Fig.56 showing experimented results as later mentioned, the strip temperature cannot be satisfactorily uniformized in the strip width.

[0011] The present invention has been provided to solve the above mentioned problems, and is to propose an equipment for cooling the metal strips and a method therefor, by which rapid cooling can be performed while uniformizing the temperature in the strip width at economical operation costs with respect to large sizes to be cooled.

DISCLOSURE OF THE INVENTION

[0012] The cooling equipment of the metal strip according to the present invention is a roll quenching equipment which wraps the metal strip around at least one cooling roll, and adjusts a wrapping length between the metal strip and the respective cooling roll by moving the cooling roll, and includes gas jet cooling equipment having nozzle means facing to the rear side of the wrapped strip section and being displaceable toward the metal strip, and further includes gas adjusting equipment which adjusts pressure or flow rate of a cooling gas flowed into the nozzle means, characterized by said gas cooling equipment having more than one nozzle header disposed in the direction of the roll axis of the respective cooling roll and being narrower than the metal strip and each being movable along the moving direction of the respective cooling roll, and at least one of the nozzle headers being movable along the roll axis.

[0013] Thus, said gas adjusting equipment adjusts the pressure or the flow rate of the cooling gas flowed into each nozzle header (the structure of which corresponds to structures of pressure control valves, gas supply blowers or a calculation device for strip temperature control which adjusts opening of pressure control valves and rotating speed of gas supply blowers as later said).

[0014] A hot point of the W-shaped non-uniform temperature distribution is small in width as stated above, and if a plurality of nozzles were provided in the width of the metal strip as seen in conventional structures and if there were the hot points in portions corresponding to partition walls, the coolings thereat would be difficult, and if the cooling were forcibly carried out, the portion around the hot point would be over-cooled. In the present structure, the nozzle header of the narrow width is moved just above the hot point, and the cooling gas whose pressure or flow rate have been adjusted by the gas control device is impinged on said hot points, thereby to carry out spot coolings thereon, so that

non-uniform temperature distribution is efficiently solved.

[0015] The reason why the nozzle headers are made movable in the moving directions of the cooling roll, is because the cooling roll is movable in a transverse direction with a strip passing line, in order that the cooling roll may change the wrapping length with the strip, it is necessary that the nozzle header may always take an optimum nozzle height for cooling the strip wrapping on the cooling roll (in this case, the nozzle header moves in the same direction as moving of the cooling roll), and the header does not contact the metal strip (when the cooling roll separates from the strip passing line and just before this separation, the nozzle header reversely moves to the direction of a retract position, and further when the cooling roll is going to contact the passing line, the nozzle header moves in a reverse direction as it approaches the cooling roll from the retract or rest position).

[0016] For suiting to the spot cooling to the hot point of the narrow width, it is advantageous to arrange, in a row along the pass line, mouths of the nozzle headers which are shaped in slit crossing almost at right angle with the strip passing line.

[0017] The nozzle mouths 11 are, as seen in Fig.44 (a) to (d), shaped in R in the inside of the cross section thereof, tapered, or projected outwardly as (c) and (d) of the same.

[0018] When two nozzle headers are provided along the roll axis, each of them is positioned at the strip edges in the width thereof, and in case the nozzle headers are three, one of them is positioned almost at the center in the strip width (the nozzle header at the center is not moved along the roll axis but may be fixed there), and when the remaining two are positioned at the strip edges, this arrangement is effective to eliminating of the W shaped non-uniform distribution of the strip temperature (said non-uniform temperature distribution is in general higher at both edges than the center, and therefore the nozzle headers at both edges are preferentially moved).

[0019] The present invention can be applied not only to the structure having one cooling roll, but to structures having two or more cooling rolls. In case of the structure having a plurality of the cooling rolls, it is sufficient that the three nozzle headers are arranged to at least first cooling roll to build the above mentioned structures. Further, these cooling rolls divided into an entry side and a delivery side and with respect to the cooling rolls of the entry side, the three nozzle headers are installed to provide the above mentioned header arrangement, while with respect to the cooling rolls of delivery section, the two nozzle headers are installed to provide the arrangement of the two nozzle headers. The reason why the nozzle headers are three installed to the first cooling roll or the cooling rolls in entry side, is because the center portion of the metal strip swells when the cooling roll begins to contact, so that the non-uniform temperature distribution is caused [as seen in Fig.45(a), the body part of the roll #1 on which the strip X does not contact due to the bad shaping of the strip, is more cooled by a coolant within the cooling roll than the contacting part, and even if the shaping is improved, the center part thereof is not cooled as in Fig.45(b) and is more elongated than both edges and resulted as in Fig.45(c). This phenomenon is called as a center swelling. In particular, in case of materials of small thickness and low rigidity, bucklings are caused therein], and because once the non-uniform temperature distribution is caused due to the properties of the cooling roll, said distribution grows thereafter, and so for preventing the bad shaping of the strip at the beginning to contact the rolls, the nozzle header is also disposed for the center part of at least the first cooling roll or the cooling rolls of entry section, so that the spot thereon and the gas jetting at the edge of wrapping strip around the cooling roll are carried out, thereby enabling to solve the problem of the center swelling (this is especially effective by means of the first roll, even if the material has a large thickness). Reversely, if the structure is composed of the three nozzle headers including the center nozzle header with respect to the first cooling roll or the cooling rolls of entry section, it is sufficient to install the nozzle headers respectively for both strip edges in the following cooling rolls.

[0020] On the other hand, when the plurality of cooling rolls are installed as mentioned above, it is also possible to set the movings of the nozzle headers such that the nozzle header of the entry section is moved in the moving direction of the roll differently from the moving of the nozzle header of the delivery section. That is, for eliminating the non-uniform temperature distribution in the strip width caused by the saddle shaped deformation, the cooling amount should be increased as much as possible at an upstream side where said deformation is generated, and aiming at early cancelling the bad shapings of the strip around a part where the strip and the cooling roll begin to contact, the cooling amount should be made as much as possible also for the rear surface of the strip wrapped around the roll in the entry section, (as to others, a thermal load is very low, and even the rolls of the entry section sometimes carry out the coolings under a condition that said rolls do not have a full shift stroke thereof). The structure allows the nozzle headers of the entry section to follow the moving of the cooling rolls such that the distances of the nozzle headers from the respective cooling rolls are maintained constant, thereby to heighten the cooling effect in the entry section. More specifically, the nozzle header is moved from the retracting position in a direction approaching the strip at the same time as beginning to contact between the strip in the pass line and the cooling roll. Further, when the shift stroke of the roll is longer than at the time of said contacting, the nozzle header is moved for maintaining the distance from the strip constant. When the strip and the cooling roll are non-contacted, the nozzle headers will be moved to the retract position. In contrast, the nozzle headers of the delivery section do not always require said requirements and may be stationary. However, the nozzle headers should be retractable, because, if nozzle headers are designed such that when the cooling rolls make the maximum shift stroke, the length of the nozzle header opposite thereto is maximum, e.g., one cooling roll

cannot be used, whereby the shift stroke of the cooling roll before or after said cooling roll is short, so that the nozzle header following the cooling roll whose shift stroke is short, or the nozzle header fixed to the rear side of the strip wrapped around the cooling rolls, contact the strip. Thus, it is possible that the nozzle header of delivery section is ordinarily set to be, at cooling, moved to determined positions and to be positioned at the retract position only in an emergency or at time of not cooling, so as not to absolutely follow the moving of the cooling rolls. That is, the nozzle header is moved in the direction toward the strip from the retract position at the same time as beginning to contact between the strip in the passing line and the cooling roll, and thereafter although the shift stroke of the cooling rolls becomes long, the nozzle header does not move to a determined position, and the nozzle headers are again retreated to the retract position just before the metal strip and the cooling roll become non-contacting.

[0021] For correcting the non-uniform temperature distributions along the strip width caused by the saddle shaped deformation, the cooling rate should be made as large as possible in the upstream side from which the deformation is derived, and the cooling on the rear side of the strip wrapped around the roll where the uniform cooling can be made in the strip width should be mainly made in the upstream side. Therefore, not only the cooling length is made large (the shift stroke of the roll is made large) by successively pushing the cooling rolls from the upstream side in the entry section, in particular in preference of the first cooling roll, but also the gas jet flow is made maximum in succession from the nozzle headers of the upstream side for carrying out the cooling, and the lacked cooling is compensated in the downstream side. Since the shift or pushing method of the cooling roll taking the large wrapping length of the strip thereon in succession from the first cooling roll is employed, and when a required cooling rate is low or when the cooling amount is low (that is, the production rate (tons/hr) is low), the nozzle header for cooling the rear of the strip wrapped around the cooling roll largely separates from the metal strip in the downstream side (even if the roll is non-contacted, said rear can be cooled by said nozzle header). For saving energy at this time, if a distance between the nozzle header and the cooling roll is larger than a certain distance, a shut-off valve of a gas supplying channel furnished in each nozzle header is closed.

[0022] On the other hand, when having a plurality of the nozzle headers in the roll axis, the moving amounts thereof in the moving direction of the cooling rolls can be made different respectively, and the distance between each nozzle header and the cooling roll can be made different in the roll axis. Such a structure can be applied for correcting it, if a required cooling rate in the transverse direction is varied in the roll length. In addition, if the cooling rate has still surplus power, the uses of facilities such as the gas blowers and others can be reduced, resulting being useful to saving the energy.

[0023] In the above structure which brings the nozzle header of the small width of the gas jet cooling equipment just above the hot point to jet the cooling gas thereto, when the strip widths largely change, a new problem arises that the nozzle headers of both strip edges cannot follow said changings, and consequently, the rear side of the strip corresponding to the hot point cannot be exactly cooled. Thereupon, with respect to the nozzle headers for at least both strip edges, the present structure combines a plurality of the header bodies in the roll axis, and when the strip widths change, the structure heightens the pressure or the flow rate of the cooling gas of the header bodies near the strip edges, thereby to compensate delay in moving of the nozzle header (the low response).

[0024] More specifically, when the strip changes from the wide width to the narrow one nearly the welding point between the strips being different in the width, the inside header bodies αc , αe or βc , βe corresponding to both edges as well as the center header bodies αb , αf or βb , βf are used as seen in Fig.46(a). When the narrow width changes to the wide one, the outside header bodies αa , αg or βa , βg corresponding to both edges as well as the center header bodies αb , αf or βb , βf are used as seen in Fig.46(b), whereby the length of the strip which has the temperature deviation in the transverse direction can be made shortest, thereby enabling to avoid rollings of the metal strip running in the heat treating furnace after the cooling apparatus.

[0025] In the structure where a plurality of the header bodies are connected along the roll axis, when the hot points are present in the parts corresponding to the partitioning walls at the connected parts of the header bodies, said parts are difficult to be cooled. In the present structure, as seen in Fig.47(a), the nozzle header 1 is structured in that the connected header bodies 10 are further plurally stepped along the running direction of the metal strip, and the nozzle mouths 11 of the header bodies 10 may be off along the roll axis with respect to the upstream and the downstream sides, whereby the position to be a partition wall in a one step is a position for installing the nozzle mouth 11 in the upper or lower step, so that said problem is solved.

[0026] Since the nozzle mouths of the header bodies have right spaces, no problem occurs about jetting the gas, however, in this structure connecting the plurality of header bodies in the roll axis, if the positions among both neighbour nozzle mouths are the same (i.e., the same position in the roll axis), turbulent flows are easily generated by the cooling gas issued therefrom, and the effective cooling cannot be promised. In the present structure, as shown in Fig.47(b), the positions of the nozzle mouths 11 of the connected header bodies 10 are deviated toward the neighbour header bodies 10 in the strip running direction, so that both neighbour nozzle mouths 11 are differently positioned and the above problem is solved (as to other, the same effect is brought about in a structure which has a plurality of the nozzle mouths in the roll axis within one nozzle header and deviates the neighbour nozzle mouths in the strip running direction).

[0027] It may be sufficient that the tension of the metal strip is varied to be higher before the above cooling roll contacts the metal strip, thereby to stabilize the shape of the strip when contacting.

[0028] As to another structure for compensating the delay in moving of the nozzle header, as shown in Figs.48 and 49, the header bodies are divided into not less than two ($\alpha a1$, $\alpha a2$, $\alpha c1$, $\alpha c2$, $\beta a1$, $\beta a2$, $\beta c1$, $\beta c2$) in the traveling direction of the strip, and are independently movable along the roll axis (or the strip width) for the nozzle headers αa , αc , βa , βc to be positioned at least at both strip edges provided to the gas jet cooling equipment for cooling the rear side of the strip wrapping around the cooling roll and/or later mentioned auxiliary gas jet cooling equipment at the outlet of the cooling rolls. As is seen in Fig.50 (a) (b) (c) and Fig.51 (a) (b) (c), just before changing the strip widths, the nozzle headers ($\alpha a1$, $\alpha c1$, $\beta a1$, $\beta c1$) for the strip edges in the upstream side have previously been moved to sides to be strip edges after changing, and the nozzle headers ($\alpha a2$, $\alpha c2$, $\beta a2$, $\beta c2$) for the strip edges in the downstream are also moved to the strip edges after changing, just before the parts of the different strip width come to these nozzle headers (Fig.50 shows the movements of the headers of the strip edges when the wide width change to the narrow width, and Fig. 51 shows the movements of the headers in a reverse case). The above structure may be installed not only as the gas jet cooling equipment and the auxiliary gas jet cooling equipment, but as an auxiliary cooling equipment to be disposed at the inlet of the roll quenching equipment.

[0029] When the above structure is installed, one or more of

a target nozzle position calculation device for strip width change (a device which trucks, at the inlet of the cooling rolls, an information concerning connections such as weldings from the changing order, the width of the metal strip or the length up to the next weld point, and calculates the time reaching to the cooling roll, and outputs a new set position of the nozzle header in the roll axis),

a strip edge position detector (a photo source and a detector, a laser source and a detector, and a later mentioned strip temperature profile measuring equipment (a profile thermometer) discriminating by difference in temperature between a high temperature part of the strip and an ambient low temperature part other than the strip, or a structure incorporated therewith), and

a strip temperature profile measuring equipment

are disposed at the inlet of the cooling rolls for obtaining an information of the width-changing weld point and the width-changing amount in accordance with the information therefrom, thereby enabling to set the nozzle headers for the edges in the strip width. When the weld point connecting the strip with the different width is coming to the inlet of the cooling rolls, an information of this weld point is trucked at the inlet. When the strip changes from the narrow width to the wide one, the movement of the nozzle headers to a predetermined position has been previously completed (the nozzle headers move far away) just before the weld point passes the inlet of the cooling rolls. Reversely when the wide width changes to the narrow one, the nozzle headers begin to move to the predetermined position after said point has passed the outlet of the cooling rolls (the nozzle headers approach each other). This is because when the narrow strip is running, a part of the roll outside the running strip causes a heat crown and that part is bad at contacting the strip even when the wide width comes, and in addition when the strip is wide, the tension of the strip is relatively lowered and contacting the strip is getting worse. Therefore, in such a case, the nozzle header has previously been moved to the predetermined position, and it is advantageous that when the strip has changed to the wide width, the contact between the strip and the roll is made satisfactory by cooling the rear side of the strip wrapped around the cooling roll. If the strip rolls, the nozzle headers follow the rolling. As said above, when the nozzle headers at both strip edges comprise the plurality of the header bodies connected in the roll axis (in the direction of the strip width), or when the header bodies of the edge nozzle headers are separated into two or more in the strip running direction and independently movable, abnormal parts by cooling in the width changing part can be more reduced and the nozzle width can be made more narrow, so that the over-coolings in the environments can be lowered.

[0030] If it is difficult to cancel the temperature deviation in the strip width by means of the above stated gas jet cooling equipment opposite the cooling rolls under conditions of wide strip thickness, traveling speed, or the strip temperature difference in the roll cooling equipment, such a problem can be solved by incorporating, other than said gas jet cooling equipment,

auxiliary gas cooling equipment which is disposed at the outlet of the cooling rolls or the cooling roll groups opposite the metal strip and has two or more gas jetting nozzle headers in the strip width, at least one of these nozzle headers (two are more preferable, and in particular each one is at the edge) being movable along the strip width, and gas adjusting equipment which adjusts the pressure or flow rate of the cooling gas flowed into the nozzle headers.

[0031] Further, when this auxiliary gas jet cooling equipment is disposed, it is allowed that at least such nozzle headers positioned at both strip edges among the nozzle headers thereof are composed of the plural header bodies connected in the strip width as a structure for compensating the delay in the moving of the nozzle headers when the

strip width changes, and at least one of said nozzle headers is movable along the strip width, or the nozzle headers positioned at both strip edges are, as seen in Fig.49, divided into two or more in the strip traveling direction and are independently movable along the strip width.

[0032] If disposing, at the inlet of the cooling rolls, one or more of the target nozzle position calculation device for the strip width change, the strip edge position detector, and the strip temperature profile measuring equipment so as to obtain an information of the width-changing weld point and the width-changing amount in accordance with the information therefrom, thereby to set the two nozzle headers for the strip edges of the gas jet cooling equipment and of the auxiliary gas jet cooling equipment, it is thus possible to move each of the nozzle headers to the predetermined positions before or after coming of the weld point of the strips being different in the widths.

[0033] Other than the above stated feed forward control, it is also possible to perform a feed back control where the strip temperature profile measuring equipment is installed at the outlet of the cooling rolls or the outlet of the auxiliary gas jet cooling equipment. In accordance with the information therefrom, each nozzle header of the gas jet cooling equipment and/or each nozzle header of the auxiliary gas jet cooling equipment are respectively set at the strip edges.

[0034] Further, the above feed back control may be also performed by adjusting the pressure or the flow rate of the cooling gas jetted from the nozzle headers of the gas jet cooling equipment and/or these of the auxiliary gas jet cooling equipment in accordance with the information of the strip temperature at the outlets with or without accompanying the moving control of the nozzle headers. In addition, it is possible to concurrently set the two nozzle headers at the strip edges and adjust the pressure or the flow rate of the gases in these nozzle headers.

[0035] The actual structure of the gas jet cooling equipment may employ the two or more nozzle headers having the narrower width than the strip width provided with the gas jetting nozzles, and moving beds for moving said nozzle headers in the direction toward the strip surface and/or in the direction of the strip width.

[0036] If the nozzle headers are moved by the moving bed to an area of a non-uniform distribution of the strip temperature and jet the cooling gas to the strip, taking a right distance (if the two nozzle headers are insufficient, they may be increased as three, four, ... in the strip width), the temperature distribution is controlled in the strip width. Thus, the distribution is uniformized thereby in the strip width, and by this uniformization, the cooling rate can be made uniform and the temperature uniformized in the strip width can be brought to an objective temperature, so that problems about bad properties or form errors of the material can be solved.

[0037] The above structure may be of course applied to cooling of the rear side of the strip wrapped around the roll on at least one roll whose interior has been cooled (preferably the nozzle header is curved to meet the curvature of the roll), and may be used as the auxiliary gas jet cooling equipment to be installed at the inlet of the roll quenching equipment or at the outlet thereof. (As to the inlet, there is the saddle shaped deformation caused by lacking of the cooling at the strip edges, and if the strip edges are in advance cooled by the gas cooling prior to the roll quenching, the saddle shaped deformation can be made small and the non-distribution of the strip temperature in the roll quenching equipment can be improved. The nozzle header herein is plain; and as to the outlet, the plain nozzle header is chiefly used.) For example, the above structure can be used to cooling system (points shown with A and B) before and/or after the roll quenching equipment, reaching a recrystallizing temperature to an over-aging treatment in a continuously annealing heat cycle of a soft and thin steel (for deep drawing) as seen in Fig.52.

[0038] The present structure can be applied, irrespective of the horizontal passing line or the vertical one. When using this structure as the auxiliary cooling structure at the inlet of the roll quenching equipment, or as the auxiliary gas jet cooling structure at the outlet thereof, the structures can be provided with respect to both of front and rear sides of the strip other than providing the nozzle headers and the moving beds for the one side of the strip. When the structures are provided at both sides, the hot point (including parts which must be hot points) is cooled on both sides, thereby enabling to heighten the cooling efficiency and check flutterings of the strip.

[0039] When the nozzle header are two in the strip width, the headers are transferred by the moving beds to both edges increasing the temperature, and when being three, the remaining one is brought to nearly the strip center of high temperature, or depending upon cases, to an appropriate position toward the strip surface for cooling the hot point by the nozzle headers. When the nozzle headers are three in the strip width, the center header may fixed not to move (the nozzle header may be allowed to move in the transverse direction).

[0040] When the cooling roll is movable in the transverse direction with the strip passing line for adjusting the cooling amount, it is also allowed that the nozzle header is made set to the moving of the cooling roll

(when the roll and the header are integral and always move together, a problem occurs other than that the roll is retreated. That is, when the roll is retreated from the pass line at standing of the line, the header often contacts the strip at its edges. Therefore, the nozzle header is made set to the moving of the cooling roll in the range not contacting the strip, though the header follows the moving of the roll)

within a range not contacting the strip on the pass line

(in particular, when a (curved) size of the nozzle header in the back yard is determined in response to meeting a case that the shift stroke of the following roll in the back yard is maximum, the nozzle header should be retreated

at emergency such as lowering the cooling load, and depending upon the positions of the cooling roll and if the nozzle header is left as the maximum pushing, it will contact the strip),
 or the nozzle header is moved independently of said moving of the cooling roll
 (as to the independent moving, other than said avoiding of the contact, fine adjustments are practicable for carrying
 5 out high cooling efficiency with the minimum gas amount, maintaining the optimum nozzle height of the highest cooling efficiency).

[0041] When the present structure is applied as an auxiliary cooling structure installed at the inlet of the roll quenching equipment as said above, it is sufficient to remove the non-uniform distribution of the temperature along the strip width before the roll quenching, or to cool the part to be the hot point by the roll quenching so as to bring to the uniform temperature distribution as nearly as possible (when carrying out the roll quenching, the non-uniform distribution is easily created or accelerated due to the relation between the saddle deformation of the metal strip and the heat crown of the roll). When the present structure is disposed as the auxiliary gas jet cooling equipment at the outlet of the roll quenching equipment, it is also useful to cancel the non-uniform temperature distribution created and accelerated in
 10 the roll quenching, or not having been dismissed by means of this cooling equipment. Further, when the above structure is used as structures of the auxiliary jet cooling at the inlet or outlet of the roll quenching equipment, the nozzle headers 1 are arranged by slightly deviating in a running direction of the metal strip X, not arranging in a one row, so that the non-uniform part can be cooled by jetting the gas even if the non-uniform width is wider than the width of the nozzle header 1 as shown in Fig.53.

[0042] With respect to the other than the above mentioned, the auxiliary gas jet cooling equipment is provided, on the passing line of the metal strip, with carts moving in parallel to the strip surface and in the direction transverse with the strip passing line, the nozzle headers in the direction of the passing line which have the nozzles narrower than the strip width, a mechanism for traveling said cart, and flexible parts or the expansion joints on the part of the gas supplying channel.

[0043] The non-uniform temperature distribution can be also cancelled by jetting the cooling gas to the strip, following moving the nozzle header mounted on the cart to the area of the non-uniform distribution of the strip temperature (if the one is insufficient, the nozzle headers may be increased as two, three... in the strip width). Thus, the distribution is uniformized thereby in the strip width, and by this uniformization, the cooling rate is made uniform and the temperature uniformized in the strip width is brought to an objective temperature, so that problems about bad properties
 25 or form errors of the material are solved.

[0044] There may be respectively furnished, at both surfaces of the strip, the cart, the nozzle headers carried thereon, and the gas supplying channels having the flexible parts or the expansion joints provided to the nozzle headers for the gas jet cooling.

[0045] The above structure may be also used as the auxiliary cooling system for cooling the strip edges and/or hot points at the inlet of the roll quenching equipment (the saddle shaped deformation can be reduced in that the strip edges have previously been cooled by the gas cooling prior to the roll quenching, and the non-uniform distribution of the strip temperature caused by the roll quenching can be improved). For example, the above structure can be used to the gas jet cooling systems before and/or after the roll quenching equipment reaching from a recrystallizing temperature to an over-aging treatment in a continuous annealing heat cycle of a soft and thin steel (for deep drawing) as
 35 seen in Fig.52.

[0046] Further, the present structure is applicable, irrespective of the horizontal or vertical passing lines.

[0047] When the nozzle headers are two in the strip width, the nozzle headers are transferred by the carts to both edges increasing the temperature, and when being three, one is brought to nearly the strip center of high temperature to cool the hot point by the nozzle headers. In addition, it is possible to dispose stationary nozzle headers other than the movable nozzle headers at the center in the strip width.

[0048] The present invention proposes such a cooling equipment of the metal strips, which wraps the strip around at least one cooling roll, and individually adjusts the wrapping lengths between the strip and the cooling rolls, providing

gas jet cooling equipment comprising three or more nozzle headers in the roll axis opposite said cooling rolls where said nozzle headers are movable along the moving directions of the cooling rolls, and at least one nozzle header is movable along the axis of the roll,
 50 strip edge position detectors,
 position adjustment devices which adjust movements of the movable nozzle headers among said nozzle headers along the roll axis,
 55 a calculation devices for nozzle header position control which controls said position adjustment devices in accordance with detected signals of said detectors,
 position adjustment devices which adjust positions of said nozzle headers with positional signals of the cooling rolls along the moving directions of the cooling roll,

strip temperature profile measuring equipment which detects the temperature distribution in the strip width at the outlet of the cooling roll, and
 a calculation device for strip temperature control which calculates the deviation in temperature with respect to the objective distribution of the strip temperature with the temperature signal put out from said measuring equipment,
 5 and adjusts the pressure or the flow rate of the cooling gas flowed into the nozzle headers in response to said temperature deviation.

[0049] The nozzle header is transferred in the roll axis in that said calculation device for nozzle header position control is based on data detected by said strip edge position detector, because a high position of the strip temperature distribution is almost determined in the strip width. But if a measuring equipment of the profile of the strip temperature is used to said strip edge position detector, the high position of the strip temperature distribution may be rendered to be moving positions of the nozzle header as the strip edges. In the present structure, the non-uniform distribution of the strip temperature is cancelled by the feed back control of the calculation device for strip temperature control which has been input with the detecting data of the strip temperature profile measuring equipment installed at the outlet of the cooling rolls or the outlet of the auxiliary gas jet cooling equipment. A method of cancelling the non-uniform distribution is practised by adjusting the pressure or the flow rate of the cooling gas flowed into each nozzle header in response to the temperature deviation to the objective distribution of the strip temperature.

[0050] As the objective distribution of the strip temperature, a pre-set one may be used. But, for example, the average temperatures (+α will occur according to cases) of two quarter parts in the strip width may be objective temperatures at the strip center, and the measured temperature at the strip center (this temperature is sometimes 0°C to 20°C lower than the temperature according to cases) may be made objective temperature at both edges of the strip.

[0051] The above structure may incorporate the auxiliary gas jet cooling equipment (including such a structure where at least the two nozzle headers, in particular each nozzle header at the edge, are movable in the strip width) together with the strip temperature profile measuring equipment.

[0052] The length of the part of the strip temperature deviation caused in both strip edges with respect to the average temperature in the strip width is relatively short as obtained in the formula 11. The average strip temperature deviation ΔT of the strip edges defined in the formula 13 is largely varied as shown in Fig.54 in response to the cooling width and strip thickness. The strip temperature deviation can be reduced to minimum by detecting both strip edges by means of said detector, and moving the nozzle headers at both edges along the roll axis (or the strip width) to the proper cooling width by means of the position adjustment device.

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$$\Delta T = \frac{1}{150} \int_0^{150} |T(x) - T_a| \cdot dx$$

ΔT : Average temperature deviation (°C) in 150 mm of the strip edges

T(x) : Temperature (°C) in position of x mm from the edges

Ta : Average temperature (°C) in the strip width

x : Distance from the strip edges

[0053] The proper cooling width Xe is expressed as the formulae 14 and 15 from Fig.54.

$$[14] \quad 6 \leq X_e \leq 45$$

herein, t < 1.3mm

$$[15] \quad 12t - 9.6 \leq X_e \leq 22t + 16.4$$

herein, t ≥ 1.3mm

Xe : Proper cooling width (mm)

t : Strip thickness (mm)

[0054] As seen in Fig.55, around the weld point of the strips X having the different widths, a length of irregular cooling in the strip length is made as short as possible, and for aiming at stable running of the strip X in the heat treating furnace after the cooling equipment, it is found that the irregular cooling length should be experimentally within 0.9Lo (Lo: the pass length between the rolls in the above heat treating furnace). The relation with the nozzle width of the nozzle header at the strip edge is expressed with the under formula 16.

$$[16] \quad Xe \leq Be - \left(\frac{\Delta w}{2} - 0.9Lo \frac{V}{S} \right)$$

Be : Width (mm) of the nozzle
 Δw : Difference in the width (mm) between the preceding and following strips
 Lo : Passing length (m) between the rolls in a heat-treating furnace after the present cooling apparatus
 V : Moving speed (mm/min) of the nozzle headers at both strip edges
 S : Line speed (mpm)

[0055] Therefore, the nozzle width Be of the nozzle headers at both edges can control the strip temperature deviation caused at the strip edges to be minimum by selecting sizes of the under formulae 1 or 2 (if the strip thicknesses are not constant and varied from 1.0 mm to 2.0 mm, the nozzle width Be is determined based on the maximum thickness).

$$[1] \quad 6 \leq Be - \left(\frac{\Delta w}{2} - 0.9Lo \frac{V}{S} \right) \leq 45$$

herein, $t < 1.3\text{mm}$

$$[2] \quad 12t - 9.6 \leq Be - \left(\frac{\Delta w}{2} - 0.9Lo \frac{V}{S} \right) \leq 22t + 16.4$$

herein, $t \geq 1.3\text{mm}$

Be : Width of the nozzle (mm)
 t : Strip thickness (mm)
 Δw : Width changing amount (mm) of the strip
 Lo : Passing length between the rolls in a heat treating furnace after the cooling apparatus
 V : Moving speed (mm/min) of the nozzle header in the roll length (or in the strip width)
 S : Line speed (mpm)

[0056] Fig.56 shows the comparison between the invention (shown with No.1) and the prior art where the cooling was carried out by the gas jet equipment which were divided into the plural number along the strip width and opposite the cooling rolls. The same shows the strip temperature distribution around the strip edges, and it is seen that the invention is less in the over-cooling range and has the uniform temperature distribution in comparison with the prior art. The experimental conditions are shown in the under Table 1

Table 1

Strip thickness:	1.3 mm
Strip width:	1450 mm
Line speed:	248/min
Strip tension:	3.1 kgf/mm ²
Average strip temperature	
at the inlet of the cooling equipment:	600°C
at the outlet of the same:	350°C
Number of the used cooling rolls:	7
Diameter of the cooling roll:	1800 mm
Average contact angle of the same:	112°C
Average heat transfer coefficient of the gas jet cooling equipment opposite the cooling rolls:	390 Kcal/m ² h°C
Average angle of the nozzle header of the same:	99°

Table 1 (continued)

Nozzle header and the metal strip of the same:	10 mm (the invention)
Cooling width of the overlapping part of the same:	250 mm (the prior art)

[0057] The length of the strip temperature deviation caused in the strip center with respect to the average temperature in the strip width is within the range shown in Fig.57. The nozzle widths B_c of each center nozzle header of the gas jet cooling equipment and that of the auxiliary gas jet cooling equipment can control the strip temperature deviation to be minimum by selecting results obtained by the formula 3, thereby to minimize the strip temperature distribution, said gas jet cooling equipment being opposite the cooling roll, and said auxiliary gas jet cooling equipment being disposed at the outlet of the cooling roll group.

$$[3] \quad 0.09 W \leq B_c \leq 0.27 W$$

B_c : Nozzle width (mm)
 W : Strip width (mm)

[0058] Almost all of the ranges having caused the temperature deviations are symmetrical with respect to the center line of the metal strip, and so the nozzles are moved and adjusted along the roll axis (or the strip width) such that the centers of the strip and the nozzle coincide each other.

[0059] Fig.58 shows a comparison between the prior art and the invention concerning an investment cost/a running cost. The investment cost/the running cost can be saved by cutting back the amount of the gas and the rotating speed of the valves as shown in the same.

[0060] The above structure has three or more nozzle headers along the roll axis, and at least such nozzle headers thereamong, positioned at both strip edges comprise a plurality of the header bodies connected in the roll axis, so that said nozzle headers are movable along the roll axis, and the gas jet cooling equipment may be composed of these nozzle headers.

[0061] Since the position which is higher in the strip temperature distribution is, as mentioned above, almost determined in the strip width, the calculation device for the nozzle header position control moves the nozzle header along the roll axis in accordance with data which has been detected by the strip edge position detector. However, if the movings of the nozzle headers at both strip edges to the edges of the strip are delayed when the strip width changes, the connected nozzle headers can cover the delaying by increasing the pressure or the flow rate of the cooling gas in the header bodies near both strip edges. Also in the present structure, the non-uniform distribution of the strip temperature is cancelled by the feed back control of the calculation device for strip temperature control which has been input with the detecting data of the strip temperature profile measuring equipment installed at the outlet of the cooling roll. The method of cancelling the non-uniform distribution is practised by adjusting the pressure or the flow rate of the cooling gas flowed into each nozzle header in response to the temperature deviation to the objective distribution of the strip temperature.

[0062] If it is difficult to cancel the temperature deviation in the strip width by means of the gas jet cooling equipment opposite the cooling rolls under conditions that large are the strip thickness, the traveling speed or the decreasing amount of the strip temperature in the cooling equipment, such a problem can be solved by incorporating the auxiliary gas jet cooling equipment composed of the plural header bodies which have three or more gas jetting nozzle headers in the strip width and are connected with such nozzle headers positioned at the both strip edges, and the gas adjusting device for adjusting the pressure or the flow rate of the cooling gas flowed into each nozzle header.

[0063] With respect to the nozzle headers of the auxiliary gas jet cooling equipment, at least such nozzle headers thereamong, positioned at both strip edges comprise the plurality of the header bodies connected in the strip width and are movable along the strip width for the same reason why the same structure is provided to the nozzle header of the gas jet cooling equipment.

[0064] The range of the strip temperature deviation caused in the strip center with respect to the average temperature in the strip width is within the limits as shown in Fig.57. If the pressure or the flow rate of the cooling gas flowed into the nozzle header is adjusted in response to the strip temperature deviation, the deviation caused at the center of the strip width as said above can be reduced to the minimum by selecting the results obtained by the above formula 3 with respect to the width B_c of the header body of each nozzle header installed at the centers of the gas jet cooling equipment opposite the cooling rolls and the auxiliary gas jet cooling equipment at the outlet of the cooling rolls.

[0065] When the nozzle headers at both strip edges are composed of three or more header bodies, the deviation caused in both strip edges can be reduced to the minimum in that the widths B_e of the header bodies select a size shown in the under formula 17, the widths B_{eo} of the nozzle headers at the outsides select the size shown in the

formula 4, the widths B_{ec} of the center header bodies select the sizes shown in the formulae 5 and 6 (if the strip thickness is not fixed and varied in the range of 1.0 mm to 2.0 mm, the nozzle width B_{ec} is determined in accordance with the maximum thickness) and the widths B_{ei} of the header bodies at the insides select the sizes shown in the formula 7.

$$[4] \quad B_{eo} \geq \Delta W_u / 2$$

ΔW_u : Changing amount (mm) of the strip width when connecting the strips from the small width to the large width

$$[5] \quad 6 \leq B_{ec} \leq 45$$

herein, $t < 1.3\text{mm}$

$$[6] \quad 12t - 9.6 \leq B_{ec} \leq 22t + 16.4$$

herein, $t \geq 1.3\text{mm}$

t : Strip thickness (mm)

$$[7] \quad B_{ei} \geq \Delta W_d / 2$$

ΔW_d : Changing amount (mm) of the strip width when connecting the strips from the large width to the small width

$$[17] \quad B_e = B_{eo} + B_{ec} + B_{ei}$$

[0066] The range of the part of the strip temperature deviation caused in both strip edges with respect to the average temperature in the strip width is relatively small. The average strip temperature deviation ΔT defined in the formula 13 is largely varied as shown in Fig.54 depending upon the strip width and thickness. Therefore, Fig.54 shows that it is preferable to set the proper cooling width B_{ec} as the above formulae 5 and 6 with respect to the center nozzle bodies of the nozzle headers at both strip edges.

[0067] The width B_{eo} of the header body positioned at the outside of the nozzle headers of both edges and the width B_{ei} of the header body positioned at the inside of the nozzle headers of the same determine the cooling widths thereof for covering the delays in moving of the nozzle headers at both strip edges when the widths change, and each of them is determined to be 1/2 of the width changing amount of the metal strip (being at both edges, 1/2 is reasonable).

[0068] For the roll quenching in the continuous annealing line, the cooling roll #1 of the structure as shown in Fig.59 is used. The cooling roll #1 has one coolant way γ as spiral in the inside thereof near the surface, and the coolant as the cooling water is made go thereinto at its one end of the way γ for cooling the roll surface, and after having deprived the heat of the contacting metal strip, the coolant is exhausted from the other end. Depending upon setting of the suitable flow velocity of the coolant, very high thermal efficiency is obtained, and by changing the contacting length with the strip, the cooling amount is easily adjusted. Thus, this cooling roll has excellent merits.

[0069] The roll quenching equipment generally uses the plurality of cooling rolls #1 to #7 which alternately contact the upper or rear surfaces of the strip X as seen in Fig. 60. The coolant is supplied into the passages γ of the rolls #1 to #7, and the heated coolant is collected at the delivery side and sent to a heat exchanger to cool down for re-using.

[0070] The metal strip X which has been cooled by the rolls #1 to #7 is ordinarily caused with the non-uniform temperature distribution shaped in W along the strip width as shown in Fig.43. This is assumed as a phenomenon caused by the saddle shaped deformation in that the strip X is curled at both edges when the cooling rolls are wrapped with the strip X given the tension in the strip passing line. The method of removing such a phenomenon has already been referred to. Indeed, the cancelling of the non-uniform temperature distribution is accelerated by the above structure, but it is not perfect, and as shown in Fig.61, rather the temperature deviation Δt_1 at both edges and that Δt_2 at both quarter parts grow large, and the non-uniform temperature distribution is not symmetrical in the strip width, and when it is remarkable, the over-cooling invites the non-uniform elongation of the strip X by the tension within the roll quenching equipment, and this causes the strip X to snake in the following treating furnace, or makes the strip properties non-uniform.

[0071] In view of the above mentioned problems, when carrying out the cooling on the metal by the metal strip cooling equipment, the present invention also proposes cooling rolls, by which non-uniform properties in the metal are not generated and a roll quenching equipment using such cooling rolls.

[0072] As the structure of the cooling roll having the coolant passage at the inside thereof, on which the metal is contacted, it is advisable to use the cooling roll provided with a plurality of cooling passages on the same plane side.

[0073] In the structure disposing the plurality of the cooling rolls in the metal passing line, and contacting the metal on the surfaces thereof, the flowing direction of the coolant in the passage of each cooling roll is inverted per one piece to build the structure for supplying the coolant.

[0074] Since the conventional cooling roll has one coolant way in the inner circumferential surface thereof, the coolant of enough low temperature at the inlet of the way freely flows and continuously exchanges the heat of the metal during transferring, but goes up to almost saturated condition in the heat exchanging amount at the outlet of the way just before boiling if the coolant is the water. On the other hand, since the plurality of the ways are formed in the same plane face, each length of the coolant ways for the necessary cooling amount can be made short, so that the heat exchanging amount can be made small, which is as a result sufficient to cool the metal in the roll surface near even the outlet of the coolant passage, and the temperature distribution is symmetrical in the metal width after cooling.

[0075] When the plurality of cooling rolls are installed along the pass line, in the conventional roll quenching equipment where the coolant is supplied into any of the cooling rolls from the same sides and exhausted from others, the gradient of the temperature between the roll surfaces of the edge near the inlet of the coolant and near the outlet thereof occurs in the same direction in each cooling roll. On the other hand, in the above second structure, the flowing direction of the coolant is converted per each roll, so that above temperature gradient turns other way per each of the rolls and becomes smaller per each of the rolls, and accordingly the gradient itself becomes naught in the cooling roll in the delivery section.

[0076] The present invention also proposes a rapidly cooling method as bringing the temperature in the strip width nearly to the objective temperature distribution with respect to the wide range of the strip.

[0077] Herein proposed is a method for cooling metal strips, said method comprising: wrapping the metal strip around at least one cooling roll and adjusting a wrapping length between said strip and the respective cooling roll by moving the roll, using gas jet cooling equipment provided with nozzle means which are opposite the respective roll via the strip so as to cool the strip on its rear surface by impinging the cooling gas from the nozzle means. According to the invention, said method is characterized by: using one or more nozzle headers which are movable in the moving direction of the respective roll and along the roll axis and having a width narrower than that of the strip; adjusting the wrapping length so as to adjust the average strip temperature or the temperature in the strip center based on the deviation from an objective strip temperature; always observing a temperature distribution in the strip width at at least one side of the inlet or outlet of the cooling roll(s), while adjusting the separating distance between the strip and nozzle headers in accordance with the position of the roll(s) and the nozzle headers, and moving the nozzle headers to a position where the temperature deviation occurring against said objective temperature distribution, thereby to control the strip temperature distribution based on the deviation.

[0078] In particular, the nozzle headers are moved to a position where the temperature deviation is naught with respect to said objective temperature distribution, so that the strip temperature distribution is controlled based on the deviation from the objective temperature distribution.

[0079] In the above W shaped non-uniform temperature distribution, the hot points in the center and both edges are narrow in the width, and the conventional structure disclosed in Japan Patent Laid Open No.60-169524 was difficult to provide the effective cooling, but in the above structure, the nozzle header of the narrow width is moved immediately above the hot point and impinges the cooling gas thereonto concentrically, thereby enabling to effectively cancel the non-uniform temperature distribution. Then, a comparision is made between the temperature in the strip center and the objective temperature having been set for practising a predetermined heating treatment on the metal strip, and the wrapping length of the metal strip and the cooling roll is adjusted for controlling the temperature in the strip center in accordance with the strip temperature deviation.

[0080] For practising the cooling of the rear side of the strip by impinging the cooling gas from the nozzle header to the strip contacting the cooling roll, while adjusting the space between the strip and the nozzle header in view of the position of the cooling roll and the position of the nozzle header and always observing the temperature distribution in the strip width at least at one of the inlet or the outlet of the cooling rolls, the nozzle header is moved to the position of cancelling the deviation from the objective temperature distribution (for this objective temperature distribution, a preset one may be used, for example, other than the objective distribution in the strip center, the actually measured temperature in the strip center or the lower temperature by 0 to 20°C than said actual temperature are made objective temperatures in both strip edges, and the objective temperature distribution may be determined thereby), and the control of the strip temperature distribution is carried out (i.e., the uniformization of the strip temperature).

[0081] With respect to the control of the strip temperature distribution, other than the moving of the nozzle header along the roll axis (in the direction of the strip width), the pressure or the flow rate of the cooling gas flowed into the

nozzle header based on the temperature deviation are adjusted, and such a structure of impinging the cooling gas to the metal strip may be incorporated therein.

[0082] The reason why a premise is based on that the nozzle header is movable along the cooling roll axis, is because the cooling roll can be moved in the direction transverse with the strip pass line in order to change its wrapping length, and the nozzle header is required to always take the distance suited to cooling the rear side of the strip wrapped around the roll, and the header does not contact the metal strip.

[0083] When the number of installing the nozzle headers is two, the nozzle headers are moved to the position cancelling the deviation from the objective distribution to control the strip temperature distribution based on the deviation, referring to the temperature deviation from the objective distribution in both strip edges. In the non-uniformity of the above stated W shaped distribution, both edges are higher than the center part in the temperature, and so the nozzle header are moved preferentially to both strip edges.

[0084] On the other hand, the hot point in the center part ordinarily has the lower temperature than both edges, and if the strip changes its width, the hot point hardly changes its position. So, the above nozzle headers should be provided at both edges, and for removing the non-uniformity the nozzle header may be disposed at the center of the strip. In this case, such a nozzle header of the strip center moves only in the moving direction of the cooling roll and does not move along the roll axis, and only adjusts the pressure or the flow rate of the cooling gas in accordance with the temperature deviation with respect to the controlling of the strip temperature deviation based on the deviation from the objective distribution, for jetting the cooling gas to the metal strip.

[0085] The present invention can be of course applied not only to the structure of one cooling roll but also to that of two or more cooling rolls. In the structure having a plurality of the cooling rolls, three of the nozzle headers are provided to at least a first cooling roll to build the above stated arrangement of the header. Further, these cooling rolls are divided into two sections of the entry section and the delivery section, and the three nozzle headers are provided to the cooling rolls in the entry section, while the two nozzle headers are provided to the cooling rolls in the delivery section. The reason why the nozzle headers are three to the first cooling roll or the cooling rolls in the entry section, is because, for the same reason as above stated, when the strip center swells at starting of the cooling, the non-uniform temperature distribution occurs, and once the non-uniformity occurs, it more grows due to the properties of the roll, and aiming at cancelling form errors at beginning to contact the roll, the nozzle header is provided to at least the first roll or the rolls in the entry section, thereby to carry out the concentric cooling thereon as well as the cooling at the rear side thereof so as to solve the problem of the center swelling. If the structure has the three nozzle headers including the center nozzle header to the first roll or the rolls in the entry section, it is sufficient to respectively install the nozzle headers to both strip edges for the subsequent cooling rolls.

[0086] When the plurality of cooling rolls are installed as said above, it is possible to make different the moving of the nozzle header of the entry section in the roll moving direction from the moving of the nozzle header in the delivery section. As to the nozzle header in the entry section, it follows the moving of the cooling roll as maintaining a certain distance therefrom, and as to the nozzle header in the delivery section, it is moved to a predetermined position when ordinarily cooling, and is retreated to the retract position only at the emergency or when the cooling amount is fairly small, so that it does not follow the moving of the cooling roll.

[0087] For deleting the non-uniform distribution in the strip width caused by said saddle shaped deformation, the cooling length is largely taken by not only successively shifting the rolls from the upstream side in preference of the rolls in the entry section, in particular the first cooling roll, but also bringing the gas jetting ability to the maximum successively from the rolls in the upstream side so as to compensate the lacked cooling in the downstream.

[0088] When cooling the rear side of the strip wrapped around the cooling roll by means of the three or more nozzle headers movable in the moving directions of the cooling roll and along the roll axis, it is also possible to control the average strip temperature, referring to the three hot points. Said control is then reduced to practice by adjusting the wrapping length between the metal strip and the cooling roll, and it is useful for the heat transfer to adjust the position as maintaining the proper distance between the nozzle header and the metal strip by making the nozzle header correspond to the locus of the strip wrapped around the cooling roll. If the distance between the nozzle header and the metal strip is 5 to 50 mm, this is effective to precision of adjusting the movings of the cooling roll and the nozzle header, or avoidance of contacting between the nozzle header and the metal strip caused with the form error (e.g., edge wavings).

[0089] The distribution of the strip temperature based on the deviation from the objective distribution is controlled together with controlling of the average strip temperature. Then, important is the control of the cooling width by moving the nozzle header. As a result of experiment and analysis by the cooling roll, using a steel strip as the metal strip, it has been found as said above that the average strip temperature deviation appearing in the steel strip edges defined in the formula 13 is largely changed by the cooling width and the strip thickness as seen in Fig. 54. While adjusting the distance between the strip and the nozzle header, obtained from the position of the roll and the nozzle header and always observing the positions of both strip edges at least at one of the inlet or the outlet of the cooling rolls, the nozzle headers are moved such that the positions of the nozzle headers positioned at both strip edges of the cooling equipment

are within the cooling ranges as defined in the under formulae 8 and 9 with respect to both strip edges, thereby enabling to make the strip temperature deviation minimum.

$$[8] \quad 6 \leq W_E \leq 45$$

herein, $t < 1.3\text{mm}$

$$[9] \quad 12t - 9.6 \leq W_E \leq 22t + 16.4$$

herein, $t \geq 1.3\text{mm}$

W_E : Cooling widths (mm) of the nozzle headers at both strip edges

t : Strip thickness

[0090] As the ranges where the deviations appear in the strip center are almost symmetrical with respect to the center line in the strip width, the nozzle header is moved so that the center in the strip width sets to the center of the nozzle header at the strip center for cooling the center part of the strip. The range of the deviation is, as seen in Fig. 57, within the range shown in the under formula 10 with respect to the strip width, and it is preferable to cool such a part.

$$[10] \quad 0.09B \leq W_C \leq 0.27B$$

W_C : Cooling width (mm) of the nozzle headers in the strip center

B : Strip width (mm)

[0091] The non-uniform strip temperature distribution can be corrected by always measuring the temperature distribution in the strip width at the outlet of the cooling rolls together with adjusting of the cooling width by moving the nozzle header, and adjusting the pressure or the flow rate of the cooling gas flowed into the nozzle header in accordance with the deviation from the objective distribution so as to impinge the cooling gas to the strip. In addition, the above stated structure may be applied to the case that when the non-uniformity cannot be corrected by the structure of the gas jet cooling equipment for cooling the rear side of the strip, the auxiliary gas jet cooling equipment (having three or more nozzle headers movable along the strip width at both sides of the metal strip, respectively) is installed auxiliarily at the outlet of the cooling rolls.

[0092] For controlling in accordance with changings in the temperature distribution in the strip width following non-uniform contacting to each cooling roll, which is generated by the form errors of the strip, the above problem may be solved by always measuring the temperature distribution in the strip width at the outlet of the cooling rolls, obtaining positions in the center of gravity of the deviation in the strip temperature of a range where the temperature deviation occurs in the edges and the center of the metal strip with respect to the objective strip temperature, moving the nozzle headers at the edges of the gas jet cooling equipment or the ones at the edges of the gas jet cooling equipment and the auxiliary gas jet cooling equipment such that a twice length of the distance from the strip edge to said center of gravity is the cooling width at the strip edges, moving the center nozzle header such that center position thereof agrees to the center of gravity at the center of the strip, and impinging the cooling gas to the metal strip from each of the nozzle headers.

[0093] When reducing to practice the method of adjusting the positions of the nozzle headers of the gas jet cooling equipment and the auxiliary gas jet cooling equipment by obtaining respectively the centers of gravity of the strip temperature deviation in the range where the deviations occur in the strip edges and the center, the strip temperature distribution is uniformized as No.2 in Fig.56 under the conditions of Table 1, taking the nozzle header at the edges, for example.

BRIEF DESCRIPTION OF THE DRAWINGS

[0094] **Fig.1** is a schematic view showing a continuous annealing line of the metal strip X, having the roll quenching section with one embodiment of the present invention; **Fig.2** is an explanatory view of one embodiment of the metal strip cooling equipment as set forth in claim 48; **Fig.3** is a perspective view of the gas jet cooling equipment disposed opposite to the cooling roll; **Fig.4** is a perspective view of the auxiliary gas jet cooling equipment installed after the cooling rolls; **Fig.5** is a perspective view of the gas jet cooling equipment as set forth in claim 51 opposite to the cooling

roll; **Fig.6** is a perspective view of the auxiliary gas jet cooling equipment installed after the cooling rolls; **Fig.7** is a schematic view of a facility showing a third embodiment where the gas jet cooling equipment as set forth in claim 32 is used in a roll quenching section of the continuous annealing line; **Fig.8** is a partially enlarged view of the present embodiment of the gas jet cooling equipment; **Fig.9** is an explanatory view showing a structure of the moving beds; **Fig.10** is a plan view showing another embodiment of the gas jet cooling equipment with a laterally fixed center nozzle as set forth in claim 33 for use of cooling the rear side of the wrapped strip around the quenching roll; **Fig.11** is a cross sectional view showing the cooling equipment for the rear side of the wrapped strip around the quenching roll at the strip edges; **Fig.12** is a cross sectional view showing the cooling equipment of the rear side of the wrapped strip around the quenching roll; **Fig.13** is a schematic view of a facility showing an embodied mechanism where the gas jet cooling equipment as set forth in claim 34 is used for cooling the rear side of the wrapped strip around the quenching roll in a roll quenching section with a horizontal strip pass line; **Fig.14** is a transverse view of a portion of the cooling roll #1 of the preceding figure; **Fig.15** is a partially enlarged view showing a laterally moving mechanism of the moving bed in this embodiment; **Fig.16** is a cross sectional view similarly showing the laterally moving structure of the same; **Fig.17** is a front view of an Example 4 relating to the auxiliary gas jet cooling equipment as set forth in claim 41; **Fig.18** is a side view of the auxiliary gas jet cooling equipment of the present embodiment; **Fig.19** is an explanatory view showing engagements between the running cart provided with the nozzle headers and a guide rail; **Fig.20** is an enlarged view showing the engagement between the wheels of an upper running cart and the guide rail; **Fig.21** is an enlarged view showing the engagement between the wheels of a lower running cart and a guide rail; **Fig.22** is an explanatory view showing a synchronized drive mechanism of the running cart; **Fig.23** is explanatory views showing the synchronized drive mechanism of the upper and lower running carts; **Fig.24** is an explanatory view showing pipings following movements of the nozzle header in this embodiment; **Fig.25** is a cross sectional view showing a mechanism of a telescopic expansion joint; **Fig.26** is a plan view of the cooling equipment which is applied to the horizontal pass roll quenching section; **Fig.27** is a side view of the same; **Fig.28** is an explanatory view showing an engagement between the wheels of the upper running cart and the guide rail in the entry side of the section; **Fig.29** is an explanatory view showing an engagement between the wheels of the upper running cart and the guide rail in the delivery side of this embodiment; **Fig.30** is an explanatory view showing an engagement between the wheels of the lower running cart at the inlet of the same and the guide rail in the entry side of the same; **Fig.31** is an explanatory view showing an engagement between the wheels of the lower running cart and the guide rail in the delivery side of the same; **Fig.32** is a cross sectional view showing the structure of the cooling roll to be used for the roll quenching equipment; **Fig.33** is a development of the same; **Fig.34** is an explanatory view showing that a cooling water flows into the quenching rolls of the roll quenching system; **Fig.35** is a graph showing relation between heat transfer from the metal strip to the roll surface and the cooling water velocity; **Fig.36** is a graph showing relation between the cooling water velocity and the pressure loss of a pump; **Fig.37** is a flow chart showing procedures of calculations of the heat transfer in each roll, the cooling rates CR (J), average cooling rates ACR, and average overall heat absorption coefficient AUo; **Fig.38** is an explanatory view showing a positional relation between the metal strip wrapped around on the two cooling rolls and the nozzle headers of the gas jet cooling equipment; **Fig.39** is a graph showing the distribution of the outlet strip temperature from the gas jet cooling equipment; **Fig.40** is a side view of a metal strip cooling equipment showing one embodiment of the prior art; **Fig.41** is a perspective view showing the structure of the gas jet nozzle headers adopted in the same; **Fig.42** is a graph showing the distribution of the strip temperature along the strip width when the strip is cooled by the cooling rolls only; **Fig.43** is a perspective view showing deformation of the strip wrapped around the cooling roll; **Fig.44** is cross sectional views showing examples of shapes of the nozzle to be applied to the nozzle headers; **Fig.45** is explanatory views showing the center parts of the metal strips; **Fig.46** is explanatory views showing the position of the nozzle headers for the strip edges when the welding point of the different width strips is passing by; **Fig.47** is explanatory views showing the arrangement of the nozzles of the headers positioned at the strip edges; **Fig.48** is perspective views showing that the separate nozzle headers for each strip edge in the cooling equipment of the rear side of the wrapped strip around the quenching roll are located along the pass line; **Fig.49** is perspective views showing that the separate nozzle headers for each strip edge in the auxiliary gas cooling equipment installed at the outlet of the roll quenching equipment are located along the pass line; **Fig.50** is explanatory views showing the way that the separate nozzle headers move when the strips change from a narrow width to a wide one; **Fig.51** is explanatory views showing the way that the separate nozzle headers move when the strips change from the wide width to the narrow one; **Fig.52** is a graph showing the heat cycle of mild steel sheets in a continuous annealing line; **Fig.53** is an explanatory view showing that the nozzle headers are slightly shifted in the direction of the strip width when the present equipment is adopted as the auxiliary cooling structure before or after the roll quenching equipment; **Fig.54** is a graph showing the relation between the cooling width in the strip edges and the deviation in the temperature in the vicinity of the strip edges; **Fig.55** is a schematic view showing the relationship between the positions of the nozzles of the gas jet cooling equipment and the cooling width in the strip edges when the strip width changes; **Fig.56** is a graph showing the distributions of the strip temperature when the strip edges are cooled with the gas jet cooling equipment installed opposite to the cooling rolls; **Fig.57** is a graph showing the temperature deviation in the strip center and the ranges thereof; **Fig.58** is a graph

showing the relative comparison in the running cost and the investment cost between the present invention and the conventional type; **Fig.59** is an explanatory view showing the structure of the conventional cooling roll to be adopted for roll quenching in the continuous annealing line; **Fig.60** is a schematic view of the roll quenching section with the above mentioned seven cooling rolls where the strip is brought into contact with the rolls on its each side alternately and quenched rapidly; and **Fig.61** is a graph showing that the temperature distribution is not symmetrical in the strip width.

MOST PREFERABLE EMBODIMENTS FOR PRACTISING THE INVENTION

(EXAMPLE 1)

[0095] One embodiment of the metal strip cooling equipment according to the present invention will be explained with reference to Figs.1 to 4 of the attached drawings.

[0096] Fig.1 is the schematic view showing the continuous annealing line of the metal strip X, which has the roll quenching section one embodiment of the present invention.

[0097] In the present embodiment, the metal strip X is uncoiled by a pay-off reel 2000, and is sheared by a shearing machine 2001 located in the entry side, followed by making a connection of a preceding coil and a subsequent coil by means of a welding machine 2002. The metal strip is electrolytically degreased by a cleaning facility 2003 at the inlet, and comes, via a tension leveler 2004 as a stretcher, to an entry looper 2005. Further, the strip is sent into a pre-heating furnace 2006 and a direct fired reducing furnace 2007 to heat at a temperature of 600 to 750°C, and heated up to a required temperature in a radiant tube furnace 2008 and maintained at this temperature in a radiant tube soaking furnace 2009, and cooled, for example, to 600°C in a gas jet cooling section 2010 and further cooled to 350°C in a roll quenching section 1000. Subsequently, having passed through an over-aging section 2011 and a fast cooling section 2012 which are installed as controlled cooling facilities with heating - cooling functions, the metal strip is quenched in a water quenching section 2013 and dried with a dryer 2014, and after having passed through a delivery looper 2015, the metal strip is rolled in a required roughness by a temper mill 2016, and is inspected by a surface defector 2017 and oiled over with an oiler 2018, and sheared into a required length by a shearing machine 2019 in the delivery side, and is coiled by tension reels 2020.

[0098] In the above mentioned arrangement, the tension leveler 2004 is installed before the direct fired reducing furnace 2007 for reasons as follows. At first, there has risen a problem of oxidation of the metal strip X in the direct fired reducing furnace 2007, however, the mechanism of oxidation has not yet been cleared, and the inventors consider this as follows. A burner flame made in the direct fired reducing furnace 2007 has a suitable range of a distance from the strip X for reducing the heating, and if the burner flame does not touch the metal strip X within the range, it does not have any effect of reduction but causes oxidation. On the other hand, for accomplishing the direct fired reduction by one pass or two passes in the furnace 2007, a distance between top and lower rolls installed in the furnace is necessary to be at least 20 m, and it causes fluttering of the strip passing in the furnace. With respect to the shape of the metal strip X, it sometimes has unevenness or swell in its center, or edge waves. If a steepness a/w becomes larger, which is expressed with a ratio of the strip width w to a strain a of the metal strip showing a degree of a raising in the center in cross section of the metal strip X, the form of the strip gets worse. If the distance between the top and lower rolls is at least 20 m, the strip flutters as stated, and in addition, the strip greatly rolls by the burner pressure at combustion. When rolling, the metal strip X does not thereby contact the burner flame within said suitable range, and a problem of local oxidation appears.

[0099] On the other hand, problems arise concerning buckling in the gas jet cooling section 2010 and concerning non-uniform cooling in the roll quenching section 1000, and these problems are considered to be due to the form error of the metal strip X. Insofar as slight form errors are concerned, it has been known that if the strip is uniformly heated rapidly in a direct fired furnace without fluttering under a condition that a certain tension is given, such form errors are corrected, or new form errors due to non-uniform heating may be prevented. However, the elongations occurring in particular area in the strip width can be hardly corrected, and if the strip is passed as it is into the gas jet cooling section 2010, it causes buckling there, and it is assumed that when the strip passes into the roll quenching equipment 1000, the part of the elongation does not fully contact the roll surface or forms a non-contacting state, so that it is difficult to make the strip temperature distribution uniform after a final cooling, and there occur metallurgically unequal quality in the strip width or the rolling.

[0100] There also arise other problems that the radiant tube contacts the metal strip X in the radiant tube furnace 2008 and soaking furnace 2009, or the gas jet nozzle contacts the same in the fast cooling section 2012. These problems are also caused by the form error of the metal strip X, and in particular the latter problem is assumed to be triggered off by the form error accelerated due to the bucklings or the like in the gas jet cooling equipment 2010 or the roll quenching section 1000.

[0101] The inventors considered that in case said problems arose due to the above stated matters, those problems

can be solved by providing a tension leveler 2004 for correcting forms of the metal strips X immediately before the heat treatment facilities and by heat-treating the metal strips X of corrected shapings. So, in view of the above mentioned fact that it was effective for improving of the form error that the uniform heating was carried out in the direct fired rapid heating without fluttering of the metal strip, when the shape of the metal strip X was corrected referring to said fact, it was cleared that if the metal strip X was once corrected before the direct fired reducing furnace 2007, the problems as mentioned above did not occur in the following facilities. The above mentioned is the reason why the tension leveler 2004 is provided before the direct fired reducing furnace 2007.

[0102] However, since it is difficult to accomplish the uniform temperature distribution in the strip width in the roll quenching section 1000 by only once correcting the shapings, said uniformization is practised together with the cooling of the rear side of the wrapped strip around the roll by the nozzle headers $\alpha 1$ to $\alpha 4$ impinging coolants to the rear side of the metal strip X contacting the cooling rolls #1 to #4 as shown in Fig.2 in this embodiment. Fig.2 is the side view of the metal strip cooling equipment, which relates to the embodiment as set forth in claim 48. After having been heated, soaked and slowly cooled, the metal strip X is given tension by bridle rolls $\epsilon 1$ to $\epsilon 3$ and $\epsilon 4$ to $\epsilon 6$ which are located before and after the strip cooling equipment.

[0103] During preparing the production, before the metal strip X contacts the cooling roll, the tension of the metal strip X is changed up until a tension (3 kgf/mm² or more) for using the roll by the bridle rolls $\epsilon 1$ to $\epsilon 6$ so as to stabilize the strip shape when contacting the roll. The cooling rolls #1 to #4 are horizontally moved to contact the metal strip X, and the cooling rate is adjusted, while the shift stroke (wrapping length) of the roll is adjusted. However, in this regards, the non-uniform temperature distribution easily occurs in the direction of the strip width, and if such a distribution has occurred in the preceding gas jet cooling section 2010, this is accelerated in the roll quenching equipment, and therefore, in this embodiment, the rear side of the wrapped strip around the rolls is cooled by the metal strip cooling apparatus as follows.

[0104] This embodiment is composed of the gas jet cooling equipment which has nozzle header groups $\alpha 1$ to $\alpha 4$ where three nozzle headers make one group; a strip edge position detector 89 which is installed near the inlet of the metal strip cooling apparatus; position adjustment devices 82a to 82d for adjusting the nozzle headers moving in the direction of the roll axis; a calculation device 88 for nozzle header position control, which controls the position adjustment devices 82a to 82d in response to signals from the position detector 89; position adjustment devices 81a to 81d which adjust the positions of said nozzle header groups $\alpha 1$ to $\alpha 4$ in the transverse direction in response to signals from roll position adjustment devices 80a to 80d which control wrapped length of the strip around the cooling rolls as well as the positions of the respective cooling rolls #1 to #4; a strip temperature profile measuring equipment 90a for measuring the temperature distribution in the strip width, which is installed at the outlet of the cooling section; and a calculation device 87 for the strip temperature control, which controls at least either of pressure control valves 84a to 84d of said gas jet cooling equipment or rotating speed of a gas supply blower 85a in response to temperature signals issued from said strip temperature profile measuring equipment 90a.

[0105] In the above stated structure, the calculation device 88 for the nozzle header position control sends position controlling signals in the direction of the roll axis with respect to said nozzle header groups $\alpha 1$ to $\alpha 4$ to the position adjustment devices 82a to 82d. Therefore, said both side nozzle headers are moved to the positions corresponding to the strip edges, while the center nozzle header is moved to the position corresponding to the strip center.

[0106] On the other hand, with respect to adjusting of the wrapping lengths of the cooling rolls #1 to #4 in accordance with the signal from the strip temperature profile measuring equipment 90 which is installed at the outlet of the roll quenching equipment, a temperature in the center part of the strip width is obtained by the calculation device 87 for the strip temperature control, and which compares this temperature at the strip center with an objective strip temperature having been determined for practising a required heat treatment to the metal strip X, and signals are, in response to a deviation thereby, sent from the calculation device 87 to the devices 80a to 80d for adjusting the contacting lengths of the cooling rolls (as to others, in accordance with the signal from the strip temperature profile measuring equipment 90, the average temperature along the strip width is obtained by the calculation device 87 and which compares this average temperature with an objective temperature having been determined for practising the required heat treatment to the metal strip X, and in response to the deviation thereby, the signal is sent from said device 87 to said devices 80a to 80d).

[0107] Further, in the present embodiment, the objective temperature in the center part of the strip width is obtained from the average strip temperature of both quarter parts, and the objective temperatures in both strip edges are obtained from the measured strip temperature of the center part by means of the calculation device 87 for the strip temperature control which has been input with temperature signals from the strip temperature profile measuring equipment 90a. Actually measured temperatures in both edges and the center part are obtained, and are compared with said objective temperatures in the strip width. In response to the deviation therebetween, the calculation device 87 uses at least one of the rotating speed control of a gas supply blower 85a or the pressure control valves 84a to 84d so as to adjust the pressure (a pressure gauge is omitted) of the cooling gas flowed into each nozzle header. Due to the above mentioned adjustment, both edges and the center of the metal strip X are cooled by the gas jetted from the nozzle header groups

$\alpha 1$ to $\alpha 4$ installed in opposition to the cooling rolls.

[0108] The positions of the nozzle header groups $\alpha 1$ to $\alpha 4$ are adjusted in the moving directions of the cooling rolls by means of the position adjustment devices 81a to 81d by the position of the cooling rolls #1 to #4 as well as the signals from the roll position adjustment devices 80a to 80d which adjust the contacting lengths of the cooling rolls.

When the cooling rolls #1 to #4 are positioned at the maximum contacting length with the metal strip, the nozzle header groups $\alpha 3$ and $\alpha 4$ may be set and fixed at positions where the distances between the metal strip and the nozzle header groups can be exactly secured for the space not to contact them and to cool the rear side of the strip effectively.

[0109] In addition, the auxiliary gas jet cooling equipment is installed at the outlet of the cooling roll groups in this embodiment so as to solve the deviation of the temperature along the width of the metal strip X, which has been difficult to perfectly overcome even in the above stated structure. That is, the calculation device 87 for the strip temperature control obtains the temperatures at both strip edges and the center part by the temperature signals from the strip temperature profile measuring equipment 90b installed around the outlet of the auxiliary gas jet cooling equipment, which can detect the temperature distribution in the strip width, or from said strip temperature profile measuring equipment 90a, and compares at the same time with said objective temperature in the strip width, and uses, in response to this deviation, at least one of the rotating speed control of the gas supply blower 85b or the pressure control valve 84e so as to adjust the pressure of the cooling gas flowed into each nozzle header. The cooling gas is impinged from the nozzle header groups $\beta 1$ and $\beta 2$ of the auxiliary gas jet cooling equipment installed in opposition to the metal strip X, and the metal strip X passing through the roll quenching equipment is cooled at both edges as well as the center part thereof.

[0110] As a result that the position control signals are sent to the position adjustment devices 83a and 83b by the calculation device for the nozzle header position control, which has received the signal from the strip edge position detector 89, said nozzle headers of the groups $\beta 1$ and $\beta 2$ are moved to the positions corresponding to the strip edges, and the center nozzle headers are moved to the positions corresponding to the center part of the metal strip.

[0111] Fig.3 is the perspective view of the nozzle header groups $\alpha 1$ to $\alpha 4$ disposed toward the cooling rolls (the position adjustment device is omitted in this figure). The nozzle headers αa and αc at both ends are used for cooling the strip edges, while the center nozzle header αb is used for cooling the strip center. With respect to these nozzle headers αa to αc , position adjustment devices 820 to 822 are controlled respectively by the order for controlling the position in the roll axis from the calculation device 88 for the nozzle header position control, so that the movements are adjusted for the strip edges and center part.

[0112] The pressure of the cooling gas flowed into each of the nozzle headers αa to αc is adjusted by adjusting the open angles of the pressure control valves 840a to 840c provided on the half ways of the pipings communicating with the nozzle headers αa to αc by the order from the calculation device 87 for the strip temperature control.

[0113] Fig.4 is the perspective view showing one side parts of the nozzle header groups of the auxiliary gas jet cooling equipment disposed at the outlet of the roll quenching equipment and opposite the metal strip. The nozzle headers βa and βc at both ends are for cooling the strip edges, while the nozzle header βb at the center is for cooling the center part of the strip. With respect to these nozzle headers βa to βc , the control of the position adjustment devices 830 to 832 is carried out respectively by the order for controlling the position in the roll axis from the calculation device 88 for nozzle header position control, so that the movements are adjusted for the strip edges and center part.

[0114] The pressure of the cooling gas flowed into each of the nozzle headers βa to βc is adjusted by adjusting the pressure control valves 843a to 843c provided on the half ways of the pipings communicating with the nozzle headers βa to βc by the order from the calculation device 87 for strip temperature control.

(EXAMPLE 2)

[0115] Fig.5 is the perspective views showing the structures of the nozzle header groups $\alpha 1$ and $\alpha 2$ of the gas jet cooling equipment in the metal strip cooling equipment opposite the cooling rolls as set forth in claim 51 (the position adjustment device is omitted in this figure). The center nozzle header αd (the header body) shown with (a) and (b) in the same is to cool the center part of the strip, while the nozzle headers αa to αc and αe to αg (the header bodies) are to cool the strip edges. In the nozzle headers for cooling the strip edges, αa and αg are the header bodies 10 positioned at the outsides of said equipment, αb and αf are the header bodies 10 positioned at the center parts thereof, and αc and αe are the header bodies 10 positioned at the insides of the same. The nozzle headers αa to αc and αe to αg are moved to both strip edges by means of the position adjustment devices 820 to 822 by the order of controlling the positions in the roll axis issued from the calculation device 88 for nozzle header position control, and then are set at positions for exactly securing the cooling widths by means of said nozzle headers αb and αf positioned at the centers of these edge position nozzle headers.

[0116] In the range excepting the vicinity of the welding parts having different strip widths, the center nozzle header αd as well as the centrally positioned header bodies αb and αf among the nozzle headers at both edges are adjusted with respect to the pressure of the cooling gas therewithin in accordance with the controlling order from the calculation

device 87a for strip temperature control. On the other hand, in the range around the welding parts of different width, when the strip changes the narrow width to the wide one, the pressure of the cooling gas within the header bodies αa and αg positioned outside of the nozzle headers, is adjusted in accordance with the control signal from the calculation device 87b for strip temperature control, based on the signals from computers C storing information of the metal strip of a subsequent size. Reversely, when strip changes the wide width to the narrow one, the pressure of the cooling gas within the header bodies αc and αe positioned inside of the nozzle headers of the edge sides is adjusted in accordance with the control signal from the calculation device 87b for strip temperature control, basing on the signals from the computers C storing the information of the metal strip of the subsequent size.

[0117] Fig.6 is the perspective views showing the structures of the nozzle header groups $\beta 1$ and $\beta 2$ of the auxiliary gas jet cooling equipment in the metal strip cooling equipment disposed at the outlet of the cooling roll groups opposite the metal strip as set forth in claim 52. The center nozzle header βd (the header body) shown with (a) and (b) in the same is to cool the center part of the strip, while the headers βa to βc and βe to βg shown with (a) and (c) are to cool the strip edges. In the nozzle headers for cooling the strip edges, βa and βg are the header bodies positioned at the outsides, βb and βf are positioned at the center parts, and βc and βe are positioned at the insides. The nozzle headers βa to βc and βe to βg are moved to both edges of the strip by means of the position adjustment devices 830 to 832 by the order of controlling the positions in the strip width issued from the calculation device 88 for nozzle header position control, and then are set at positions for exactly securing the cooling widths by means of said nozzle headers βb and βf positioned at the center of these edge position nozzle headers.

[0118] In the range excepting the vicinity of the welding parts having different strip widths, the center nozzle header βd as well as the centrally positioned header bodies βb and βf among the nozzle headers at both edges are adjusted in accordance with the controlling order from the calculation device 87a for strip temperature control. On the other hand, in the range around said welding parts of the different width, when the strip changes the narrow width to the wide one, the pressure of the cooling gas within the header bodies βa and βg positioned outside of the nozzle headers of the edge sides, is adjusted in accordance with the control signal from the calculation device 87b for strip temperature control, based on the signals from computers C storing information of the metal strip of a subsequent size. Reversely, when strip changes the wide width to the narrow one, the pressure of the cooling gas within the header bodies βc and βe positioned inside of the nozzle headers of the edge sides is adjusted in accordance with the control signal from the calculation device 87b for strip temperature control, based on the signals from the computers C storing the information of the metal strip of the subsequent size.

(EXAMPLE 3)

[0119] A further explanation will be made to an embodiment as set forth in claim 32, which is employed as another gas jet cooling equipment of the metal strip cooling equipment.

[0120] Figs. 7 to 9 show the embodiments where the gas jet cooling equipment is employed to the structure of cooling the rear side of the strip wrapped around the cooling roll, which is provided in the roll quenching equipment of the continuous annealing line for the metal strip X.

[0121] In a vertical roll quenching equipment encircled with a furnace shell, the cooling rolls #1 to #7 are vertically disposed in succession between the bridle roll $\epsilon 1$ at the inlet and the bridle roll $\epsilon 2$ at the outlet which give predetermined tension to the metal strip X, and the wrapping length between the roll and the metal strip is adjusted by the shifts in the horizontal direction of the respective cooling rolls. In this drawing, the reference numeral 91 designates a profile thermometer at the inlet, 90 is a strip temperature measuring equipment at the outlet of the roll quenching equipment, 92 is a profile thermometer at the outlet, $\beta 1$ and $\beta 2$ are the auxiliary gas jet cooling equipment.

[0122] Curved nozzle headers $\alpha 1$ to $\alpha 7$ shown with the numeral 1 are disposed to the rear sides of the metal strip X wrapping around the cooling rolls. As shown in Figs.8 and 9, each of the nozzle headers 1 is installed with a moving bed 3 which moves said nozzle header in the width of the metal strip X (called as "lateral directions" hereinafter) and the direction toward the surface of the metal strip (called as "back and forth directions" hereinafter). The moving bed 3 is installed at the outside of the furnace shell.

[0123] The nozzle headers 1 are three provided at right, left and center along the cooling roll axis, and the cooling roll at the delivery section is determined in a curved size in accordance with the maximum shift stroke of the roll, and the width of each cooling roll is narrower than that of the metal strip X, and is designed in response to the width of the hot point when the temperature distribution is non-uniform in the strip width. Nozzle mouths which are horizontally elongated and slitted are disposed in the plural steps at the surface of the gas impinging side. Header supporters 100 of supporting the headers 1 are provided at a further rear side, which supply the cooling gas from the outsides to the headers 1. Since the header supporters 100 are projected outside of the furnace shell, a heat resistant non metallic bellows 101 is used between the circumference of the furnace shell and a penetrating part thereof, thereby to secure an enough moving range as keeping the air sealing.

[0124] The moving bed 3 comprises guide rails 31a, 31b provided in the back and force directions on a stationary

bed 30; a base 32 movable therealong; a drive device 33 moving the base 32 in the back and forth directions; lateral guide rails 34a to 34c provided on the base 32 independently for the center, right and left nozzle headers; moving beds 35a to 35c laterally movable therealong; and drive devices 36a to 36c independently transferring the moving beds 35a to 35c in the lateral directions. The header supporters 100 are fixed on the laterally movable beds 35a to 35c, respectively. Therefore, the three nozzle headers 1 concurrently move in the back and forth directions by the same stroke by the drive device 33, and each of the center, right and left nozzle headers 1 moves independently in the lateral directions. The drive devices 33 and 36a to 36c are those to be applied to linear motions as a hydraulic oil cylinder, an electric power cylinder, or a combination of a ball screw and an electric motor. If direct acting bearings are used as the guide rails 31a and 34a to 34c, the movement can be made at high precision. It is desirable to determine the moving speeds in the lateral directions with the under formula 18 and the moving speed in the back and forth directions with the under formula 19.

$$[18] \quad (\Delta W/2)/VN1 < L/VS$$

herein,

ΔW : Maximum value (mm) of the width changing amount of the strip

$VN1$: Moving speed (mm/min) of the nozzle header

L : Allowance (m) of impossible length of controlling the temperature distribution

VS : Transferring speed (m/min) of the strip

$$[19] \quad VN2 > VR$$

herein,

$VN2$: Moving speed (mm/min) of the nozzle header

VR : Moving speed (mm/min) of the roll

[0125] A following explanation will be made to the shift of the cooling rolls in the above roll quenching equipment and the operation of the gas jet cooling equipment in the present embodiment. In the present roll quenching equipment, the tension of the metal strip X is varied to the tension (3 kgf/mm² or more) of using the roll by the bridle rolls $\epsilon 1$ or $\epsilon 2$. Subsequently, the cooling rolls #1 to #7 are shifted horizontally to contact the metal strip X, and the cooling amount is adjusted as adjusting the shift stroke of the roll (wrapping length), however, in the present roll quenching equipment, the non-uniform temperature distribution easily arises along the width of the metal strip, and if such a non-uniform distribution has arisen in the gas jetting zone (not shown) in the entry section, it is accelerated in the present roll quenching equipment, and so the cooling at the rear side of the strip wrapped around the roll is carried out by the gas jet cooling equipment. For cooling the rear side of the strip wrapped around the roll, there are adjustments of the movements in the back and forth directions and in the lateral directions of the nozzle headers 1, and each of them will be referred to as follows.

[0126] Firstly with respect to the adjustment in the back and forth directions, differently move a group of the nozzle headers $\alpha 1$ and $\alpha 2$ directing to the cooling rolls #1 and #2 of the entry section and a group of the nozzle headers $\alpha 3$ and $\alpha 7$ directing to the cooling rolls #3 to #7 of the delivery section. That is, the group of the headers $\alpha 1$ and $\alpha 2$ goes forward, taking the maximum moving stroke of the headers from the retract or rest position at the same time of starting the contact between the metal strip X in the pass line and the cooling rolls #1 and #2. When the shift stroke of the cooling rolls #1 and #2 is more, said group goes backward to maintain a certain distance in relation with the metal strip X (said movement is made reversed by making the shift stroke of the cooling rolls #1 and #3 short). On the other hand, the group of the headers $\alpha 3$ to $\alpha 7$ once goes forward from the retract position (which is, when any of the rolls cannot be used because of troubles, a retreating position determined in view of avoiding the contact with said roll, since this is so designed that the maximum length of the nozzle header can be taken by the maximum shift stroke of the rolls) at the same time of contacting between the strip X in the passing line and the cooling rolls #3 to #7, and the headers do not move even if the shift stroke of the cooling rolls #3 to #7 is longer. The reason for the difference in moving among these nozzle headers, is because the non-uniform distribution is further accelerated, unless cancelling such non-uniform distribution arising along the width of the metal strip during beginning of contacting with the cooling rolls, which distribution causes an occurrence of the saddle shaped deformation of the metal strip X by the shifting of the cooling rolls and an occurrence of a heat crown in the cooling rolls (the other reason is because in a case of very low heat transfer, even the cooling rolls #1 and #2 might carry out the cooling under a condition of not reaching the maximum

shift stroke).

[0127] With respect to the adjustment of the nozzle header in the lateral directions, the profile thermometer 91 measures the temperature distribution in the strip width at the outlet of a gas jetting section. If the distribution is not uniform, the three cooling positions of the center, right and left nozzle headers 1 are determined for cooling the rear sides of the strip wrapped around the rolls in accordance with measured data thereby and detecting data of the strip edges by the profile thermometers 91 and 92, and the nozzle header 1 are individually moved to the hot points of the center in the strip width and the right and left strip edges thereof. Such cooling positions of the nozzle headers 1 is also determined in accordance with the measured result of the distribution by the profile thermometer 92 at the outlet of the roll quenching equipment, but the former feed-forward control is usually carried out in preference to this feed back control (either of the former feed-forward control or latter feed-back control may be of course practised). With respect to the condition of the non-uniform temperature distribution, even if the strip width changes, the position of the center hot point does not change, and besides since the temperature in the center is lower than that of the strip edges, the center nozzle header does not laterally move but moves back and forth as seen in Figs.10 to 12. The capacity of the center nozzle header may be smaller than those of the right and left nozzle headers 1. In the present embodiment, the cooling efficiency by the gas jetting of the header is controlled by controlling the the gas jetting amount or the gas pressure in accordance with the measuring values of the profile thermometer 92 at the outlet.

[0128] The adjustment of the nozzle header 1 moving in the lateral directions is also required when the welding point (the strip particular point) where the strip width changes, enters the rolls. That is, the information of the strip particular point is input in advance from the inlet of the line, so that when the material of the narrow width changes to that of the wide width, the moving of the right and left nozzle headers to the predetermined position has completed before said strip particular point passes the profile thermometer 91 at the inlet. Reversely, when the material of the wide width changes to that of the narrow width, the right and left nozzle headers are moved to the predetermined position after the particular point passes the profile thermometer 92 at the outlet.

[0129] The auxiliary gas jet cooling systems $\beta 1$ and $\beta 2$ are auxiliary structures for cancelling the non-uniformity of the temperature distribution along the strip width which has not been completely cancelled by the above mentioned structure of cooling the rear side of the strip wrapped around the cooling roll in this embodiment, and laterally move the nozzle headers at the backward of the gas jet cooling equipment for jetting the cooling gas toward the hot points.

[0130] The effects brought about by this embodiment will be explained. In the conventional roll quenching equipment which did not carry out the cooling of the rear side of the strip wrapped around the cooling roll, the non-uniformity arose in the strip temperature distribution along the strip width as seen in Fig.42, however, such non-uniformity has been cancelled depending upon the present embodied structure. The deviation in the strip temperature in regard to the average temperature in the strip width when employing the present embodiment has been smaller than the case by the conventional structure, and besides in this embodiment, an over-cooling area has been smaller, thereby enabling to uniformize the strip temperature distribution.

[0131] Figs. 10 to 12 show an embodiment as claimed in claim 33 where the center nozzle header 1 does not laterally move. The header supporter 100 for the center nozzle header 1 is directly fixed on the base 32 of the moving bed 3 (there are neither the guide rail 34b, the lateral moving bed 35b nor the drive device 36b. See Fig. 12). The nozzle headers 1 at both edges can, as seen in Fig.11, move in the lateral directions as in the preceding embodiment. With respect to the non-uniform strip temperature distribution along the strip width, since the temperature in the strip center is lower than that in the edges, the cooling ability of the center nozzle header 1 is smaller than those of the right and left nozzle headers 1.

[0132] The above stated structure may be also applied to when the pass line is horizontal. Figs.13 to 16 show a structure as claimed in claim 34 which is applied to the cooling equipment of the horizontal pass line. In Fig. 13, #1 to #3 designate the cooling rolls, and the curved nozzle headers 1 are disposed at the rear sides thereof via the metal strip X. These header supporters 100 penetrate outside through the furnace shell, and bellows 101 are attached at the penetrating parts.

[0133] Fig.14 shows the transversely cross sectional view of the cooling roll #1 of the preceding figure. Herein, the three nozzle headers 1 are arranged just above the metal strip X in parallel along the width direction, and the header supporters 100 pass outside through the bellows 101. These header supporters 100 are held under a condition that they are movable laterally, back and forth in the outside by the moving bed 3. That is, the header supporters 100 pass through an elevator 37 of the moving bed 3, and are, as shown in Figs.15 and 16, suspended from carts 35a to 35c which are movable along guide rails 34a to 34c installed on the elevator 37 along the strip width, and further are connected to rods of drive devices 36a to 36c, and since the header supporters 100 are laterally moved by the drive devices 36a to 36c, the three nozzle headers can be laterally moved, respectively. The elevator 37 is connected to rods of elevating devices 38a and 38b, so that the elevator 37 can be moved back and forth by the driving of the elevating devices 38a and 38b.

(EXAMPLE 4)

[0134] A further explanation will be made to an embodiment as claimed in claim 41 using as another structure of the auxiliary gas jet cooling equipment of the metal strip cooling equipment.

[0135] Figs. 17 and 18 show an embodiment where the present embodiment is used to the auxiliary gas jet cooling equipment installed at the outlet of the roll quenching equipment of the continuous annealing line.

[0136] In the vertical roll quenching equipment encircled with the furnace shell in this embodiment, the cooling rolls #1 to #7 contacting the metal strip X are successively installed in the vertical direction, and the auxiliary gas jet cooling equipment of the present structure is disposed at the outlet as seen in the preceding embodiment.

[0137] In this embodiment, guide rails 4 are provided in parallel to the pass line of the metal strip X, and the running cart 5 is mounted on the guide rails 4, and the above mentioned moving device is composed of these two structures. The running cart 5 is mounted with nozzle headers β having gas jetting nozzles and narrower widths than the strip width in parallel to the pass line, said nozzle headers being two at the one side, i.e., four ($\beta 1$ to $\beta 4$) in total at both sides. The cart 5 runs along the guide rails 4 by a running mechanism 6, so that the nozzle headers β can be moved along the strip width. Each of the nozzle headers β is provided with a piping 7 to be a gas supply passage, and said piping 7 is diverged at the center thereof and connected to the upper and lower parts of each nozzle header β . In this embodiment, as shown in Fig. 17, center nozzle headers $\beta 5$ and $\beta 6$ (the rear side) are fixed along the pass line at the center in the strip width so as to cool the hot points occurring in the center in the strip width. However, the hot points in this part are almost at the same positions, even if the widths of the metal strip change, and since the temperature in said hot point in the center is usually lower than those in both strip edges, the position of the header is not changed, and the length thereof is shorter than those of the other nozzle headers $\beta 1$ to $\beta 4$.

[0138] The guide rails 4 are provided transversely and in parallel with the strip width, said guide rails being two at the upper and lower parts of the one side of the metal strip X, i.e., four in total at both sides. The upper guide rails 40 and 41 are, as seen in Figs. 19 and 20, wedge-shaped in cross section so as not to make rattling when upper running carts 50 to 53 mount thereon, having wheels 500 defined with conical groove, and such a structure provides a proper space between the nozzle header β and the metal strip X. Lower guide rails 42 and 43 have structures which make plays Y1 and Y2 to the upper and the right and left between bobbin shaped wheels 501 of the lower carts 54 and 57, taking into consideration influences by heat expansion of the nozzle header β and warp of the rail (Y1 is determined considering the providing precision of the nozzle header β and the heat expansion, and Y2 is determined considering the providing precision of the rail). As shown in Fig. 19, shielding plates 502 are furnished at the sides facing the metal strip X so that the upper and lower guide rails 4 are not bent due to local heating by radiation from the strip.

[0139] With respect to the running cart 5, there are the upper carts 50 to 53 mounting the wheels 500 on the upper guide rails 40 and 41, and the lower carts 54 to 57 idling the wheels 501 on the lower guide rails 42 and 43, and the upper carts 50 to 53 suspend the nozzle header β , and the lower carts 54 to 57 are used so that the lengthy nozzle header β keeps parallel with the metal strip X.

[0140] The nozzle header β is lengthy along the pass line. A plurality of nozzles lengthy along the nozzle width are provided at the surface and the width of the nozzle is predetermined in accordance with the temperature distribution. The distance between the nozzle and the metal strip X should be for obtaining desired heat transfer and avoiding the contact with the metal strip X. As said above, the nozzle header β is substantially suspended from the upper carts 50 to 53, and is auxiliarily supported by the lower carts 54 to 57.

[0141] With respect to the running mechanism 6, screw jacks 600 which are provided to the outside of the furnace shell along the guide rails 4, are basically composed of two at the upper and lower parts of one side in the strip width and four at the upper and rear sides, i.e., eight in total, and comprise drive shafts 602 connected thereto by encircling expansions 601, drive motors 603a and 603b disposed in the strip width for giving the driving force to the screw jacks 600, gear boxes 604 for transmitting the driving force, synchronous rotation gears 605 mounted on input shafts of the screw jacks 600 for transmitting the driving force, and roller chains 606 bridged between the upper and lower synchronous gears 605. That is, as seen in Figs. 22 and 23, the driving motors 603a or 603b are positioned at respective one sides of the furnace shell, and the rotating shafts thereof are connected to the gear boxes 604 and divided into two shafts which joint with input shafts of the screw jacks 600 for moving the drive shafts 602 back and forth. Since the respective drive shafts 602 are connected to the lower carts 54 and 56 or 55 and 57, the lower carts run along the lower guide rails 42 and 43 by moving the drive shafts back and forth. On the other hand, the synchronous rotating gears 605 mounted on the input shafts of both screw jacks 600 transmit their own rotating drive force to the synchronous rotating gears 605 of the upper screw jacks 600 so as to move back and forth the drive shafts 602 connected to said screw jacks 600 in the same manner. Accordingly, the rotation of one driving motor 603a or 603b causes the upper and lower carts 5 which are four in total at one side of the strip width to run along the upper and lower guide rails 40 to 43 synchronously. Since the upper and lower carts move at both sides of the strip X by the same distance in the same direction, the nozzle headers $\beta 1$, $\beta 2$ or $\beta 3$, $\beta 4$ can move toward the required positions to the strip width under the condition of maintaining the vertical posture without inclining. The reference numeral 607 of Fig. 22 designates

a sensor for detecting the position of the header, which counts the rotation number of the screw jack 600 and transmits it to a motor control device 608, whereby this device 608 controls the drive motor 603a or 603b. The moving distance of the cart at this time is determined considering the width of the metal strip X.

[0142] As seen in Figs.17 and 18, the piping 7 laid from the outside of the furnace shell into the inside thereof, and are branched into the upper and lower parts and connected with the the upper and lower parts of one nozzle header β for supplying the cooling gas from the outside into the nozzle header β . As mentioned above, since the nozzle headers $\beta 1$ to $\beta 4$ are moved along the strip width by the carts 50 to 57 running, the piping 7 is also interposed with expansions 70 in the branched part, thereby enabling to follow the movings of the nozzle headers $\beta 1$ to $\beta 4$. Controlling the gas pressure or amount of the cooling gas supplied through the piping 7, causes the cooling amount control to the strip X using each of the nozzle headers $\beta 1$ to $\beta 4$. Further, it is sufficient to interpose, as seen in Fig.25, a telescopic means 71 instead of said expansion 70 or employ a flexible structure to be used under the air sealing condition.

[0143] A following explanation will be made to the operation of the auxiliary gas jet cooling equipment in the above mentioned roll quenching equipment. The cooling rolls #1 to #7 are, as said above, moved horizontally to contact the metal strip X at a time when the tension of the metal strip X is varied up to the tension (3 kgf/mm² or more) for using the roll by the bridle rolls $\epsilon 1$ and $\epsilon 2$, and the cooling rate is adjusted as adjusting the shift stroke of the roll (the wrapping length), and also in the present roll quenching equipment, the rear side of the strip wrapped around the roll is cooled by the gas jet cooling equipment. For cooling the rear side of the strip wrapped around the roll, the headers $\alpha 1$ to $\alpha 7$ for cooling the rear sides of the strip wrapped around the rolls are moved to the hot points by controlling the movements of the headers $\alpha 1$ to $\alpha 7$ in the transverse direction with the strip surface and in the strip width direction. Thus, the rear side of the strip is cooled as maintaining suitable distances.

[0144] The auxiliary gas jet cooling equipment at the delivery section is provided as an auxiliary cooling structure for the roll quenching equipment to cancel the non-uniform temperature distribution occurring along the strip width, which could not be completely cancelled with said rear cooling equipment, and the nozzle headers $\beta 1$ to $\beta 4$ are moved laterally in the delivery section to impinge the cooling gas toward the hot points from both surfaces of the metal strip X.

[0145] Adjusting of the moving of the nozzle header will be explained. When measuring the temperature distribution in the strip width with the profile thermometer 92 and if the distribution is non-uniform, the positions to be cooled of the nozzle headers $\beta 1$ to $\beta 4$ are determined in accordance with the measured data and the detected data of the strip edges by the profile thermometers 91 and 92, driving the drive motors 603a and 603b so as to individually move the groups of the carts 50, 52, 54, 56 and the group of the carts 51, 53, 55, 57, and respectively moving the groups of the nozzle headers $\beta 1$ and $\beta 3$ as well as $\beta 2$ and $\beta 4$ to the hot points of both strip edges in the strip X width. In regard to the condition where the temperature distribution is non-uniform along the strip width, the position of the hot point in the strip center is not changed though the strip width is varied, and since the temperature thereof is lower than that of the strip edge, the nozzle headers $\beta 5$ and $\beta 6$ of the center are fixed, and the cooling ability of the header is smaller than those of the right and left nozzle headers $\beta 1$ to $\beta 4$.

[0146] The adjustment of the movement in the strip edges of the nozzle headers $\beta 1$ to $\beta 4$ is necessary also when the welding part (the particular point) of the strip is coming. That is, when the information of the particular point is in advance obtained from the inlet of the line, changing from the narrow width to the wide width, the nozzle headers $\beta 1$ to $\beta 4$ have been moved to the predetermined positions before said particular point passes the profile thermometer 91. Reversely when changing from the wide width to the narrow one, the nozzle headers $\beta 1$ to $\beta 4$ begin to move toward the predetermined positions after the particular point passes the profile thermometer.

[0147] The operation of this embodiment will be explained. In the conventional roll quenching equipment which did not carry out the cooling of the rear side of the strip wrapped around the cooling roll, the non-uniform temperature distribution occurred along the strip width as seen in Fig.42. But such non-uniformity has been mitigated by using the structure of cooling the rear side of the strip wrapped around the roll. Further, the auxiliary gas jet cooling equipment has been employed in this embodiment, whereby the non-uniformity has been completely cancelled thereby (results were near as shown in Fig.56).

[0148] The instant structure can be also applied to the horizontal pass line. Figs.26 to 31 show the structure as claimed in claim 41 where this structure is applied to that the pass line of the metal strip X is horizontal. Fig.26 is a plan view of one side of the horizontal pass line, and the guide rails 4 are laterally provided to the pass line, and the running cart 5 is movable along the guide rails 4. As seen in Fig.27, the nozzle header β mounted on the cart 5 and having the gas jetting nozzles, which has the narrower width than the strip width, is parallel to the pass line. The running cart 5 travels on the guide rails 4 by means of the running mechanism 6 (which is composed of eight screw jacks 600 along the guide rails 4 outside of the furnace shell, drive shafts 602 connected thereto by encircling the expansions 601, drive motors 603a, 603b giving the driving force to the input shafts of the screw jacks 600, synchronous rotating gears 605 mounted on the rotation shafts of the screw jacks 600 for transmitting the driving force, and a roller chain 606 bridged between the synchronous rotating gears 605), so that the nozzle header β can be moved in the strip width direction. Catenaries sometimes occur in the metal strip X, and so hydraulic or air pressure cylinders 44 are provided at the supporters of the guide rails 41 and 43 of the lower nozzle headers $\beta 3$ and $\beta 4$, thereby to adjust the

height of the headers $\beta 3$ and $\beta 4$.

[0149] Fig.28 shows the engagement between the guide rail 40 and the wheel 503 of the upper running cart 51 at the inlet of the preceding figure. Fig.29 shows the engagement between the guide rail 42 and the wheel 504 of the upper running cart at the outlet, Fig.30 shows the engagement between the guide rail 41 of the wheel 503 of the lower cart 53 at the inlet, and Fig.31 shows the engagement between the guide rail 43 and the wheel 504 of the lower cart 57 at the outlet. In these figures, the upper and lower guide rails 40 and 41 at the inlet are shaped in wedge in cross section so as not to make rattlings when the wheel 503 of the conical groove mounts thereon as shown in the preceding embodiment, while, taking the amount $\Delta 1$ of thermal expansion into consideration, the guide rails 42 and 43 at the upper and lower outlet have plain structures of width of at least $\Delta 1$ so that the disc shaped wheel 504 may slide thereon.

(EXAMPLE 5)

[0150] A still further explanation will be made to an embodiment as claimed in claim 54, suitable to the roll quenching equipment which is provided with the metal strip cooling equipment.

[0151] The structure of the cooling rolls #1 to #7 to be used to the roll quenching equipment 1000 are made as shown in Fig.32 illustrating the cross sectional structure of the roll and Fig.33 illustrating the development thereof, and the cooling water running channels into the cooling rolls #1 to #7 are shown in Fig.34.

[0152] Each of the roll bodies of the cooling rolls #1 to #7 is composed of an inner tube 1001 formed with water flowing passages γ as coolant passages and all outer tube 1002 secured to the circumference of the inner tube 1001 by a shrinkage fitting. With respect to the water flowing passage γ , as seen in Fig.33, six passages $\gamma 1$ to $\gamma 6$ are spirally provided in the direction of the roll shaft in parallel on the same plain surface.

[0153] The water flowing channels into the cooling rolls #1 to #7 have, as shown in Fig.34, two passages of cooling water supplying pipes 1010 and cooling water discharging pipes 1011. The supplying pipes 1010a and the discharging pipes 1011b are alternately disposed at one sides of the cooling rolls #1 to #7, while discharging pipes 1011a and supplying pipes 1011b are correspondingly disposed at the other sides, and thus the supplying and discharging pipings are connected such that they are alternately opposed by the back and forth pipings. The flowing directions of the cooling water in the passages γ of the cooling rolls #1 to #7 may be reversed per each of them.

[0154] The above water passages are six in the present embodiment, and a general determination of several passages will be referred to. The flow velocity of the cooling water in the passage must be set to be 1.3 to 4.0 m/sec at the part of a wall around the outlet of the water to be at high temperature. This is why (1) the cooling water must not be boiled in the water passage of the cooling roll of the equipment where a thermal load is high (the wrapping angle is large), and the flow velocity in this case becomes 1.3 m/sec or more, (2) the heat exchanger duty to be required per each of the roll quenching equipment is determined, but the flow velocity of the cooling water in the passage where the heat exchanger duty of said required amount or more is obtained in view of Fig.35 (for example, not less than 0.6 m/sec) (3) since at least 0.6 m/sec or more is required as the flow velocity not generating scales in the passage, the lower limit of the flow velocity therein is determined in accordance with the condition (1), and on the other hand, (4) if the flow velocity exceeds 4.0 m/sec, the pressure loss of a pump for feeding the cooling water reaches 4.4 kg/cm² or more, and the power loss or the pressure loss extremely increase when the scales attach, and accordingly the upper limit of the flow velocity is determined.

[0155] If the temperature of the water within said flowing range in the passage exceeds 70°C, the scales easily occur, and the temperature at the outlet of the cooling roll must be determined to be not higher than 70°C.

[0156] On the other hand, until the heat exchanger duty Q_H between the metal strip and the cooling water becomes equal to the cooling value Q_s , a heat transfer calculation is made in each roll in accordance with the procedure shown in the flow chart of Fig. 37, and subsequently, the calculations are made to the cooling rate CR (J) of each roll, the average cooling rate ACR and the average overall heat absorption rate AUo.

[0157] Thus, the number of the water passages is selected which satisfies the flow velocity of the cooling water, the water temperature at the outlet of the roll, the cooling rate CR (J), the average cooling rate ACR, and the average overall heat absorption rate AUo.

[0158] The calculation shown in the flow chart of Fig.37 is as follows. At first, the roll position $[X(l), Y(l)]$ at a time of the maximum wrapping of the metal strip X is read out, and this position is made an initial value. Subsequently, calculations are made of the roll wrapping length LS (l) of the metal strip X, the wrapping angle AR(l), the total wrapping length TLL, and the total pass length LO. Conditions are determined that the strip temperature at the inlet TSE is as TS (l), the water temperature at the inlet TWE is as TWE (l), the wrapping length LS is as LS (l), the wrapping angle AR is as AR (l), the thickness RST of the roll shell is as RT (l), and the roll diameter D is as D (l). Based on them and following the under procedure, obtained are the strip temperature TSD at the outlet of the roll, the water temperature TWD at the outlet of the roll, the heat exchanger duty Q_H between the metal strip X and the cooling water, and the average overall heat absorption rate Uo. In other words, (C1) the strip temperature TSD at the roll outlet is supposed and the cooling value Q_s of the metal strip X is obtained by the under formula 20;

(C2) assuming that the cooling value Q_s is a heat Q_w derived by the cooling water, the inner temperature TRSI of the shell is obtained by the under formula 21;

(C3) assuming that this cooling value Q_s is a heat capacity Q_R by the heat transfer of the roll shell, the outer temperature TRSO of the shell is obtained by the under formula 22;

(C4) the heat transfer λ_L of the material at the side of the low temperature is obtained from TRSO, and assuming that the temperature of the metal strip X is TRSA = (TSE + TSD)/2, the heat transfer λ_H of the material at the side of the high temperature is obtained;

(C5) the vickers hardness Hv is obtained by TRSA, and the surface pressure P is obtained from the roll diameter D, the strip thickness ST and the line tension LTENS;

(C6) the contacting heat conductance Hc is obtained by these λ_L , λ_H , P and Hv in accordance with the under formula 23;

(C7) the average overall heat absorption rate Uo and the heat exchanger duty Q_H between the metal strip and the water are obtained from this Hc in accordance with the formulae 24 and 25;

(C8) the strip temperature TSD at the outlet of the roll is re-set until the cooling capacity Q_s of the metal strip becomes equal to the heat exchanger duty Q_H between the metal strip and the water, and the above procedures (C1) to (C7) are repeated. When the heat transfer calculations of the above (C1) to (C8) have been completed per one cooling roll, assuming that the strip temperature TSD at the outlet of the cooling roll is a strip temperature TSI at the inlet of the following cooling roll and memorizing the other TWD, Uo and Q_H as the same values, the heat transfer calculation of each roll is repeated (I = 1 to the number NR of the rolls). If the strip temperature TS (NR+1) at the outlet of the cooling roll is equal to the objective strip temperature TSDA, the calculations are made of the cooling rate CR (J) of each roll, the average cooling rate ACR, and the average overall heat absorption rate AUo. The calculated results are input. When both values are equal, the shift stroke DY of the cooling roll to be moved is calculated, only said roll [CRT (I) = 1] resets the roll position and again returns to re-start the calculations of the roll rapping length LS (I) of the metal strip X, the wrapping angle AR (I), the total wrapping length TLL and the total pass length LO.

$$[20] \quad Q_s = (HSE - HSD) \times ST \times W \times V \times 60 \times 7.85 \times 10^{-3}$$

herein,

HSE : Heating value (kcal/kg) at the inlet of strip
HSD : Heating value (kcal/kg) at the outlet of strip
ST : Strip thickness (mm)
W : Strip width (mm)
V : Line speed (mpm)

$$[21] \quad QW = ALPHI \times AI \times (TRSI - TWA)$$

herein

ALPHI : Heat transmissibility (kcal/m²h°C) within the pipe
AI : Heat transfer area (m²) in the water channel

$$[22] \quad QR = THCRSA \times RST \times 10^{-3} \times AM \times (TRSO - TRSI)$$

herein,

THCRSA: Heat transfer (kcal/m²h°C) of the shell
AM : Average heat transfer area (m²)

$$[23] \quad Hc = 3 \times 10^4 \times \left(\frac{P}{Hv} \cdot \frac{\lambda_L \cdot \lambda_H}{\lambda_L + \lambda_H} \right) + 2 \times 10^3$$

herein

Hc : Contacting heat transfer (kcal/m²h°C)

$$[24] \quad U_o = 20.1 \times Hc^{0.8} \times RST^{-0.22} \times AR^{-0.23}$$

herein,

U_o : Summerized heat absorption (kcal/m²h°C)

$$[25] \quad Q_H = U_o \times W \times LS \times 10^{-6} \times TM$$

herein,

LS : Mounting length (mm) of the strip on the roll

TM : Difference in logarithmic average temperature (°C)

[0159] In the continuous annealing line composed as stated above of the present embodiment, if the tension leveler 2004 is disposed at the upstream side of the direct fired reducing furnace 2007, the running ability of the metal strip is improved within the furnace 2007, and the heating quality for reduction is stably provided.

[0160] Shapes of elongated parts in the metal strip X may be corrected by the tension leveler 2004, thereby to create no buckling in the gas jet cooling section 2010 and largely improve the buckling and the non-uniform cooling in the roll quenching equipment 1000, and as a result, the metal strip X does not roll in said line, and qualities of products are improved. Further, there have been no problems of contacting with the tubes in the radiant tube furnace 2008 and the soaking furnace 2009, contacting with the gas jetting nozzle in the gas jet cooling section 2010, contacting with the nozzle headers α1 to α7 for jetting the cooling gas to the rear sides of the strip wrapped around the cooling rolls in the roll quenching equipment 1000 and contacting with the gas jetting nozzles in the fast cooling section 2012.

[0161] Next explanations will be made to the water supplying manner and the movings of the cooling rolls #1 to #7 in the roll quenching equipment 1000, and the operation of the nozzle headers α1 to α7 for cooling the rear sides of the strip. At preparation for running the roll quenching equipment 1000, the water is supplied into the water passages shown in Fig.34, and the passing directions of the cooling water in all six water passages γ1 to γ6 are turned over per each of the rolls. The tension of the metal strip X is varied until the tension (3 kgf/mm² or more) for using the roll by means of the bridle rolls ε1 and ε2, and the cooling rolls #1 to #7 are moved in the horizontal direction to contact the metal strip X, and the cooling amount is adjusted as controlling the shift stroke (the wrapping length).

[0162] In the cooling rolls #1 to #7 of this embodiment, the water passages γ1 to γ6 spirally running are six, and so the length of each of the passages γ1 to γ6 can be made short, and the heat exchanger duty of the cooling water can be made small. As a result, the cooling is sufficiently effective to the metal strip X at the roll surface at the edges near the outlet of the passage, and after cooling, the temperature distribution along the strip width is almost symmetrical. In addition, since the water flowing directions in the passages γ of the cooling rolls #1 to #7 are turned reversely per each of the rolls, a temperature gradient between the roll surface at the edges near the inlet of the passage γ and the roll surface at the edges near the outlet is reversed per each of the rolls, and there is finally no temperature gradient itself in the cooling rolls in the delivery section.

(EXAMPLE 6)

[0163] Finally, an example will be explained to a method of cooling metal strips as claimed in claim 64 wherein the metal strip cooling structure of the above stated embodiment 1 is employed.

[0164] In the roll quenching equipment as shown in Fig.2, the rear of the strip wrapped around the cooling rolls is cooled in the metal strip cooling structure as said under in the present embodiment.

[0165] The temperature distribution in the strip width X is detected by the strip temperature profile measuring equipment 90a intalled at the outlet of the cooling roll groups #1 to #4, and in accordance with the temperature signals thereof, a comparison is made between the temperature in the strip center and an objective temperature of the strip by means of the calculation device 87 for strip temperature control. With respect to the control of the average strip temperature based on the deviation of the strip temperature therebetween, the wrapping length between each of the cooling roll groups #1 to #4 and the metal strip X is adjusted by the roll position adjustment device 80.

[0166] Further, with respect to controlling of the temperature distribution based on the objective strip temperature distribution, a locus of the metal strip X wrapping around the cooling rolls is obtained from the position of each of the cooling rolls #1 to #4 such that the metal strip X does not contact the nozzle headers α1 to α4 of the gas jet cooling

equipment installed against the cooling roll groups #1 to #4, and each nozzle header of the gas jet cooling equipment is moved in the moving direction of the cooling roll by the position adjustment device 81 so as to provide an appropriate distance therebetween.

[0167] An assumption is made by the calculation device 88 for nozzle header position control in regard to both strip edges and the center of the strip width in the respective positions of the gas jet cooling equipment and the auxiliary gas jet cooling equipment positioned at the outlet of the cooling roll groups #1 to #4 from positional signals of both strip edges detected by the strip edge position detectors 89 installed at the inlet and the outlet of the cooling roll groups #1 to #4. The nozzle headers at both strip edges and the strip center are moved along the strip width by means of the position adjustment devices 82 and 83 connected to the respective nozzle headers of the gas jet cooling equipment and the auxiliary gas jet cooling equipment. Thus, the positional adjustments are respectively made so as to provide a cooling width (the cooling width at the super-imposed part of the nozzle header and the metal strip) shown in the formulae 8 and 9 to the nozzle headers of both edges, and so as to provide coincide between the center of the strip width and the center of the nozzle headers with respect to the center nozzle header. More specifically referring to with Figs.3 and 4, the nozzle headers αa and αc at both edge sides of the gas jet cooling equipment facing the cooling rolls are adjusted positionally by means of the position adjustment devices 820 and 822 in the devices 82 connected to the nozzle headers of both edges, while the center nozzle header αb is adjusted positionally by means of the position adjustment device 821 connected to the center nozzle header. Similarly, the nozzle headers βa and βc of both edges of the auxiliary gas jet cooling equipment installed at the outlet of the cooling roll groups #1 to #4 are adjusted positionally by means of the position adjustment devices 830 and 832 connected to the nozzle headers at both edges in the devices 83, while the center nozzle header βb is adjusted positionally by means of the position adjustment device 831 connected to the center nozzle header.

[0168] Based on the temperature signals along the strip width detected by the strip temperature profile measuring equipment 90a installed at the outlet of the cooling roll groups #1 to #4 and the strip temperature profile measuring equipment 90b installed at the outlet of the auxiliary gas jet cooling equipment, the measured strip temperature distribution and the objective strip temperature distribution are compared by the calculation device 87 for strip temperature control. In response to the deviation therebetween, at least one of rotating speed of the cooling gas supplying blowers 85a and 85b or the pressure control valves 84a to 84e is used to adjust the cooling gas pressure (a pressure gauge is omitted) within the nozzle headers α , β of the gas jet cooling equipment and the auxiliary gas jet cooling equipment, and impinge the adjusted cooling gas to the metal strip X. The cooling gas is supplied to the gas jet cooling equipment and the auxiliary gas jet cooling equipment from the interior of the furnace (omitted in Fig.2) via the heat exchanger 86 and the cooling gas supplying blower 85.

[0169] In Fig.2, the strip temperature profile measuring equipment are installed at the outlets of the cooling roll groups #1 to #4 and the auxiliary gas jet cooling equipment, but it is sufficient to install the measuring equipment only at the outlet of the auxiliary gas jet cooling equipment.

[0170] An explanation will be made to a calculating method for an optimum position (i.e. an optimum separating distance) of the nozzle header of the gas jet cooling equipment to the cooling rolls.

[0171] In the two cooling rolls #1 and #2, it is assumed that the radii of the rolls are $F1$ and $F2$, the axis distance between the rolls is $L0$, the projecting lengths of the rolls from the basic line when the roll are not made contact the strip X, are $L1$ and $L2$, the wrapping angle of the roll and the strip X is θ , and angles of the nozzle headers $\alpha1$, $\alpha2$ are $\eta1$ and $\eta2$. Under such conditions, the lower nozzle header $\alpha2$ is considered.

[0172] A coordinate of A point as a contact point between the strip X and the lower cooling roll #2 is expressed by the under formula 26.

$$[26] \quad (-L2+F2-F2 \cdot \cos\theta, F2 \cdot \sin\theta)$$

[0173] A coordinate of B point as a contact point between the strip X and the upper cooling roll #1 is expressed by the under formula 27.

$$[27] \quad (L1-F1+F1 \cdot \cos\theta, L0-F1 \cdot \sin\theta)$$

[0174] The inclination of a linear part of the strip X is expressed by the under formula 28.

$$[28] \quad 1/\tan\theta$$

[0175] The contact angle θ is expressed by the under formula 29.

$$[29] \quad \frac{L0 - F1 \cdot \sin \theta - F2 \cdot \sin \theta}{L1 - F1 + F1 \cdot \cos \theta + L2 - F2 + F2 \cdot \cos \theta} = \frac{1}{\tan \theta}$$

[0176] From this formular 29, the under formula 30 will be given.

$$[30] \quad \theta = \tan^{-1} \{ X2 / \sqrt{1 - X2^2} \} - \tan^{-1} X1$$

$$X1 = (F1 + F2 - L1 - L2) / L0$$

$$X2 = (F1 + F2) / \sqrt{L0^2 + (F1 + F2 - L1 - L2)^2}$$

[0177] The linear part of the strip X is expressed by the under formula 31.

$$[31] \quad y - F2 \cdot \sin \theta = (X + L2 - F2 + F2 \cdot \cos \theta) / \tan \theta$$

[0178] If assuming that the minimum separating distance between the nozzle header $\alpha 2$ and the strip X is G, the optimum position of the nozzle header $\alpha 2$ is as under.

- 1) When the length of the strip wrapping around the roll is longer than the nozzle header $\alpha 2$, that is, in case of $\theta \geq (\eta 1) / 2$, the optimum position of the nozzle header is that a distance between the center position E point of the nozzle header $\alpha 2$ and the strip X.
- 2) When said length is smaller than the nozzle header $\alpha 2$, that is, in case of $\theta < (\eta 1) / 2$, the coordinates of D point, C point and E point are as shown in the formulae 32, 33 and 34.

$$[32] \quad (X3, Y3) = [X3, (F2 + G) \sin(\eta 2 / 2) - G \cdot \sin \theta]$$

herein, X3 is a value obtained by substituting y in the formula 29.

$$[33] \quad (X4, Y4) = (X3 - G \cdot \cos \theta, Y3 + G \cdot \sin \theta)$$

$$[34] \quad (X5, Y5) = \{ X4 - (F2 + G) [1 - \cos(\eta 2 / 2)], 0 \}$$

[0179] Therefore, the optimum position is such a position of the nozzle header $\alpha 2$ that the distance between the strip X and the center position E of the nozzle header $\alpha 2$ is IX5I.

[0180] As examples of controlling the strip temperature distribution to the objective distribution, an explanation will be made with Fig.39 to an calculating method for the optimum position of the nozzle header in the strip width of the gas jet cooling equipment and the auxiliary gas jet cooling equipment for responding to changings in profile of the temperature distribution along the strip width.

- 1) Estimation of the distribution of the strip temperature

First is to estimate the distribution of the strip temperature. The distribution of the temperature along the strip width can be expressed by the power series of four order shown in the formula 35.

$$[35] \quad T(X) = a_1 X^4 + a_2 X^3 + a_3 X^2 + a_4 X + a_5$$

herein, X is normalized in the width direction, and $-1 \leq X \leq 1$.

The function of the formula 35 is obtained by the method of least square from the measured result of the strip temperatuer ("90" of Fig.2).

- 2) Calculation of the optimum position of the nozzle header in the strip width.

Subsequently, the calculation is made for the position of the nozzle header in the strip width. When the temperature distribution along the strip width at the outlet of the cooling roll group obtained by said estimation is as

shown in Fig.39, bad ranges of the temperature in the side at the higher temperature than the distribution $T'(x)$ of the objective strip temperature are

$$(C1) \quad -1 \leq X \leq X_1$$

$$(C2) \quad X_2 \leq X \leq X_3$$

$$(C3) \quad X_4 \leq X \leq 1.$$

herein, X_1, X_2, X_3, X_4 are divided into the boundaries of the bad ranges of the high strip temperature (see the hatched ranges of Fig.39).

[0181] The positions X_{e1}, X_{e2} of center of gravity where the deviation in the strip temperatures at both edges occurs and the position X_c of center of gravity where the deviation in the temperature of the strip center occurs are obtained by calculating the centers of gravity of the under formulae 36, 37 and 38.

[3 6]

$$X_{e1} = \frac{\int_{-1}^{x_1} |T(X) - T'(X)| \cdot x \cdot dx}{\int_{-1}^{x_1} |T(X) - T'(X)| dx}$$

[3 7]

$$X_{e2} = \frac{\int_{x_4}^1 |T(X) - T'(X)| \cdot x \cdot dx}{\int_{x_4}^1 |T(X) - T'(X)| dx}$$

[3 8]

$$X_c = \frac{\int_{x_2}^{x_3} |T(X) - T'(X)| \cdot x \cdot dx}{\int_{x_2}^{x_3} |T(X) - T'(X)| dx}$$

[0182] Therefore, the nozzle headers at both edges are controlled respectively such that the cooling widths l_{e1}, l_{e2} are as shown in the formulae 39 and 40, and the center position of the nozzle header at the center is moved to the position of X_c , and the cooling gas pressure flowed into each nozzle header is adjusted in accordance with the deviation of the strip temperature at each range so as to follow variations in profile the strip temperature distribution by jetting the adjusted cooling gas to the metal strip X .

$$[39] \quad l_{e1} = (X_{e1} + 1) \cdot B$$

$$[40] \quad l_{e2} = (1 - X_{e2}) \cdot B$$

herein

B : Strip width (mm)
 l_{e1} , l_{e2} : Cooling widths (mm) at the edges

herein,

B: the strip width (mm)

l_{e1} and l_{e2} : the cooling widths at the strip edges

[0183] According to the structures of this invention, the cooling can be quickly provided at low costs as bringing the temperature distribution in the strip width to the objective distribution of the strip temperature.

[0184] Further according to the structures as claimed in claims 14 to 17, 29 and 30, 51 to 53, 56 and 57, the cooling may be properly practised as covering the delays in moving of the nozzle headers in the line where the strip width is frequently changed, thereby enabling to cool in the strip width uniformly and quickly.

[0185] Depending upon the structures as claimed in claims 31 to 41 and 58 to 63, the nozzle headers are moved to the non-uniform ranges of the strip temperature distribution, and the cooling gas is impinged as maintaining the appropriate separating distance so that the temperature distribution can be controlled along the strip width.

[0186] In addition, depending upon the cooling roll as claimed in claim 54, since the cooling roll has many passages of the cooling water in the inside thereof, each length of the passages can be as a whole made short, and the heat exchanger duty of the coolant running in the passage can be reduced. As a result, the metal is also effectively cooled on the roll surfaces at the edges near the outlet of the coolant passage, and the temperature distribution along the strip width can be uniformized during cooling, and the temperature distribution is almost symmetric in the strip width after cooling. Following the cooling structure as claimed in claim 55, since the flowing direction of the coolant in each cooling roll is reversed per each of the rolls, the gradient in temperature is reversed per each of the rolls between the roll surfaces at the edges near the inlet of the coolant passage and the roll surfaces at the edges near the outlet, so that the cooling rate in the metal strip can be uniformized, and the nearer are the cooling rolls in the delivery section, the less is the gradient itself in temperature. Accordingly, qualities of the metals to be produced are made uniform in the widths thereof.

INDUSTRIAL APPLICABILITY

[0187] The present invention can be applied to cooling structure of the rear sides of the strip wrapped around the cooling rolls of the roll quenching equipment, and to the auxiliary cooling structure at the inlet and outlet of the roll quenching equipment.

Claims

1. An equipment for cooling metal strips, which wraps the metal strip (X) around at least one cooling roll (#1 - #4), and adjusts a wrapping length between the metal strip (X) and the respective cooling roll (#1 - #4) by moving the cooling roll (#1), and includes gas jet cooling equipment having nozzle means (α_1) facing to the rear side of the wrapped strip (X) section and being displaceable toward the metal strip (X), and further includes gas adjusting equipment (87) which adjusts pressure or flow rate of a cooling gas flowed into the nozzle means (α_1),

characterized by

said gas cooling equipment having more than one nozzle header (α_a , α_b , ...) disposed in the direction of the roll axis of the respective cooling roll (#1 - #4) and being narrower than the metal strip (X) and each being movable along the moving direction of the respective cooling roll (#1 - #4), and at least one of the nozzle headers (α_a , α_b , ...) being movable along the roll axis.

2. The equipment as claimed in claim 1, characterized in that nozzle mouths of said nozzle headers are formed in slits crossing at right angle with a passing line of the metal strip, and arranged in a row along the passing line.

3. The equipment as claimed in claim 2, characterized in that an inside edge of said nozzle mouth is R-shaped or tapered in cross section thereof.

4. The equipment as claimed in claim 2, characterized in that the nozzle mouth is projected outwardly.

5. The equipment as claimed in claim 1, characterized in that the nozzle headers are two which are disposed at the

edges in the strip width.

6. The equipment as claimed in claim 1, characterized in that the nozzle headers are three, one of which is disposed at a center in the strip width, and the other two are disposed at the edges in the strip width.

7. The equipment as claimed in claim 1 or 6, characterized in that a plurality of cooling rolls are installed, at least the first cooling roll thereof has three nozzle headers, one of them being located at the center part of the strip width, and the other two being located at the strip edges.

8. The equipment as claimed in claim 1 or 6, characterized in that a plurality of cooling rolls are installed, at least the cooling rolls of an entry section respectively have three nozzle headers, one of them being located at the center part of the strip width, and the other two being located at the strip edges, and the cooling rolls of a delivery section respectively have two nozzle headers.

9. The equipment as claimed in claim 1, characterized in that the nozzle headers facing at least the first cooling roll are moved from a retract place toward the metal strip pass line at the same time of beginning the contact between said cooling roll and the metal strip, and when the shift stroke of the cooling roll is longer than that at a time of said contacting, the nozzle headers are moved to maintain required spacing distances from the metal strip, and when the metal strip is non-contacted with the cooling roll, the nozzle headers are moved till said retract place.

10. The equipment as claimed in claim 1, characterized in that in case a plurality of cooling rolls are disposed, the nozzle headers other than the nozzle headers opposite to at least the first cooling roll are designed to obtain a maximum length of the nozzle header by a maximum shift stroke of the following roll, and said nozzle headers move from the retract place to the metal strip pass line at the same time of beginning the contact between said cooling roll and the metal strip, and do not move thereafter even if said shift stroke of the cooling roll is long, and the nozzle header is retreated to said retract place before becoming non-contacted between the metal strip and the cooling roll.

11. The equipment as claimed in claim 1, characterized in that in case a plurality of cooling rolls are disposed, the longer shift stroke is taken, the nearer goes the cooling roll to the entry section.

12. The equipment as claimed in claim 1, characterized in that in case a plurality of cooling rolls are disposed, the nearer goes the cooling roll to the entry section, the longer is the shift stroke of the roll, and with respect to the nozzle header facing the cooling roll, the nearer goes the nozzle header to the entry section, the maximum comes near the gas jetting rate.

13. The equipment as claimed in claim 1, characterized in that in case a plurality of nozzle headers are disposed along the roll axis, the moving amounts of the nozzle headers are respectively varied in the moving direction of the cooling rolls, and the spaces between the nozzle headers and the cooling rolls are respectively varied in the roll axis.

14. The equipment as claimed in claim 1, characterized in that two or more nozzle headers are disposed in the direction of the roll axis to said cooling rolls via the metal strip, said nozzle headers being movable along the moving directions of the cooling rolls, and at least the roll cooling equipment located at both strip edges having such nozzle headers which are composed of the plural header bodies connected along the length of the rolls and are narrower than the metal strip.

15. The equipment as claimed in claim 14, characterized in that said nozzle headers are composed of plural header bodies located at both strip edges and connected in the roll axis, and said connected header bodies are further provided in plural steps along the strip running direction, and a position of each nozzle mouth of the header bodies is deviated along the roll axis in the entry side and the delivery side.

16. The equipment as claimed in claim 14, characterized in that said nozzle headers are composed of plural header bodies located at both strip edges and connected in the roll axis, and said connected header main bodies are arranged by sliding the nozzle mouths along the strip running direction.

17. The equipment as claimed in claim 1, characterized in that two or more nozzle headers are disposed in the direction of the roll's axis to said cooling rolls via the metal strip and are divided into two or more in the strip running direction, and at least the roll cooling equipment located at both strip edges are composed of such nozzle headers which

have narrower width than the strip width and are independently movable along the roll axis.

18. The equipment as claimed in claim 1, characterized in that tension of the metal strip is heightened before the cooling roll contacts the metal strip, whereby the shape of the strip is made stable when contacting.

19. The equipment as claimed in claim 7, characterized by:

a target nozzle position calculation device for Strip width change,
a strip edge position detector, and
a strip temperature profile measuring equipment

disposed at an inlet of the cooling rolls, and nozzle headers for the strip edges are set to the edges of the strip width by obtaining an information of width-changing part or amount therefrom.

20. The equipment as claimed in claim 19, characterized in that when a welding point as a connected part of different widths comes into an inlet of the cooling rolls, said information is obtained in advance from the inlet of the line, when the strip changes from a narrow width to a wide width, the nozzle headers for the strip edges have been set to the edges of the strip of the wide width before said welding point goes into the inlet of the cooling rolls, and when changing from the wide width to the narrow width, said nozzle headers are set to the edges of the strip of the wide width after said welding point has entered the inlet of the cooling rolls.

21. The equipment as claimed in claim 7, characterized in that, the strip temperature profile measuring equipment is installed at the outlet of the cooling rolls, and in accordance with the information therefrom, the nozzle headers for the strip edges of the gas jet cooling equipment are set at the edges in the strip width.

22. The equipment as claimed in claim 7, characterized in that, the strip temperature profile measuring equipment is installed at the outlets of the cooling rolls, thereby, in accordance with the information therefrom, to adjust the pressure or the flow rate of the cooling gas of the nozzle headers for the strip edges of the gas jet cooling equipment.

23. The equipment as claimed in claim 7 or 19, characterized in that the strip temperature profile meansuring equipment is installed at the outlet of the cooling rolls, and in accordance with said information, the nozzle headers for the strip edges of the gas jet cooling equipment are set at the edges in the strip width, thereby to adjust the pressure or the flow rate of the cooling gas of the nozzle headers for the strip edges of the gas jet cooling equipment.

24. The equipment as claimed in claim 1, characterized by:

said gas jet cooling equipment being provided with two nozzle headers which are disposed at edges in the strip width in the direction of the roll axis to said cooling rolls via the metal strip, and being narrower than the metal strip,
auxiliary gas cooling equipment having two or more gas jetting nozzle headers in the strip width, and enabling to move the nozzle headers located at at least both strip edges along the strip width, and
said gas ajusting devices for said auxiliary gas cooling equipment adjusting the pressure or the flow rate of the cooling gas flowed into each nozzle header.

25. The equipment as claimed in claim 1, characterized by:

said gas jet cooling equipment being provided with three nozzle headers which are disposed at a center and edges in the strip width in the direction of the roll axis to said cooling rolls via the metal strip, and being narrower than the metal strip, said nozzle headers at least at both edges being movable along the roll axis,
auxiliary gas cooling equipment having two or more gas jetting nozzle headers in the strip width, and enabling to move the nozzle headers located at at least both strip edges along the strip width, and
said gas ajusting devices for said auxiliary gas cooling equipment adjusting the pressure or the flow rate of the cooling gas flowed into each nozzle header.

26. The equipment as claimed in claim 25, characterized by

said gas jet cooling equipment being provided with three nozzle headers which are disposed at a center and edges in the strip width in the direction of the roll axis to at least first cooling roll of said cooling rolls via the metal strip.

27. The equipment as claimed in claim 25,
said gas jet cooling equipment being provided with three nozzle headers which are disposed at a center and edges in the strip width in the direction of the roll axis to at least cooling rolls in an entry section of said cooling rolls via the metal strip.
28. The equipemnt as claimed in claim 26, characterized in that at least two nozzle headers for the strip edges in the auxiliary gas jet cooling equipment are movable along the strip width.
29. The equipment as claimed in claim 24, characterized in that at least nozzle headers located at both edges among the nozzle headers of the auxiliary gas jet cooling equipment installed at the outlet of the cooling rolls comprise a plurality of header bodies connected along the strip width, and at least one of said nozzle headers is movable along the strip width.
30. The equipment as claimed in claim 24, characterized in that at least nozzle headers located at both strip edges among the nozzle headers of the auxiliary gas jet cooling equipment installed at the outlet of the cooling rolls are divided into two or more in the running direction of the metal strip, and said nozzle headers are independently movable along the strip width.
31. The equipment as claimed in claim 14 or 17, characterized by having two or more nozzle headers which are provided with the nozzles for impinging the gas to the metal strip, the width of which is narrower than the strip width, and which has the moving bed for moving the nozzle header in the transverse direction with the strip surface and/or along the strip width.
32. The equipment as claimed in claim 31, characterized in that in case said nozzle headers are two or three in the strip width, the moving beds thereof are movable in the transverse direction with the strip surface and along the strip width.
33. The equipment as claimed in claim 31, characterized in that in case said nozzle headers are three in the strip width, the moving bed for moving the center nozzle header is movable only in the transverse direction with the strip surface, and the moving beds for moving the right and left nozzle headers are movable in the transverse direciton with the strip surface and in the direction of the strip width.
34. The equipment as claimed in claim 1, characterized in that the strip metal passing line of said roll quenching equipment is horizontal or vertical.
35. The equipment as claimed in claim 26, characterized by providing, as the auxiliary gas jet cooling equipment, the two or more nozzle headers, the width of which is narrower than the strip width, said nozzle header being provided with nozzle for impinging the gas to the metal strip and the moving beds which move said nozzle headers in the direction transverse with the strip surface and/or in the strip width.
36. The equipment as claimed in claim 35, characterized in that in case the nozzle headers and the moving beds are provided as the auxiliary gas jet cooling equipment, said nozzle headers and moving beds are provided for both surfaces of the metal strip.
37. The equipment as claimed in claim 35, characterized in that the metal strip passing line is horizontal or vertical.
38. The equipment as claimed in claim 26, characterized by installing, as the auxiliary gas jet cooling equipment, a moving device which is movable in parallel to the strip surface and along the strip width, disposing the nozzle headers having the nozzles for impinging the gas to the metal strip, the nozzle headers being provided to said moving device, the width of which is narrower than the strip width, having a running mechanism for moving said moving device, and providing flexible parts or expansion joints at one part of said gas supplying channel.
39. The equipment as claimed in claim 38, characterized by providing the moving devices, the nozzle headers attached to said moving devices, and the gas supplying channels attached to said nozzle headers and having the flexible or expansible joints with respect to both surfaces of the metal strip.
40. The equipment as claimed in claim 38 characterized in that the nozzle headers are fixed around the strip center for impinging the gas.

41. The equipment as claimed in claim 38, characterized in that the metal strip passing line is horizontal or vertical.

42. The equipment as claimed in claim 26, characterized by, disposed at the inlet of the cooling rolls,

5 a target nozzle position calculation device for strip width change,
a strip edge position detector, and
a strip temperature profile measuring equipment,

10 obtaining an information of the width-changing weld point and the width-changing amount in accordance with the information therefrom, thereby to respectively set the nozzle headers for the strip edges of the gas jet cooling equipment and the two nozzle headers for the strip edges of the auxiliary gas jet cooling equipment.

15 43. The equipment as claimed in claim 42, characterized in that in case the particular point as the welding part of different widths comes into the inlet of the cooling rolls, said information is obtained in advance at the inlet of the line, and when the strip changes from the narrow width to the wide width, the nozzle headers for the strip edges of the gas jet cooling equipment and the two nozzle headers for the strip edges of the auxiliary gas jet cooling equipment have respectively been set at the strip edges before said particular point goes into the inlet of the cooling rolls, and when the strip changes from the wide width to the narrow width, these nozzle headers are respectively set to the strip edges of the narrow width after said particular point goes into the inlet of the cooling rolls.

20 44. The equipment as claimed in claim 24, characterized in that, the strip temperature profile measuring equipment is installed at the outlet of the auxiliary gas jet cooling equipment, and in accordance with the information therefrom, nozzle headers for the strip edges of the gas jet cooling equipment and the two nozzle headers for the strip edges of the auxiliary gas jet cooling equipment are respectively set at the strip edges.

25 45. The equipment as claimed in claim 24, characterized in that, the strip temperature profile measuring equipment is installed at the outlet of the auxiliary gas jet cooling equipment, thereby, in accordance with the information therefrom, to adjust the pressure or the flow rate of the cooling gas in the nozzle headers of the gas jet cooling equipment and of the auxiliary gas jet cooling equipment.

30 46. The equipment as claimed in claim 24, characterized in that, the strip temperature profile measuring equipment is installed at the outlet of the auxiliary gas jet cooling equipment, and in accordance with the information therefrom, the nozzle headers for the edges of the gas jet cooling equipment and the two nozzle headers for the edges of the auxiliary gas cooling equipment are respectively set to the strip edges, thereby to adjust the pressure or the flow rate of the cooling gas in each nozzle header.

35 47. The equipment as claimed in claim 1, characterized by

40 said gas jet cooling equipment being provided with at least three nozzle headers disposed in the roll axis to said cooling rolls, said nozzle headers being movable along the moving directions of the cooling rolls, and at least one nozzle header being movable along the roll axis;

strip edge position detectors for detecting the strip edges of said metal strip;

position adjustment devices which adjust movements of the movable nozzle headers among said nozzle headers along the roll axis;

45 a calculation device for nozzle header position control which controls said position adjustment devices in accordance with the detected signals of said detectors;

position adjustment devices which adjust positions of said nozzle headers in accordance with positional signals of the cooling rolls along the moving directions of the cooling rolls;

50 strip temperature profile measuring equipment which is installed at the outlet of the cooling rolls and detects the temperature distribution in the strip width; and

a calculation device for strip temperature control which calculates the deviation in temperature with respect to the objective distribution of the strip temperature in accordance with the temperature signal put out from said measuring equipment, and adjusts the pressure or the flow rate of the cooling gas flowed into the nozzle headers in response to said temperature deviation.

55 48. The as claimed in claim 47, characterized by auxiliary gas jet cooling equipment which has three or more nozzle headers along the strip width disposed to the metal strip at the outlet of the cooling rolls and at least one of said nozzle header being movable along the strip width and the strip temperature profile measuring equipment disposed

at the outlet of said auxiliary gas jet cooling equipment.

49. The equipment as claimed in claim 48, characterized in that at least two of the nozzle headers for the strip edges of the auxiliary gas jet cooling equipment are respectively movable along the strip width.

50. The equipment as claimed in claim 47, characterized in that the nozzle widths Be of the nozzle headers at both sides of the gas jet cooling equipment and/or the auxiliary gas jet cooling equipment satisfy the relations of the under formulae 1 and 2 and the nozzle width Bc of the center nozzle header satisfies the relation of the under formula 3

$$[1] \quad 6 \leq Be - \left(\frac{\Delta W}{2} - 0.9 Lo \frac{V}{S} \right) \leq 45$$

herein, $t < 1.3\text{mm}$

$$[2] \quad 12t - 9.6 \leq Be - \left(\frac{\Delta W}{2} - 0.9 Lo \frac{V}{S} \right) \leq 22t + 16.4$$

herein, $t \geq 1.3\text{mm}$

Be : Nozzle width (mm)

t : Strip thickness (mm)

ΔW : Width changing amount (mm) of the metal strip

Lo : Passing length (m) between the rolls in a heat treating furnace after the cooling apparatus

V : Moving speed (mm/min) of the nozzle header in the roll length (or in the strip width)

S : Line speed (mpm)

$$[3] \quad 0.09 W \leq Bc \leq 0.27 W$$

Bc : Nozzle width (mm)

W : (Strip width (mm))

51. The equipment as claimed in claim 47 characterized by at least the nozzle headers located at both strip edges comprising a plurality of the header bodies connected along the roll axis and movable along the roll axis.

52. The equipment as claimed in claim 51, characterized by auxiliary gas jet cooling equipment which has three or more nozzle headers in the strip width disposed to the metal strip at the outlet of the cooling rolls, and move along the strip width at least nozzle headers located at both strip edges comprising a plurality of header bodies connected along the strip width, and gas adjusting device for adjusting the pressure and the flow rate of a cooling gas flowed into each nozzle header.

53. The equipment as claimed in claim 51, characterized in that in case the nozzle headers located at both strip edges of the gas jet cooling equipment and/or the auxiliary gas jet cooling equipment comprise three or more header bodies, the widths Beo of the headers bodies at the outermost side of said three or more header bodies satisfy the relation of the under formula 4, and the width Bec of the center header bodies thereof satisfy the relations of the under formulae 5 and 6, the width Bei of the header bodies at the innermost side thereof satisfy the relation of the under formula 7, and the width Bc of the nozzle header located at the center of the metal strip satisfy the relation of the under formula 3

$$[4] \quad Beo \geq \Delta Wu / 2$$

ΔWu : Changing amount (mm) of the strip width when connecting the strips from the small width to the large width

$$[5] \quad 6 \leq Bec \leq 45$$

herein, $t < 1,3\text{mm}$

$$[6] \quad 12t - 9.6 \leq B_{ec} \leq 22t + 16.4$$

herein, $t \geq 1.3\text{mm}$

t : Strip thickness

$$[7] \quad B_{ei} \geq \Delta Wd/2$$

ΔWd : Changing amount (mm) of the strip width when connecting the strips from the large width to the small width

$$[3] \quad 0.09 W \leq B_c \leq 0.27 W$$

B_c : Nozzle width (mm)

W : Strip width (mm)

54. The equipment as claimed in claim 1, characterized in that the cooling rolls to be used therein are provided with a plurality of coolant passages formed in the same plane side of the interior of said rolls.

55. The equipment as claimed in claim 1, characterized in that the plurality of cooling rolls to be used therein are disposed along the metal strip passing line, and in case the metal strip is cooled by wrapping therearound, the flowing direction of the coolant in the passage of each cooling roll is inverted per one piece to build the structure for supplying said coolant.

56. The equipment as claimed in claim 1, characterized in that further nozzle headers of an auxiliary gas cooling equipment are provided at the inlet of a roll quenching equipment for cooling a metal strip by wrapping around one or more rolls which are cooled at the interior thereof, said nozzle headers being opposite the metal strip and being located two or more in the strip width, and at least such nozzle headers located at both strip edges comprising a plurality of header bodies connected along the strip width, where at least one nozzle header is movable along the strip width.

57. The equipment as claimed in claim 56, characterized by, said further nozzle headers being opposite the metal strip and being located two or more in the strip width, And at least such nozzle headers installed at both strip edges comprising header bodies which are divided into two or more in the strip running direction, where each of said nozzle headers is independently movable along the strip width.

58. The equipment as claimed in claim 56, characterized by said further nozzle headers which are provided with nozzles for impinging gas to the metal strip being not less than one, the width of which is narrower than that of the metal strip, and moving beds which move said nozzle headers in the direction transverse with the strip surface and/or in the direction of the strip width.

59. The equipment as claimed in claim 56, characterized by, said further nozzle headers being two or three which are provided with nozzles for impinging gas to the metal strip, the width of which is narrower than that of the metal strip, and moving beds which move said nozzle headers in the direction transverse with the strip surface and along the direction of the strip width.

60. The equipment as claimed in claim 56, characterized by, said further nozzle headers being three, which are provided with nozzles for impinging gas to the metal strip, the width of which is smaller than that of the metal strip, and moving beds which support the nozzle headers for the center of the metal strip are movable only in the direction transverse with the strip surface, and the moving beds for supporting the nozzle headers for both strip edges are movable in the direction transverse with the strip surface and along the direction along the strip width.

61. The equipment as claimed in claim 58, characterized by providing said nozzle headers and moving beds at one side of the metal strip or both sides thereof.

62. The equipment as claimed in claim 58, characterized in that the metal strip passing line is horizontal or vertical.

63. The equipment as claimed in claim 56, characterized by said further nozzle headers being movable in parallel to the strip surface and along the strip, and providing, along the passing line, nozzle headers which are disposed to said rails and whose width is narrower than that of the metal strip, said nozzle header having nozzles for impinging gas to the metal strip, and providing traveling mechanisms for moving said carts and flexible or expansion joints on the part of the gas supplying channel.

64. A method for cooling metal strips, said method comprising:

wrapping the metal strip around at least one cooling roll and adjusting a wrapping length between said strip and the respective cooling roll by moving the roll, using gas jet cooling equipment provided with nozzle means which are opposite the respective roll via the strip so as to cool the strip on its rear surface by impinging the cooling gas from the nozzle means,

characterized by

using one or more nozzle headers which are movable in the moving direction of the respective roll and along the roll axis and having a width narrower than that of the strip, adjusting the wrapping length so as to adjust the average strip temperature or the temperature in the strip center based on the deviation from an objective strip temperature, always observing a temperature distribution in the strip width at at least one side of the inlet or outlet of the cooling roll(s), while adjusting the separating distance between the strip and nozzle headers in accordance with the position of the roll(s) and the nozzle headers, and moving the nozzle headers to a position where the temperature deviation occurring against said objective temperature distribution, thereby to control the strip temperature distribution based on the deviation.

65. The method as claimed in claim 64, characterized by adjusting the pressure and the flow rate of the cooling gas flowed into the nozzle headers based on said temperature deviation, thereby to control the strip temperature distribution based on the deviation.

66. The method as claimed in claim 64, characterized in that the two nozzle headers are provided to the gas jet cooling equipment, and these nozzle headers are moved with respect to controlling of the strip temperature distribution based on the deviation occurring against the objective strip temperature distribution, aiming at the part of deviations occurring against the objective strip temperatures at both strip edges, so as to cancel the deviation.

67. The method as claimed in claim 66, characterized by, installing, other than said two nozzle headers provided to said gas jet cooling equipment, nozzle headers for the strip center at a position corresponding to the center in the strip width, said nozzle headers being only movable in the moving directions of the cooling roll and immovable along the roll axis, and at the center nozzle headers only adjusting the pressure and the flow rate of the cooling gas flowed into the header based on the temperature deviation occurring against the objective strip temperature distribution with respect to controlling of the strip temperature distribution based on said deviation so as to impinge the cooling gas to the metal strip.

68. The method as claimed in claim 64, characterized by providing three or more nozzle headers to said gas jet cooling equipment, and

with respect to controlling of average strip temperature or center strip temperature based on the deviation against the objective strip temperature, adjusting the wrapping length between the metal strip and the cooling roll, and

with respect to controlling of the strip temperature distribution based on the deviation from the objective strip temperature distribution, adjusting the separating distance between the metal strip and these nozzle headers in accordance with the position of the cooling rolls and the nozzle headers, always observing a temperature distribution in the strip width at least at the inlet or outlet of the cooling rolls, moving the edge-positioned nozzle headers to both strip edges such that cooling widths are to be as shown with the under formulae 8 and 9, moving the center position of the center positioned nozzle header to set to the center position in the strip width such that the cooling width is to be as shown with the under formula 10, always observing the temperature distribution in the strip width at the outlet of the cooling rolls, and adjusting the pressure and the flow rate of

the cooling gas flowed into the nozzle header so as to impinging the cooling gas to the strip metal

$$[8] \quad 6 \leq W_E \leq 45$$

herein, $t < 1.3 \text{ mm}$

$$[9] \quad 12t - 9.6 \leq W_E \leq 22t + 16.4$$

herein, $t \geq 1.3 \text{ mm}$

W_E : Cooling width (mm) of the nozzle headers at both strip edges

t : Strip thickness (mm)

$$[10] \quad 0.09B \leq W_C \leq 0.27B$$

W_C : Cooling width (mm) of the center nozzle headers

B : Strip width (mm)

69. The method as claimed in claim 68, characterized by using auxiliary gas jet cooling equipment disposed at the outlet of the cooling rolls and provided, at the upper and rear surfaces of the metal strip, with three or more nozzle headers movable along the strip width, moving the edge-positioned nozzle headers of the gas cooling equipment and the auxiliary gas cooling equipment to both strip edges such that cooling widths are to be as shown with said formulae 8 and 9.

70. The method as claimed in claim 69, characterized by always observing the temperature distribution in the strip width at the outlet of the cooling rolls, respectively obtaining positions in the center of gravity of the deviation in the strip temperature at a range where the temperature deviation occurs in the edges and the center of the metal strip with respect to the objective strip temperature, moving the nozzle headers at the edges of the gas jet cooling equipment or the gas jet cooling equipment and the auxiliary gas jet cooling equipment such that a twice length of the distance from the strip edge to said center of gravity is the cooling width at the strip edges, moving the center nozzle header such that center position thereof agrees to the center of gravity at the center of the strip width, and impinging the cooling gas to the metal strip from each of the nozzle headers.

Patentansprüche

1. Vorrichtung zum Kühlen von Metallbändern, welche das Metallband (X) um mindestens eine Kühlwalze (#1 - #4) wickelt und eine Wickellänge zwischen dem Metallband (X) und der jeweiligen Kühlwalze (#1 - #4) durch Bewegen der Kühlwalze (#1) einstellt, und eine Gasstrahlkühlvorrichtung mit einer der Rückseite des gewickelten Bandabschnitts (X) zugewandten Düseneinrichtung (α_1) aufweist und zu dem Metallband (X) verschiebbar ist, und weiterhin eine Gaseinstellvorrichtung (87) enthält, welche Druck oder Strömungsrate eines in die Düseneinrichtung (α_1) strömenden Kühlgases einstellt, dadurch gekennzeichnet, daß die Gaskühleinrichtung mehr als einen Düsenkopf ($\alpha_a, \alpha_b, \dots$) aufweist, die in der Richtung der Walzenachse der jeweiligen Kühlwalze (#1 - #4) angeordnet und schmaler als das Metallband (X) und jeweils längs der Bewegungsrichtung der jeweiligen Kühlwalze (#1 - #4) bewegbar sind, und wobei mindestens einer der Düsenköpfe ($\alpha_a, \alpha_b, \dots$) längs der Walzenachse bewegbar ist.
2. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß Düsenmündungen der Düsenköpfe in eine Durchlaufelinie des Metallbandes unter einem rechten Winkel kreuzenden Schlitten gebildet und in einer Reihe längs der Durchlaufelinie angeordnet sind.
3. Vorrichtung nach Anspruch 2, dadurch gekennzeichnet, daß eine Innenkante der Düsenmündung R-förmig ist oder sich in ihrem Querschnitt verjüngt.

4. Vorrichtung nach Anspruch 2, dadurch gekennzeichnet, daß die Düsenmündung auswärts vorspringt.
5. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß es zwei Düsenköpfe gibt, welche an den Kanten in der Bandbreite angeordnet sind.
- 5 6. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß es drei Düsenköpfe gibt, von welchen einer im Zentrum der Breite des Bandes und die anderen beide an den Kanten in der Bandbreite angeordnet sind.
- 10 7. Vorrichtung nach Anspruch 1 oder 6, dadurch gekennzeichnet, daß eine Anzahl von Kühlwalzen angebracht sind, wobei mindestens die erste Kühlwalze davon drei Düsenköpfe hat, von denen einer im Zentrumsbereich der Bandbreite angeordnet ist und die anderen zwei an den Kanten des Bandes angeordnet sind.
- 15 8. Vorrichtung nach Anspruch 1 oder 6, dadurch gekennzeichnet, daß eine Anzahl von Kühlwalzen angebracht sind, wobei mindestens die Kühlwalzen eines Eingangsabschnitts jeweils drei Düsenköpfe haben, von denen einer im Zentrumsbereich der Breite des Bandes angeordnet ist und die anderen zwei an den Kanten des Bandes angeordnet sind, und die Kühlwalzen eines Abgabeabschnitts jeweils zwei Düsenköpfe haben.
- 20 9. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die zumindest der ersten Kühlwalze gegenüberliegenden Düsenköpfe gleichzeitig mit dem Beginn des Kontakts zwischen der Kühlwalze und dem Metallband von einem zurückgezogenen Ort zu der Durchlaufinie des Metallbandes bewegt werden, und wenn der Verschiebungshub der Kühlwalze länger als der zur Zeit des Kontakts ist, die Düsenköpfe im Sinne eines Beibehaltens erforderlicher Abstandsentfernungen von dem Metallband bewegt werden, und wenn das Metallband nicht im Kontakt mit der Kühlwalze ist, die Düsenköpfe bis zu dem zurückgezogenen Ort bewegt werden.
- 25 10. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß in dem Fall, daß eine Anzahl von Kühlwalzen vorgesehen sind, die anderen Düsenköpfe als die zumindest der ersten Kühlwalze gegenüberliegenden Düsenköpfe so ausgebildet sind, daß eine maximale Länge des Düsenkopfes durch einen maximalen Verschiebungshub der folgenden Walze erhalten wird, und sich die Düsenköpfe gleichzeitig mit dem Beginn des Kontakts zwischen der Kühlwalze und dem Metallband von dem zurückgezogenen Ort zu der Durchlaufinie des Metallbandes bewegen, und sich danach nicht bewegen, selbst wenn der Verschiebungshub der Kühlwalze lang ist, und der Düsenkopf zu dem zurückgezogenen Ort zurückgenommen wird bevor das Metallband und die Kühlwalze außer Kontakt kommen.
- 30 11. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß in dem Fall, daß eine Anzahl von Kühlwalzen vorgesehen sind, ein um so längerer Verschiebungshub genommen wird, je mehr sich die Kühlwalze dem Eingangsabschnitt nähert.
- 35 12. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß in dem Fall, daß eine Anzahl von Kühlwalzen vorgesehen sind, sich die Kühlwalze um so mehr dem Eingangsabschnitt nähert, je länger der Verschiebungshub der Walze ist, und in Bezug auf den der Kühlwalze gegenüberliegenden Düsenkopf die Gasstrahlrate sich dem Maximum nähert, je mehr sich der Düsenkopf dem Eingangsabschnitt nähert.
- 40 13. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß in dem Fall, daß eine Anzahl von Düsenköpfen längs der Walzenachse vorgesehen sind, die Beträge der Bewegung der Düsenköpfe jeweils in Bewegungsrichtung der Kühlwalzen variiert werden, und die Abstände zwischen den Düsenköpfen und den Kühlwalzen jeweils bezüglich der Walzenachse variiert werden.
- 45 14. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß zwei oder mehr Düsenköpfe in der Richtung der Walzenachse der Kühlwalze über dem Metallband angeordnet sind, wobei die Düsenköpfe längs der Bewegungsrichtungen der Kühlwalzen bewegbar sind, und zumindest die an beiden Bandkanten angeordnete Walzenkühlvorrichtung solche Düsenköpfe aufweist, welche aus mehreren Düsenkopfkörpern gebildet sind, die längs der Länge der Walzen verbunden und schmaler als das Metallband sind.
- 50 15. Vorrichtung nach Anspruch 14, dadurch gekennzeichnet, daß die Düsenköpfe aus mehreren an beiden Bandkanten angeordneten und bezüglich der Walzenachse verbundenen Düsenkopfkörpern gebildet sind, und die verbundenen Düsenkopfkörper weiterhin in mehreren Stufen längs der Bandlaufrichtung vorgesehen sind, und die Position jeder Düsenmündung der Düsenkopfkörper längs der Walzenachse an der Eingangsseite und der Abgabe-
55 seite abweicht.

16. Vorrichtung nach Anspruch 14, dadurch gekennzeichnet, daß die Düsenköpfe aus mehreren an beiden Bandkanten angeordneten und in der Walzenachse verbundenen Düsenkopfkörpern gebildet sind, und die verbundenen Düsenkopfhauptkörper im Sinne eines Gleitens der Düsenmündungen entlang der Bandlaufrichtung angeordnet sind.
17. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß zwei oder mehr Düsenköpfe in der Richtung der Walzenachse an den Kühlwalzen über dem Metallband vorgesehen und in zwei oder mehr in Bandlaufrichtung unterteilt sind, und mindestens die an den beiden Bandkanten vorgesehene Walzenkühlvorrichtung aus solchen Düsenköpfen gebildet ist, welche eine schmälere Breite als die Breite des Bandes haben und unabhängig längs der Walzenachse bewegbar sind.
18. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Spannung des Metallbandes erhöht wird bevor die Kühlwalze mit dem Metallband in Kontakt kommt, wodurch die Form des Bandes beim Kontakt stabilisiert wird.
19. Vorrichtung nach Anspruch 7, gekennzeichnet durch:
- eine Zieldüsenpositionsberechnungseinrichtung für eine Bandbreitenänderung,
einen Bandkantenpositionsdetektor, und eine Bandtemperaturprofilmeßvorrichtung,
die am Einlaß der Kühlwalzen vorgesehen sind, und wobei die Düsenköpfe für die Bandkanten auf die Kanten der Bandbreite eingestellt werden, indem eine Information des Breitenänderungsbruchteils oder -betrags von dort erhalten wird.
20. Vorrichtung nach Anspruch 19, dadurch gekennzeichnet, daß wenn ein Schweißpunkt als Verbindungsbereich von verschiedenen Breiten in den Einlaß der Kühlwalzen gelangt, diese Information vorher vom Einlaß der Linie erhalten wird, wobei, wenn das Band sich von einer schmalen Breite zu einer breiten Breite ändert, die Düsenköpfe für die Bandkanten auf die Kanten des Bandes der breiten Breite eingestellt worden sind bevor der Schweißpunkt in den Einlaß der Kühlwalzen gelangt, und bei einer Änderung von der breiten Breite zu der schmalen Breite die Düsenköpfe auf die Kanten des Streifens der breiten Breite eingestellt werden nachdem der Schweißpunkt in den Einlaß der Kühlwalzen eingetreten ist.
21. Vorrichtung nach Anspruch 7, dadurch gekennzeichnet, daß die Streifentemperaturprofilmeßvorrichtung am Auslaß der Kühlwalzen angebracht ist, und entsprechend der Information davon die Düsenköpfe für die Bandkanten der Gasstrahlkühlvorrichtung auf die Kanten in der Breite des Bandes eingestellt werden.
22. Vorrichtung nach Anspruch 7, dadurch gekennzeichnet, daß die Bandtemperaturprofilmeßvorrichtung an den Auslässen der Kühlwalzen vorgesehen ist, um dadurch entsprechend der Information davon den Druck oder die Strömungsrate des Kühlgases der Düsenköpfe der Gasstrahlkühlvorrichtung für die Bandkanten einzustellen.
23. Kühlvorrichtung nach Anspruch 7 oder 19, dadurch gekennzeichnet, daß die Bandtemperaturprofilmeßvorrichtung am Auslaß der Kühlwalzen vorgesehen ist, und entsprechend der Information die Düsenköpfe der Gasstrahlkühlvorrichtung für die Bandkanten auf die Kanten in der Bandbreite eingestellt werden, um dadurch den Druck oder die Strömungsrate des Kühlgases der Düsenköpfe der Gasstrahlkühlvorrichtung für die Bandkanten einzustellen.
24. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß:
- die Gasstrahlkühlvorrichtung mit zwei Düsenköpfen versehen ist, welche an Kanten in der Bandbreite in Richtung der Walzenachse an den Kühlwalzen über dem Metallband angeordnet und schmaler als das Metallband sind,
eine Hilfsgaskühlvorrichtung mit zwei oder mehr Gasstrahldüsenköpfen in der Bandbreite vorgesehen ist, die es gestattet die an zumindest beiden Bandkanten angeordneten Düsenköpfe längs der Streifenbreite zu bewegen, und
wobei die Gaseinstelleinrichtungen für die Hilfsgaskühlvorrichtung den Druck oder die Strömungsrate des in jeden Düsenkopf strömenden Kühlgases einstellen.
25. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß:
- die Gasstrahlkühlvorrichtung mit drei Düsenköpfen versehen ist, welche im Zentrum und an den Kanten in der Bandbreite in der Richtung der Walzenachse an den Kühlwalzen über dem Metallband angeordnet und

schmäler als das Metallband sind, wobei die Düsenköpfe zumindest an beiden Kanten längs der Walzenachse bewegbar sind,

eine Hilfsgaskühlvorrichtung mit zwei oder mehr Gasstrahldüsenköpfen in der Streifenbreite vorgesehen ist, die es gestattet die an zumindest beiden Streifenkanten vorgesehenen Düsenköpfe längs der Streifenbreite zu bewegen, und

die Gaseinstelleinrichtungen für die Hilfsgaskühlvorrichtung den Druck oder die Strömungsrate des in jeden Düsenkopf strömenden Kühlgases einstellen.

26. Vorrichtung nach Anspruch 25, dadurch gekennzeichnet, daß die Gasstrahlkühlvorrichtung mit drei Düsenköpfen versehen ist, welche im Zentrum und an den Kanten in der Bandbreite in Richtung der Walzenachse an mindestens der ersten Kühlwalze von den Kühlwalzen über dem Metallband angeordnet sind.

27. Vorrichtung nach Anspruch 25, dadurch gekennzeichnet, daß die Gasstrahlkühlvorrichtung mit drei Düsenköpfen versehen ist, welche im Zentrum und an den Kanten in der Bandbreite in Richtung der Walzenachse an mindestens den Kühlwalzen in einem Eingangsabschnitt der Kühlwalzen über dem Metallband angeordnet sind.

28. Vorrichtung nach Anspruch 26, dadurch gekennzeichnet, daß mindestens zwei Düsenköpfe für die Bandkanten in der Hilfsgasstrahlkühlvorrichtung längs der Bandbreite bewegbar sind.

29. Vorrichtung nach Anspruch 24, dadurch gekennzeichnet, daß mindestens die an beiden Kanten angeordneten Düsenköpfe unter den Düsenköpfen der am Auslaß der Kühlwalzen angeordneten Hilfsgasstrahlkühlvorrichtung eine Anzahl von längs der Bandbreite verbundenen Düsenköpfenkörpern umfassen, und mindestens einer der Düsenköpfe längs der Bandbreite bewegbar ist.

30. Vorrichtung nach Anspruch 24, dadurch gekennzeichnet, daß mindestens an beiden Bandkanten angeordnete Düsenköpfe unter den Düsenköpfen der am Auslaß der Kühlwalzen angeordneten Hilfsgasstrahlkühlvorrichtung in zwei oder mehr in der Laufrichtung des Metallbandes unterteilt sind, und die Düsenköpfe unabhängig längs der Bandbreite bewegbar sind.

31. Vorrichtung nach Anspruch 1, 14 oder 17, dadurch gekennzeichnet, daß sie zwei oder mehr Düsenköpfe aufweist, die mit Düsen zum Einwirken des Gases auf das Metallband versehen sind, deren Breite schmaler als die Bandbreite ist, und welche eine Bewegungsbettung zum Bewegen des Düsenkopfes in der Querrichtung zur Bandoberfläche und/oder längs der Bandbreite aufweist.

32. Vorrichtung nach Anspruch 31, dadurch gekennzeichnet, daß in dem Fall, daß es zwei oder drei Düsenköpfe in der Breite des Bandes gibt, die Bewegungsbettungen davon in der Querrichtung zur Bandoberfläche und längs der Bandbreite bewegbar sind.

33. Vorrichtung nach Anspruch 31, dadurch gekennzeichnet, daß in dem Fall, daß es drei Düsenköpfe in der Bandbreite gibt, die Bewegungsbettung zum Bewegen des mittleren Düsenkopfes nur in Querrichtung zur Bandoberfläche bewegbar ist, und die Bewegungsbettungen zum Bewegen der rechten und linken Düsenköpfe in Querrichtung zur Bandoberfläche und in Richtung der Bandbreite bewegbar sind.

34. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Durchlaufinie des Metallbandes der Walzenkühlvorrichtung horizontal oder vertikal ist.

35. Vorrichtung nach Anspruch 26, dadurch gekennzeichnet, daß als Hilfsgasstrahlkühlvorrichtung zwei oder mehr Düsenköpfe vorgesehen werden, deren Breite schmaler als die Bandbreite ist, wobei die Düsenköpfe mit Düsen zum Einwirken von Gas auf das Metallband versehen sind, und mit Bewegungsbettungen, welche die Düsenköpfe in Richtung quer zur Bandoberfläche und/oder in der Bandbreite bewegen.

36. Vorrichtung nach Anspruch 35, dadurch gekennzeichnet, daß in dem Fall, daß Düsenköpfe und Bewegungsbettungen als Hilfsgasstrahlkühlvorrichtung vorgesehen sind, die Düsenköpfe und Bewegungsbettungen für beide Oberflächen des Metallbandes vorgesehen sind.

37. Vorrichtung nach Anspruch 35, dadurch gekennzeichnet, daß die Durchlaufinie des Metallstreifens horizontal oder vertikal ist.

38. Vorrichtung nach Anspruch 26, dadurch gekennzeichnet, daß als Hilfsgasstrahlkühlvorrichtung eine Bewegungseinrichtung vorgesehen ist, welche parallel zur Bandoberfläche und längs der Bandbreite bewegbar ist, die Düsenköpfe mit den Düsen zum Einwirken des Gases auf das Metallband verteilt sind, die Düsenköpfe an der Bewegungseinrichtung vorgesehen sind, deren Breite schmaler als die Bandbreite ist, wobei sie einen Antriebsmechanismus zum Bewegen der Bewegungseinrichtung aufweist, und flexible Teile oder dehnbare Verbindungen an einem Teil eines Gaszuführungskanals vorgesehen sind.

39. Vorrichtung nach Anspruch 38, dadurch gekennzeichnet, daß die Bewegungseinrichtungen vorgesehen sind, die Düsenköpfe an den Bewegungseinrichtungen befestigt sind, und die Gaszuführungskanäle an den Düsenköpfen befestigt sind und Verbindungen haben, die flexibel oder ausdehnbar in Bezug auf beide Oberflächen des Metallbandes sind.

40. Vorrichtung nach Anspruch 38, dadurch gekennzeichnet, daß die Düsenköpfe zum Einwirken des Gases um das Zentrum des Bandes angeordnet sind.

41. Vorrichtung nach Anspruch 38, dadurch gekennzeichnet, daß die Durchlaufinie des Metallstreifens horizontal oder vertikal ist.

42. Vorrichtung nach Anspruch 26, dadurch gekennzeichnet, daß am Einlaß der Kühlwalzen angeordnet sind:

eine Zieldüsenpositionsberechnungseinrichtung für eine Änderung der Bandbreite, ein Bandkantenpositionsdetektor, und eine Bandtemperaturprofilmeßvorrichtung, die eine Information über einen breitenändernden Schweißpunkt und den breitenändernden Betrag entsprechend der Information davon erhalten, um dadurch jeweils die Düsenköpfe der Gasstrahlkühlvorrichtung für die Bandkanten und die zwei Düsenköpfe der Hilfsgasstrahlkühlvorrichtung für die Bandkanten einzustellen.

43. Vorrichtung nach Anspruch 42, dadurch gekennzeichnet, daß in dem Fall, daß ein besonderer Punkt als Schweißbereich von verschiedenen Breiten in den Einlaß der Kühlwalzen gelangt, diese Information vorher am Einlaß der Linie erhalten wird, und wenn das Band sich von der schmalen Breite zu der breiten Breite ändert, die Düsenköpfe der Gasstrahlkühlvorrichtung für die Bandkanten und die zwei Düsenköpfe der Hilfsgasstrahlkühlvorrichtung für die Bandkanten jeweils auf die Bandkanten eingestellt worden sind bevor der besagte besondere Punkt in den Einlaß der Kühlwalzen gelangt, und wenn das Band sich von der breiten Breite zu der schmalen Breite ändert, diese Düsenköpfe jeweils auf die Bandkanten der schmalen Breite eingestellt werden nachdem der besagte besondere Punkt in den Einlaß der Kühlwalzen gelangt.

44. Vorrichtung nach Anspruch 24, dadurch gekennzeichnet, daß die Bandtemperaturprofilmeßvorrichtung am Auslaß der Hilfsgasstrahlkühlvorrichtung angebracht ist, und entsprechend der Information davon die Düsenköpfe der Gasstrahlkühlvorrichtung für die Bandkanten und die zwei Düsenköpfe der Hilfsgasstrahlkühlvorrichtung für die Bandkanten jeweils auf die Bandkanten eingestellt werden.

45. Vorrichtung nach Anspruch 24, dadurch gekennzeichnet, daß die Bandtemperaturprofilmeßvorrichtung am Ausgang der Hilfsgasstrahlkühlvorrichtung angebracht ist, um dadurch entsprechend der Information davon den Druck oder die Strömungsrate des Kühlgases in den Düsenköpfen der Gasstrahlkühlvorrichtung und der Hilfsgasstrahlkühlvorrichtung einzustellen.

46. Vorrichtung nach Anspruch 24, dadurch gekennzeichnet, daß die Bandtemperaturprofilmeßvorrichtung am Ausgang der Hilfsgasstrahlkühlvorrichtung angebracht ist, und entsprechend der Information davon die Düsenköpfe der Gasstrahlkühlvorrichtung für die Kanten und die zwei Düsenköpfe der Hilfsgasstrahlkühlvorrichtung für die Kanten jeweils auf die Bandkanten eingestellt werden, um dadurch den Druck oder die Strömungsrate des Kühlgases in jedem Düsenkopf einzustellen.

47. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Gasstrahlkühlvorrichtung mit mindestens drei Düsenköpfen versehen ist, die in der Walzenachse an den Kühlwalzen angeordnet sind, wobei die Düsenköpfe längs der Bewegungsrichtungen der Kühlwalzen bewegbar sind, und mindestens ein Düsenkopf längs der Walzenachse bewegbar ist; und durch

Bandkantenpositionsdetektoren zum Erfassen der Bandkanten des Metallbandes; Positionseinstelleinrichtungen, welche Bewegungen der bewegbaren Düsenköpfe unter den Düsenköpfen

längs der Walzenachse einstellen;
 eine Berechnungseinrichtung zur Düsenkopfpositionssteuerung, welche die Positionseinstelleinrichtungen entsprechend den von den Detektoren erfaßten Signalen steuert;
 Positionseinstelleinrichtungen, welche die Positionen der Düsenköpfe entsprechend Positionssignalen der
 5 Kühlwalzen längs der Bewegungsrichtungen der Kühlwalzen einstellen;
 eine Bandtemperaturprofilmeßvorrichtung, welche am Auslaß der Kühlwalzen angebracht ist und die Temperaturverteilung in der Bandbreite erfaßt; und
 eine Berechnungseinrichtung zur Bandtemperatursteuerung, welche die Abweichung der Temperatur in Bezug auf die angestrebte Verteilung der Bandtemperatur entsprechend dem von der Meßvorrichtung ausgegebenen
 10 Temperatursignal berechnet und den Druck oder die Strömungsrate des in die Düsenköpfe strömenden Kühlgases entsprechend der Temperaturabweichung einstellt.

48. Vorrichtung nach Anspruch 47, gekennzeichnet durch eine Hilfsgasstrahlkühlvorrichtung, welche drei oder mehr
 15 Düsenköpfe längs der Bandbreite aufweist, die am Ausgang der Kühlwalzen an dem Metallband angeordnet sind, und wobei mindestens einer der Düsenköpfe längs der Bandbreite beweglich ist und die Bandtemperaturprofilmeßvorrichtung am Ausgang der Hilfsgasstrahlkühlvorrichtung angeordnet ist.

49. Vorrichtung nach Anspruch 48, dadurch gekennzeichnet, daß mindestens zwei der Düsenköpfe der Hilfsgasstrahl-
 20 kühlvorrichtung für die Bandkanten jeweils längs der Bandbreite bewegbar sind.

50. Vorrichtung nach Anspruch 47, dadurch gekennzeichnet, daß die Düsenbreite Be der Düsenköpfe an beiden Seiten der Gasstrahlkühlvorrichtung und/oder der Hilfsgasstrahlkühlvorrichtung die Beziehungen der untenstehenden
 25 Formeln 1 und 2 und die Düsenbreite Bc des mittleren Düsenkopfs die Beziehung der unten stehenden Formel 3 erfüllen.

$$(1) \quad 6 \leq Be - \left(\frac{\Delta w}{2} - 0,9 Lo \frac{V}{S} \right) \leq 45$$

wobei $t < 1,3 \text{ mm}$

$$(2) \quad 12 t - 9,6 \leq Be - \left(\frac{\Delta w}{2} - 0,9 Lo \frac{V}{S} \right) \leq 22 t + 16,4$$

wobei $t \geq 1,3 \text{ mm}$

Be: Düsenbreite (mm)
 t: Banddicke (mm)
 Δw : Breitenänderungsbetrag (mm) des Metallbandes
 Lo: Durchlauflänge (m) zwischen den Walzen in einem Wärmebehandlungssofen hinter der Kühlvorrichtung
 40 V: Bewegungsgeschwindigkeit (mm/min) des Düsenkopfs in der Walzenlänge (oder in der Bandbreite)
 S: Liniengeschwindigkeit (m/min)

$$(3) \quad 0,09 W \leq Bc \leq 0,27 W$$

Bc: Düsenbreite (mm)
 W: Bandbreite (mm)

51. Vorrichtung nach Anspruch 47, dadurch gekennzeichnet, daß mindestens die an beiden Bandkanten angeordneten
 50 Düsenköpfe eine Anzahl von Düsenkopfkörpern enthalten, die längs der Walzenachse verbunden und längs der Walzenachse bewegbar sind.

52. Vorrichtung nach Anspruch 51, gekennzeichnet durch eine Hilfsgasstrahlkühlvorrichtung, welche drei oder mehr
 55 Düsenköpfe in der Bandbreite aufweist, die am Auslaß der Kühlwalzen an dem Metallband angeordnet sind, und längs der Bandbreite mindestens an beiden Bandkanten angeordnete Düsenköpfe bewegen, die eine Anzahl von längs der Bandbreite verbundenen Düsenkopfkörpern enthalten, sowie eine Gaseinstelleinrichtung zum Einstellen des Drucks und der Strömungsrate eines in jeden Düsenkopf strömenden Kühlgases.

53. Vorrichtung nach Anspruch 51, dadurch gekennzeichnet, daß in dem Fall, daß die an beiden Bandkanten angeordneten Düsenköpfe der Gasstrahlkühlvorrichtung und/oder der Hilfsgasstrahlkühlvorrichtung drei oder mehr Düsenkopfkörper enthalten, wobei die Breite Beo der Düsenkopfkörper an der äußersten Seite der drei oder mehr Düsenkopfkörper die Beziehung der untenstehenden Formel 4 erfüllen, und die Breite Bec der mittleren Düsenkopfkörper davon die Beziehungen der untenstehenden Formeln 5 und 6 erfüllen, die Breite Bei der Düsenkopfkörper an der innersten Seite davon die Beziehung der untenstehenden Formel 7 erfüllen, und die Breite Bc des am Zentrum des Metallbandes angeordneten Düsenkopfs die Beziehung der untenstehenden Formel 3 erfüllen.

$$(4) \quad Beo \geq \Delta Wu/2$$

ΔWu : Änderungsbetrag (mm) der Bandbreite beim Verbinden der Bänder von der kleinen Breite zu der großen Breite

$$(5) \quad 6 \leq Bec \leq 45$$

wobei $t < 1,3$ mm

$$(6) \quad 12t - 9,6 \leq Bec \leq 22t + 16,4$$

wobei $t \geq 1,3$ mm

t: Streifendicke

$$(7) \quad Bei \geq \Delta Wd/2$$

ΔWd : Änderungsbetrag (mm) der Bandbreite beim Verbinden der Bänder von der großen Breite zu der kleinen Breite

$$(3) \quad 0,09 W \leq Bc \leq 0,27 W$$

Bc: Düsenbreite (mm)

W: Banddicke (mm)

54. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die dabei verwendeten Kühlwalzen mit einer Anzahl von Kühlmittelpassagen versehen sind, die in der gleichen Ebene im Inneren der Walzen ausgebildet sind.

55. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Anzahl von verwendeten Kühlwalzen längs der Durchlaufinie des Metallbandes angeordnet sind, und daß die Struktur zur Zuführung des Kühlmittels so aufgebaut ist, daß beim Kühlen des Metallbandes durch das Herumwickeln die Strömungsrichtung des Kühlmittels in Durchgang einer jeden Kühlwalze für jedes Stück umgekehrt ist.

56. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß weitere Düsenköpfe einer Hilfsgaskühlvorrichtung am Einlaß einer Walzenkühlvorrichtung zum Abkühlen des Metallbandes durch Wickeln um eine oder mehrere an deren Innenseite gekühlte Walzen vorgesehen sind, wobei die Düsenköpfe dem Metallband gegenüberliegen und zwei oder mehr in der Bandbreite angeordnet sind, und mindestens solche Düsenköpfe an beiden Bandkanten angeordnet sind, die eine Anzahl von längs der Bandbreite verbundenen Düsenköpfen umfassen, wobei mindestens ein Düsenkopf längs der Bandbreite bewegbar ist.

57. Vorrichtung nach Anspruch 56, dadurch gekennzeichnet, daß die weiteren Düsenköpfe dem Metallband gegenüberliegen und zwei oder mehr in der Bandbreite angeordnet sind, und mindestens solche Düsenköpfe an beiden Bandkanten angeordnet sind, die Düsenkopfkörper enthalten, welche in zwei oder mehr in der Laufrichtung des Bandes unterteilt sind, wobei jeder der Düsenköpfe unabhängig längs der Bandbreite bewegbar ist.

58. Vorrichtung nach Anspruch 56, dadurch gekennzeichnet, daß die weiteren Düsenköpfe, welche mit Düsen zum Einwirken von Gas auf das Metallband versehen sind, nicht weniger als einer sind, wobei die Breite schmaler als die des Metallbandes ist, und Bewegungsbettungen vorgesehen sind, welche die Düsenköpfe in Richtung quer zur Bandoberfläche und/oder in der Richtung der Bandbreite bewegen.

59. Vorrichtung nach Anspruch 56, dadurch gekennzeichnet, daß es zwei oder drei weitere Düsenköpfe gibt, welche mit Düsen zum Einwirken von Gas auf das Metallband versehen sind, deren Breite schmaler als die des Metallbandes ist, und Bewegungsbettungen vorgesehen sind, welche die Düsenköpfe in der Richtung quer zur Bandoberfläche und längs der Richtung der Bandbreite bewegen.

60. Vorrichtung nach Anspruch 56, dadurch gekennzeichnet, daß es drei weitere Düsenköpfe gibt, welche mit Düsen zum Einwirken von Gas auf das Metallband versehen sind, deren Breite kleiner als die des Metallbandes ist, und Bewegungsbettungen, welche die Düsenköpfe für das Zentrum des Metallbandes tragen, nur in Richtung quer zur Bandoberfläche bewegbar sind, und die Bewegungsbettungen zum Tragen der Düsenköpfe für beide Bandkanten in der Richtung quer zur Bandoberfläche und längs der Richtung längs der Bandbreite bewegbar sind.

61. Vorrichtung nach Anspruch 58, dadurch gekennzeichnet, daß die Düsenköpfe und die Bewegungsbettungen an einer Seite des Metallbandes oder an beiden Seiten davon vorgesehen sind.

62. Vorrichtung nach Anspruch 58, dadurch gekennzeichnet, daß die Durchlaufinie des Metallbandes horizontal oder vertikal ist.

63. Vorrichtung nach Anspruch 56, dadurch gekennzeichnet, daß die weiteren Düsenköpfe parallel zur Bandoberfläche und längs des Bandes bewegbar sind, und daß längs der Durchlaufinie Düsenköpfe vorgesehen sind, welche an den Schienen angeordnet sind und deren Breite schmaler als die des Metallbandes ist, wobei die Düsenköpfe Düsen zum Einwirken von Gas auf das Metallband aufweisen, und daß ein Bewegungsmechanismus zum Bewegen von Wägen und flexiblen oder Ausdehnungsverbindungen an dem Teil des Gaszuführungskanals vorgesehen sind.

64. Verfahren zum Kühlen von Metallbändern, enthaltend:

Wickeln des Metallbandes um mindestens eine Kühlwalze und Einstellen einer Wickellänge zwischen dem Band und der jeweiligen Kühlwalze durch Bewegen der Walze,
Verwendung einer Gasstrahlkühlvorrichtung, die mit gegenüber der jeweiligen Walze über dem Band vorgesehenen Düseneinrichtungen versehen ist, um das Band an seiner rückwärtigen Oberfläche durch Einwirken des Kühlgases von der Düseneinrichtung zu kühlen,

gekennzeichnet durch

Verwenden von einem oder mehreren Düsenköpfen, welche in der Bewegungsrichtung der jeweiligen Walze und längs der Walzenachse bewegbar sind und eine Breite schmaler als die des Bandes haben,
Einstellen der Wickellänge, um die mittlere Bandtemperatur oder die Temperatur im Zentrum des Bandes basierend auf der Abweichung von einer angestrebten Bandtemperatur einzustellen, stetes Beobachten einer Temperaturverteilung in der Bandbreite an mindestens einer Seite des Einlasses oder Auslasses der Kühlwalze(n), wobei die Trennentfernung zwischen dem Band und den Düsenköpfen entsprechend der Position der Walze(n) und der Düsenköpfe eingestellt wird, und Bewegen der Düsenköpfe auf eine Position, wo die Temperaturabweichung gegenüber der angestrebten Temperaturverteilung auftritt, um dadurch die Temperaturverteilung des Bandes basierend auf der Abweichung zu regeln.

65. Verfahren nach Anspruch 64, dadurch gekennzeichnet, daß der Druck und die Strömungsrate des in die Düsenköpfe strömenden Kühlgases basierend auf der Temperaturabweichung eingestellt wird, um dadurch die Temperaturverteilung des Bandes basierend auf der Abweichung zu regeln.

66. Verfahren nach Anspruch 64, dadurch gekennzeichnet, daß zwei Düsenköpfe an der Gasstrahlkühlvorrichtung vorgesehen sind, und diese Düsenköpfe basierend auf der gegenüber der angestrebten Temperaturverteilung des Bandes auftretenden Abweichung zur Steuerung der Temperaturverteilung des Bandes bewegt werden, abzielend auf den gegen die angestrebten Bandtemperaturen an beiden Bandkanten auftretenden Teil der Abweichungen, um so die Abweichung aufzuheben.

67. Verfahren nach Anspruch 66, dadurch gekennzeichnet, daß außer den zwei an der Gasstrahlkühlvorrichtung vorgesehenen Düsenköpfen Düsenköpfe an einer der Mitte der Bandbreite entsprechenden Position Düsenköpfe für die Bandmitte vorgesehen werden, wobei diese Düsenköpfe nur in den Bewegungsrichtungen der Kühlwalze bewegbar und längs der Walzenachse unbewegbar sind, und daß an den mittleren Düsenköpfen nur der Druck und die Strömungsrate des in die Düsenköpfe fließenden Kühlgases eingestellt werden basierend auf der Temperaturabweichung, die gegenüber der angestrebten Bandtemperaturverteilung auftritt in Bezug auf die Steuerung der Bandtemperaturverteilung basierend auf der Abweichung, um das Kühlgas auf das Metallband einwirken zu lassen.

68. Verfahren nach Anspruch 64, dadurch gekennzeichnet, daß

drei oder mehr Düsenköpfe an der Gasstrahlkühlvorrichtung vorgesehen werden, und daß in Bezug auf die Steuerung der mittleren Bandtemperatur oder die Temperatur in der Mitte des Bandes basierend auf der Abweichung gegenüber der angestrebten Bandtemperatur die Wikkellänge zwischen dem Metallband und der Kühlwalze eingestellt wird, und daß in Bezug auf die Steuerung der Bandtemperaturverteilung basierend auf der Abweichung von der angestrebten Bandtemperaturverteilung die Trennentfernung zwischen dem Metallband und diesen Düsenköpfen entsprechend der Position der Kühlwalzen und der Düsenköpfe eingestellt wird, wobei stets die Temperaturverteilung in der Bandbreite mindestens am Einlaß oder Auslaß der Kühlwalzen beobachtet wird, die an den Kanten positionierten Düsenköpfe an beiden Bandkanten so bewegt werden, daß die Kühlbreiten so sind, wie in den untenstehenden Formeln 8 und 9 gezeigt, wobei die zentrale Position des in der Mitte angeordneten Düsenkopfs im Sinne eines Einstellens auf die zentrale Position in der Streifenbreite so bewegt wird, daß Kühlbreite so ist, wie in der untenstehenden Formel 10 gezeigt, wobei stets die Temperaturverteilung in der Streifenbreite am Ausgang der Kühlwalzen beobachtet wird, und wobei der Druck und die Strömungsrate des in den Düsenkopf strömenden Kühlgases eingestellt wird, um das Kühlgas auf das Metallband einwirken zu lassen

$$(8) \quad 6 \leq W_E \leq 45$$

wobei $t < 1,3 \text{ mm}$

$$(9) \quad 12t - 9,6 \leq W_E \leq 22t + 16,4$$

wobei $t \geq 1,3 \text{ mm}$

W_E : Kühlbreite (mm) der Düsenköpfe an beiden Bandkanten
 t : Banddicke (mm)

$$(10) \quad 0,09B \leq W_C \leq 0,27B$$

W_C : Kühlbreite (mm) an den mittleren Düsenköpfen
 B : Bandbreite (mm)

69. Verfahren nach Anspruch 68, gekennzeichnet durch Verwendung einer Hilfsgasstrahlkühlvorrichtung, die am Auslaß der Kühlwalzen angeordnet ist und an den oberen und rückwärtigen Oberflächen des Metallbandes mit drei oder mehr längs der Bandbreite bewegbaren Düsenköpfen versehen ist, Bewegen der an den Kanten positionierten Düsenköpfe der Gaskühlvorrichtung und der Hilfsgaskühlvorrichtung an beiden Bandkanten so, daß die Kühlbreiten so wie in den Formeln 8 und 9 angegeben ist.

70. Verfahren nach Anspruch 69, dadurch gekennzeichnet, daß stets die Temperaturverteilung in der Bandbreite am Ausgang der Kühlwalzen beobachtet wird, wobei jeweils Positionen im Schwerpunkt der Abweichung in der Bandtemperatur in einem Bereich erhalten werden, wo eine Temperaturabweichung an den Kanten und im Zentrum des Metallbandes in Bezug auf eine angestrebte Bandtemperatur auftritt, die Düsenköpfe der Gasstrahlkühlvorrichtung oder der Gasstrahlkühlvorrichtung und der Hilfsgasstrahlkühlvorrichtung an den Kanten so bewegt werden, daß die doppelte Länge der Entfernung von der Bandkante zu dem besagten Schwerpunkt die Kühlbreite an

den Bandkanten ist, der zentrale Düsenkopf so bewegt wird, daß dessen zentrale Position mit dem Schwerpunkt im Zentrum der Bandbreite übereinstimmt, und daß Kühlgas von jedem der Düsenköpfe auf das Metallband einwirkt.

5

Revendications

1. Equipement de refroidissement de feuillards métalliques qui enveloppe le feuillard métallique (X) autour d'au moins un rouleau refroidisseur (#1- #4) et qui ajuste une longueur d'enveloppement entre le feuillard métallique (X) et le rouleau refroidisseur (#1- #4) respectif par un déplacement du rouleau refroidisseur (#1- #4), et qui comporte un équipement de refroidissement à jets de gaz comprenant un moyen à buses (α_1) tourné vers la face arrière de la section enveloppée du feuillard (X) et pouvant être déplacé vers le feuillard métallique (X), et qui comporte additionnellement un équipement de réglage du gaz (87) qui règle la pression ou le débit d'un gaz de refroidissement s'écoulant dans le moyen à buses (α_1), caractérisé en ce que l'équipement de refroidissement à jets de gaz comporte plusieurs collecteurs à buses ($\alpha_a, \alpha_b, \dots$) disposés dans la direction de l'axe longitudinal du rouleau refroidisseur (#1- #4) respectif et plus étroits que le feuillard métallique (X), chacun d'eux étant mobile suivant la direction de déplacement du rouleau refroidisseur (#1- #4) respectif et l'un au moins des moyens à buses ($\alpha_a, \alpha_b, \dots$) étant mobile le long de l'axe du rouleau refroidisseur.
2. Equipement suivant la revendication 1 caractérisé en ce que les orifices des buses des collecteurs à buses ont la forme de fentes s'étendant à angle droit par rapport à une ligne de passage du feuillard métallique et disposées suivant une rangée s'étendant le long de la ligne de passage.
3. Equipement suivant la revendication 2 caractérisé en ce que le bord interne de l'orifice d'une buse est en forme de R ou évasé vu en coupe.
4. Equipement suivant la revendication 2 caractérisé en ce que l'orifice d'une buse fait saillie vers l'extérieur.
5. Equipement suivant la revendication 1 caractérisé en ce que les collecteurs à buses sont au nombre de deux et ils sont disposés à l'endroit des bords du feuillard suivant la largeur du feuillard.
6. Equipement suivant la revendication 1 caractérisé en ce que les collecteurs à buses sont au nombre de trois parmi lesquels l'un est disposé au centre de la largeur du feuillard tandis que les deux autres sont disposés à l'endroit des bords du feuillard suivant la largeur du feuillard.
7. Equipement suivant la revendication 1 ou 6 caractérisé en ce qu'une pluralité de rouleaux refroidisseurs sont installés parmi lesquels au moins le premier rouleau refroidisseur comporte trois collecteurs à buses dont l'un est situé dans la partie centrale de la largeur du feuillard tandis que les deux autres sont situés à l'endroit des bords du feuillard.
8. Equipement suivant la revendication 1 ou 6 caractérisé en ce qu'une pluralité de rouleaux refroidisseurs sont installés parmi lesquels au moins les rouleaux refroidisseurs d'une section d'entrée comportent respectivement trois collecteurs à buses dont l'un est situé dans la partie centrale de la largeur du feuillard tandis que les deux autres sont situés à l'endroit des bords du feuillard et les rouleaux refroidisseurs d'une section de sortie comportent respectivement deux collecteurs à buses.
9. Equipement suivant la revendication 1 caractérisé en ce que les collecteurs à buses tournés au moins vers le premier rouleau refroidisseur sont déplacés, à partir d'une position de retrait, en direction de la ligne de passage du feuillard métallique au même instant où commence le contact entre le rouleau refroidisseur et le feuillard métallique, et, lorsque la course de décalage du rouleau refroidisseur est plus longue que celle existant à l'instant de la mise en contact, les collecteurs à buses sont déplacés afin de maintenir les distances d'espacement nécessaires à partir du feuillard métallique, et, lorsque le feuillard métallique n'est pas en contact avec le rouleau refroidisseur, les collecteurs à buses sont déplacés jusqu'à la position de retrait.
10. Equipement suivant la revendication 1 caractérisé en ce que dans le cas où une pluralité de rouleaux refroidisseurs sont montés, les collecteurs à buses autres que les collecteurs à buses opposés au moins au premier rouleau refroidisseur, sont conçus de manière à obtenir une longueur maximale du collecteur à buses par une course de décalage maximale du rouleau suivant, et les collecteurs à buses se déplacent à partir de la position de retrait,

en direction de la ligne de passage du feuillard métallique, à l'instant même où commence le contact entre le rouleau refroidisseur et le feuillard métallique, et ils ne se déplacent plus ensuite même si la course de décalage du rouleau refroidisseur est longue, et le collecteur à buses est ramené à la position de retrait avant qu'il ne se produise plus de contact entre le feuillard métallique et le rouleau refroidisseur.

- 5 11. Equipement suivant la revendication 1 caractérisé en ce que dans le cas où une pluralité de rouleaux refroidisseurs sont montés, plus la course de décalage est longue, plus le rouleau refroidisseur est proche de la section d'entrée.
- 10 12. Equipement suivant la revendication 1 caractérisé en ce que dans le cas où une pluralité de rouleaux refroidisseurs sont montés, plus le rouleau refroidisseur est proche de la section d'entrée, plus la course de décalage du rouleau est longue et, en ce qui concerne le collecteur à buses tourné vers le rouleau refroidisseur, plus le collecteur à buses est proche de la section d'entrée, plus le débit de projection de jets de gaz s'approche du maximum.
- 15 13. Equipement suivant la revendication 1 caractérisé en ce que dans le cas où une pluralité de collecteurs à buses sont montés le long de l'axe du rouleau, les grandeurs des déplacements des collecteurs à buses sont respectivement modifiées dans la direction du déplacement des rouleaux refroidisseurs et les espacements entre les collecteurs à buses et les rouleaux refroidisseurs sont respectivement modifiés dans l'axe du rouleau.
- 20 14. Equipement suivant la revendication 1 caractérisé en ce qu'au moins deux collecteurs à buses sont disposés dans la direction de l'axe du rouleau, vers les rouleaux refroidisseurs, par l'intermédiaire du feuillard métallique, ces collecteurs à buses étant mobiles suivant les directions de déplacement des rouleaux refroidisseurs, et au moins l'équipement de refroidissement à rouleaux situé à l'endroit des deux bords du feuillard comporte de tels collecteurs à buses qui sont composés de plusieurs corps de collecteurs connectés suivant la longueur des rouleaux et qui sont plus étroits que le feuillard métallique.
- 25 15. Equipement suivant la revendication 14 caractérisé en ce que les collecteurs à buses sont composés de plusieurs corps de collecteurs situés à l'endroit des deux bords du feuillard et connectés suivant l'axe du rouleau et les corps de collecteurs connectés sont en outre constitués en plusieurs étages suivant la direction de défilement du feuillard, et une position de chaque orifice de buse des corps de collecteurs est décalée suivant l'axe du rouleau du côté de l'entrée et du côté de la sortie.
- 30 16. Equipement suivant la revendication 14 caractérisé en ce que les collecteurs à buses sont composés de plusieurs corps de collecteurs situés à l'endroit des deux bords du feuillard et connectés suivant l'axe du rouleau et les corps principaux de collecteurs connectés sont disposés en décalant les orifices des buses suivant la direction de défilement du feuillard.
- 35 17. Equipement suivant la revendication 1 caractérisé en ce qu'au moins deux collecteurs à buses sont disposés dans la direction de l'axe du rouleau, vers les rouleaux refroidisseurs, par l'intermédiaire du feuillard métallique, et ils sont divisés en au moins deux parties dans la direction de défilement du feuillard, et au moins l'équipement de refroidissement à rouleaux situé à l'endroit des deux bords du feuillard est composé de tels collecteurs à buses qui ont une largeur plus petite que la largeur du feuillard et qui sont mobiles d'une manière indépendante suivant l'axe du rouleau.
- 40 18. Equipement suivant la revendication 1 caractérisé en ce que la tension du feuillard métallique est augmentée avant que le rouleau refroidisseur ne vienne en contact avec le feuillard métallique de telle façon que la forme du feuillard soit rendue stable au moment du contact.
- 45 19. Equipement suivant la revendication 7 caractérisé en ce qu'il comprend un dispositif de calcul de la position visée pour les buses dans le cas d'une variation de la largeur du feuillard, un détecteur de la position du bord du feuillard et un appareil de mesure du profil de température en travers du feuillard disposé à l'entrée des rouleaux refroidisseurs, et les collecteurs à buses associés aux bords du feuillard sont adaptés aux bords de la largeur du feuillard en obtenant une information d'une partie à variation de largeur ou une grandeur de celle-ci.
- 50 20. Equipement suivant la revendication 19 caractérisé en ce que, lorsqu'un point de soudure, assurant la connexion de feuillards de différentes largeurs, arrive à l'entrée des rouleaux refroidisseurs, l'information est obtenue à l'avance à partir de l'entrée de la ligne et, lorsque le feuillard passe d'une petite largeur à une grande largeur, les collecteurs à buses associés aux bords du feuillard ont été réglés de manière à se trouver à l'endroit des bords du feuillard de grande largeur avant que le point de soudage ne passe à l'entrée des rouleaux refroidisseurs, et,
- 55

lorsque le feuillard passe d'une grande largeur à une petite largeur, les collecteurs à buses sont réglés de manière à correspondre aux bords du feuillard de grande largeur après que le point de soudage est passé à l'entrée des rouleaux refroidisseurs.

- 5 **21.** Equipement suivant la revendication 7 caractérisé en ce que l'appareil de mesure du profil de température du feuillard est installé à la sortie des rouleaux refroidisseurs et, en fonction de l'information provenant de cet appareil, les collecteurs à buses associés aux bords du feuillard de l'équipement de refroidissement à jets de gaz sont réglés de manière à se trouver, suivant la largeur du feuillard, à l'endroit des bords de celui-ci.
- 10 **22.** Equipement suivant la revendication 7 caractérisé en ce que l'appareil de mesure du profil de température du feuillard est installé à la sortie des rouleaux refroidisseurs et, en fonction de l'information provenant de cet appareil, on règle la pression ou le débit du gaz de refroidissement des collecteurs à buses, associés aux bords du feuillard, de l'équipement de refroidissement à jets de gaz.
- 15 **23.** Equipement suivant l'une quelconque des revendications 7 ou 19 caractérisé en ce que l'appareil de mesure du profil de température du feuillard est installé à la sortie des rouleaux refroidisseurs et, en fonction de l'information provenant de cet appareil, les collecteurs à buses associés aux bords du feuillard de l'équipement de refroidissement à jets de gaz sont réglés de manière à se trouver, suivant la largeur du feuillard, à l'endroit des bords de celui-ci de manière à régler la pression ou le débit du gaz de refroidissement des collecteurs à buses, associés
20 aux bords du feuillard, de l'équipement de refroidissement à jets de gaz.
- 25 **24.** Equipement suivant la revendication 1 caractérisé en ce que l'équipement de refroidissement à jets de gaz est pourvu de deux collecteurs à buses qui sont disposés à l'endroit des bords suivant la largeur du feuillard, dans la direction de l'axe du rouleau, vers les rouleaux refroidisseurs, par l'intermédiaire du feuillard métallique, et qui sont
30 plus étroits que le feuillard métallique, l'équipement de refroidissement auxiliaire à jets de gaz comporte au moins deux collecteurs à buses de projection de gaz suivant la largeur du feuillard, ses collecteurs à buses disposés à l'endroit des deux bords du feuillard ayant la possibilité d'être déplacés, suivant la largeur de celui-ci, et les dispositifs de réglage du gaz, pour l'équipement de refroidissement auxiliaire à jets de gaz, règlent la pression ou le débit du gaz de refroidissement s'écoulant vers et dans chaque collecteur à buses.
- 35 **25.** Equipement suivant la revendication 1 caractérisé en ce que l'équipement de refroidissement à jets de gaz est pourvu de trois collecteurs à buses qui sont disposés au centre et à l'endroit des bords suivant la largeur du feuillard, dans la direction de l'axe du rouleau, vers les rouleaux refroidisseurs, par l'intermédiaire du feuillard métallique, et qui sont plus étroits que le feuillard métallique, les collecteurs à buses qui se trouvent au moins à
40 l'endroit des deux bords, pouvant se déplacer suivant l'axe du rouleau, l'équipement de refroidissement auxiliaire à jets de gaz comporte au moins deux collecteurs à buses de projection de gaz suivant la largeur du feuillard, ses collecteurs à buses disposés au moins à l'endroit des deux bords du feuillard ayant la possibilité d'être déplacés, suivant la largeur de celui-ci, et les dispositifs de réglage du gaz, pour l'équipement de refroidissement auxiliaire à jets de gaz, règlent la pression ou le débit du gaz de refroidissement s'écoulant vers et dans chaque collecteur à buses.
- 45 **26.** Equipement suivant la revendication 25 caractérisé en ce que l'équipement de refroidissement à jets de gaz est pourvu de trois collecteurs à buses qui sont disposés au centre et à l'endroit des bords suivant la largeur du feuillard, dans la direction de l'axe du rouleau, vers au moins un premier rouleau refroidisseur parmi les rouleaux refroidisseurs, par l'intermédiaire du feuillard métallique.
- 50 **27.** Equipement suivant la revendication 25 caractérisé en ce que l'équipement de refroidissement à jets de gaz est pourvu de trois collecteurs à buses qui sont disposés au centre et à l'endroit des bords suivant la largeur du feuillard, dans la direction de l'axe du rouleau, vers au moins des rouleaux refroidisseurs dans une section d'entrée des rouleaux refroidisseurs, par l'intermédiaire du feuillard métallique.
- 55 **28.** Equipement suivant la revendication 26 caractérisé en ce qu'au moins deux collecteurs à buses associés aux bords du feuillard, dans l'équipement de refroidissement auxiliaire à jets de gaz, sont mobiles suivant la largeur du feuillard.
- 29.** Equipement suivant la revendication 24 caractérisé en ce qu'au moins les collecteurs à buses situés à l'endroit des deux bords du feuillard, parmi les collecteurs à buses de l'équipement de refroidissement auxiliaire à jets de gaz installé à la sortie des rouleaux refroidisseurs, comprennent une pluralité de corps de collecteurs connectés

suivant la largeur du feuillard, et l'un au moins de ces collecteurs à buses est mobile suivant la largeur du feuillard.

- 5 30. Equipement suivant la revendication 24 caractérisé en ce qu'au moins les collecteurs à buses situés à l'endroit des deux bords du feuillard, parmi les collecteurs à buses de l'équipement de refroidissement auxiliaire à jets de gaz installé à la sortie des rouleaux refroidisseurs, sont divisés en au moins deux parties dans la direction du défilement du feuillard métallique et ces collecteurs à buses sont mobiles d'une manière indépendante suivant la largeur du feuillard.
- 10 31. Equipement suivant l'une quelconque des revendications 14 ou 17 caractérisé en ce qu'il comporte au moins deux collecteurs à buses pourvus de buses pour la projection du gaz vers le feuillard métallique, la largeur de ces collecteurs étant inférieure à la largeur du feuillard, et il comporte un banc mobile pour déplacer le collecteur à buses dans la direction perpendiculaire à la surface du feuillard et/ou suivant la largeur du feuillard.
- 15 32. Equipement suivant la revendication 31 caractérisé en ce que dans le cas où les collecteurs à buses sont au nombre de deux ou de trois suivant la largeur du feuillard, leurs bancs mobiles peuvent être déplacés dans la direction perpendiculaire à la surface du feuillard et suivant la largeur de ce feuillard.
- 20 33. Equipement suivant la revendication 31 caractérisé en ce que dans le cas où les collecteurs à buses sont au nombre de trois suivant la largeur du feuillard, le banc mobile pour le déplacement du collecteur à buses central peut être déplacé uniquement dans la direction perpendiculaire à la surface du feuillard et les bancs mobiles pour le déplacement des collecteurs à buses droit et gauche peuvent être déplacés dans la direction perpendiculaire à la surface du feuillard et dans la direction de la largeur du feuillard.
- 25 34. Equipement suivant la revendication 1 caractérisé en ce que la ligne de passage du feuillard métallique de l'équipement de trempe à rouleaux est horizontale ou verticale.
- 30 35. Equipement suivant la revendication 26 caractérisé en ce qu'on prévoit, en tant qu'équipement de refroidissement auxiliaire à jets de gaz, au moins deux collecteurs à buses dont la largeur est inférieure à la largeur du feuillard, ces collecteurs à buses étant *pourvus* de buses pour projeter le gaz vers le feuillard métallique et des bancs mobiles déplacent les collecteurs à buses dans la direction perpendiculaire à la surface du feuillard et/ou suivant la largeur de ce feuillard.
- 35 36. Equipement suivant la revendication 35 caractérisé en ce que dans le cas où les collecteurs à buses et les bancs mobiles sont prévus en tant qu'équipement de refroidissement auxiliaire à jets de gaz, les collecteurs à buses et les bancs mobiles sont prévus pour les deux faces du feuillard métallique.
- 40 37. Equipement suivant la revendication 35 caractérisé en ce que la ligne de passage du feuillard métallique est horizontale ou verticale.
- 45 38. Equipement suivant la revendication 26 caractérisé en ce qu'on installe, en tant qu'équipement de refroidissement auxiliaire à jets de gaz, un dispositif mobile qui peut être déplacé parallèlement à la surface du feuillard et suivant la largeur de celui-ci, en disposant les collecteurs à buses comportant les buses pour projeter le gaz vers le feuillard métallique, les collecteurs à buses étant prévus sur le dispositif mobile, ayant une largeur inférieure à celle du feuillard, comportant un mécanisme de déplacement pour déplacer le dispositif mobile, et des parties flexibles ou des joints d'expansion sont prévus à l'endroit d'une partie du conduit d'alimentation en gaz.
- 50 39. Equipement suivant la revendication 38 caractérisé en ce qu'il comporte les dispositifs mobiles, les collecteurs à buses attachés à ces dispositifs mobiles et les conduits d'alimentation en gaz attachés aux collecteurs à buses et comportant les joints flexibles ou expansibles en ce qui concerne les deux faces du feuillard métallique.
- 55 40. Equipement suivant la revendication 38 caractérisé en ce que les collecteurs à buses sont fixés autour du centre du feuillard pour projeter le gaz.
41. Equipement suivant la revendication 38 caractérisé en ce que la ligne de passage du feuillard métallique est horizontale ou verticale.
42. Equipement suivant la revendication 26 caractérisé en ce qu'à l'entrée des rouleaux refroidisseurs sont disposés un dispositif de calcul de la position visée des buses en vue d'un changement de largeur du feuillard, un détecteur

de la position des bords du feuillard et un appareil de mesure du profil de température du feuillard, obtenant une information relative au point de soudure où a lieu la variation de la largeur et la grandeur de la variation de largeur en fonction de l'information obtenue, afin de régler respectivement les collecteurs à buses associés aux bords du feuillard de l'équipement de refroidissement à jets de gaz et les deux collecteurs à buses associés aux bords du feuillard de l'équipement de refroidissement auxiliaire à jets de gaz.

43. Equipement suivant la revendication 42 caractérisé en ce que dans le cas où le point particulier correspondant au point de soudage de parties de différentes largeurs arrive à l'entrée des rouleaux refroidisseurs, l'information est obtenue à l'avance à l'entrée de la ligne et, lorsque le feuillard passe d'une petite largeur à une grande largeur, les collecteurs à buses associés aux bords du feuillard de l'équipement de refroidissement à jets de gaz et les deux collecteurs à buses associés aux bords du feuillard de l'équipement de refroidissement auxiliaire à jets de gaz ont été respectivement réglés, à l'endroit des bords du feuillard, avant que le point particulier ne passe à l'entrée des rouleaux refroidisseurs, et lorsque le feuillard passe d'une grande largeur à une petite largeur, ces collecteurs à buses sont respectivement réglés, en regard des bords du feuillard de petite largeur, après que le point particulier est passé à l'entrée des rouleaux refroidisseurs.

44. Equipement suivant la revendication 24 caractérisé en ce que l'appareil de mesure du profil de température du feuillard est installé à la sortie de l'équipement de refroidissement auxiliaire à jets de gaz et, en accord avec l'information reçue de cet appareil, les collecteurs à buses associés aux bords du feuillard de l'équipement de refroidissement à jets de gaz et les deux collecteurs à buses associés aux bords du feuillard de l'équipement de refroidissement auxiliaire à jets de gaz sont respectivement ajustés à l'endroit des bords du feuillard.

45. Equipement suivant la revendication 24 caractérisé en ce que l'appareil de mesure du profil de température du feuillard est installé à la sortie de l'équipement de refroidissement auxiliaire à jets de gaz afin de régler, en accord avec l'information reçue de cet appareil, la pression ou le débit du gaz de refroidissement dans les collecteurs à buses de l'équipement de refroidissement à jets de gaz et de l'équipement de refroidissement auxiliaire à jets de gaz.

46. Equipement suivant la revendication 24 caractérisé en ce que l'appareil de mesure du profil de température du feuillard est installé à la sortie de l'équipement de refroidissement auxiliaire à jets de gaz et, en accord avec l'information reçue de cet appareil, les collecteurs à buses associés aux bords du feuillard de l'équipement de refroidissement à jets de gaz et les deux collecteurs à buses associés aux bords du feuillard de l'équipement de refroidissement auxiliaire à jets de gaz sont ajustés respectivement en regard des bords du feuillard, afin de régler ainsi la pression ou le débit du gaz de refroidissement dans chaque collecteur à buses.

47. Equipement suivant la revendication 1 caractérisé en ce que l'équipement de refroidissement à jets de gaz comporte au moins trois collecteurs à buses disposés suivant l'axe du rouleau et tournés vers les rouleaux refroidisseurs, ces collecteurs à buses étant mobiles suivant les directions de déplacement des rouleaux refroidisseurs, et au moins un collecteur à buses étant mobile suivant l'axe du rouleau, des détecteurs de la position des bords du feuillard pour détecter les bords du feuillard métallique, des dispositifs de réglage de position qui règlent les mouvements des collecteurs à buses mobiles, parmi l'ensemble des collecteurs à buses, suivant l'axe du rouleau, un dispositif de calcul pour la commande de la position des collecteurs à buses, lequel commande les dispositifs de réglage de position en accord avec les signaux détectés provenant des détecteurs, des dispositifs de réglage de position qui ajustent les positions des collecteurs à buses en accord avec des signaux de position des rouleaux refroidisseurs suivant les directions de déplacement de ces rouleaux refroidisseurs, un appareil de mesure du profil de température du feuillard qui est installé à la sortie des rouleaux refroidisseurs et qui détecte la répartition de la température dans la largeur du feuillard, et un dispositif de calcul pour la commande de la température du feuillard, lequel calcule l'écart de température par rapport à la répartition visée de la température du feuillard, en accord avec le signal de température émis à partir de l'appareil de mesure, et qui règle la pression ou le débit du gaz de refroidissement s'écoulant dans les collecteurs à buses en réponse à cet écart de température.

48. Equipement suivant la revendication 47 caractérisé en ce que l'équipement de refroidissement auxiliaire à jets de gaz comporte au moins trois collecteurs à buses le long de la largeur du feuillard, tournés vers le feuillard métallique, à la sortie des rouleaux refroidisseurs, et l'un au moins de ces collecteurs à buses est mobile suivant la largeur du feuillard, et l'appareil de mesure du profil de température du feuillard disposé à la sortie de l'équipement de refroidissement auxiliaire à jets de gaz.

49. Equipement suivant la revendication 48 caractérisé en ce qu'au moins deux des collecteurs à buses associés aux

bords du feuillard de l'équipement de refroidissement auxiliaire à jets de gaz sont respectivement mobiles suivant la largeur du feuillard.

50. Equipement suivant la revendication 47 caractérisé en ce que les largeurs Be des buses des collecteurs à buses situés des deux côtés de l'équipement de refroidissement à jets de gaz et/ou de l'équipement de refroidissement auxiliaire à jets de gaz satisfont aux relations exprimées par les formules 1 et 2 ci-dessous et la largeur Bc des buses du collecteur à buses central satisfait à la relation exprimée par la formule 3 ci-dessous

$$6 \leq Be - \left(\frac{\Delta w}{2} - 0,9L \circ \frac{V}{S} \right) \leq 45 \quad [1]$$

dans laquelle $t < 1,3$ mm

$$12t - 9,6 \leq Be - \left(\frac{\Delta w}{2} - 0,9L \circ \frac{V}{S} \right) \leq 22t + 16,4 \quad [2]$$

dans laquelle $t \geq 1,3$ mm et Be est la largeur de la buse en millimètres, t est l'épaisseur du feuillard en millimètres, Δw est la grandeur de la variation de largeur du feuillard métallique, en millimètres, L o est la longueur de passage en mètres entre les rouleaux dans un four de traitement thermique après l'appareil de refroidissement, V est la vitesse de déplacement, en millimètres par minute, du collecteur à buses suivant la longueur du rouleau ou la largeur du feuillard, et S est la vitesse de la ligne (mpm),

$$0,09W \leq Bc \leq 0,27W \quad [3]$$

dans laquelle B c est la largeur de la buse en millimètres et W est la largeur du feuillard en millimètres.

51. Equipement suivant la revendication 47 caractérisé en ce qu'au moins les collecteurs à buses situés à l'endroit des deux bords du feuillard comprennent une pluralité de corps de collecteurs connectés suivant l'axe du rouleau et mobiles suivant cet axe.

52. Equipement suivant la revendication 51 caractérisé en ce que l'équipement de refroidissement auxiliaire à jets de gaz comporte au moins trois collecteurs à buses suivant la largeur du feuillard, tournés vers le feuillard métallique, à la sortie des rouleaux refroidisseurs, et suivant la largeur du feuillard peuvent se déplacer au moins les collecteurs à buses situés à l'endroit des deux bords du feuillard et comprenant une pluralité de corps de collecteurs connectés suivant la largeur du feuillard, un dispositif de réglage du gaz étant prévu pour régler la pression et le débit d'un gaz de refroidissement s'écoulant vers et dans chaque collecteur à buses.

53. Equipement suivant la revendication 51 caractérisé en ce que dans le cas où les collecteurs à buses situés à l'endroit des deux bords du feuillard de l'équipement de refroidissement à jets de gaz et/ou de l'équipement de refroidissement auxiliaire à jets de gaz comprennent au moins trois corps de collecteurs, les largeurs Beo des corps de collecteurs, à l'endroit du côté situé le plus à l'extérieur des au moins trois corps de collecteurs, satisfont à la relation exprimée par la formule 4 ci-dessous et la largeur Bec des corps de collecteurs situés au centre satisfait aux relations exprimées par les formules 5 et 6 ci-dessous, la largeur Bei des corps de collecteurs situés à l'endroit du côté situé le plus à l'intérieur satisfait à la relation indiquée par la formule 7 ci-dessous et la largeur Bc du collecteur à buses situé au centre du feuillard métallique satisfait à la relation exprimée par la formule 3 ci-dessous

$$Beo \geq \Delta W u/2 \quad [4]$$

dans laquelle ΔWu est la grandeur de variation, en millimètres, de la largeur du feuillard lorsque sont connectés des feuillards passant d'une petite largeur à une grande largeur

$$6 \leq Bec \leq 45 \quad [5]$$

dans laquelle $t < 1,3$ mm

$$12 t - 9,6 \leq B_{ec} \leq 22t + 16,4 \quad [6]$$

dans laquelle $t \geq 1,3$ mm
et t est l'épaisseur du feuillard

$$B_{ei} \geq \Delta W d/2 \quad [7]$$

dans laquelle ΔW_u est la grandeur de variation, en millimètres, de la largeur du feuillard lorsque sont connectés des feuillards passant d'une grande largeur à une petite largeur

$$0,9W \leq B_c \leq 0,27W \quad [3]$$

dans laquelle B_c est la largeur de la buse en millimètres et W est la largeur du feuillard en millimètres.

54. Equipement suivant la revendication 1 caractérisé en ce que les rouleaux refroidisseurs destinés à être utilisés dans l'équipement sont pourvus d'une pluralité de passages d'un fluide de refroidissement formés dans le même côté plan de l'intérieur des rouleaux.

55. Equipement suivant la revendication 1 caractérisé en ce que la pluralité de rouleaux refroidisseurs destinés à être utilisés dans l'équipement sont disposés suivant la ligne de passage du feuillard métallique et dans le cas où le feuillard métallique est refroidi en l'enroulant autour des rouleaux, la direction d'écoulement du fluide de refroidissement dans le passage de chaque rouleau refroidisseur est inversée d'un rouleau à l'autre pour créer la structure fournissant le fluide de refroidissement.

56. Equipement suivant la revendication 1 caractérisé en ce que des collecteurs à buses additionnels d'un équipement de refroidissement auxiliaire à jets de gaz sont prévus à l'entrée d'un équipement de trempe à rouleaux pour refroidir un feuillard métallique en l'enroulant autour d'un ou plusieurs rouleaux qui sont refroidis à l'intérieur de ceux-ci, les collecteurs à buses étant situés en regard du feuillard métallique et étant disposés au nombre d'au moins deux suivant la largeur du feuillard, et au moins les collecteurs à buses qui sont situés à l'endroit des deux bords du feuillard, comprennent une pluralité de corps de collecteurs connectés suivant la largeur du feuillard, l'un au moins des collecteurs à buses étant mobile suivant la largeur du feuillard.

57. Equipement suivant la revendication 56 caractérisé en ce que les collecteurs à buses additionnels sont disposés en regard du feuillard métallique et sont au nombre d'au moins deux suivant la largeur du feuillard et au moins les collecteurs à buses qui sont situés à l'endroit des deux bords du feuillard, comprennent des corps de collecteurs qui sont divisés en au moins deux parties dans la direction du défilement du feuillard, chacun de ces collecteurs à buses étant mobile d'une manière indépendante suivant la largeur du feuillard.

58. Equipement suivant la revendication 56 caractérisé en ce que les collecteurs à buses additionnels qui sont pourvus de buses pour projeter du gaz vers le feuillard métallique, ont une largeur inférieure à celle du feuillard métallique et des bancs mobiles assurent le déplacement des collecteurs à buses dans la direction perpendiculaire à la surface du feuillard et/ou dans la direction de la largeur du feuillard.

59. Equipement suivant la revendication 56 caractérisé en ce que les collecteurs à buses additionnels, au nombre de deux ou trois, qui sont pourvus de buses pour projeter du gaz vers le feuillard métallique, ont une largeur inférieure à celle du feuillard métallique et des bancs mobiles assurent le déplacement des collecteurs à buses dans la direction perpendiculaire à la surface du feuillard et dans la direction de la largeur du feuillard.

60. Equipement suivant la revendication 56 caractérisé en ce que les collecteurs à buses additionnels sont au nombre de trois, ils sont pourvus de buses pour projeter du gaz vers le feuillard métallique, leur largeur est inférieure à celle du feuillard métallique, des bancs mobiles qui supportent les collecteurs à buses associés à la partie centrale du feuillard métallique, sont mobiles uniquement dans la direction perpendiculaire à la surface du feuillard, et les bancs mobiles qui supportent les collecteurs à buses associés aux deux bords du feuillard, sont mobiles dans la direction perpendiculaire à la surface du feuillard et dans la direction de la largeur de ce feuillard.

61. Equipement suivant la revendication 58 caractérisé en ce que les collecteurs à buses et les bancs mobiles sont prévus d'un côté du feuillard métallique ou des deux côtés de celui-ci.
- 5 62. Equipement suivant la revendication 58 caractérisé en ce que la ligne de passage du feuillard métallique est horizontale ou verticale.
- 10 63. Equipement suivant la revendication 56 caractérisé en ce que les collecteurs à buses additionnels sont mobiles parallèlement à la surface du feuillard et le long de celui-ci, le long de la ligne de passage sont prévus des collecteurs à buses qui sont montés sur les rails et dont la largeur est plus petite que celle du feuillard métallique, ces collecteurs à buses comportant des buses pour projeter du gaz vers le feuillard métallique, et des mécanismes de déplacement sont prévus pour déplacer les chariots et des joints flexibles ou expansibles sont prévus sur la partie du conduit d'alimentation en gaz.
- 15 64. Procédé pour refroidir des feuillards métalliques, ce procédé comprenant les étapes consistant à enrouler le feuillard métallique autour d'au moins un rouleau refroidisseur et à ajuster la longueur d'enveloppement entre le feuillard et le rouleau refroidisseur respectif en déplaçant le rouleau, et à utiliser un équipement de refroidissement à jets de gaz pourvu de moyens à buses qui sont disposés en regard du rouleau respectif par l'intermédiaire du feuillard, afin de refroidir le feuillard, sur sa surface arrière, en projetant le gaz de refroidissement à partir des moyens à buses, caractérisé en ce qu'on utilise au moins un collecteur à buses mobile dans la direction du déplacement du rouleau respectif et suivant l'axe du rouleau, et ayant une largeur plus petite que celle du feuillard, on ajuste la longueur d'enveloppement de manière à régler la température moyenne du feuillard ou la température au centre du feuillard sur la base de l'écart par rapport à une température de feuillard visée et on examine en permanence la répartition de la température dans la largeur du feuillard à l'endroit d'au moins un côté parmi le côté d'entrée et le côté de sortie du ou des rouleaux refroidisseurs tout en ajustant la distance de séparation entre 20 le feuillard et les collecteurs à buses en fonction de la position du ou des rouleaux et des collecteurs à buses, et on déplace les collecteurs à buses vers une position où apparaît l'écart de température par rapport à la répartition de la température visée, afin de contrôler ainsi la répartition de la température du feuillard en se basant sur l'écart de température.
- 25 65. Procédé suivant la revendication 64 caractérisé en ce qu'on règle la pression et le débit du gaz de refroidissement s'écoulant vers et dans les collecteurs à buses en fonction de l'écart de température, afin de contrôler ainsi la répartition de la température du feuillard en fonction de l'écart de température.
- 30 66. Procédé suivant la revendication 64 caractérisé en ce que deux collecteurs à buses sont prévus dans l'équipement de refroidissement à jets de gaz et ces collecteurs à buses sont déplacés en vue du contrôle de la répartition de la température du feuillard en fonction de l'écart apparaissant par rapport à la répartition visée de la température du feuillard, en tenant compte de la partie des écarts, par rapport aux températures du feuillard visées, apparaissant à l'endroit des deux bords du feuillard, de manière à annuler ainsi l'écart de température.
- 35 67. Procédé suivant la revendication 66 caractérisé en ce qu'on installe, en plus des deux collecteurs à buses prévus dans l'équipement de refroidissement à jets de gaz, des collecteurs à buses associés à la partie centrale du feuillard, dans une position correspondant au centre de la largeur du feuillard, ces collecteurs à buses pouvant être déplacés uniquement dans les directions de déplacement du rouleau refroidisseur et ne pouvant pas se déplacer suivant l'axe du rouleau, et uniquement pour les collecteurs à buses disposés au centre, on règle la pression et le débit du gaz de refroidissement s'écoulant vers et dans les collecteurs à buses en fonction de l'écart de température apparaissant par rapport à la répartition visée de la température du feuillard, en ce qui concerne le contrôle de la répartition de la température du feuillard en fonction de l'écart de température, de manière à projeter le gaz de refroidissement vers le feuillard métallique.
- 40 45 68. Procédé suivant la revendication 64 caractérisé en ce qu'on prévoit au moins trois collecteurs à buses dans l'équipement de refroidissement à jets de gaz et, en ce qui concerne le contrôle de la température moyenne du feuillard ou de la température au centre du feuillard en fonction de l'écart par rapport à la température du feuillard visée, on ajuste la longueur d'enveloppement entre le feuillard métallique et le rouleau refroidisseur, et, en ce qui concerne le contrôle de la répartition de la température du feuillard en fonction de l'écart par rapport à la répartition visée de la température du feuillard, on ajuste la distance de séparation entre le feuillard métallique et les collecteurs à buses en fonction de la position des rouleaux refroidisseurs et des collecteurs à buses, on examine en permanence une répartition de la température dans la largeur du feuillard au moins à l'entrée ou à la sortie des rouleaux refroidisseurs, on déplace les collecteurs à buses se trouvant sur les bords en direction des deux bords du feuillard de 50 55

telle façon que des largeurs de refroidissement soient telles que représentées par les formules 8 et 9 ci-dessous, on déplace la position centrale du collecteur à buses disposé au centre afin de régler la position centrale, suivant la largeur du feuillard, de telle façon que la largeur de refroidissement soit telle qu'indiquée par la formule ci-dessous 10, on examine en permanence la répartition de la température dans la largeur du feuillard à la sortie des rouleaux refroidisseurs, et on ajuste la pression et le débit du gaz de refroidissement s'écoulant vers et dans le collecteur à buses de manière à projeter le gaz de refroidissement vers le feuillard métallique

$$6 \leq W_E \leq 45 \quad [8]$$

dans laquelle $t < 1,3$ mm

$$12 t - 9,6 \leq W_E \leq 22 t + 16,4 \quad [9]$$

dans laquelle $t \geq 1,3$ mm, W_E est la largeur de refroidissement, en millimètres, des collecteurs à buses se trouvant à l'endroit des deux bords du feuillard, et t est l'épaisseur du feuillard en millimètres.

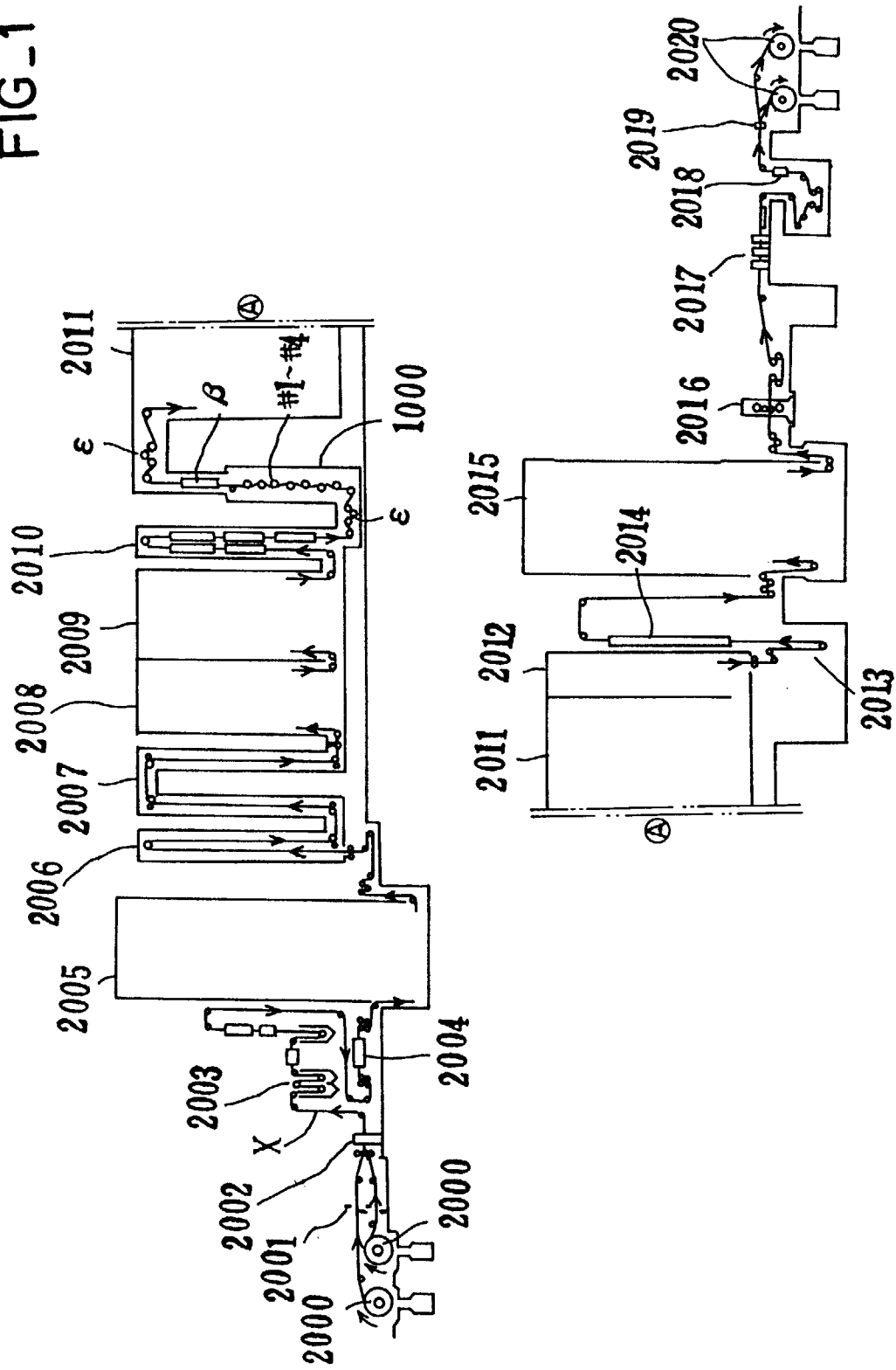
$$0,09 B \leq W_c \leq 0,27 B \quad [10]$$

dans laquelle W_c est la largeur de refroidissement, en millimètres, des collecteurs à buses centraux et B est la largeur du feuillard en millimètres.

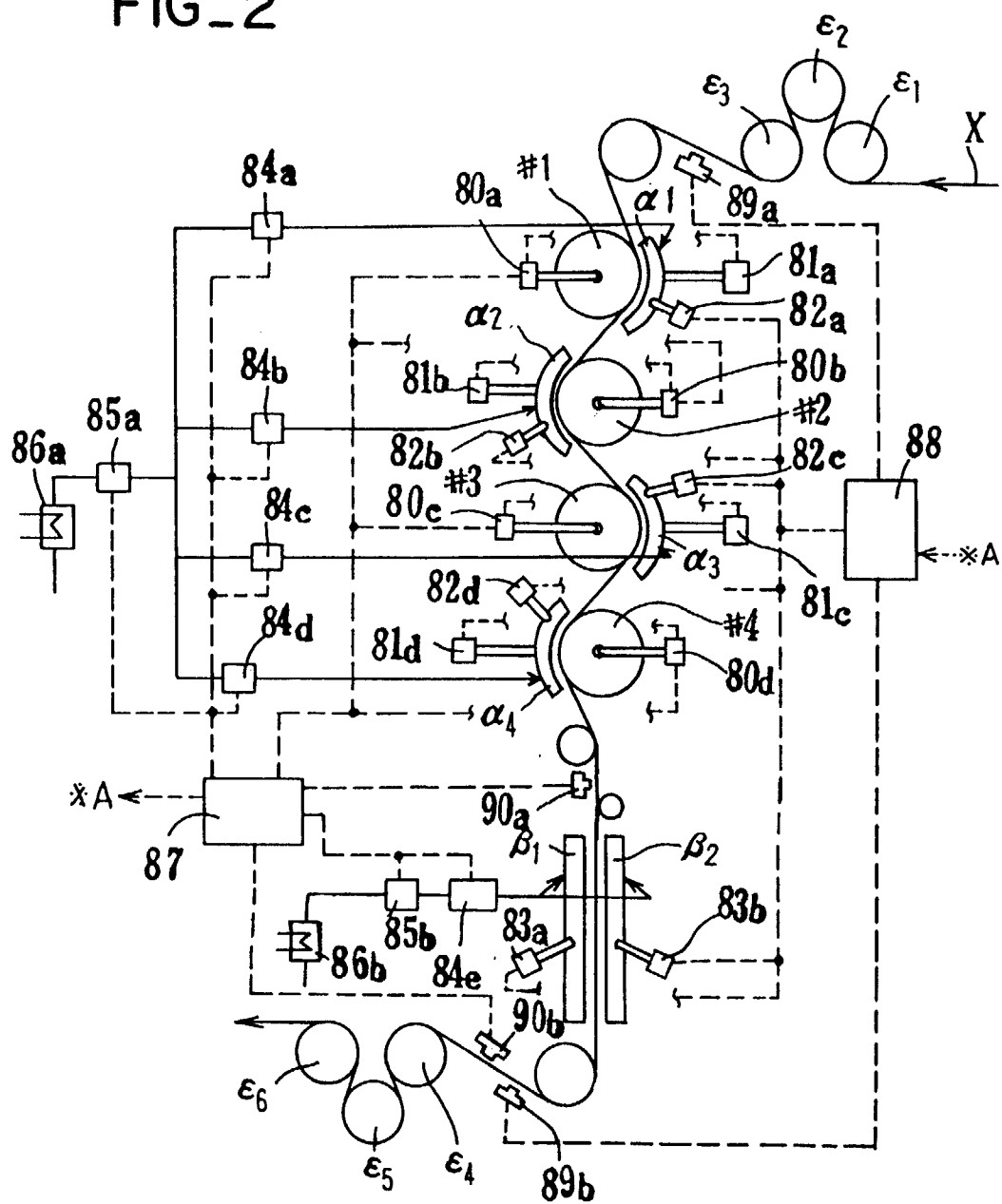
69. Procédé suivant la revendication 68 caractérisé en ce qu'on utilise un équipement de refroidissement auxiliaire à jets de gaz disposé à la sortie des rouleaux refroidisseurs et qui est pourvu, à l'endroit des surfaces supérieure et arrière du feuillard métallique, d'au moins trois collecteurs à buses pouvant être déplacés suivant la largeur du feuillard, et on déplace les collecteurs à buses qui sont situés sur les bords du feuillard, de l'équipement de refroidissement à jets de gaz et de l'équipement de refroidissement auxiliaire à jets de gaz vers les deux bords du feuillard de telle façon que les largeurs de refroidissement soient telles qu'indiquées par les formules 8 et 9.

70. Procédé suivant la revendication 69 caractérisé en ce qu'on examine en permanence la répartition de la température suivant la largeur du feuillard, à la sortie des rouleaux refroidisseurs, on obtient respectivement des positions du centre de gravité de l'écart de la température du feuillard à l'endroit d'une plage où l'écart de température apparaît dans les bords et dans la partie centrale du feuillard métallique par rapport à la température visée du feuillard, on déplace les collecteurs à buses qui sont disposés à l'endroit des bords du feuillard, de l'équipement de refroidissement à jets de gaz et de l'équipement de refroidissement auxiliaire à jets de gaz de telle façon qu'une longueur double de la distance entre le bord du feuillard et le centre de gravité soit la largeur de refroidissement à l'endroit des bords du feuillard, on déplace le collecteur à buses central de telle façon que sa position centrale concorde avec le centre de gravité au centre de la largeur du feuillard, et on projette le gaz de refroidissement vers le feuillard métallique à partir de chacun des collecteurs à buses.

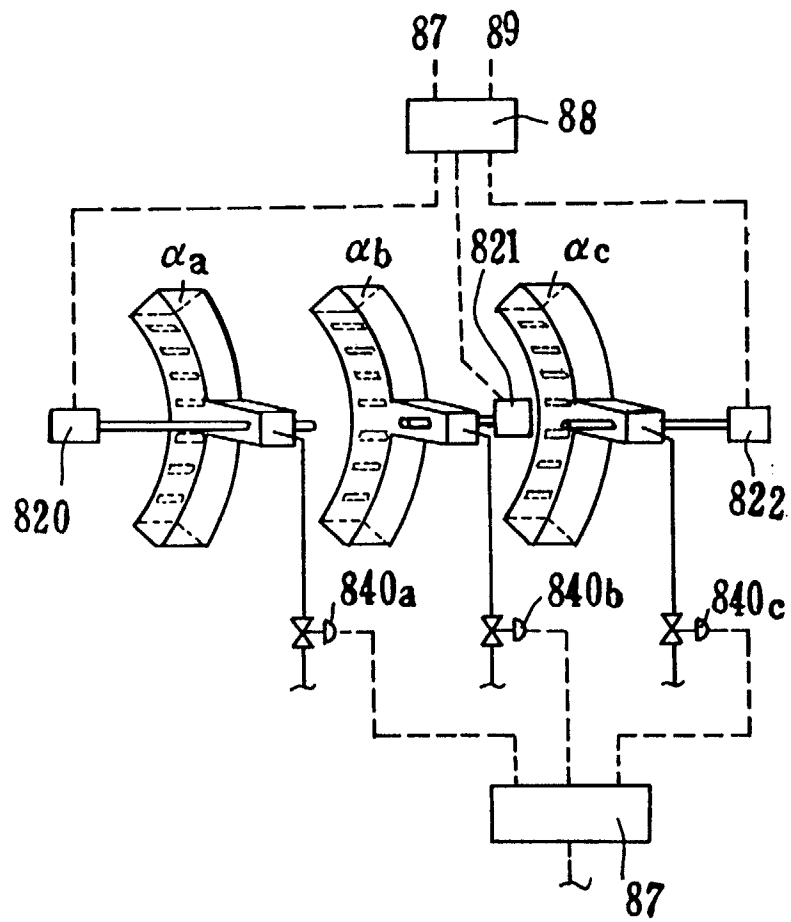
FIG_1



FIG_2



FIG_3



FIG_4

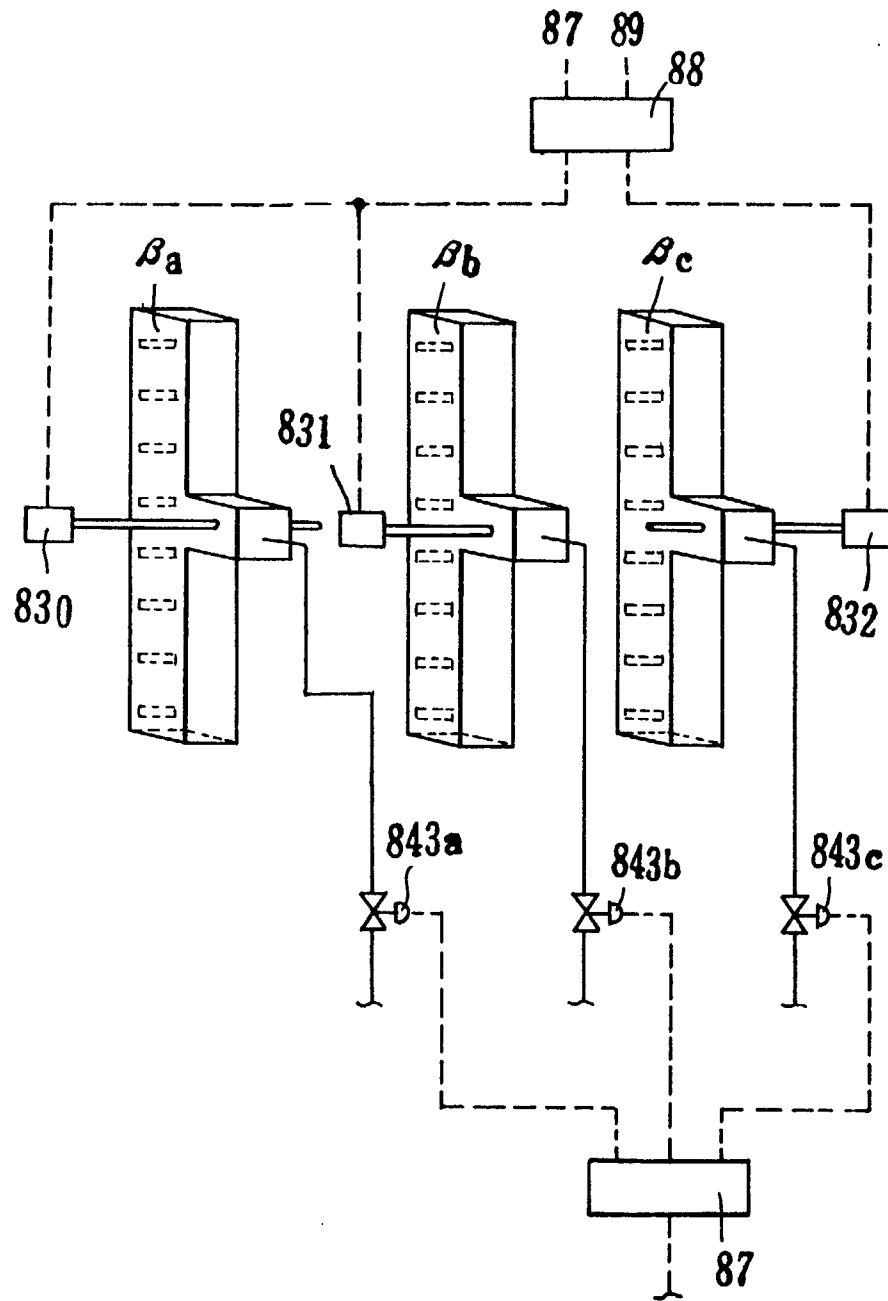


FIG. 5A

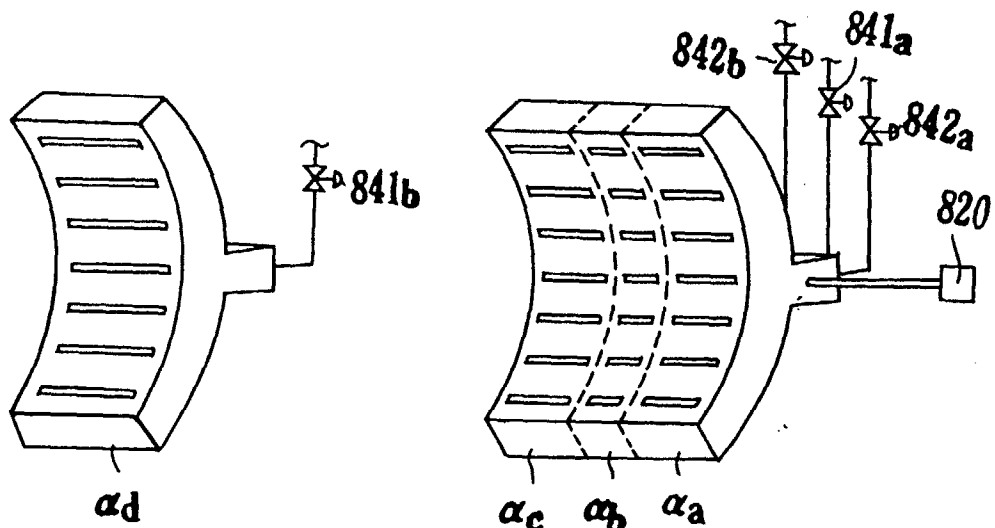
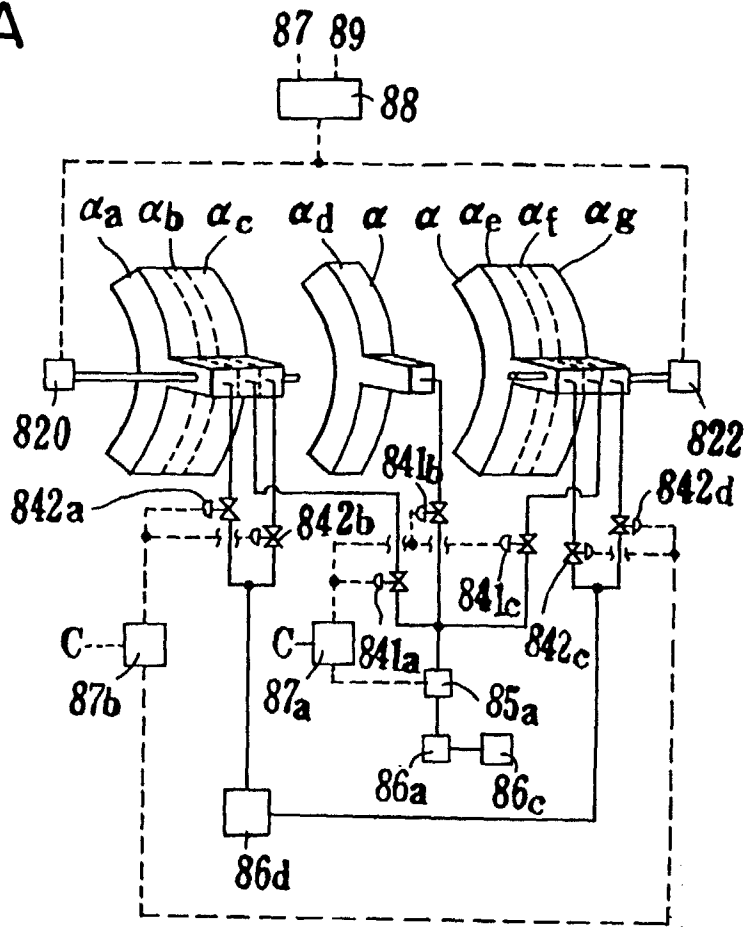


FIG. 5B

FIG. 5C

FIG. 6A

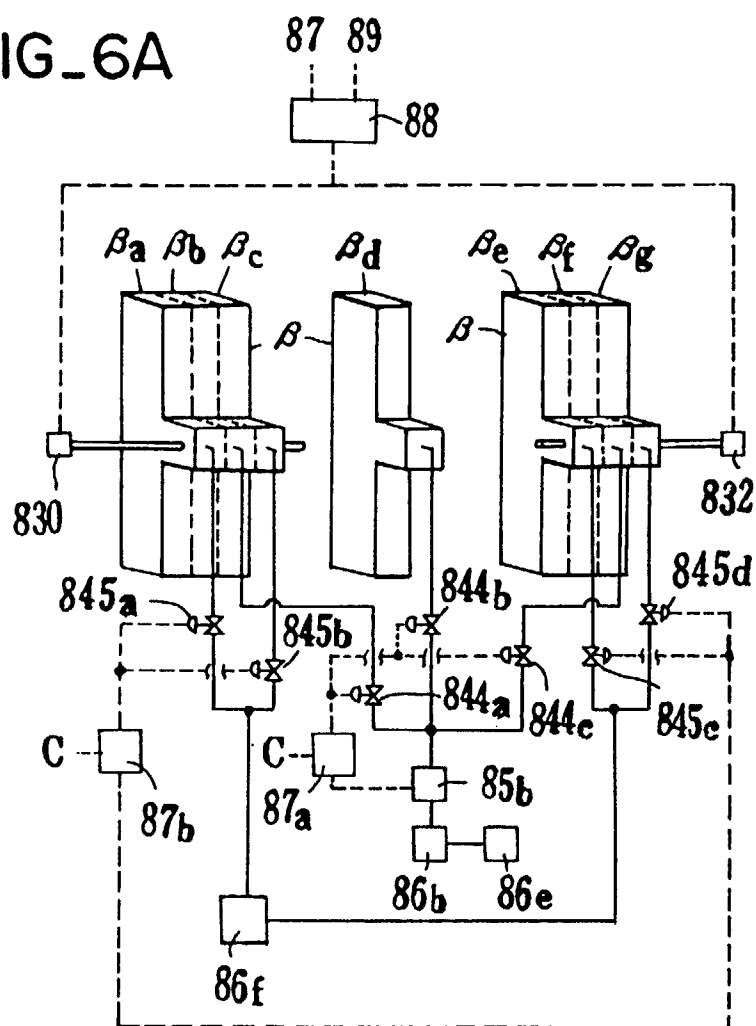


FIG. 6B

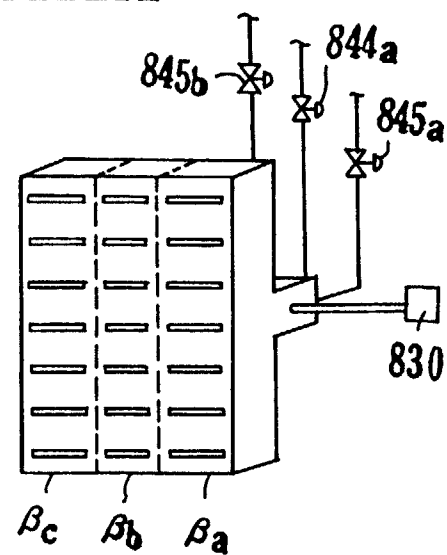
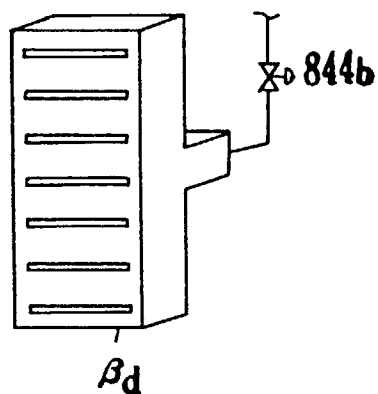
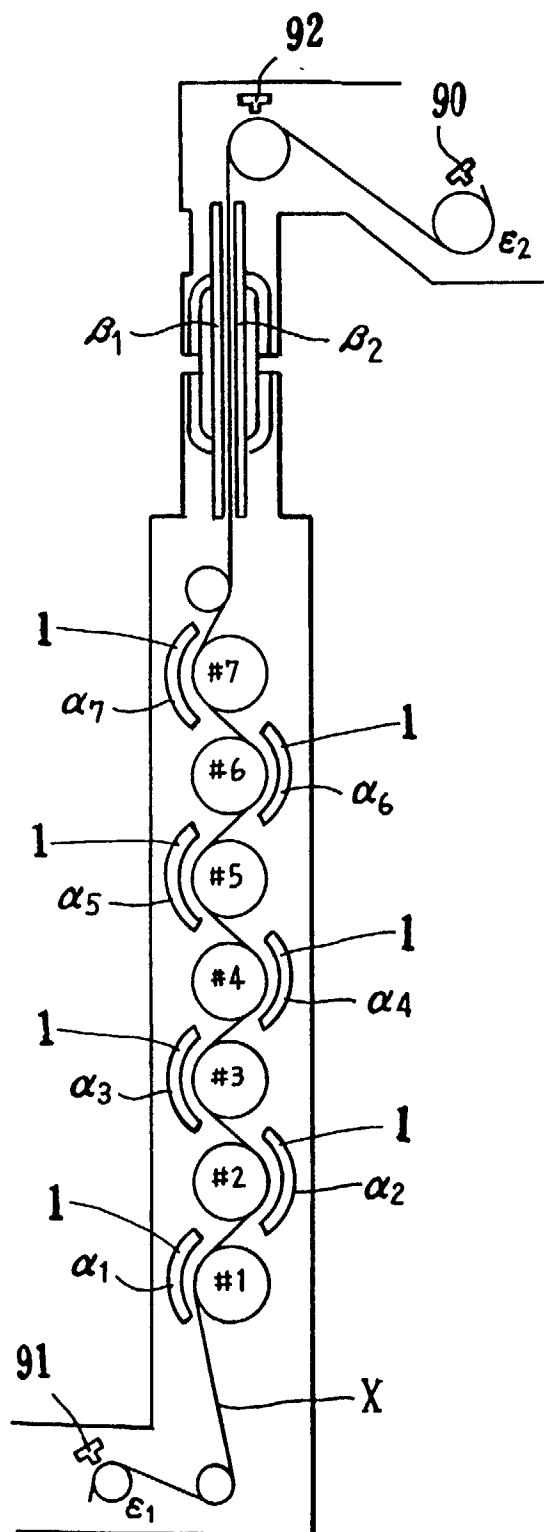
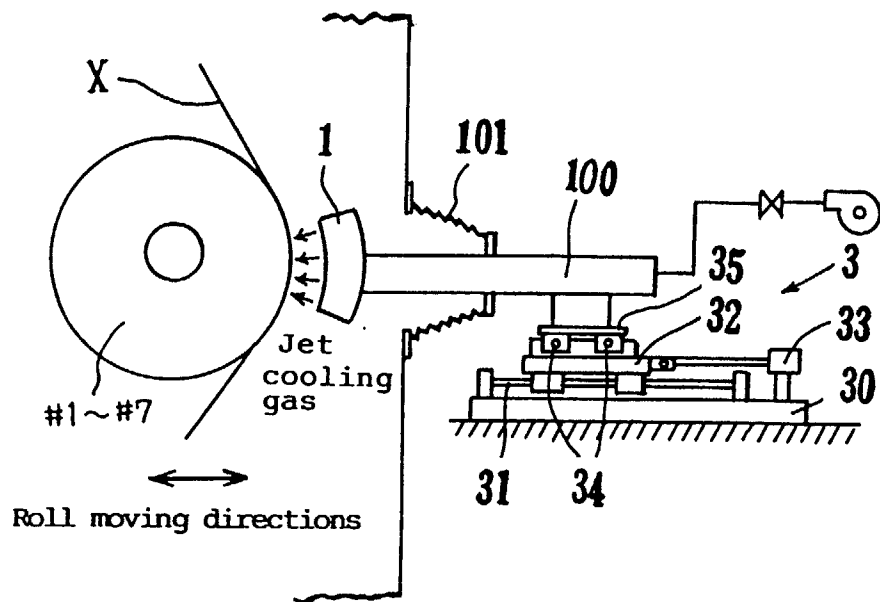


FIG. 6C

FIG_7



FIG_8



FIG_9

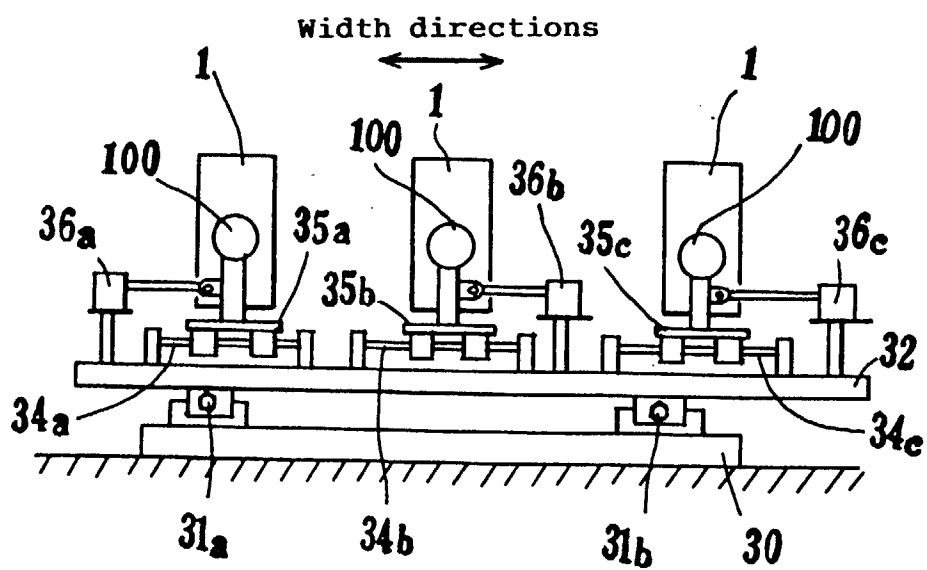


FIG. 10

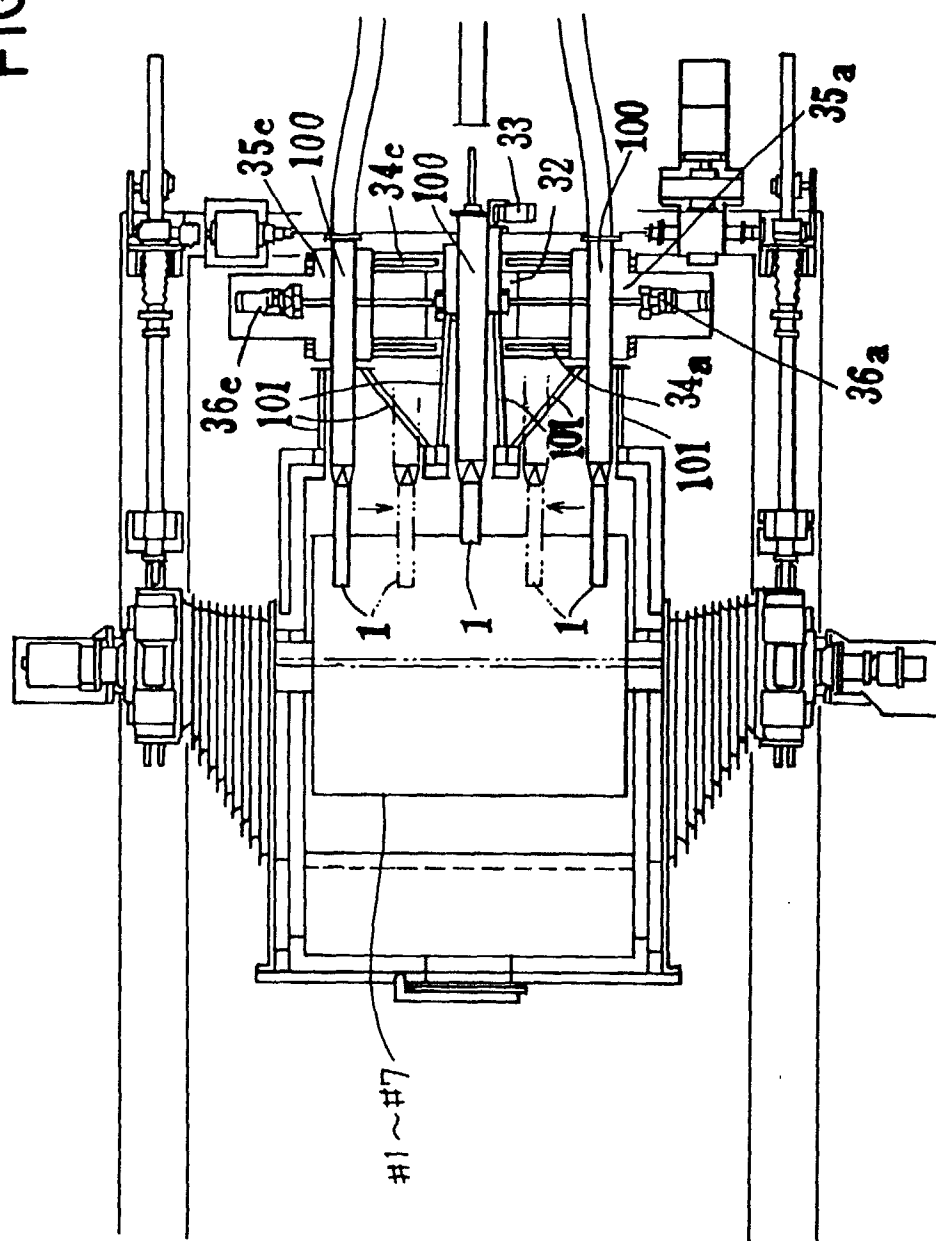
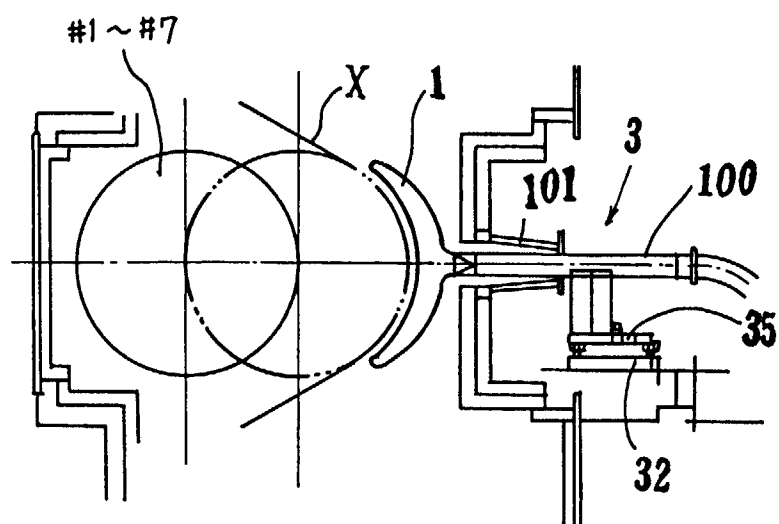
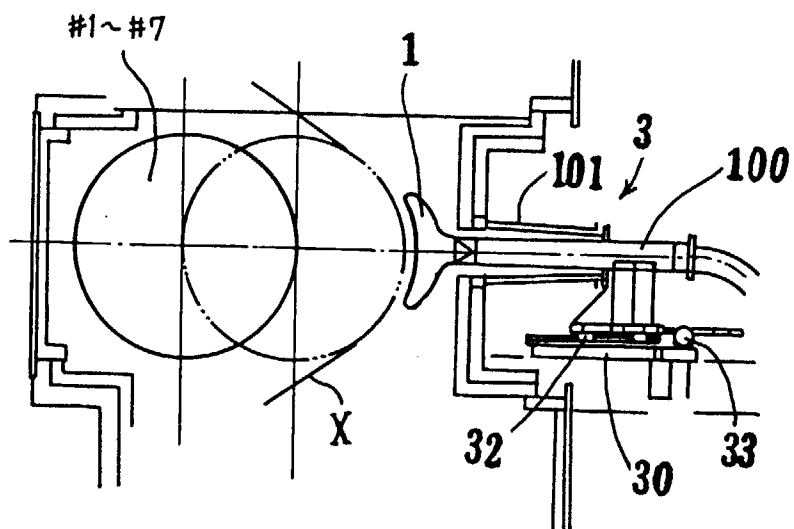


FIG. 11



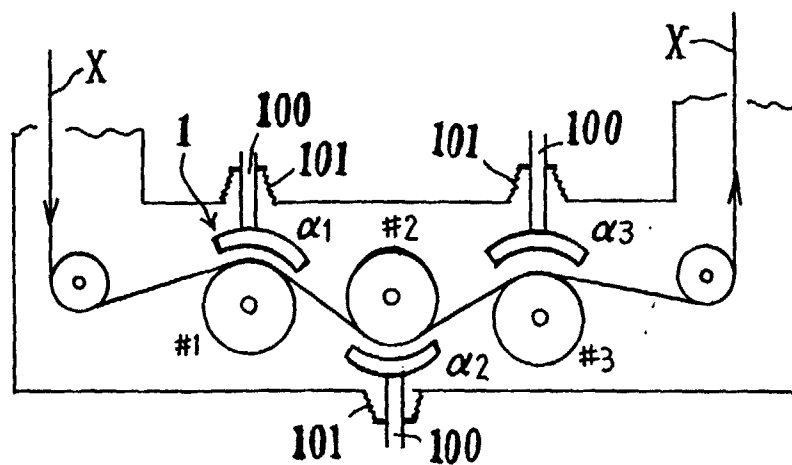
Cross section of the edge portion

FIG. 12



Cross section of the roll center portion

FIG_13



FIG_14

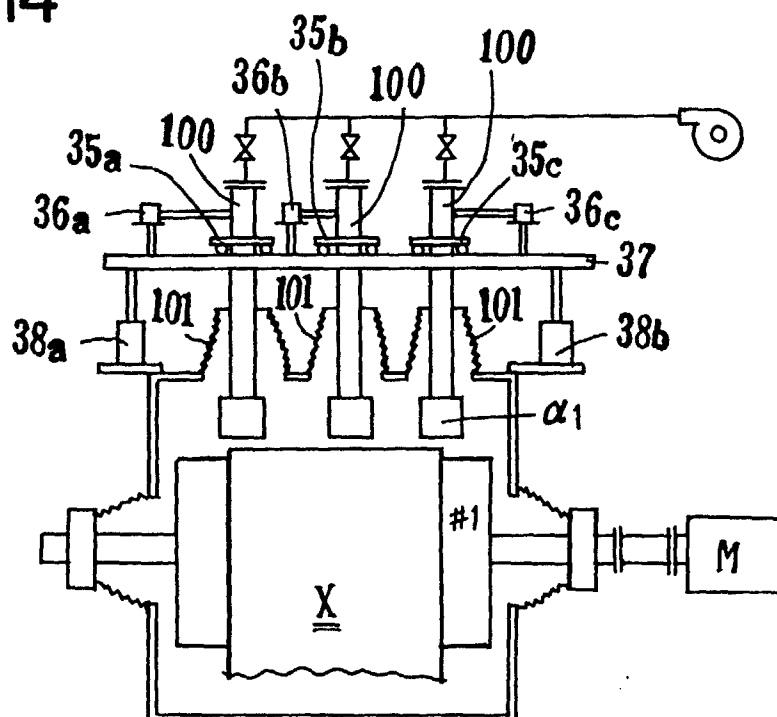


FIG. 15

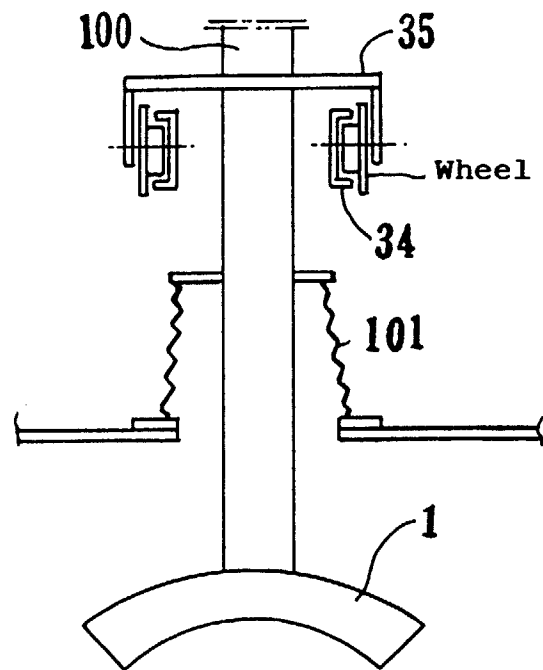


FIG. 16

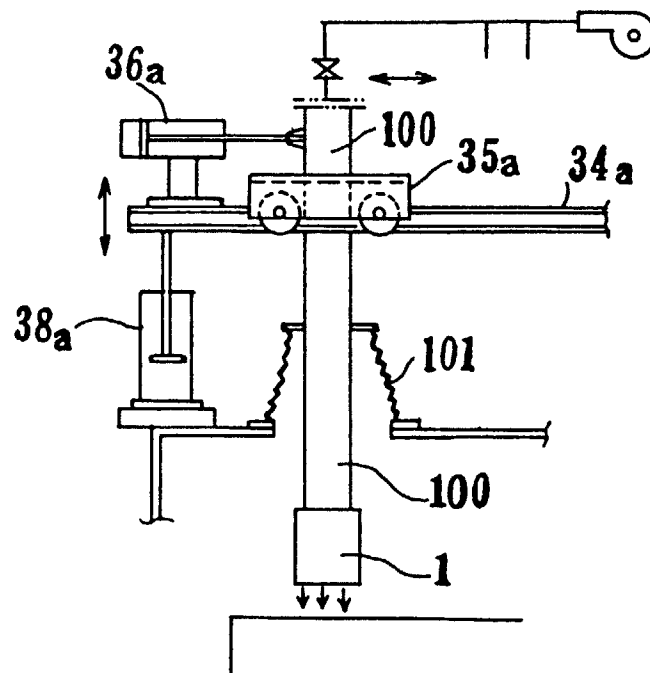


FIG. 17

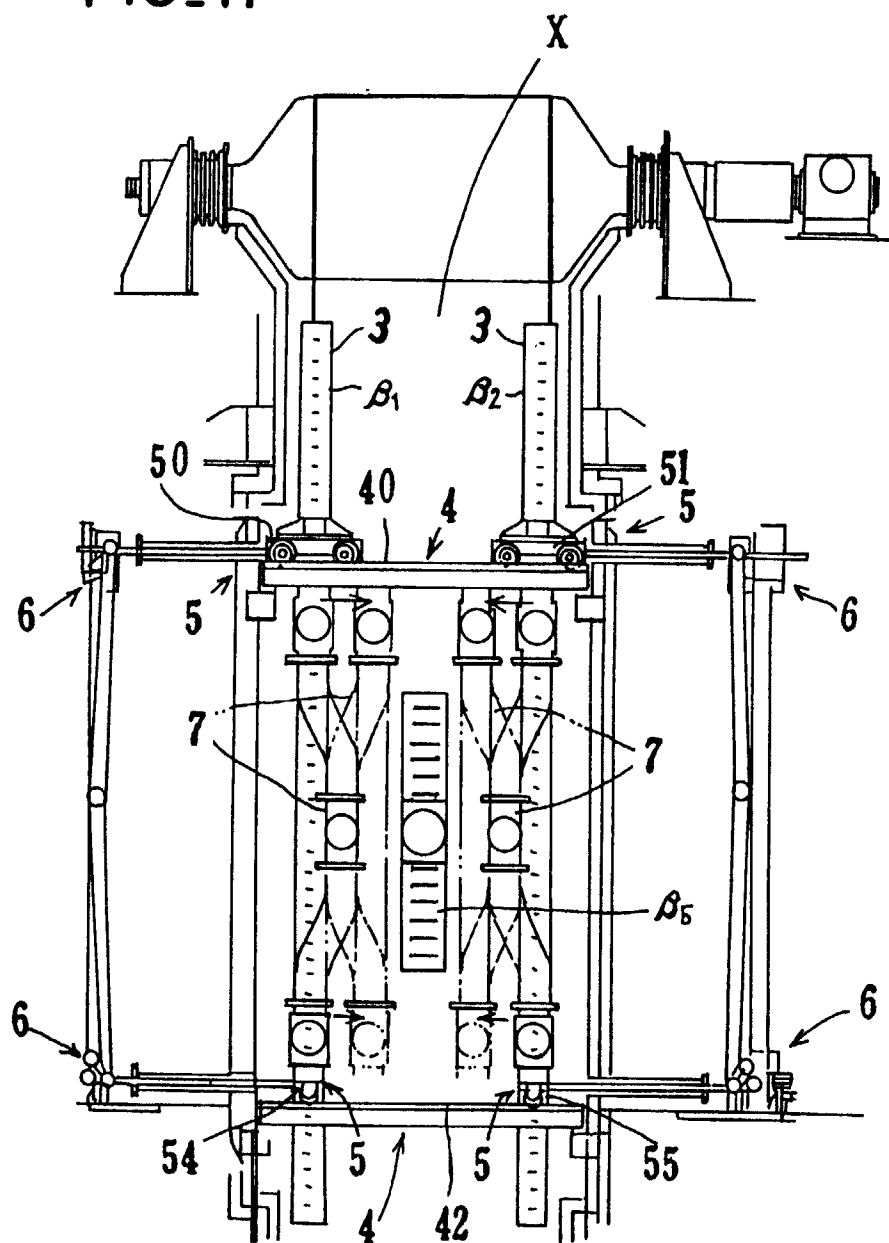


FIG. 18

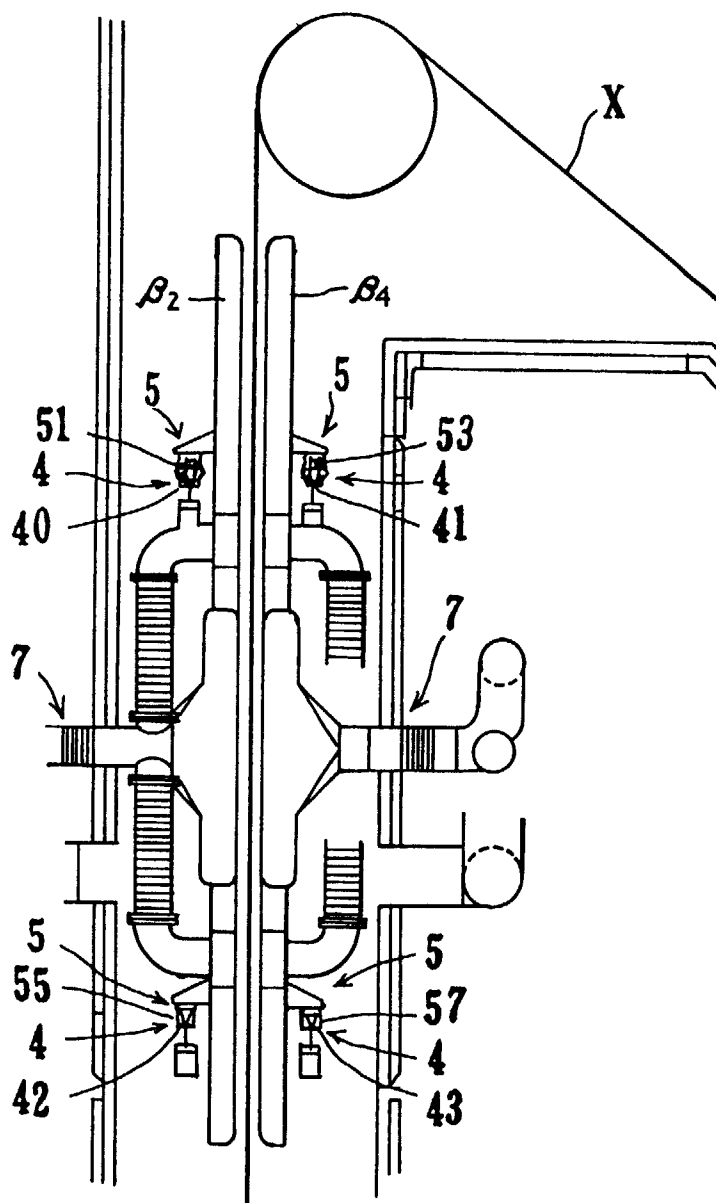


FIG. 19

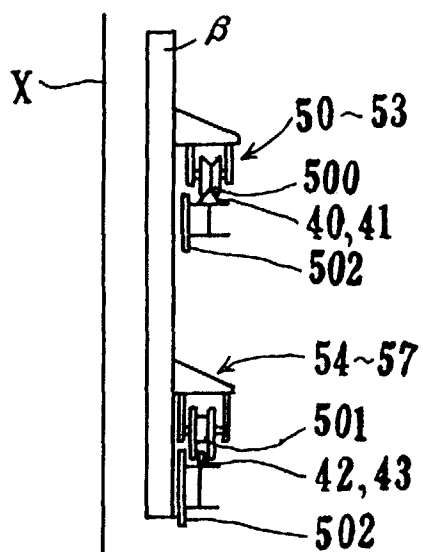


FIG. 20

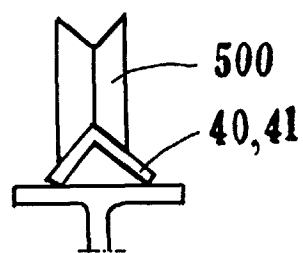


FIG. 21

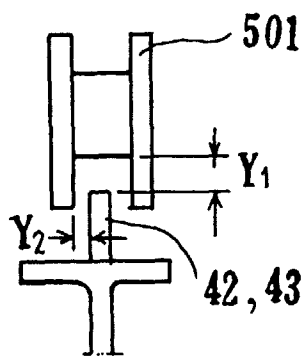
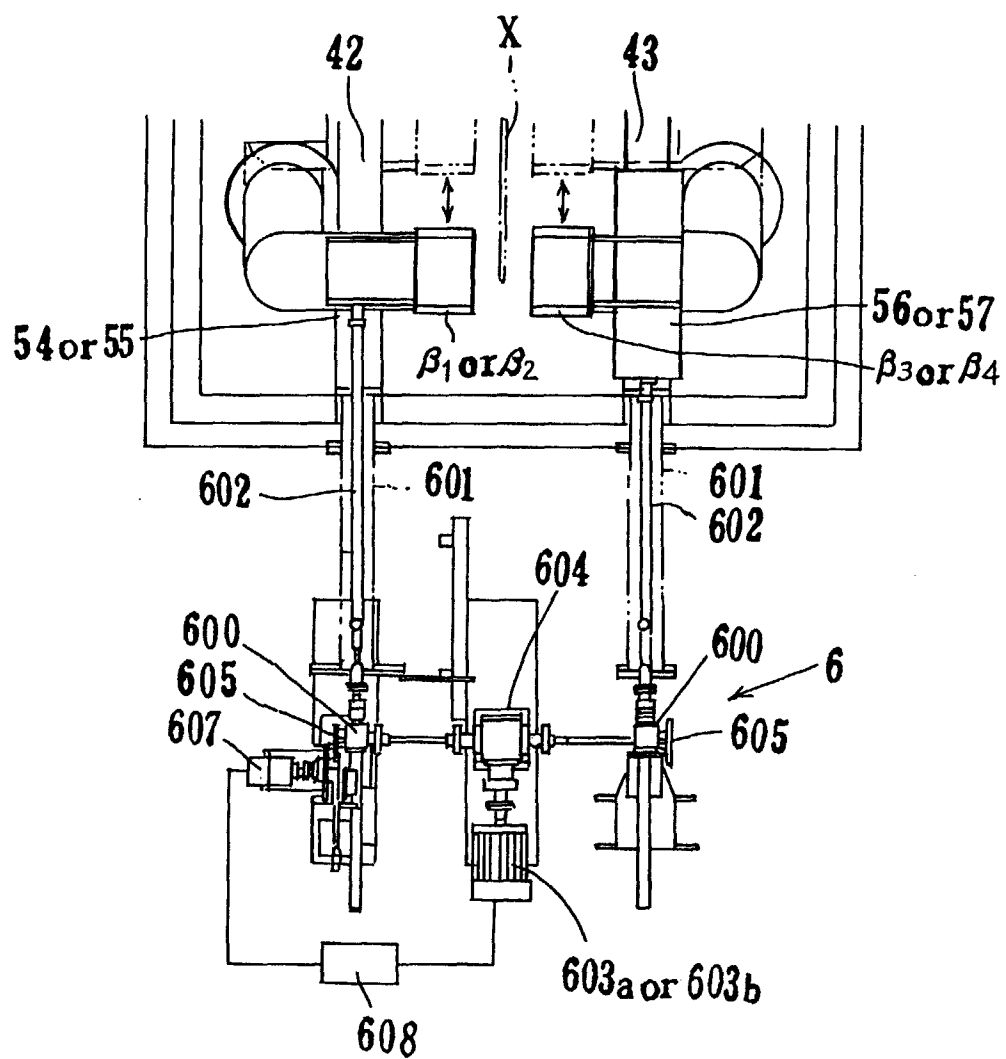
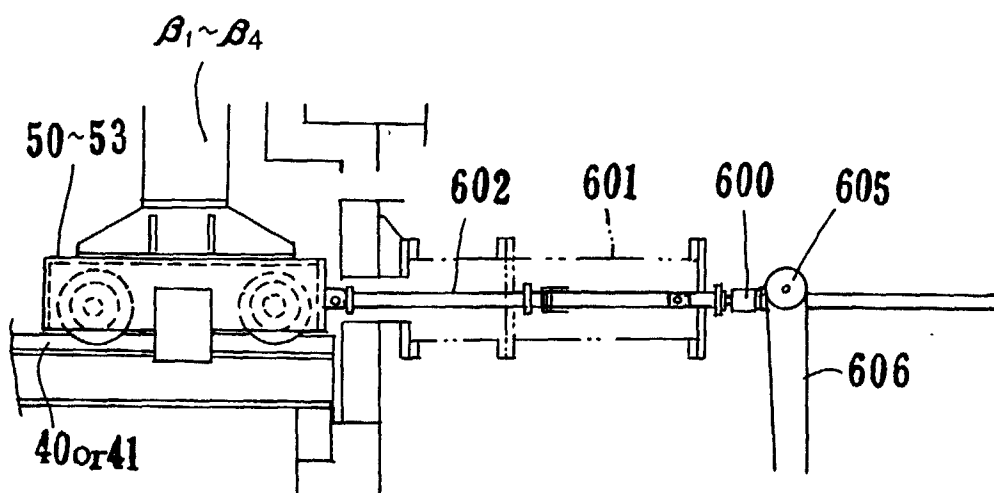


FIG. 22



FIG_23A



FIG_23B

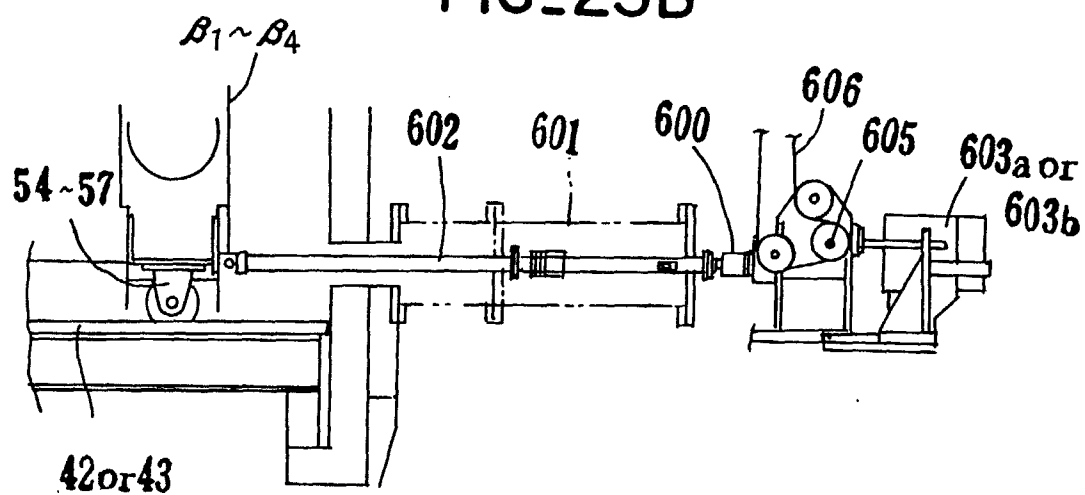


FIG. 24

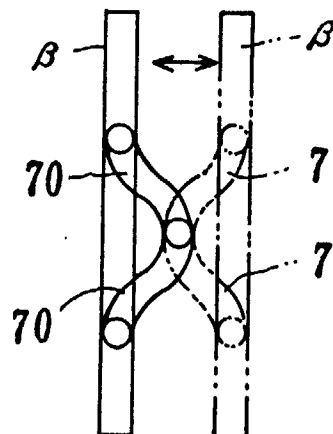
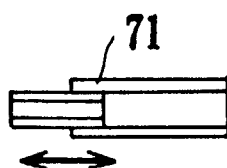
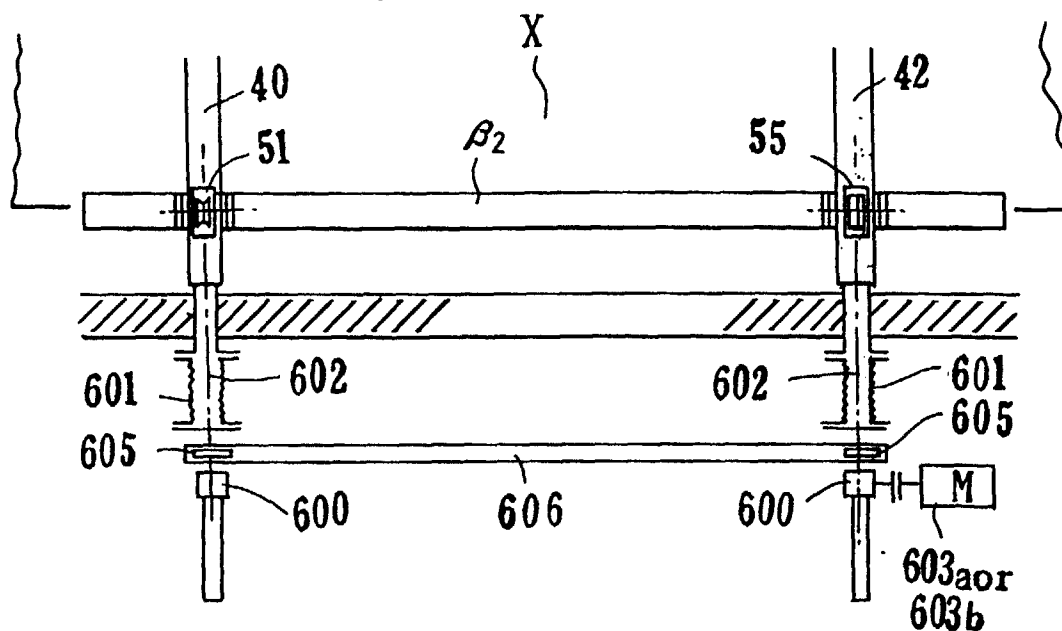


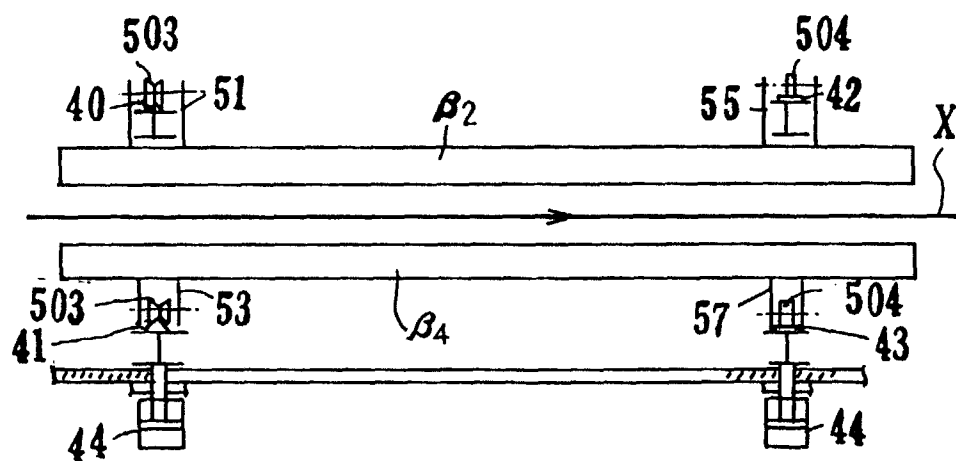
FIG. 25



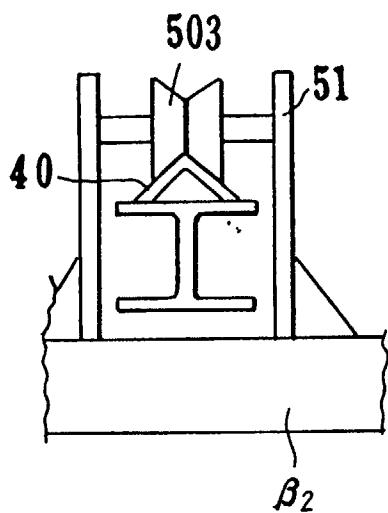
FIG_26



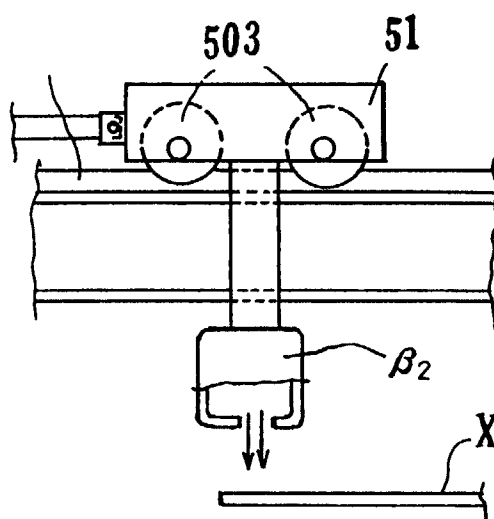
FIG_27



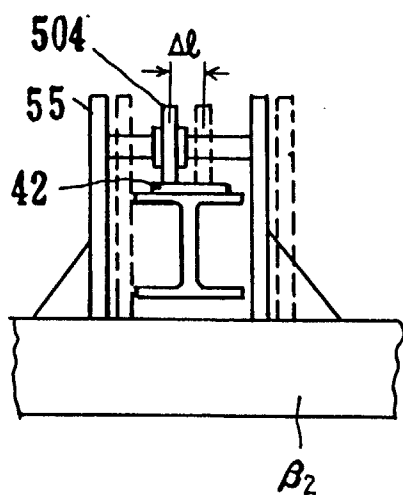
FIG_28A



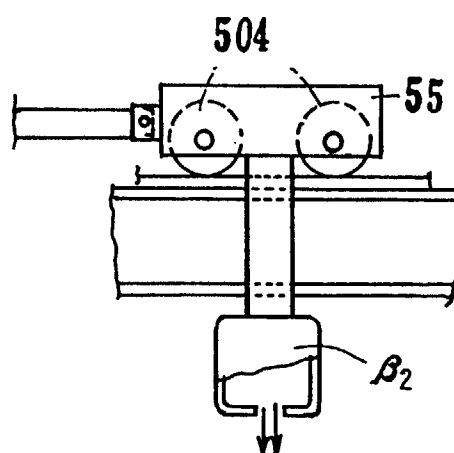
FIG_28B



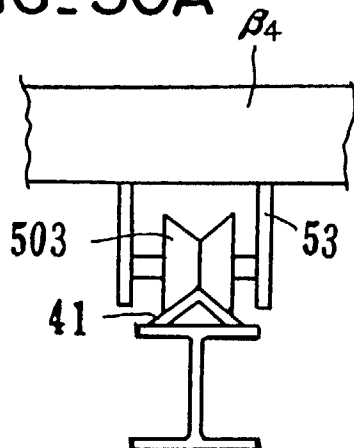
FIG_29A



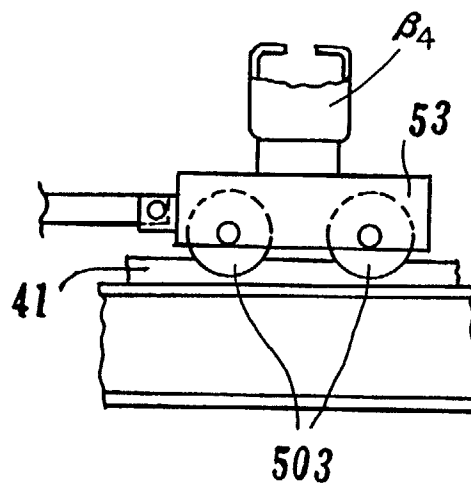
FIG_29B



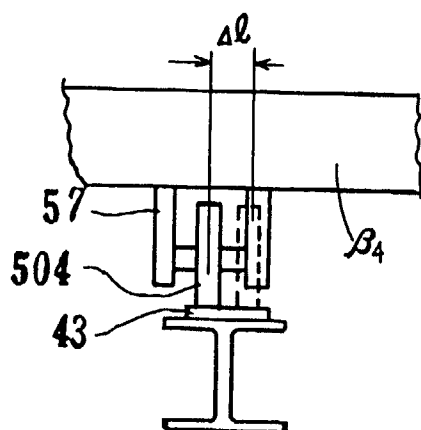
FIG_30A



FIG_30B



FIG_31A



FIG_31B

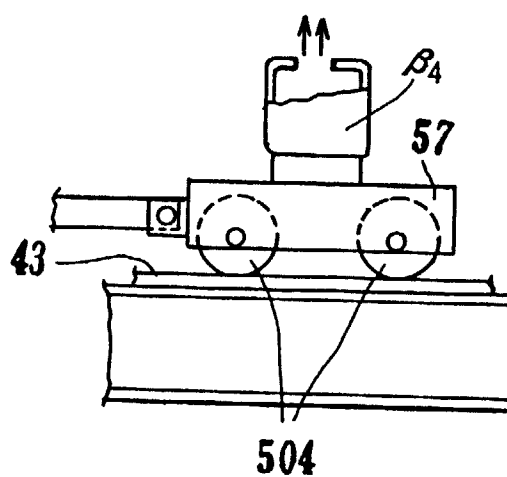


FIG. 32

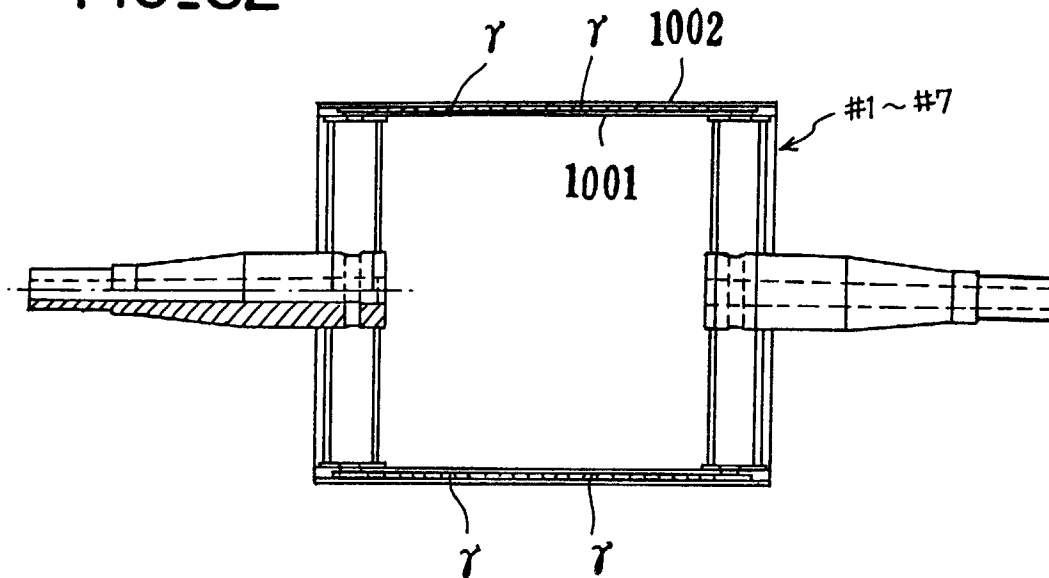


FIG. 33

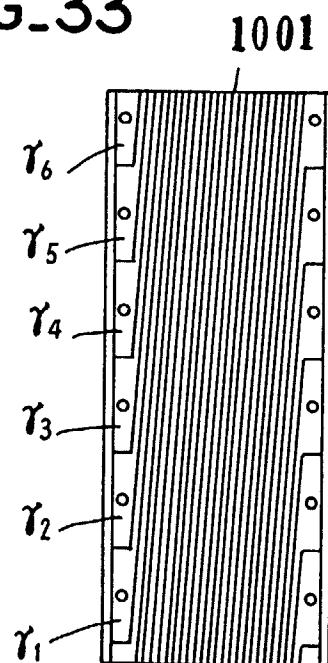


FIG. 34

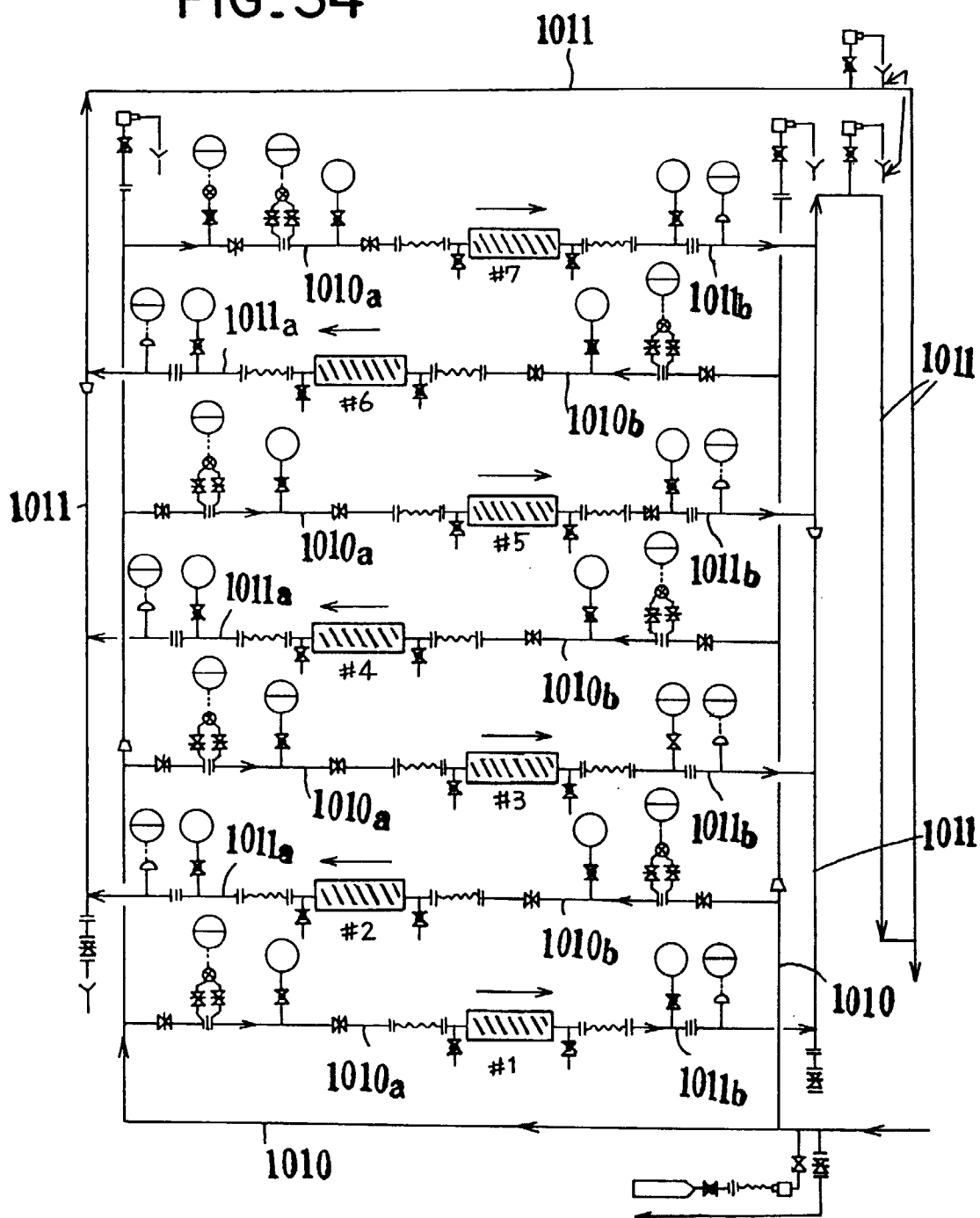


FIG. 35

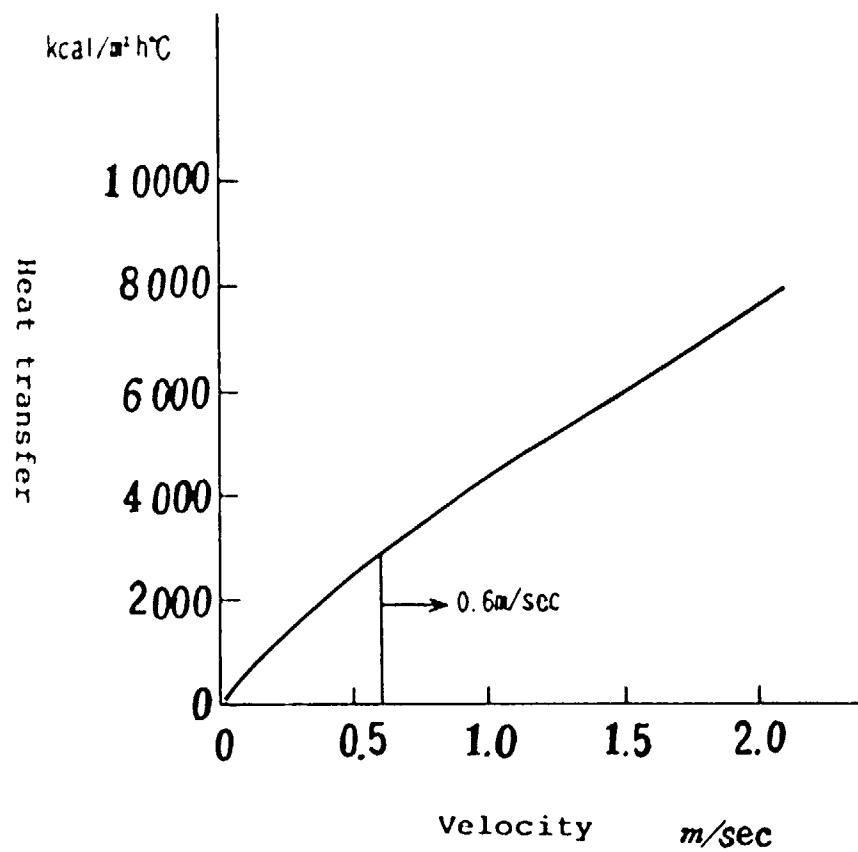


FIG. 36

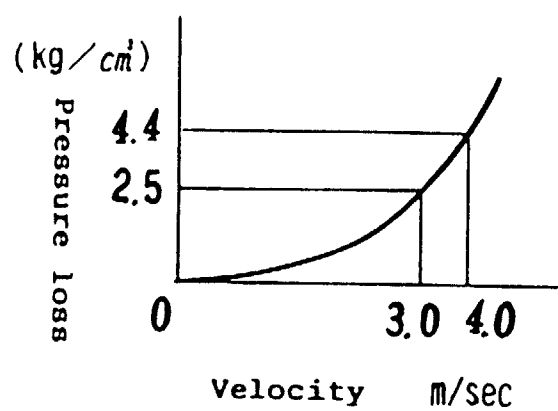
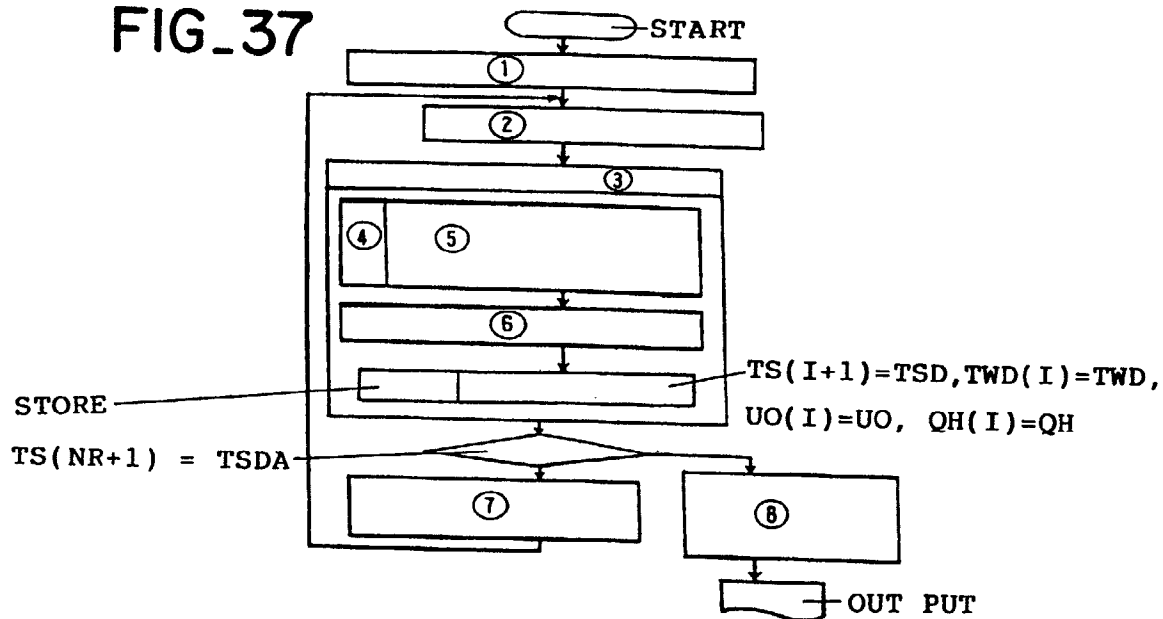


FIG. 37



- ① Read $(X(I), Y(I))$ of the roll position when the strip is wrapped around the roll at maximum, and this position is an initial value.
- ② Calculations of wrapped length $LS(I)$, wrapped angle $AR(I)$ total wrapped length TLL , and total pass length $L0$
- ③ $I = 1$ to NR (Calculation of heat transfer in each roll)
- ④ Conditions
- ⑤ Strip temperature at the inlet of the cooling rolls $TSE = TS(I)$
 Water temperature at the inlet of the cooling rolls $TWE = TWE(I)$
 Wrapped length $LS = LS(I)$
 Wrapped angle $AR = AR(I)$
 Shell thickness $RST = RT(I)$
 Roll diameter $D = D(I)$
- ⑥ TSD, TWD, QH and UO are obtained from calculations of heat transfer of the formulae 1 to 6
- ⑦ Moving amount DY of the cooling roll to be controlled is calculated, and only the roll ($CTR(I)=1$) is reset with respect to the roll position.
- ⑧ Calculations of cooling rate of the roll $CR(J)$, average cooling rate ACR , and average overall heat transfer AUo

FIG. 38

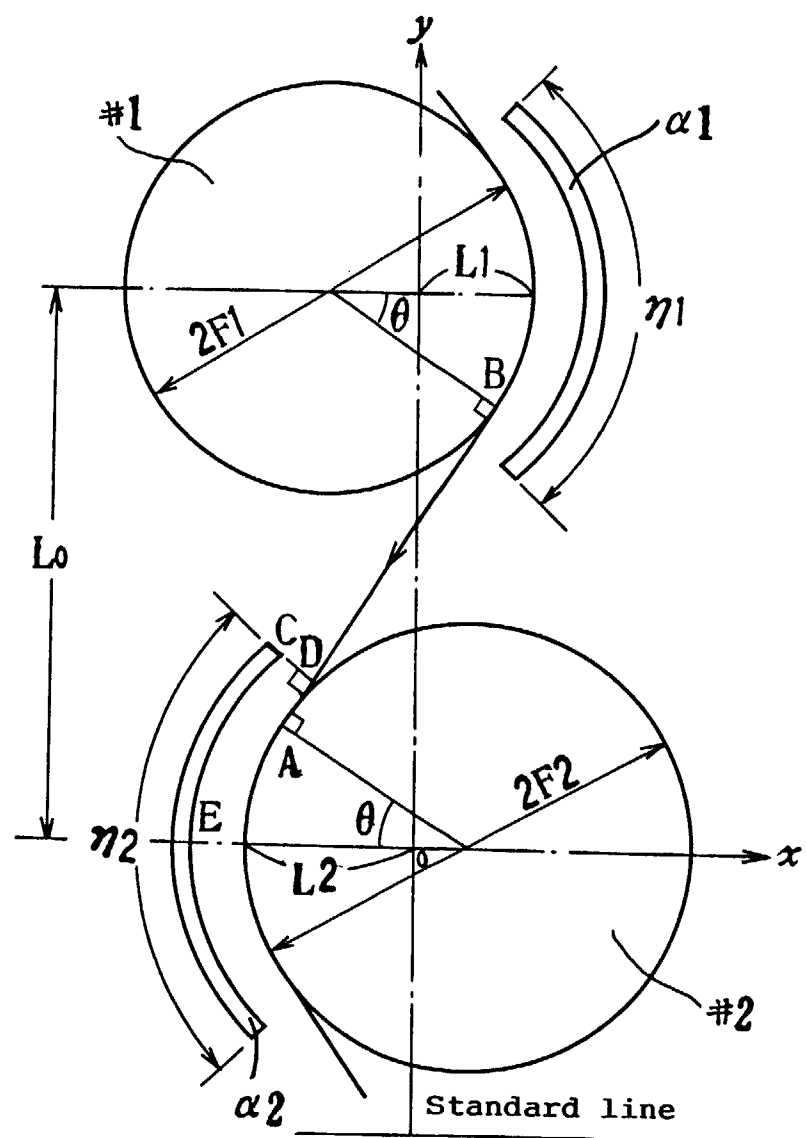


FIG. 39

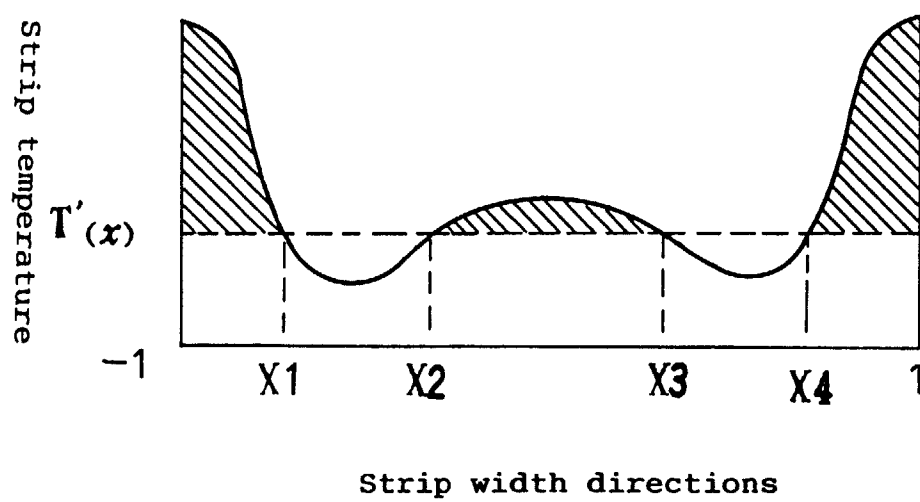


FIG. 40

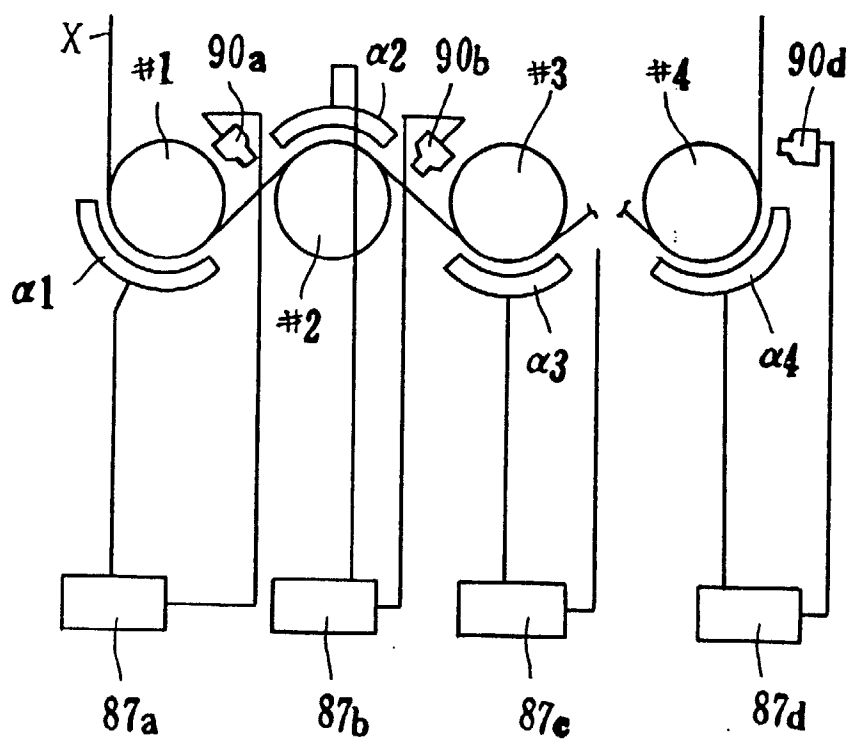


FIG. 41

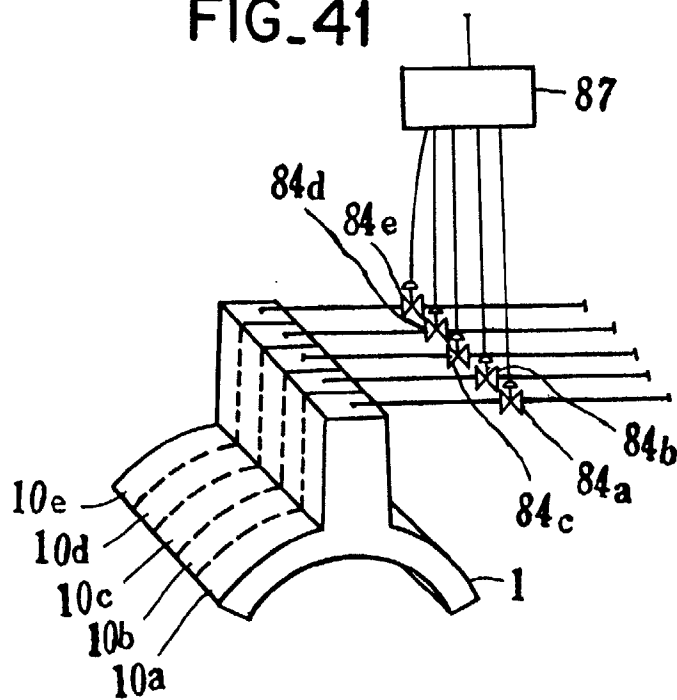


FIG. 42

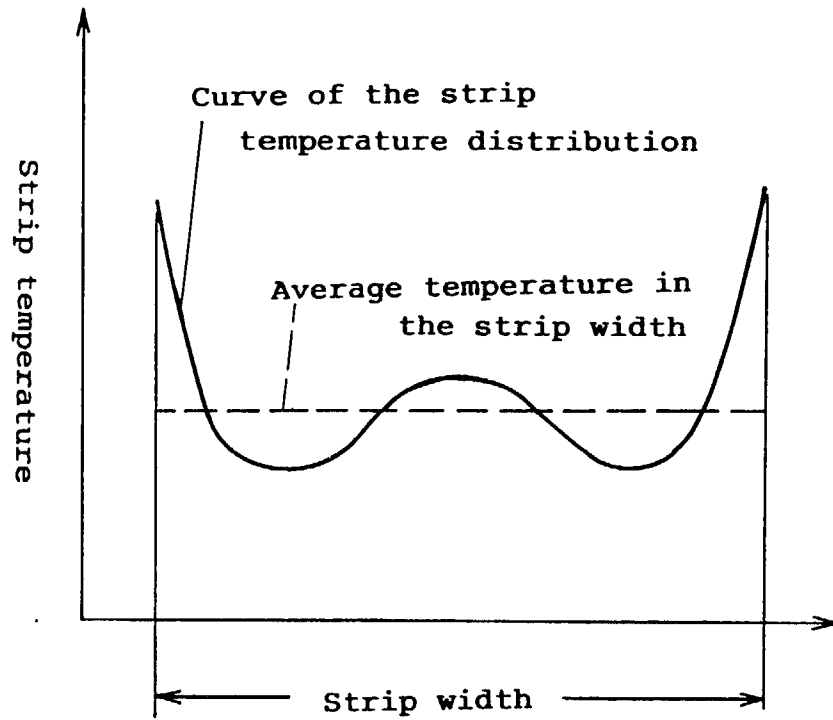
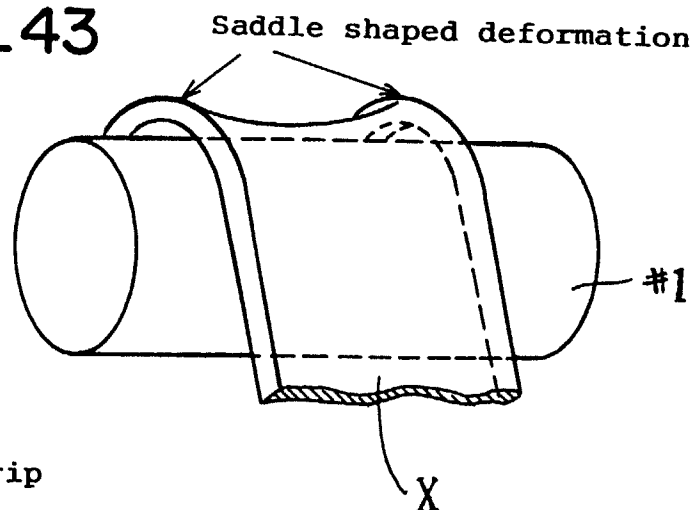


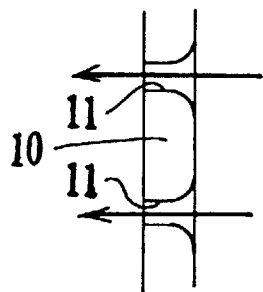
FIG. 43



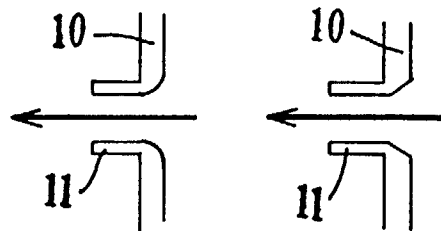
X... Metal strip

#1... Cooling roll

FIG_44A



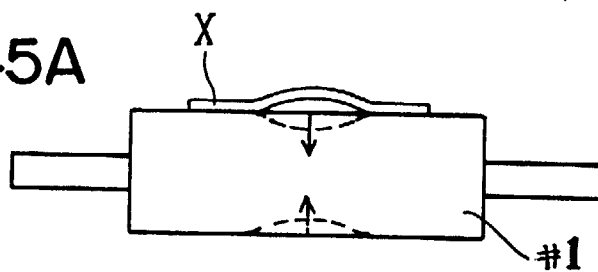
FIG_44C



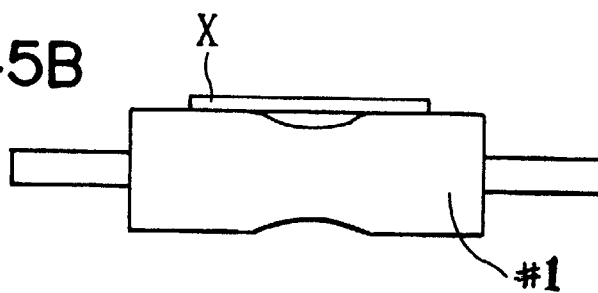
FIG_44D

FIG_44B

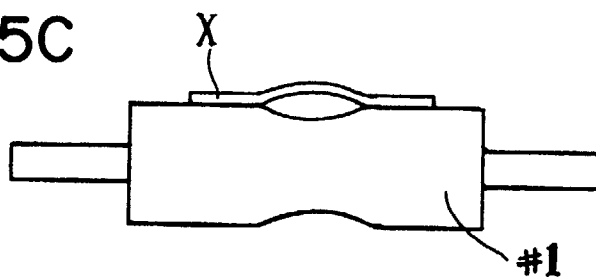
FIG_45A



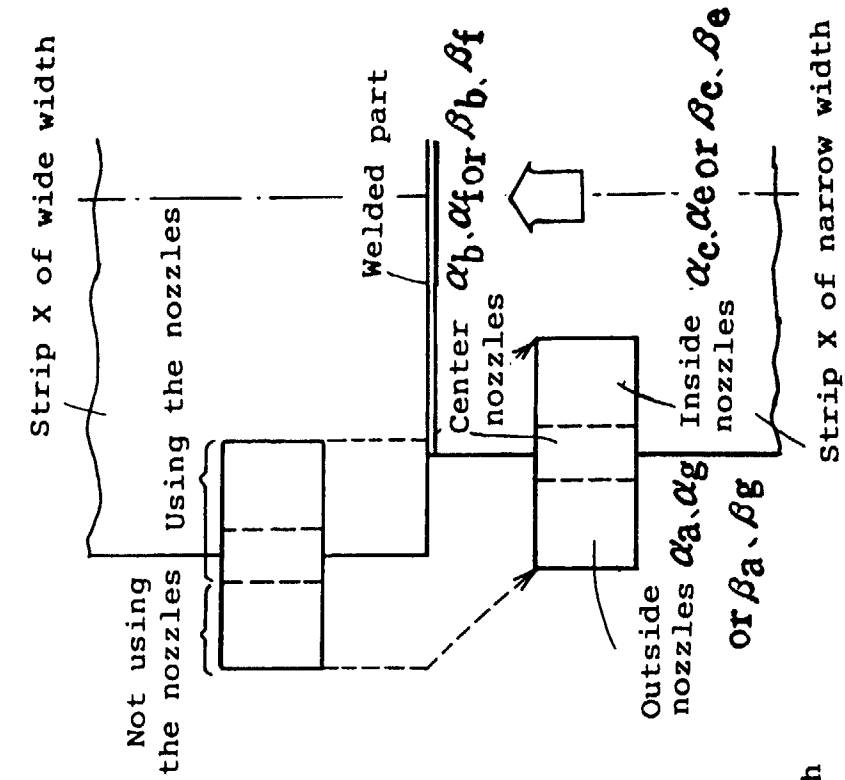
FIG_45B



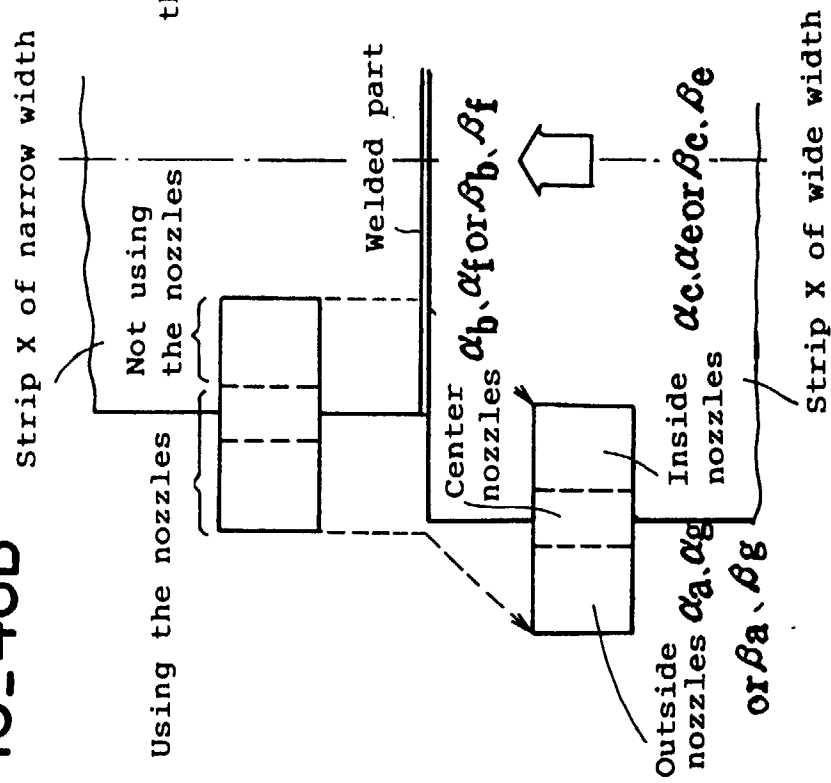
FIG_45C



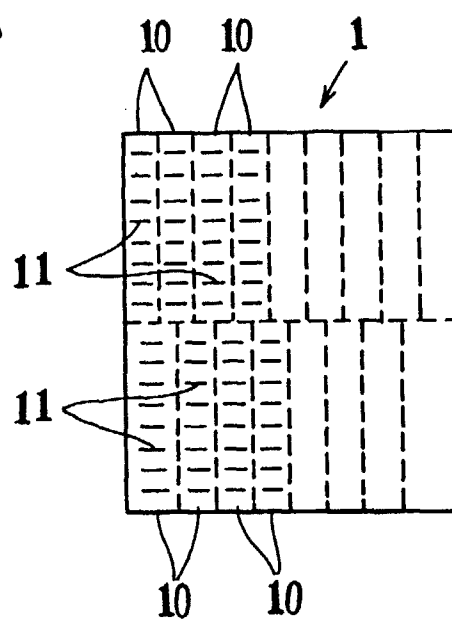
FIG_46A



FIG_46B



FIG_47A



FIG_47B

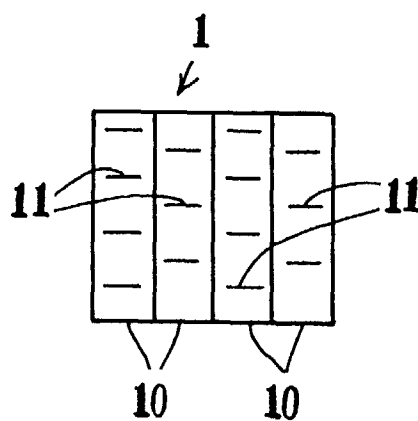
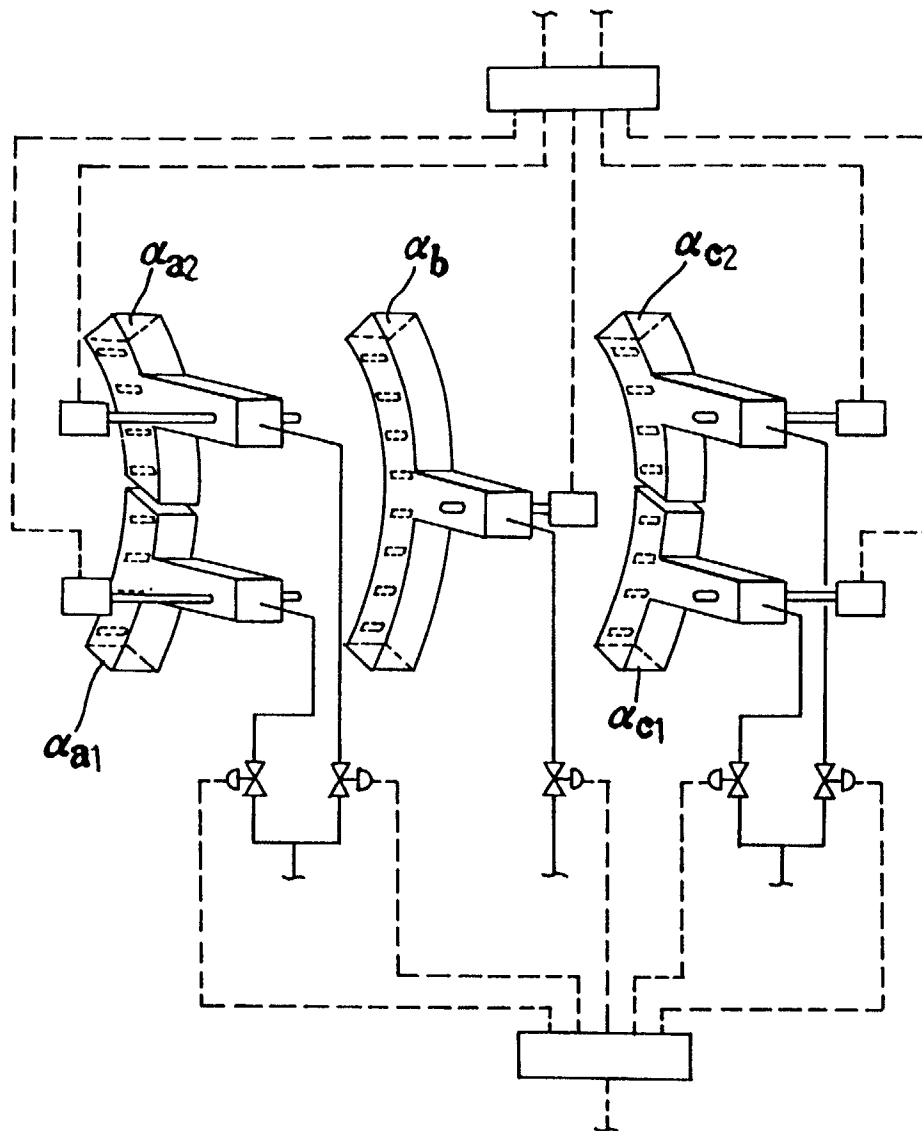


FIG. 48



FIG_49

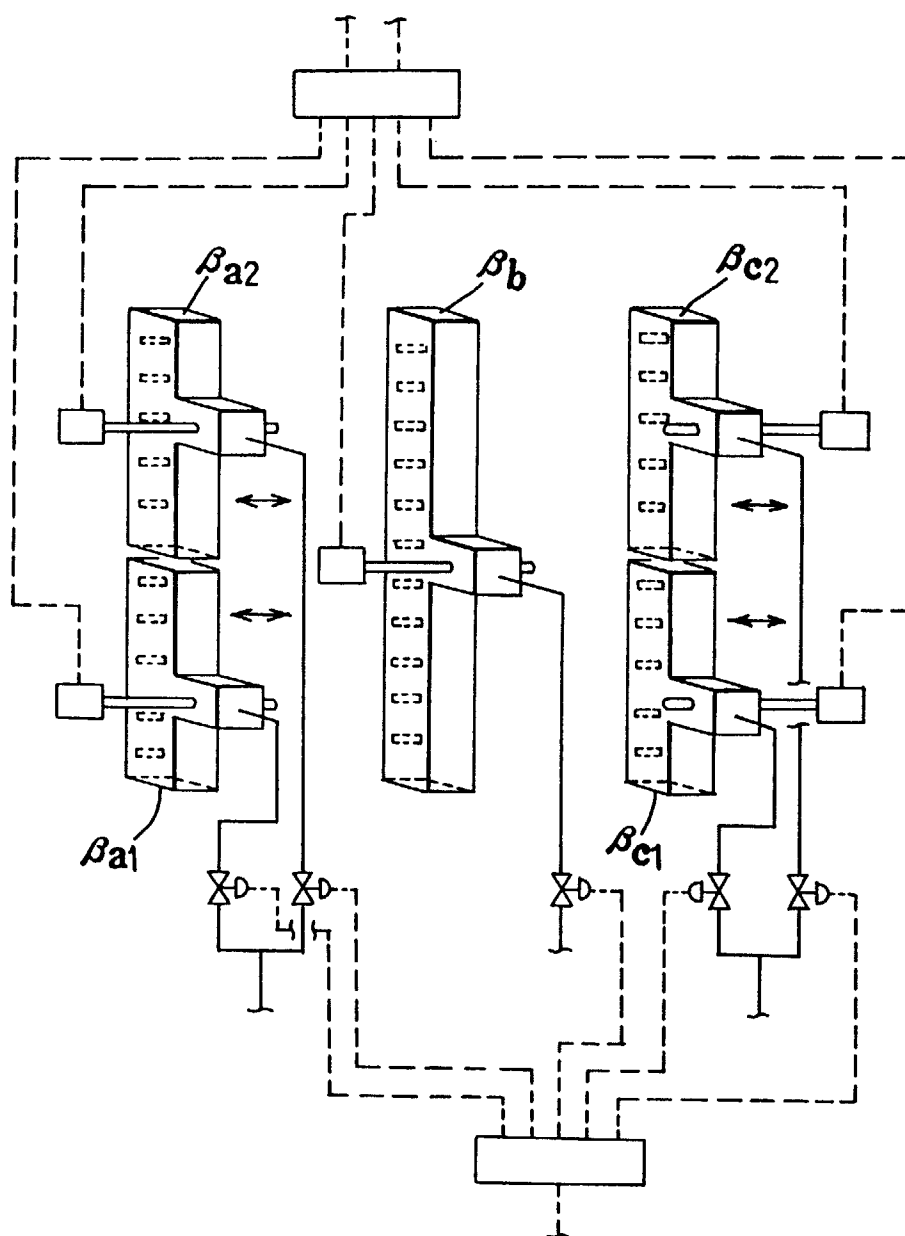


FIG. 50A

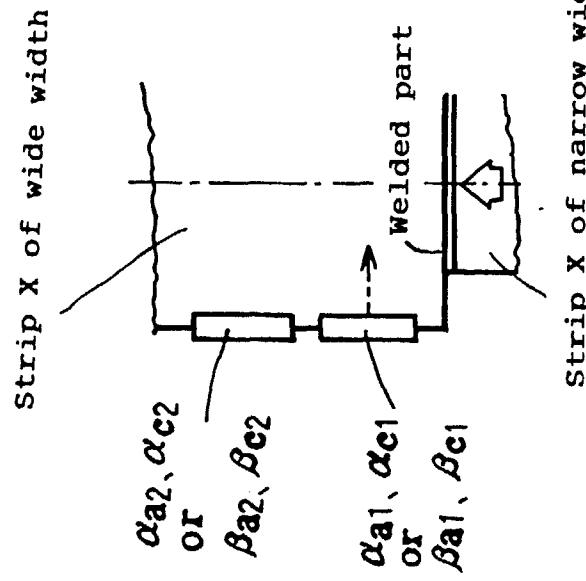


FIG. 50B

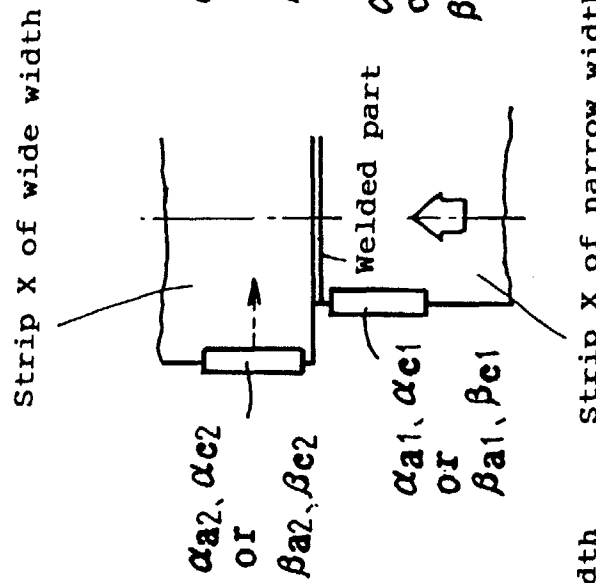
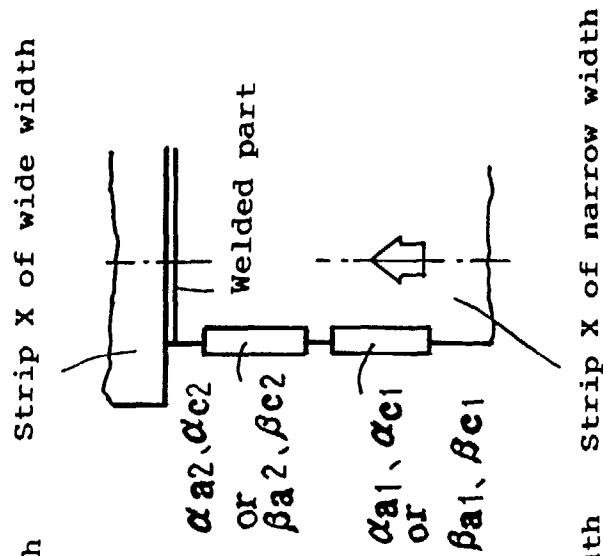


FIG. 50C



FIG_51A

FIG_51B

FIG_51C

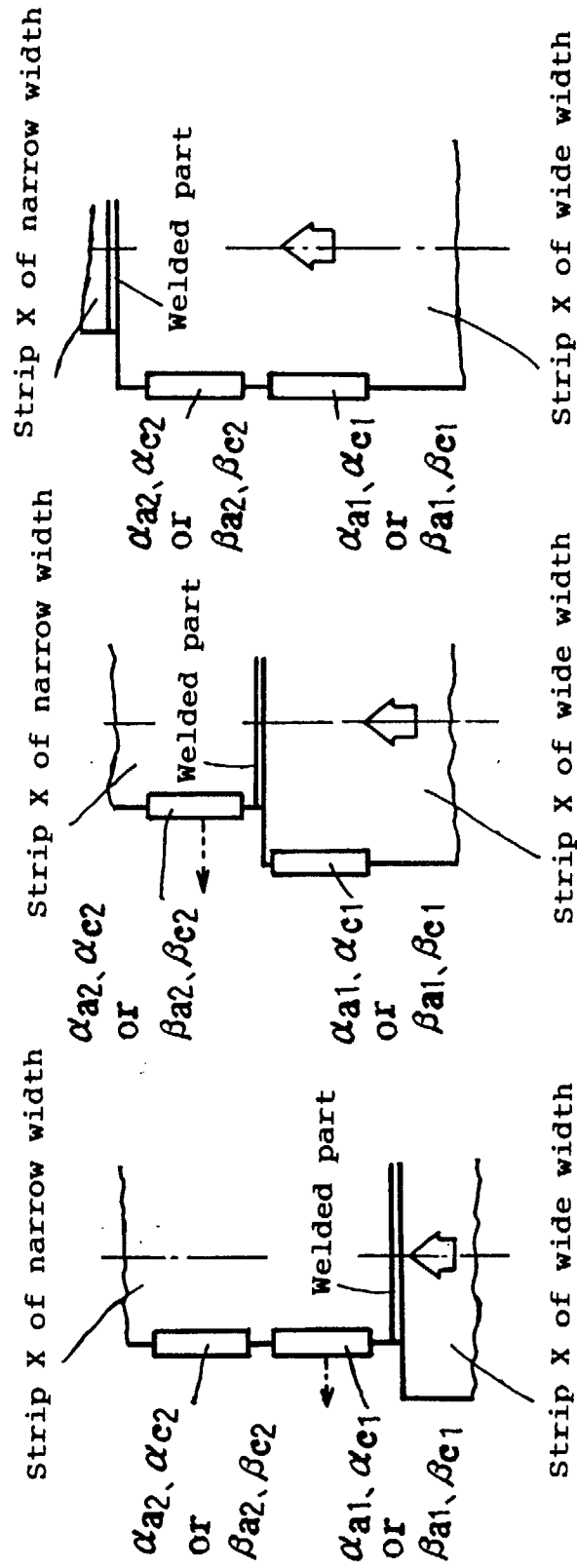


FIG. 52

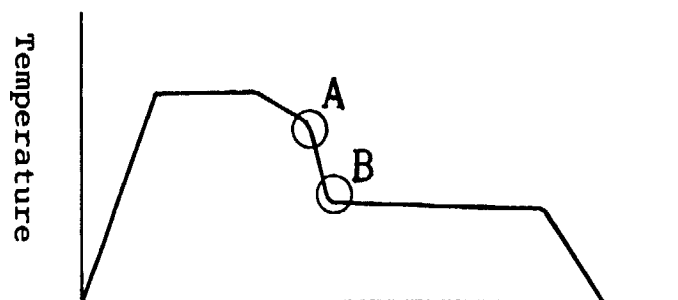
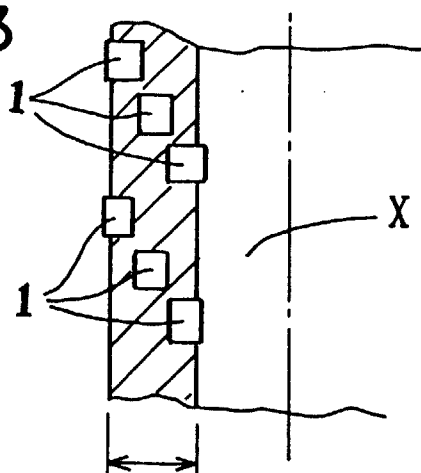


FIG. 53



Not uniform strip temperature

FIG. 54

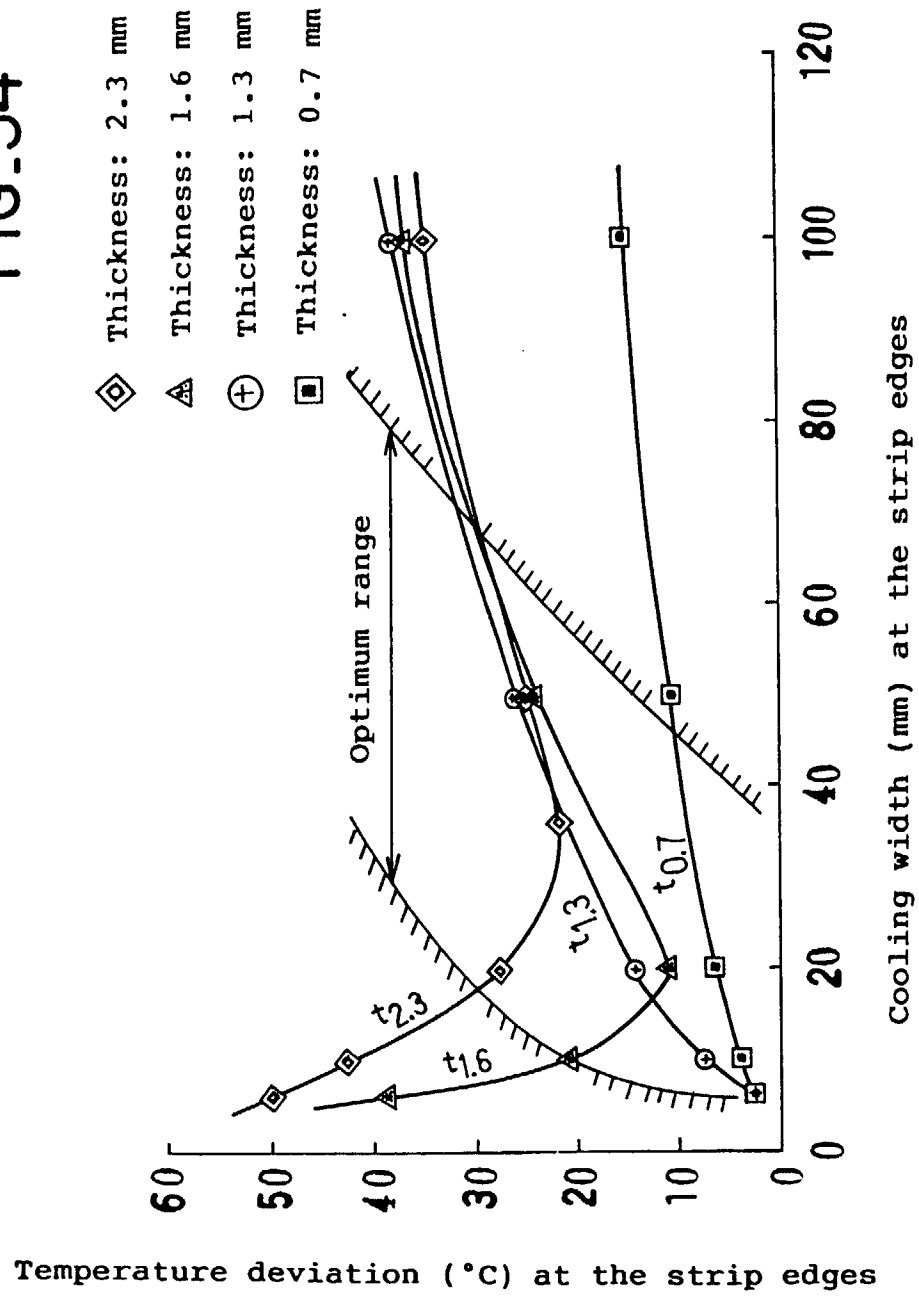


FIG. 55

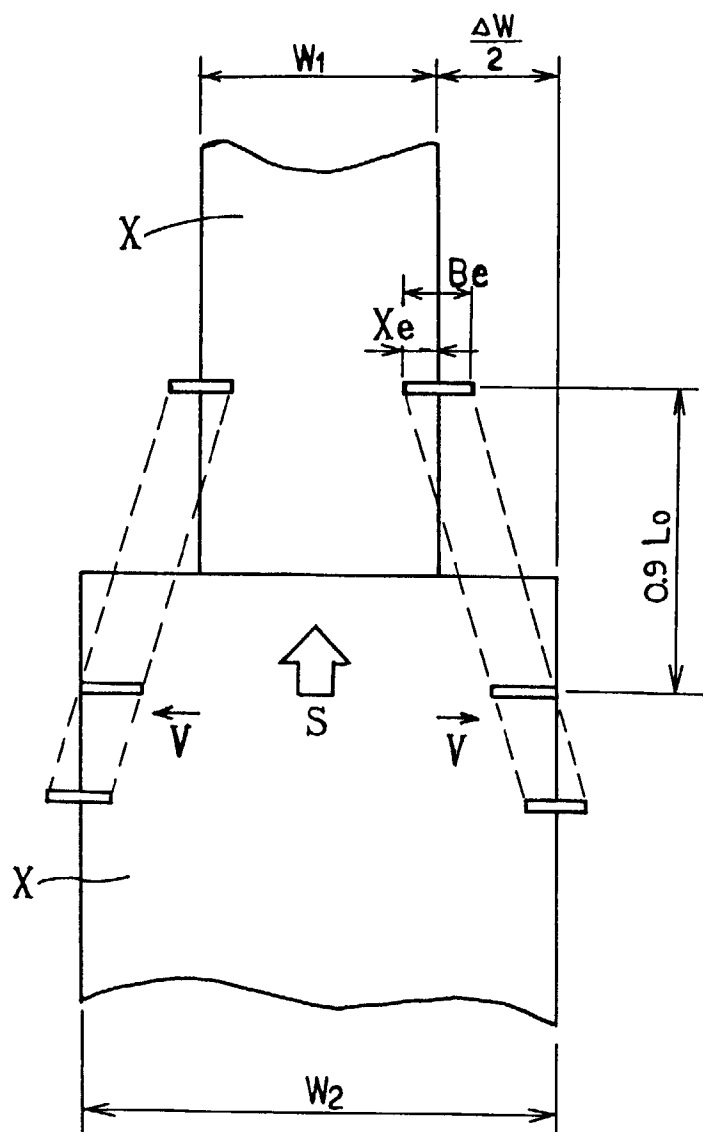


FIG. 56

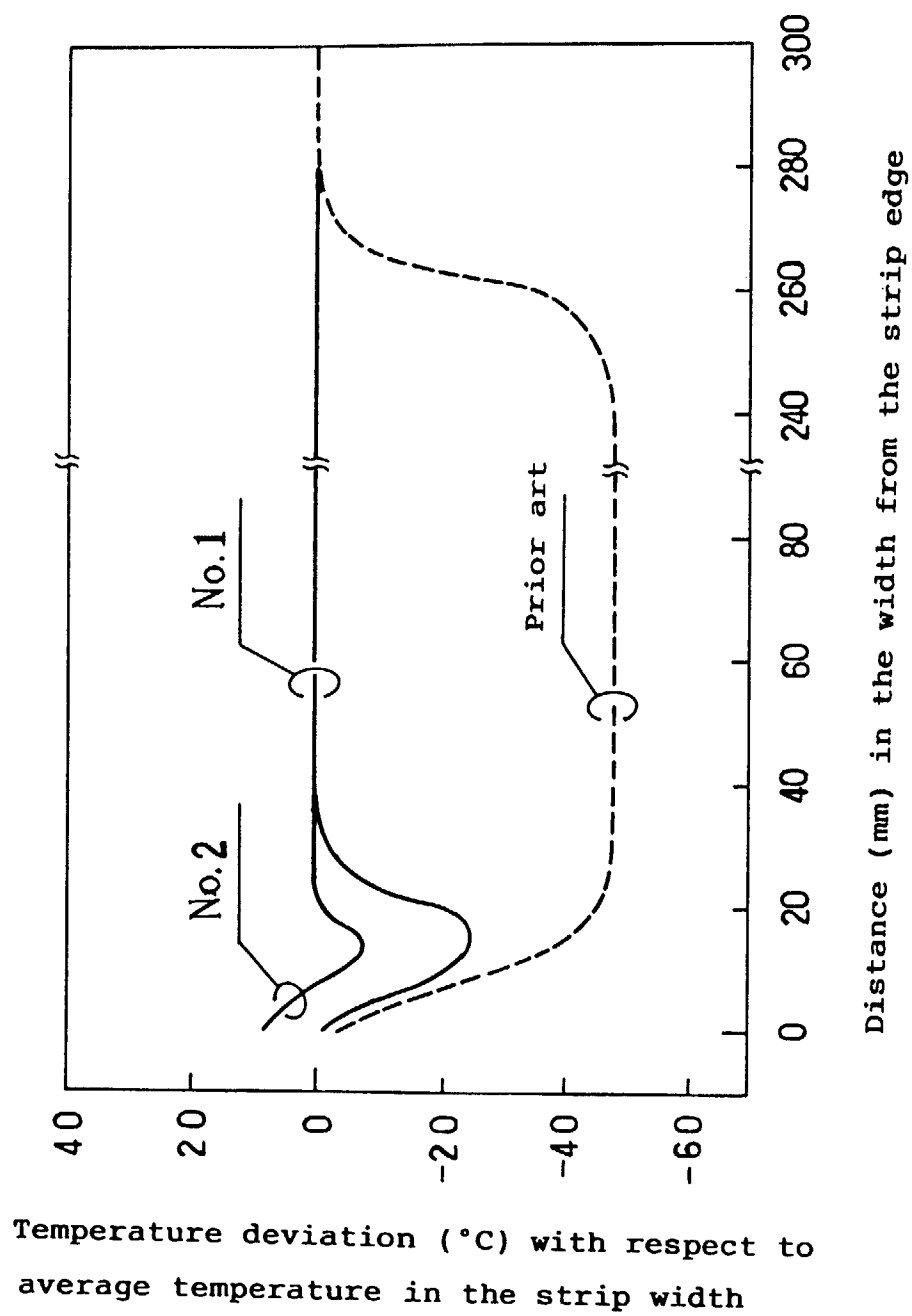


FIG. 57

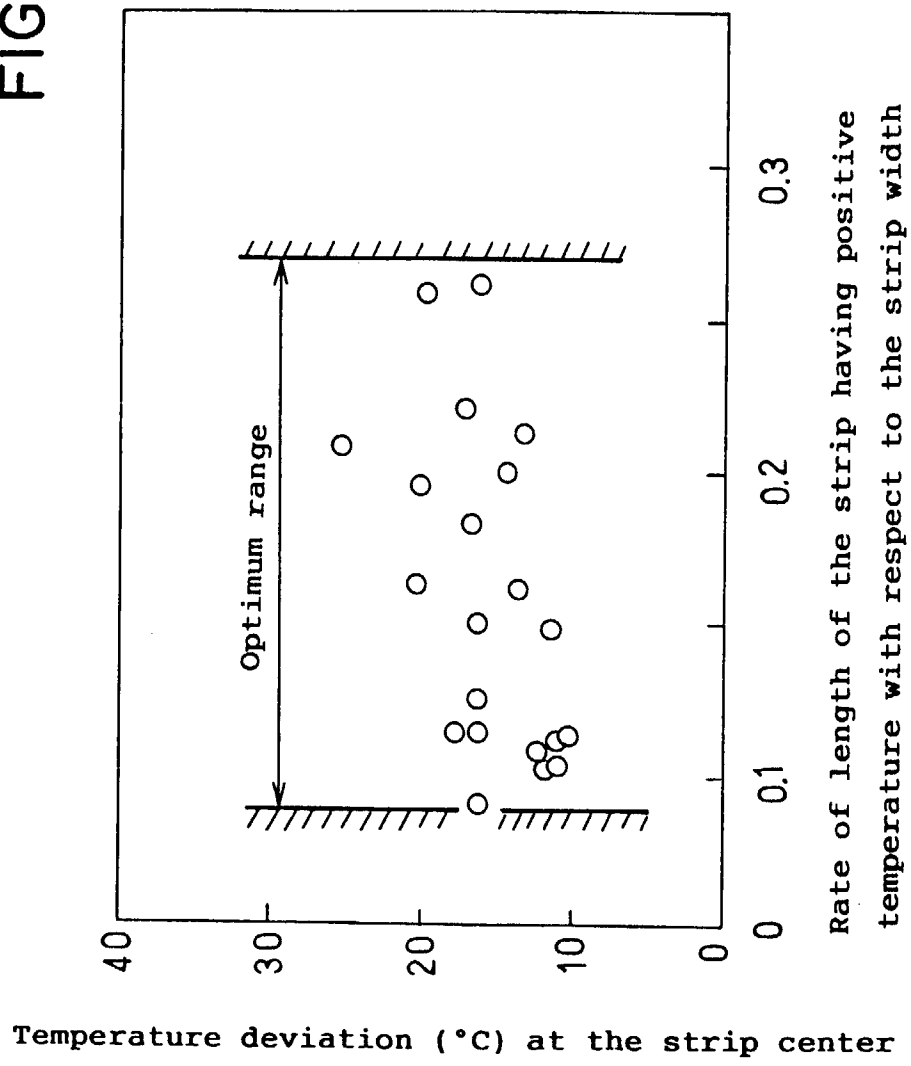


FIG. 58

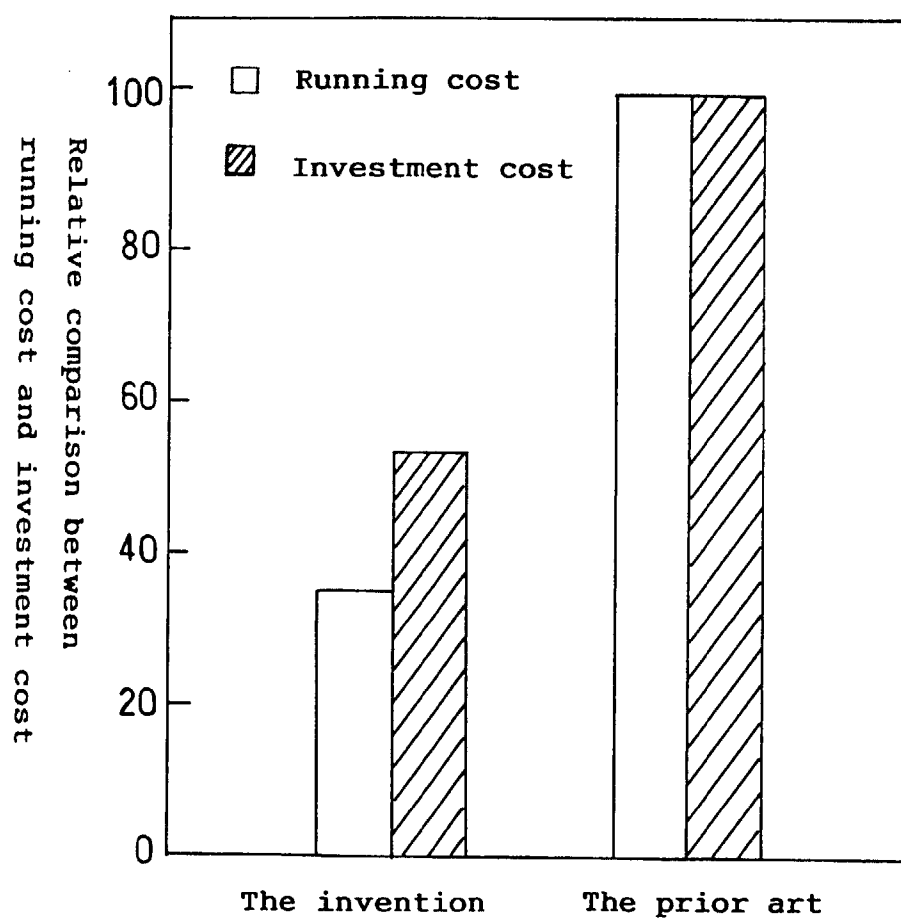


FIG. 59

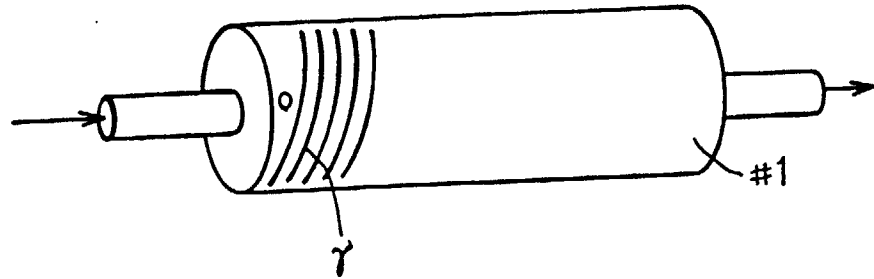


FIG. 60

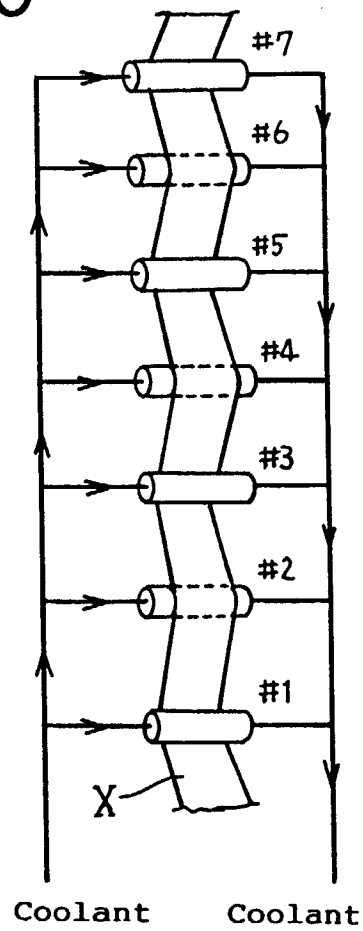


FIG. 61

