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

(11) **EP 2 708 616 A1**

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

(43) Date of publication:
19.03.2014 Bulletin 2014/12

(21) Application number: **12782900.0**

(22) Date of filing: **07.05.2012**

(51) Int Cl.:
C23C 2/20 *(2006.01)* ***C23C 2/40*** *(2006.01)*

(86) International application number:
PCT/JP2012/061644

(87) International publication number:
WO 2012/153702 (15.11.2012 Gazette 2012/46)

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

(30) Priority: **09.05.2011 JP 2011104089**
12.03.2012 JP 2012054183

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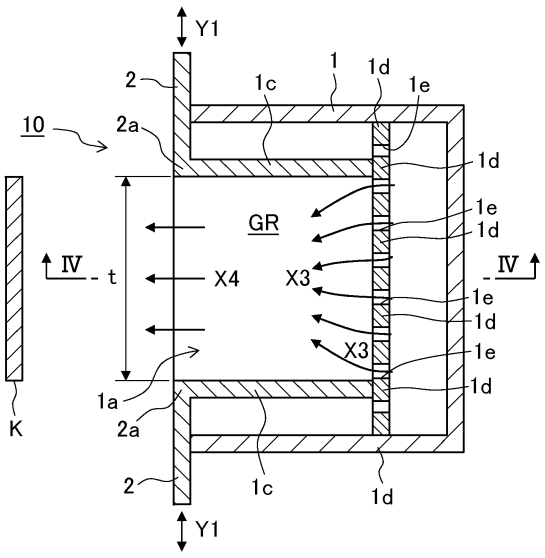
(54) GAS WIPING DEVICE

(57) Provided is a gas wiping device having a gas wiping nozzle for adjusting the amount of molten metal for plating that becomes attached to a surface of a steel strip, by spraying a gas onto the surface, the gas wiping device having an excellent effect of suppressing overcoating or splashing at width-direction edges of the steel strip. A gas wiping nozzle 1 is provided with: a slit 1a' extending along a width direction of a steel strip K for blowing a gas out of a hollow; and gas introducing openings 1e for introducing the gas into the hollow. The slit 1a' is provided with slidable left and right blocking members 2, 2 for blocking left and right areas of the slit, with a gas outlet 1a formed between the blocking members 2, 2. In the hollow, left and right rectification pieces 1c, 1c are disposed, extending from gas outlet side ends 2a, 2a of the respective left and right blocking members 2, 2 toward a partition wall 1d. Between the left and right rectification pieces 1c, 1c, a gas flow passageway GR is formed. The gas outlet 1a and the gas flow passageway GR have the same width.

Fig. 3



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Description

TECHNICAL FIELD

[0001] The present invention relates to a gas wiping device for adjusting the amount of molten metal for plating that becomes attached to a surface of a steel strip as the steel strip is continuously transported and immersed in a plating bath, by spraying gas onto the surface.

BACKGROUND ART

[0002] When molten metal plating is performed by continuously immersing a steel strip in a molten metal plating bath, so-called gas wiping is generally performed, whereby gas is sprayed onto an unsolidified plated surface of the steel strip after immersion so as to adjust the amount of attached molten metal. For example, gas wiping devices with gas wiping nozzles are disposed on both sides of the continuously transported steel strip, and gas wiping is performed by blowing gas onto both sides of the steel strip.

[0003] The gas wiping nozzles have an elongated shape corresponding to the length of the steel strip in the width direction thereof. The steel strip is transported upward in front of the gas wiping nozzles while being immersed in the molten metal in the plating pot. The gas wiping nozzles have a slit-shaped gas outlet for blowing out the gas that extends along the width direction (longitudinal direction) of the steel strip. By spraying the gas out of the gas outlet onto the steel strip linearly across one end to the other in the width direction of the steel strip, the molten metal on the surface of the steel strip is removed in a desired manner, thus adjusting the amount of attached molten metal.

[0004] The gas wiping is associated with the problem of overcoating in which the amount of molten metal attached to the edges of the steel strip in the width direction becomes greater than at other portions, or splashing in which the molten metal removed by the gas is scattered at the edges. The problems of overcoating and splashing are caused by turbulence produced by the collision of the streams of gas discharged out of opposing gas wiping nozzles near the edges of the steel strip, for example.

[0005] In order to decrease the overcoating or splashing at the edges of the steel strip in the width direction, Patent Document 1 discloses a gas wiping device including a slit blocking mechanism for making the edge positions of the slit of each of the pair of opposing nozzles variable; a slit width adjusting mechanism for adjusting the edge positions of the slit to the edge positions of the steel strip; and a gas flow rate adjusting mechanism for achieving a uniform velocity of the flow discharged out of the nozzle.

[0006] This gas wiping device adjusts the edge positions of the slit of each of the pair of nozzles opposed to each other across the steel strip to the edge positions of the steel strip, so as to obtain a state in which the jet flows from the opposing nozzles do not strongly collide with each other, thereby eliminating the turbulence caused by the collision of the jet flows. In this way, the distribution of the molten metal that becomes attached onto the steel strip surface is made uniform as much as possible, whereby the splashing and the overcoating at the edges are described to be suppressed.

[0007] However, in the gas wiping device disclosed in Patent Document 1, only the gas outlet is blocked to decrease the gas spraying width. Thus, the gas that has been circulated through the hollow of the nozzle is considerably contracted by the outlet. The contracted flow periodically produces vortexes, which disturb the gas flow and cause intermittent overcoating or splashing at the edges of the steel strip in the width direction. Accordingly, the overcoating or splashing cannot be completely suppressed.

[0008] The above will be described with reference to a schematic diagram shown in FIG. 11, schematically illustrating a gas wiping device W according to Patent Document 1. Two blocking members H, H are slidably (Y1-direction) disposed in a front portion, and the width of a central gas outlet E enclosed by the blocking members H, H is variably adjusted as the blocking members H, H are slid. A gas introduced from the rear of the gas wiping device W (X3-direction) flows forward via the hollow of the gas wiping device W, and is discharged via the gas outlet E (X4-direction). The flow of the gas that has reached the blocking members H, H via the hollow is sharply contracted toward the center (X5-direction), whereby the above-described vortexes are produced. The vortexes disturb the flow of gas, thereby causing intermittent overcoating or splashing at the edges of the steel strip in the width direction.

PRIOR ART DOCUMENT

[0009] Patent Document 1: JP Patent Publication (Kokai) No. 2007-284732 A1

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0010] The present invention was made in view of the above problem, and relates to a gas wiping device including a gas wiping nozzle for adjusting the amount of molten metal for plating attached to a surface of a steel strip by spraying gas onto the surface. An object of the present invention is to provide a gas wiping device that can highly effectively suppress overcoating or splashing at the edges of the steel strip in the width direction.

MEANS FOR SOLVING THE PROBLEM

[0011] In order to achieve the object, a gas wiping device according to the present invention includes a hollow gas wiping nozzle for adjusting the amount of molten metal for plating attached to a surface of a steel strip by spraying a gas onto the surface. The gas wiping nozzle includes a slit extending along a width direction of the steel strip for blowing the gas out of the hollow, and a partition wall having a gas introducing opening for introducing the gas into the hollow. The slit is provided with left and right blocking members for blocking left and right areas in accordance with a width of the steel strip, the left and right blocking members being slidable along the slit, with a gas outlet formed between the left and right blocking members. In the hollow, left and right rectification pieces extending from respective gas outlet side ends of the left and right blocking members toward the partition wall are disposed, with a gas flow passageway formed between the left and right rectification pieces. The gas outlet and the gas flow passageway have the same width.

[0012] The gas wiping nozzle of the gas wiping device according to the present invention is opposed to the steel strip, and the elongated slit extending along the width direction of the steel strip is provided with the left and right blocking members that block the left and right areas of the slit and that are slidable along the slit. The gas outlet is formed between the left and right blocking members of the slit, and the width of the gas outlet can be freely adjusted by sliding the left and right blocking members. The mode of sliding of the left and right blocking members includes a mode such that the left and right blocking members are slid in a synchronized manner and by the same amount, and a mode such that only one of the left and right blocking members is slid. By sliding the left and right blocking members, the width of the gas outlet can be adjusted to be approximately the same as the width of the steel strip. More specifically, the width of the steel strip on the order of 700 mm to 1800 mm may be adjusted to be the same as the width of the gas outlet, or the width of the gas outlet may be adjusted to extend beyond each of the left and right edges of the steel strip by approximately 10 mm.

[0013] In the hollow of the gas wiping nozzle, the left and right rectification pieces extending from the left and right edges of the gas introducing opening to the respective gas outlet side ends of the left and right blocking members are disposed, the left and right rectification pieces defining the gas flow passageway in the hollow. Thus, of the gas introduced via the gas introducing opening, particularly the gas that flows along the rectification pieces at the left and right ends of the gas flow passageway can be smoothly discharged out of the gas outlet via the rectification pieces and the continuous gas outlet side ends of the blocking members.

[0014] Namely, the considerable (sharp) contraction, by the gas outlet, of the gas that has been circulated through the hollow of the gas wiping nozzle, and the resultant generation of the periodic vortexes that disturb the flow of gas, do not occur. Thus, the overcoating or splashing at the width direction edges of the steel strip due to the flow of gas disturbed by the generated vortexes can be completely eliminated.

[0015] In the present specification, regarding the terms "left and right", the width direction of the steel strip as it is transported upward from the plating pot is defined as a left/right direction. Thus, references to the "left and right" of the steel strip, the "left and right" areas of the slit, and the "left and right" edges of the gas introducing opening are with respect to the width direction of the steel strip.

[0016] The width of the gas flow passageway defined by the left and right rectification pieces in the hollow of the gas wiping nozzle, and the width of the gas outlet are constantly maintained to be the same. When the width of the gas outlet is varied by the sliding of the left and right blocking members, the variation is tracked by sliding the left and right rectification pieces so that the width of the gas flow passageway and the width of the gas outlet are varied in the same state. Because the left and right rectification pieces are slid, the rectification pieces according to the present embodiment are structurally separated from the partition wall.

[0017] In a preferred embodiment of the gas wiping device according to the present invention, the gas wiping nozzle may include a hanging piece fixed to an upper surface of the hollow, the hanging piece not reaching a lower surface, and a rising piece fixed to the lower surface at a position spaced apart from the hanging piece, the rising piece not reaching the upper surface, and the gas introduced into the gas flow passageway via the gas introducing opening may be rectified in a process of being circulated along the hanging piece and the rising piece.

[0018] Because the hanging piece and the rising piece are disposed at an interval in the gas flow passageway, the gas is rectified as it is circulated along the hanging piece and the rising piece in a meandering manner, whereby the gas

pressure or flow velocity in the width direction of the gas flow passageway is made as uniform as possible.

[0019] In an embodiment related to the sliding control of the left and right blocking members, the left and right blocking members may be configured to be slidable by a left sliding mechanism and a right sliding mechanism, respectively, as specific sliding mechanisms; the left sliding mechanism and the right sliding mechanism may be mounted on a common base, the base being connected to a base sliding mechanism and slidable; a position sensor for detecting a steel strip position may be disposed near the gas outlet; the left sliding mechanism and the right sliding mechanism may be configured to slide the left and right blocking members to adjust the width of the gas outlet; and the base sliding mechanism may be configured to slide the base based on steel strip position data detected by the position sensor, the sliding of the base causing the right sliding mechanism and the left sliding mechanism to slide, thus causing the left and right blocking members to slide while the already adjusted width of the gas outlet is maintained.

[0020] According to the present embodiment, the sliding control of the left and right blocking members is implemented by the specific sliding mechanisms, i.e., the left sliding mechanism and the right sliding mechanism, respectively. The sliding mechanism may include a cylinder device for sliding the blocking member, or an electric slider device that slides over a slide substrate. When the cylinder device is used, the device may include a slidable piston with the blocking member attached to the end of the piston, so that the blocking member can be slid to the left or right as the piston is slidably moved. When the electric slider device is used, an electric slider and the blocking member may be connected via a wire and the like, so that the blocking member can be slid to the left or right in accordance with the sliding of the electric slider to the left or right on the slide substrate.

[0021] For example, data about the width of the steel strip inputted to a process computer is transmitted to the left and right sliding mechanisms, and the left and right sliding mechanisms are slid based on the transmitted data, thus adjusting the width of the gas outlet to a desired width.

[0022] The steel strip transported from the reduction annealing furnace is immersed in the molten metal in the plating pot, and then vertically upwardly transported via the sink roll in the plating pot. Some of the molten metal that becomes attached to both sides of the steel strip is removed by the gas blown out of the gas wiping devices disposed on both sides of the transport path of the vertically upward transported steel strip, whereby the attached molten metal is adjusted to a desired attached amount. Although the width of the gas outlet is adjusted to the desired width based on the data about the width of the steel strip, the steel strip may meander during the transport process. As a result, the center line of the steel strip may often be displaced from the center line of the gas outlet with an already adjusted width.

[0023] Thus, according to the present embodiment, the left sliding mechanism and the right sliding mechanism are mounted on the common base, and the base is connected to the base sliding mechanism and configured to be slidable. Further, the position sensor for detecting the steel strip position is disposed near the gas outlet, and the base sliding mechanism slides the base as desired based on steel strip position data from the position sensor (center line position data of the steel strip, or position data of the left and right edges of the steel strip), whereby the left and right sliding mechanisms are slid to correspond to the steel strip position without changing the relative positions of the left and right sliding mechanisms defining the width of the gas outlet.

[0024] The base sliding mechanism may include a cylinder device or an electric slider device, as in the case of the left and right sliding mechanisms. Regarding the position sensor for detecting the steel strip position disposed near the gas outlet, while it may be preferable to dispose the position sensor as near to the gas outlet as possible from the viewpoint of blowing the gas against the steel strip more accurately, the term "near" herein may include a relatively wide range, extending from the bath level in the pot to an area above the gas wiping device, for example.

[0025] In another embodiment related to the sliding control of the left and right blocking members, the left and right blocking members may be configured to be slidable by a left sliding mechanism and a right sliding mechanism, respectively, as specific sliding mechanisms; a position sensor for detecting a steel strip position may be disposed near the gas outlet; the left sliding mechanism and the right sliding mechanism may be configured to slide the left and right blocking members so as to adjust the width of the gas outlet; and the left sliding mechanism and the right sliding mechanism may be configured to slide the left and right blocking members based on steel strip position data detected by the position sensor, while the already adjusted width of the gas outlet is maintained.

[0026] According to the present embodiment, while the width of the gas outlet is adjusted by the left sliding mechanism and the right sliding mechanism, as according to the foregoing embodiments, the left and right sliding mechanisms are not mounted on a common base. The left and right sliding mechanisms are slid in a synchronized manner in the same direction and by the same amount based on the steel strip position information data received from the position sensor, whereby the left and right blocking members are controlled to be slid to correspond to the steel strip position while the already adjusted width of the gas outlet is maintained.

[0027] Preferably, the left and right edges of the steel strip and the respective gas outlet side ends of the left and right blocking members may have gaps of the same adjusted length s, where s is in a range of $0 \leq s \leq 10$ mm.

[0028] Based on the results of investigations by the present inventors, it has been proved that there is no or very little splashing and that no clogging of the nozzle is caused when the gap s between the left and right edges of the steel strip and the respective gas outlet side ends of the left and right blocking members is in the rage of $0 \leq s \leq 10$ mm.

EFFECTS OF THE INVENTION

[0029] As will be understood from the above, the gas wiping device according to the present invention is provided with the extremely simple structural improvement that the gas outlet side ends of the left and right blocking members in the slit forming the gas outlet are connected to the left and right rectification pieces defining the gas flow passageway in the hollow of the gas wiping nozzle. As a result, the generation of periodic vortexes by considerable flow contraction of the gas circulated through the hollow of the gas wiping nozzle by the gas outlet, and the resultant disturbance of the flow of gas by the vortexes, are eliminated. Thus, the overcoating or splashing at the width direction edges of the steel strip due to the disturbed flow of gas can be completely eliminated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030]

FIG. 1 is a schematic diagram illustrating a configuration of a molten metal plating apparatus.
FIG. 2 is a perspective view of an embodiment of a gas wiping device.
FIG. 3 is a III-III sagittal view of FIG. 2.
FIG. 4 is a IV-IV sagittal view of FIG. 3.
FIG. 5 is a cross sectional view of another embodiment of the gas wiping device, corresponding to FIG. 3.
FIG. 6 is a VI-VI sagittal view of FIG. 5.
FIG. 7 is a schematic diagram of an embodiment of a sliding mechanism for left and right blocking members.
FIG. 8 is a schematic diagram of another embodiment of the sliding mechanism for the left and right blocking members.
FIG. 9(a) is a longitudinal cross sectional view of an analysis model, and FIG. 9(b) is a b-b sagittal view of FIG. 9(a).
FIG. 10(a) illustrates an analysis result for a comparative example, and FIG. 10(b) illustrates an analysis result for an example.
FIG. 11 is a schematic diagram illustrating a sharp contraction of gas caused by slidable blocking members in a conventional gas wiping device.

MODE FOR CARRYING OUT THE INVENTION

[0031] In the following, embodiments of the gas wiping device according to the present invention will be described with reference to the drawings.

(Plating apparatus)

[0032] FIG. 1 is a schematic diagram of a molten metal plating apparatus. The plating apparatus includes a plating pot Y containing plating bath of a molten metal M of molten zinc or molten aluminum, with the inside of the plating pot Y lined with fire bricks and the like, which are not illustrated. In the plating pot Y, a sink roll R is rotatably disposed. A steel strip K transferred from a reduction annealing furnace via a snout and the like, which are not illustrated, is immersed in the molten metal M and then transported vertically upward via the sink roll R (X1-direction).

[0033] The steel strip K transported vertically upward has molten metal attached onto both sides thereof. Above the plating pot Y, gas wiping devices 10, 10 are disposed on both sides of the vertically upward transport path of the steel strip K. The gas wiping devices 10, 10 blow out a gas (air, nitrogen, inert gas, or the like) in order to remove a part of the molten metal that is attached onto the both sides of the steel strip K, thus adjusting the attached molten metal to a desired amount.

(First embodiment of gas wiping device)

[0034] FIG. 2 is a perspective view of an embodiment of the gas wiping devices of the plating apparatus of FIG. 1. FIG. 3 is a III-III sagittal view of FIG. 2. FIG. 4 is a IV-IV sagittal view of FIG. 3.

[0035] The gas wiping device 10 illustrated in FIGS. 2 to 4 includes a hollow gas wiping nozzle 1, and a gas supply device (gas supply source), not illustrated, which is disposed behind the gas wiping nozzle 1 and configured to supply the gas to gas inlet pipes 1b via which the gas is supplied into the hollow of the gas wiping nozzle 1.

[0036] The gas wiping nozzle 1 includes a slit 1a' (with a full width T) extending in a width direction of the steel strip K for blowing the gas out of the hollow. In the slit 1a', left and right blocking members 2, 2 for blocking left and right areas of the slit 1a' are disposed slidably along the slit 1a' (direction Y1). A gas outlet 1a is formed between a slit area between the left and right blocking members 2, 2 spaced apart from each other.

[0037] The gas inlet pipes 1b are in communication with the inside of the gas wiping nozzle 1 at a rear portion thereof,

and a partition wall 1d with a plurality of gas introducing openings 1e is disposed at the front of the rear portion. The gas supplied via the gas supply device, not illustrated, is introduced into the gas wiping nozzle 1 via the gas inlet pipes 1b (X2-direction), and is further introduced into the hollow via the gas introducing openings 1e.

[0038] In the hollow of the gas wiping nozzle 1, left and right rectification pieces 1c, 1c are disposed, extending from respective gas outlet side ends 2a, 2a of the left and right blocking members 2, 2 toward the partition wall 1d. A space defined by the left and right rectification pieces 1c, 1c and the upper and lower surfaces of the hollow provides a gas flow passageway GR.

[0039] The gas wiping device 10 is configured such that the gas flow passageway GR formed between the left and right rectification pieces 1c, 1c has a width t which is the same as a width t of the gas outlet 1a at all times. Namely, the left and right rectification pieces 1c, 1c are orthogonally fixed at one ends to the gas outlet side ends 2a, 2a of the left and right blocking members 2, 2, respectively, with the other ends of the left and right rectification pieces 1c, 1c completely separated from the partition wall 1d. Thus, the width t of the gas outlet 1a and the width t of the gas flow passageway GR can be variably adjusted by the same width.

[0040] By sliding the left and right blocking members 2, 2 (Y1-direction), the width t of the gas outlet 1a can be freely adjusted. For example, in an adjustment mode, the width t of the gas outlet 1a is adjusted to be the same as the width of the steel strip K, which may vary between approximately 700 mm to 1800 mm. In another adjustment mode, the width t of the gas outlet 1a may be adjusted to extend beyond each of the left and right edges of the steel strip K by approximately 10 mm. Thus, the width t of the gas outlet 1a can be adjusted as desired in accordance with a variation in the width of the steel strip K.

[0041] The sliding mode of the left and right blocking members 2, 2 includes a mode in which both are slid by the same amount in a synchronized manner, and a mode in which only one of the left and right blocking members is slid.

[0042] As will be seen from FIG. 3, of the gas introduced into the gas flow passageway GR via the gas introducing openings 1e (X3-direction), particularly the gas that flows along the rectification pieces 1c, 1c at the left and right ends of the gas flow passageway GR is smoothly discharged out of the gas outlet 1a via the rectification pieces 1c, 1c and the continuous gas outlet side ends 2a of the blocking members 2 (X4-direction).

[0043] Namely, the sharp contraction, by the gas outlet 1a, of the gas that has been circulated through the hollow of the gas wiping nozzle 1, and the resultant periodic generation of the vortexes that disturb the flow of gas, do not occur. Thus, the overcoating or splashing at the edges of the steel strip in the width direction due to the flow of gas disturbed by the produced vortexes can be completely eliminated.

(Second embodiment of gas wiping device)

[0044] FIG. 5 is a cross sectional view of another embodiment of the gas wiping device, illustrated in a manner corresponding to FIG. 3. FIG. 6 is a VI-VI sagittal view of FIG. 5.

[0045] The illustrated gas wiping device 10A includes a hanging piece 3a fixed to an upper surface of the hollow in the gas flow passageway GR, the hanging piece 3a not reaching a lower surface. At a position spaced apart from the hanging piece 3a on the lower surface of the hollow, a rising piece 3b that does not reach the upper surface is fixed. Thus, the gas introduced into the gas flow passageway GR via the gas introducing openings 1e is rectified in the process (X3') of being circulated along the hanging piece 3a and the rising piece 3b.

[0046] The other ends of the left and right rectification pieces 1c, 1c are located forwardly of the rising piece 3b and the hanging piece 3a, so that the left and right rectification pieces 1c, 1c can be slid in front of the rising piece 3b and the hanging piece 3a as the width of the gas outlet 1a is varied.

[0047] By such rectification, the flow velocity or pressure of the gas introduced via the gas introducing openings 1e is made as uniform as possible with respect to the width direction of the gas flow passageway GR, whereby the gas having a uniform flow velocity or pressure can be provided along the width direction of the steel strip K.

[0048] In the gas wiping device 10A according to the present embodiment, too, of the gas introduced into the gas flow passageway GR via the gas introducing openings 1e, particularly the gas that flows along the rectification pieces 1c, 1c at the left and right ends of the gas flow passageway GR is smoothly discharged out of the gas outlet 1a via the rectification pieces 1c and the continuous gas outlet side ends 2a of the blocking members 2, so that the generation of the vortexes and the resultant disturbance of the flow of gas do not occur.

(First embodiment of sliding mechanism for left and right blocking members)

[0049] With reference to FIG. 7, a first embodiment of a sliding mechanism for the left and right blocking members of the gas wiping device 10 will be described.

[0050] In the illustrated sliding mechanism, the left and right blocking members 2, 2 are slidable to the left and right by their specific left sliding mechanism 5A and right sliding mechanism 5B. The left sliding mechanism 5A and the right sliding mechanism 5B are mounted on a common base 6. The common base 6 is connected to a base sliding mechanism

7 and configured to be slidable.

[0051] The left blocking member 2 and an electric slider constituting the left sliding mechanism 5A are connected substantially in a ring shape by two wires W1, W1 via pulleys 9. Thus, when the left sliding mechanism 5A is slid to the left or right (Z1-direction), the left blocking member 2 is can also be slid to the left or right in a synchronized manner (Z1'-direction). Similarly, the right blocking member 2 and an electric slider constituting the right sliding mechanism **5B** are connected by two wires W2, W2 in a substantially ring shape via pulleys 9. Thus, when the right sliding mechanism 5B is slid to the left or right (Z2-direction), the right blocking member 2 is also slid to the left or right in a synchronized manner (Z2'-direction).

[0052] Further, the common base 6 on which the left sliding mechanism 5A and the right sliding mechanism 5B are mounted is slidable by an electric cylinder constituting the base sliding mechanism 7. With the left and right sliding mechanisms 5A and 5B, which enable the sliding of the left and right blocking members 2, 2 positioned to define the gas outlet 1a of the desired width t, fixedly positioned, the base sliding mechanism 7 is controlled to slide the base 6, whereby a center line CL2 of the steel strip K as it meanders during transport and a center line CL1 of the gas outlet 1a are aligned.

[0053] Specifically, data concerning the width of the steel strip K being transported is transmitted from a process computer PC to the left and right sliding mechanisms 5A and 5B, and the left and right sliding mechanisms 5A and 5B are slid based on the transmitted signal, whereby the left and right blocking members 2, 2 are slid to form the gas outlet 1a with a desired width t.

[0054] Meanwhile, two sets of position sensors 4, 4 are disposed near the gas outlet 1a to sense the steel strip K in the vicinity of the left and right edges thereof as the steel strip K travels along the transport path, and obtained sensing data is transmitted to the base sliding mechanism 7. Based on the sensing data from the left and right position sensors 4, 4, the center line CL2 of the steel strip K near the gas outlet 1a is determined. When the center line CL2 is not aligned with the center line CL1 of the gas outlet 1a, the base sliding mechanism 7 and the base 6 are slid (Z3-direction) by an amount corresponding to the difference. As the base 6 is slid, the left and right sliding mechanisms 5A and 5B mounted thereon are slid in a synchronized manner, and the left and right blocking members 2, 2 are slid correspondingly to align the center lines CL1 and CL2 of the gas outlet 1a and the steel strip K.

(Second embodiment of sliding mechanism for left and right blocking members)

[0055] With reference to FIG. 8, a second embodiment of the sliding mechanism for the left and right blocking members of the gas wiping device 10 will be described.

[0056] The sliding mechanism illustrated in FIG. 8 differs from the sliding mechanism of FIG. 7 in that the left and right sliding mechanisms 5A and 5B are not mounted on a common base; that the left and right sliding mechanisms 5A and 5B, after the gas outlet 1a with the desired width t is formed, are slid in a synchronized manner and by the same amount in accordance with the meandering of the steel strip K, thus tracking the steel strip K as it meanders; and that only the right edge ed of the steel strip K is sensed by a single position sensor 4A which is slidable by a position sensor sliding mechanism 8.

[0057] The right edge ed of the steel strip K is sensed while the position sensor 4A is slid by the position sensor sliding mechanism 8 to track the steel strip K as it meanders, and the sensing data is transmitted to the left and right sliding mechanisms 5A and 5B. The left and right sliding mechanisms 5A and 5B are slid in the same direction and by the same amount, whereby the left and right blocking members 2, 2 are slid in the same direction and by the same amount. Thus, the right edge ed of the steel strip K is controlled to be positioned at a desired position with respect to the gas outlet 1a.

[Turbulence analysis investigating the degree of splashing, and its result]

[0058] The present inventors created an analysis model simulated as illustrated in FIG. 9(a) and (b) using a computer, and performed an LES turbulence analysis (LES: a non-steady turbulence analysis method by which a vortex greater than an analysis cell is directly calculated rather than modeled). As illustrated in FIG. 9(b), a steel strip had a width t1 of 150 mm; an inner width t2 of the gas discharge opening and a gas spraying width t3 were both 150 mm; the gas discharge opening had a height t4 of 1.2 mm; and the two gas wiping devices opposed to each other across the steel strip had a gas discharge opening interval t5 of 20 mm. An internal air pressure in the gas discharge opening was 40 kPa.

[0059] The modeling involved modeling a half area with respect to the center of the steel strip, as illustrated in FIG. 9 (b) (the total number of cells of the model was 2,654,640). Of an analysis result chart formed on a computer screen, an analysis result chart modeling the conventional example of FIG. 11 is illustrated in FIG. 10(a), while an analysis result chart modeling an example according to the present invention is illustrated in FIG. 10(b).

[0060] In a right edge area of FIG. 10(a), the air flow directions are inclined in diagonally upper-right and lower-right directions (which proves that the splashes are large). In a right portion area of FIG. 10(b), the air flow directions are inclined in the upper-right or lower-right direction in significantly smaller proportions, thus proving that the occurrence

of splashing is extremely small.

[Experiment regarding range of steel strip feeding rate (transport rate) during plating process, and its result]

[0061] The present inventors conducted an experiment to identify a possible range concerning steel strip feeding rate in the case of the gas wiping device illustrated in FIGS. 3 and 4 (example) and the case of the conventional gas wiping device illustrated in FIG. 11 (comparative example). Specifically, when the steel strip had a thickness of 0.4 mm and a width of 1200 mm, and the gap between the left and right edges of the steel strip and the edges of the gas outlet was 0 mm, a strip feeding rate range such that the amount of zinc as a plating molten metal that became attached to both sides of the steel strip was 120 g/m^2 was investigated. The present experiment was not conducted with regard to the gas wiping device according to the second embodiment illustrated in FIGS. 5 and 6. However, it should be noted that obviously the gas wiping device according to the second embodiment would provide an even higher effect than the effect of the experiment on the gas wiping device according to the first embodiment illustrated in FIGS. 3 and 4 because a further gas rectification effect can be expected from the hanging piece and the rising piece.

[0062] Table 1 shows the result of the experiment. In Table 1, "Good" indicates that there was little splashing and no re-attachment onto the steel strip; "Poor" indicates that, while there was some attachment to the nozzle due to splashing, there was no re-attachment to the steel strip; and "Bad" indicates there was much splashing, causing attachment to the nozzle and re-attachment to the steel strip.

[0063] As shown in Table 1, in the case of the gas wiping device according to the example, it was confirmed that there was no re-attachment of splashing onto the steel strip when the strip feeding was conducted in a strip feeding rate range of up to 240 mpm.

[0064] On the other hand, the strip feeding rate range such that a similar effect could be expected from the gas wiping device according to the comparative example was a range of up to 180 mpm.

[0065] Thus, the experimental result proves that, compared with the use of the conventional gas wiping device, an operation with a 30% or more increase in strip feeding rate can be performed.

Table 1

N_2 gas source pressure (kPa)	Strip feeding rate (mpm)	Comparative example (model of FIG. 11)				Example (FIG. 1)			
		Gap				Gap			
		0 mm	5 mm	10 mm	15 mm	0 mm	5 mm	10 mm	15 mm
40	160	Good	Good	Good	Poor	Good	Good	Good	Poor
50	180	Poor	Poor	Poor	Bad	Good	Good	Good	Poor
70	200	Bad	Bad	Bad	Bad	Good	Good	Good	Poor
90	220	Bad	Bad	Bad	Bad	Good	Good	Good	Bad
110	240	Bad	Bad	Bad	Bad	Poor	Poor	Poor	Bad
130	250	Bad	Bad	Bad	Bad	Bad	Bad	Bad	Bad

[Experiment investigating an optimum range of gap between left and right edges of steel strip and gas outlet edges, and its result]

[0066] The present inventors further conducted an experiment regarding the magnitude of the problem of splashing and the presence or absence of re-attachment to the steel strip with varying gaps between the left and right edges of the steel strip and the gas outlet edges. The various conditions and the experimental result are shown in Table 1.

[0067] The experimental result indicates that the example provides good results even in higher gas source pressure and strip feeding rate ranges compared with the comparative example. The experimental result for the example also proves that the gap between the left and right edges of the steel strip and the gas outlet edges is preferably in a range of from 0 mm to 10 mm.

[0068] While the embodiments of the present invention have been described with reference to the drawings, specific configurations are not limited to the embodiments, and design variations and the like within the scope that does not depart from the gist of the present invention shall be included in the present invention.

REFERENCE SIGNS LIST

[0069]

1	Gas wiping nozzle
1a	Gas outlet
1a'	Slit
1b	Gas inlet pipe
1c	Rectification piece
1d	Partition wall
1e	Gas introducing opening
2	Blocking member
2a	Gas outlet side edge of blocking member
3a	Hanging piece
3b	Rising piece
4, 4A	Position sensor
5A	Left sliding mechanism
5B	Right sliding mechanism
6	Base (common base)
7	Base sliding mechanism
8	Position sensor sliding mechanism
10, 10A	Gas wiping device
M	Molten metal (plating bath)
K	Steel strip
Y	Plating pot
R	Sink roll
W1, W2	Wire
PC	Process computer
CL1	Center line of gas outlet
CL2	Center line of steel strip
ed	Right edge of steel strip

Claims

1. A gas wiping device comprising a hollow gas wiping nozzle for adjusting the amount of molten metal for plating attached to a surface of a steel strip by spraying a gas onto the surface,
wherein:

the gas wiping nozzle includes a slit extending along a width direction of the steel strip for blowing the gas out of the hollow, and a partition wall having a gas introducing opening for introducing the gas into the hollow;
the slit is provided with left and right blocking members for blocking left and right areas in accordance with a width of the steel strip, the left and right blocking members being slidable along the slit, with a gas outlet formed between the left and right blocking members spaced apart from each other;
in the hollow, left and right rectification pieces extending from respective gas outlet side ends of the left and right blocking members toward the partition wall are disposed, with a gas flow passageway formed between the left and right rectification pieces; and
the gas outlet and the gas flow passageway have the same width.

2. The gas wiping device according to claim 1, wherein the left and right blocking members and the left and right rectification pieces are configured to be slid in a synchronized manner so as to adjust the width of the gas outlet and the width of the gas flow passageway.

3. The gas wiping device according to claim 1 or 2, wherein:

the gas wiping nozzle includes a hanging piece fixed to an upper surface of the hollow, the hanging piece not reaching a lower surface, and a rising piece fixed to the lower surface at a position spaced apart from the hanging piece, the rising piece not reaching the upper surface; and

the gas introduced into the gas flow passageway via the gas introducing opening is rectified in a process of being circulated along the hanging piece and the rising piece.

4. The gas wiping device according to any one of claims 1 to 3, wherein:

the left and right blocking members are slidable by a left sliding mechanism and a right sliding mechanism, respectively, as specific sliding mechanisms;
the left sliding mechanism and the right sliding mechanism are mounted on a common base, the base being connected to a base sliding mechanism and slidable;
a position sensor for detecting a steel strip position is disposed near the gas outlet;
the left sliding mechanism and the right sliding mechanism are configured to slide the left and right blocking members to adjust the width of the gas outlet; and
the base sliding mechanism is configured to slide the base based on steel strip position data detected by the position sensor, the sliding of the base causing the right sliding mechanism and the left sliding mechanism to slide, thus causing the left and right blocking members to slide while the already adjusted width of the gas outlet is maintained.

5. The gas wiping device according to any one of claims 1 to 3, wherein:

the left and right blocking members are slidable by a left sliding mechanism and a right sliding mechanism, respectively, as specific sliding mechanisms;
a position sensor for detecting a steel strip position is disposed near the gas outlet;
the left sliding mechanism and the right sliding mechanism are configured to slide the left and right blocking members so as to adjust the width of the gas outlet; and
the left sliding mechanism and the right sliding mechanism are configured to slide the left and right blocking members based on steel strip position data detected by the position sensor while the already adjusted width of the gas outlet is maintained.

6. The gas wiping device according to claim 4 or 5, wherein the left and right edges of the steel strip and the respective gas outlet side ends of the left and right blocking members have gaps of the same adjusted length s, where s is in a range of $0 \leq s \leq 10$ mm.

Fig. 1

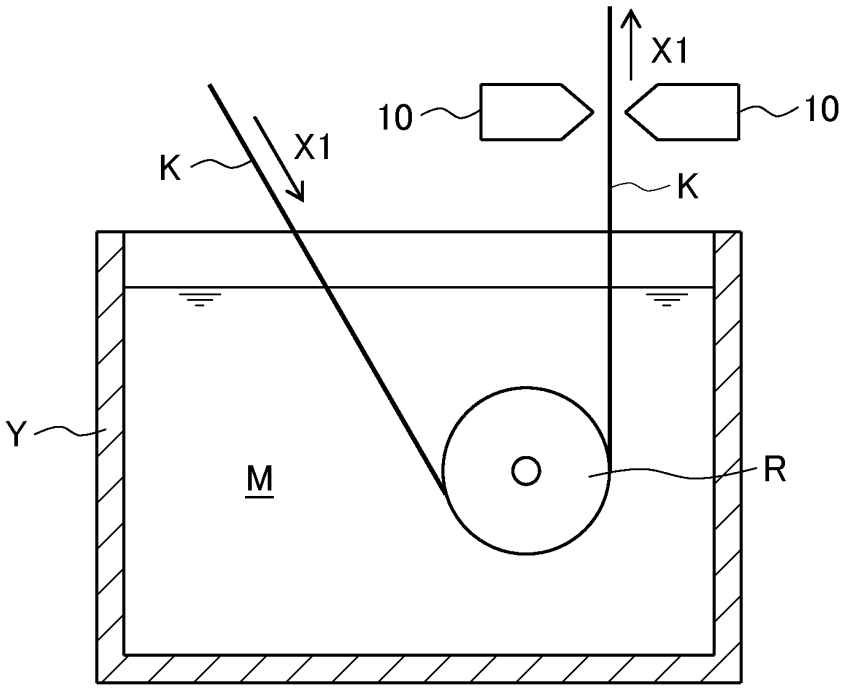


Fig. 2

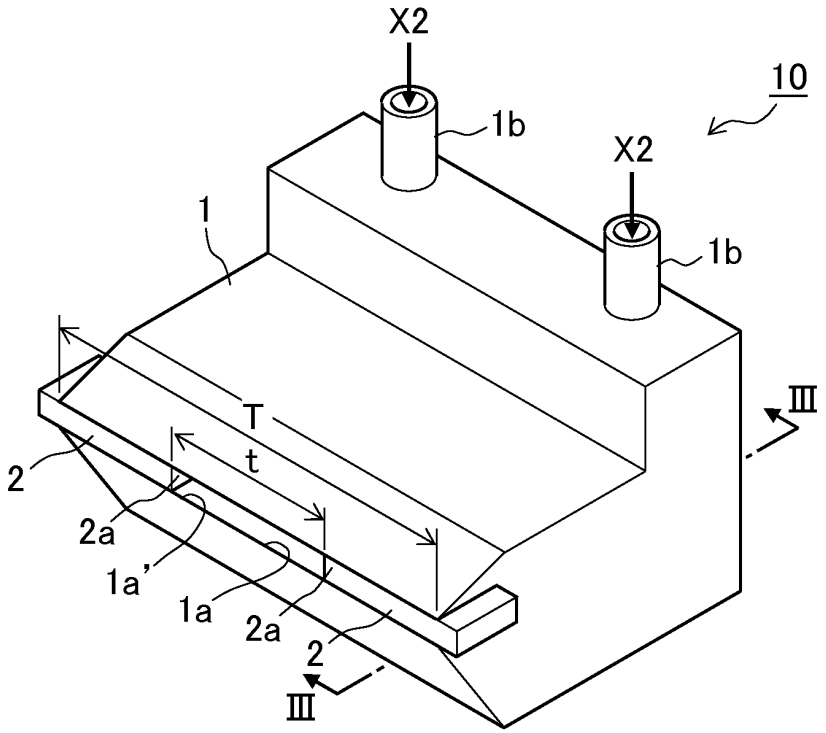


Fig. 3

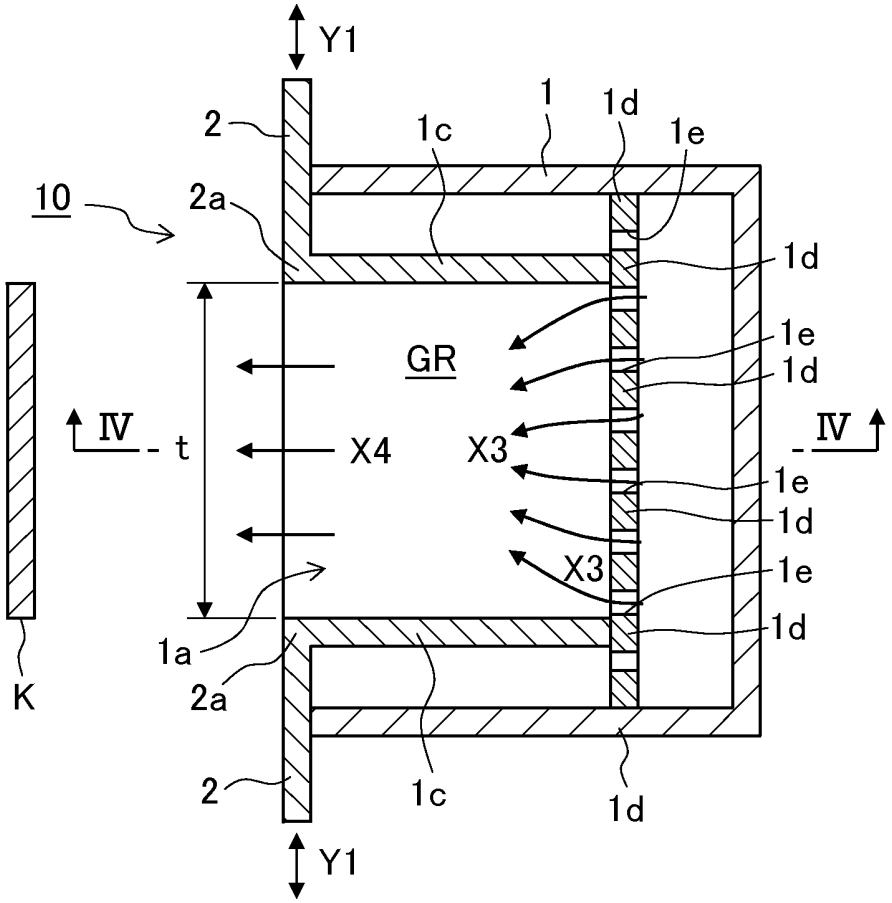

Y1
2
1c
1
1d
1e
10
2a
1d
1e
GR
1d
IV
t
X4
X3
IV
1e
1d
X3
1e
1d
1a
2a
K
2
1c
1d
Y1

Fig. 4

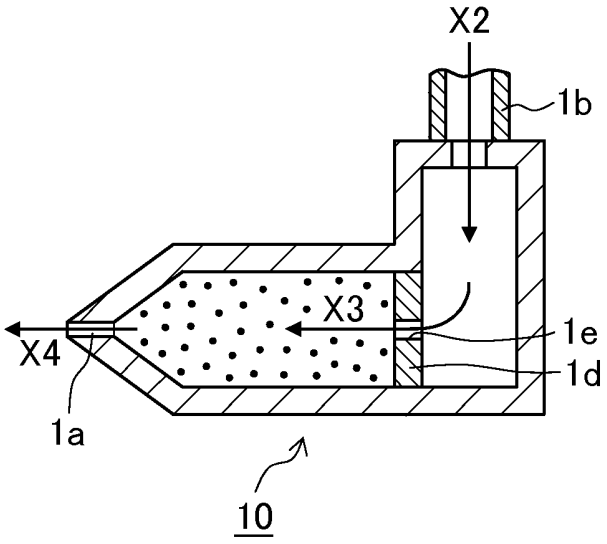

X2
1b
X3
1e
X4
1d
1a
10

Fig. 5

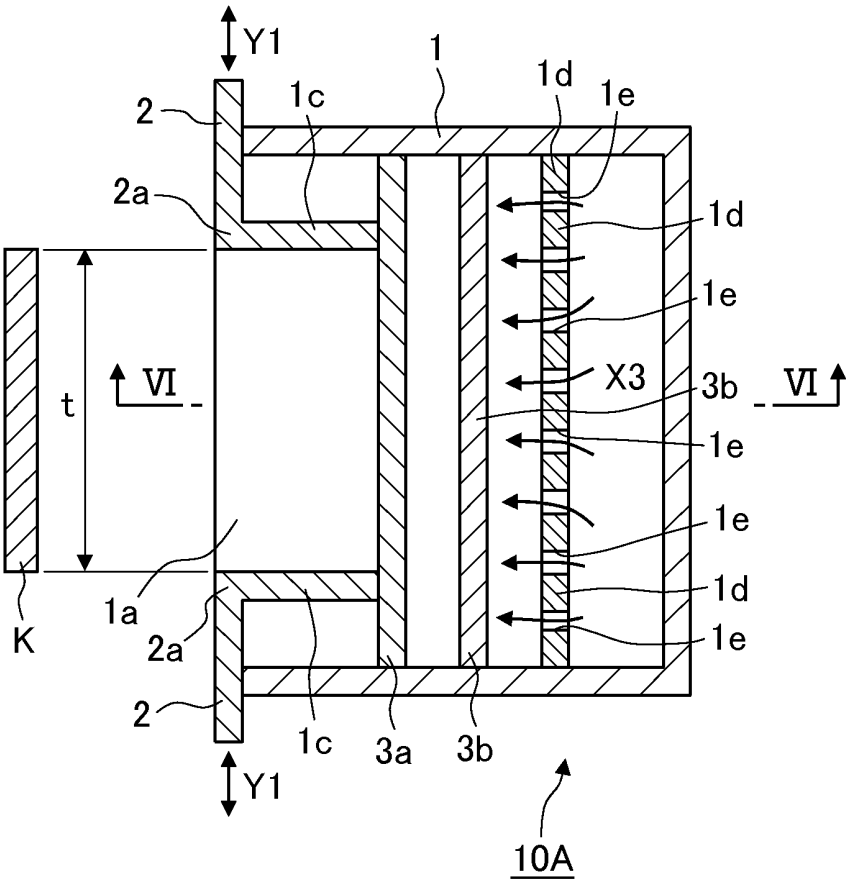

Y1
1
1d
1e
2
1c
2a
1d
1e
X3
3b
VI
VI
t
1e
1e
1d
1e
K
1a
2a
2
1c
3a
3b
Y1
10A

Fig. 6

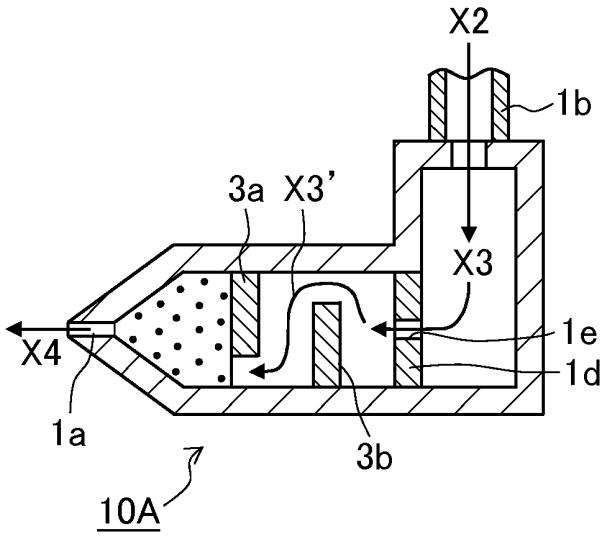

X2
1b
3a
X3'
X3
1e
X4
1d
1a
3b
10A

Fig. 7

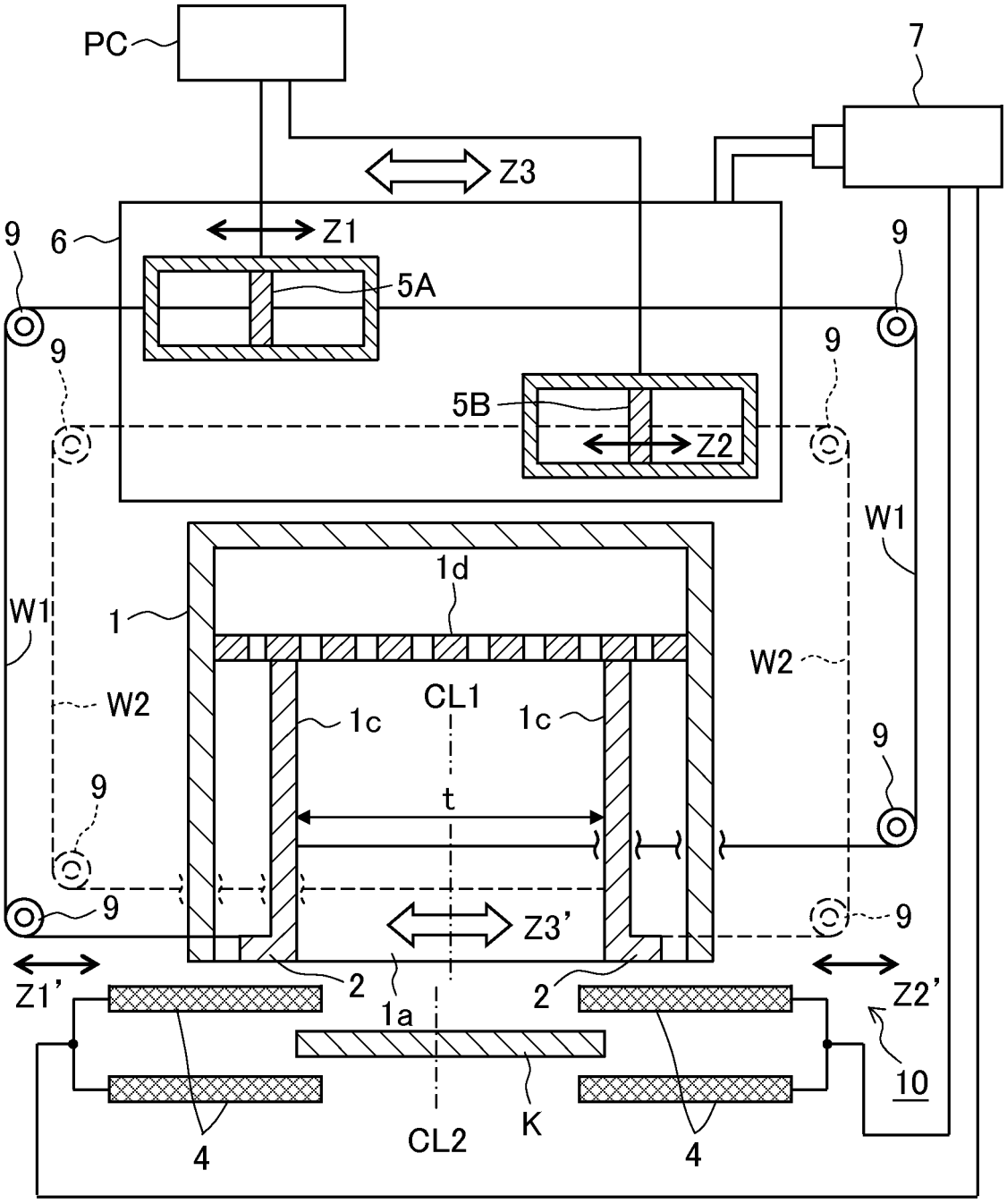

PC
7
Z3
9
6
Z1
5A
9
9
9
5B
Z2
W1
1d
W1
1
W2
CL1
W2
1c
1c
9
t
9
9
9
Z3'
Z1'
2
1a
2
Z2'
10
4
CL2
K
4

Fig. 8

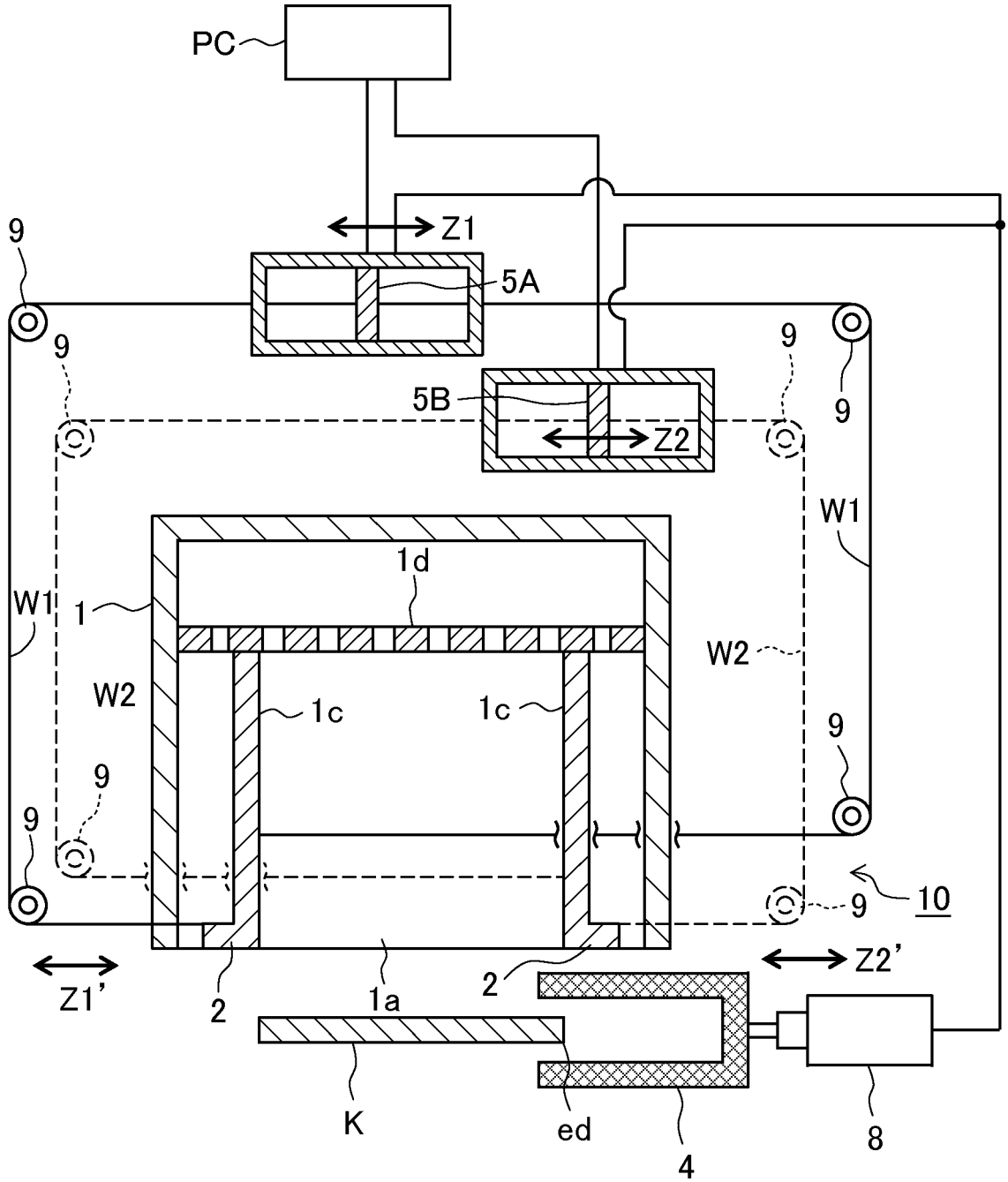
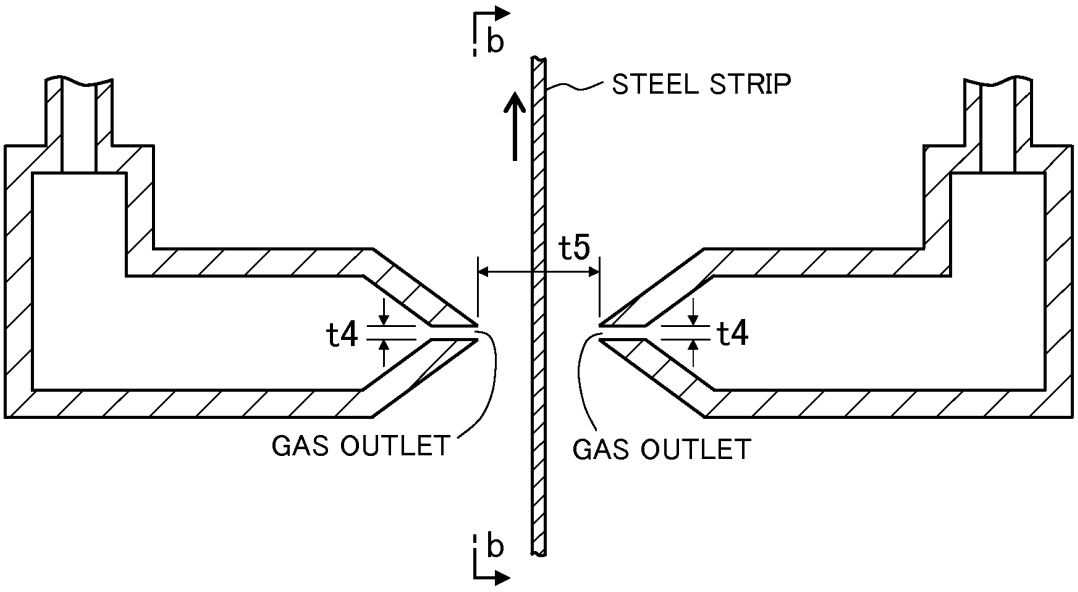


Fig. 9

(a)


b
STEEL STRIP
t5
t4
t4
GAS OUTLET
GAS OUTLET
b

(b)

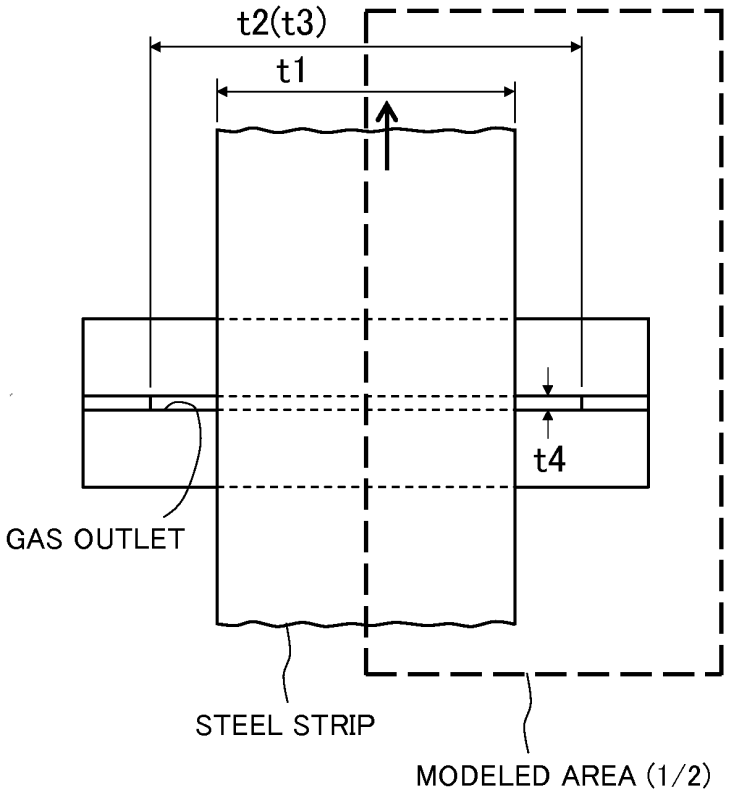

t2(t3)
t1
t4
GAS OUTLET
STEEL STRIP
MODELED AREA (1/2)

Fig. 10

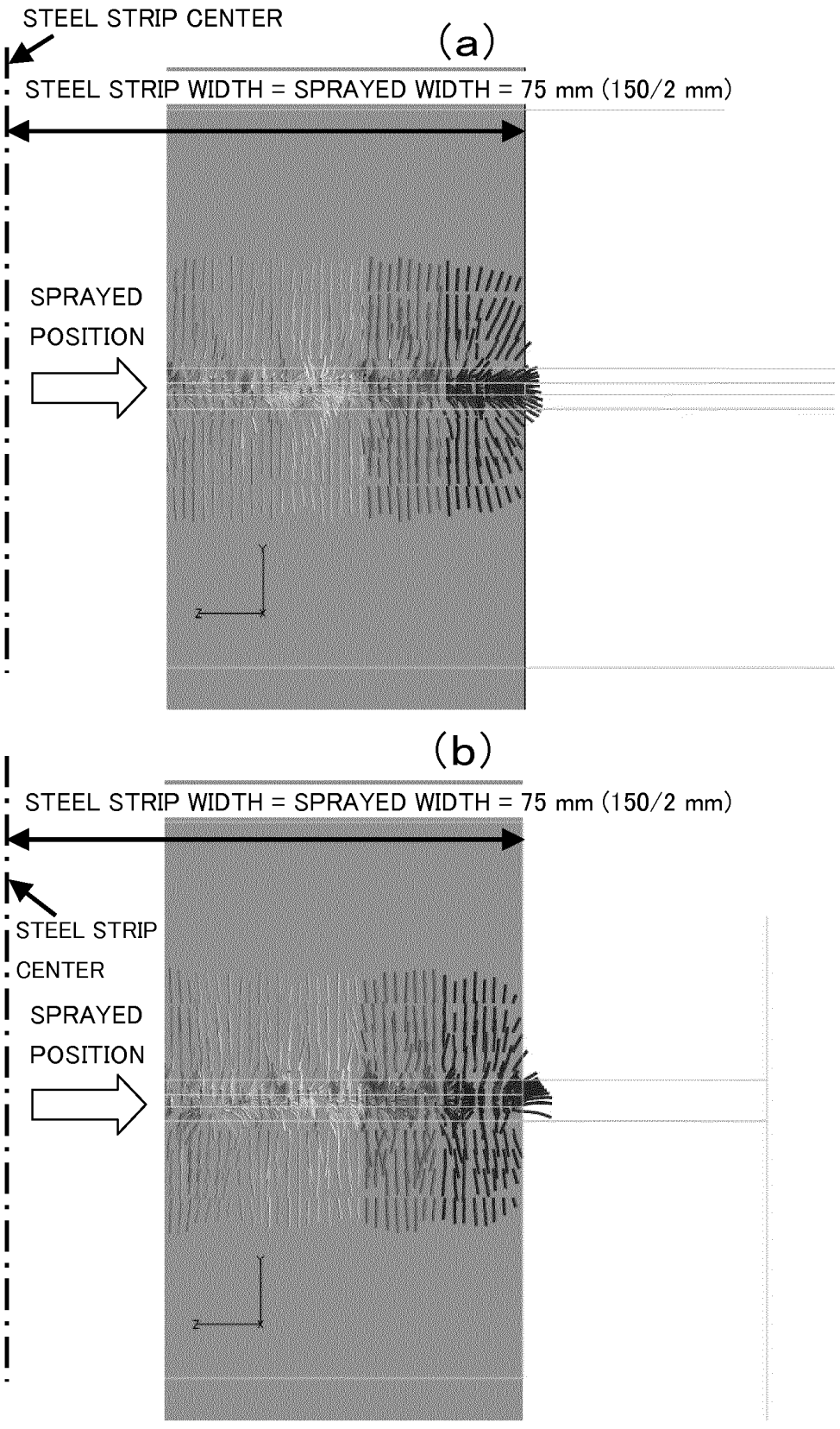
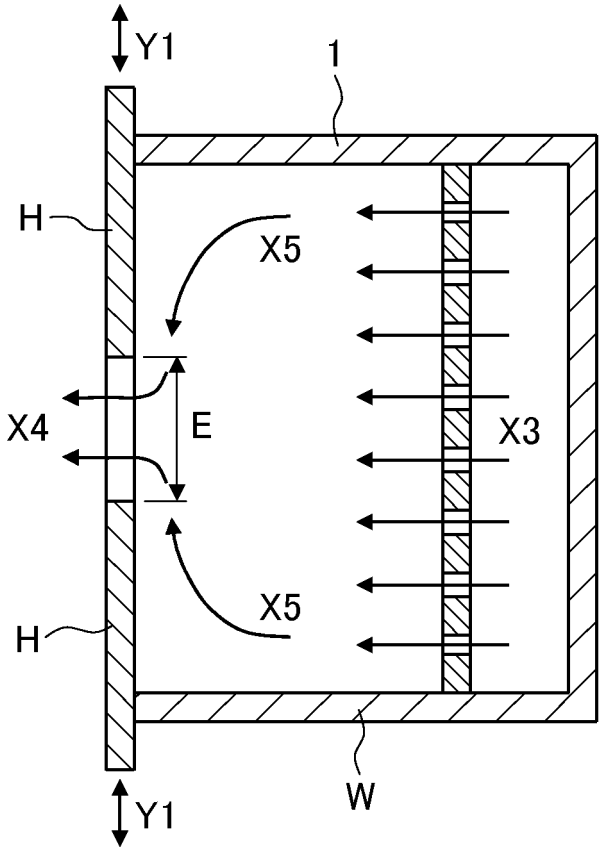

STEEL STRIP CENTER
(a)
STEEL STRIP WIDTH = SPRAYED WIDTH = 75 mm (150/2 mm)
SPRAYED
POSITION
Y
Z
(b)
STEEL STRIP WIDTH = SPRAYED WIDTH = 75 mm (150/2 mm)
STEEL STRIP
CENTER
SPRAYED
POSITION
Y
Z

Fig. 11



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/061644

A. CLASSIFICATION OF SUBJECT MATTER
C23C2/20(2006.01)i, *C23C2/40*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C23C2/20, C23C2/40

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2012
Kokai Jitsuyo Shinan Koho 1971-2012 Toroku Jitsuyo Shinan Koho 1994-2012

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2007-284732 A (Nippon Steel Corp.), 01 November 2007 (01.11.2007), claims (Family: none)	1-6
A	JP 52-141430 A (Nisshin Steel Co., Ltd.), 25 November 1977 (25.11.1977), claims; fig. 1 to 4 (Family: none)	1-6

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

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
07 August, 2012 (07.08.12)	14 August, 2012 (14.08.12)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/061644

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 030569/1990(Laid-open No. 125058/1991) (Nisshin Steel Co., Ltd.), 18 December 1991 (18.12.1991), claims; fig. 1 (Family: none)	1-6
A	JP 01-290755 A (Sumitomo Metal Industries, Ltd.), 22 November 1989 (22.11.1989), claims; fig. 1 (Family: none)	1-6

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2007284732 A **[0009]**