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

(11) EP 4 414 466 A1

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

(43) Date of publication:
14.08.2024 Bulletin 2024/33

(21) Application number: **22903782.5**

(22) Date of filing: **28.07.2022**

(51) International Patent Classification (IPC):
C21D 9/573 *(2006.01)* ***C21D 1/00*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
C21D 1/00; C21D 9/573

(86) International application number:
PCT/JP2022/029133

(87) International publication number:
WO 2023/105846 (15.06.2023 Gazette 2023/24)

(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
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **10.12.2021 JP 2021200510**

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(54) STEEL STRIP PRODUCTION DEVICE, CONTINUOUS ANNEALING FACILITY, AND PRODUCTION METHOD

(57) An apparatus for manufacturing a steel strip according to the present invention includes: a first water tank part that stores cooling water for immersing and cooling a steel strip; a water cooling nozzle unit that is provided in the first water tank part and injects cooling water to a surface of the steel strip; a second water tank part connected to the first water tank part through a joining port; and an opening and closing door that opens and closes the joining port; and a conveyance control part that conveys the water cooling nozzle unit such that the water cooling nozzle unit passes through the joining port and is positioned at either a cooling water injection position inside the first water tank part or a non-water cooling standby position inside the second water tank part.

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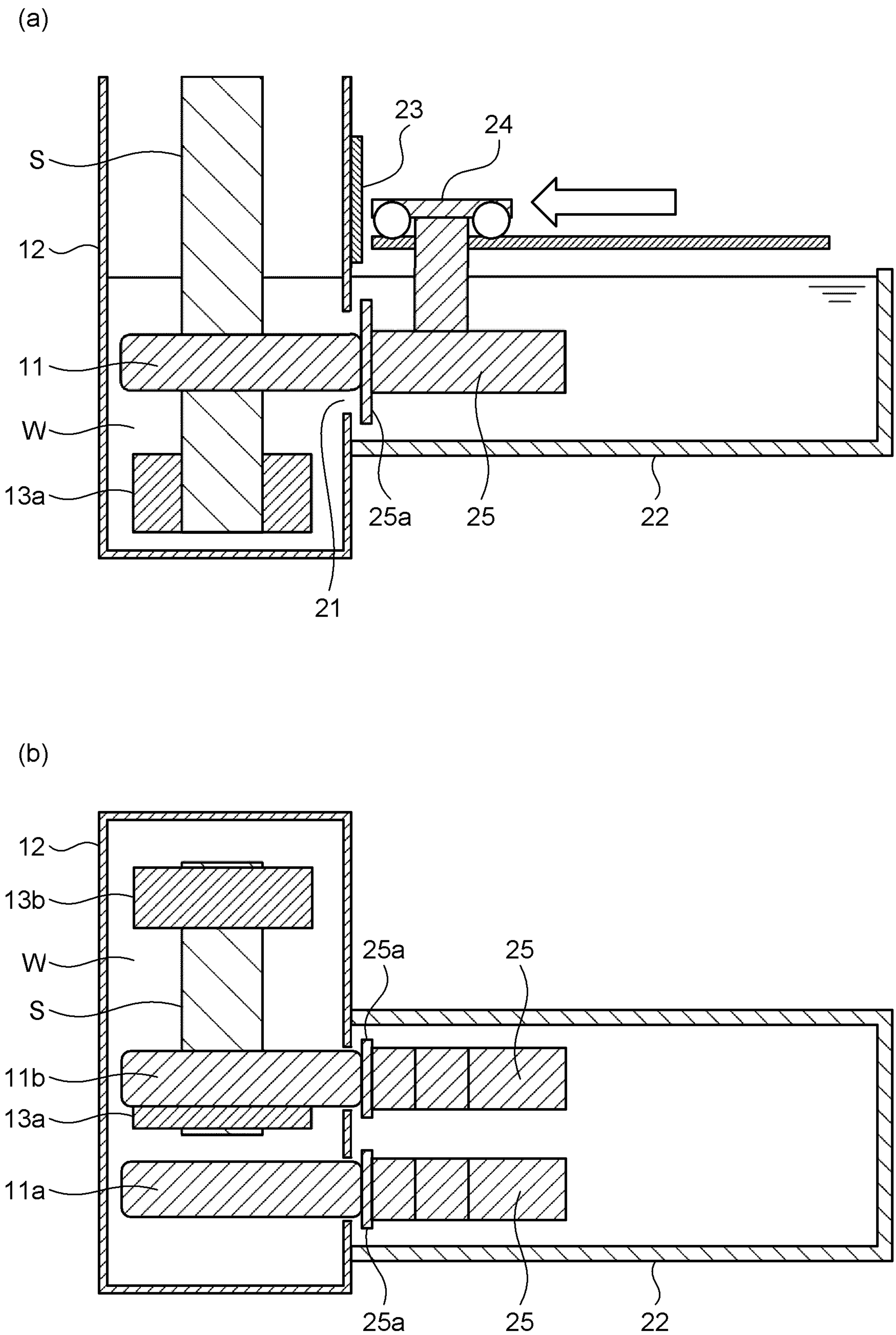
FIG.4


(a)
S
12
11
W
13a
23
24
25a
25
22
21
(b)
12
13b
W
S
11b
13a
11a
25a
25
25a
25
22

Description

Field

[0001] The present invention relates to an apparatus for manufacturing a steel strip, a continuous annealing facility, and a manufacturing method.

Background

[0002] In order to impart mechanical properties required for a steel strip in a continuous annealing process of the steel strip, it is important to control heat treatment conditions of heating and cooling. In particular, in order to control a microstructure of the steel by actively utilizing characteristics of phase transformation of the steel, it is important to control a cooling speed of the steel strip. In general, a continuous annealing line that performs the continuous annealing process of the steel strip includes a heating zone, a soaking zone, and a cooling zone. Cooling methods for the steel strip in the cooling zone include a water quenching method, a roll cooling method, a gas-water mixing (mist) cooling method, a gas jet cooling method, and the like, and an appropriate cooling method is selected in order to control a material of the steel strip. In particular, in manufacturing of a high-tensile steel sheet, the water quenching method is often used because the cooling speed is high and addition of an alloy element for increasing strength can be reduced. In the water quenching method, a method of immersing the steel strip in cooling water and cooling the steel strip with cooling water injected from a water cooling nozzle unit provided inside the cooling water is used.

[0003] Incidentally, when the cooling method of the steel strip is switched from the water quenching method to another cooling method, an inside of the cooling zone can be in a relatively high-temperature state in the cooling method other than the water quenching method, and thus the water cooling nozzle unit needs to be protected from heat. Therefore, when the cooling method of the steel strip is switched from the water quenching method to another cooling method, at least the water cooling nozzle unit is carried out from an inside of a furnace. However, when the water cooling nozzle unit is carried out from the inside of the furnace, it is necessary to perform an operation of opening a part of the furnace to an air atmosphere, carrying the water cooling nozzle unit out of the furnace, and replacing an atmosphere in the furnace with a non-oxidizing gas again, so that it takes much time to switch the cooling method. From such a background, Patent Literature 1 proposes an apparatus for manufacturing a steel strip in which a reflection plate for suppressing radiation and heat conduction from the steel strip is provided between water injection nozzles and the steel strip, and a cooling gas can be supplied to the water injection nozzles. According to this apparatus for manufacturing a steel strip, even when the water quenching method is switched to another cooling method, the work of carrying out the water injection nozzles from the inside of the furnace can be omitted, so that switching time of the cooling method can be shortened.

Citation List

Patent Literature

[0004] Patent Literature 1: Japanese Patent No. 5891857 Summary

Technical Problem

[0005] However, in the cooling method other than the water quenching method, a temperature of the steel strip in the cooling zone becomes a high temperature of 200°C or more, and operation time becomes long. Therefore, even in the apparatus for manufacturing a steel strip described in Patent Literature 1, there is a problem that a life of the water injection nozzles is shortened by heat. In addition, when the water quenching method is switched to another cooling method, it is necessary to dry the water injection nozzles by supplying a cooling gas, and a dew point inside the furnace may fluctuate before the water injection nozzles dry. Therefore, there is room for improvement in that it takes much time to switch the cooling method and stabilize heat treatment conditions of the steel strip.

[0006] The present invention has been made to solve the above problem, and an object of the present invention is to provide an apparatus for manufacturing a steel strip, a continuous annealing facility, and a manufacturing method capable of reducing time required for switching a cooling method between a water cooling method and a non-water cooling method.

Solution to Problem

[0007] To solve the problem and achieve the object, an apparatus for manufacturing a steel strip according to the present invention includes: a first water tank part that stores cooling water for immersing and cooling a steel strip; a water cooling nozzle unit that is provided in the first water tank part and injects cooling water to a surface of the steel strip; a second water tank part connected to the first water tank part through a joining port; an opening and closing door that opens and closes the joining port; and a conveyance control part that conveys the water cooling nozzle unit such that the water cooling nozzle unit passes through the joining port and is positioned at either a cooling water injection position inside the first water tank part or a non-water cooling standby position inside the second water tank part.

[0008] Moreover, the water cooling nozzle unit may be supported by a support part connected to the conveyance control part, and the support part may include an eaves portion that closes the joining port when the water cooling nozzle unit is located at the cooling water injection position.

[0009] Moreover, the water cooling nozzle unit may include a restraint roll that restrains the steel strip by at least a pair of rolls, in addition to a water injection nozzle that injects the cooling water to the surface of the steel strip.

[0010] Moreover, a continuous annealing facility for a steel strip according to the present invention includes the apparatus for manufacturing a steel strip according to the present invention in a cooling zone.

[0011] Moreover, the cooling zone may be supplied with a reducing gas or a non-oxidizing gas.

[0012] Moreover, a method for manufacturing a steel strip according to a first aspect of the present invention is the method using the apparatus for manufacturing a steel strip according to the present invention. The method according to the first aspect includes: a non-water cooling step of cooling the steel strip without injecting cooling water to the surface of the steel strip in the first water tank part; a water supply step of supplying cooling water to the first water tank part and the second water tank part after completion of the non-water cooling step; an opening step of opening the opening and closing door of the joining port; a nozzle unit inserting step of conveying the water cooling nozzle unit such that the water cooling nozzle unit passes through the joining port and moves from the non-water cooling standby position to the cooling water injection position; and a water cooling step of injecting cooling water to the surface of the steel strip using the water cooling nozzle unit, and immersing and cooling the steel strip in the cooling water stored in the first water tank part.

[0013] Moreover, a method for manufacturing a steel strip according to a second aspect of the present invention is the method using the apparatus for manufacturing a steel strip according to the present invention. The method according to the second aspect includes: a water cooling step of injecting cooling water to the surface of the steel strip using the water cooling nozzle unit, and immersing and cooling the steel strip in the cooling water inside the first water tank part; a nozzle unit retreating step of conveying the water cooling nozzle unit such that that the water cooling nozzle unit passes through the joining port after completion of the water cooling step and moves from the cooling water injection position to the non-water cooling standby position; a closing step of closing the opening and closing door of the joining port; a draining step of draining at least the cooling water inside the first water tank part; and a non-water cooling step of cooling the steel strip without injecting cooling water to the surface of the steel strip in the first water tank part.

[0014] Moreover, a method for manufacturing a steel strip according to the present invention is the method in which a steel strip is manufactured using the continuous annealing facility for a steel strip according to the present invention.

Advantageous Effects of Invention

[0015] According to the apparatus for manufacturing a steel strip, the continuous annealing facility, and the manufacturing method according to the present invention, it is possible to shorten time required for switching the cooling method between the water cooling method and the non-water cooling method.

Brief Description of Drawings

[0016]

FIG. 1 is a schematic diagram illustrating a configuration of a continuous annealing facility according to one embodiment of the present invention.

FIG. 2 is a diagram illustrating a thermal history of a steel strip in an annealing process and a reheating process.

FIG. 3 is a side view illustrating a configuration of a cooling apparatus by a water cooling method.

FIG. 4 is a front view and a top view illustrating the configuration of the cooling apparatus by the water cooling method.

FIG. 5 is a view illustrating a configuration example of opening portions of a joining port.

FIG. 6 is a side view illustrating a configuration of a modification of the cooling apparatus illustrated in FIG. 3.

FIG. 7 is a side view illustrating a configuration of a cooling apparatus by a non-water cooling method.

FIG. 8 is a front view and a top view illustrating the configuration of the cooling apparatus by the non-water cooling method.

FIG. 9 is a view for describing a method for switching from the non-water cooling method to the water cooling method according to the one embodiment of the present invention.

FIG. 10 is a view for describing a method for switching from the water cooling method to the non-water cooling method according to the one embodiment of the present invention.

Description of Embodiments

[0017] Hereinafter, an apparatus for manufacturing a steel strip, a continuous annealing facility, and a manufacturing method according to one embodiment of the present invention will be described with reference to the drawings. Note that the apparatus for manufacturing a steel strip according to the one embodiment of the present invention configures a part of the continuous annealing facility that performs a heat treatment of a steel sheet that has undergone a hot rolling process, a pickling process, and a cold rolling process and whose thickness has been reduced to a predetermined sheet thickness. In addition, at least in the hot rolling process or later, the steel sheet is wound into a coil shape and then subjected to the heat treatment or the like, and thus the steel sheet is referred to as a "steel strip" in the present specification.

[Continuous annealing facility]

[0018] Hereinafter, a configuration of the continuous annealing facility according to the one embodiment of the present invention will be described with reference to FIGS. 1 and 2.

[0019] FIG. 1 is a schematic diagram illustrating the configuration of the continuous annealing facility according to the one embodiment of the present invention. As illustrated in FIG. 1, a continuous annealing facility 1 according to the one embodiment of the present invention is a facility for manufacturing a cold-rolled steel sheet, and is provided in a continuous annealing line (CAL) that executes a process of manufacturing the cold-rolled steel sheet including an annealing process. In the present embodiment, the continuous annealing facility 1 includes an inlet facility, a furnace body, and an outlet facility.

[0020] The inlet facility includes a pay-off reel, a welding machine, an electrolytic cleaning apparatus, and an inlet looper. The furnace body includes an annealing part and a reheating part. The annealing part includes a heating zone 2, a soaking zone 3, and a cooling zone 4, and may have a preheating zone on an upstream side of the heating zone 2. The reheating part includes a reheating zone, an overaging zone, and a final cooling zone, and an induction heating apparatus 5 is disposed in a reheating zone. The outlet facility includes an outlet looper, a temper rolling facility, an inspection facility, and a tension reel.

[0021] The annealing process is a process of raising a temperature of the steel strip from around a room temperature, holding the steel strip at a predetermined temperature, and then lowering the temperature to around the room temperature. In the continuous annealing facility 1 illustrated in FIG. 1, the annealing process is executed in the heating zone 2, the soaking zone 3, and the cooling zone 4. A reheating process is a process of performing an overaging treatment of a steel strip S passing through the cooling zone 4. In the continuous annealing facility 1 illustrated in FIG. 1, the reheating process is executed in the reheating zone, the overaging zone, and the final cooling zone.

[0022] The heating zone 2 is a facility for raising the temperature of the steel strip S, and heats the steel strip S to a preset temperature within a range of about 600 to 900°C depending on a steel type. In the heating zone 2, a direct flame or radiant combustion burner is used as a heating apparatus. Since these heating apparatuses have a large heating capacity and a relatively fast response, it is easy to change a temperature rising history at the time of changing a heat cycle. The soaking zone 3 is a facility for holding the steel strip S at a predetermined temperature, and is a facility having a heating capacity enough to compensate for heat dissipation from the furnace body and the like.

[0023] The cooling zone 4 is a facility for cooling the steel strip S to a predetermined temperature, and water cooling (water quenching), gas jet cooling, roll cooling, mist cooling (gas-liquid mixed cooling), or the like is used as cooling means. The water cooling is cooling means for cooling the steel strip S by immersing the steel strip S in an immersion water tank installed on a downstream side of the soaking zone 3. The gas jet cooling is a cooling means for cooling the steel strip S by blowing a gas from a nozzle to a surface of the steel strip S. The roll cooling is cooling means for cooling the steel strip S by bringing the steel strip S into contact with a water cooling roll. The mist cooling is cooling means for cooling the steel strip S by spraying water in a form of fine mist and absorbing heat of vaporization.

[0024] In the present embodiment, a cooling method using the water cooling as the cooling means is referred to as a water cooling method, and a cooling method using other cooling means is referred to as a non-water cooling method. Note that although water is used as a refrigerant in the mist cooling, water droplets to be sprayed are very fine water droplets each having a size of about 0.1 to 1 mm. Since the water droplets collide with the steel strip S to vaporize the refrigerant, a water tank for recovering water is not required. Therefore, the mist cooling is included in the non-water cooling method. That is, in the present embodiment, a method in which the immersion water tank is used and the steel strip S is immersed in the immersion water tank is defined as the cooling method of the steel strip S is referred to as the water cooling method, and a method in which cooling is performed by other methods is referred to as the non-water cooling method. Note that the gas jet cooling, the roll cooling, and the mist cooling mentioned as the non-water cooling methods may cool the steel strip S by combining two or more in the cooling zone 4, and such cases are also included in the non-water cooling methods. However, in a case where the water cooling method using the immersion water tank is combined with the non-water cooling method, the method is the water cooling method.

[0025] The reheating zone is disposed on a downstream side of the cooling zone 4 and reheats the steel strip S to a temperature of about 300 to 400°C using the induction heating apparatus 5. The overaging zone is a facility for performing the overaging treatment in which the reheated steel strip S is held for a predetermined time. The final cooling zone is a facility for finally cooling the steel strip S subjected to the overaging treatment to around the room temperature. However, the continuous annealing facility may not include the reheating zone.

[0026] FIG. 2 is a diagram showing a thermal history of the steel strip in the annealing process and the reheating process. In FIG. 2, a horizontal axis represents time, and a vertical axis represents the steel strip temperature. The steel strip temperature is, for example, a surface temperature of the steel strip S. The annealing process is executed by the heating zone 2, the soaking zone 3, and the cooling zone 4, and then the reheating process is executed by the reheating zone, the overaging zone, and the final cooling zone. In order to restrain a material from varying depending on a position of the steel strip S in a longitudinal direction, a conveying speed (line speed) of the steel strip S during the annealing process is kept constant. However, when the steel strips S having different thicknesses, widths, steel types, and the like are welded, the conveying speed may change while a welded part passes through the continuous annealing facility. Operating conditions of the continuous annealing facility including operating conditions of the cooling apparatus are set by a control computer that controls operation of the continuous annealing facility, and are appropriately reset in accordance with a change in the conveying speed or the like.

[0027] A mixed gas containing hydrogen, nitrogen, and water vapor is supplied into the heating zone 2, the soaking zone 3, and the cooling zone 4 in which the annealing process is performed, thereby controlling an atmosphere of the annealing process. Since the atmosphere of the annealing process affects oxides and the like generated on the surface of the steel strip S, a composition and a flow rate of the gas to be supplied are adjusted. For example, a reducing gas or a non-oxidizing gas is supplied to the cooling zone 4. As the reducing gas, a H_2-N_2 mixed gas is usually used, and for example, a gas (dew point: about -60°C) having a composition containing 1 to 20 vol% of H_2 and a balance N_2 and unavoidable impurities is supplied. In addition, as the non-oxidizing gas, for example, a gas having a composition containing N_2 and unavoidable impurities (dew point: about -60°C) is used.

[0028] Inside the cooling zone 4, the gas for controlling the atmosphere in the furnace is supplied from two or more charging ports in a height direction and two or more charging ports in a longitudinal direction of the cooling zone 4 such that the reducing gas or the non-oxidizing gas is uniformly supplied. In addition, since the gas supplied to the heating zone 2, the soaking zone 3, and the cooling zone 4 contains water vapor, not only the gas composition but also a dew point of the atmosphere in the annealing process is adjusted. For this reason, a certain degree of airtightness is ensured such that the atmosphere inside the heating zone 2, the soaking zone 3, and the cooling zone 4 is maintained to be different from the atmosphere outside the furnace.

[Cooling apparatus by water cooling method]

[0029] Next, a configuration of a cooling apparatus by the water cooling method will be described with reference to FIGS. 3 to 6.

[0030] FIG. 3 is a side view illustrating the configuration of the cooling apparatus when the steel strip S is cooled by the water cooling method in the cooling zone 4. As illustrated in FIG. 3, a cooling apparatus 10 includes a water cooling nozzle unit 11 including water injection nozzles, an immersion water tank 12, and deflector rolls 13a, 13b. In addition, the cooling apparatus 10 is provided with pressing rolls 14 for suppressing flutter of the steel strip S. In the cooling apparatus 10, the steel strip S that has passed through the immersion water tank 12 is sent to the reheating zone after cooling water W adhering to the surface is removed by draining rolls 15 and then dried in a drying furnace 16.

[0031] Note that the draining rolls 15 are each preferably a metal roll so as to have a sufficient heat resistance even when the cooling by the non-water cooling method is performed. However, instead of the draining rolls 15, a gas type wiping apparatus that injects a gas to the surface of the steel strip S may be used. In addition, in order to suppress temperature rise of the cooling water W stored in the immersion water tank 12 and control the water temperature of the cooling water W within a predetermined range, the cooling apparatus 10 may include a cooling chiller that circulates and cools the cooling water W inside the immersion water tank 12.

[0032] The water cooling nozzle unit 11 injects the cooling water to the steel strip S to cool the steel strip S. In the water cooling nozzle unit 11, in order to inject the cooling water to front and back surfaces of the traveling steel strip S, a pair of water injection nozzles is disposed in a plurality of stages on each of front and back surface sides of the traveling steel strip S. The steel strip S having passed through the soaking zone 3 can be cooled by injecting the cooling water from the water injection nozzles in the plurality of stages to the front and back surfaces of the steel strip S.

[0033] The immersion water tank 12 has a container shape so as to be able to store the cooling water W for immersing and cooling the steel strip S. In addition, the immersion water tank 12 includes a water supply valve for supplying the cooling water W to an inside of the immersion water tank 12 and a drain valve for discharging the cooling water W stored inside the immersion water tank 12. In the present embodiment, the immersion water tank 12 includes a water supply/drain apparatus 20 that shares the water supply valve and the water drain valve, and a liquid level height of the cooling water

W stored in the immersion water tank 12 is adjusted by adjusting opening degrees of the water supply/drain valve. However, the liquid level of the cooling water W may be adjusted by an operator visually adjusting an opening degree of the water supply valve or the drain valve, or may include a liquid level control part that controls the opening degree of the water supply valve or the drain valve using a liquid level gauge.

[0034] The deflector rolls 13a, 13b generate a predetermined tension in the steel strip S and change a conveying direction of the steel strip S while restraining the steel strip S. As a result, the steel strip S immersed in the cooling water W stored in the immersion water tank 12 is guided upward from the liquid level of the cooling water W. In this case, at least one of the deflector rolls 13a, 13b is disposed so as to be immersed in the cooling water W of the immersion water tank 12.

[0035] FIGS. 4(a), 4(b) are a front view and a top view illustrating the configuration of the cooling apparatus that cools the steel strip S by the water cooling method. Note that the immersion water tank 12 configuring the cooling apparatus 10 is hereinafter referred to as a first water tank part 12. As illustrated in FIGS 4(a), 4(b), in the present embodiment, a second water tank part 22 having a joining port 21 with the first water tank part 12 is disposed on a side surface portion of the first water tank part 12. The side surface portion of the first water tank part 12 means a side surface in the conveying direction of the steel strip S, and is a direction referred to as a so-called machine side of the continuous annealing facility. In this case, the second water tank part 22 may be disposed on the machine side of a working side of the continuous annealing facility, or may be disposed on the machine side of a driving side.

[0036] The second water tank part 22 also has a container shape so as to be able to store the cooling water W. In addition, the second water tank part 22 includes a water supply valve for supplying the cooling water W therein and a drain valve for discharging the cooling water W stored therein. The joining port 21 is opened such that the cooling water W stored in the first water tank part 12 and the second water tank part 22 can flow to each other. In addition, the joining port 21 has an opening portion through which the water cooling nozzle unit 11 is conveyed and which is movable between the first water tank part 12 and the second water tank part 22. Any shape, size, and number of the opening portions may be used as long as the water cooling nozzle unit 11 can pass through the opening portion.

[0037] In the present embodiment, the water cooling nozzle unit 11 includes a front surface nozzle unit 11a that injects the cooling water W to the front surface of the steel strip S and a back surface nozzle unit 11b that injects the cooling water W to the back surface, and the joining port 21 includes two opening portions through which the respective nozzle units can pass. Note that the opening portions of the joining port 21 may be one opening portion through which both the nozzle units can pass. However, when the cooling water W for performing the cooling by the water cooling method is stored in the first water tank part 12, the opening portions of the joining port 21 need to be disposed at a position lower than the liquid level. That is, the opening portions of the joining port 21 are disposed such that a state in which the entire opening portions are submerged by the cooling water W can be realized when the cooling water W is stored in the first water tank part 12 and the cooling by the water cooling method is performed.

[0038] FIG. 5 is a view illustrating a configuration example of the opening portions of the joining port 21 through which the front surface nozzle unit 11a and the back surface nozzle unit 11b pass. FIG. 5 illustrates a state in which the opening portions are viewed from the side surface of the first water tank part 12. Note that a method for joining the first water tank part 12 and the second water tank part 22 is not limited to a form in which a wall surface separating the first water tank part 12 and the second water tank part 22 is opened. For example, the first water tank part 12 and the second water tank part 22 may be joined by a tubular member having a steel pipe shape or a square pipe shape, and the water cooling nozzle unit 11 may pass through an inside of the tubular member.

[0039] As illustrated in FIG. 5, in the present embodiment, the joining port 21 between the first water tank part 12 and the second water tank part 22 includes an opening and closing door 23 for opening and closing the opening portions. Any means may be used as the opening and closing door 23 as long as the opening portions can be closed such that the cooling water W does not mutually move between the first water tank part 12 and the second water tank part 22, and the opening portions can be opened such that the cooling water W can mutually move between them. However, the opening and closing door 23 preferably includes a shutter mechanism that can be automatically opened and closed by an external operation. As a material making the opening and closing door 23, similarly to a material making a furnace wall of the annealing furnace, heat-resistant steel, stainless steel, or the like is suitably used.

[0040] In addition, the opening and closing door 23 preferably has an airtightness for blocking a gas atmosphere inside the furnace from the air atmosphere outside the furnace when the cooling by the non-water cooling method described later is performed. For example, it is preferable to use a sealing member in which a material of a packing, a gasket, or the like as the sealing member is made of graphite or metal having an excellent heat resistance. Furthermore, in order to improve airtightness of each of the opening portions, it is preferable that the opening and closing door 23 includes a mechanism that presses the opening and closing door 23 against a wall portion around the opening portion using hydraulic pressure, pneumatic pressure, or the like. However, a method in which the opening and closing door 23 is brought into close contact with the wall portion around the opening portion by squill vice or screw clamp may be adopted. In addition, in order to further improve the airtightness, a double or triple opening and closing door may be used as the opening and closing door 23 instead of a single opening and closing door.

[0041] Refer back to FIG. 4. As illustrated in FIG. 4(a), the water cooling nozzle unit 11 includes a conveyance control part 24 that conveys the water cooling nozzle unit 11 so as to pass through the joining port 21 and to be positioned at either a cooling water injection position or a non-water cooling standby position. In the present embodiment, the water cooling nozzle unit 11 is supported by support parts 25, and the conveyance control part 24 conveys the water cooling nozzle unit 11 by moving the support parts 25. The support parts 25 preferably support the water cooling nozzle unit 11 in a cantilever manner in a direction in which the water cooling nozzle unit 11 reciprocates. In addition, means for reciprocating each of the support parts 25 may be arbitrary, and means for conveying the support part by hydraulic pressure or pneumatic pressure, or means for linearly moving the support part using an electric motor, a rack, and a pinion may be adopted. Further, a mechanism may be used in which a wheel is provided in the support part 25 and the support part 25 reciprocates on a track. FIG. 4(a) illustrates an example of the conveyance control part 24 that reciprocates the water cooling nozzle unit 11 on the track while supporting the support part 25 in a suspending manner.

[0042] The conveyance control part 24 controls the water cooling nozzle unit 11 to be located at either the cooling water injection position or the non-water cooling standby position. The cooling water injection position of the water cooling nozzle unit 11 refers to a position at which the cooling water is injected to the front and back surfaces of the steel strip S by the water injection nozzles of the water cooling nozzle unit 11 when the cooling water W is stored in the first water tank part 12 and the cooling by the water cooling method is executed. That is, since the water cooling nozzle unit 11 is located at the cooling water injection position, it is possible to perform the normal cooling by the water cooling method. The position of the water cooling nozzle unit 11 illustrated in FIGS. 4(a), 4(b) is the cooling water injection position, and the water cooling nozzle unit 11 is inside the first water tank part 12. On the other hand, the non-water cooling standby position of the water cooling nozzle unit 11 is a position where the water cooling nozzle unit 11 is disposed when the cooling by the non-water cooling method described later is performed, and refers to a state where the water cooling nozzle unit 11 is inside the second water tank part 22. That is, this means a position where the opening and closing door 23 can be closed by housing the water cooling nozzle unit 11 inside the second water tank part 22.

[0043] The water injection nozzles configuring the water cooling nozzle unit 11 can be appropriately selected in accordance with the cooling speed required for securing the material of the steel strip S to be manufactured. Since the cooling speed of the steel strip S depends on an injection flow rate of the cooling water injected from the water injection nozzles, the cooling speed can be increased by using the water injection nozzles having the large injection flow rate. However, when the cooling speed becomes a predetermined value or more, the cooling speed does not increase much even if the injection flow rate is increased. Specifically, when the injection flow rate is, for example, 2 m/s or more, a cooling effect is not improved even if the injection flow rate is increased, and change in the cooling speed of the steel strip S is substantially flat. On the other hand, the cooling speed can be increased as a water temperature of the cooling water injected from the water injection nozzles is lower. Therefore, in order to obtain the higher cooling speed, it is preferable to lower the temperature of the cooling water injected by the water cooling nozzle unit 11. For example, the temperature of the cooling water injected from the water injection nozzles is preferably 10°C or more and less than 40°C, and is preferably controlled to, for example, about 30°C using the cooling chiller.

[0044] Here, when the cooling water W is stored in the first water tank part 12 and the second water tank part 22, the cooling apparatus 10 is preferably capable of adjusting the liquid level of the cooling water W using the supply/drain valve. Further, it is preferable that the water cooling nozzle unit 11 includes a mechanism capable of adjusting a height position, and a height at which the water cooling nozzle unit 11 is disposed with respect to the liquid level can be adjusted. For example, a guide part that can slide in an up-down direction is provided in the water cooling nozzle unit 11, and a relative height direction position with respect to the support part 25 can be adjusted. This is because the material of the steel strip S and a shape at the time of cooling can be adjusted by adjusting cooling start timing of the steel strip S with the cooling water. For example, by installing a part of the water injection nozzles configuring the water cooling nozzle unit 11 at a position higher than the liquid level, preliminary cooling by the water injection nozzles can be performed immediately before the rapid cooling is performed by the first water tank part 12. Therefore, deterioration of the shape of the steel strip S due to thermal shrinkage or phase transformation can be suppressed, and the steel strip S having a good shape can be manufactured.

[0045] In addition, the water cooling nozzle unit 11 may include restraint rolls that restrain the steel strip S by at least a pair of rolls together with the water injection nozzles. For example, as illustrated in FIG. 6, restraint rolls 26 that apply a pressing force toward the steel strip S may be provided between the plurality of water injection nozzles configuring the water cooling nozzle unit 11. By providing the restraint rolls, it is possible to suppress the shape of the steel strip S from being disturbed by transformation expansion when the steel strip S undergoes phase transformation. However, a number and an installation position of the restraint rolls can be appropriately changed in accordance with cooling conditions applied to the steel strip S. When such restraint rolls are provided in the water cooling nozzle unit 11, the restraint rolls are preferably supported by the support part 25 integrally with the water cooling nozzle unit 11, and conveyed together with the water cooling nozzle unit 11 by the conveyance control part 24.

[Cooling apparatus by non-water cooling method]

[0046] Next, a configuration of a cooling apparatus by a non-water cooling method will be described with reference to FIGS. 7 and 8.

[0047] FIG. 7 is a side view illustrating the configuration of the cooling apparatus when the steel strip S is cooled by the non-water cooling method in the cooling zone 4. As illustrated in FIG. 7, the cooling apparatus 10 in a case where the steel strip S is cooled by the non-water cooling method is configured by cooling means including the gas jet cooling, the mist cooling, or combination thereof. When the steel strip S is cooled by the non-water cooling method, non-water cooling nozzle units 27 are disposed so as to cool the steel strip S by injecting a gas or a mist to the steel strip S. In the cooling by the non-water cooling method by the gas jet cooling, as each of the non-water cooling nozzle units 27, one in which a pair of gas injection nozzles is disposed in a plurality of stages on each of the front and back surface sides of the traveling steel strip S is used. On the other hand, in the cooling by the non-water cooling method by the mist cooling, as each of the non-water cooling nozzle units 27, one in which a pair of mist injection nozzles is disposed in a plurality of stages on each of the front and back surface sides of the traveling steel strip S is used. In addition, in the cooling by the non-water cooling method by the roll cooling, an internal water cooling roll is disposed in the cooling zone 4 instead of the non-water cooling nozzle unit 27. Although only a pair of non-water cooling nozzle units 27 is illustrated in an example illustrated in FIG. 7, a plurality of non-water cooling nozzle units 27 are usually disposed along the cooling zone 4. In the example illustrated in FIG. 7, only a part thereof is illustrated.

[0048] In the cooling apparatus capable of switching the cooling method between the water cooling method and the non-water cooling method as in the present embodiment, it is preferable to switch the cooling method without changing the configurations of the instruments as much as possible. This is because the larger a number of instruments whose configurations are changed is, the longer time required for switching between the water cooling method and the non-water cooling method is. Therefore, in the example illustrated in FIG. 7, the deflector rolls 13a, 13b, the pressing rolls 14, the draining rolls 15, and the drying furnace 16 are commonly used in the non-water cooling method and the water cooling method. In addition, it is not necessary to move the immersion water tank 12 and the non-water cooling nozzle units 27 in switching of the cooling method, and the immersion water tank 12 and the non-water cooling nozzle unit 27 are disposed at fixed positions. In this case, the cooling water W is stored in the immersion water tank 12 in the water cooling method, and the cooling water W is discharged from the immersion water tank 12 in the non-water cooling method.

[0049] The non-water cooling nozzle units 27 inject the refrigerant from the gas injection nozzles or the mist injection nozzles toward the steel strip S in the non-water cooling method, but basically maintain a state of not injecting the refrigerant in the water cooling method. In addition, even if the injection nozzles facing the front surface of the steel strip S and the injection nozzles facing the back surface of the same are moved to the extent of retreating so as to be separated from each other, the non-water cooling nozzle units 27 are not carried out of the furnace. In addition, in the non-water cooling method, it is not always necessary to use the draining rolls 15, and when the draining is not performed, the steel strip S may be passed in a state where the opposing rolls are separated. Similarly, in the drying furnace 16, the steel strip S may be dried as necessary in the non-water cooling method, and when the drying is not performed, the steel strip S may be passed in a state where an output of the drying furnace 16 is lowered. In any case, the cooling apparatus 10 when the cooling by the non-water cooling method illustrated in FIG. 7 may have an instrument configuration in which at least the water cooling nozzle unit 11 is carried out with respect to the instrument configuration when the water cooling by the water cooling method is performed.

[0050] An injection pressure of the gas injection nozzles when the gas jet cooling is performed by the non-water cooling nozzle units 27 is usually set to about 0 to 10 kPa, and the cooling by the non-water cooling method is performed. When the injection pressure exceeds 10 kPa, even if the injection pressure is increased, improvement of the cooling capacity equivalent to increase in a power cost of a blower cannot be expected. In addition, since vibration of the steel strip S increases due to increase in a gas flow rate due to the increase in the injection pressure, there is a risk that non-uniformity of cooling occurs. An opening portion for the gas injection in each of the gas injection nozzles may have a round hole shape or a slit shape. The shape of the opening portion for the gas injection may be appropriately selected in accordance to the capacity to cool the steel strip S required for the cooling by the non-water cooling method and uniformity of the cooling. On the other hand, when the mist cooling is performed by the non-water cooling nozzle units 27, although a gas pressure for atomizing droplets greatly varies depending on a type and a structure of the nozzle, a nozzle that has an appropriate value of the gas pressure of about 3 to 1000 kPa is used. An injection shape of the mist injected from each of the mist cooling nozzles may be a conical shape or a fan shape, and can be appropriately selected in accordance with the cooling capacity required for obtaining a target material of the steel strip S and the uniformity of cooling.

[0051] FIG. 8 is a front view and a top view illustrating the configuration of the cooling apparatus when the cooling by the non-water cooling method is performed. Note that the first water tank part 12, the joining port 21, the second water tank part 22, the opening and closing door 23, the conveyance control part 24, and the support parts 25 are the same as those in the cooling apparatus when the cooling by the water cooling method is performed. However, when the cooling by the non-water cooling method is performed, the cooling water W is not stored in the first water tank part 12 and the second water tank part 22. In addition, the water cooling nozzle unit 11 is in a state located at the non-water cooling standby position, and the opening portion of the joining port 21 is closed by the opening and closing door 23. As a result, the atmosphere inside the furnace in the cooling zone 4 is blocked from the air atmosphere, and the furnace atmosphere suitable for the annealing process is maintained.

[0052] As described above, in the cooling apparatus 10 according to the one embodiment of the present invention, when the cooling by the water cooling method is performed, the joining port 21 between the first water tank part 12 and the second water tank part 22 is filled with the cooling water W by storing the cooling water W in the first water tank part 12 and the second water tank part 22. Therefore, even when the opening and closing door 23 of the joining port 21 is opened, the atmosphere inside the furnace and the air atmosphere outside the furnace are blocked by the cooling water W. As a result, even when the water cooling nozzle unit 11 is moved between the cooling water injection position and the non-water cooling standby position using the conveyance control part 24, it is possible to maintain a state in which the furnace atmosphere is blocked from the air atmosphere. On the other hand, when the cooling by the non-water cooling method is performed, the opening and closing door 23 between the first water tank part 12 and the second water tank part 22 is closed in the state where the water cooling nozzle unit 11 is located at the non-water cooling standby position. Accordingly, even when the cooling water W stored in the first water tank part 12 and the second water tank part 22 is drained, the joining port 21 is closed by the opening and closing door 23, so that it is possible to maintain the state in which the furnace atmosphere is blocked from the air atmosphere.

[0053] That is, according to the cooling apparatus 10 of the one embodiment of the present invention, when the cooling method is switched between the water cooling method and the non-water cooling method, the furnace atmosphere is maintained in the state of being blocked from the air atmosphere. As a result, it is not necessary to perform working for gas replacement or the like when the water cooling nozzle unit 11 is carried into the furnace or carried out of the furnace as in the conventional case, and the time required for switching the cooling method can be significantly shortened. In addition, since it is not necessary to dispose the water cooling nozzle unit 11 inside the furnace even when the cooling by the non-water cooling method is performed, it is possible to suppress fluctuation in the dew point inside the furnace due to moisture adhering to the water cooling nozzle unit 11. In addition, since the water cooling nozzle unit 11 is not left inside the furnace when the cooling by the non-water cooling method is performed, a life of the water cooling nozzle unit 11 can be prolonged, and an update cost of the instruments can be reduced.

[0054] Note that each of the support parts 25 preferably includes an eaves portion capable of closing the joining port 21 when the water cooling nozzle unit 11 is located at the cooling water injection position. Specifically, as illustrated in FIGS. 4(a), 4(b), each eaves portion 25a is a member fixed to the support part 25 that supports the water cooling nozzle unit 11, and has a shape that covers the opening portion of the joining port 21 between the first water tank part 12 and the second water tank part 22. In addition, the eaves portion 25a is disposed on the support part 25 so as to close the opening portion of the joining port 21 in the state where the conveyance control part 24 positions the water cooling nozzle unit 11 at the cooling water injection position.

[0055] The eaves portion 25a has a function of suppressing free movement of the cooling water W between the first water tank part 12 and the second water tank part 22 in the cooling by the water cooling method. In the first water tank part 12, since the high-temperature steel strip S is continuously immersed in the cooling water W, the temperature of the cooling water W gradually increases when the cooling by the water cooling method is performed. Since the cooling capacity of the steel strip S decreases when the temperature of the cooling water W increases, it is preferable to include the cooling chiller that suppresses the temperature increase of the cooling water W while circulating the cooling water W in the first water tank part 12. However, when the opening and closing door 23 is opened, the entire cooling water W stored in the first water tank part 12 and the second water tank part 22 needs to be cooled by the cooling chiller. When the movement of the cooling water W between the first water tank part 12 and the second water tank part 22 is suppressed by the eaves portions 25a, the cooling chiller only needs to have the ability to circulate and cool the cooling water W inside the first water tank part 12, and a running cost can also be suppressed. Note that as a member configuring the eaves portion 25a, it is preferable to use heat-resistant steel, stainless steel, or the like, similarly to the opening and closing door 23. However, when the cooling by the non-water cooling method is performed, it is not necessary to have airtightness (sealability) that blocks the atmosphere inside the furnace from the atmosphere outside the furnace like the opening and closing door 23. In the cooling by the water cooling method, it is sufficient that a degree of sealing at which the movement of the cooling water W between the first water tank part 12 and the second water tank part 22 is suppressed to some extent is secured in a state where the opening and closing door 23 is opened. Therefore, an opening portion may be formed in a part, and cooling water may slightly move between the first water tank part 12 and the second water tank part 22.

[Method for switching from non-water cooling method to water cooling method]

[0056] Next, with reference to FIG. 9, a method for switching from the non-water cooling method to the water cooling method in the cooling apparatus according to the one embodiment of the present invention will be described.

[0057] Switching from the non-water cooling method to the water cooling method is started from a non-water cooling step of performing the cooling by the non-water cooling method illustrated in FIG. 9(a). Note that at an end of the non-water cooling step, it is preferable to decelerate the line speed of the continuous annealing facility. This is because during the switching of the cooling method, variations in material occur in the steel strip S passing through the cooling zone 4, so that a length of the steel strip S in which a material defect occurs can be shortened. More preferably, it is decelerated to a lowest speed of the line speed of the continuous annealing facility. In that case, it is preferable to reduce outputs of the combustion burners in the heating zone 2 and the soaking zone 3 in accordance with the line speed, and to reset operating conditions of the annealing process such that the steel strip S is not overheated. However, when it is difficult to adjust the burner outputs, such as when direct flame type burners are used, it is necessary to convey the steel strip S at a constant line speed or more. In addition, it is not preferable to stop the conveyance of the steel strip S during the switching of the cooling method. This is because if the conveyance of the steel strip S is stopped, it is necessary to lower the furnace temperatures in the heating zone 2 and the soaking zone 3 in order to suppress the overheating of the steel strip S, and it takes time to raise the temperatures to predetermined furnace temperatures when the conveyance of the steel strip S is restarted.

[0058] After the end of the non-water cooling step, the processing proceeds to a water supply step of supplying water to the first water tank part 12 and the second water tank part 22. The water supply step is a step of operating the respective water supply valves of the first water tank part 12 and the second water tank part 22 to store the cooling water W. As illustrated in FIG. 9(b), the water is supplied to the first water tank part 12 and the second water tank part 22 such that the liquid level of the cooling water W is higher than a position of the opening portions of the joining port 21. However, when there occurs a pressure difference between a pressure inside the cooling zone 4 and an atmospheric pressure when the cooling by the water cooling method is performed, there may be a difference between the liquid level of the first water tank part 12 and the liquid level of the second water tank part 22. Therefore, it is preferable to adjust the liquid level of the cooling water W to be higher than the positions of the opening portions even during steady operation in consideration of such a pressure difference. The water supply to the first water tank part 12 and the second water tank part 22 is performed in a state where the opening and closing door 23 is closed, and thus the water supply is individually performed by each of the water supply valves. In this case, it is preferable to adjust the liquid level such that a liquid level position of the first water tank part 12 and a liquid level position of the second water tank part 22 are substantially the same. This is because the liquid level position of the first water tank part 12 and the liquid level position of the second water tank part 22 are different from each other, so that a resistance due to water pressure is generated when the opening and closing door 23 is opened in a state in which the water pressure difference is generated inside. On the other hand, the water supply to the second water tank part 22 may be performed in advance while the cooling by the non-water cooling method is being performed, and the water supply to the first water tank part 12 may be performed after the cooling by the non-water cooling method is finished. This is because the water supply time can be shortened. In this case, since air is mixed in the water injection nozzles in the state where the water cooling nozzle unit 11 is located at the non-water cooling standby position, it is preferable to inject the water at the non-water cooling standby position and discharge the air inside the water injection nozzles in advance. Further, when the cooling water W is supplied to the first water tank part 12, a temperature at which the steel strip S passes through the first water tank part 12 is preferably 400°C or lower. When the temperature of the steel strip S is in a high temperature state exceeding 400°C, a contact position between the cooling water W during the water supply and the steel strip S changes. This is because a thermal deformation of the steel strip S may occur largely at a boundary portion between a portion to which the cooling water W is supplied and a portion to which the cooling water W is not supplied, and there is a risk that a plate passing state becomes unstable.

[0059] When the cooling water supply step is completed, as illustrated in FIG. 9(c), the processing proceeds to an opening step of opening the opening and closing door 23. By opening the opening and closing door 23 that separates the first water tank part 12 and the second water tank part 22 in the opening step, the cooling water W becomes flowable between the first water tank part 12 and the second water tank part 22. However, since the opening portions of the joining port 21 are filled with the cooling water W, a gas inside the furnace and a gas outside the furnace do not move to each other through the joining port 21. Therefore, a state in which the atmosphere inside the furnace in the cooling zone 4 and the air atmosphere in contact with the liquid level of the second water tank part 22 are blocked is maintained. Upon an end of the opening step, the processing proceeds to a nozzle unit inserting step. As illustrated in FIG. 9(d), the nozzle unit inserting step is a step in which the water cooling nozzle unit 11 is inserted so as to pass through the joining port 21 opened by the opening step and move from the non-water cooling standby position to the cooling water injection position. The conveyance of the water cooling nozzle unit 11 to the cooling water injection position is executed by the conveyance control part 24. As a result, the water cooling nozzle unit 11 is disposed at the cooling water injection position, and can execute the cooling by the water cooling method with the cooling water W stored in the first water tank part 12. Then, when the nozzle unit inserting step ends, the line speed of the continuous annealing facility is increased in order to perform the cooling by the water cooling method. The outputs of the combustion burners of the heating zone 2 and the soaking zone 3 are also controlled so as to satisfy annealing conditions set in advance for the steel strip S to be subjected to the cooling by the water cooling method, and operation of the continuous annealing facility in which the cooling method is the water cooling method is executed.

[Method for switching from water cooling method to non-water cooling method]

[0060] Next, with reference to FIG. 10, a method for switching from the water cooling method to the non-water cooling method in the cooling apparatus according to the one embodiment of the present invention will be described.

[0061] Switching from the water cooling method to the non-water cooling method is started from a water cooling step of performing the cooling by the water cooling method illustrated in FIG. 10(a). At an end of the water cooling step, it is preferable to decelerate the line speed of the continuous annealing facility. This is because during the switching of the cooling method, variations in material occur in the steel strip S passing through the cooling zone 4, so that the length of the steel strip S in which a material defect occurs can be shortened. More preferably, it is decelerated to the lowest speed of the line speed of the continuous annealing facility. In that case, it is preferable to reduce the outputs of the combustion burners in the heating zone 2 and the soaking zone 3 in accordance with the line speed, and to reset the operating conditions of the annealing process such that the steel strip S is not overheated. However, when it is difficult to adjust the burner outputs, such as when direct flame type burners are used, it is necessary to convey the steel strip S at a constant line speed or more.

[0062] After the end of the water cooling step, the processing proceeds to a nozzle unit retreating step. As illustrated in FIG. 10(b), the nozzle unit retreating step is a step in which the water cooling nozzle unit 11 retreats so as to pass through the joining port 21 opened in the water cooling step and move from the cooling water injection position to the non-water cooling standby position. The conveyance of the water cooling nozzle unit 11 to the non-water cooling standby position is executed by the conveyance control part 24. Accordingly, the water cooling nozzle unit 11 is disposed at the non-water cooling standby position. After an end of the nozzle unit retreating step, as illustrated in FIG. 10(c), the processing proceeds to a closing step of closing the opening and closing door 23. According to the closing step, by closing the opening and closing door 23 that separates the first water tank part 12 and the second water tank part 22, mutual flows of the cooling water W between the first water tank part 12 and the second water tank part 22 are stopped. When the closing step is completed, the processing shifts to a draining step of draining the cooling water W stored in the first water tank part 12 and the second water tank part 22 as illustrated in FIG. 10(d).

[0063] The draining step is a step of draining the cooling water W using the respective drain valves of the first water tank part 12 and the second water tank part 22. Since the joining port 21 is in the state of being blocked by the opening and closing door 23, the drainage from the first water tank part 12 and the second water tank part 22 is individually performed. However, the cooling water W stored in the second water tank part 22 does not necessarily need to be drained. This is because when the cooling water W stored in the first water tank part 12 is drained, the cooling water W for performing the immersion cooling is removed, so that the cooling by the non-water cooling method can be executed on the steel strip S. In this case, the cooling water W stored in the second water tank part 22 may be kept stored until next transition to the cooling by the water cooling method, or the cooling water W stored in the second water tank part 22 may be drained while the cooling by the non-water cooling method is performed. By keeping the cooling water W stored in the second water tank part 22 in the draining step, the water supply to the second water tank part 22 can be omitted in the water supply step when the method is switched to the next water cooling method.

[0064] In the draining step, when at least the drainage from the first water tank part 12 is completed, the line speed of the continuous annealing facility is increased in order to perform the cooling by the non-water cooling method. The outputs of the combustion burners of the heating zone 2 and the soaking zone 3 are also controlled so as to satisfy annealing conditions set in advance for the steel strip S to be subjected to the cooling by the non-water cooling method, and the processing proceeds to an annealing process in which the cooling zone 4 is operated by the non-water cooling method. As described above, in each of the steps of switching from the water cooling method to the non-water cooling method, the first water tank part 12 and the second water tank part 22 are in the state of being always blocked by the stored cooling water W or the opening and closing door 23. As a result, it is possible to switch the cooling method while maintaining the state in which the atmosphere inside the furnace in the cooling zone 4 and the air atmosphere outside the furnace are blocked. Note that the operation of each of the instruments in the switching from the non-water cooling method to the water cooling method, and the switching from the water cooling method to the non-water cooling method may be performed by the control computer that controls the operation of the continuous annealing facility. In addition, a cooling apparatus switching part that controls the switching operation of the cooling apparatus may be provided to execute the switching operation of the cooling apparatus.

[Method for manufacturing steel strip]

[0065] In the method for manufacturing a steel strip according to one embodiment of the present invention, by manufacturing the steel strip S using the continuous annealing facility 1, the steel strip S cooled by the water cooling method and the steel strip S cooled by the non-water cooling method as the cooling method can be separately manufactured. In the water cooling method and the non-water cooling method, different cooling speeds can be applied to the steel strip S whose temperature is raised in the heating zone and the soaking zone, so that the thermal history of the steel strip S in the continuous annealing can be changed. As a result, a degree of freedom of microstructure control of the steel strip S is improved, and a steel strip having various quality characteristics can be manufactured.

[Examples]

[0066] Hereinafter, the present invention will be described more specifically using examples. In the present example, in the continuous annealing facility that operates by switching between the water cooling method and the non-water cooling method (gas jet cooling method) as the cooling zone, switching from the cooling by the non-water cooling method to the cooling by the water cooling method was performed. As illustrated in FIGS. 4 and 8, the cooling apparatus used in the present example includes the water cooling nozzle unit 11 that injects the cooling water W to the surface of the steel strip S, and the first water tank part 12 that stores the cooling water W for immersing and cooling the steel strip S. In addition, the cooling apparatus according to the present example includes the second water tank part 22 disposed on the side surface portion of the first water tank part 12 and having the joining port 21 between the first water tank part 12 and the second water tank part 22, and the opening and closing door 23 that opens and closes the joining port 21 between the first water tank part 12 and the second water tank part 22. In addition, the cooling apparatus used in the present example includes the conveyance control part 24 that conveys the water cooling nozzle unit 11 such that the water cooling nozzle unit 11 passes through the joining port 21 and is positioned at either the cooling water injection position or the non-water cooling standby position.

[0067] The switching from the cooling by the non-water cooling method to the cooling by the water cooling method in the present example was performed by the steps illustrated in FIGS. 9(a) to 9(d). Required time for the steps is illustrated in Table 1 below. Time required for preparing for the switching of the cooling method (at the end of the non-water cooling step) in Table 1 is time required for preparing for the switching of the cooling method after normal operation (steady operation) by the non-water cooling method as the cooling method ends. That is, it is shown that the time required to change operating conditions of the heating furnace so as to reduce the line speed of the continuous annealing facility, reduce the burner output of the heating zone, and maintain a temperature when the steel strip passed through the cooling zone at 400°C or lower was 0.2 hours. Next, the water supply step was a step of supplying the cooling water W to the first water tank part 12 and the second water tank part 22, and required time was 0.5 hours. After the cooling water W was stored such that the joining port 21 was submerged by the water supply step, the opening step was executed, and time required for opening the opening and closing door 23 was 0.1 hours. Subsequently, in the nozzle unit inserting step, 0.1 hours was required until the water cooling nozzle unit 11 was conveyed to the cooling water injection position by the conveyance control part 24. Then, as operation preparation for the water cooling method (at the start of the water cooling step), it took 0.2 hours to increase the line speed of the continuous annealing facility and to bring the outputs of the combustion burners in the heating zone and the soaking zone to the annealing conditions set in advance for the steel strip to be cooled by the water cooling method. As described above, in the present example, the switching from the cooling by the non-water cooling method to the cooling by the water cooling method was performed with the required time of 1.1 hours.

[0068] On the other hand, as a comparative example, required time in a case where the switching from the cooling by the non-water cooling method to the cooling by the water cooling method was performed without using the facility of the above example is illustrated in Table 2 below. In this case, it was necessary to open the furnace in the cooling zone, and thus 2.0 hours was required to prepare for switching the cooling method (at the end of the non-water cooling step). In this case, it was necessary to open a part of the cooling zone to the air atmosphere, and thus the line of the continuous annealing facility was temporarily stopped to open the furnace. In addition, it took a relatively long time to temporarily lower the furnace temperature so that the high-temperature atmosphere in the furnace did not adversely affect facilities outside the furnace and a worker. In addition, even if the furnace temperature was lowered, it took 1.0 hours as an air replacement step to perform switching operation after performing air replacement and gas concentration measurement for a certain period of time in consideration of safety of the worker who works around the continuous annealing facility. Further, in the nozzle unit inserting step, unlike the facility of the present example, since the conveyance control part of the water cooling nozzle unit was not provided, in carrying out the water cooling nozzle unit, it was necessary for a worker to enter the furnace and perform working, and it took 2.0 hours. Thereafter, 1.0 hours was required for a gas replacement step of closing a furnace cover and replacing the atmosphere inside the furnace with a non-oxidizing atmosphere. Time required for supplying water to an immersion water tank for performing immersion cooling was the same as that in the above example and was 0.5 hours. However, in the operation preparation for the water cooling method (at start of the water cooling step), it took 5.0 hours to increase the ambient temperature inside the furnace that had decreased to a room temperature and restart the line operation. As a result, in the comparative example, it took 11.5 hours to switch from the cooling by the non-water cooling method to the cooling by the water cooling method.

[0069] Note that even if the conveyance control part of the water cooling nozzle unit is provided in the nozzle unit inserting step as in the present example, the time required for the nozzle unit inserting step is only shortened from 2.0 to 0.1 hours. For this reason, total required time is 9.6 hours, which is longer than the method in which the atmosphere in the furnace and the atmosphere outside the furnace are blocked and the switching is as in the present example. On the other hand, since the switching from the water cooling method to the non-water cooling method requires substantially the same time as described above, in the manufacturing facility that switches between the water cooling method and the non-water cooling method, the time required for switching the cooling method can be significantly shortened as compared with the conventional one. In particular, in the continuous annealing facility that operates by switching between the water cooling method and the non-water cooling method (gas jet cooling method) as the cooling zone, a production capacity of the steel strip can be improved.

Table 1

Switching step	Contents	Required time (Hr)
Switching preparation for cooling method (at end of non-water cooling step)	Reduction of line speed, change of operating conditions of heating furnace	0.2
Water supply step	Water supply to first water tank part and second water tank part	0.5
Opening step	Opening of opening and closing door	0.1
Nozzle unit inserting step	Movement of water cooling nozzle unit to water injection position	0.1
Operating preparation for water cooling method (at start of water cooling step)	Increase of line speed, change of operating conditions of heating furnace	0.2

Table 2

Switching step	Contents	Required time (Hr)
Switching preparation for cooling method (at end of non-water cooling step)	Line stop, lowering of furnace temperature	2.0
Air replacement step	Opening of furnace cover, and air replacement of furnace inside	1.0
Nozzle unit inserting step	Movement of water cooling nozzle unit to water injection position	2.0
Gas replacement step	Closing of furnace cover, and gas replacement of furnace inside	1.0
Water supply step	Water supply to immersion water tank	0.5
Operating preparation for water cooling method (at start of water cooling step)	Restart of line operation, raising of furnace temperature	5.0

Reference Signs List

[0070]

1 CONTINUOUS ANNEALING FACILITY

2 HEATING ZONE

3 SOAKING ZONE

4 COOLING ZONE

5	INDUCTION HEATING APPARATUS
10	COOLING APPARATUS
11	WATER COOLING NOZZLE UNIT
11a	FRONT SURFACE NOZZLE UNIT
11b	BACK SURFACE NOZZLE UNIT
12	IMMERSION WATER TANK, FIRST WATER TANK PART
13a, 13b	DEFLECTOR ROLL
14	PRESSING ROLL
15	DRAINING ROLL
16	DRYING FURNACE
20	WATER SUPPLY/DRAIN APPARATUS
21	JOINING PORT
22	SECOND WATER TANK PART
23	OPENING AND CLOSING DOOR
24	CONVEYANCE CONTROL PART
25	SUPPORT PART
25a	EAVES PORTION
27	NON-WATER COOLING NOZZLE UNIT
S	STEEL STRIP
W	COOLING WATER

Claims

1. An apparatus for manufacturing a steel strip, comprising:

a first water tank part that stores cooling water for immersing and cooling a steel strip;
a water cooling nozzle unit that is provided in the first water tank part and injects cooling water to a surface of the steel strip;
a second water tank part connected to the first water tank part through a joining port;
an opening and closing door that opens and closes the joining port; and
a conveyance control part that conveys the water cooling nozzle unit such that the water cooling nozzle unit passes through the joining port and is positioned at either a cooling water injection position inside the first water tank part or a non-water cooling standby position inside the second water tank part.

2. The apparatus for manufacturing a steel strip according to claim 1, wherein the water cooling nozzle unit is supported by a support part connected to the conveyance control part, and the support part includes an eaves portion that closes the joining port when the water cooling nozzle unit is located at the cooling water injection position.

3. The apparatus for manufacturing a steel strip according to claim 1 or 2, wherein the water cooling nozzle unit includes a restraint roll that restrains the steel strip by at least a pair of rolls, in addition to a water injection nozzle that injects the cooling water to the surface of the steel strip.

4. A continuous annealing facility for a steel strip, comprising the apparatus for manufacturing a steel strip according to claim 1 or 2 in a cooling zone.

5. The continuous annealing facility for a steel strip according to claim 4, wherein the cooling zone is supplied with a reducing gas or a non-oxidizing gas.

6. A method for manufacturing a steel strip using the apparatus for manufacturing a steel strip according to claim 1 or 2, the method comprising:

   a non-water cooling step of cooling the steel strip without injecting cooling water to the surface of the steel strip in the first water tank part;
   a water supply step of supplying cooling water to the first water tank part and the second water tank part after completion of the non-water cooling step;
   an opening step of opening the opening and closing door of the joining port;
   a nozzle unit inserting step of conveying the water cooling nozzle unit such that the water cooling nozzle unit passes through the joining port and moves from the non-water cooling standby position to the cooling water injection position; and
   a water cooling step of injecting cooling water to the surface of the steel strip using the water cooling nozzle unit, and immersing and cooling the steel strip in the cooling water stored in the first water tank part.

7. A method for manufacturing a steel strip using the apparatus for manufacturing a steel strip according to claim 1 or 2, the method comprising:

   a water cooling step of injecting cooling water to the surface of the steel strip using the water cooling nozzle unit, and immersing and cooling the steel strip in the cooling water inside the first water tank part;
   a nozzle unit retreating step of conveying the water cooling nozzle unit such that that the water cooling nozzle unit passes through the joining port after completion of the water cooling step and moves from the cooling water injection position to the non-water cooling standby position;
   a closing step of closing the opening and closing door of the joining port;
   a draining step of draining at least the cooling water inside the first water tank part; and
   a non-water cooling step of cooling the steel strip without injecting cooling water to the surface of the steel strip in the first water tank part.

8. A method for manufacturing a steel strip, in which a steel strip is manufactured using the continuous annealing facility for a steel strip according to claim 5.

FIG.1

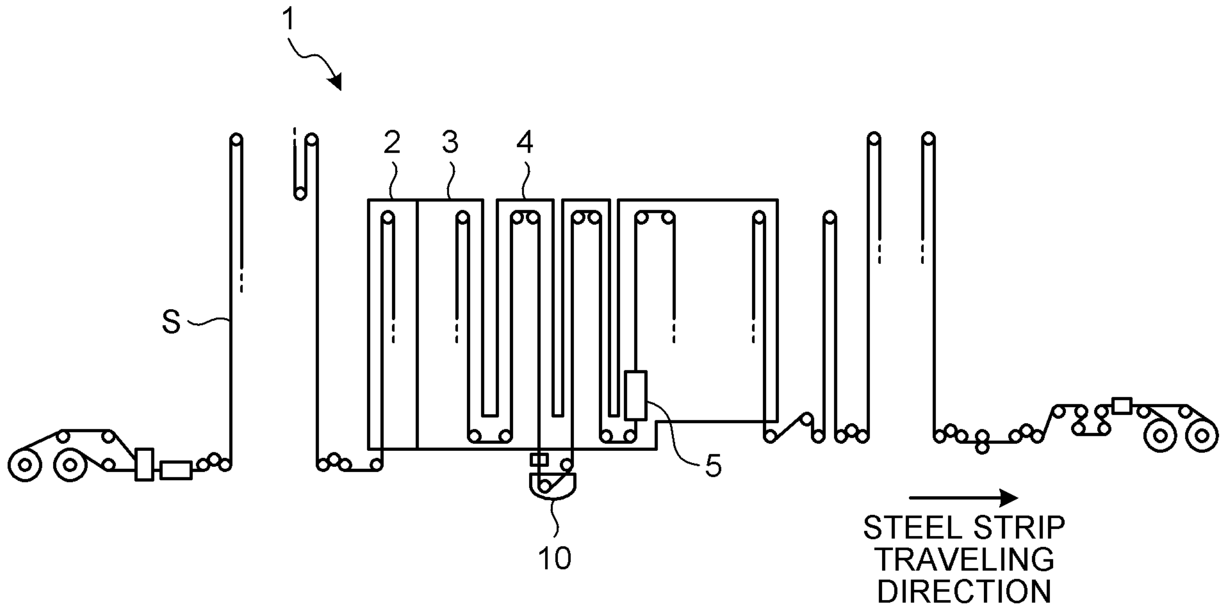

1
2
3
4
S
5
10
STEEL STRIP
TRAVELING
DIRECTION

FIG.2

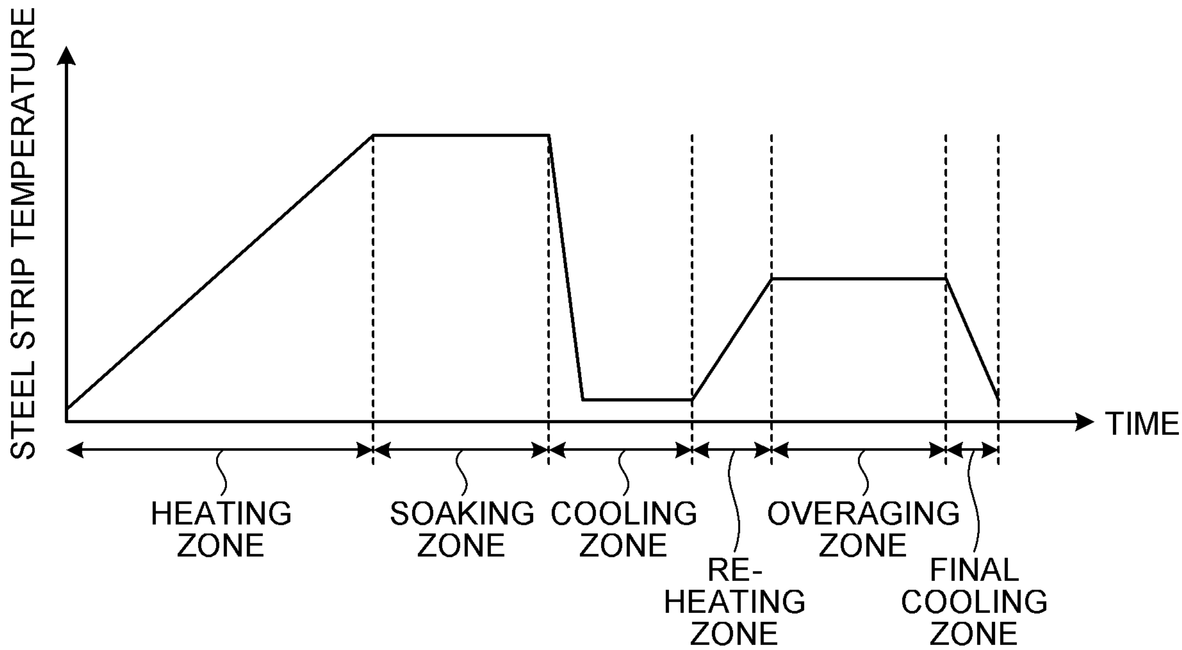

STEEL STRIP TEMPERATURE
TIME
HEATING
ZONE
SOAKING
ZONE
COOLING
ZONE
RE-
HEATING
ZONE
OVERAGING
ZONE
FINAL
COOLING
ZONE

FIG.3

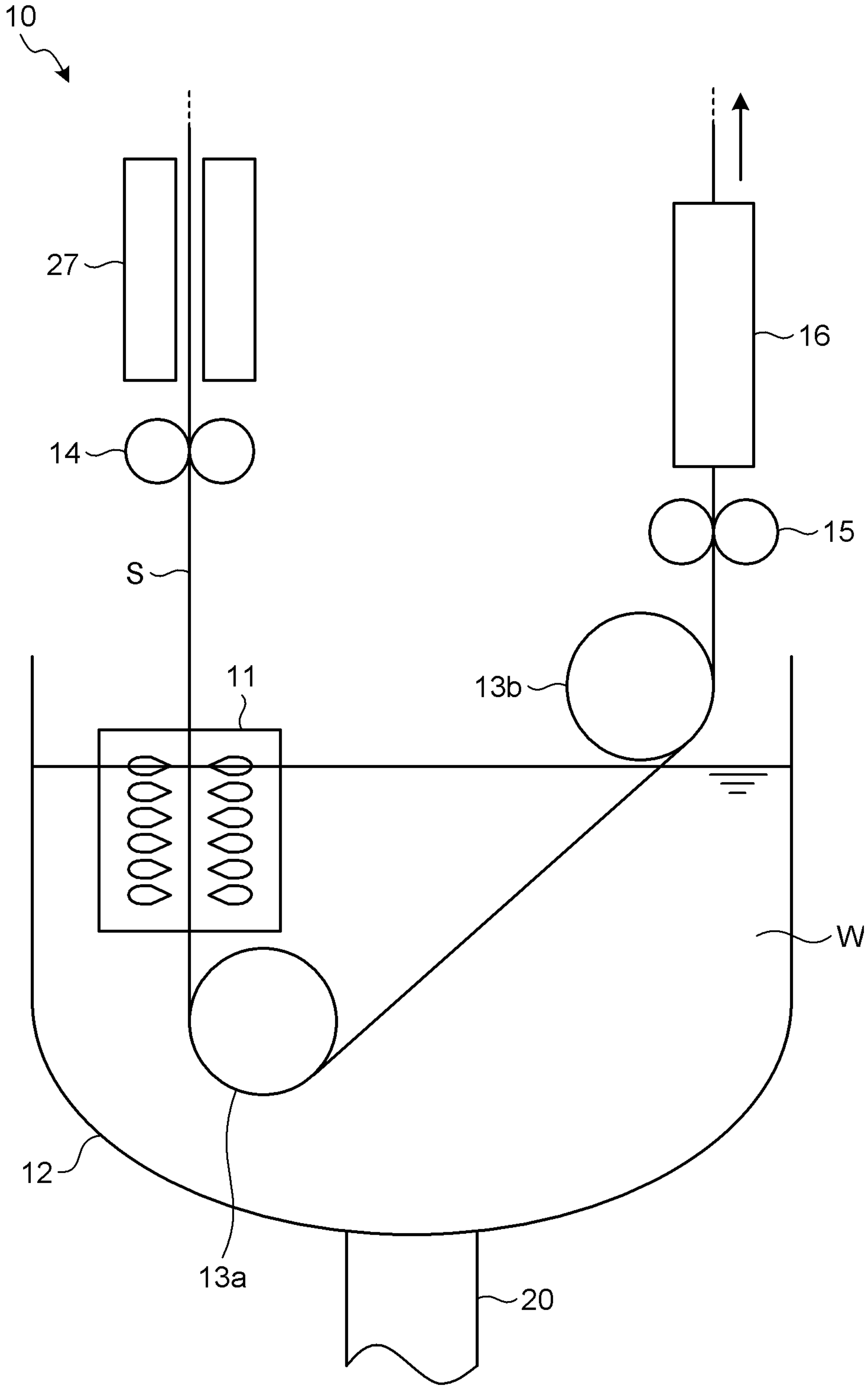
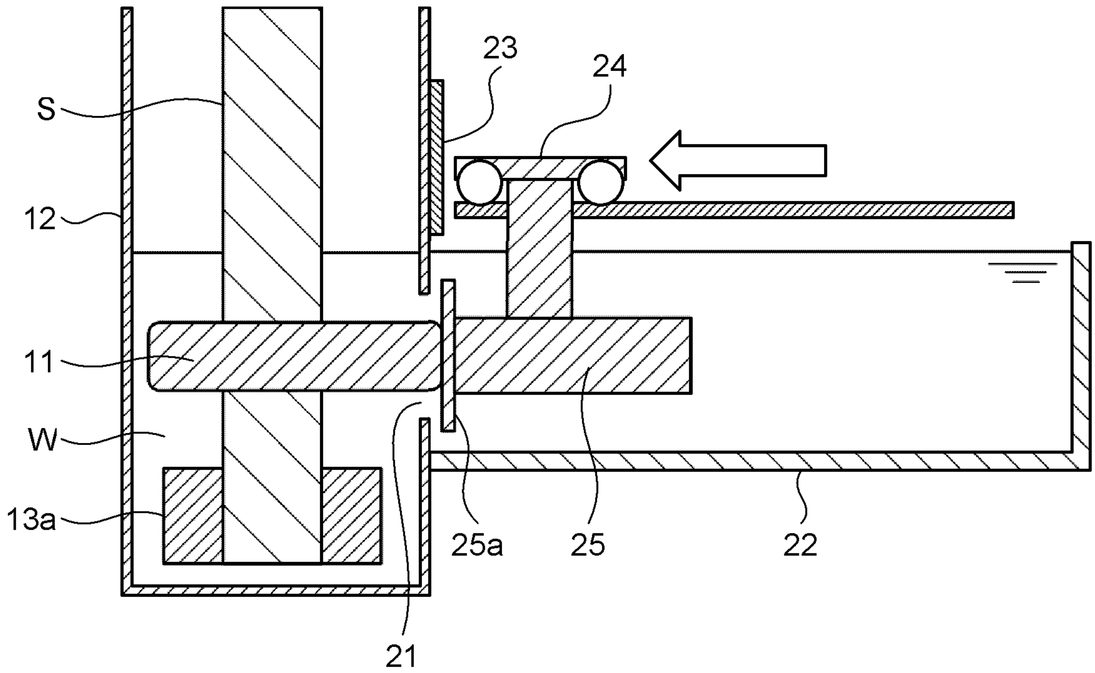


FIG.4

(a)


23
24
S
12
11
W
13a
25a
25
22
21

(b)

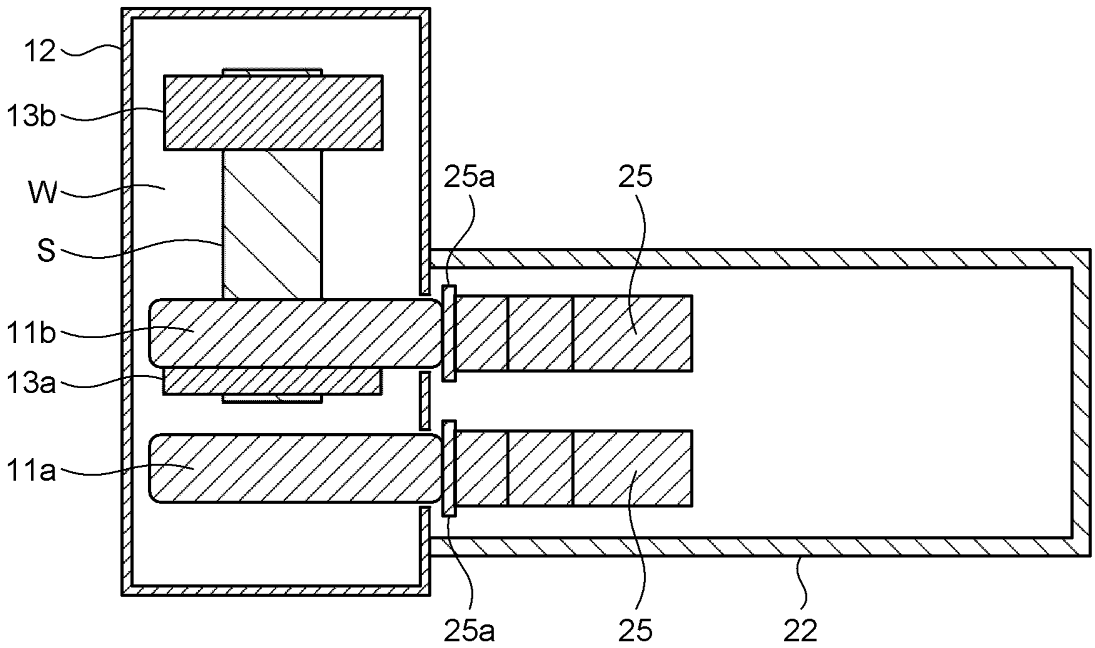

12
13b
W
S
11b
13a
11a
25a
25
25a
25
22

FIG.5

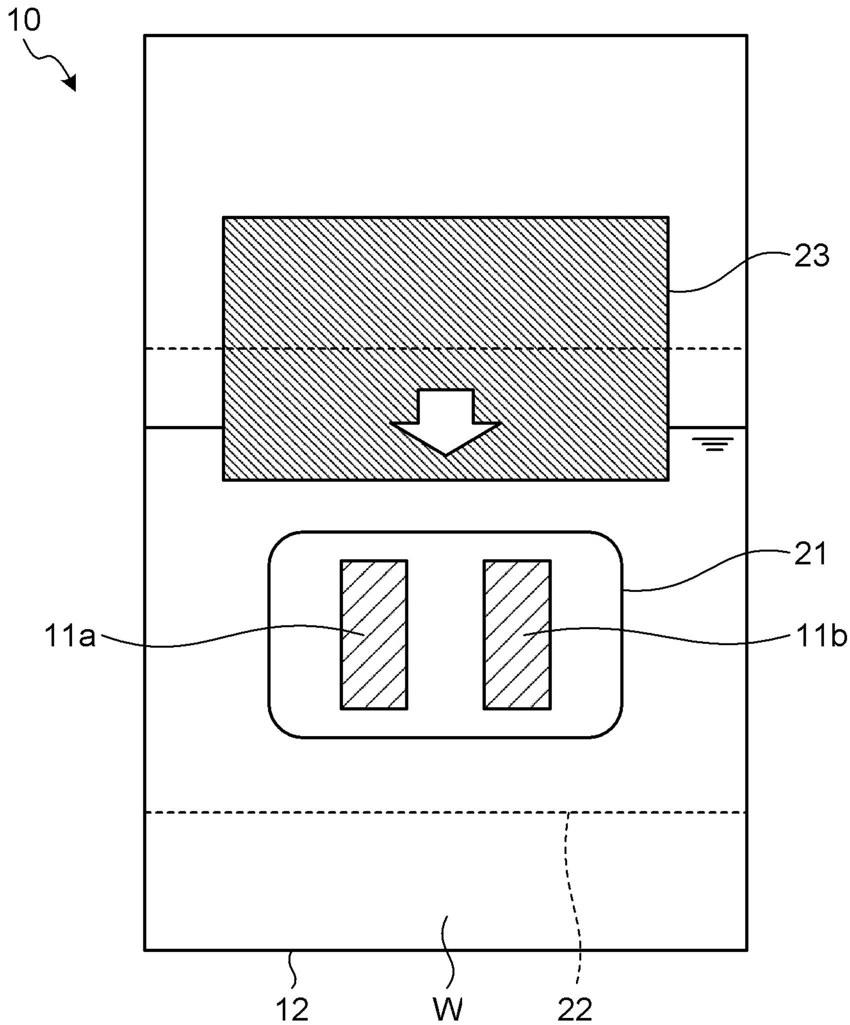


FIG.6

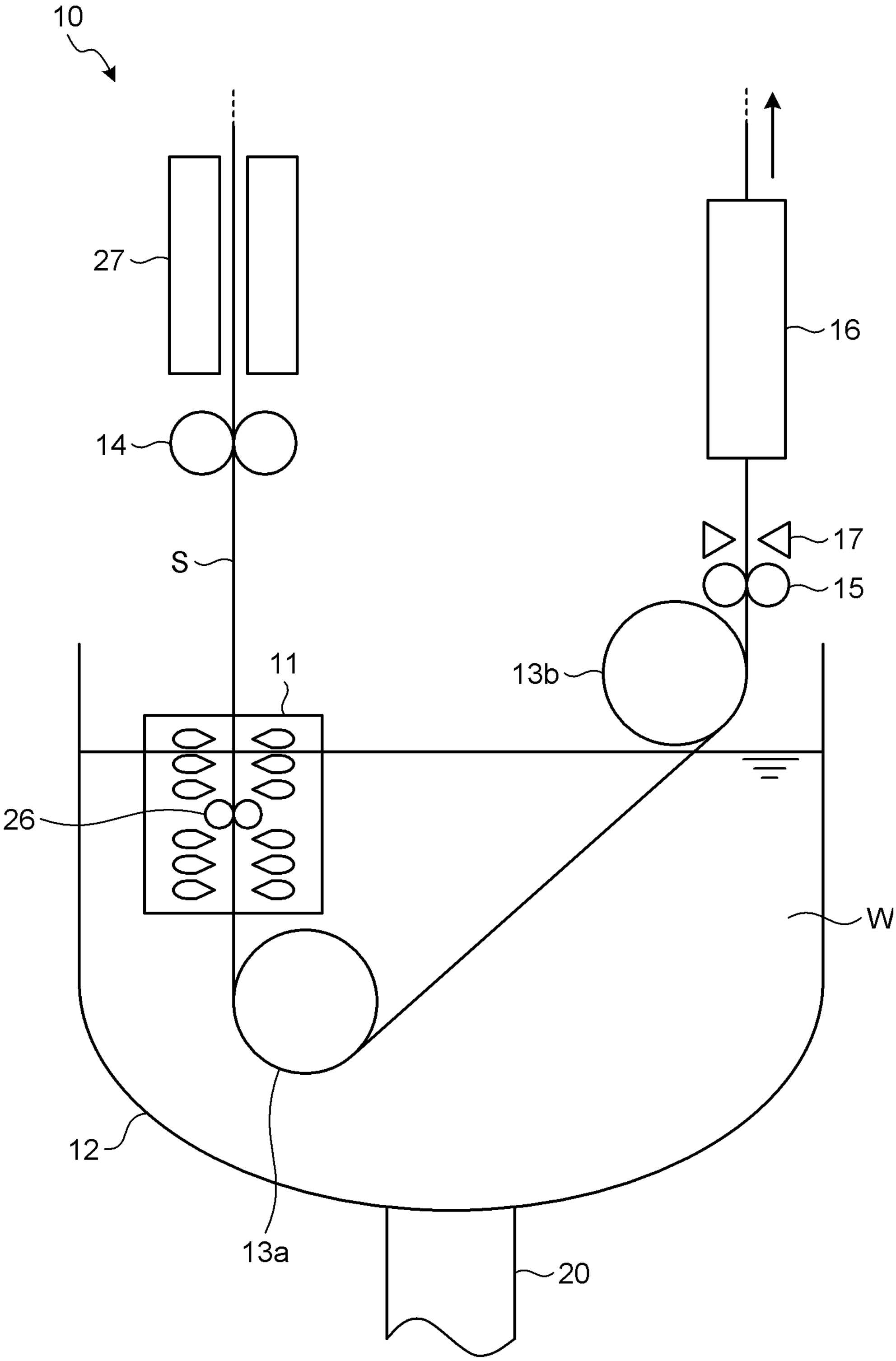


FIG.7

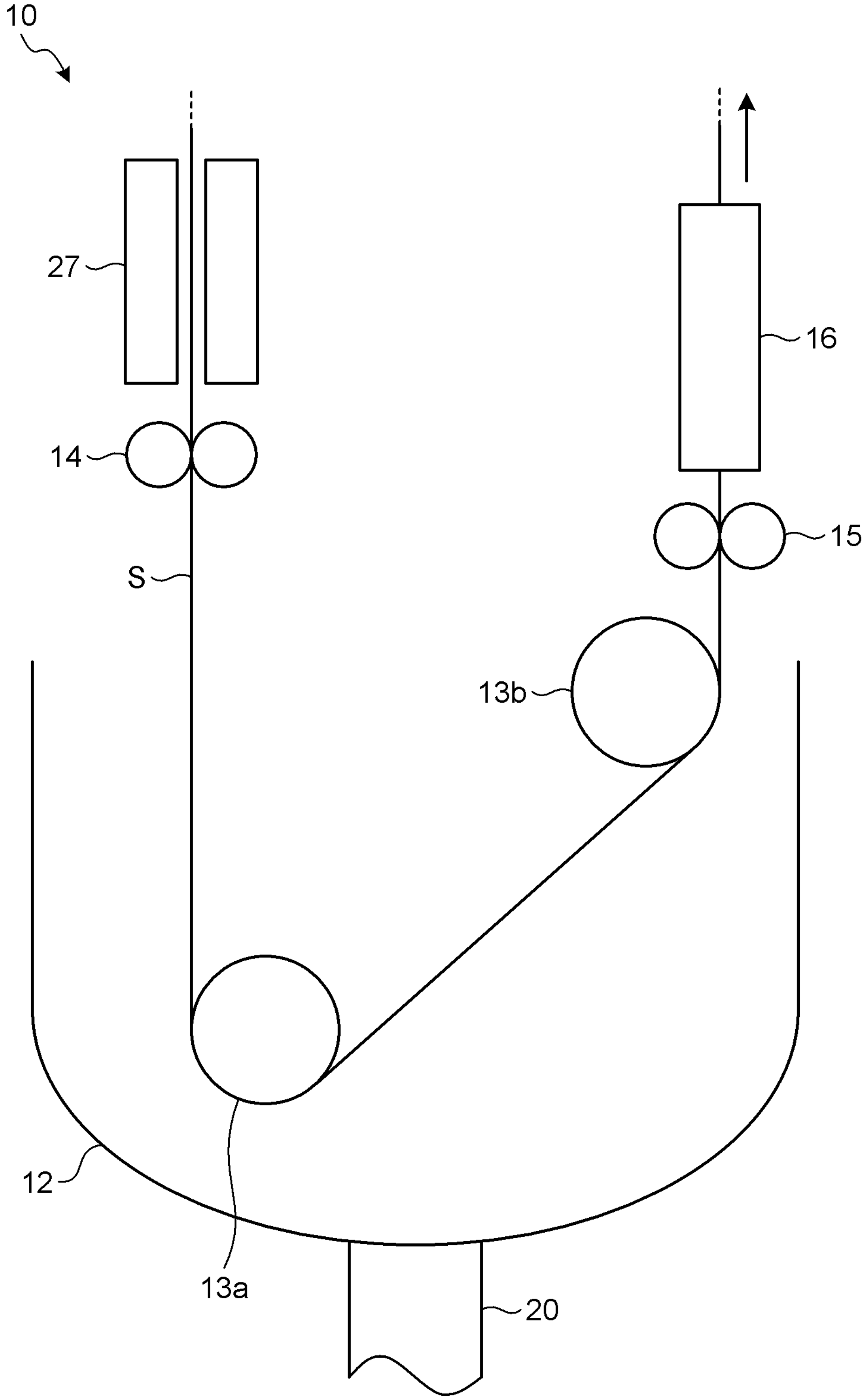


FIG.8

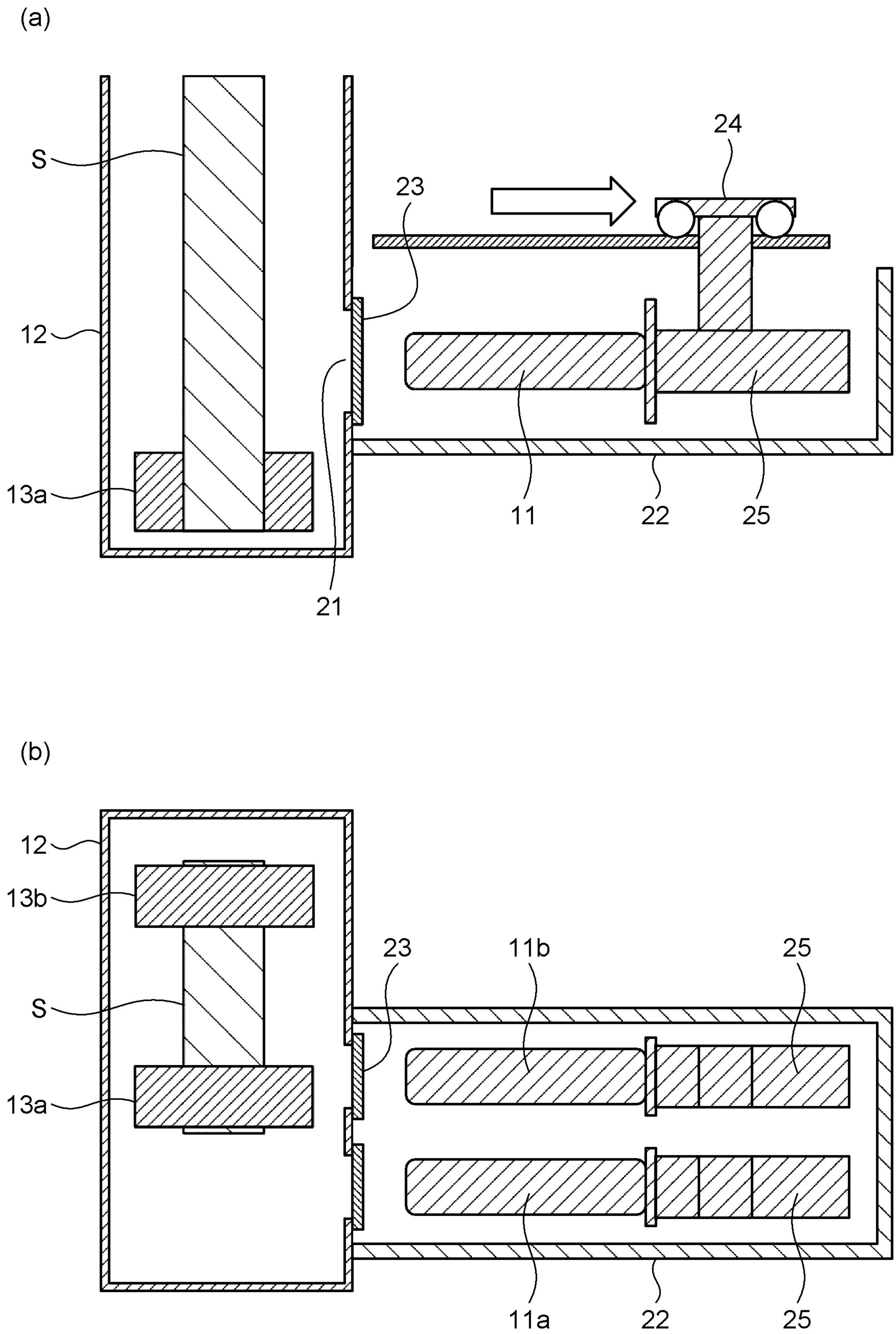
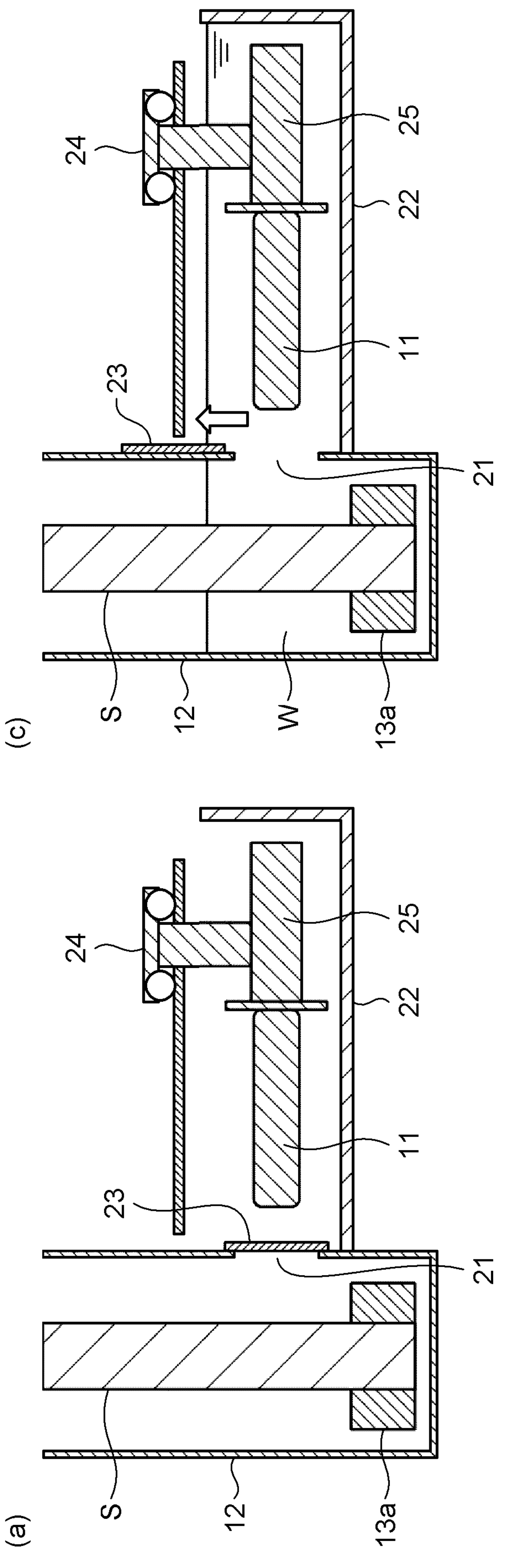


FIG.9


(a)
S
12
13a
21
23
11
22
25
24
(b)
S
12
W
13a
21
23
11
22
25
24
(c)
S
12
W
13a
21
23
11
22
25
24
(d)
S
12
11
W
13a
21
23
24
25
22

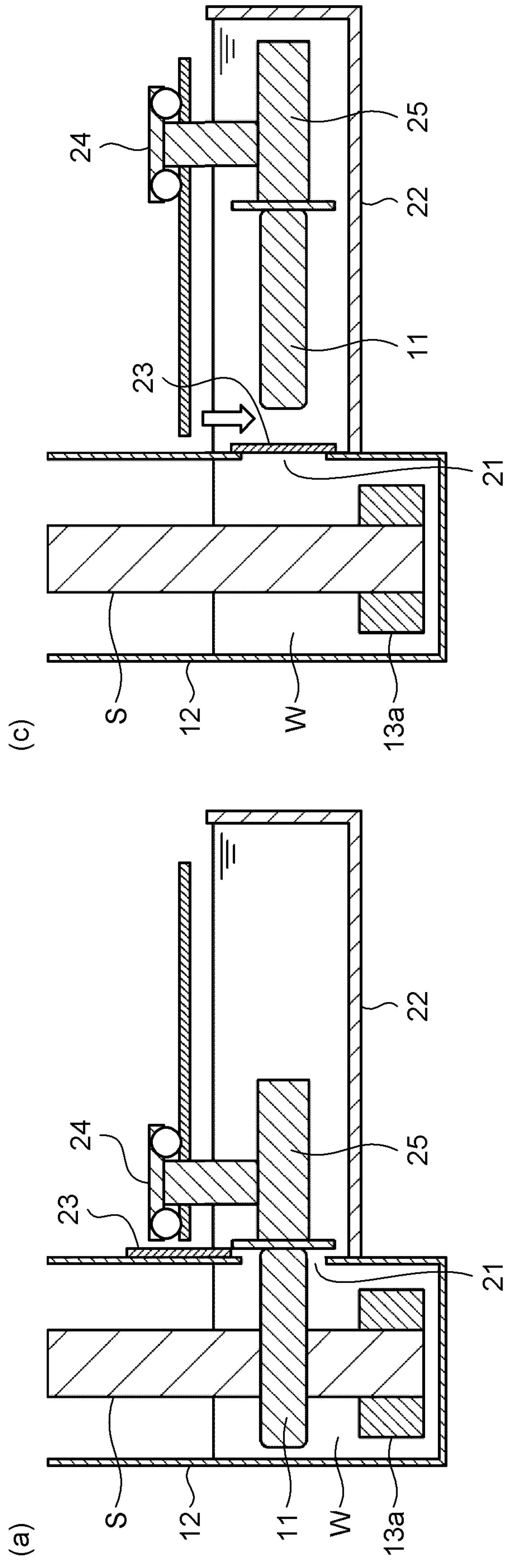


FIG.10

INTERNATIONAL SEARCH REPORT

International application No. **PCT/JP2022/029133**

A. CLASSIFICATION OF SUBJECT MATTER

C21D 9/573(2006.01)i; ***C21D 1/00***(2006.01)i
FI: C21D9/573 101Z; C21D1/00 121; C21D1/00 123A

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)

C21D9/52-9/66; C21D1/00; C21D1/63; F27B9/00-9/40

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

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.
X	JP 59-35634 A (NIPPON KOKAN KK) 27 February 1984 (1984-02-27) claims, p. 3, upper left column, line 5 to lower right column, line 20, p. 5, upper left column, line 14 to lower left column, line 10, fig. 2-3	1, 4-8
Y		3
A		2
Y	JP 2018-135552 A (JFE STEEL CORP) 30 August 2018 (2018-08-30) paragraphs [0021]-[0027], fig. 1	3
A		1-2, 4-8
A	JP 2014-70272 A (JFE STEEL CORP) 21 April 2014 (2014-04-21)	1-8
A	JP 61-183415 A (NIPPON KOKAN KK) 16 August 1986 (1986-08-16)	1-8
A	JP 58-120748 A (NIPPON STEEL CORP) 18 July 1983 (1983-07-18)	1-8

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 August 2022	**13 September 2022**

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office (ISA/JP) **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/029133

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 59-35634 A	27 February 1984	(Family: none)	
JP 2018-135552 A	30 August 2018	(Family: none)	
JP 2014-70272 A	21 April 2014	(Family: none)	
JP 61-183415 A	16 August 1986	(Family: none)	
JP 58-120748 A	18 July 1983	EP 0086331 A1	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 5891857 B **[0004]**