

(19)



(11)

EP 4 488 608 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
08.01.2025 Bulletin 2025/02

(21) Application number: **23183522.4**

(22) Date of filing: **05.07.2023**

(51) International Patent Classification (IPC):
F27D 17/00 (2006.01) **F27B 9/06** (2006.01)
F27B 9/28 (2006.01) **C21D 1/74** (2006.01)
C21D 1/46 (2006.01) **C23C 2/00** (2006.01)
C23C 2/02 (2006.01) **C23C 2/40** (2006.01)

(52) Cooperative Patent Classification (CPC):
C23C 2/003; C21D 1/74; C21D 9/56; C21D 9/561;
C21D 9/60; C23C 2/0038; C23C 2/0222;
C23C 2/0224; C23C 2/40; C23C 2/50; F27B 9/067;
F27B 9/28; F27D 17/004

(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 ME MK MT NL
NO PL PT RO RS SE SI SK SM TR
 Designated Extension States:
BA
 Designated Validation States:
KH MA MD TN

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(54) **PREHEATING FURNACE FOR CONTINUOUS HOT DIP COATING INSTALLATION**

(57) A continuous hot dip coating installation, upstream of a molten metal bath, in which the furnace (1) comprises a fumes pipe (6) fluidly connecting the second section (4) to the first section (3) so that to deflect fumes (9) from the direct fired furnace toward the preheating section and generate a post-combustion of the fumes (9) during pre-heating of the metal strip in the first section (3), characterized in that the intermediate section (5) is provided with an electric induction heating system (11) capable to cooperate with said preheating for boosting the productivity of the line, while essentially keeping unchanged by its presence the pass line of the metal strip.

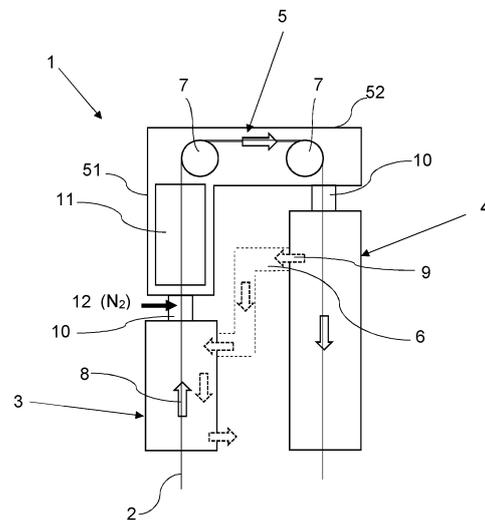


FIG. 2A

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Description

Field of the invention

[0001] The present invention relates to a heating process used in continuous hot dip coating lines, such as galvanizing lines, of cold rolled steel strips. The invention also concerns the industrial installation for carrying out the heating process.

Background and Prior Art

[0002] The coating process consisting in dipping a metal strip in a bath of molten metal is well-known and used all over the world, especially in the case of galvanization. Before coating, the steel strips have to be heated in a furnace, on the one hand, to reach at least the temperature of the liquid metal and on the other hand, to induce the recrystallization of the cold rolled sheets as well as to reduce the surface oxide that inhibits a good wetting in the bath and an improved adhesion of the coating on the strip.

[0003] In galvanizing, it is known that the production cost per unit of material produced is directly related to the line productivity. Indeed, the fixed costs of the installation are then divided by the amount of material produced. The more material is produced in a period of time, the lower the cost. It is also known that the adjustment of the coating thickness by the air knives is very difficult below a certain line speed that is estimated in the range of 35mpm for a zinc coating of 20 μ m and of 55 to 60mpm for a zinc coating of 40 μ m. This is actually related to the physics of wiping and the oxidation of the liquid metal. Those minimal speeds also depend on the type of coating. For example, in case of aluminized coating, the minimal speed is around 50mpm for a 20 μ m coating thickness. Therefore, the general trend of the industry is to increase the line productivity, which is even more important for a thick strip (for example over 2mm) where the benefits on costs are supplemented by those of quality.

[0004] Various furnace technologies exist to heat strips before coating. Among them, the so-called direct fired furnace (DFF) is a well-known technology, especially in galvanizing. It has the advantage to combine heating with cleaning of the strip. In addition, heat transfer that is mostly performed by radiation of the flame of the furnace to the strip, is very high due to the high temperature of the flame and refractories. The temperatures are typically of 1150 to 1350°C. The advantage of such a furnace is to provide a limited length for a defined productivity.

[0005] This technology has however some strict requirements because the flames are in direct contact with the strip and so may oxidize it, as the burners are directly located inside the furnace. Therefore, such a furnace is usually divided in two sections, as illustrated in Figure 1, where a standard design used by many manufacturers is represented. The first section is the pre-heating zone 3,

also named "post-combustion chamber", that is located on the entry side of the furnace. The second section is strictly speaking the direct fired furnace 4, in which the strip 2 is heated before coating.

[0006] In the first section 3, the metal strip 2 running continuously is pre-heated to approximately 200-300°C, with the aid of the exhaust gases 9 from the direct fired furnace in the second section 4. This first section 3 receives some additional air to burn the residual CO and H₂ in order to ensure a complete combustion of the exhaust gases 9 and finally have fumes with about 2 to 5% O₂ at the stack. The gas radiates to the strip 2 and heats it, but the strip 2 should not reach a temperature higher than 300-350°C, and preferably higher than 300°C, due to excess oxygen, in order to avoid its oxidation.

[0007] The second section 4 uses an under-stoichiometric combustion to reach a wall temperature up to 1250-1350°C for heating the strip 2 before coating. Again, to avoid strip oxidation, the oxygen content of the gas in contact with the steel strip 2 must be low, and typically below 0.1 %, as soon as the temperature of strip 2 is over 250°C. Therefore, in the second section 4, the combustion being done with under-stoichiometry conditions, CO and H₂ in the fumes remain in a range typically between 2 and 6%. Standard target strip temperatures are typically between 620 and 730°C at the outlet of the DFF operating in under-stoichiometric conditions. Above 730°C, it is known that the strip 2 starts to oxidize dew, most probably up to the high dew point of the gas. For environmental constraints as well as energy savings, the fumes exiting the DFF 4 receive additional oxygen to complete the combustion. This is realised in a separate chamber, namely in the first section 3 as explained above.

[0008] A direct fired furnace can be horizontal or vertical. Usually vertical implementation is preferred especially for high production rates. It has the advantage to avoid support rolls that need to be water cooled, which in turn induces a significant reduction in thermal efficiency but also induces a risk of scratches on the strip. It is also known that the height of such a furnace from the inlet (or entrance of the strip) to the rolls at the top is between 10 and 30 meters.

[0009] When such a furnace has a vertical implementation, the two vertical sections 3, 4 are height linked by a horizontal section 5 as illustrated in Figure 1. The first section 3 corresponds to the upleg, that is the section where the strip 2 is running up, and the second section 4 corresponds to the downleg, that is the section where the strip 2 is running down. The direction change of the strip 2 from running up to running down is done thanks to deflecting rolls 7 (typically two, as illustrated in Figure 1, due to layout constraints) installed in the horizontal section. Due to the high temperature of the gas exiting the DFF section 4, the horizontal section 5 is a section separated from the first and the second vertical sections 3, 4, that is cooled and operating in non-oxidizing atmosphere. Nar-

row openings are then provided to let the strip 2 go through. Furthermore, a special by-pass piping 6 is installed between the first and the second vertical sections 3, 4, so that the fumes 9 go from the direct fired furnace 4 to the post-combustion chamber 3. The fumes 9 are then exiting the first section 3 through a duct provided for waste gases at a temperature comprised between 800 and 1000°C (not shown).

[0010] The three different sections above are connected with narrow sections or airlocks 10 to avoid that the horizontal section 5 reaches a too high temperature.

[0011] There is a genuine need to improve the productivity of the lines with such standard or existing furnaces. However such an improvement faces the constraint of minimizing the modification of the line and especially the layout and position of the rolls.

[0012] For example, document FR 2 369 349 A discloses the classical technique for a vertical strip heating furnace including vertical direct fired heating chambers, as described above.

[0013] Document US 11,193,182 B2 discloses a method for heat-treating a metal strip, where the metal strip is continuously pre-heated in a pre-heating zone with the aid of hot inert gas and subsequently undergoes further heat treatment in a direct fired furnace in a reducing and/or oxidizing atmosphere. This document proposes a solution consisting in the use of an induction heating provided before entry in the DFF. The induction heating is provided in a supplementary vertical section located between the pre-heating zone and the DFF section. This installation requires substantial modifications with respect to existing lines, as hot waste gases produced in the DFF section exchange heat in a heat recovery system comprising two successive heat exchangers and a boiler. The second heat exchanger heats the inert gas used for pre-heating the pre-heating zone of the furnace. At no time there is direct contact of the strip in the pre-heating section with hot waste gases.

Aims of the Invention

[0014] The present invention aims to provide a solution intended to overcome the drawbacks of prior art.

[0015] In particular, the invention aims to improve the productivity of a line containing a furnace, while keeping mostly unchanged the design of an existing system for hot-dip coating including an annealing furnace, particularly the pass line of the strip therein. A further goal of the present invention is to increase the line productivity and consequently to decrease its cost, especially in the case of producing strips having a thickness greater than 2mm, for example 6mm.

[0016] Moreover, the invention aims at providing very reactive heating in an existing standard furnace while requiring minimal modifications of an existing line, essentially without increasing the total furnace height.

[0017] The present invention relates also in particular to an improvement of the heating capacity while keeping

the existing furnace length as well as the constraints related with gas composition necessary to avoid strip oxidation.

5 Summary of the Invention

[0018] A first aspect of the present invention relates to an industrial installation for continuous hot dip coating, such as a galvanizing installation, comprising, upstream of a molten metal bath, a furnace having :

- a first section for the pre-heating of a running metal strip ;
- a second section comprising a direct fired furnace ;
- 15 - an intermediary section or pass chamber located between the first section and the second section, comprising two deflecting rolls for changing the direction of the running metal strip and defining with the first section and the second section a pass line of the metal strip ;

the first section and the second section being vertical and the intermediate section being horizontal, or partly vertical and partly horizontal, respectively defining a horizontal path and a vertical/horizontal path for the metal strip, the three said sections being separated by sealing means providing a narrow path to the strip ;

25 the furnace further comprising a fumes pipe fluidly connecting the second section to the first section so that to deflect fumes from the direct fired furnace toward the preheating section and generate a post-combustion of the fumes during pre-heating of the metal strip in the first section ;

30 characterized in that the intermediate section is provided with an electric induction heating system capable to cooperate with said preheating for boosting the productivity of the line, while essentially keeping unchanged by its presence the pass line of the metal strip.

[0019] According to preferred embodiments, the installation is further limited by at least one of the following characteristics or a suitable combination thereof:

- the intermediate section has the form of a L- box comprising two legs, a vertical leg in the prolongation of the first section and an horizontal leg comprising deflecting rolls for changing the direction of the strip, the vertical leg comprising the electric induction heating system ;
- the intermediate section has the form of a horizontal box comprising deflecting rolls for changing the direction of the strip, the electric induction heating system being integrated between the two deflecting rolls ;
- 50 - the electric induction heating system has a minimal power of 1 MW ;

- the electric induction heating system is a longitudinal flux induction heating system ;
- the power of the electric induction heating system is chosen to define a temperature raise of the strip ;
- the installation comprises means for injecting air into the deflected fumes so that to help attaining complete combustion of the fumes in the first section, with a content of oxygen in the fumes being comprised between 2 and 5% in volume ;
- the installation contains means for operating the direct fired furnace of the second section in understoichiometric conditions ;
- the installation contains means for operating the first section in oxidizing conditions and the intermediate section in non-oxidizing condition ;
- the installation further comprises a narrow path device to inject an inert gas such as nitrogen, or fumes extracted from the second section and cooled, in the top of or above the first section so that to counter-balance the buoyancy effect of the fumes.

[0020] Another aspect of the present invention relates to a method for improving the line productivity in a continuous hot dip coating installation, comprising an installation with a furnace according with the features described above, wherein the method presents at least the following successive steps:

- pre-heating a running strip until a maximum temperature of 350°C, preferably comprised between 250 and 300°C, in an oxidizing gas atmosphere having an oxygen content > 1%, and preferably comprised between 2 and 5% in volume, the rest being essentially nitrogen, carbon dioxide and water, in the first section of the furnace, in order to obtain a pre-heated metal strip ;
- further heating the pre-heated metal strip in the intermediate section until a maximum temperature of 700°C, preferably comprised between 400°C and 600°C, with the electric induction heating system installed in a vertical part or a horizontal part of the intermediate section, said intermediate section being maintained in an non-oxidizing or slightly oxidizing atmosphere, preferably with an oxygen content less than 1% in volume, and still preferably below a few ppm ;
- changing the direction of the metal strip toward and out of a horizontal part of the intermediate section thanks to the two deflecting rolls ;
- further heating the metal strip in the second section comprising the direct fired furnace until a temperature of 780°C but preferably comprised between 650°C and 750°C, in understoichiometric conditions and with a CO+H₂ content of the combustion gases preferably lower than 6% in volume ;

wherein the pre-heating of the running strip in the first section is obtained thanks to the post-combustion of the

fumes deflected from the second section toward the first section through the fumes pipe fluidly connecting the second section to the first section, said deflected fumes containing residual H₂ and CO > 1% in volume.

[0021] According to preferred embodiments, the method is further limited by at least one of the following characteristics or a suitable combination thereof:

- additional air is injected to the fumes deflected toward the first section so that to help attaining complete combustion of the deflected fumes in the first section, while controlling a content of oxygen in the fumes comprised between 2 and 5% in volume ;
- the intermediate section is maintained in a non-oxidizing atmosphere ;
- an inert gas such as nitrogen is injected in the top of or above the first section so that to counter-balance the buoyancy effect of the fumes ;
- the fumes are exiting the first section through a duct provided for waste gases at a temperature comprised between 800 and 1000°C ;
- the running strip is a hot-rolled steel strip of thickness higher than 2mm, and preferably higher than 6mm, or a cold-rolled steel strip of thickness comprised between 2 and 3mm.

Brief Description of the Drawings

[0022]

Figure 1 represents a standard furnace of the prior art.

Figures 2A and 2B represent examples of embodiments for a furnace according to the present invention.

Detailed Description of the invention

[0023] The present invention relates to a continuous hot dip coating installation 1 such as a galvanizing installation, as illustrated in Figures 2A and 2B, comprising an electric heating system 11, such as an induction heating, which is located in a specific manner, either vertical or horizontal. Indeed, the choice of the location of this electric system 11 depends on several parameters. As explained above, the invention aims at taking advantage of e.g. using induction heating in an existing standard furnace with minimal modifications of the existing line and without increasing the total furnace height.

[0024] The galvanizing installation successively comprises a first section 3 and a second section 4, linked by an intermediary section 5 which is perpendicular to the first and the second sections 3, 4. These three sections 3, 4, 5 are separated by sealing means 10, allowing to keep separate different atmospheres and temperatures in each section. Preferably, the first and the second sections 3, 4 are vertical and the intermediary section 5 is horizontal.

[0025] The first section 3, which is located at the entry of the furnace, is a pre-heating zone used for pre-heating the running metal strip 2. The strip 2 is pre-heated until maximum 350°C, preferably between 250 and 300°C, using hot fumes extracted from section 4 in order to recover as much heat as possible.

[0026] The intermediary section 5, located between the first section 3 and the second section 4, comprises at least two deflector rolls 7 to change the direction of the running strip 2. The deflector rolls 7 define a pass line for the travelling strip and intermediary section 5 is the pass chamber.

[0027] According to a first embodiment of the present invention, represented in Figure 2A, the intermediary section 5 is a L-shaped box comprising two legs, a first leg 51 in the prolongation of the first section 3 and a second leg 52, which is perpendicular to the first leg 51. Preferably, the first leg 51 is vertical and the second leg 52 is horizontal.

[0028] The first leg 51 comprises the electric heating system 11. The electric heating system has preferably a power of minimum 1MW. It allows to heat the pre-heated metal strip 2 until maximum 700°C, preferably between 400°C-600°C.

[0029] According to a second embodiment of the present invention, represented in Figure 2B, the intermediary section 5 is a horizontal box perpendicular to the first and the second sections 3, 4, just like in prior art. The electric heating 11 is integrated in the horizontal box between the two deflector rolls 7.

[0030] The second section 4 comprises a direct fired furnace to heat the steel strip 2 before performing the coating. Preferably, this second section 4 is vertical. The strip 2 is heated until 780°C but preferably between 620°C and 730°C. The heating is realized with under-stoichiometric conditions in order to avoid oxidizing of the steel strip 2.

[0031] In a preferred embodiment, the installation 1 comprises a fumes pipe 6 between the direct fired furnace of the second section 4 and the top of the first section 3. In this way, the first section 3 is heated with the aid of the exhaust gases 9 which are extracted/deflected from the direct fired furnace to obtain a post combustion of the fumes to pre-heat the metal strip 2. The first section 3 can advantageously receive some additional air (not shown) to burn residual CO and H₂ in the furnace so that to ensure a complete combustion of the exhaust gases 9. Finally, at the stack of first section 3, the fumes contain about 2 to 5% O₂. The gas radiates to the strip 2 to heat it, but the strip 2 cannot reach a temperature higher than 300-350°C (preferably below 300°C) due to the excess oxygen, in order to avoid its oxidation.

[0032] Still in a preferred embodiment, the installation 1 comprises a narrow path 12 to inject some N₂ (or similar oxygen-free gas like for example fumes from the furnace that will be cooled in the top of the first section 3) at the location of the sealing means 10, in order to counter-

balance the buoyancy effect of the fumes 9. In still another embodiment (not shown), N₂ can also be injected from the intermediate section 5 to the second section 4 at the location of the sealing means 10, in order to prevent contamination of the non-oxidizing intermediate section 5 by the fumes generated by combustion in the direct fired furnace.

Decision parameters for induction heating location

[0033] The inventors have found that induction heating using the longitudinal flux technology is suitable especially when the total length of the furnace is defined. The space required for an induction section is small versus a total available heating power that can reach more than 4MW. However, if such an induction section was installed at the entry of the furnace, for example before the first section 3 and then before the post-combustion, the benefit would be limited because the strip 2 is expected to exit first section 3 at maximum 300°C-350°C, a temperature where the risk of strip oxidation is very high due to O₂ content.

[0034] On the contrary, if the induction section is installed at the exit of the furnace, for example after the direct fired furnace of the second section 4, the efficiency becomes very low due to the Curie point. There is an alternative solution that consists in using a transversal induction furnace but such a technology is much more expensive and more delicate to carry out than the classical longitudinal flux due to the sensitivity of the product width.

[0035] The inventors have thus found that the best location for installing the induction heating is between the post-combustion chamber 3 and the direct fired furnace 4. The challenge to meet is that the construction should be designed to resist to a very high gas temperature, more than 1100°C. Therefore, an objective would be to locate the induction heating 11 within the intermediary section 5. However, the implementation of an induction furnace in the horizontal part between the two deflecting rolls would require an excellent tension control at that location due to the catenary effect of the strip in relation with the small opening of such an induction furnace, typically 80 to 200mm and preferably 100 to 150mm.

[0036] Therefore, the present invention solves the above problems by providing a specific intermediary section 5 which receives the two deflecting rolls 7 as well as the electric system 11.

[0037] With this specific geometry, fumes 9 from the direct fired furnace 4 can be extracted/deflected toward the post-combustion section 3. In addition, to avoid the up flow of the fumes 9 of the post combustion section 3, a dedicated seal is provided, consisting in a narrow path 12 where some N₂ is injected to counter-balance the buoyancy effect. This means that the induction heating 11 can be kept reasonably "cold" because the environment temperature is kept in the range of 300-600°C.

[0038] The furnace for a hot dip coating line of the

present invention is very different of the installation disclosed in US 11,193,182 B2. According to this document, the strip is heated in a pre-heating zone by convection and circulation of an inert gas, which is itself heated through a complex heat recovery system fed by the hot fumes produced in the DFF section. This installation thus requires substantial modification of existing lines. In addition, it requires that the strip temperature at the exit of the induction section is as high as 500°C. This means that it cannot enter a direct fired furnace having an excess of oxygen, because it is well known that in hot dip galvanizing (and contrary for example to stainless steel treatment) the strip cannot be in contact with oxygen when its temperature is higher than about 300°C, and so the direct fired furnace must be run with a lambda coefficient below 1 (which is not the teaching of this document). So the furnace of US 11,193,182 B2 is not adapted to be run in galvanization lines.

[0039] The embodiments according to the present invention totally avoid this potential problem as well as an expensive implementation and maintenance of heat exchangers and blowers. The present invention ensures energy savings and further line productivity increase especially for thick strips, combined with the high reactivity of the induction heating system, while keeping the strip in contact with oxidizing fumes below 300°C in the preheating section as it should be the case.

List of reference symbols

[0040]

1	Heating installation	
2	Steel strip	
3	Pre-heating section (or post-combustion chamber)	35
4	DFF section	
5	Intermediary section (horizontal or L-shaped box)	
51	Vertical leg of the L-shaped intermediary section	
52	Horizontal leg of the L-shaped intermediary section	40
6	Fumes pipe	
7	Deflecting roll(s)	
8	Strip direction	
9	Fumes direction	45
10	Sealing means	
11	Electric heating system	
12	N ₂ path	

Claims

1. A continuous hot dip coating installation comprising, upstream of a molten metal bath, a furnace (1) having :
 - a first section (3) for the pre-heating of a running metal strip (2) ;
 - a second section (4) comprising a direct fired

furnace ;

- an intermediary section or pass chamber (5) located between the first section (3) and the second section (4), comprising two deflecting rolls (7) for changing the direction of the running metal strip (2) and defining with the first section (3) and the second section (4) a pass line of the metal strip ;

the first section (3) and the second section (4) being vertical and the intermediate section (5) being horizontal, or partly vertical and partly horizontal, respectively defining a horizontal path and a vertical/horizontal path for the metal strip, the three said sections (3, 4, 5) being separated by sealing means (10) providing a narrow path to the strip ;

the furnace (1) further comprising a fumes pipe (6) fluidly connecting the second section (4) to the first section (3) so that to deflect fumes (9) from the direct fired furnace toward the preheating section and generate a post-combustion of the fumes (9) during pre-heating of the metal strip in the first section (3) ; **characterized in that** the intermediate section (5) is provided with an electric induction heating system (11) capable to cooperate with said preheating for boosting the productivity of the line, while essentially keeping unchanged by its presence the pass line of the metal strip.

2. The installation according to claim 1, wherein the intermediate section (5) has the form of a L- box comprising two legs, a vertical leg (51) in the prolongation of the first section (3) and an horizontal leg (52) comprising deflecting rolls (7) for changing the direction of the strip (2), the vertical leg (51) comprising the electric induction heating system (11).
3. The installation according to claim 1, wherein the intermediate section (5) has the form of a horizontal box comprising deflecting rolls (7) for changing the direction of the strip (2), the electric induction heating system (11) being embedded between the two deflecting rolls (7).
4. The installation according claim 1, wherein the electric induction heating system (11) has a minimal power of 1MW.
5. The installation according to claim 4, wherein the electric induction heating system (11) is a longitudinal flux induction heating system.
6. The installation according to claim 4, wherein the power of the electric induction heating system (11) is chosen to define a temperature raise of the strip.
7. The installation according to anyone of the preceding

- claims, wherein it comprises means for injecting air into the deflected fumes so that to help attaining complete combustion of the fumes in the first section (3), with a content of oxygen in the fumes being comprised between 2 and 5% in volume.
8. The installation according to anyone of the preceding claims, wherein it contains means for operating the direct fired furnace of the second section (4) in understoichiometric conditions.
9. The installation according to anyone of the preceding claims, wherein it contains means for operating the first section (3) in oxidizing conditions and the intermediate section (5) in non-oxidizing conditions.
10. The installation according to anyone of the preceding claims, wherein it further comprises a narrow path device (12) to inject an inert gas such as nitrogen, or fumes extracted from the second section (4) and cooled, in the top of or above the first section (3) so that to counter-balance the buoyancy effect of the fumes (9).
11. A method for improving the line productivity in a continuous hot dip coating installation, comprising an installation with a furnace (1) according to anyone of the preceding claims, wherein the method presents at least the following successive steps:
- pre-heating a running strip (2) until a maximum temperature of 350°C, preferably comprised between 250 and 300°C, in an oxidizing gas atmosphere having an oxygen content > 1%, and preferably comprised between 2 and 5% in volume, the rest being essentially nitrogen, carbon dioxide and water, in the first section (3) of the furnace (1), in order to obtain a pre-heated metal strip (2) ;
 - further heating the pre-heated metal strip (2) in the intermediate section (5) until a maximum temperature of 700°C, preferably comprised between 400°C and 600°C, with the electric induction heating system (11) installed in a vertical or a horizontal part of the intermediate section (5), said intermediate section (5) being maintained in a non-oxidizing or slightly oxidizing atmosphere, preferably with an oxygen content less than 1% in volume, and still preferably below a few ppm ;
 - changing the direction of the metal strip (2) toward and out of a horizontal part of the intermediate section (5) thanks to the two deflecting rolls (7) ;
 - further heating the metal strip (2) in the second section (4) comprising the direct fired furnace until a temperature of 780°C but preferably comprised between 650°C and 750°C, in understoe-
- chiometric conditions and with a CO+H₂ content of the combustion gases preferably lower than 6% in volume ;
- wherein the pre-heating of the running strip (2) in the first section (3) is obtained thanks to the post-combustion of the fumes (9) deflected from the second section (4) toward the first section (3) through the fumes pipe (6) fluidly connecting the second section (4) to the first section (3), said deflected fumes containing residual H₂ and CO > 1% in volume.
12. The method according to claim 11, wherein additional air is injected to the fumes deflected toward the first section (3) so that to help attaining complete combustion of the deflected fumes in the first section (3), while controlling a content of oxygen in the fumes comprised between 2 and 5% in volume.
13. The method according to claim 11 or 12, wherein the intermediate section (5) is maintained in a non-oxidizing atmosphere.
14. The method according to anyone of claims 11 to 13, wherein an inert gas such as nitrogen is injected in the top of or above the first section (3) so that to counter-balance the buoyancy effect of the fumes (9).
15. The method according to anyone of claims 11 to 14, wherein the fumes (9) are exiting the first section (3) through a duct provided for waste gases at a temperature comprised between 800 and 1000°C.
16. The method according to anyone of claims 11 to 15, wherein the running strip is a hot-rolled steel strip of thickness higher than 2mm, and preferably higher than 6mm, or a cold-rolled steel strip of thickness comprised between 2 and 3mm.

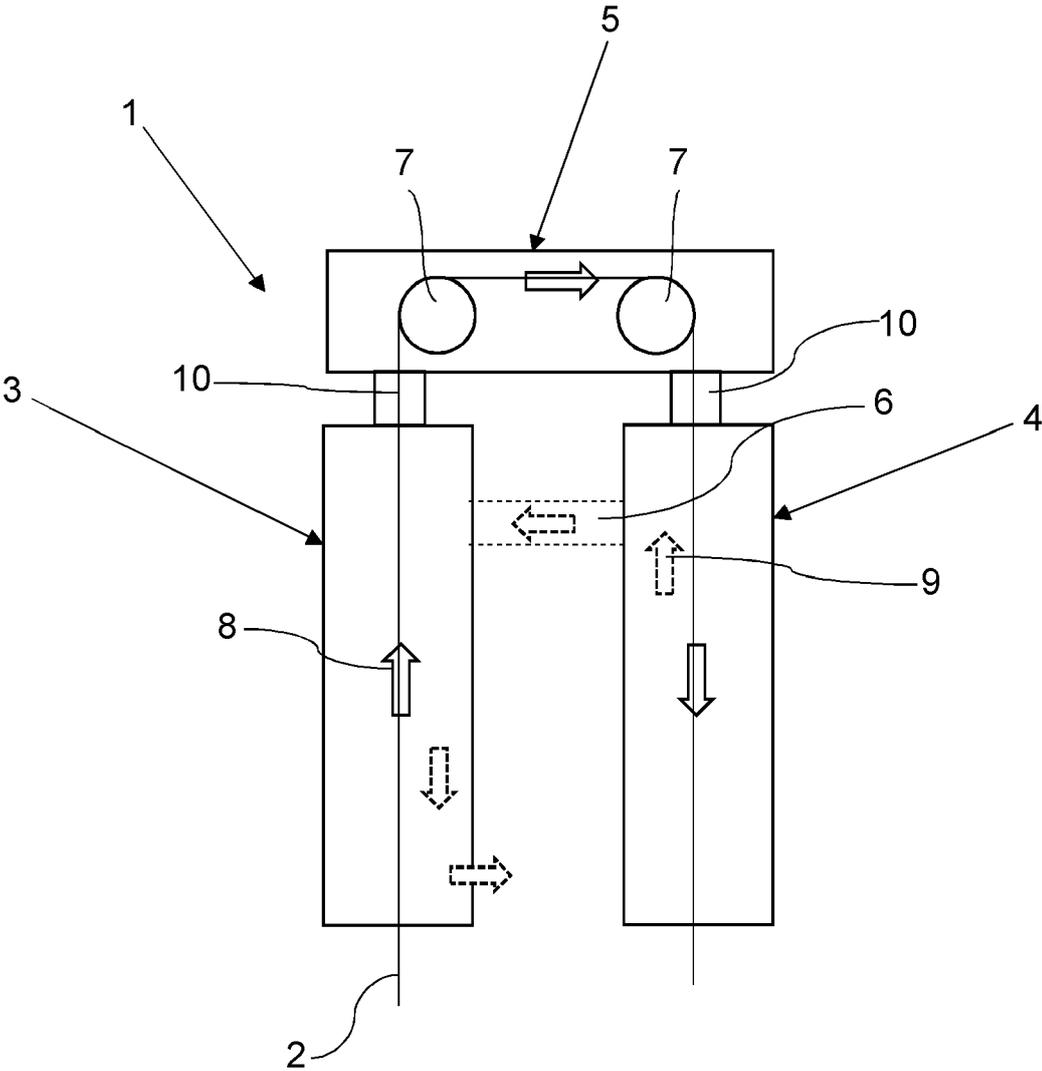


FIG. 1

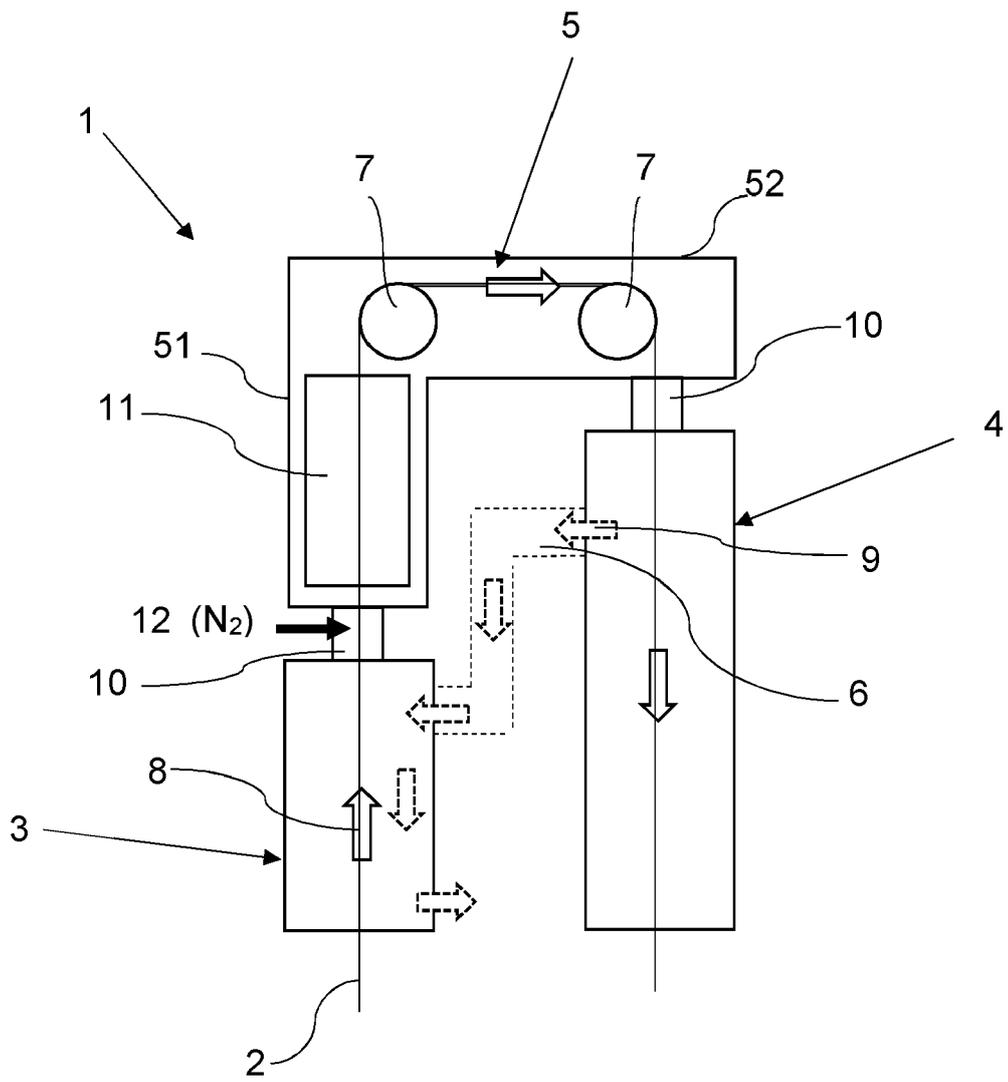


FIG. 2A

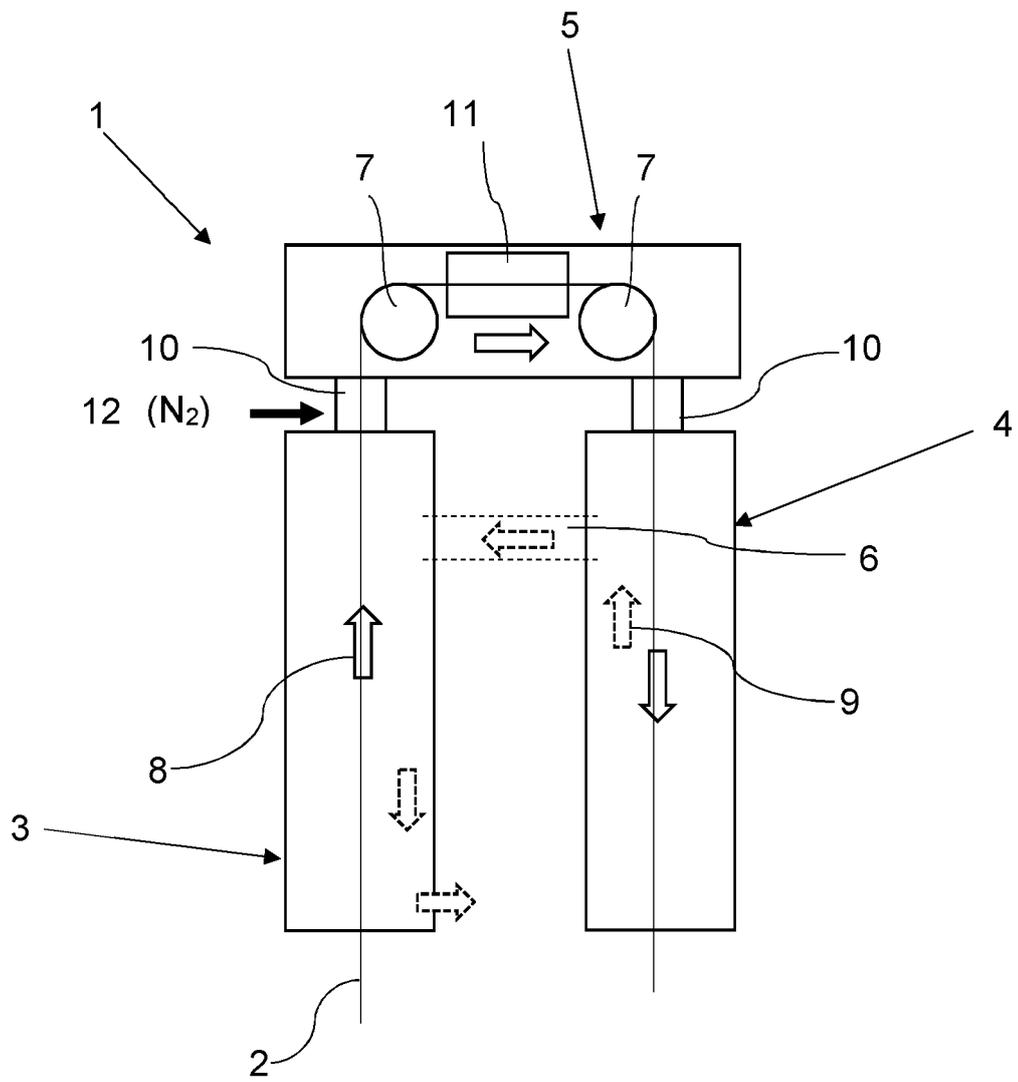


FIG. 2B



EUROPEAN SEARCH REPORT

Application Number

EP 23 18 3522

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2019/119777 A1 (BORREL PIERRE-JEROME [FR] ET AL) 25 April 2019 (2019-04-25) * claims 10-29; figures 1-2 * * paragraphs 1-2,11-18 - column 2, line 40 * * paragraphs [0024] - [0027] * -----	1-16	INV. F27D17/00 F27B9/06 F27B9/28 C21D1/74 C21D1/46 C23C2/00
A	US 4 165 964 A (KOBAYASHI KATSUYOSHI [JP] ET AL) 28 August 1979 (1979-08-28) * column 3, line 1 - line 27 * * column 3, line 40 - column 5, line 59 * * column 6, line 15 - column 7, line 42; claims 1-6; figures 1-3 * -----	1-16	C23C2/02 C23C2/40
			TECHNICAL FIELDS SEARCHED (IPC)
			F27D F27B C21D C23C
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		7 November 2023	Ovejero, Elena
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