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(54) **Apparatus for the treatment of a metal strip in a vertical annealing plant**

(57) The object of the present invention is an apparatus for treatment of a metal strip in a vertical annealing plant system, in which the metal strip passes through a central zone of the system, where bright annealing thermal treatment is carried out in a controlled atmosphere containing gas, and comprising in a sequence a first vertical strip entry conduit, a second horizontal joining conduit, a third vertical strip exit conduit, and comprising electromechanical locking and partitioning means, suitable for operating downstream of said first vertical entry conduit, preferably in said third vertical exit conduit, by locking directly on the metal strip and hermetic partitioning, thereby controlling the circulation of the gases, in said second and third conduits delimiting a first zone upstream of this electromechanical means and operating in a controlled atmosphere and in a second zone downstream of this electromechanical means and operating in a controlled atmosphere or in an ambient atmosphere.

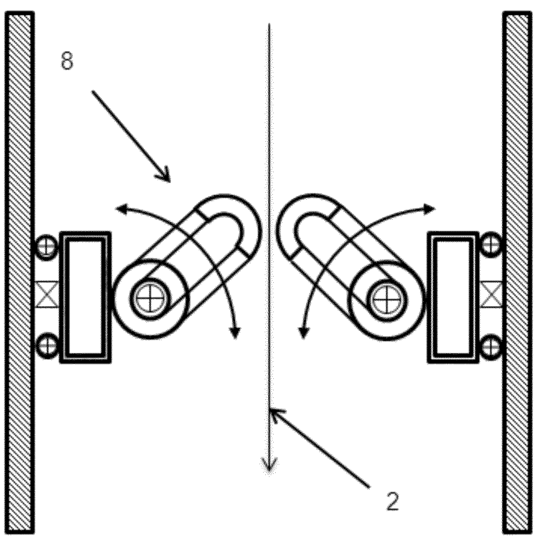

FIG.3

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Description

[0001] The present invention refers to an apparatus to be used in vertical bright annealing furnaces for treating metal products such as stainless steel strips.

[0002] The invention consists in a new apparatus, by means of which, in the case of a plant system stop, conditions for checking and restoring normal operation of the process are facilitated by means of a particular control system controlling the engineering of the furnace and thus the heat annealing process.

[0003] Thermal treatments are used to impart to various types of stainless steel specific properties based on their end use.

[0004] Thermal treatment consists of an operation or a series of operations in the case of a complex treatment process, during which the steel is subjected to one or more thermal cycles, that is to variations within given temperature limits based on time.

[0005] A thermal cycle normally involves heating the steel to a given temperature, possibly holding it at this temperature for a given period of time and then cooling it to ambient temperature, employing different modes according to the effects desired.

[0006] The treatment cycles are selected based on the desired characteristics relating to hardness, toughness, microstructure and workability. The operating parameters of the treatment cycle must be established based not only on the type of steel, but also according to the dimensions of the pieces and the characteristics of the heating means and the cooling means.

[0007] The annealing process represents a typical thermal treatment process, the principal aim of which is to eliminate residual stresses and work hardening, alterations of the microstructure, and segregation, reduce hardness and increase ductility.

[0008] For stainless steels, a particular type of controlled-atmosphere thermal treatment defined as recrystallization or solution annealing depending upon whether they are Martensitic, ferritic or Austenitic steels, is realized so as to obtain products with a bright annealed (BA) type of surface finish.

[0009] Consideration of the issues involved with the surface finish of products made of stainless steel, self-passivating materials, is important in order to ensure adequate aesthetic features and to optimize the behaviour of such products in certain corrosive environments, or to enhance inherent characteristics such as the hygienic properties thereof.

[0010] Bright annealing (BA) is carried out by application of a particular thermal cycle on metal products such as stainless steel sheets and strips, on which skin-pass rolling is carried out following cold rolling performed previously using polished rollers.

[0011] BA controlled-atmosphere thermal treatment is applied on practically all types of stainless steels, including Martensitic, ferritic, and Austenitic steels, and it makes it possible to obtain a product having a particularly bright surface, given that during the heating stage, oxide films are not formed owing precisely to the absence of an oxidizing atmosphere during treatment.

[0012] In general, the controlled atmospheres for these types of annealing furnaces are based on inert gases (nitrogen or argon) with additions of hydrogen. Nitrogen is the principal component of these mixtures and it prevents oxidation; hydrogen serves to reduce oxides and to obtain a clean bright surface.

[0013] According to the type of metal and the technical specifications, the hydrogen content may range between 5 and 100% expressed as volume percent.

[0014] In addition to temperature and pressure, the dew point, typically ranging between - 62°C and -73° C, is also an important operating parameter for this type of treatment.

[0015] BA-type furnaces for stainless steels may be horizontal or vertical, with the latter being preferred as they make it possible to prevent damage to the bright finish of the surface of the material being processed during the annealing process.

[0016] The typical structure of a BA vertical furnace, which comprises heights ranging from 20 to 65 metres, is realized by means of a structure configured in a schematic upside-down U shape and exhibiting in a sequence: a first vertical entry section, a second horizontal section and a third vertical exit section.

[0017] With reference to the engineering layout of a vertical furnace for thermal treatment of a product being processed such as a stainless steel strip, in the first vertical section it comprises a first entry zone, a second heating zone and a third cooling zone; in the second horizontal section it comprises a fourth holding zone and in the third vertical exit section, a fifth product holding and exit zone.

[0018] The heating zone comprises direct heating systems such as electric radiant elements, or indirect heating systems such as gas-fired muffle furnaces, or a combination of these two heating systems.

[0019] With direct heating systems, the product being processed is heated by means of radiant elements realized with electrical resistors of the molybdenum and/or tungsten alloy type, which are thus costly and sensitive to changes in temperature with the risk of sublimation in the case of rapid changes in temperature.

[0020] The main advantage of using systems with direct heating by means of electrical resistors lies in the higher production rates and the higher temperatures achievable, with the resistors of the electric elements being capable of reaching temperatures of 1400-1500°C.

[0021] The cooling system, which is positioned downstream of the heating system, can be realized in one or more stages according to the desired cooling rate.

[0022] All of following treatment zones, until to the exit zone, contributes to the positive realization of the process and it is therefore important that throughout the furnace, from the entry zone to the exit zone, precise operating parameters are respected, in terms of temperatures, gaseous atmospheres, pressures and dew point, in order to obtain products having high surface quality.

[0023] Considering the dimensions of the furnace, particularly the heights, which can also be on the order of 65 metres, there must be particularly careful regulation and management of volumes of circulating gases and of the operating parameters under normal operating conditions and operative management is extremely problematic in the case of non-steady-state operation, due for example to the metal strip being processed breaking or tearing into two pieces, a situation that typically takes place in the descending vertical section.

[0024] The non-steady state conditions related to the breakage of the metal strip lead to stoppage of the plant system and in general about 170 hours are needed to restore normal operating conditions, resulting in considerable losses in production.

[0025] From non-steady-state conditions, this situation can easily degenerate into critical conditions, given that being in the presence of a controlled atmosphere containing nitrogen/hydrogen, problems such as fires and explosions can arise.

[0026] US 6015526 discloses a plant system with a vertical annealing furnace, where there is an attempt to find a solution to problems relating to high productivity by proposing a complex structure of a muffle furnace that is capable of expansion. However, the document does not provide a solution for cases in which the plant system is stopped for checking and restoring normal operation of the process.

[0027] A solution to the technical issues mentioned and still existing in the state of the art is therefore highly desirable.

[0028] An aim of the present invention is to offer an apparatus that is capable of facilitating procedures for restoring production operations between two steady states in the event of accidental breakage of the metal strip being processed and a resulting production halt, making it possible to reduce to a minimum the procedures and time required for restoring steady-state operation, while also facilitating restoring procedures and conditions for a return to the steady-state situation, reducing the risk of fire and explosions to a minimum, and reducing to a minimum the need to replace the costly electrical resistors in the direct heating furnace because of damage.

[0029] An object of the present invention is an apparatus for treatment of a metal strip in a vertical annealing plant system, in which the metal strip passes through a central zone of the system, where bright annealing thermal treatment is carried out in a controlled atmosphere containing gas, and comprising in a sequence a first vertical strip entry conduit, a second horizontal joining conduit, a third vertical strip exit conduit, the latter comprising electromechanical locking and partitioning means, suitable for operating downstream of said first vertical entry conduit, preferably in said third vertical exit conduit, for acting by locking directly on the metal strip, and for hermetically partitioning, thereby controlling the circulation of the gases, said second or third conduit delimiting a first zone upstream of this electromechanical means and operating in a controlled atmosphere and a second zone downstream of this electromechanical means and operating in a controlled atmosphere or in an ambient atmosphere.

[0030] The apparatus disclosed by the present invention further comprises:

- means for controlling and regulating a controlled atmosphere, suitable for operating in said second or third conduit in the zone upstream and the zone downstream in which said electromechanical locking and partitioning means are positioned
- electromechanical hermetic closure means, suitable for controlling the circulation of gas, for operating in said second or third vertical conduit, for acting by locking directly on the strip in synchrony with said electromechanical locking and partitioning means.

[0031] The electromechanical locking and partitioning means and the electromechanical hermetic closure means are suitable for operating directly on the strip by means of reversible locking, moreover the electromechanical locking and partitioning means are suitable for moving in translational motion parallel to the longitudinal axis of the second or third conduit, preferably by means of guides, rails, or runners preferably positioned within these conduits.

[0032] Means for controlling and regulating a controlled atmosphere are suitable for entering or removing gas or mixtures of gases and for regulating the temperature, dew point, and pressure and such means comprise detection and analysis sensors, gas storage systems, intake and extraction systems and connection and joining systems.

[0033] The electromechanical hermetic closure means for controlling the circulation of gas are suitable for opening and closing in synchrony with said electromechanical locking and partitioning means in such a manner as to partition and limit the passage of gas in controlled atmosphere zones.

[0034] The electromechanical locking and partitioning means and said electromechanical hermetic closure means comprise movable, preferably metal, elements suitable for acting directly on the metal strip and suitable for being covered with elastic material including natural or synthetic rubbers, preferably silicone rubbers, resistant to temperatures greater than ambient temperature, preferably to temperatures in the range of 20°C to 90°C.

[0035] The movable locking and partitioning elements are suitable for acting simultaneously on both larger sides of the metal strip, achieving hermetic closure towards both larger surfaces of the strip and they are realized in a form selected from the group comprising: at least one metal plate that is slidable towards the strip, at least one pair of metal plates that are slidable towards the strip, several metal plates that are slidable, operating telescopically, and such as to extend from the outside inwards towards the strip, and at least one pair of elements that are movable towards the strip and suitable for rotating on at least one pair of hinges towards the strip.

[0036] The movable elements of the electromechanical hermetic closure means comprise elements, preferably metal elements suitable for reversibly moving in translational motion and rotating until entering in contact with the metal strip and they are realized with a covering made of material suitable for preventing marks from being left on the strip and for ensuring a hermetic seal preferably realized with material selected from the set comprising: felt, synthetic or natural fabric, or cotton.

[0037] The means for controlling and reinstating a controlled atmosphere is suitable for entering at least one gaseous form selected from the group comprising: hydrogen, nitrogen, a mixture of hydrogen and nitrogen, air and said metal strip is made of steel, preferably of stainless steel.

[0038] A general description of the present invention has been provided up to this point.

[0039] With the aid of the attached figures and examples, a more detailed description of particular embodiments will now be provided with the aim of offering a better understanding of the aims, characteristics, advantages and modes of application of the invention.

Fig. 1 - Figure 1 is a diagram of a vertical annealing line.

Fig. 2 - Figure 2 is a diagram of the central section of the vertical annealing line, where a general diagram of an embodiment of the object of the present invention is represented.

Fig. 3 - Figure 3 is a detailed diagram of an embodiment of the present invention.

[0040] Figure 1 is a diagram of a vertical annealing line, in which a metal strip 2 initially wound on an uncoiler, is sent, passing through an entry accumulation tower, into a central strip treatment section 1 for treatment.

[0041] The strip then travels through the exit accumulation tower, the skin-pass rolling line and in conclusion, it is wound on the recoiler.

[0042] Figure 2 represents a diagram of a central treatment section of an annealing line incorporating the object of the present invention. In Figure 2, the central treatment section is indicated in its entirety by the number 1 and the strip being treated in the plant system is indicated by the number 2. During the annealing process, the strip 2 passes through the vertical conduit 3 first, then the horizontal conduit 4 and lastly it exits from the vertical conduit 5.

[0043] The furnace is under controlled atmosphere conditions and operates under overpressure conditions with respect to the atmospheric pressure. Once the strip 2 has entered the conduit 3, it is subjected to a thermal cycle and travels first through the indirect heating furnace and then through the direct heating furnace, both of which are indicated in their entirety by the number 6. Then the strip 2 travels through the slow- and rapid-cooling zone, which is indicated in its entirety by the number 7. The strip 2 then travels through the conduit 4 and begins to travel through the conduit 5, but in non-steady state operation, such as an abnormal situation involving breakage of the strip, it is locked inside the conduit 5.

[0044] In the absence of that which constitutes the object of the present invention, in order to resolve the abnormal situation that has arisen with the breakage of the strip, it would be necessary to attempt to extract the strip upstream - by action of the uncoiler with a high risk of damaging not only the supporting rollers, but also the thermally active zones, particularly the heating furnaces and the cooling areas - and to extract the strip downstream - by action of the recoiler, thereby jeopardizing not only the product being processed but also future processing.

[0045] In order to resolve the abnormal situation related to breakage of the strip, typically into two pieces, the apparatus 8 constituting the object of the present invention intervenes by moving in translational motion in relation to the conduit 5 or 4 based on the position occupied by the broken strip section, locks the same strip upstream of the breakage point achieving a hermetic closure with respect to the gases present and divides the conduit into a zone upstream of the breakage point, where the operating conditions and parameters (i.e., pressure, temperature, dew point, H2/N2 mixture) are kept under control, and a zone downstream of the breakage point, where work can be done under holding temperature and atmosphere conditions and conditions for restoring steady state operation.

[0046] During the transitional procedures involved in repairing the strip, which take place in the zone downstream of the breakage point in an environment containing air, following the locking of the strip, the broken strip and a backing strip or terminal are brought close together and welded, after repairs, in the zone downstream of the breakage point, the section of the conduit involved is then suitably washed with nitrogen.

[0047] Subsequently, in order to restore normal operating conditions in the zone between the strip breakage point and the exit, after having re-established the proper operating parameters only in the zone downstream of the breakage point and not throughout the entire central thermal treatment section, by means of temperature, pressure, dew point and gas supply control systems 9 and by means of hermetic sealing systems 10, the production line is then rendered operative.

[0048] Direct intervention in the strip breakage zone makes it possible to avoid having to re-establish all the conditions connected with the operating parameters throughout the entire central thermal treatment section.

[0049] In this manner, considerable savings can be achieved in terms of the gas to be used and replenished, considering the high volumes of the treatment areas, as well as considerable energy savings by preserving the thermal operating conditions, considering the high temperatures for treatment, to reduce the risk of fire and explosions to a minimum, and to reduce to a minimum the need to replace the costly tungsten- and/or molybdenum-based electrical resistors in the direct heating furnace.

[0050] Lastly, considering the time involved in the operation between the beginning and end of the problem, between transient and normal operation, there is a marked reduction in stoppage time and therefore production is resumed in a considerably short amount of time.

EXAMPLE 1

[0051] An AISI 304 Austenitic steel strip is being processed on a BA bright annealing line and during a production stage, normally of duration of 60 minutes per 25t-reel, a situation with breakage of the strip has been simulated in the vertical exit conduit in the central thermal treatment section.

[0052] The strip in the process of being treated is 1000 mm in width and 1 mm thick, at a rate of 28m/min.

[0053] Once the strip has entered the vertical entry conduit in the central section of the thermal treatment system, it travels first through the indirect heating muffle furnace, where it is heated to a temperature of about 1000°C, and then to the direct heating furnace, where it is heated to temperatures of about 1100°C by means of electrical resistors.

[0054] In the operative environment there is an atmospheric overpressure of about 10390 mm of H_2O and a dew point of -40°C. The strip subsequently travels through the slow cooling zone and then the rapid cooling zone and is cooled to about 50°C.

[0055] Then the strip travels through the horizontal conduit and begins to travel through the vertical exit conduit, but owing to a simulated breakage of the strip at about 1/3 of the passage through the vertical exit conduit 5, the production line is stopped.

[0056] In this situation, the apparatus constituting the object of the present invention intervenes, and moving in translational motion parallel to the conduit 5 according to the position occupied by the edge of the broken strip, it locks the strip by means of a system of elastomer-coated elements that rotate about a hinge (Fig. 3).

[0057] The closure elements lock the strip in such a manner as to also ensure hermetic closure with respect to the gases present. By means of the hermetic closure, the exit conduit is partitioned in a zone downstream of the breakage point and in a zone upstream of the breakage point of the strip, where the operating conditions and parameters (pressure, dew point, and gaseous atmosphere) are checked.

[0058] On the breakage point of the strip, downstream of the locking and partitioning elements, a welding procedure is carried out between the broken strip upstream and a backing strip or terminal downstream, by means of which production will be re-started again.

[0059] Following repair of the broken strip, in the zone downstream of the breakage point, the zone previously occupied by air is suitably washed with gas (nitrogen) and the gaseous hydrogen/nitrogen atmosphere for normal operation is then re-established.

[0060] Subsequently, all the correct operating parameters are re-established by means of operating parameter control and management systems and then the production line is re-started.

[0061] By means of the apparatus constituting the object of the present invention and inserted in the production line, the time involved in the supplementary maintenance work has decreased tenfold and owing to the hermetic seal achieved, the oxygen in the air has not entered into direct contact with the electrical resistors of the heating furnace, thus making it possible to avoid having to proceed with replacement of these resistors because of contact with the oxygen and resulting sublimation and to avoid having to restore the operating parameters throughout the system, which thus makes it possible to achieve an overall marked increase in productivity.

EXAMPLE 2

[0062] An AISI 430 ferritic steel strip is being processed on a BA bright annealing line and during the production stage, normally of duration of 60 minutes per 25t-reel, a situation with breakage of the strip has been simulated in the vertical exit conduit in the central thermal treatment section.

[0063] The strip in the process of being treated is 1500 mm in width and 1,2mm thick, at a rate of 22m/min.

[0064] Once the strip has entered the vertical entry conduit in the central section of the thermal treatment system, it travels first through the indirect heating muffle furnace, where it is heated to a temperature of about 1000°C, and then to the direct heating furnace, where it is heated to temperatures of about 1000°C by means of electrical resistors.

[0065] In the operative environment there is an atmospheric overpressure of 10390 mm of H_2O and a dew point of -40°C. The strip subsequently travels through the slow cooling zone and then the rapid cooling zone and is cooled to about 50°C.

[0066] Then the strip travels through the horizontal conduit and begins to travel through the vertical exit conduit, but owing to a simulated breakage of the strip at about 2/3 of the passage through the vertical exit conduit 5, the production line is stopped.

[0067] In this situation, the apparatus of the present invention intervenes by moving in translational motion parallel to the conduit 5 according to the position occupied by the edge of the broken strip, it locks the strip by means of a system of elastomer-coated sliding panels.

[0068] The closure elements lock the strip in such a manner as to also ensure hermetic closure with respect to the gases present. By means of the hermetic closure, the exit conduit is partitioned in a zone downstream of the breakage point and in a zone upstream of the breakage point of the strip, where the operating conditions and parameters (pressure, dew point, and gaseous atmosphere) are checked.

[0069] On the breakage point of the strip, downstream of the locking and partitioning elements, a welding procedure is carried out between the broken strip upstream and a backing strip or terminal downstream, by means of which production will be re-started.

[0070] Following repair of the broken strip, in the zone downstream of the breakage point, the zone previously occupied by air is suitably washed with gas (nitrogen) and the hydrogen/nitrogen atmosphere for normal operation is then re-established.

[0071] Subsequently, the correct operating parameters are re-established by means of operating parameter control and management systems and then the production line is re-started.

[0072] By means of the apparatus constituting the object of the present invention and inserted in the production line, the time involved in the supplementary maintenance work has decreased tenfold and owing to the hermetic seal achieved, the oxygen in the air has not entered into direct contact with the electrical resistors of the heating furnace, thus making it possible to avoid having to proceed with replacement of these resistors because of contact with the oxygen and resulting sublimation and to avoid having to restore the operating parameters throughout the system, which thus makes it possible to achieve an overall marked increase in productivity.

Claims

1. An apparatus for treatment of a metal strip in a vertical annealing plant system comprising a zone wherein bright annealing thermal treatment of a metal strip is carried out in a controlled atmosphere containing gas, said zone comprising in sequence: a first vertical entry conduit of a strip, a second horizontal joining conduit, a third vertical exit conduit of the strip, and **characterized in that** it comprises: electromechanical means for locking and partitioning the metal strip, suitable for operating downstream of said first vertical entry conduit, preferably in said third vertical exit conduit, such as to directly lock said metal strip, and to hermetically partition, thereby controlling the circulation of gases, delimiting a first zone upstream of said electromechanical means and operating in a controlled atmosphere and a second zone downstream of said electromechanical means and operating in a controlled atmosphere or in an ambient atmosphere.

2. The apparatus as in claim 1, further comprising:

   - means for controlling and regulating a controlled atmosphere, suitable for operating in said second or third conduit in the upstream zone and in the downstream zone, where said electromechanical locking and partitioning means are positioned;
   - electromechanical hermetic closure means, suitable for controlling the circulation of gas, for operating in said second or third vertical conduit, for acting by locking directly on the strip in synchrony with said electromechanical locking and partitioning means.

3. The apparatus as in claim 1 or 2, wherein said electromechanical locking and partitioning means and said electromechanical hermetic closure means operate directly on the strip by means of reversible locking.

4. The apparatus as in claim 3, wherein said electromechanical locking and partitioning means are suitable for moving in translational motion parallel to the longitudinal axis of the second or third conduit, preferably by means of guides, rails, or runners preferably positioned within these conduits.

5. The apparatus as in claim 2, wherein said means for controlling and regulating a controlled atmosphere are suitable for entering or removing gas or mixtures of gases and for regulating the temperature, the dew point, and the pressure and such means comprise detection and analysis sensors, gas storage systems, intake and extraction systems and connection and joining systems.

6. The apparatus as in claim 3, wherein said electromechanical hermetic closure means for controlling the circulation of gas are suitable for opening and closing in synchrony with said electromechanical locking and partitioning means in such a manner as to partition and limit the passage of gas in controlled atmosphere zones.

7. The apparatus as in any one of claims 1 to 6, wherein said electromechanical locking and partitioning means and said electromechanical hermetic closure means comprise movable, preferably metal, elements suitable for acting directly on the metal strip and covered with elastic material such as natural or synthetic rubbers, preferably silicone rubbers, resistant to temperatures greater than ambient temperature, preferably to temperatures in the range of 20°C to 90°C.

8. The apparatus as in claim 7, wherein said movable locking and partitioning elements are suitable for acting simultaneously on both larger sides of the metal strip, achieving hermetic closure towards both larger surfaces of the strip and they are realized in a form selected from the group comprising: at least one metal plate that is slidable towards the strip, at least one

pair of metal plates that are slidable towards the strip, a number of metal plates that are slidable, operating telescopically, and such as to extend from the outside inwards towards the strip, and at least one pair of elements that are movable towards the strip and suitable for rotating on at least one pair of hinges towards the strip.

9. The apparatus as in claim 8, wherein said movable elements of said electromechanical hermetic closure means comprise elements preferably metal elements suitable for reversibly moving in translational motion and rotating until entering in contact with the metal strip and they are realized with a covering made of material suitable for preventing marks from being left on the strip and for ensuring a hermetic seal preferably selected from the group comprising: felt, synthetic or natural fabric, or cotton.

10. The apparatus as in any one of the preceding claims, wherein said means for controlling and reinstating a controlled atmosphere are suitable for entering at least one gaseous form selected from the group comprising: hydrogen, nitrogen, a mixture of hydrogen and nitrogen, air and said metal strip is made of steel, preferably of stainless steel.

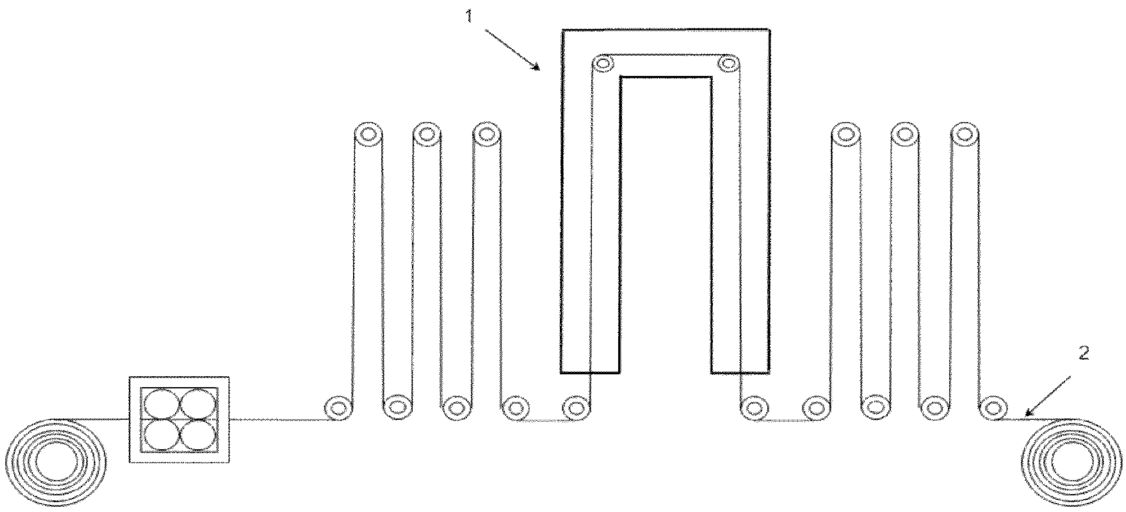

FIG. 1

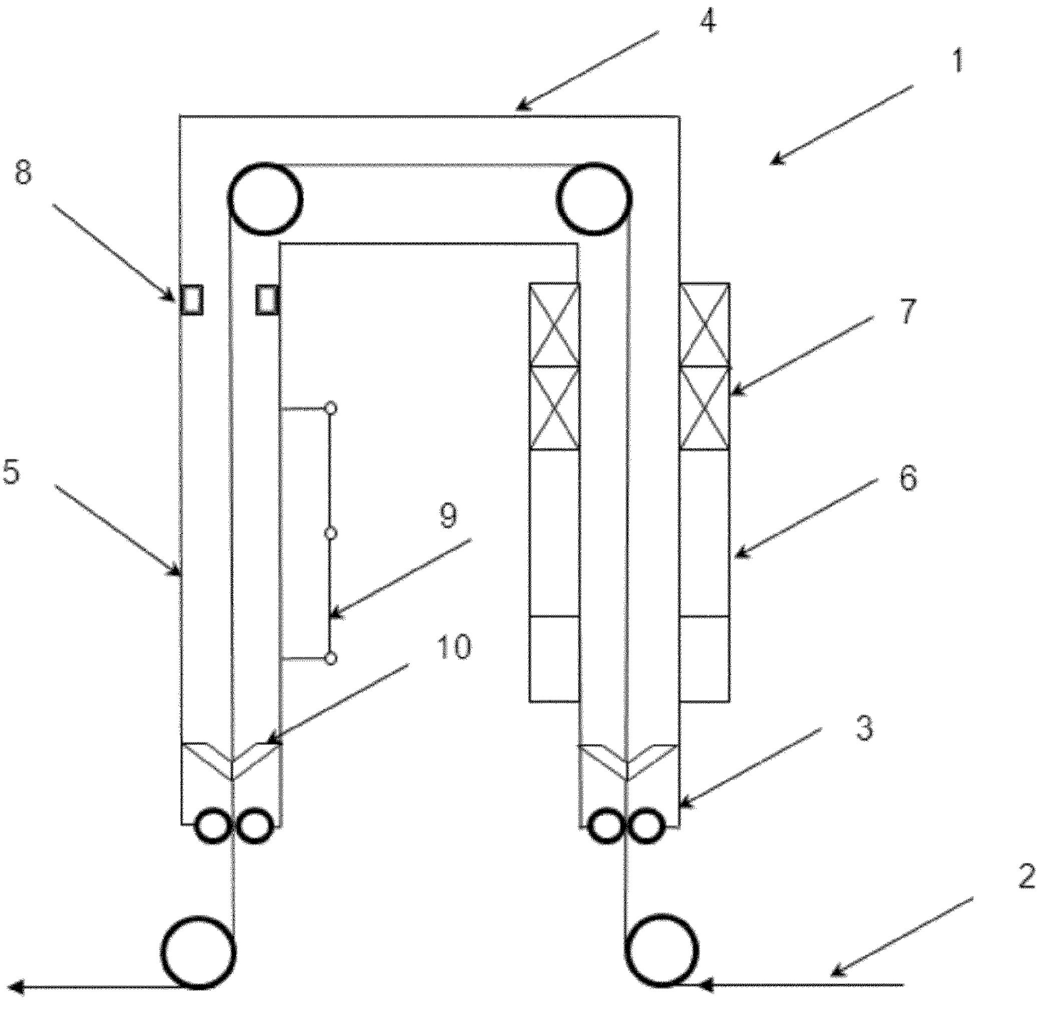

FIG.2

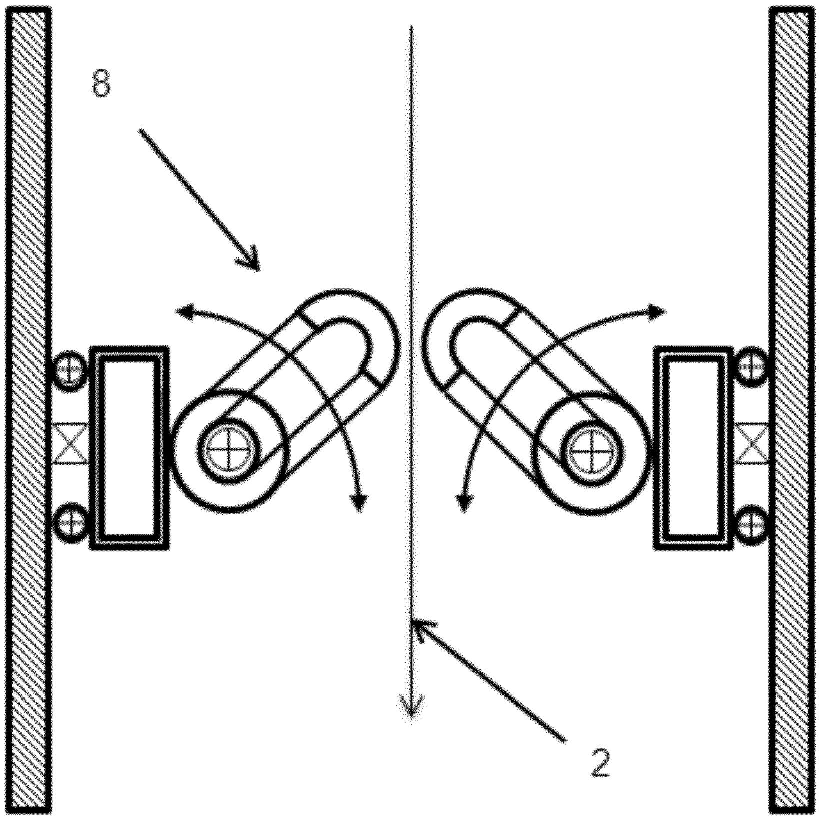

FIG.3

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EUROPEAN SEARCH REPORT

Application Number
EP 15 15 7289

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 2009/158975 A1 (CLUZEL XAVIER [FR] ET AL) 25 June 2009 (2009-06-25) * paragraphs [0009], [0033] - [0038], [0049], [0071], [0072]; claims 1-15; figures 5-8 *	1-10	INV. C21D1/74 C21D9/56 C21D9/66 F27D7/06 F27D9/00
X	US 6 547 898 B2 (MIGNARD FRANCOIS [FR] ET AL) 15 April 2003 (2003-04-15) * column 2, line 15 - column 3, line 47; claims 1-7; figures 1-8 *	1-10	
X	JP H10 158750 A (DAIDO STEEL CO LTD; NISSHIN STEEL CO LTD) 16 June 1998 (1998-06-16) * abstract; figures 1,2 *	1-10	
A	JP H07 331337 A (NISSHIN STEEL CO LTD) 19 December 1995 (1995-12-19) * figures 1,2 *	1-10	
A	EP 0 535 439 A1 (JUNKER GMBH O [DE]) 7 April 1993 (1993-04-07) * claims 1-10; figures 1,2 *	1-10	TECHNICAL FIELDS SEARCHED (IPC)
			C21D F27D
A	US 5 683 651 A (NAKAMURA TERUHISA [JP]) 4 November 1997 (1997-11-04) * claims 1-20; figures 1-11 *	1-10	
A	EP 1 371 738 A1 (CENTRE RECH METALLURGIQUE [BE]) 17 December 2003 (2003-12-17) * figures 1,2 *	1-10	
A	US 6 190 164 B1 (UENO NAOTO [JP] ET AL) 20 February 2001 (2001-02-20) * claims 1-5; figures 1-4 *	1-10	

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	6 July 2015	Catana, Cosmin

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 15 15 7289

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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06-07-2015

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009158975 A1	25-06-2009	AU 2007264871 A1	03-01-2008
		BR PI0713295 A2	20-03-2012
		CA 2655924 A1	03-01-2008
		CN 101466852 A	24-06-2009
		EA 200970076 A1	30-06-2009
		EP 2035588 A1	18-03-2009
		FR 2903122 A1	04-01-2008
		JP 2009541598 A	26-11-2009
		KR 20090034814 A	08-04-2009
		US 2009158975 A1	25-06-2009
		WO 2008000945 A1	03-01-2008
		ZA 200809288 A	27-01-2010
US 6547898 B2	15-04-2003	CN 1327144 A	19-12-2001
		DE 1160342 T1	23-05-2002
		DE 60114085 D1	24-11-2005
		DE 60114085 T2	13-07-2006
		EP 1160342 A1	05-12-2001
		ES 2165342 T1	16-03-2002
		FR 2809418 A1	30-11-2001
		JP 4988096 B2	01-08-2012
		JP 2002003954 A	09-01-2002
		US 2001045024 A1	29-11-2001
JP H10158750 A	16-06-1998	JP 4014174 B2	28-11-2007
		JP H10158750 A	16-06-1998
JP H07331337 A	19-12-1995	NONE	
EP 0535439 A1	07-04-1993	DE 9112225 U1	05-12-1991
		EP 0535439 A1	07-04-1993
US 5683651 A	04-11-1997	AT 205549 T	15-09-2001
		CN 1129016 A	14-08-1996
		DE 69522656 D1	18-10-2001
		DE 69522656 T2	20-06-2002
		EP 0721992 A1	17-07-1996
		ES 2161890 T3	16-12-2001
		US 5683651 A	04-11-1997
		WO 9533078 A1	07-12-1995
EP 1371738 A1	17-12-2003	BE 1014880 A4	04-05-2004
		EP 1371738 A1	17-12-2003
US 6190164 B1	20-02-2001	BR 9904910 A	20-06-2000
		CA 2290949 A1	07-10-1999

EPO FORM P0459

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 15 15 7289

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

06-07-2015

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		CN 1286729 A	07-03-2001
		DE 69918821 D1	26-08-2004
		DE 69918821 T2	13-10-2005
		DE 69930330 T2	24-08-2006
		EP 1069193 A1	17-01-2001
		EP 1408126 A2	14-04-2004
		US 6190164 B1	20-02-2001
		WO 9950464 A1	07-10-1999

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 6015526 A **[0026]**