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(54) **ANNEALING INSTALLATION WITH M-SHAPED STRIP TREATMENT TUNNEL**

AUSGLÜHINSTALLATION MIT M-FÖRMIGEM STREIFENBEHANDLUNGSTUNNEL

INSTALLATION DE RECUIT DOTÉE D'UN TUNNEL DE TRAITEMENT DE RUBAN EN FORME DE M

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(73) Proprietor: **Andritz Thermtec B.V.
3011 WT Rotterdam (NL)**

(72) Inventor: **Ruiter, Leo Antonius
50450 Kuala Lumpur (MY)**

(74) Representative: **Riemens, Roelof Harm
Exter Polak & Charlouis B.V. (EP&C)
P.O. Box 3241
2280 GE Rijswijk (NL)**

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Description

[0001] The invention relates to an annealing installation for the continuous annealing of metal strip guided through the installation. The metal strip being made continuous in the processing section, by welding or otherwise connecting strip fed in coil form, and later recoiling.

[0002] Annealing of metal strip, in particular so-called bright annealing of cold-rolled metal strip, for example stainless steel strip, is known to take place in a continuous annealing process with heating and cooling stations, in which the strip is protected with hydrogen containing shielding gas. For BA (Bright Annealed) quality stainless steel strip this process usually takes place in vertically orientated furnaces. The strip is then guided through the vertical furnace at a constant speed, while only at the top and/or bottom side of the furnace being guided over rollers. This contactless guiding of the strip through the furnace is necessary to prevent damage to the hot strip surface during the annealing phase.

[0003] A furnace for bright-annealing of for example stainless steel strip is filled with a shielding gas as protective atmosphere usually containing 70-100 vol% of H₂, rest being N₂, or occasionally filled with Argon, with a dew point of lower than -40 degrees Celsius. The shielding gas is required in order to dispel air which would otherwise cause oxidation and discoloration of the metal strip treated inside the furnace.. This shielding gas however is highly explosive and thus requires extreme safety measures. In addition, the bright-annealing process requires an extremely low dew point atmosphere, and thus an extremely gastight furnace, as even a small infiltration of air would deteriorate the dew point condition and again could result in oxidation of the strip surface and discoloration.

[0004] For these safety and process reasons, all existing vertical bright-annealing furnaces are of the inverted U-type having the open end of the U-shape at its bottom, with special seals at the lower outer ends of the legs at this bottom of the inverted U. An example of a continuous heat treatment line of metal strips of such an inverted U-type is disclosed in US 2009/158975. For the past 50 years or so, that is to say ever since vertical bright-annealing furnaces were first designed in the late 1950's, every vertical bright-anneal furnace had this inverted U shape in order to guarantee that the highly explosive shielding gas is locked up inside the inverted U-shape of the furnace. Even if one of the seals of the strip inlet and outlet would malfunction or get damaged, then the shielding gas, because of it being lighter in weight than the surrounding air, would still remain trapped inside the inverted U-shape. With this it is noticed that even without such a malfunctioning, the seals of the strip inlet and outlet are sometimes required to be temporarily opened for a very short period, typically about 10 seconds, during the passing of a thickened weld in the strip material fed into the installation, mainly to prevent damage to the seals. Depending upon the production rate a weld be-

tween strip coils typically occurs at ½ - 2 hour intervals. Also the seals may need to be temporarily opened when a correction needs to take place in the case of strip running excessively off-centerline. During such temporary openings it is also required that the shielding gas will stay naturally inside the installation and that air is prevented from entering the installation..

[0005] An example of a bright annealing installation is for example known from EP 0 914 481. This installation comprises an inverted U-shaped strip treatment tunnel with two vertical legs connected to each other via a top roller chamber. The vertically upwards directed leg, that is to say the leg through which the strip is guided in an upwards direction during annealing, is formed by a shielded entrance chute with a pre-heating station provided in the upper part thereof. The vertically downwards directed leg, that is to say the leg through which the strip is guided in a downwards direction during annealing, has a muffle type heating station in its upper part and a cooling station in its lower part. The entrance chute, the muffle type heating station and the cooling station are connected to each other substantially gastight. The lower end of the entrance chute and the lower end of the cooling station form a strip inlet and a strip outlet respectively which are both provided with shielding gas closures. With this type of installation the strip, during annealing, is mainly heated and cooled with a downwards strip transportation direction.

[0006] Another example of a bright annealing installation is known from EP 0 675 208. This installation also comprises an inverted U-shaped strip treatment tunnel with two legs connected to each other via a top roller chamber. The vertically upwards directed leg is now formed by a muffle type heating station in its lower part, a refractory type heating station in its intermediate part and a cooling station in its upper part. The vertically downwards directed leg forms a shielded discharge chute. Again the muffle and refractory type heating stations, the cooling station and the discharge chute are connected to each other substantially gastight, and the lower ends of the muffle type heating station and the discharge chute form a strip inlet and outlet which are both provided with shielding gas closures. During annealing, the strip is fully heated and cooled with an upwards strip transportation direction.

[0007] In both examples, the strip coming out of the heating station(s) is in the same leg cooled down in the cooling station by means of forced gas circulation (so-called Jet cooling). The heating station and the cooling station are both filled with the shielding gas. The cooling of the strip is done to a temperature which is low enough to be able to expose the annealed strip to the air, without the contact with the air leading to discolouration or other damages to the strip surface.

[0008] The gas closures of the strip inlet and outlet, for example rubber coated rollers or fibre strokes, in both examples, are required in order to minimize or substantially prevent loss of the hydrogen containing shielding

gas. This is of great importance since any leaking out of the H₂ containing shielding gas could immediately result in a dangerous situation by causing an explosion or fire. Also the gas closures make it possible to maintain the heating station during annealing under sufficient overpressure, to prevent ingress of air should somewhere a leak spot occur.

[0009] A disadvantage with both examples is that their maximum building height is limited, and thus also the production capacity. Both installations are characterized in that the main heating and cooling actions take place in one and the same upwards or downwards leg of the installation. Building this leg of the installation too high would result in the deadweight of the amount of strip hanging beneath its hottest point in the leg, causing high tensions in the hot strip. Particularly in EP 0 675 208 this might be a problem, since there the strip reaches its hottest point in the upper part of the heating station(s), in the top half of the leg, and thus this hottest point has to carry a lot of deadweight of strip, plus any additional strip tension as may be required for proper strip travel and guidance. With the muffle type heating station of this EP 0 675 208 the limitation in building height also applies, but from the maximum height of the muffle, as the deadweight of hot muffle material hanging downwards from a hot point of the muffle at its top end, will at some height exceed the maximum allowable hot stress of the muffle.

[0010] Another disadvantage with both examples is that any particles falling down during the annealing process may nest themselves in the inlet or outlet gas closure and there may lead to damage of the strip surface having to run through the closure. For a refractory type heating station, those particles may be formed by brick dust or grains coming off from the insulation bricks of the heating station. During heating those insulation bricks undergo severe thermal expansion and retraction caused by strong heat radiation of the electrical heating elements mounted closely in front of the insulation bricks. If for example a temperature of 1200 C needs to be reached in the heating station, then the electrical heating elements themselves may reach temperatures of about 1700 C. The brick dust or grains coming off from the insulation bricks eventually may fall down in the gas closure. For the muffle type heating station those particles may be formed by particles which attached themselves at an earlier stage to the muffle wall or other interior parts, and which at some moment come off and fall down into the closure. Those earlier settled particles may be formed by dust particles in general or by components of the strip material, which at an earlier stage evaporated out of the strip material during annealing and which then sublimated at colder surface parts of the heating or cooling stations.

[0011] The present invention aims to overcome one or more of the abovementioned disadvantages and/or to provide a usable alternative. In particular, the invention aims to provide for an efficient and safe operating annealing installation with which a high production capacity,

a high annealing quality and/or low production costs can be realized. More in particular it is a main objective of the present invention to provide an entirely new type of furnace for bright-annealing at substantially higher production capacities than achievable in state of the art vertical furnaces of the inverted U-type design, and also improve the safety of such installations by reducing the explosion hazard.

[0012] This aim is achieved by the annealing installation according to claim 1. The annealing installation comprises an entrance chute, a heating station with heating means, a cooling station with cooling means, and a discharge chute. The entrance chute, the heating station, the cooling station and the discharge chute are positioned one after the other and are connected to each other substantially gastight. Together they delimit an M-shaped longitudinal meandering substantially gastight strip treatment tunnel which is to be filled with a shielding gas and which has four vertically directed legs connected to each other by means of a first top roller chamber, a lower turning section, and a second top roller chamber. Each top roller chamber has at least one roller for guiding the strip from the one to the other leg above which it is positioned. The tunnel has a strip inlet and a strip outlet at the lower ends of the entrance and discharge chutes, which are both provided with shielding gas closures. The entrance chute extends along the first one of the legs. The heating station and the cooling station extend along the second one of the legs, as well as along the lower turning section and along the third one of the legs. The discharge chute extends along the fourth one of the legs. Strip feeding means and strip discharging means are provided for continuously guiding the strip as a free-hanging loop between the two top roller chambers along the second leg, lower turning section and third leg during a process of annealing.

[0013] During annealing metal strip runs continuously into the installation via the gas closure at the inlet, and subsequently in the upwards direction through the entrance chute towards the first top roller chamber. After the top roller chamber the strip runs as a free-hanging loop downwardly and upwardly through the heating and cooling stations towards the second top roller chamber. In the heating station the strip is brought to its desired annealing end temperature, in particular a temperature of between 800 - 1200 C, depending on the type of strip material being annealed. In the cooling station the strip's temperature is reduced to an acceptable low level for it to be guided over the roller(s) of the second top roller chamber, without getting distorted or damaged, in particular to a temperature of between 80 - 230 C. After the second top roller chamber the strip runs downwards through the discharge chute, where it may be further cooled prior to discharge, to exit the installation via the gas closure at the outlet.

[0014] The entire installation is thus characterized by the M-shape in which the strip in the actual process zone, that is to say in between the two top roller chambers,

hangs down in a free sagging loop (chain line) under the influence of its own weight, and without being guided over some kind of roller in the lower turning point. In the entrance and discharge chute the strip runs vertically upwards and downwards respectively.

[0015] The described M-shape in combination with the specific provision of the chutes and stations there along, offers a number of important advantages. First of all they make it possible to largely increase the production capacity and/or to reduce the production costs, by making it possible to build an installation with a substantially longer heating and cooling length. The second and third legs together offer a longer available length, along which the critical annealing heating and cooling can take place, than can be achieved in the known furnace arrangements with heating and cooling in the same vertical pass. Secondly, because of the M-shape, distinctive entrance and discharge chutes have come available which separate the actual heating and cooling station from the gas closures at the inlet and outlet.

[0016] The strip inlet and outlet are provided at the lower outer ends of the first and fourth legs at lower levels than the top roller chambers which are delimiting the second and third legs at their upper ends. Owing to this, a highly explosive lightweight shielding gas present inside the heating and cooling sections of the second and third legs, as well as inside the entrance and discharge chutes of the first and fourth legs, advantageously remains trapped therein naturally, even if one of the gas closures were to disfunction or break.

[0017] In a specific embodiment it is the object of the present invention of the M-shaped furnace, to use a low H₂ percentage shielding gas in the 1st (inlet) and 4th (outlet) legs, to reduce the amount of H₂ escaping through the seals, and separate the high H₂ percentage process section in the 2nd and 3rd legs from air infiltration through the seals. This measure substantially reduces the risk of fire at the seals, and explosion hazards.

[0018] Insulation brick dust or grains or other particles falling down in the heating and/or cooling station can no longer get entrapped in the gas closures (seals) and thus can no longer cause damage to the strip surface. This helps to improve the quality of the annealing process and eliminates the losses caused by strip damaged in the gas closure from such cause.

[0019] Strip tensioning losses in the gas closures of the inlet and outlet and in the top roller chambers no longer have an influence on the strip tension in the hot process part, since the strip there merely hangs down in its free loop by its own weight only. As no additional strip tension in between the top roller chambers has to be arranged, the tension in the hottest point of the strip in the actual process zone will be at a lower value. The hottest point of the strip advantageously can be positioned along the height of the second or third leg at a relative low height above the turning point of the strip. Thus the strip tension in this hottest point, under the influence of the weight of strip hanging beneath it, remains

low. The free hanging loop makes it possible for the strip to freely thermally expand or contract, during a strip stop or speed change, without causing an immediate risk for breakage of the strip, and without special constructional measures having to be taken for this thermal expansion / contraction.

[0020] The max height that could be designed for the known inverted U type bright-annealing furnaces is about 80-85m. Above such height, the weight of the strip hanging below its hottest point is likely to create so much stress in the hot strip that the strip might deform, rendering it useless. This effectively limits the maximum production capacity that can be achieved with such inverted U type furnace design to about 110,000-150,000 t/a, depending upon the product mix. Now, with the new M-shape design according to the invention, the capacity can be substantially increased to about double the capacity that could be achieved with existing technology.

[0021] At such high production rates and strip speeds contemplated for the new M-shape annealing installation, the separate entrance chute, that is to say the first leg of the M, can advantageously be used to purge/reduce the molecular layer of air that is still adhering to the strip surface after having passed the seals at the strip inlet, prior to the strip entering the second leg where it will be quickly heated to a high temperature. If this very thin layer of air would not have been diluted or removed prior to the strip reaching the high annealing temperature, then the strip surface could be prone to oxidation and discoloration in the annealing process, which would be unacceptable.

[0022] The contactless turning around of the strip in the lower turning section has a stabilizing influence on the strip shape in the second and third leg, because the strip is prone to lie substantially flat in the turning point. Because of the M-shape of the installation it is no longer necessary to position the gas closures of the inlet and/or outlet at the lowest points of the installation. It is possible to provide the gas closures at a somewhat higher level of the first and fourth leg compared to the lowest point of the turning section extending between the second and third leg. Owing to this the travel of the strip through the gas closures can be improved by means of for example an efficient control of a steering roller provided at a sufficiently large distance upstream or downstream of the closure.

[0023] It is noted that an M-shape furnace design with a free hanging center loop of the strip is not known from publications, nor is known to exist in this industrial application. While inverted U-shape furnace designs are well known for bright-annealing, normal U-shape furnace designs, through which strip can be guided as a free-hanging loop between two top roller chambers, are also known in the state of the art for other purposes than bright-annealing, like for example for open flame annealing using direct firing burners. See for example JP-51109204 and NL-1013752. Those known U-shape furnace designs however are not integrated into an M-shape treatment

tunnel and more importantly are unsuitable for bright-annealing. This is particularly because U-shaped furnaces are not built for containing a highly explosive shielding gas containing H₂. If such furnace were filled with a H₂ containing shielding gas this would immediately burn / explode when used in combination with their direct firing burners. But even when used with indirect heaters, then a number of H₂ explosion hazards still would be created in a U-shaped furnace with openings at its top.

[0024] The light H₂ gas could then easily escape in the upwards direction via the strip inlet and outlet which are present at the upper ends of the legs of the U-shape. Thus, the highly combustible H₂ gas could then easily escape from the furnace interior to the surrounding air and air could then enter the H₂ containing furnace, replacing the escaped H₂.

[0025] With strip inlet and outlet at the top a small leak in a lower furnace section would create the risk of air entering in the H₂ furnace atmosphere, due to the stack action of the hot furnace.

[0026] If there would be a failure of top seals of the strip inlet and outlet, or those seals would accidentally stay open for a prolonged time, then a very dangerous situation could quickly result, because large amounts of the H₂ gas would then naturally escape and flow out into the environment because of its lighter weight compared to the surrounding air, causing almost immediately a fire or explosion hazard.

[0027] In conclusion, the explosion and fire hazards of a U-shaped furnace would be completely unacceptable for bright-annealing, and such design would not be approved by any regulatory safety authority. Hence, the present invention of an M-shape treatment tunnel with dedicated inlet and outlet tunnels in the first and fourth leg presents an entirely new approach to bright-annealing installations.

[0028] In a preferred embodiment according to the present invention the heating station extends at least along part of the second leg, while the cooling station extends along at least part of the third leg. Thus the lower turning section can either be used for the heating of the metal strip guided past it, or for already starting to slowly cooling the strip after it has been annealed sufficiently. This helps to improve the capacity of the installation and/or the quality of the annealing process.

[0029] In a particular embodiment according to the present invention the heating station is provided to extend not only along the second leg, but also along the lower turning section and along a lower part of the third leg. The cooling station is then provided to extend along an upper part of the third leg. This advantageously makes it possible to further increase the production capacity and/or to lower the production costs owing to a greater length of strip treatment tunnel along which the heating and cooling of the strip can take place. Furthermore, the height of the part of the heating station along the lower part of the third leg can be chosen such that the transition with the cooling station can advantageously be posi-

tioned in a part of the free hanging loop where the strip already runs steep and nearly vertical. This substantially minimizes the chance of the strip accidentally running against this transition and/or against walls of the cooling station. Also this makes it possible to make the opening of the transition sharply reduced relative to the tunnel width inside the third chamber. This slender transition helps to prevent heat losses towards the cooling station.

[0030] In an alternative embodiment, the heating station ends right after the lower turning section and the cooling station begins immediately after the lower turning section. This is particularly possible if used in combination with the provision of a pre-heating station extending along an upper part of the first and/or an upper part of the second leg, because then the strip can still be brought to its required annealing temperature in one and the same leg when passing the heating station provided there along. If for example the upper part of the second leg is used for such a pre-heating station, then the pre-heating station can be built as jet pre-heating station which comprises ventilators for blowing hot gas against the strip in order to thus preheat it to a temperature of up to 850 degrees Celsius. The heating station below it in the second leg, for example a muffle type heating station, can then be used to heat the strip to a temperature of up to 1100 degrees Celsius or more. The third leg can then advantageously be used in its entirety to cool the strip back to an acceptably low temperature of for example 150 degrees Celsius, before having it run over the second top roller chamber. It is then also possible to use the lower turning section as (soft) cooling section in which a gradual cooling back of the annealed strip can already start to take place.

[0031] The heating station can be formed by one single or a plurality of heating chambers. Preferably however, the heating station comprises at least three separate heating chambers. A first chamber extending along the second leg, a second chamber extending along the lower turning section, and a third chamber extending along the lower part of the third leg. Those distinctive heating chambers are separated from each other by means of substantially gastight flexible connections, in particular flexible (stainless steel) bellows. By splitting up the heating station in three chambers, each of the chambers can comprise its own set of heating means and/or its own type of heating means and construction, and can be better shielded from interaction between heating station sections. The second chamber for example can be kept at a relative lower temperature than the first and third chambers. The choice of insulation and heating means for this second chamber then becomes less critical for being able to maintain a low dew point in the annealing process. Since no heating energy is lost at the transitions between the first and second and between the second and third chamber, those gastight flexible connections can be construed with relative large passages so that the strip can run freely through the transitions without getting damaged by bumping or running against them. Any heat ra-

diated from the preferably hotter first and /or third chamber towards the second chamber there aids to the heating of this second chamber.

[0032] Because of movements/deformations of the strip in the first chamber (bulging or warping caused by tempering of rolling tensions in the strip) a difference in strip temperature can start to occur over the width of the strip. By selecting the temperature of the second chamber closer to the temperature that the strip reaches at the end of the first chamber, those differences in strip temperature can be diminished. This aids to the strip being able to reach better temperature uniformity over its entire width at the end of the third chamber.

[0033] The first, second and third heating chambers can be of the muffle or of the refractory type. All kinds of combinations are possible. This selection may depend on the energy costs in a particular building location for the installation, the desired strip annealing temperature, or the preference of the user. Refractory type heating chambers make it possible to obtain higher production capacities, but require an insulation layer of special high purity Al₂O₃ grade heat-resistant bricks which take a long time to be heated-up and conditioned to the low dew point condition required for processing, or to be cooled down again. Muffle type heating chambers can more quickly be heated to their low dew point condition and cooled down again, because the shielding gas comes only in direct contact with the muffle and not with the furnace insulation layer (for example ceramic fibres) surrounding the muffle.

[0034] The second heating chamber preferably is of the refractory type with the heating means directly radiating heat towards the strip during a process of annealing. With the lower operating temperature of the second chamber, this second chamber for example can be entirely or largely covered with fibre isolation and be heated with standard Cr/Ni electrical resistance heating elements, or with radiation tubes. This makes it possible to quickly heat up and cool down and/or condition this second chamber.

[0035] This being able to quickly heat up and/or cool down the second chamber is beneficial in the case of strip breakage. If the strip breaks it falls freely downward into the bottom of the part of the heating station extending along the lower turning section, in this case the bottom of the second chamber. By positioning both ends of the broken strip by means of suitably driving the rollers of the top roller chambers, both strip ends can be brought in the bottom of the heating station. By providing this bottom with a lock door it is possible to simply and quickly connect the two strip ends together again. Furthermore, the bottom can be provided with a special receiving section with gas closures to form a sluice. The sluice helps to prevent shielding gas from escaping when opening the lock door for re-connecting a broken strip and prevents the rest of the heating station to be exposed to the air.

[0036] In a variant an upper part of the entrance chute

is provided with a further shielding gas gate such that together with the shielding gas closure near the strip inlet at the lower part of the entrance chute, a sluice for shielding gas is formed. Likewise, an upper part of the discharge chute can also be provided with a further shielding gas gate such that together with the shielding gas closure near the strip outlet at the lower part of the discharge chute, a sluice for shielding gas is formed. The sluices make it possible to fill the entrance and/or discharge chutes with other types of shielding gases than what is used in the actual processing zone of the heating and cooling stations. For example the shielding gas in the chutes may have a lower content of hydrogen and a higher dew point than what is needed in the actual processing zone, whereas in the heating and cooling stations a shielding gas with a high amount of hydrogen (mostly 70-100% H₂, rest N₂) and a very low dew point (in particular lower than -40 °C) is needed. The use of low H₂ content shielding gas in the chutes saves costs and enhances the safety of the installation because of a lower danger of fire or explosion with the lower H₂ content shielding gas in the chutes, both during normal annealing processing as well as during short time openings of the inlet and/or outlet gas closures. It also makes it possible to circulate the shielding gas in the heating and cooling station through a gas cleaning and conditioning system in order to keep it in proper condition, without having to do the same for the gas in the chutes. If the strip deviates sideways in its inlet or outlet closure, it may become necessary to temporarily open the closure to reposition the strip in its correct (centre) position. This temporary opening of the closure may also be necessary if a welding seam of the strip needs to pass the closure. Because of the provision of the sluices, and the lower H₂ content shielding gas present therein, a temporary opening of the closures advantageously is of a lesser problem than would be the case if the chutes were to be filled with the same explosive and expensive high-grade shielding gas as used in the heating and cooling stations.

[0037] Further advantageous embodiments are stated in the subclaims.

[0038] The invention also relates to the use of an annealing installation according to claim 18 or 19.

[0039] The invention shall be explained in more detail below with reference to the accompanying drawings, in which:

Fig. 1 schematically shows a first embodiment of an annealing installation according to the invention having two muffle type and one refractory type heating chamber;

Fig. 2 shows a variant of fig. 1 having a pre-heating station in an upper part of the first leg;

Fig. 3 shows another variant of fig. 1 having one muffle type and two refractory type heating chambers; and

Fig. 4 shows another variant of fig. 1 having a pre-heating station in an upper part of the second leg.

[0040] In fig. 1 the annealing installation in its entirety has been given the reference numeral 1. The installation 1 comprises an M-shaped treatment tunnel which is successively delimited by an entrance chute 2, a first top roller chamber 3, a first muffle type heating chamber 4, a second refractory type heating chamber 5, a third muffle type heating chamber 6, a static cooling section 7, a jet-cooling section 8, a second top roller chamber 9 and a discharge chute 10. During an annealing process a strip 14 is run at substantially continuous speed through the tunnel by suitable actuation of strip feeding means and strip discharging means, in order for the strip to be annealed at a certain desired annealing temperature during a certain period of time, and thereafter to be cooled down again. The strip feeding and discharging means can be provided in upstream of the inlet and downstream of the outlet and for example can be formed by driven rollers.

[0041] The entrance chute 2 delimits a first leg of the M-shape, and is provided with a gas closure 16 at its inlet 17 and with a gas gate 18 in its upper part. The gas closure comprises a set of rollers between which the strip is able to run substantially gastight through them to enter the chute. The sluice formed in between the gas closures 16 and gas gate 18 is filled with a shielding gas. The gas gate 18 may for example be formed by mechanical means (rollers) or aerodynamic means (gas knives).

[0042] The top roller chambers 3, 9 each comprise a set of guidance rollers 20, 21 which guide the strip 14 from running vertically upwards to vertically downwards. The guidance rollers preferably are connected to drives for driving them in rotation whenever necessary.

[0043] The first heating chamber 4 delimits a second leg of the M-shape and comprises a long cylindrical muffle 24 which is enclosed by an insulation casing 25, in which heating means (burners) are disposed for externally heating the muffle 24. The muffle is thus able to indirectly heat up the strip 14 running through it. Since the muffle 24 reaches very high temperatures, it will expand considerably in the longitudinal direction. The muffle 24 has the freedom to expand upwardly by means of an expansion section 26, in particular a balanced expansion section according to EP 0 914 481. At its lower side the muffle 24 is connected to the second heating chamber 5 by means of a gastight flexible stainless steel bellows 27. This bellows 27 also is able to take up expansion of the muffle 24.

[0044] The second heating chamber 5 delimits a lower turning section of the M-shape and comprises an insulation wall with electrical heating elements mounted in front thereof. The heating elements are thus able to directly heat up the strip 14 running past them. In its bottom the chamber 5 is provided with a sluice 28 having a lock door 29. The sluice comprises a gas closure 30 formed for example by suitable rollers or movable gates. If desired protective rollers or another type of strip catching device may be provided at the bottom, which during normal annealing processing do not have to come into contact with the strip. At its upper side the chamber 5 is con-

nected to the third heating chamber 6 by means of a gastight flexible stainless steel bellows 31.

[0045] The third heating chamber 6 delimits a lower part of the third leg of the M-shape, in particular about half the length of the third leg, and comprises a long cylindrical muffle 34 which is enclosed by an insulation casing 35, in which heating means are disposed for externally heating the muffle 34. Expansion again is taken up at the lower side of the muffle 34 by the bellows 31. The muffle 34 also has the freedom to expand upwardly by means of an expansion section, in particular an expansion section according to EP 0 914 481.

[0046] Together the chambers 4, 5 and 6 form a heating station with a total length along which the strip 14 is well able to obtain its required annealing treatment. The hottest point HP of the strip 14 occurs at the end of the third heating chamber 6. The static cooling section 7 and the jet-cooling section 8 together form a cooling station with a total length along which the annealed strip 14 is well able to be cooled down again to a temperature below the maximum temperature allowable in the second top roll station (in particular below 250 C).

[0047] The discharge chute 10 delimits a fourth leg of the M-shape, and is provided with a gas closure 36 at its outlet 37 and with a gas gate 38 in its upper part. The gas closure comprises a set of rollers between which the strip is able to run substantially gastight through them to exit the chute. The sluice formed in between the gas closure 36 and gas gate 38 is filled with a shielding gas. The gas gate 38 may for example be formed by mechanical means (rollers) or aerodynamic means (gas knives).

[0048] In the upper part of the discharge chute 10 an after-cooling station 40 is provided which is of the jet-cooling type. The gas gate 38 is provided just beneath this after-cooling station 40.

[0049] The top roller chamber 3, the heating chambers 4, 5, 6, the static cooling section 7, the jet-cooling section 8, the top roller chamber 9 and the after-cooling station 40 are all constructed gastight and are all connected gastight with each other such that they can be filled with a shielding gas suitable for the required annealing process, for example H₂, H₂/N₂, Argon or the like. The shielding gas used in the entrance and discharge chutes 2, 10 is chosen different from the shielding gas used in the heating and cooling stations, in particular with a lower content of H₂.

[0050] In fig. 2 a variant is shown in which the upper part of the entrance chute 2 is provided with a pre-heating station 45 of the jet-preheating type. Flue gasses coming from the burners of the first and third heating chambers 4, 6 are used to indirectly heat the pre-heating station 45. The heat of those flue gasses can for example by means of gas heat exchangers be transmitted to a shielding gas circulating through the pre-heating station. Thus, a further reduction in costs can be achieved.

[0051] In fig. 3 a further variant is shown in which the third heating chamber 6 is now of the refractory type having an insulation wall 50 with electrical heating elements

mounted in front thereof.

[0052] In fig. 4 a further variant is shown in which a pre-heating station 60 of the jet pre-heating type is provided along an upper part of the second leg of the M-shaped treatment tunnel. The pre-heating station 60 has been placed in line with a first muffle type heating chamber 61 which has been provided along a lower part of the second leg. A second refractory type heating chamber 62 delimits the lower turning section of the M-shape. The third leg of the M-shape is now entirely formed by a cooling station. This cooling station comprises a static cooling 63 and a jet cooling section 64.

[0053] The jet preheating station 60 operates like the other installation sections with the shielding gas and by means of forced convection transfers its heat to the strip. The advantage of this embodiment is that a second muffle-type heating chamber is no longer necessary. This makes the construction of the installation easier and cheaper. The strip can be even be pre-heated to temperatures between 400-800 degrees Celsius in the pre-heating section, depending on the desired annealing process, the total costs and expenditure values. Advantageously the convection type pre-heating is able to more quickly heat up the strip compared to a muffle type heater. Thus, within only the length of the first leg it is still possible to reach the desired high annealing temperatures. The lower turning section can now advantageously be used as pure soaking section or as slow-cooling section, both of which only need a restricted capacity.

[0054] When it is desired to perform maintenance to the muffle type heating chamber 61, then the pre-heating section 60 can be displaced sideways such that the muffle can be lifted up in the vertical direction. In the embodiment shown, the third and fourth leg have been constructed somewhat shorter than the first and second leg, such that the pre-heating station 60 can be displaced sideways while moving over the third and fourth legs. Displacement of the pre-heating station 60 in another direction is however also possible if more length for the third and fourth legs is needed.

[0055] Besides the embodiments shown numerous variants are possible. For example the shapes and dimensions of the chutes, heating chambers and other parts may be varied. Also other types and numbers of heating stations and/or cooling stations can be used. Instead of the muffles mainly having to expand upwards, they can also be mounted such that they mainly expand in the downwards direction. The annealing installation preferably is used for bright annealing of stainless steel strip with the earlier mentioned BA quality. It can however also be used for quasi bright annealing of a so-called 2B quality rolled stainless steel strip. With the installation according to the invention such 2B grade strip can be annealed such that a further pickling treatment can fully or partly be eliminated, even when using a less critical shielding gas (lower % H₂ and higher dew point) than used for the BA quality. It is possible to maintain the strip temperature in the second top roller chamber relatively

high, for example 150-200 C, and use specially designed turning rollers which at that temperature do not damage the strip. It is then also possible to obtain a convective heat exchange between the entrance chute and the discharge chute by further cooling of the strip in the discharge chute and transporting this heat to the strip entering the entrance chute. This also may help to save energy.

[0056] Thus according to the invention an annealing installation is obtained which is not only improved in safety and annealing quality, but with which it is at the same time possible to reach a production capacity of 200,000-230,000 tons per year in an embodiment with two muffle type heating chambers, and a production capacity of even 300,000 tons per year or more in an embodiment with two refractory type heating chambers, as compared to typically 70,000-130,000 tons per year for state of the art vertical bright-annealing installations (of the inverted U type).

Claims

1. Annealing installation for the continuous annealing of metal strip guided through the installation, comprising:

- an entrance chute (2);
- a heating station with heating means;
- a cooling station with cooling means;

the entrance chute (2), the heating station and the cooling station being positioned one after the other and being connected to each other substantially gastight such that they delimit a longitudinal meandering substantially gastight strip treatment tunnel which is to be filled with a shielding gas and which has vertically directed tunnel parts connected to each other by means of a top roller chamber (3, 9) having at least one roller (20, 21) for guiding the strip (14) from the one to the other vertically directed tunnel part, the tunnel having a strip inlet (17) and a strip outlet (37) at its respective outer ends which are both provided with shielding gas closures (16, 36),

characterized in that,

the installation further comprises a discharge chute (10) downstream of the cooling station and being connected substantially gastight thereto, the entrance chute (2), a first one (3) of the top roller chambers, the heating station, the cooling station, a second one (9) of the top roller chambers and the discharge chute

(10) together delimiting an M-shaped meandering tunnel with four legs connected with each other via the two top roller chambers (3, 9) and a lower turning section, in which:

- the entrance chute (2) extends along the first one of the legs;
- the heating and the cooling stations extend along the second one of the legs, the lower turning section and the third one of the legs; and
- the discharge chute (10) extends along the fourth one of the legs,

in which strip feeding means and strip discharging means are provided for continuously guiding the strip (14) as a free-hanging loop between the two top roller chambers (3, 9) through the heating and cooling stations extending along the second leg, the lower turning section and the third leg during a process of annealing, and in which the strip inlet (17) and the strip outlet (37) are provided at lower ends of the entrance and discharge chutes (2 resp. 10).

2. Annealing installation according to claim 1, wherein the heating station extends at least along part of the second leg, and wherein the cooling station extends at least along part of the third leg.
3. Annealing installation according to claim 2, wherein the heating station further extends along the lower turning section.
4. Annealing station according to one of the preceding claims, wherein the cooling station extends along substantially the entire third leg.
5. Annealing installation according to claim 3, wherein the heating station further extends along a lower part of the third leg, and wherein the cooling station extends along an upper part of the third leg.
6. Annealing installation according to one of claims 3-5, wherein the heating station comprises at least two separate heating chambers (4, 5):
 - a first chamber (4) extending along the second leg, and
 - a second chamber (5) extending along the lower turning section,

the chambers being separated from each other by means of substantially gastight flexible connections.
7. Annealing installation according to claims 5 and 6,

wherein the heating station further comprises:

- a third chamber (6) connecting to the second chamber (5) and extending along the lower part of the third leg.

8. Annealing installation according to claim 6 or 7, wherein the heating chambers (4, 5, 6) are separated from each other by means of substantially gastight flexible betiows (27).
9. Annealing installation according to one of the preceding claims 6-8, wherein the second heating chamber (5) is of the refractory type with the heating means directly radiating heat towards the strip (14) during a process of annealing.
10. Annealing installation according to one of the preceding claims, wherein an upper part of the entrance chute (2) is provided with a further shielding gas gate (18) such that together with the shielding gas closure (16) near the strip inlet (17) at the lower part of the entrance chute (2), a sluice for shielding gas is formed, and/or wherein an upper part of the discharge chute (10) is provided with a further shielding gas gate (38) such that together with the shielding gas closure (36) near the strip outlet (37) at the lower part of the discharge chute (10), a sluice for shielding gas is formed.
11. Annealing installation according to one of the preceding claims, wherein the entrance chute (2) extending along the first leg in its upper part comprises a pre-heating station (45).
12. Annealing installation according to one of the preceding claims, wherein the discharge chute (10) extending along the fourth leg in its upper part comprises an after-cooling station (40).
13. Use of an annealing installation according to one of the preceding claims for the annealing of metal strip, comprising the steps of:
 - filling the M-shaped meandering tunnel with a protective shielding gas; and
 - annealing metal strip (14) by guiding it through the M-shaped tunnel while having it heated in the heating station and then having it cooled in the cooling station.
14. Use according to claim 13 for the bright-annealing of stainless steel strip (14), wherein the shielding gas contains at least 50% H₂, and wherein the heating station is heated to a temperature of at least 850 degrees Celsius in order to heat the stainless steel strip (14) therein to a temperature of at least 700 degrees Celsius.

15. Use according to claim 13 or 14, wherein a low H2 percentage shielding gas is present in the first and fourth leg, separated from a high H2 percentage shield gas in the second and third legs.

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Patentansprüche

1. Ausglühinstallation für das kontinuierliche Ausglühen eines Metallstreifens, welcher durch die Installation geführt wird, umfassend:

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- einen Eingangsschacht (2);
- eine Heizstation mit Heizmitteln;
- eine Kühlstation mit Kühlmitteln;

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wobei der Eingangsschacht (2), die Heizstation und die Kühlstation nacheinander angeordnet sind und miteinander im Wesentlichen gasdicht derart verbunden sind, dass sie einen längs laufenden geschlängelten im Wesentlichen gasdichten Streifenbearbeitungstunnel begrenzen, welcher mit einem Schutzgas zu füllen ist und welcher vertikal gerichtete Tunnelteile aufweist, welche miteinander mittels einer oberen Rollenkammer (3, 9) verbunden sind, welche mindestens eine Rolle (20, 21) zum Führen des Streifens (14) von dem einen zu dem anderen vertikal gerichteten Tunnelteil aufweist,

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dadurch gekennzeichnet, dass

die Installation ferner einen Ausgangsschacht (10) stromabwärts von der Kühlstation umfasst und damit im Wesentlichen gasdicht verbunden ist, der Eingangsschacht (2), eine erste (3) der oberen Rollenkammern, die Heizstation, die Kühlstation, eine zweite (9) der oberen Rollenkammern und der Ausgangsschacht (10) zusammen einen M-förmigen geschlängelten Tunnel mit vier Beinen begrenzen, welche miteinander über die zwei oberen Rollenkammern (3, 9) und einen unteren Wendeabschnitt verbunden sind, wobei:

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- sich der Eingangsschacht (2) entlang dem ersten der Beine erstreckt;
- sich die Heiz- und die Kühlstation entlang dem zweiten der Beine, dem unteren Wendeab-

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schnitt und dem dritten der Beine erstrecken; und
- sich der Ausgangsschacht (10) entlang dem vierten der Beine erstreckt,

wobei Streifenzuführungsmittel und Streifenausgangsmittel vorgesehen sind für ein kontinuierliches Führen des Streifens (14) während eines Ausglühvorgangs als eine frei hängende Schleife zwischen den zwei oberen Rollenkammern (3, 9) durch die Heiz- und Kühlstation, welche sich entlang dem zweiten Bein, dem unteren Wendeabschnitt und dem dritten Bein erstrecken, und wobei der Streifeneinlass (17) und der Streifenauslass (37) an unteren Enden des Eingangs- und Ausgangsschachts (2 bzw. 10) vorgesehen sind.

2. Ausglühinstallation nach Anspruch 1, wobei sich die Heizstation zumindest entlang eines Teils des zweiten Beins erstreckt, und wobei sich die Kühlstation zumindest entlang eines Teils des dritten Beins erstreckt.

3. Ausglühinstallation nach Anspruch 2, wobei sich die Heizstation ferner entlang dem unteren Wendeabschnitt erstreckt.

4. Ausglühinstallation nach einem der vorhergehenden Ansprüche, wobei sich die Kühlstation im Wesentlichen entlang dem dritten Bein erstreckt.

5. Ausglühinstallation nach Anspruch 3, wobei sich die Heizstation ferner entlang einem unteren Teil des dritten Beins erstreckt, und wobei sich die Kühlstation entlang einem oberen Teil des dritten Beins erstreckt.

6. Ausglühinstallation nach einem der Ansprüche 3-5, wobei die Heizstation mindestens zwei getrennte Heizkammern (4, 5) umfasst:

- eine erste Kammer (4), welche sich entlang dem zweiten Bein erstreckt, und
- eine zweite Kammer (5), welche sich entlang dem unteren Wendeabschnitt erstreckt,

wobei die Kammern mittels im Wesentlichen gasdichter flexibler Verbindungen voneinander getrennt sind.

7. Ausglühinstallation nach Anspruch 5 und 6, wobei die Heizstation ferner umfasst:

eine dritte Kammer (6), welche mit der zweiten Kammer (5) verbunden ist und sich entlang dem unteren Teil des dritten Beins erstreckt.

8. Ausglühinstallation nach Anspruch 6 oder 7, wobei die Heizkammern (4, 5, 6) voneinander mittels im Wesentlichen gasdichter flexibler Bälge (27) getrennt sind.
9. Ausglühinstallation nach einem der vorhergehenden Ansprüche 6-8, wobei die zweite Heizkammer (5) von einer hitzebeständigen Art ist, wobei das Heizmittel während eines Ausglühvorgangs Hitze direkt in Richtung des Streifens (14) strahlt.
10. Ausglühinstallation nach einem der vorhergehenden Ansprüche, wobei ein oberer Teil des Eingangsschachts (2) mit einem weiteren Schutzgasdurchgang (18) versehen ist, so dass zusammen mit dem Schutzgasverschluss (16) nahe dem Streifeneinlass (17) an dem unteren Teil des Eingangsschachts (2) eine Schleuse für das Schutzgas ausgebildet wird, und/oder wobei ein oberer Teil des Ausgangsschachts (10) mit einem weiteren Schutzgasdurchgang (38) versehen ist, so dass zusammen mit dem Schutzgasverschluss (36) nahe dem Streifenauslass (37) an dem unteren Teil des Ausgangsschachts (10) eine Schleuse für das Schutzgas ausgebildet wird.
11. Ausglühinstallation nach einem der vorhergehenden Ansprüche, wobei der Eingangsschacht (2), welcher sich entlang dem ersten Bein erstreckt, in seinem oberen Teil eine Vorheizstation (45) umfasst.
12. Ausglühinstallation nach einem der vorhergehenden Ansprüche, wobei der Ausgangsschacht (10), welcher sich entlang dem vierten Bein erstreckt, in seinem oberen Teil eine Nachkühlstation (40) umfasst.
13. Verwendung einer Ausglühinstallation nach einem der vorhergehenden Ansprüche für das Ausglühen eines Metallstreifens, umfassend die Schritte:
- Füllen des M-förmigen geschlängelten Tunnels mit einem schützenden Schutzgas; und
 - Ausglühen eines Metallstreifens (14) durch Führen durch den M-förmigen Tunnel, während er in der Heizstation erwärmt wird und dann in der Kühlstation gekühlt wird.
14. Verwendung nach Anspruch 13 für das Blankglühen eines Edelstahlstreifens (14), wobei das Schutzgas mindestens 50 % H₂ enthält, und wobei die Heizstation auf eine Temperatur von mindestens 850 °C erhitzt wird, um den Edelstahlstreifen (14) darin auf eine Temperatur von mindestens 700 °C zu erhitzen.
15. Verwendung nach Anspruch 13 oder 14, wobei ein Schutzgas mit einem geringen H₂-Prozentsatz in dem ersten und vierten Bein vorhanden ist, welches von einem Schutzgas mit einem hohen H₂-Prozent-

satz in dem zweiten und dritten Bein getrennt ist.

Revendications

1. Installation de recuit pour le recuit continu de ruban en métal guidé à travers l'installation, comprenant:

une goulotte d'entrée (2);
 une station de chauffage avec des moyens de chauffage;
 une station de refroidissement avec des moyens de refroidissement;
 la goulotte d'entrée (2), la station de chauffage et la station de refroidissement étant positionnées les unes après les autres et étant raccordées entre elles de manière sensiblement étanche au gaz de sorte qu'elles délimitent un tunnel de traitement de ruban sensiblement étanche au gaz formant des méandres longitudinaux qui doit être rempli avec un gaz protecteur et qui a des parties de tunnel dirigées verticalement raccordées entre elles au moyen d'une chambre de rouleau supérieure (3, 9) ayant au moins un rouleau (20, 21) pour guider le ruban (14) de l'une à l'autre partie de tunnel dirigée verticalement,
 le tunnel ayant une entrée de ruban (17) et une sortie de ruban (37) au niveau de ses extrémités externes respectives qui sont toutes deux prévues avec des fermetures de gaz protecteur (16, 36),

caractérisée en ce que:

l'installation comprend en outre une goulotte de décharge (10) en aval de la station de refroidissement et y étant raccordée de manière sensiblement étanche au gaz,
 la goulotte d'entrée (2), une première chambre (3) des chambres de rouleau supérieures, la station de chauffage, la station de refroidissement, une deuxième chambre (9) des chambres de rouleau supérieures et la goulotte de décharge (10) délimitant ensemble un tunnel formant des méandres en forme de M avec quatre sections raccordées entre elles via les deux chambres de rouleau supérieures (3, 9) et une section de retournement inférieure, dans laquelle:

la goulotte d'entrée (2) s'étend le long de la première des sections;
 les stations de chauffage et de refroidissement s'étendent le long de la deuxième des sections, la section de retournement inférieure et la troisième des sections; et
 la goulotte de décharge (10) s'étend le

long de la quatrième des sections, dans laquelle les moyens d'alimentation en ruban et les moyens de décharge de ruban sont prévus pour guider de manière continue le ruban (14) comme une boucle librement suspendue entre les deux chambres de rouleau supérieures (3, 9) à travers les stations de chauffage et de refroidissement s'étendant le long de la deuxième section, de la section de retournement inférieure et de la troisième section pendant un procédé de recuit, et dans laquelle l'entrée de ruban (17) et la sortie de ruban (37) sont prévues au niveau des extrémités inférieures des goulottes d'entrée et de décharge (2 resp. 10).

2. Installation de recuit selon la revendication 1, dans laquelle la station de chauffage s'étend au moins le long d'une partie de la deuxième section, et dans laquelle la station de refroidissement s'étend au moins le long d'une partie de la troisième section. 20
3. Installation de recuit selon la revendication 2, dans laquelle la station de chauffage s'étend en outre le long de la section de retournement inférieure. 25
4. Installation de recuit selon l'une des revendications précédentes, dans laquelle la station de refroidissement s'étend sensiblement le long de toute la troisième section. 30
5. Installation de recuit selon la revendication 3, dans laquelle la station de chauffage s'étend en outre le long d'une partie inférieure de la troisième section, et dans laquelle la station de refroidissement s'étend le long d'une partie supérieure de la troisième section. 35
6. Installation de recuit selon l'une des revendications 3 à 5, dans laquelle la station de chauffage comprend au moins deux chambres de chauffage séparées (4, 5); une première chambre (4) s'étendant le long de la deuxième section, et une deuxième chambre (5) s'étendant le long de la section de retournement inférieure, les chambres étant séparées l'une de l'autre au moyen de raccords flexibles sensiblement étanches au gaz. 40
7. Installation de recuit selon les revendications 5 et 6, dans laquelle la station de chauffage comprend en outre: 45

une troisième chambre (6) se raccordant à la deuxième chambre (5) et s'étendant le long de

la partie inférieure de la troisième section.

8. Installation de recuit selon la revendication 6 ou 7, dans laquelle les chambres de chauffage (4, 5, 6) sont séparées les unes des autres au moyen de soufflets flexibles sensiblement étanches au gaz (27). 5
9. Installation de recuit selon l'une des revendications 6 à 8, dans laquelle la deuxième chambre de chauffage (5) est du type réfractaire avec les moyens de chauffage qui rayonnent directement la chaleur vers le ruban (14) pendant un procédé de recuit. 10
10. Installation de recuit selon l'une des revendications précédentes, dans laquelle une partie supérieure de la goulotte d'entrée (2) est prévue avec une autre porte de gaz protecteur (18) de sorte que conjointement avec la fermeture de gaz protecteur (16) à proximité de l'entrée de ruban (17) au niveau de la partie inférieure de la goulotte d'entrée (2), un conduit de décharge pour le gaz protecteur est formé, et/ou dans laquelle une partie supérieure de la goulotte de décharge (10) est prévue avec une autre porte de gaz protecteur (38) de sorte que conjointement avec la fermeture de gaz protecteur (36) à proximité de la sortie de ruban (37) au niveau de la partie inférieure de la goulotte de décharge (10), un conduit de décharge pour le gaz protecteur est formé. 15
11. Installation de recuit selon l'une des revendications précédentes, dans laquelle la goulotte d'entrée (2) s'étendant le long de la première section dans sa partie supérieure comprend une station de préchauffage (45). 30
12. Installation de recuit selon l'une des revendications précédentes, dans laquelle la goulotte de décharge (10) s'étendant le long de la quatrième section dans sa partie supérieure comprend une station de post-refroidissement (40). 35
13. Utilisation d'une installation de recuit selon l'une des revendications précédentes pour le recuit de ruban en métal, comprenant les étapes consistant à: 40

remplir le tunnel formant des méandres en forme de M avec un gaz protecteur; et

recuire le ruban en métal (14) en le guidant à travers le tunnel en forme de M tout en l'ayant chauffé dans la station de chauffage et en l'ayant ensuite refroidi dans la station de refroidissement. 45
14. Utilisation selon la revendication 13 pour le recuit blanc du ruban en acier inoxydable (14), dans laquelle le gaz protecteur contient au moins 50% de H₂, et dans laquelle la station de chauffage est 50

chauffée à une température d'au moins 850 degrés Celsius afin de chauffer le ruban en acier inoxydable (14) à l'intérieur de cette dernière à une température d'au moins 700 degrés Celsius.

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15. Utilisation selon la revendication 13 ou 14, dans laquelle un gaz protecteur à faible pourcentage en H₂ est présent dans la première et la quatrième section, séparé du gaz protecteur à pourcentage élevé en H₂ dans les deuxième et troisième sections.

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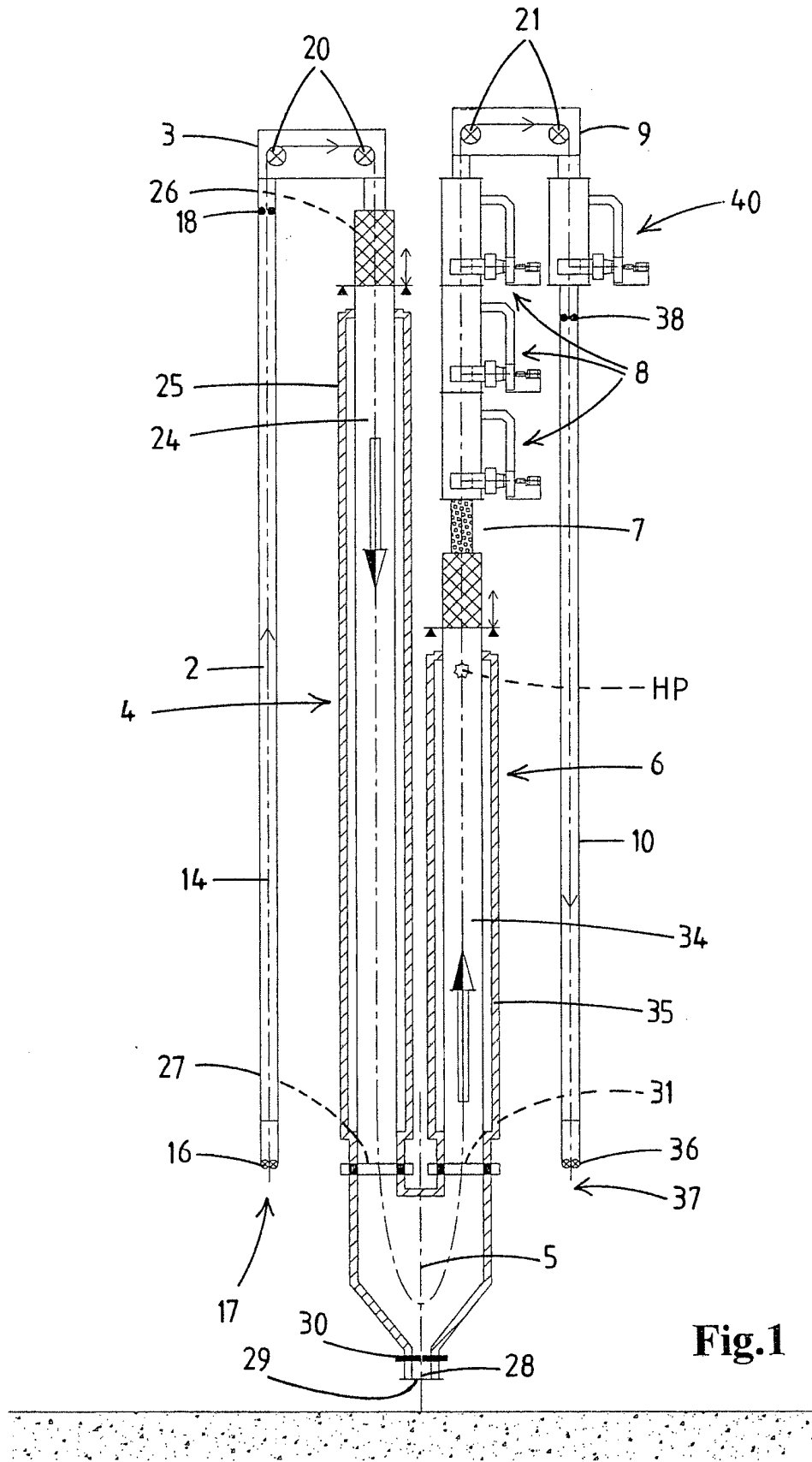


Fig.1

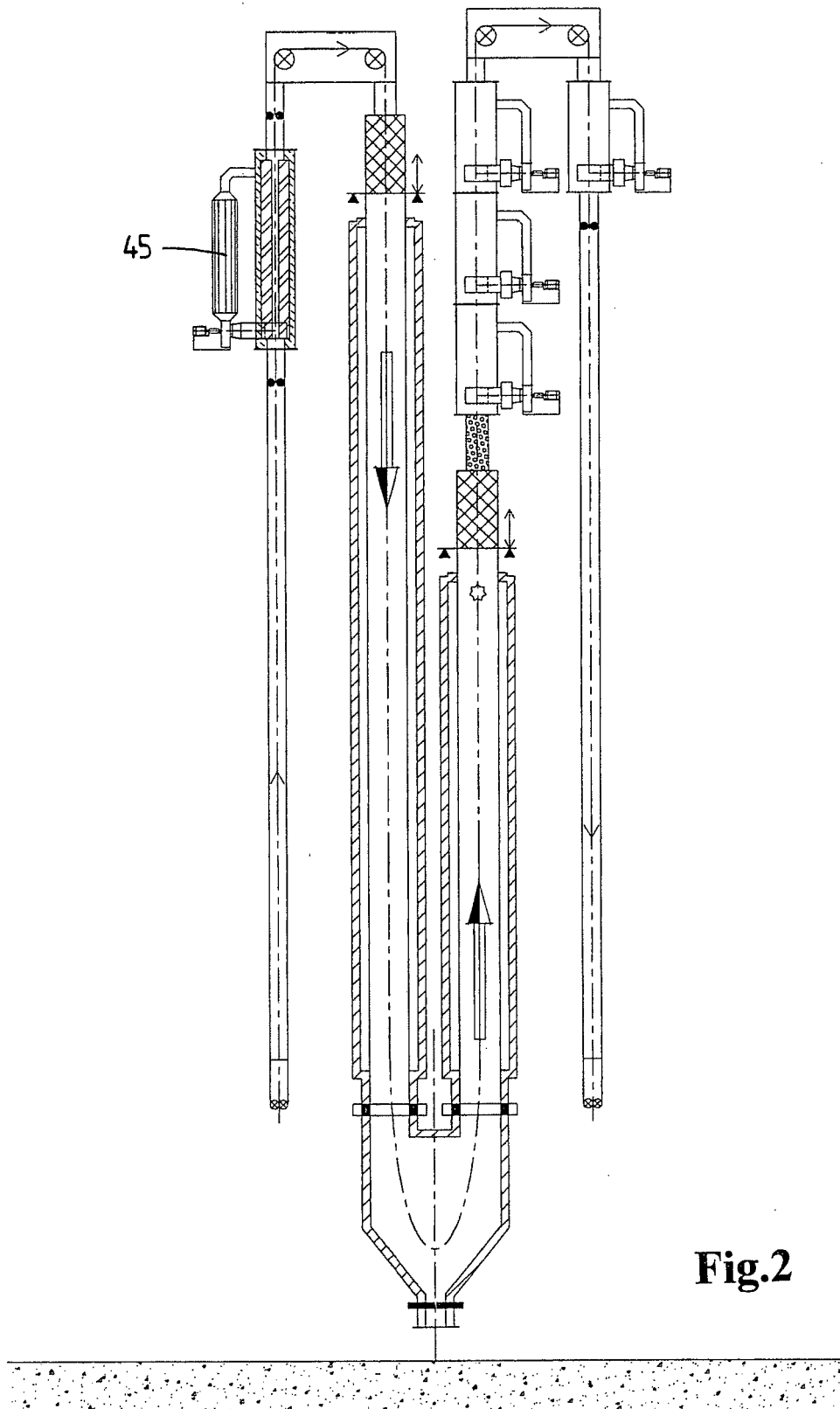
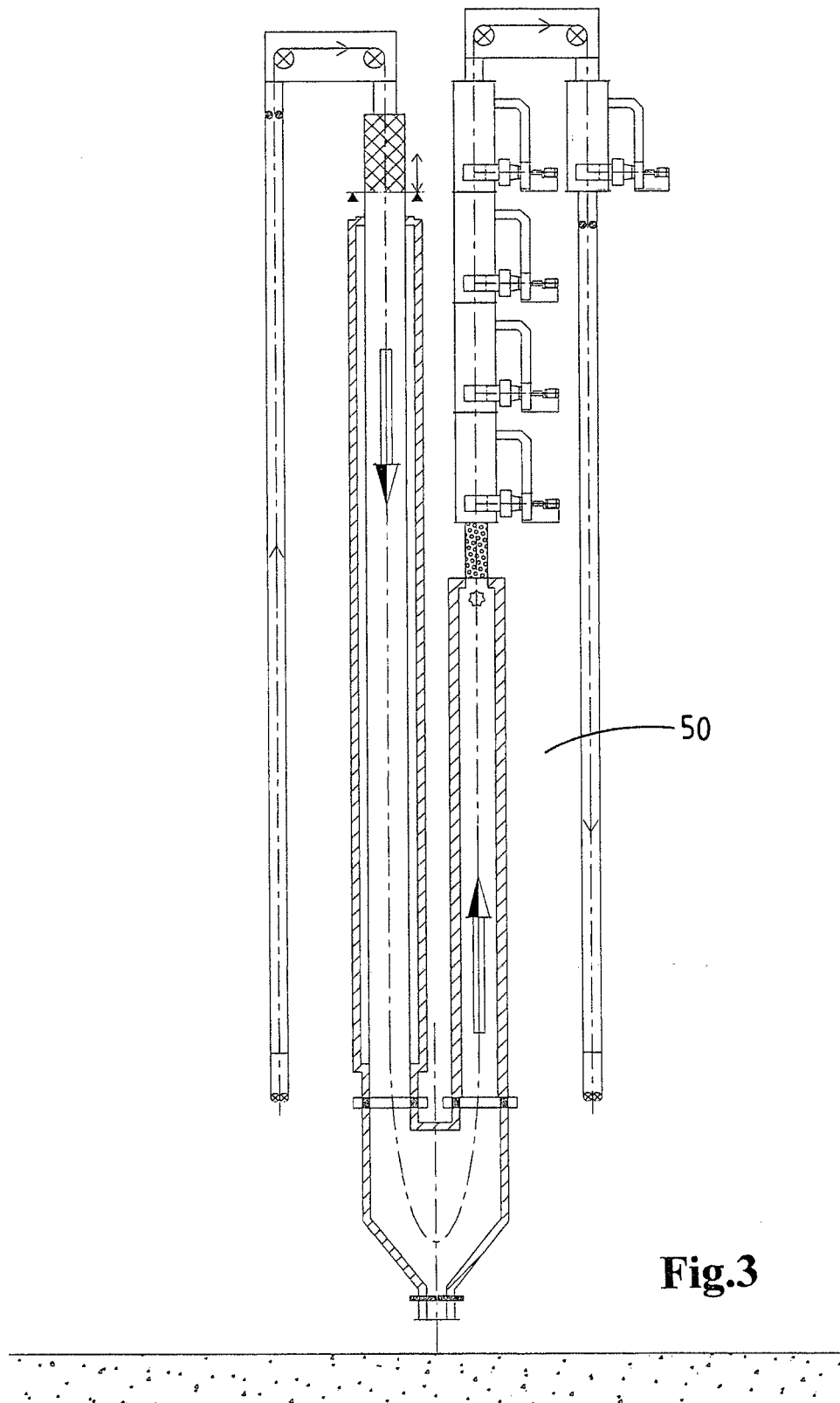


Fig.2



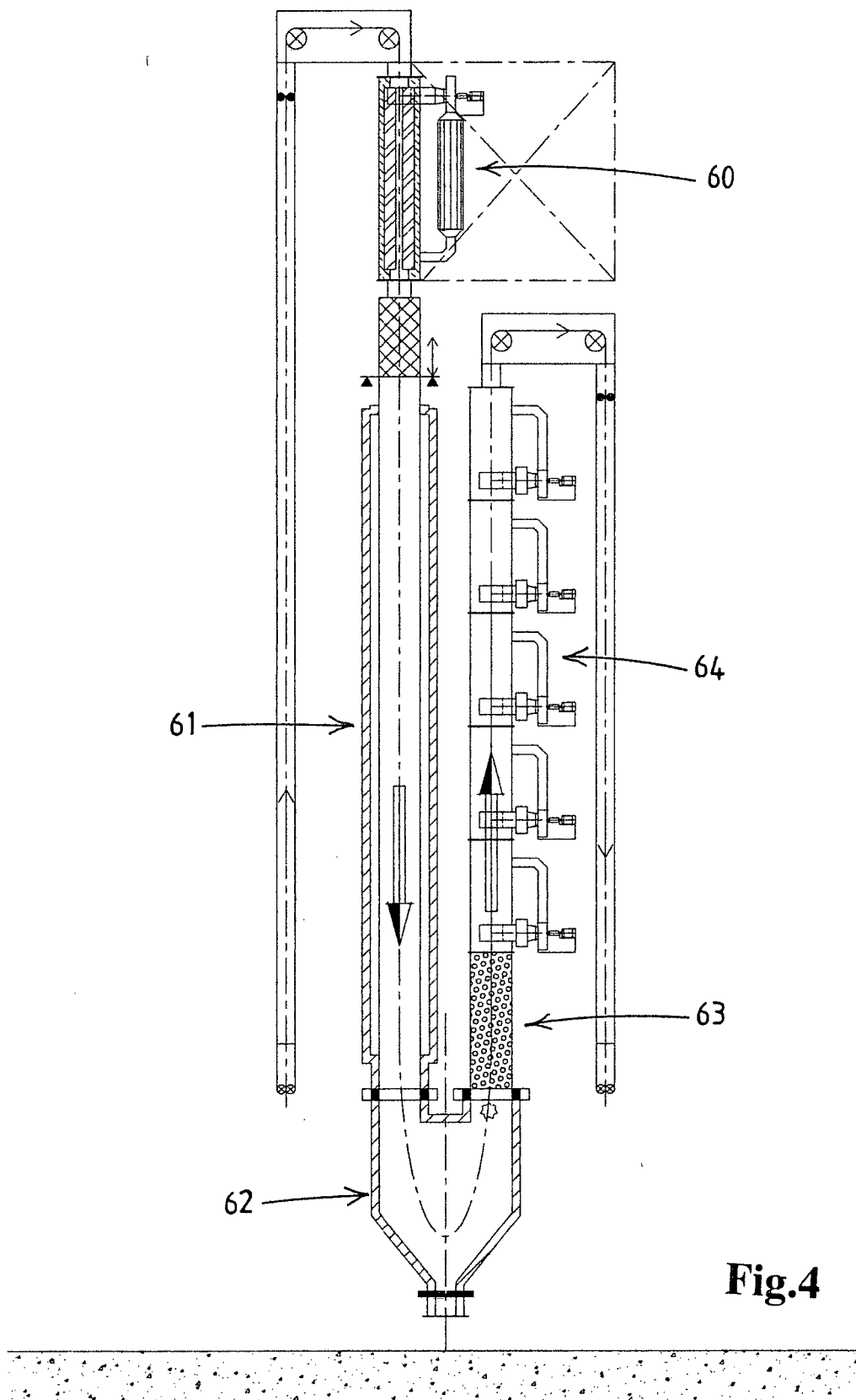


Fig.4

REFERENCES CITED IN THE DESCRIPTION

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