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APPARATUS FOR CONTINUOUS HEAT TREATMENT AND METAL-COATING OF METALLIC OBJECTS

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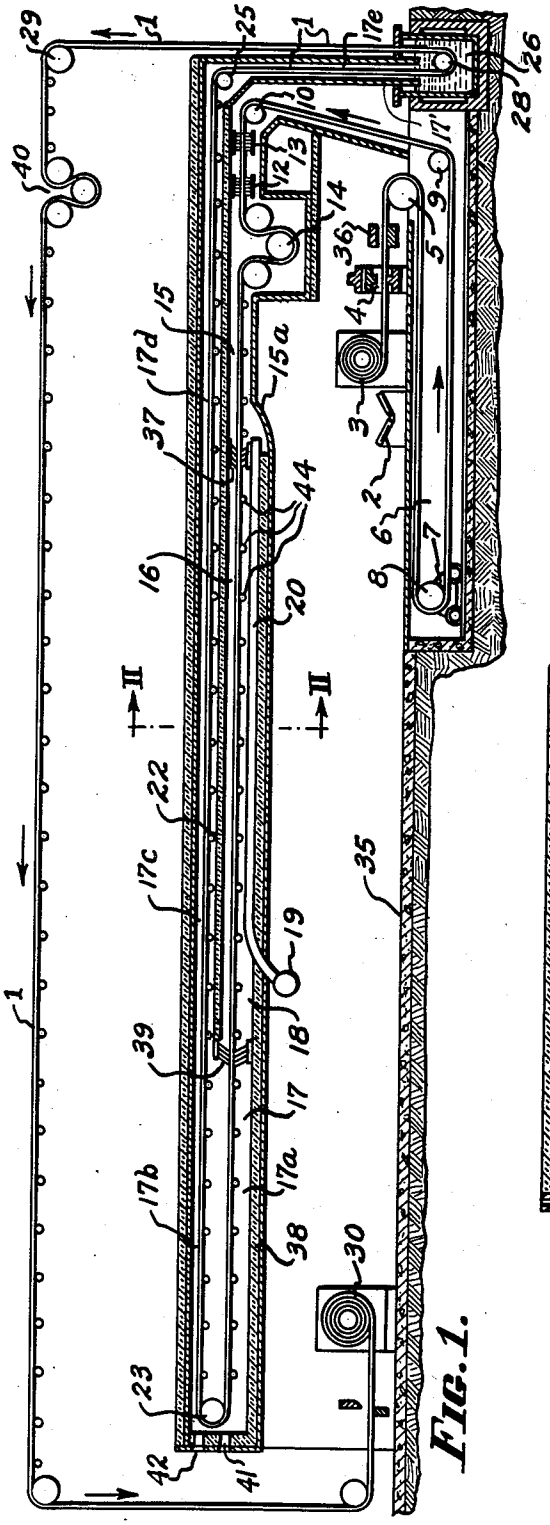


FIG. 1.

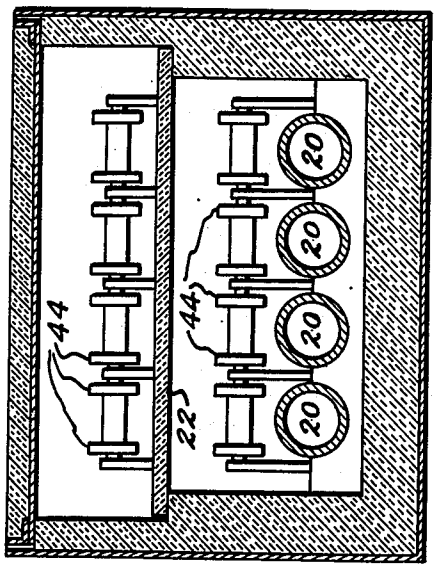


FIG. 2.

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APPARATUS FOR CONTINUOUS HEAT TREATMENT AND METAL COATING OF METALLIC OBJECTS

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13 Claims. (Cl. 91—12.5)

This invention is related to a process of coating metal objects with molten metal as set forth in my co-pending application Ser. No. 31,699, filed July 16, 1935, and entitled "Process for coating metal objects with a layer or layers of another metal," wherein the general process comprises treating the scale-free metallic object in such a way as to form upon its surfaces a very thin, uniform, reducible coating of oxide, hydroxide or the like, then subjecting the object to a heat treatment in a reducing atmosphere whereby the coating is reduced, then cooling the object to the required degree and passing it into a bath of the coating metal while protecting it and the bath with a neutral or reducing atmosphere. In the present case I set forth certain improvements in apparatus and process. The teachings of this case are also applicable to the process of my co-pending application Ser. No. 138,432 filed April 22, 1937, and entitled "Process for galvanizing sheet metal."

In processes where metallic strip, wire and the like are treated in a continuous manner, and especially where at least one part of the treatment is to take place at elevated temperatures, and/or in special atmospheres, the apparatus used in connection therewith must of necessity be very long. It therefore is expensive and is particularly subject to breakdowns and numerous disadvantages in actual shop practice. Also the mechanical parts used in such apparatus are subject to rapid wear and frequently require attention.

The present invention eliminates the above-named inconveniences and makes it possible to obtain certain advantages which make such processes still more valuable, as will be shown below.

The apparatus forming the subject of the present application relates primarily to processes in which a metal article, for instance a steel strip as it comes from a cold rolling mill, is first subject to a pre-treatment which may be a cleaning operation, either wet or dry, and which may also be a pre-heating operation in which the strip is slightly oxidized. Such pre-treatment may be followed by an annealing or normalizing operation under reducing or non-oxidizing conditions, a soaking or grain-growing period, preferably under a temperature slightly below the highest temperature to which the strip was heated during annealing or normalizing, and preferably under conditions of a slowly decreasing temperature, then a cooling period, carrying the strip down to a predetermined temperature, as required for the hot-dip in the metal bath used for coating, with preferably the latter portion of the cooling period accomplished at a faster rate of cooling than the first portion, when a soft low-carbon strip is to be obtained and the maximum length of the cooling chamber is limited. At the end of the cooling period comes the dip in the coating bath, or any other suitable means for bringing the surface of the strip into contact with the coating metal, under suitable conditions of said surface and said coating metal, and finally the withdrawal of the strip from such coating bath and solidification of the coating as by cooling.

Metal coated soft steel strip is in many instances required to be in an unhardened and ductile condition; and it has been found that such steel when heated above the upper critical range, or say 1750° F., must be cooled in the aforesaid manner for at least two to three, or even more minutes, down to the temperature at which it is dipped into the coating metal bath, such as zinc (for which metal the strip should have about 900 to 950° F. at the moment it is dipped) and then, on emerging from said metal bath, must be cooled naturally in air, in order to reach the required physical condition of softness and ductility.

In view of the fact that a strip should have a speed of at least 50 to 100 ft. per minute, if the unit is to produce on a paying basis, or say from 100 to 300 tons per 24 hrs. of a light gauge strip between 30 inches and 50 inches wide, it is clear that the cooling chamber alone must have a length of 100 to 300 ft. which, with the annealing part and the pre-heating part added to it, would make an installation very expensive in first cost, (as practically all of it must be gas-tight and heavily insulated) would take up a tremendous amount of floorspace and, what is still more important, would be very difficult to thread up and very capricious in operation, the inner portions of the installation being almost completely inaccessible.

In the practice of my invention the necessary over-all length is diminished by causing the strip to run through the furnace not in one straight line, but first in one direction through a heating portion of the furnace then returning it over a pulley situated usually in the first part of the cooling chamber, and back again either above or below the first portion of the furnace.

With the furnace constructed for forward and reverse travel of the strip or the like, a number of additional advantages are secured. The problem of gas seals is simplified since the furnace

is closed at one end. The problem of insulation is simplified because the two parts of the furnace can be insulated together. Heat exchange between parts of the furnace can be utilized to good effect.

By my invention, also, the furnace is raised, with the utilization of the space beneath to save additional floor space, and with a betterment of the working conditions near the furnace.

The objects of my invention will be apparent to one skilled in the art from the foregoing discussion and from the description which follows. The objects of my invention are attained by that certain construction and arrangement of parts of which I shall now describe a typical or exemplary embodiment. Reference is made to the drawing which forms a part hereof and in which:

Figure 1 is an elevational and semi-diagrammatic view of the organization of the apparatus, with the furnace and attendant parts shown in longitudinal section.

Fig. 2 is a lateral section of the furnace taken along the lines II—II of Figure 1.

The typical embodiment of the present invention is shown in Fig. 1. The whole heat treatment unit is here shown elevated clear off the floor level 35, so that the space under the furnace may be used for uncoiling and handling the raw coils as well as for coiling or shearing the finished coated material. This also tends to make the working conditions in the shop more comfortable, since no men are required to work in close proximity to the furnace, and the dissipated heat rises towards the top of the building.

The strip is here indicated at 1. A roller conveyor is shown at 2, on which a coil is deposited and which may be tilted so that the coil is deposited by gravity upon the uncoiler 3. A stitcher 4 or a welding machine or the like is employed to connect the trailing end of one coil with the leading end of the next one. As this operation may take as long as one minute, a looping means is provided, preferably in a ditch 6, the strip 1 passing successively over the pulleys 5, 8 and 9, of which the pulley 8 is mounted upon a carriage pulled in any convenient way, such as by gravity, or driven by a suitable special electric motor, as is known in the art, so as to exert a certain tension on the strip.

When a new strip is to be joined, the trailing end of the first strip is firmly held, as by a brake 36. Thereupon the pulley 8 begins to move with its carriage 7 towards the pulleys 5 and 9 and against its motor which, in this instance turns in a direction opposite to its torque. This occurs because the furnace takes up the strip always at a constant rate of speed, and should not be stopped if production of defective material is to be avoided. The length of the ditch is so calculated that it gives the welder enough time to join a strip even when the furnace operates at its maximum velocity.

From pulley 9 the strip 1 moves upward over a pulley 10, fairly close to the vertical part of the cooling chamber of the furnace hereinafter to be described, and is slightly pre-heated in this way. Such warmed-up strip goes through a feeding machine 14 which may consist of pinch rolls or pulleys or the like and which insures a steady feed of the strip 1 into the furnace and overcoming the resistance of the uncoiler 3, or the tension of the looping carriage 7, and the resistance of all the pulleys up to pulley 10 including the resistance of the several brushes or cleaners 12, 13 which remove dust, impurities, excess lubricant etc. from the surface of the strip. This feeding machine is an important feature of the invention. It is operated in synchronism with the pulling mechanism on the other side of the furnace and permits running the strip 1 through the furnace practically without any tension at all. This helps in a remarkable way to preserve both the strip and the pulleys, rollers etc. of the furnace in good condition.

The strip 1 is next heated in the chambers or zones 15 and 16. The zone 15 is a zone in which the thin, uniform, reducible coating is formed on the strip. It may be heated indirectly as will hereinafter be described, by products of combustion from the reducing and annealing furnace zone 16. Heat is shown, in zone 16, as applied from beneath, by the exterior surfaces of radial tubes 20 which are heated from the inside by the combustion of gases coming through burners at 19. The combustion gases move in counterflow to the movement of the strip 1 which permits their best utilization and are finally taken up by the hood 15a of the chamber 15 where they give up the rest of their heat by heating up the strip 1 by direct contact with it, burning off any adhering oil or organic material which may pass the brushes and cleaners 12, 13. In this chamber 15 the strip is also slightly oxidized. It passes through a seal 37 before entering the annealing furnace 16. This furnace has a reducing atmosphere, so that the strip, upon reaching the annealing temperature, or even below, so that the freshly obtained oxide film is promptly reduced to the basic metal, forming a purified film of metal of special properties for future coating.

The atmosphere in the furnace section 16 is maintained reducing, as will hereinafter be set forth. It is, of course, independent of the atmosphere in the tubes 20. Sealing means 37 are employed between the zones 15 and 16.

The zone 18 which is located beyond the furnaces 19 is a soaking section, the strip having already acquired the necessary annealing temperature before leaving the section 16.

The strip next passes through the cooling chamber 17. The first part of it, 17a, is a continuation of the original furnace structure, and the direction of movement of the strip 1 therein is the same. This being incidentally the period of the fastest grain growth in the strip, the cooling rate is here reduced to the degree required, as by a suitable insulation 38. The temperature is, however, somewhat lower, as the strip reaches the pulley 23, which by this fact, is subject to less deterioration.

The upper part of the cooling chamber is indicated at 17b and it may or may not be separated from 17a, by an insulated wall, depending on the rate of cooling which is desired in both zones. The zone 17c of the cooling chamber is situated directly above the annealing furnace which, by this fact, only needs a thin insulated wall 22 on the top, in comparison with a thick insulated wall on the bottom, as the temperature gradient is much less, between the heated strip 1 in the annealing furnace 16 and the still hot strip in the cooling zone 17c, than between the annealing zone 16, and especially its heating tubes 20, and the outside atmosphere. This fact, together with the feature of having the annealing furnace and the cooling chamber superposed, by passing the strip over a pulley 23 disposed at a suitable place in the cooling chamber, and then returning it in the opposite direction, reduce very appreciably the cost of such a furnace, as the two zones,

the heating and the cooling, are both comprised into one air and gas-tight structure with its blind end (at the pulley 23) free to expand on heating.

17*d* is a further section of the cooling chamber, after which the strip 1 goes over the pulley 25 and then, preferably vertically, through the last part of the cooling chamber 17*e*, into the coating bath 26, over the roll 28, within said bath and up into the air, for solidification of the coating and for cooling in the air, or as required.

As will be clear to anyone skilled in the art, this arrangement permits easy control of the rate of cooling in the various zones of the cooling chamber and thereby produces a strip of such grain and of such characteristics as are best suited for the purpose for which such strip is to be used.

It has been indicated above that a low-carbon steel strip, suitably coated, for instance with zinc, aluminum, tin etc. and required for stamping or drawing tins, boxes and the like, should preferably be fairly soft, that is, it must have a grain not below a certain size. It has been found that this can best be accomplished by having the cooling rate rather slow in the upper range of the cooling zone; and the strip may then be permitted to cool at a somewhat faster rate of speed. Such conditions can very easily be obtained with this apparatus as the insulation 24 is composed of removable sections which may be put on in single or multiple thickness, or even completely removed, depending upon the annealing temperature, the thickness and speed of the strip 1 and also upon the cooling cycle which has been found to be most desirable.

I may dispose electric or other heating elements (not shown) at various places within the cooling zone 17, in order to be able to start the unit with the minimum amount of scrap, before the strip itself finally brings the whole cooling chamber up to the required temperature. Under certain special cooling conditions, such heating elements or at least some of them, can even be used at all times as it may be desirable to soak the strip at any point of the cooling cycle and prevent, at such point such loss of temperature as might occur if heat were not supplied from the outside. Or, it may be desirable even to interrupt the cooling cycle and raise the temperature of the strip at certain points, in order to obtain certain characteristics of grain and properties of the strip.

The last portion of the cooling chamber, the zone 17*e*, may under circumstances not be insulated at all, as the cooling rate of this portion may be higher than in the other zones. This, of course, increases the rate of pre-heating of the incoming strip ahead of the feeding apparatus 14. A certain amount of insulation may, however, be found necessary on the part of the chamber 17*e* which faces the up-going coated strip, since too much heat applied to the coated strip might prevent the solidification of the coating safely below the pulley 29 or might adversely influence the formation of spangle, e. g. on zinc-coated strip.

Radiation from the cooling chamber, especially from the zones 17*d* and 17*e*, may be further diminished at such points where it would interfere with the operation of machines or appliances, such as the feeding machine 14, or the brushes 12, 13. The retardation of the rate of cooling of the strip by the fact that extra insulation is put in such places, has very little effect on the final result, as the length of such specially insulated zones is insignificant, in comparison with the total cooling length.

Suitable reducing gases may be supplied by tube connections, or at any suitable place or places. They preferably should be supplied to some part of the cooling chamber, since there they should be in their purest form. While in the cooling chamber, the gases only protect the strip from oxidation. Therefore there is no chemical reaction and they are unimpaired, provided the chamber is sufficiently air- and gas-tight. From the cooling chamber, the gases enter into the soaking and annealing furnace, through baffle plates 39 which diminish the rate of infiltration or diffusion of contaminated furnace gases into the cooling chamber. If the velocity of the gas flow towards the furnace, at this point, is greater than said rate and velocity of diffusion, then there will be no contamination of the atmosphere of the cooling chamber.

The rate of cooling, within the cooling chamber, can be further increased by placing, at certain points within the chamber, fans which cause the atmosphere of the chamber to move and increase the rate of cooling by convection. This additional means of cooling is especially effective when the atmosphere consists in a large part of hydrogen which gas has a much higher heat conductivity than other gases. Again blowers may be installed to circulate a part of the gases and cool or treat them, e. g. for the removal of moisture in suitable air-tight devices outside of the cooling chamber, returning them back to the chamber in a cooled condition.

The seals 37 and 39 may conveniently comprise the interspaced baffles of light spring metal bearing against the strip 1, more particularly described in the second of my co-pending applications referred to above.

For cooling the coated strip, it may be passed back the length of the furnace over suitable idlers and coiled as at 30. To move the strip through the furnace and bath, there will, of course, be a puller 40, preferably located as shown beyond the roll 29. In the furnace sections the strip is supported by suitable refractory or temperature resisting rolls 44.

One of the most important features of the invention may now be clearly seen: the apparatus has been divided into three straight sections of such length that threading by the use of ordinary tools is still quite convenient. For the purpose of threading, the strip would be brought up to the proximity of the seal 37, which can be done by hand. Then a thick and narrow strip of a heat-resisting metal is pushed through an opening 41 in the other end of the furnace, after having removed a plug. The heat-resisting strip is quickly pushed over the roller bed of the furnace and through the seal 37 which may be slightly opened to facilitate its passage. This strip is now joined with the steel strip at this point, as by binding with wire, and by pulling the heat-resisting strip back through the furnace, the strip is threaded through the lower part of it. It is then disconnected from the heat-resisting strip beyond the pulley 23 but still within the cooling chamber. The heat-resisting strip is now introduced through the opening 42 and connected with the first end of the steel strip which has just been threaded through up to this point. By quickly pushing the heat-resisting strip along the upper part of the cooling chamber 17 right beyond the pulley 25, with the first end of the regular strip attached to it, it is pos-

sible to thread up to that point. Similar operations are performed to bring the strip into the metal coating bath from which it is easily withdrawn by catching it from the outside.

Modifications may be made in my invention without departing from the spirit thereof. Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In a combination oxidizing and reducing furnace an elongated housing, means for passing a strip of metal therethrough, means dividing said housing into two parts, sealing means for engaging the material being passed therethrough and acting to segregate the atmospheres in said two parts, internal combustion radiant tubes located in one of said parts without having communication therewith, said tubes opening into the other of said parts whereby products of combustion from within said tubes may be delivered to the other of said parts to produce an atmosphere therein.

2. In a combination oxidizing and reducing furnace an elongated housing, means for passing a strip of metal therethrough, means dividing said housing into two parts, sealing means for engaging the material being passed therethrough and acting to segregate the atmospheres in said two parts, internal combustion radiant tubes located in one of said parts without having communication therewith, said tubes opening into the other of said parts whereby products of combustion from within said tubes may be delivered to the other of said parts to produce an atmosphere therein, and means for producing a reducing atmosphere in the first mentioned of said parts.

3. In a metal coating means, an elongated housing, means for passing a continuous supply of metal to be treated through said housing in one direction and then in another, means dividing said housing into parts appropriate to the forward and reverse movement of said continuous supply, radiant tube means in a portion of said housing but out of gas communication therewith, means for sealing said portion of said housing from another portion thereof, said radiant tubes being in gas communication with said other portion.

4. In a metal coating means, an elongated housing, means for passing a continuous supply of metal to be treated through said housing in one direction and then in another, means dividing said housing into parts appropriate to the forward and reverse movement of said continuous supply, radiant tube means in a portion of said housing but out of gas communication therewith, means for sealing said portion of said housing from another portion thereof through which said supply of metal first passes, said radiant tubes being in gas communication with said other portion, a metal coating apparatus at one end of said furnace comprising a container for molten metal and a hood connecting said furnace with said molten metal and means for maintaining said continuous supply in a reducing atmosphere within said furnace and until it has passed beneath the surface of said molten metal.

5. In a metal coating means, an elongated housing, means for passing a continuous supply of metal to be treated through said housing in one direction and then in another, means dividing said housing into parts appropriate to the forward and reverse movement of said continuous supply, radiant tube means in a portion of said housing but out of gas communication therewith, means for sealing said portion of said housing from another portion thereof through which said supply of metal first passes, said radiant tubes being in gas communication with said other portion, a metal coating apparatus at one end of said furnace comprising a container for molten metal and means for maintaining said continuous supply in a reducing atmosphere within said furnace and until it has passed beneath the surface of said molten metal, said means constituting means for causing a reducing atmosphere to pass in countercurrent to the movement of said continuous supply.

6. In a device for the purpose described, an elongated furnace housing having insulated walls, means dividing said housing in the direction of its length into two parts, said means in part at least permitting heat exchange between said parts, means for passing strip material through said housing from one end to the other in one of said parts, and back again in the other of said parts, gas-tight partitioning dividing said furnace transversely to the movement of said strip material into at least two sections in which different atmospheres may be maintained, means for heating said strip material in an oxidizing atmosphere in the first of said sections in the direction of movement of said strip material, and means for heating said strip material in a non-oxidizing atmosphere in a succeeding section.

7. In a metal coating apparatus, operating upon endless lengths of metal, and having means for joining together sheets or strips of metal to form a continuous supply, and means for cutting the continuous supply apart after coating into useful units, an elongated furnace raised above the floor, said means for forming and severing said continuous supply being located on said floor beneath said furnace, said furnace having two sequential portions divided at least as to atmosphere, the first of said portions comprising a heating chamber in which said continuous supply is heated in an oxidizing atmosphere, and the second of said portions comprising a heating chamber in which said continuous supply is heated in a reducing atmosphere, coating means at one end of said furnace, means connecting said furnace with said coating means for leading said continuous supply into said coating means while still in said last mentioned atmosphere, and means for returning the coated continuous supply above the furnace from the said end to the other end for cooling purposes.

8. Apparatus as claimed in claim 7, in which said second portion of said furnace includes a cooling chamber for said continuous supply, said cooling chamber being in connection with said means for leading said continuous supply into said coating means.

9. Apparatus as claimed in claim 7, in which said second portion of said furnace includes a cooling chamber for said continuous supply, said cooling chamber being in connection with said means for leading said continuous supply into said coating means, and in which said coating means is located on said floor and in which said connecting means passes downwardly from said furnace to said coating means.

10. Apparatus as claimed in claim 7, in which said second portion of said furnace includes a cooling chamber for said continuous supply, said cooling chamber being in connection with said means for leading said continuous supply into said coating means, and in which said coating means is located on said floor and in which said

connecting means passes downwardly from said furnace to said coating means, and in which said joining means include a decoiler and a take-up means permitting continuous operation of the furnace, and in which said cutting means include coiling means.

11. Apparatus as claimed in claim 7, in which said furnace is divided horizontally by a partition into upper and lower parts, and in which said continuous supply traverses said furnace twice from end to end, once in each of said parts, the said lower part being divided into the said oxidizing and reducing portions, and said upper part comprising a cooling chamber.

12. Apparatus as claimed in claim 7, in which said furnace is divided horizontally by a partition into upper and lower parts, and in which said continuous supply traverses said furnace twice from end to end, once in each of said parts, the said lower part being divided into the said oxidizing and reducing portions, and said upper part comprising a cooling chamber, said partition permitting heat interchange between the said parts.

13. A continuous heat treating apparatus for obtaining large grain, equiaxed steel strip, consisting of a horizontally disposed furnace, divided into parts by a partition, and comprising a heating chamber with radiation heating elements, located in one of said parts, and a soaking chamber disposed in continuation of the heating chamber and occupying portions of both of said parts, said soaking chamber being heat insulated so as to obtain a controllable but relatively slight drop of the temperature of the strip therein, a further cooling chamber disposed in continuation of the said soaking chamber in the second of said parts, and juxtaposed to the heating chamber in one portion, another portion being arranged in heat exchange relationship to the incoming strip whereby to heat up the incoming strip and increase the rate of cooling of the outgoing strip, in combination with an apparatus for continuously metal coating the said outgoing strip, the said heat treating apparatus being at a higher level than the said metal coating apparatus and connected therewith by a substantially vertical portion of said cooling chamber, the said outgoing strip in said cooling chamber being in heat exchange relationship with the said incoming strip.

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