March 23, 1954 W. M. HEPBURN ET AL 2,673,080

STRIP HEATING

Filed May 3, 1950

FIG. 1.

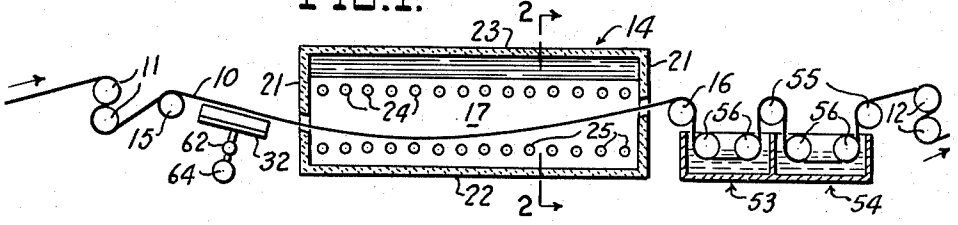


FIG. 2.

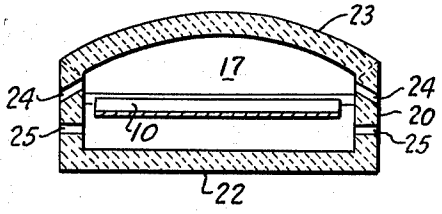


FIG. 3.

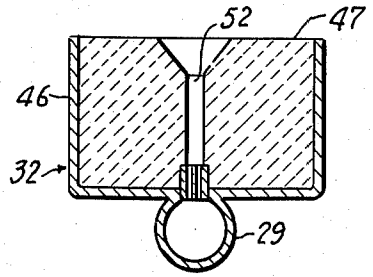


FIG. 4.

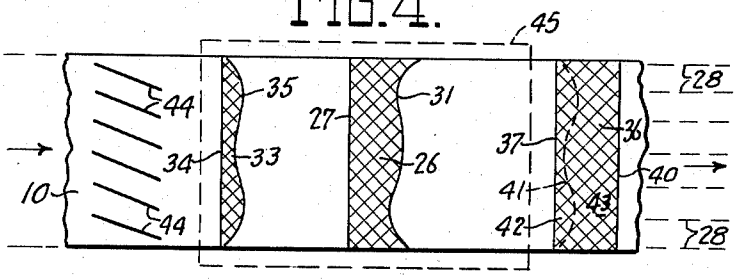


FIG. 5.

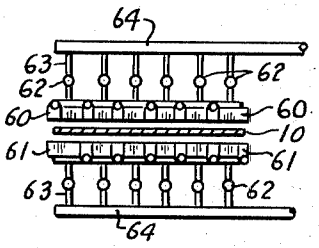
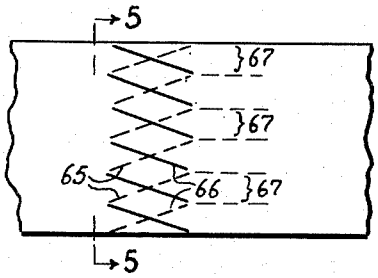


FIG. 6.



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STRIP HEATING

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4 Claims. (Cl. 263—3)

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The present invention relates to continuous heating of an elongated, substantially flat strip such as steel produced in a continuous strip mill, and more particularly to apparatus for and a method of obtaining uniform heating of the strip which is being heated by a high head heat source such as a radiant heater to a relatively low temperature. When continuous strips of steel are passed through a radiant heating furnace whose walls are at a temperature of 2200° F. and the strip is passed so rapidly through the furnace that it reaches only 230° F. surface temperature it will be appreciated that the uniformity of temperature from side to side in the strip will depend upon the uniformity in the rate of heating in the furnace, since there is no soaking or temperature equalizing zone in the furnace to correct any inequalities of temperature imparted to the strip during heating.

If a strip is passed through a conventional heating chamber which has a uniform heat input to its walls, geometrical considerations cause the center of the strip to overheat, the sides to underheat and its extreme edges to overheat due to edge heating effects. This extreme edge heating effect is most pronounced on relatively thick strips, whereas on relatively thin strips it may be negligible, as is well known. The same result obtains when heating the strip with high heat input line burners disposed across the entire width of the strip. Attempts have been made to correct this non-uniformity of heating in furnace chambers by careful spacing of fuel fired burners or by careful spacing of the turns on electrical radiant heating elements. These attempts, while partially successful, are not capable of the flexibility required for a variety of widths of strip and for other changing conditions which may arise. It is the general object of this invention to accomplish a uniformity in heating of strip material by means that are flexible and adaptable to changing conditions.

For a consideration of what we believe to be novel and our invention attention is directed to the following specification and the claims appended thereto.

In the drawings forming a part of this specification:

Fig. 1 is a schematic sectional view of the heating and pickling portion of a continuous tin plating line.

Fig. 2 shows a cross sectional view of the heating furnace of Fig. 1 on line 2—2.

Fig. 3 is a cross sectional view of a burner employed in the present invention.

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Fig. 4 is a layout of the strip being heated showing diagrammatically the location of preheat burners and the resulting heat input therefrom.

Fig. 5 is an end view of alternate strip heating apparatus.

Fig. 6 is a layout of strip showing the position of the burners of Fig. 5 relative to a strip to be heated.

Referring to Figs. 1 and 2, steel strip to be treated is indicated at 10 and will normally require to be pickled and rinsed after heating as it passes from tension rolls 11 to pullout rolls 12. The strip will normally be fed to the tension rolls 11 from suitable pay off reels, stitcher and looping pit apparatus and will pass from the pullout rolls 12 to suitable drying, plating and winding reel apparatus. Interposed in the line of travel of the strip between the two sets of rolls 11 and 12 is a furnace 14 in the chamber of which the strip is heated with a high heat head to substantially the desired temperature. The strip is supported by rolls 15 and 16 at either end of the furnace without any intermediate support. The furnace 14 is of more or less conventional construction, having a chamber 17 defined by laterally spaced side walls 20, longitudinally spaced end walls 21, a bottom wall 22 and an arched roof 23. Heat is produced in the furnace chamber by upper and lower rows of burners 24 and 25, respectively, hence the interior wall surfaces of the chamber are heated quite uniformly. However, due to the geometry of the heat radiation from the furnace to the strip it is practically impossible to obtain uniform radiation effects across varying widths of strip 10. In other words, a uniformly heated furnace will not necessarily uniformly heat a strip due to geometrical considerations, and moreover its normal heating pattern may vary by failure of burners, or in electrical heating furnaces by failure of heating elements, or the normal heating pattern will vary with changes in strip thickness and speed of travel through the furnace, variations in strip width and the like.

Under a given set of conditions the quantity of heat input to the strip from the radiant wall surfaces of the furnace chamber 17 may correspond to the shaded area 26 between lines 27 and 31, the curved line 31 showing the temperature variation from side to side. To compensate for such non-uniform heating of the strip a lateral series of longitudinally extending burners 32 are installed to supplement the heating of the furnace 14. These auxiliary burners 32 may follow

or precede the furnace 14, and may locally apply controlled heat to the strip in a relatively small quantity, but sufficient to compensate for temperature variations in the strip due to the heating by furnace 14. When used as preheat burners, for example, the burners 32 may impart heat to the strip in proportions complementary to those imparted by the furnace 14, as illustrated by the shaded area 33 between the base line 34 and the temperature curve 35. In relatively thick strip the edge overheating illustrated is of primary importance, whereas in relatively thin strip the center overheating is of primary importance, the edge heating effects being negligible where the edge area to receive radiation becomes negligible. The total heat imparted to the strip is thus uniform across its width as illustrated by the shaded area 36 between base line 37 and the temperature curve 40. The broken line 41 divides the shaded area 36 into two portions 42 and 43 illustrative of the proportionate quantities of heat imparted to the strip by the auxiliary or preheat burners 32 and the furnace 14.

The parallel series of lines 44 indicates the relative location of the preheat burners 32 and the rectangular outline 45 shows the relative location of the furnace 14. The heat input to the furnace 14 may be controlled in any suitable way, as by proportioning the heat input to the weight of strip heated or to the velocity of strip travel, or the furnace may be controlled to maintain a given wall temperature within the furnace chamber. The preheat burners 32 are shown disposed in parallel relation and at an angle to the direction of travel of the strip in such a manner as to allow selective portions 28 of the strip to be heated by control of the individual burners 32.

The burners 32 may comprise a metallic shell 46 lined with a refractory wall 47 surrounding the combustion gas discharge slot 52 which serves as a combustion chamber. These burners are preferably individually hand adjusted to give a uniformly heated strip leaving the furnace 14 as measured by the oxide thickness variation from side to side, but may of course be automatically controlled as by radiation pyrometers or X-ray devices in line with each burner at the discharge end of the furnace 14. Radiation pyrometers, however, are not sufficiently sensitive in the low temperature range, although they would be serviceable in the higher temperature ranges, and the manual control has proven satisfactory.

From the support roll 16 at the discharge end of the furnace the strip ordinarily passes through one or more pickle tanks 53 and one or more rinse tanks 54, being supported through the tanks by support rolls 55 and hold down rolls 56, the strip then passing through the pull out rolls as aforesaid. The strip 10 entering the pickling solution in the pickle tank 53 will have a surface temperature of about 230° F. so as to maintain the acid pickling solution in the tank at about 210° F. without requiring the solution in the pickle tank to heat the entering strip 10.

When extremely large heat inputs are required to heat strip, it is preferred to use a large radiant heating furnace to supply most of the heat together with supplementary line burners individually controlled to precompensate for the inherent non-uniformity of the large furnace, thus uniformly heating the strip.

When heat inputs required are on a lesser scale such as can be conveniently handled by a series of line burners, it is preferred to utilize the line burners without the large furnace, each burner being arranged to heat but a portion of the strip and so adjusted as to heat that portion of the strip to the desired temperature.

In Figs. 5 and 6 the strip 10 is heated by two series of line burners, one series 60 disposed above the strip and another series 61 disposed below the strip. The fuel input to the burners is individually controlled by valves 62 in fuel supply lines 63 leading from the fuel supply manifold 64. The position of the overhead burners 60 is indicated relative to the strip 10 by parallel lines 65 and the position of the burners 61 disposed below the strip is indicated by parallel dashed lines 66. Each burner heats but a portion of the strip, and is controlled to compensate for non-uniform heat losses characteristic of the heating of strip which ordinarily cause the strip to emerge from the apparatus unevenly heated from side to side. The net heating of the strip by the burners 60 and 61 is therefore uniform.

The present invention is advantageously used in preheating for a pickling operation, for flash annealing and for like processes where rapid heating to a uniform temperature is desirable.

Preheating prior to liquid bath treatments such as pickling, tinning, galvanizing and the like reduces the heating load on the liquid bath and correspondingly reduces heat transmission required through the walls of the liquid container, or pot. Although it is known that pot life can be markedly increased by reduction of the heat transmission through the pot walls, it has heretofore been impractical to preheat thin strip material without a heat soaking, or temperature equalizing step in the heating process where uniform heating across the strip is required. In a pickle line uniform heating provides uniform acid action across the strip. In higher temperature flash annealing and the like other advantages appear, such as uniformity of anneal by having the entire strip reach the same maximum temperature, uniformity of grain size, uniformity of oxidation and other metallurgical factors. When heating to the higher temperature ranges the supplementary burners are more desirable as preheat burners than as post heat burners because in that case non-uniformity is at a minimum in the higher temperature ranges and the effective times at temperature are direct functions of the maximum temperature attained.

A great mechanical advantage is obtained when the strip is heated to the higher temperature ranges, such as about 800° F. and above. The tension in the strip tends to flatten the strip at the higher temperatures, and if the maximum temperature of the strip is not uniform across its face, the strip will upon cooling shrink or contract proportionate to its drop in temperature and it consequently will have ruffles and pockets across its face which would have been substantially avoided by application of the present invention and which must be removed by stretch operations, cold, to flatten the strip. This is a difficult operation at best. The present invention provides a relatively simple means for and method of accomplishing its intended purpose of providing uniform continuous heating of strip.

What we claim is:

1. The method of heating an elongate, substantially flat moving strip which comprises: initially applying more heat to the strip on either side of the center at two spaced points than at the center and edges, in a first heating zone; and subsequently applying heat in a second zone to

a greater degree at the center and edges than at said two points.

2. The method of heating a relatively thin, elongate, substantially flat moving strip which comprises: initially applying more heat to the strip on either side of the center at two spaced points than at the center, in a first heating zone; and subsequently applying heat in a second zone to a greater degree at the center than at said two points.

3. Apparatus for heating an elongate, substantially flat moving strip, which comprises, a first series of parallel line burners, each burner of said series being at an angle to the direction of travel of the strip and arranged to heat an individual portion of the strip, and a second series of parallel line burners on the opposite side of the strip, each burner of said second series being at an angle opposite to that of the burners of first series, and each burner of said second series being arranged to heat an individual portion of the strip.

4. The method of heating a relatively thick, substantially flat elongate moving strip which comprises: initially applying more heat to the strip in a central portion than at the edges thereof, in a first heating zone; and subsequently applying heat in a second zone to a greater degree at the edges than at said central portion.

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