June 25, 1940. R. J. WEAN ET AL 2,205,915

METHOD AND APPARATUS FOR ANNEALING STRIP

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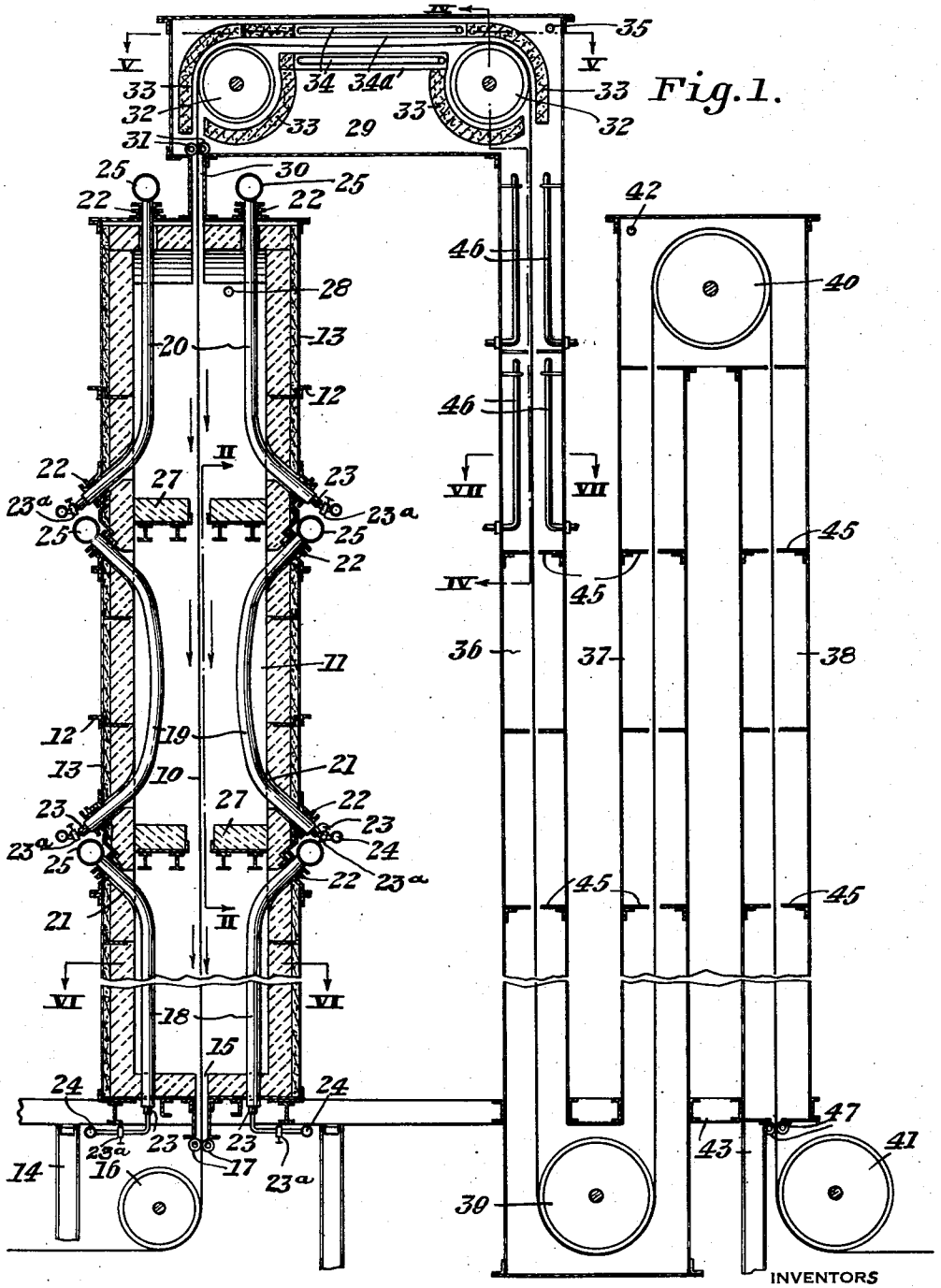


Fig. 1.

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Fig. 3.

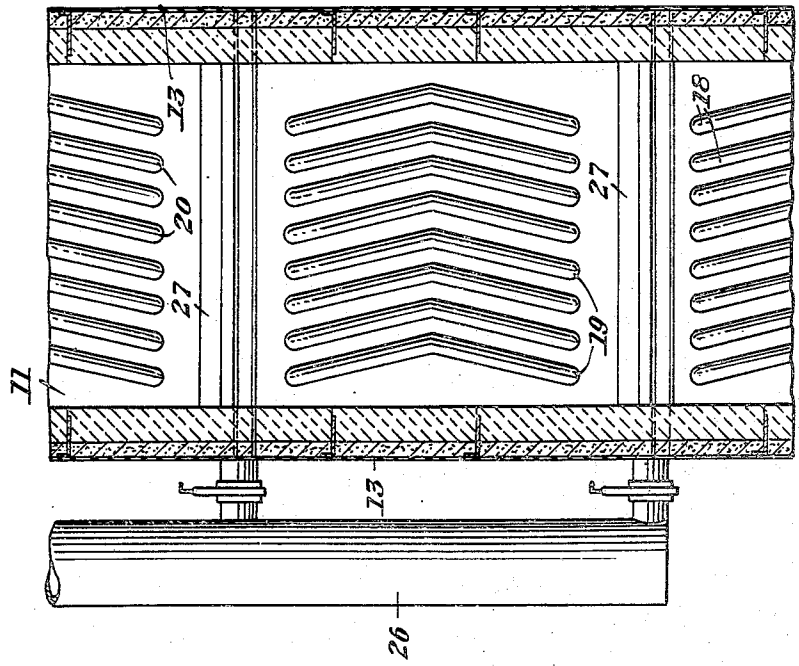
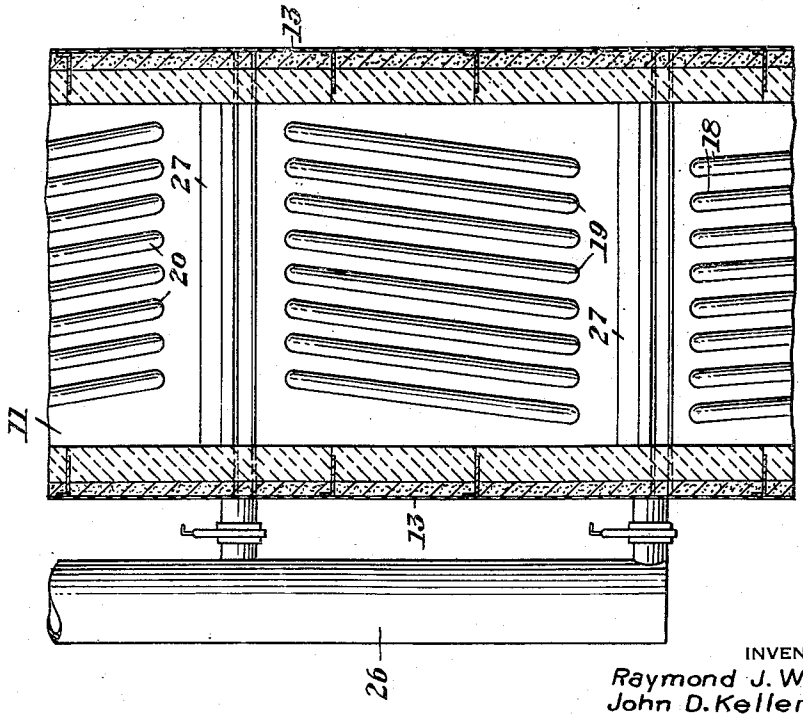


Fig. 2.



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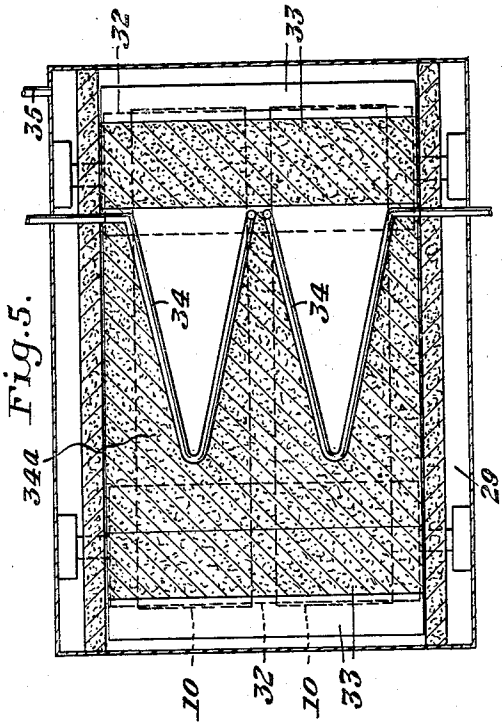


Fig. 5.

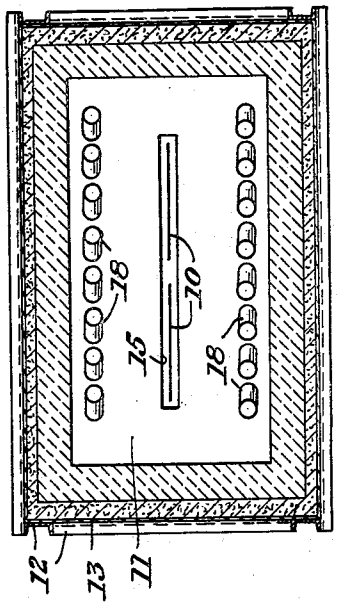


Fig. 6.

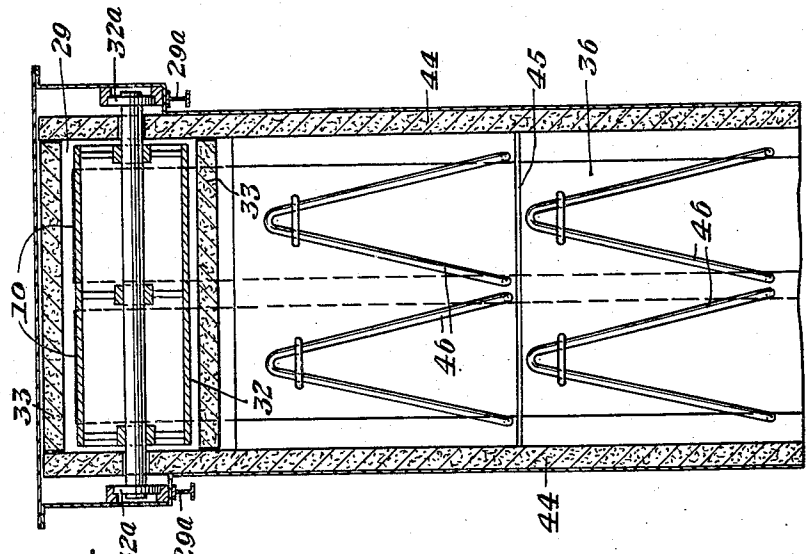


Fig. 4.

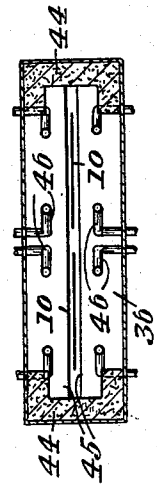


Fig. 7.

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Patented June 25, 1940 2,205,915

UNITED STATES PATENT OFFICE

2,205,915

METHOD AND APPARATUS FOR ANNEALING STRIP

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Application February 9, 1939, Serial No. 255,430

6 Claims. (Cl. 263—52)

This invention relates to the metallurgical processing of metal in strip form, e. g., the annealing of cold rolled steel strip.

It has been the practice heretofore to anneal thin metal strip such as cold rolled steel strip by enclosing the material, either in the form of sheets or coils, in annealing boxes and charging the latter into annealing furnaces, or by the use of cover type furnaces. Regardless of the apparatus employed, an excessively long time is required to bring the material up to the proper temperature and to permit the cooling thereof to a temperature below which atmospheric oxidation proceeds rapidly. Because of the considerable length of time required by the annealing operation as practiced heretofore, the investment in apparatus per ton of weekly or monthly capacity is quite high and the cost of the annealing operation has remained correspondingly high.

In order to overcome the aforementioned and other objections to the present annealing practice, we have invented a novel apparatus and method for annealing strip continuously in strand form. In a preferred form, our invention comprises an elongated heating chamber which may conveniently be disposed with its length substantially vertical, and an arrangement of cooling chutes or ducts communicating therewith having means whereby a strip may be drawn continuously through the heating chamber and the cooling chutes, and the annealing cycle performed progressively on each successive unit length of material quite rapidly with a marked reduction in the time required for annealing a given amount of strip, as well as in the cost of the equipment necessary to maintain a given weekly or monthly production. These advantages, of course, are reflected in the reduction in the overall cost of the finished material.

The structure and practice of our invention will be described in detail herebelow with reference to the accompanying drawings illustrating a preferred embodiment and procedure. In the drawings

Fig. 1 is a central, vertical section through the heating chamber and cooling chutes of a strip annealing apparatus according to the invention;

Fig. 2 is a partial sectional vew taken along the line II—II of Fig. 1;

Fig. 3 is a view similar to Fig. 2 showing a slight modification;

Fig. 4 is a partial sectional view taken substantially along the line IV—IV of Fig. 1;

Fig. 5 is a sectional view taken along the line V—V of Fig. 1;

Fig. 6 is a sectional view taken along the line VI—VI of Fig. 1; and

Fig. 7 is a partial sectional view taken along the line VII—VII of Fig. 1.

Referring now in detail to the drawings, a length of strip 10 is delivered from any convenient source such as a coil supported in a suitable holder (not shown) to an elongated heating chamber or tower 11. If desired, the strip may be passed through suitable cleaning apparatus such as an electrolytic pickling line before it enters the chamber 11. The chamber comprises a bottom, side and end walls and a roof composed of refractory brick, backed up by thermal insulation and assembled within an enclosure including structural shapes 12 and sheathing plates 13. The chamber 11 is carried on a supporting framework 14 and has a slot 15 in the bottom thereof through which the strip enters. The entering strip is trained around a guide drum 16 and between rolls 17 which substantially seal the lower end of the slot 15.

The strip 10 is heated during its passage through the chamber 11 by radiation from heat-exchange combustion tubes arranged in superposed banks on opposite side walls of the furnace, as indicated at 18, 19 and 20. The lower ends of the tubes of the bank 18 extend through holes in the bottom of the chamber and their upper ends through ports 21 in the side walls. The annular spaces between the tubes and the side walls are sealed off by packing rings, expansion bellows or glands 22 which are preferably of such construction as to permit elongation of the tubes resulting from the expansion thereof on heating. Such devices are well-known and require no detailed description. A burner 23 extends into the lower end of each tube in the banks 18 and fuel is supplied to the burners from manifolds 24. The upper ends of the tubes in banks 18 communicate with exhaust headers 25 connected to a stack 26.

The tubes of banks 19 and 20 are similarly disposed and arranged and differ from the tubes of bank 18 principally in shape, as shown. Sealing rings 22 are provided at both ends of the tubes of the upper banks to prevent the escape of the protective atmosphere supplied by means to be described shortly. Such rings are not required on the lower ends of the tubes in bank 18 because there is less tendency for the atmosphere to escape at that point. The clearance between the tubes of the several banks and the ports 21 in the walls through which the ends of the tubes protrude is sufficient to permit the removal of

the tubes endwise after releasing the sealing rings 22 and disconnecting the tubes from the fuel supply manifold and exhaust header.

Baffles 27 extend inwardly from the side walls of the chamber 11 between adjacent tube banks and divide the chamber into a plurality of substantially separate heating compartments or zones. These baffles are effective to prevent any vigorous circulation of the protective atmosphere in the heating chamber which might result from the natural draft upwardly therethrough in the absence of the baffles. At the same time, the space between adjacent baffles is sufficient to permit a gentle downflow of the gas composing the atmosphere in the heating chamber along opposite sides of the strip. Deoxidizing gas is preferably supplied to the heating chamber through an inlet 28 and flows downwardly as indicated by the arrows, thus serving to sweep downwardly along the strip any vapors which might be evolved from material adhering to the strip, e. g., the oil applied during cold rolling. Any excess of the protective atmosphere escapes through the slot 15 or around the lower ends of the tubes of bank 18 and carries the evolved vapors with it. This prevents smudging of the strip which might result from carbonization of the adherent oil film at the higher temperatures to which the strip is subjected as it ascends the heating chamber or tower 11. The tubes of the several banks may be controlled to produce the desired temperature gradient in the strip as it ascends. Generally speaking, it will be desirable to control the supply of fuel to the tubes of the several banks so that the strip entering the chamber will be subjected to a quick heating to a moderate temperature. In the second zone, a prolonged heating of somewhat less intensity is produced, while in the third zone, the strip is brought to its final temperature. We control the amount of fuel supplied to the burners in the tubes in each bank, furthermore, by suitably adjusting the usual burner valves 23a, so that a greater amount of heat will be radiated to the edges of the strip adjacent the end walls of the chamber than to the portions of the strip adjacent the middle of the chamber. We thus maintain the strip at a substantially uniform temperature across its width.

It will be noted that the heating tubes extend in the general direction of strip travel. To avoid any possible striation or variation in temperature across the width of the strip at any point, because of the necessity for spacing the tubes slightly from each other, the tubes are disposed at a slight angle to the direction of strip travel, as illustrated in Fig. 2, the tubes on opposite sides of the strip preferably being sloped in opposite directions. As an alternative, the tubes may, as shown in Fig. 3, have substantially herringbone configuration to achieve the same result.

An initial cooling chamber 29 is disposed above the heating chamber 11 and extends laterally thereof. The chamber 29 communicates with the chamber 11 through a neck or duct 30 of reduced cross sectional area. Sealing rolls 31 engage the strip as it enters the chamber 29 and spaced guide drums 32 convey it therethrough. The construction of these drums is shown in Fig. 4. As there illustrated, they are journaled in bearings 32a within the chamber 29 which are supported on suitable frame members 29a. The drums 32 may be of any suitable material and, if desired, may be provided with scrapers (not shown) to remove any accretions which might be picked up thereby from the strip and cause scratches in the surface of portions of the strip subsequently passing over the drums. The drums may be of a heat resisting alloy such as nichrome with a highly polished surface to which the metal of the strip will have little tendency to adhere. Alternatively, the drums may be of material which is softer than the material of the strip, such as copper or Monel metal.

The drums 32 are preferably provided, throughout at least a portion of their circumference, with shrouds 33 of thermal insulation. These shrouds maintain the drums at an elevated temperature to which they are heated by contact with the strip emerging from the chamber 11, thus preventing excessively rapid cooling of the strip as it engages the drums and the objectionable buckling resulting therefrom. Between the drums 32, cooling tubes 34 are disposed, preferably of hairpin or V-shape with the apex of the V toward the heating chamber 11 and the open end of the V toward the cooling chamber 36. The tubes 34 are backed by thermal insulation 34a cooperating with the shrouds 33 to prevent excessively rapid cooling of the strip. The shape of the tubes causes cooling of the strip to start at the middle and proceed toward the edges as the strip moves forward. This avoids buckling which might result from an attempt to cool the strip simultaneously throughout its width, at one point in its travel. Any suitable cooling fluid such as water may be circulated through the tubes 34 at a rate sufficient to produce an initial reduction in the temperature of the strip from the maximum to which it was heated in the chamber 11. An inlet 35 for deoxidizing gas extends into the chamber 29.

A cooling chute or duct 36 extends downwardly from the chamber 29 and similar ducts 37 and 38 are disposed in succession therewith. Guide drums 39, 40 and 41 journaled in or adjacent the ends of the ducts convey strip successively therethrough to permit gradual cooling thereof. A deoxidizing gas inlet 42 is located at the top of the duct 37. The ducts 36, 37 and 38, as well as the chamber 29, are composed of sheet metal erected on suitable frame members, with gastight joints and carried on supports 43 tied in with the frame 14. The end walls of the ducts are provided with thermal insulation as shown at 44 to prevent cooling of the outer edges of the strip at an excessively rapid rate since the loss of heat from the strip would otherwise be greater near the outer edges than adjacent the middle thereof. The ducts are provided with baffles 45 similar in arrangement and function to the baffles 27. Cooling tubes 46 are mounted in the upper end of the chute 45. By circulating cooling fluid through the tubes 46, the cooling of the strip initiated by the tubes 34 is continued. The tubes are also of hair-pin or inverted V-shape and thus function in the same manner as the tubes 34.

The cooling of the strip continues as it passes through the ducts 36, 37 and 38 and when it finally emerges from the latter between sealing rolls 47, it has been reduced to a temperature at which atmospheric oxidation does not proceed rapidly and is, therefore, ready for re-coiling or for further immediate processing, e. g., stamping, coating, or the like. The strip may be pulled through the heating chamber and cooling ducts by a coiling reel or pinch rolls located adjacent the exit end. Except for the tubes 34 and 46 the cooling of the strip is effected by the absorption

of heat therefrom by the walls of the ducts which are cooled by atmospheric convection.

It will be understood that the speed of travel of the strip and the dimensions of the heating and cooling chambers are determined by the temperature to which the material must be heated and the rate at which heat can be efficiently delivered from the tube banks to the strip. The arrangement of the apparatus illustrated, therefore, is purely by way of example and may be modified as required to meet the exigencies of a specific installation.

It will be apparent that the invention provides a method and apparatus for annealing strip with a considerable saving in time and reduction in cost as compared to the previous practice. The strip being subjected to heating in single thickness or strand form, is raised to the desired maximum temperature very quickly, as compared to the considerable time necessary for the heat to soak through multiple layers of the material in the conventional procedure of annealing in stacks or coils. A more accurate control of the heating stage of the cycle is made possible by the use of a plurality of banks of heating tubes in combination with the baffles which divide the heating chamber as a whole into substantially separate compartments or zones. The apparatus required is relatively simple and inexpensive compared to that which has been used previously for annealing sheet steel and the thermal efficiency of the system is considerably higher than that obtainable in the ordinary annealing furnace since the losses involved in heating massive annealing boxes are entirely avoided. About the only heat lost from the system illustrated is that actually required for heating the material being annealed and the slight amount which passes through the furnace walls. The location of the cooling chute 36 in spaced relation to the heating chamber 11 provides sufficient room therebetween to facilitate the removal of heating tubes from the adjacent side of the chamber.

A further advantage of the invention is that each unit length of the strip is subjected to the same treatment and the resulting product is therefore highly uniform in quality and characteristics, in marked contrast to the product of the conventional annealing methods.

While we have illustrated and described but a single preferred embodiment and practice with a partial modification of the former, it will be understood that changes in the apparatus and procedure shown may be made without departing from the spirit of the invention or the scope of the appended claims. The apparatus shown, for example, is adapted for the simultaneous treatment of two widths of relatively narrow strip but may, with slight modification, be arranged for treating a single strip of greater width.

We claim:

1. Apparatus for treating strip comprising a chamber through which strip may be drawn in strand form, strip heating means in the form of radiant members mounted in the chamber and extending generally in the direction of travel of the strip, said members being inclined slightly to said direction in a plane substantially parallel to that traversed by the strip to prevent striations of different temperatures in said strip.

2. Apparatus for treating strip which has been progressively heated, comprising an initial cooling chamber, a guide drum in said cooling chamber, and a shroud of thermal insulation spaced radially from the drum, extending therealong and around a substantial portion of the circumference of said drum, effective to maintain the drum at an elevated temperature and thereby prevent excessively rapid cooling of the strip on contact with the drum.

3. Apparatus for treating strip comprising a vertical heating tower, vertically spaced banks of substantially vertical heating tubes mounted on opposite side walls of said chamber, the intermediate portions of the tubes lying within the chamber and their ends extending outwardly through said walls, and baffles extending inwardly from said side walls between adjacent banks of tubes effective to divide the chamber into a plurality of substantially separate heating zones and largely limit natural circulation of gases vertically of the tower.

4. Apparatus for treating strip comprising a heating tower having a plurality of superposed banks of radiant tubes mounted on opposite side walls thereof effective to heat strip traveling vertically in strand form, each of said tubes having a curved end penetrating said walls, a cooling duct adjacent said tower having means for conducting strip vertically therethrough in strand form, said duct being spaced laterally from said tower by a distance sufficient to permit endwise withdrawal of the tubes from the adjacent side wall of the tower, and a preliminary horizontal cooling chamber extending from the upper end of the tower to the upper end of the duct.

5. In a method of annealing strip, the steps including advancing the strip longitudinally along a predetermined path, radiating heat to the strip in a portion of its path from a plurality of points closely spaced across the width of the strip and lying substantially in a plane parallel thereto, and so controlling the radiation of heat to the strip that a greater amount is delivered adjacent the edges thereof than adjacent the middle.

6. Strip-treating apparatus including a substantially vertical duct through which strip may be passed in strand form, said duct being subject to atmospheric cooling and composed of material adapted to absorb heat from the strip, strip-guiding drums at opposite ends of the duct, the end walls of said duct and the portions of the side walls adjacent the end walls being provided with thermal insulation whereby to prevent cooling of the edges of the strip at a rate substantially greater than that at which the middle of the strip cools.

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