Nov. 4, 1941. K. TAMELE ET AL 2,261,702

ANNEALING FURNACE

Filed April 30, 1940 2 Sheets-Sheet 1

Fig. 1a

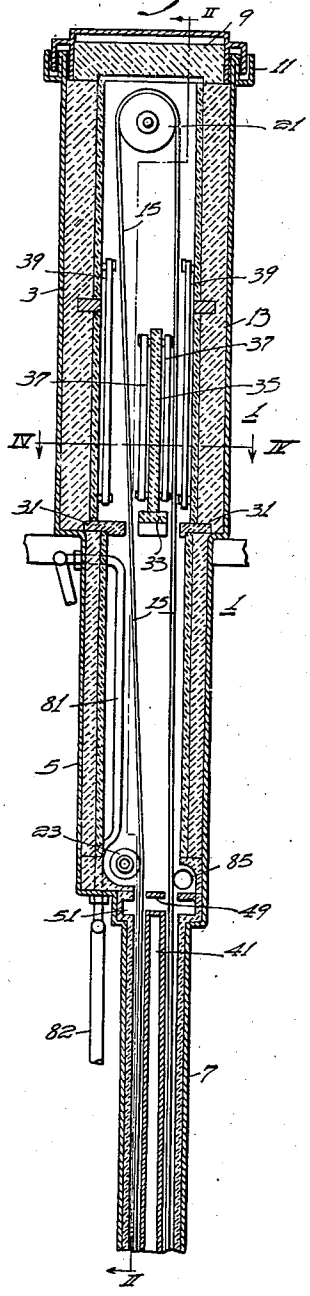


Fig. 2a

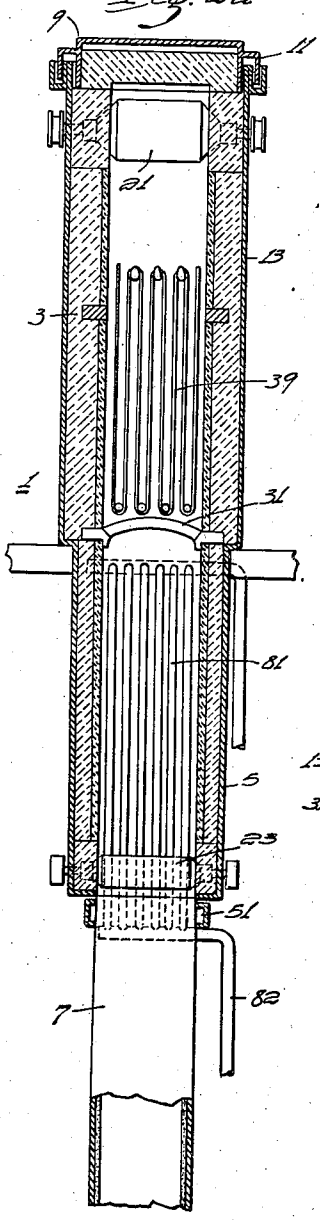


Fig. 3.

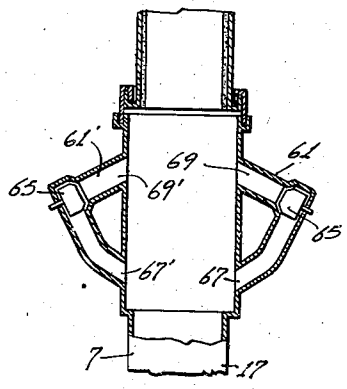
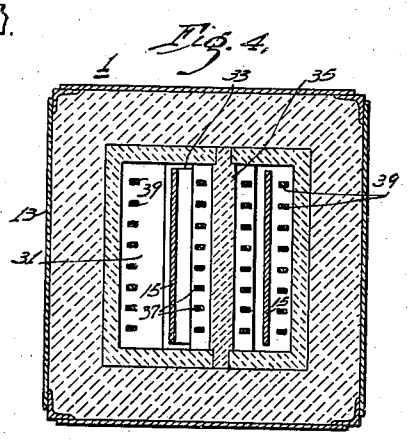


Fig. 4.



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ANNEALING FURNACE

Filed April 30, 1940 2 Sheets-Sheet 2

Fig. 1b.

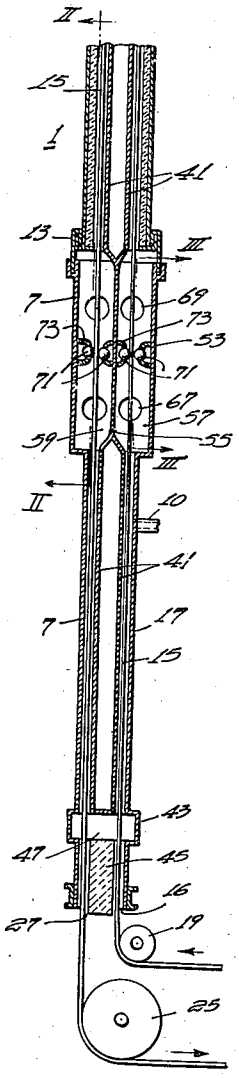
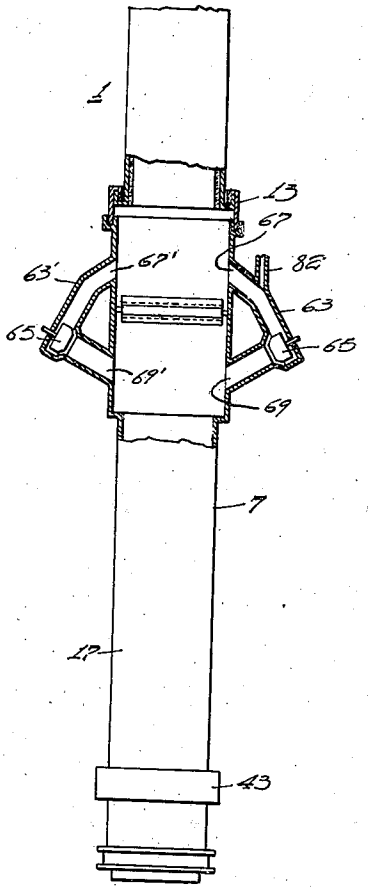


Fig. 2b



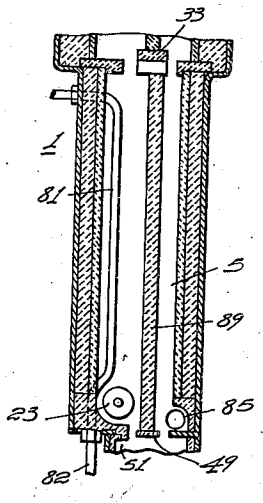


Fig. 5.

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UNITED STATES PATENT OFFICE

2,261,702

ANNEALING FURNACE

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Application April 30, 1940, Serial No. 332,494
In Germany February 9, 1939

10 Claims. (Cl. 266—3)

This invention relates more particularly to a furnace through which metal strip is continuously fed for heat treatment while enveloped by a special or controlled gaseous atmosphere of any desired composition.

An object of our invention is to provide a furnace in which continuously-fed strip can be uniformly annealed without distortion or any significant surface contamination.

A further object of our invention is to construct a furnace of the type mentioned which will occupy relatively little floor space, and to this end the furnace is built high in a vertical direction, that is, the furnace is of a tower type with a long relatively-narrow, vertically-extending chamber in which the strip is first conducted upward from an entrance at the bottom of the furnace, reversed by a guide roller at the top of the furnace, and then conducted downward to an exit also at the bottom of the furnace.

In accordance with our invention, the furnace comprises a heating or annealing zone at the top of the furnace, a heating intermediate zone below the heating zone and in which strip on its way to the heating zone absorbs heat from strip coming from the annealing zone, the latter being thereby cooled, and a bottom or lower zone in which the entering strip may be initially preheated and the leaving strip cooled. This cycle is carried out with provisions for maintaining the strip flat and for preventing distortion such as might occur if any of the heat-treatments on the strip were drastically non-uniform on one of its sides as compared to the other.

To assure uniform and constantly satisfactory annealing, the strip is, in accordance with our invention, at all times uniformly heated or cooled on both of its sides as it passes through the successive heat-treating zones. In furtherance of uniform heat-treatment of the strip, the gaseous atmosphere enveloping it is circulated completely about the strip, preferably moving longitudinally of the strip and enveloping both its sides and edges.

In accordance with the invention, the protective atmosphere enveloping the strip also acts in the additional capacity of a heat-exchange medium for cooling the portions of the strip coming from the heating zone of the furnace, and preheating the portions going to that zone. Consequently, the gaseous atmosphere is, in the main, passed longitudinally of the strip, and, in the preferred embodiment, is recirculated in a path which has a portion for cooling the recirculated gas. Therefore, the gas-flow channels correspond with the channels in the furnace through which the strip passes, but certain booster means for causing or aiding the gas-flow is employed disposed in short branch conduits paralleling the gas-flow channels.

Preferably the atmosphere is admitted to the furnace, or distributed therein, or both, on both sides of the strip by an expedient which involves having all gas exit and entrance openings directed toward the rim edge of the strip and extending beyond both sides of these edges. In other obvious embodiments, nozzles, or tubes having gas-distributing means, may project and advance the gas in a direction longitudinal of the strip. Additionally the gas-flow is preferably regulatable, and valves, dampers, pet-cocks, baffles, or other such expedients may be provided for the purpose.

As before-mentioned, the controlled atmosphere is recirculated by blowers which can be deemed gas-flow booster means, these being disposed in bypass conduits which are located approximately at the center of the lowermost zone of the furnace, with the intake and discharge ends of the booster means spaced apart slightly in the direction of gas-flow. In order to prevent a direct short circuit between the outlets or discharge of the gas-flow booster means and its intake or inlet gas-flow, air-flow restriction means or curtains are provided in the gas-flow channels between the inlets and outlets so that the gas-flow will not be short-circuited. Such gas-flow booster means and restrictive curtains are provided in both the strip-ascending channel and strip-descending channel of the furnace, and are, therefore, located on opposite sides of the gas-recirculating system. This disposition, together with the exhaust and admission of the gas from and on both sides of the strip, has the advantage that the pressure of the gas can be comparatively small so that the gas losses are reduced, but, the pressure is nevertheless sufficient to prevent infiltration into the furnace of air or other obnoxious gases.

One of the primary purposes of our invention is to provide a furnace which will heat-treat strip uniformly on all its surfaces and, nevertheless, be economical and efficient. To this end the intermediate heat-exchange zone has provisions whereby the hot descending strip heats the cool ascending strip by radiation. This is accomplished by having the two strips move in opposite directions in close proximity to each other and with one face or side of the descending strip facing one face or side of the ascending strip.

To assure cooling of the descending strip on its other side, a cooling device is provided in the form of pipes through which cooler controlled atmosphere flows and absorbs heat. This heated atmosphere is discharged on the other side of the ascending strip so that this last side is thereby heated. Consequently, both sides of the ascending strip and the descending strip are heated and cooled, respectively, so that neither will have any appreciable tendency to distort or warp.

To achieve also in the top heating zone of the furnace a uniform heating of the strip, heating means are disposed on both sides of the strip, the heating means having units between which the strip moves.

Many other purposes and features of our invention not particularly described or mentioned above will be apparent from the following descirption thereof, taken in conjunction with the drawings, in which:

Figures 1*a* and 1*b* are to be vertically juxtaposed with Fig. 1*a* on top, and together represent a vertical cross-sectional view of a preferred embodiment of our invention.

Figs. 2*a* and 2*b* are similarly to be vertically juxtaposed, and together represent a vertical cross-sectional view, with some parts in elevation and the metal strip omitted for clarity of illustration, of our furnace at right angles to that of Fig. 1 and taken substantially on the line II—II of Fig. 1.

Fig. 3 represents a vertical cross-sectional view of a portion of a furnace substantially along the line III—III of Fig. 1*b*.

Fig. 4 is an enlarged horizontal cross-sectional view through the heating zone of the furnace taken substantially along the line IV—IV of Fig. 1*a*, and

Fig. 5 is a vertical cross-sectional view of part of a modified furnace indicating a partition in the intermediate zone for dividing it into gas channels.

A furnace in accordance with our invention is designed to occupy little room horizontally and it is, therefore, extended, or elongated, vertically. The furnace in its entirety is represented by the numeral 1 and is divided into a number of vertically contiguous and communicating sections comprising an upper section 3, an intermediate section 5, and a lower section 7.

The upper section 3 comprises the heating or annealing zone of the furnace and includes suitable non-metallic heat-insulating and refractory side walls and a similar top wall, the top wall preferably comprising a removable covering 9.

The intermediate section 5 comprises a heat-exchange zone where the ascending strip is exposed to the descending strip for heat-exchange between the two. This section also has heat-insulated walls which need not be as thick as those of the heating section.

The lower section is also a heat-exchange section by which heat from the descending strip is transferred to the ascending strip, preferably by the recirculation of the controlled atmosphere permeating the furnace. The upper part of this lower section can be insulated while the lower part comprises exposed metal whereby recirculating atmosphere can be better cooled for cooling the strip; although the lowermost section at its bottom where the strip leaves it may be provided with a length of a water-cooled jacket for further cooling the strip, as is well known in the art. The lower section 7 also includes a central part having provisions for forcing the gaseous atmosphere through the furnace, preferably in a recirculating path with a major part of the atmosphere recirculating in the lower section 7. Controlled atmosphere may be admitted to the furnace through an inlet pipe 10.

The entire furnace is supported in any suitable manner and is preferably encased in a gas-tight metallic shell having suitable gas seals such as 11 and 13 where the different sections or parts of the furnace abut. These latter features are common to furnaces employing a controlled gaseous atmosphere and are not shown in any great detail since they do not form the important features of our invention.

As can be seen from Fig. 1*b*, the strip 15 enters through an opening 16, into an inlet channel 17 at the bottom of the lower zone 7 which, in general, consists of sheet metal. The strip 15 passes about a guide roller 19 and continues upwardly through the lower section 7, through the intermediate section 5, and the heating section 3, at the top of which it is reversed by a roller 21, and then comes down the other side of the heating section 3, the intermediate section 5 and the lower section 7, in succession, being guided by suitable rollers as, for example, the roller 23 at the bottom of the intermediate section and the roller 25 below the strip outlet 27 at the bottom of the lower section 7. The arrows at the strip indicate its direction of movement which can be accomplished in any suitable manner as, for example, by making the roller 25 a driving roller, assisted, if necessary, by the roller 21 which also can be power-driven in suitable synchronized speed relation to the roller 25. It may thus be observed that the strip in the furnace goes up one side of it through the respective zones and then is reversed in the top of the heating chamber 3 to go down the respective zones in the reverse sequence.

The heating section is insulated from the intermediate section by non-metallic refractory tile, or the like, 31 and 33 arranged to provide slots through which the strip passes, the tile extending between two end walls of the furnace, and the intermediate tile 33 further acting as a support for a partition 35 extending up into the heating section between the strip portions and supporting heating units 37 for heating one side or face of the ascending and descending strip portions. Heating units 39 are suitably supported on two side walls of the furnace opposite the transversely-extending partition 35 so that the strip portions are necessarily heated on both of their sides.

The major portion of the gas circulation is accomplished in the lower section 7, and to this end a closed partition 41, paralleling the strip and extending between two end walls, divides the lower section into an ascending channel and a descending channel. The partition 41 terminates somewhat short of the bottom of the section 7 where an enlarged transverse channel 43 is provided in the furnace shell. A partition 45 is spaced below the partition 41 and channel 43 to form a transverse passage 47 which, in cooperation with the channel 43 around the periphery of the furnace provides a free path enabling reversal of the direction of gas flow.

A transverse bar 49 between the lower section 7 and the intermediate section 5 is spaced somewhat above the top of the partition 41 to provide a suitable top cross channel for the other turn of the recirculating gases, and the edge walls

of the furnace may be also provided with channels 51 to enlarge the gas-turn passage.

In the middle part 53 of the lower section 7 an air-flow producing means is provided and to this end the partition 41, which otherwise extends in fairly close proximity to the sides of the strip is narrowed in this section 53, as indicated at 55, to form with the side walls of the furnace an enlarged gas channel 57 for the ascending strip and an enlarged gas channel 59 for the descending strip. To produce a gas circulation, each of these channels 57 and 59 has branch conduits 61, 61' and 63, 63', respectively, on both of its edge sides. Blowers 65 are disposed in these conduits, preferably of the centrifugal type. As may be seen in Figs. 1b and 3, the outlets 67 and 67' of the branch conduits 61 and 61' are spaced somewhat from the inlets 69 and 69', respectively, the spacing being in the direction of gas flow, but counter to the direction of movement of the strip. Preferably, the blowers are driven by direct current motors whose speed can be regulated.

The bilateral arrangement of the blowers on both edges of the ascending strip and correspondingly on the descending strip offers the advantage that the strip is uniformly cooled. In this same connection, gas inlets and the gas outlets for each of the branch conduits are so designed that they span and extend beyond the rim or edge of the strip on both sides.

In order to prevent a direct flow of gaseous atmosphere from the outlets to the inlets of the branch conduits, a gas-flow restrictive means or resistance is provided in the form of rollers 71 which are covered by asbestos cloth, and may have additional shields 73 over them to further restrict the air flow directly through the central section 53.

Accordingly, it may be observed that in operation of the furnace thus far described, the conduits 63 and 63' force the gas upwardly along the descending portion of the strip while the conduits 61 and 61' force the gas downwardly in the ascending portion of the strip, the recirculating air turning at the channel 43 and gas passages 47 in the lower part of the section 7, and at the channel 51 and the gas passage between the top of the partition 43 and cross bar 49, at the top of the lower section 7. However, there is sufficient space between the cross bar 49 and the side walls of the furnace to provide slots through which the strip passes, and to permit a fraction of the recirculating gases to enter into the upper sections of the furnace, corresponding slots being also provided between the tile 31 and the intermediate tile 33 separating the intermediate section 5 from the heating section 3. Accordingly, the entire furnace will be permeated by the protective atmosphere. It may be preferable to restrict the openings 16 and 27 in order to permit only a slight leakage of the protective atmosphere sufficient only to prevent infiltration of air or other obnoxious gases, it being understood that the pressure of the gaseous atmosphere within the furnace is maintained slightly above atmospheric for this purpose.

In view of the circulation of the gaseous atmosphere, as described, it is obvious that heat on the descending portion of the strip will be conveyed to the ascending portion of the strip by the circulation of the atmosphere so that the ascending portion of the strip in the lower section 7 is necessarily preheated to some extent, and the descending strip cooled.

Further heat exchange is provided for in the intermediate section 5 which in one embodiment has no partition between the ascending and descending strip. Accordingly, the ascending strip is directly exposed to radiation from the descending strip so that the former will be further preheated and the latter cooled. In this intermediate section 5 a further cooling device 81 is provided on the side of the descending strip opposite to the ascending strip. This device 81 consists of a tube system which may be connected by a pipe 82 to the pressure side of a branch conduit as, for example, the conduit 63 whose associated motor is suitably adjusted to run, therefore, at a slightly higher speed than the other motors. Protective atmosphere is, accordingly, conveyed through the tube system 81 and can discharge at the bottom of the intermediate section 5 at an outlet 85 located at the side of the ascending strip which is not exposed to the descending strip. Consequently, both sides of the descending strip are cooled, the side facing the ascending strip being cooled by radiation and by contact with the turbulent gaseous atmosphere between the two strips and the other side cooled by the tube system 81. In the same way the ascending strip is heated on both its sides, the one side by exposure to the radiation from the descending strip and contact with the gases between the strips, and the other side by heated gases flowing from the outlet 85.

In the modification shown in Fig. 5, the intermediate section 5 is provided with a central partition 89 and in this case the gas will have confined recirculating paths through the upper section of the furnace, as well as through the lower section 7.

Accordingly, it may be seen that we have provided a furnace in which the strip is heat-treated uniformly on both its sides and while enveloped by a gaseous atmosphere. Moreover, we have created a furnace in which the heat is utilized to its maximum extent, being taken from the portions of the strip already heated and transferred to portions of the strip to be heated.

We claim as our invention:

1. An elongated vertical furnace of the type described for the heat-treatment of metal strip while enveloped by a controlled gaseous atmosphere and continuously fed through said furnace, said furnace comprising vertically contiguous and communicating sections including, an insulated upper section comprising a heating zone closed at the top and having heating means therein, and a lower furnace section comprising a zone for cooling the descending strip and preheating the ascending strip, means for directing said strip up a side of said sections, reversing it in the upper portion of said heating section, and then directing it back down another side of said sections opposite the first said side whereby the strip in the furnace takes the general form, in effect, of an inverted U, partition means in said sections for forming gas passages completely about the ascending strip and about the descending strip, said partition means terminating in said heating section short of the bend of said strip and means for circulating controlled atmosphere through said passages along the length of said strip.

2. An elongated vertical furnace of the type described for the heat-treatment of metal strip while enveloped by a controlled gaseous atmosphere and continuously fed through said furnace, said furnace comprising vertically contiguous and communicating sections including, an insulated upper section comprising a heating zone closed

at the top and having heating means therein, and a lower furnace section comprising a zone for cooling the descending strip and preheating the ascending strip, means for directing said strip up a side of said sections, reversing it in the upper portion of said heating section, and then directing it back down another side of said sections opposite the first said side whereby the strip in the furnace takes the general form, in effect, of an inverted U, partition means forming gas passages paralleling said ascending strip and said descending strip, and means for circulating controlled atmosphere through said passages, comprising blower and branch conduit means for the said gas passages, having an inlet opening and an outlet opening spaced from said inlet opening in a direction longitudinally of the strip, and means for increasing the gas-flow resistance of the direct passage along said strip between said inlet and outlet openings.

3. The structure of claim 2 in which said inlet and outlet openings are edgewise of said strip and each extends beyond both sides of the edges of said strip.

4. An elongated vertical furnace of the type described for the heat-treatment of metal strip while enveloped by a controlled gaseous atmosphere and continuously fed through said furnace, said furnace comprising vertically contiguous and communicating sections including, an insulated upper section comprising a heating zone closed at the top and having heating means therein, an insulated intermediate section comprising a heat-exchange zone, and a lower section having an entrance and exit for said strip, means for directing said strip up a side of said sections, reversing it in the upper portion of said heating section, and then directing it back down another side of said sections opposite the first said side whereby the strip in the furnace takes the general form, in effect, of an inverted U, and means for circulating controlled atmosphere in said furnace longitudinally of the strip and completely enveloping it, said last means including branch conduits with blower means having entrance and discharge openings in said lower section spaced respectively in a direction opposite to that of the movement of said strip.

5. The structure of claim 4 including gas-flow restrictive means within said furnace between said openings.

6. An elongated vertical furnace of the type described for the heat-treatment of metal strip while enveloped by a controlled gaseous atmosphere and continuously fed through said furnace, said furnace comprising vertically contiguous and communicating sections including an insulated upper section comprising a heating zone closed at the top and having heating means therein, an insulated intermediate section comprising a heat-exchange zone, and a lower section having an entrance and exit for said strip, means for directing said strip up a side of said sections, reversing it in the upper portion of said heating section, and then directing it back down another side of said sections opposite the first said side whereby the strip in the furnace takes the general form, in effect, of an inverted U, and insulated separating means between said heating section and said intermediate section having slot provisions through which the strip and controlled atmosphere pass, said directing means guiding said strip in said intermediate section so that the sides of the descending and ascending strip are in proximity to each other for heat-exchange whereby the ascending strip is preheated, and the descending strip cooled, said intermediate section including cooling means on the side of said descending strip away from said ascending strip, and preheating means on the side of said ascending strip away from said descending strip.

7. An elongated vertical furnace of the type described for the heat-treatment of metal strip while enveloped by a controlled gaseous atmosphere and continuously fed through said furnace, said furnace comprising vertically contiguous and communicating sections including, an insulated upper section comprising a heating zone closed at the top and having heating means therein, an insulated intermediate section comprising a heat-exchange zone, and a lower section having an entrance and exit for said strip, means for directing said strip up a side of said sections, reversing it in the upper portion of said heating section, and then directing it back down another side of said sections opposite the first said side whereby the strip in the furnace takes the general form, in effect, of an inverted U, means in said lower section including a blower for circulating controlled atmosphere in gas-paths substantially paralleling said strip, said intermediate section including cooling pipe means on the side of said descending portion of said strip away from the ascending side, said pipe means being connected to pass cooling controlled atmosphere therethrough by having an inlet at said blower exhaust, and a discharge into said gas paths at the side of the ascending portion of said strip away from the descending portion.

8. An elongated furnace of the type described for the heat-treatment of metal strip while enveloped by a controlled gaseous atmosphere and continuously fed through said furnace, said furnace comprising a strip heating section, and a heat-exchange section, means for directing strip to be heated along a side of said heat-exchange section and heated strip along the opposite side of said heat-exchange section in such manner that the strip to be heated and the heated strip move in opposite directions with their large sides facing for heat exchange, heating means in said heat exchange section for heating the other large side of said strip to be heated, and cooling means in said heat-exchange section for cooling the other large side of said heated strip.

9. A furnace for the heat-treatment of metal strip while enveloped by a gaseous atmosphere, said furnace comprising an elongated passageway closely encompassing said strip, means for moving said strip through said passageway, means for permeating said passageway with a gaseous atmosphere, and gas-moving means comprising a gas-conduit means having an inlet and an outlet in and along said pasageway intermediate the ends of said passageway, said inlet being relatively closely spaced from said outlet with respect to the distance between the ends of said passageway, said gas-moving means further comprising a device in said gas-conduit means for forcibly moving the gaseous atmosphere through said gas-conduit means.

10. An elongated furnace of the type described for the heat-treatment of metal strip while enveloped by a controlled gaseous atmosphere and continuously fed through said furnace, said furnace comprising contiguous and communicating sections including an insulated

end section comprising a heating zone closed at one end and having heating means therein, a second section adjacent said end section, means for directing said strip along a side of said sections, reversing it in said heating zone, and then directing it back along another side of said sections opposite the first said side, and means for recirculating controlled atmosphere for enveloping said strip, the last said means comprising a pair of enlarged gas-reversing passages spaced along said sections and spanning said sides, the last said means further comprising gas-propelling means between said passages and comprising a branch conduit having an inlet and an outlet spaced longitudinally of said strip.

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