May 24, 1932. D. M. SHANAFELT ET AL 1,859,802

PROCESS AND APPARATUS FOR ANNEALING SHEET STEEL

Filed June 22, 1929 4 Sheets-Sheet 1

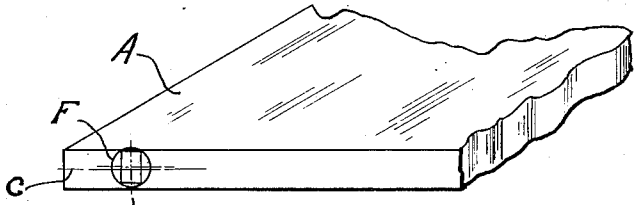


Fig. 1

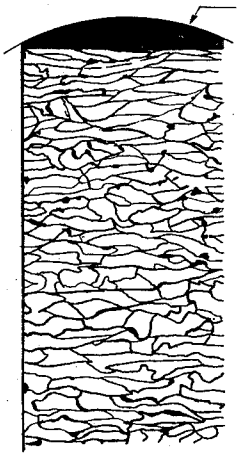


Fig. 2.

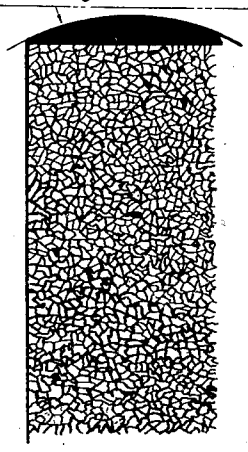


Fig. 3.

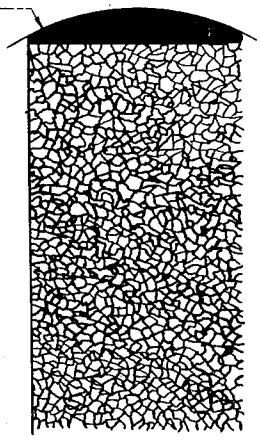


Fig. 4.

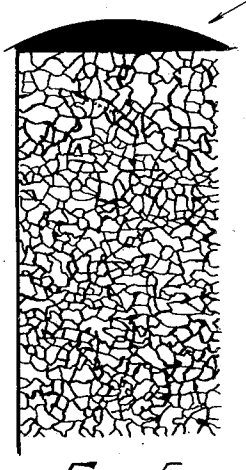


Fig. 5.

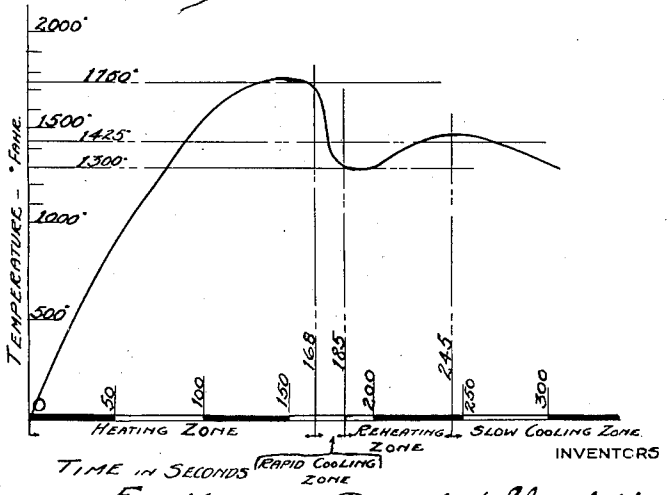


Fig. 14.

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PROCESS AND APPARATUS FOR ANNEALING SHEET STEEL

Filed June 22, 1929 4 Sheets-Sheet 2

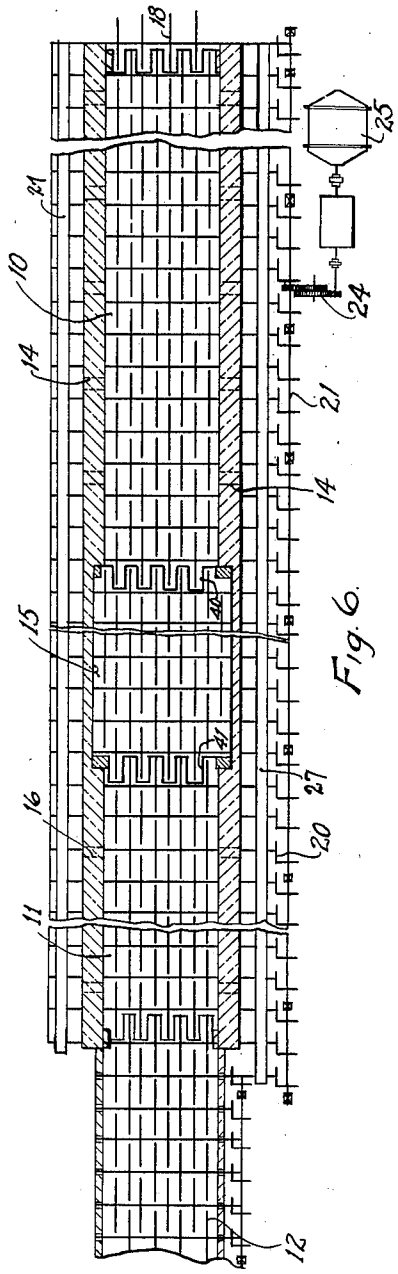


Fig. 6.

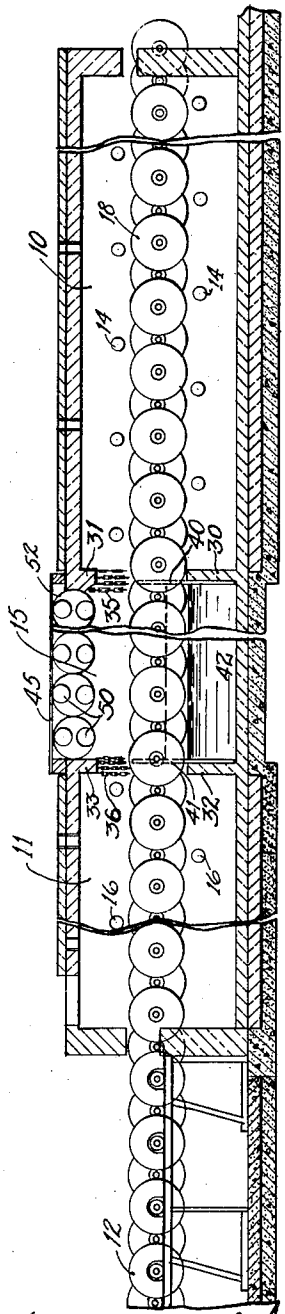


Fig. 7

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PROCESS AND APPARATUS FOR ANNEALING SHEET STEEL

Filed June 22, 1929 4 Sheets-Sheet 3

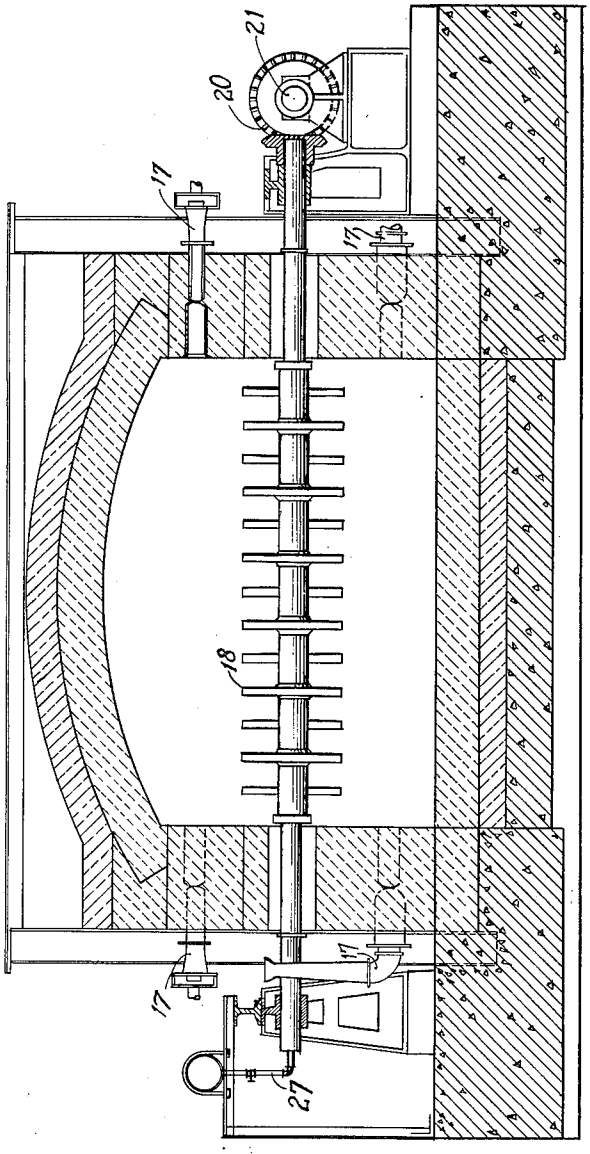


Fig. 8.

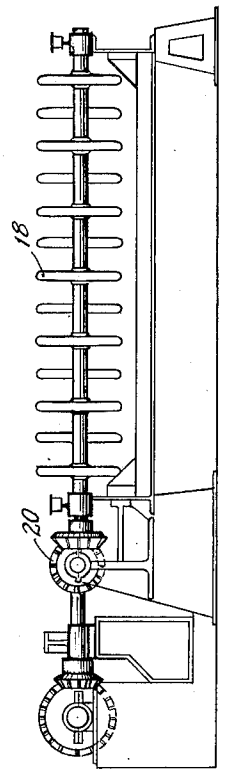


Fig. 9.

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PROCESS AND APPARATUS FOR ANNEALING SHEET STEEL

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Fig. 13.

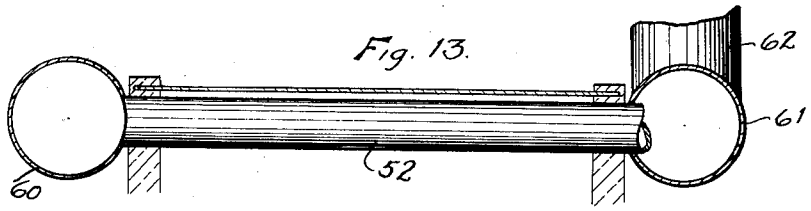
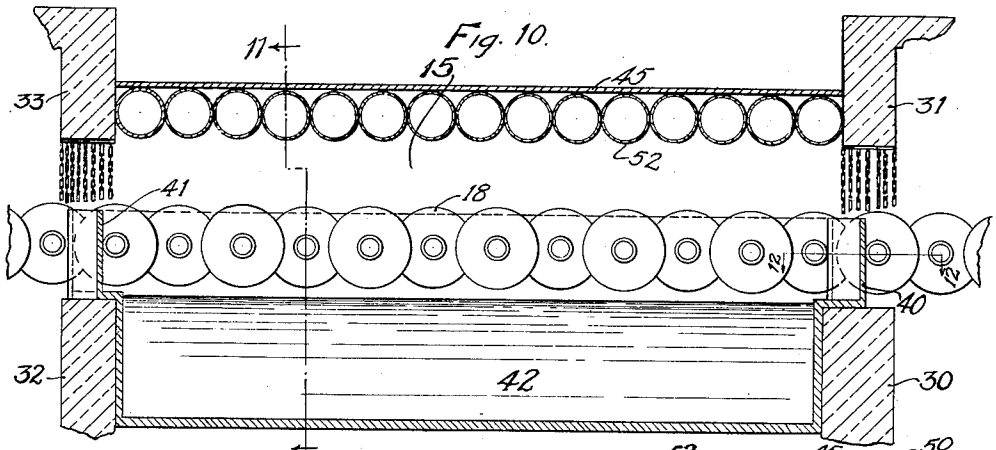


Fig. 10.



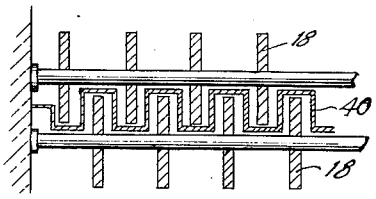


Fig. 12

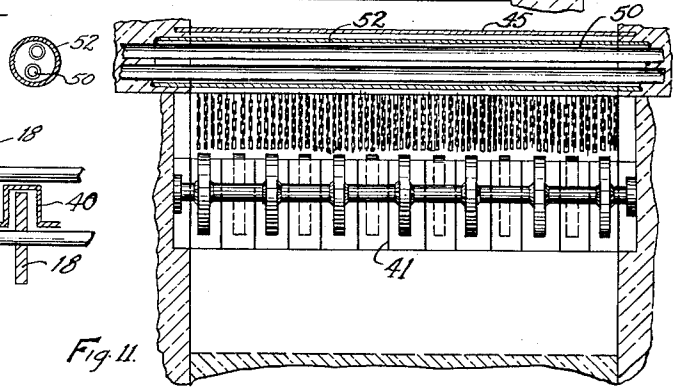


Fig. 11.

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UNITED STATES PATENT OFFICE

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PROCESS AND APPARATUS FOR ANNEALING SHEET STEEL

Application filed June 22, 1929. Serial No. 372,812.

This invention relates to a process and apparatus for annealing sheet steel. After steel has been rolled into sheets its characteristic of grain structure, toughness and ductility are not suitable for many of the uses to which it is to be put. It is common practice to anneal such sheets in furnaces known as normalizing furnaces, in which the sheets are moved progressively through a heating zone, where the temperature of the sheets is raised to a point at which the sheet becomes normalized, namely, at which the grain structure is substantially a homogeneous mass, and the ingredients of the steel, by reason of the heat, are thoroughly commingled. The sheet then passes through a cooling zone, which permits the reformation of the grain into more or less uniform nodules, giving it a degree of ductility and tempered condition approximating that desired.

During this normalizing heating and cooling, scaling of the sheets by contact with oxygen of the air is prevented as far as practical by causing the sheet to be surrounded or enveloped in neutral or non-oxidizing atmosphere. This neutral atmosphere may be obtained by utilizing the products of combustion of the heating zone.

It has been attempted in using such normalizing furnaces to control the grain structure of these sheets by regulation of the times and temperatures to which the sheets are subjected. We have found by experience with such normalizing furnaces that various difficulties are encountered in controlling the grain structure to meet the increasingly rigid and exacting requirements desired, arising from the uses to which the sheets are to be put and subsequent forms which are given them by working and drawing operations.

The general object of the present invention is so to control the heating and cooling times and temperatures as to very accurately govern the final results, and to provide desired specific grain structures, giving normalized sheets the desired ductility or drawability, temper and toughness.

A further object is to arrange a simple economical apparatus for carrying out the necessary steps of the process.

We have found that after the sheet has been heated to a normalizing temperature, a very quick cooling of the sheet will cause a crystal or nodule formation of fine uniform grains. This prevents the tendency of the grains to revert back to, or reform, substantially like or somewhat like the hot milled structure of the original rolled sheet, as results from comparatively slow cooling. This quick cooling or quenching, however, hardens the metal and sets up strains, both of which may be eliminated by reheating to a definite predetermined temperature materially below that of the normalizing temperature. This reheating and further comparative slow cooling will result in somewhat enlarging the crystals or nodules of the steel, at the same time retaining the uniformity of the structure with an accompanying softening or annealing of the steel.

By the use of these steps as stated, with predetermined times and temperatures, the varying grain structures desired may be obtained and a better sheet produced for the purposes for which they are to be used.

In carrying out our invention we prefer to utilize a horizontal continuous type of furnace, provided with a heating zone through which the sheets are passed and heated to a point above normalizing temperature in a non-oxidizing atmosphere of the products of combustion. Immediately following the heating zone is a quick cooling or quenching zone, in which the sheets are cooled to a temperature well below the normalizing temperature, and from which they pass to a reheating and slower cooling zone. The sheets are enveloped during all these operations in the products of combustion, whereby the air with its dangerous scaling oxygen is excluded. In this reheating zone, through a predetermined period, the sheets are raised to a softening or temper drawing temperature, and are thereafter allowed to cool slowly to such degree that the sheets will be safe from scaling. The cooling then may be finished by exposing the sheets to the open atmosphere.

Our invention is more fully described in connection with the accompanying draw-

ings, illustrating a normalizing furnace suitably equipped for carrying out our process. The above and other objects will become more apparent in the following description.

In the drawings—

Fig. 1 is a fragmentary view of a portion of a sheet.

Figs. 2, 3 and 4 are pen reproductions of microphotographs taken from a field indicated by a circle appearing on Fig. 1. These figures respectively illustrate the grain structures of the milled sheet before normalizing, and after quick cooling, and after reheating and slow cooling.

Fig. 5 is a similar reproduction of a microphotograph of the same character of sheet, treated only by normalizing and comparatively slowly cooling.

Fig. 6 is a somewhat diagrammatic sectional plane of such an annealing furnace.

Fig. 7 is a vertical longitudinal sectional view of the same.

Fig. 8 is an enlarged transverse section taken through the heating zone.

Fig. 9 is a view showing the rollers and the mechanism for driving them.

Fig. 10 is an enlarged longitudinal section through the quick cooling zone.

Fig. 11 is a transverse section taken on a plane indicated by the line 11—11 of Fig. 10.

Fig. 12 is a sectional detail taken substantially on the line indicated by line 12—12 of Fig. 10.

Fig. 13 is a modification of the cooling elements of the upper part of the sections shown in Figs. 10 and 11.

Fig. 14 is a graph curve illustrative of times and temperatures, the temperatures being taken on the ordinate and the times on the abscissa.

The fragmentary section A of the sheet shown in Fig. 1 is enlarged for convenience to indicate the location of the field circle F of the microphotographic views and shows it taken slightly off the median line C on an edge of the sheet. Such sheets vary in thicknesses, but are of the gauges widely used, ranging from those for automobile fenders up to the thickness of frame parts, or even heavier sheets.

Figs. 6 and 7 illustrate a suitable type of continuous horizontal furnace having a heating zone, for example, 50 to 100 ft. long, indicated at 10, and a cooling zone indicated at 11, which may be somewhat shorter. At 12 is indicated a carrier table for conveying sheets away from the furnace. Arranging our furnace for the purpose of the present invention, we interpose a quenching zone 15 relatively very much shorter than the zones 10 and 11, being for example only 5 to 10 ft. long. The sheets are conveyed through the furnace on rollers 18 and passed out on the carrier table 12. The shafts of the rollers are shown as provided with gearing connections 20 on a longitudinal shaft 21 rotated at a predetermined speed by any suitable means indicated as gears 24 and a motor 25. Burners 17 may project through openings 14 of the heating zone to provide the proper normalizing temperatures, and a lesser number of burners, projecting through openings 16, may be used to reheat the sheets in part of the cooling zone 11.

Such a furnace is usually constructed on a suitable foundation and comprises walls of refractory masonry. If desired, the shafts for the disks 18 may be water cooled by the pipes 27.

A suitable arrangement of the quenching zone 15 is shown as comprising baffle walls 30 and 31 at the inner end of the heating zone and 32 and 33 separating it from the reheating and cooling zone above and below the rollers. The flow of the hot gases into this quenching zone is retarded preferably by the use of flexible baffles 35 and 36, which may comprise chains, as indicated, or closely hung swinging strips of heat resisting alloy extending below the baffles 31 and 33 to a plane just above the path of the sheets on top of the rollers. If desired, offset baffles may comprise extensions 40 and 41 of walls of a suitable water tank indicated at 42 (Figs. 7, 10 and 12).

The quenching zone is enclosed at the top by a suitable plate 45, and beneath it are additional cooling means such as water pipes or cold air pipes or the like. In Figs. 7 and 11 are indicated water pipes 50 within surrounding air pipes 52. These protect the water pipes and prevent condensation from the pipes 50 from dripping onto the sheets.

The water pipes may be omitted and instead only a large volume of relatively cool air forced through the pipes 52, a header pipe 60 and a suitable header and stack 61 and 62 being provided for conducting forced circulating air through and away from these cooling pipes.

In carrying out our process by the use of such an apparatus, the milled sheets having an elongated or banded grain structure (illustrated in Fig. 2) are caused to enter the heating zone 10. In treating 20 gauge sheets, for example, good results are obtained by raising them in a period of approximately 3 minutes to a temperature of about 1750° F. They then pass into the short quick cooling or quenching zone 15, while still enveloped in a non-oxidizing atmosphere, the air being excluded by the arrangement shown and described, and this zone being filled with the cooled products of combustion. Here the sheet is suddenly quenched to a temperature materially below that of normalizing heat, preferably 1300° F. or below. This very sudden cooling hardens the metal, whose grains form in fine even nodule arrangements illustrated in Fig. 3. The desired softening and

resulting enlarging of the crystals and the releasing of the so-called strains set up by the quenching in the rapid cooling zone are effected by regulated reheating to a desired temperature. Such temperatures range upwardly again in about one minute to about 1450° F., or less, as desired.

Variations in these reheating temperatures produce varying results which are satisfactory up to something below the normalizing temperatures. The sheets continue moving beyond the burners of the reheating zone and cool in the products of combustion to a temperature at which it is safe to expose them to the open air. They then may be stacked and otherwise treated, as desired.

Exemplary relative times and temperatures producing satisfactory results are illustrated in the graph, Fig. 14, the ordinate indicating the temperatures in °F., and the abscissa the time in seconds. The relative positions and steps of the process are indicated by legends.

From the foregoing description it will be seen that by our method of normalizing and annealing, we have accomplished our method of continuous treatment of such sheets by a very simple additional step and rearrangement for quick cooling treatment, and furthmore, that the process lends itself to use with very simple and inexpensive apparatus in conjunction with normalizing furnace equipment.

It is to be understood that the times and temperatures as well as the furnace construction shown and described may be varied to suit varying conditions and final results desired, and that such variations do not depart from the spirit of the invention as defined in the appended claims. The term "normalizing" used in the description and claims is a well understood term in the art, and as a class furnaces for heating steel sheets are so designated and as herein used, is intended to mean the reforming of the mill rolled sheets to a fine granular structure and by the temperature required, causing the thorough commingling and homogenizing of the ingredients of the steel, and is inclusive of the subsequent treatment to render the steel workable for its uses.

We claim:

1. A normalizing furnace comprising a tunnel structure and means for continuously transporting therethrough the materials to be treated, said furnace including successively in the direction of movement of said materials a heating compartment and a contiguous communicating quick quenching compartment and a contiguous communicating reheating and cooling compartment, burners for heating said heating compartment and said reheating and cooling compartment, and means to remove heat from said quick quenching compartment, baffle means restricting the entrance and exit passages of said quick quenching compartment whereby the passage of heat from adjacent compartments thereinto is partially impeded and products of combustion may enter the same.

2. A normalizing furnace comprising a tunnel structure and means for continuously transporting therethrough the materials to be treated, said furnace including successively in the direction of movement of said materials a heating compartment and a contiguous communicating quick quenching compartment and a contiguous communicating reheating and cooling compartment, fuel burners in spaced relation along said heating compartment and said cooling and reheating compartment for heating the same and for maintaining predetermined temperatures at different portions thereof, baffles at the entrance and exit ends of said quick quenching zones defining passages of substantially the same cross sectional shape and slightly larger than the material to be treated, and means to restrict the entrance and exit of said tunnel structure for maintaining the products of combustion from said fuel burners in all of said compartments and excluding oxidizing atmosphere.

3. A furnace for continuously heat treating steel sheets, comprising a tunnel structure and a conveyor extending therethrough for progressing therethrough the sheets to be treated, said structure being divided successively in the direction of progression into a heating compartment, and a contiguous communicating quenching compartment and a contiguous communicating reheating and cooling compartment, said compartments being closed to the outside atmosphere for retaining non-oxidizing products of combustion therein and said quenching compartment being very short relative to the heating compartment, burners in said heating compartment and said reheating and cooling compartments, and means to remove heat from the quenching compartment including a water tank below the conveyor therein, and pipes extending therethrough above the conveyor and sealed within the quenching compartment, means for circulating a cooling fluid through said pipes, and partially open baffles separating the quenching compartment from each of the contiguous compartments.

4. A furnace for continuously heat treating steel sheets, comprising a tunnel structure and a conveyor extending therethrough for progressing therethrough the sheets to be treated, said structure being divided successively in the direction of progression into a heating compartment and a contiguous communicating quenching compartment and a contiguous communicating reheating and cooling compartment, said compartments be-

ing closed to the outside atmosphere for retaining non-oxidizing products of combustion therein, and said quenching compartment being very short relative to the heating compartment, burners in said heating compartment and said reheating and cooling compartments, and means to remove heat from the quenching compartment including a water tank below the conveyor therein, and pipes extending therethrough above the conveyor and sealed within the quenching compartment, means for circulating a cooling fluid through said pipes, means restricting the passages into said quenching compartment including downwardly extending baffles terminating slightly above the conveyors and partially open to permit products of combustion to filter into said compartment and upwardly extending baffles terminating just below the undersurface of the sheets.

5. A normalizing furnace for steel sheets comprising a tunnel structure sealed sufficiently to exclude outside atmosphere, and means for continuously transporting therethrough the materials to be treated, said furnace including successively in the direction of movement of said materials, a heating section, a contiguous communicating quick quenching section and a contiguous reheating and cooling section, burners for heating said heating section and part of said reheating and cooling section, baffle means restricting the entrance and exit passages of said quick quenching section whereby the passage of heat from adjacent compartments thereinto is partially impeded and products of combustion are passed thereinto for maintaining a non-oxidizing atmosphere therein.

6. A normalizing furnace for normalizing steel sheets comprising a continuous elongated tunnel structure, said structure being substantially sealed to exclude outside atmosphere along its entire length and means for continuously transporting therethrough a series of sheets to be treated, said tunnel structure comprising in the direction of movement of the sheets therethrough successively a heating section, a contiguous communicating quick cooling section and a contiguous communicating reheating and slow cooling section, means including burners discharging into the heating section and reheating section for maintaining predetermined temperatures in said sections and for supplying therein in intimate contact with the sheets passing therethrough non-oxidizing products of combustion whereby said sheets are protected from non-oxidation during passage through the entire furnace.

7. A furnace for treating steel sheets, comprising a continuous tunnnel structure substantially sealed for excluding outside atmosphere, and comprising in the order named a heating compartment for heating the steel above normalizing temperature for the particular steel being treated during passage of the sheets therethrough, a contiguous communicating quick cooling compartment for very suddenly chilling the steel to a temperature below normalizing temperature and to about 1300° F. during passage of the sheets therethrough, and a contiguous communicating reheating and cooling compartment for respectively reheating the sheets to a temperature below normalizing temperature and above 1300° F. for materially affecting the grain growth and for gradually cooling the sheets to a temperature at which they may be exposed to the atmosphere without scaling during passage of the sheets through said last mentioned compartment, and means for continuously passing a series of sheets through said compartments in the order named, and means for heating said heating and reheating sections and for maintaining in all of said compartments a non-oxidizing atmosphere.

8. The process of treating sheets of steel which comprises continuously transporting a series of sheets in succession along a predetermined path, heating said sheets to a normalizing temperature and up to about 1750° F. as a maximum during passage along part of said path, immediately suddenly cooling the sheets to a temperature below normalizing temperature and to about 1300° F. during passage of the sheets along a succeeding portion of said path of movement, and then reheating the sheets to a temperature below normalizing temperature for the particular sheets and above 1300° F. and gradually cooling the same to a non-scaling temperature during passage of the sheets along the remainder of the path of movement and maintaining the sheets in a non-oxidizing atmosphere during all of said steps.

9. The process of treating sheets of steel, which comprises continuously transporting a series of sheets in succession along a given path, heating said sheets to a normalizing temperature and up to about 1750° F. during their passage along part of said path and in a period of about three minutes, immediately suddenly cooling the sheets to a temperature of about 1300° F. during passage of the sheets along a contiguous portion of the path of movement and in about one-third of a minute, and then reheating the sheets to a temperature of about 1500° F. in a period of one minute and gradually cooling the sheets to a non-scaling temperature during passage of the sheets along the remainder of the path of movement and maintaining the sheets in a non-oxidizing atmosphere during all of said steps.

10. A normalizing furnace for steel sheets comprising a continuous elongated tunnel structure substantially sealed along its length to exclude outside atmosphere, and means for

continuously transporting therethrough a series of sheets to be treated, said tunnel structure including successively in the direction of movement of said sheets a heating section, a contiguous communicating quick cooling section and a contiguous communicating reheating and cooling section, and means for heating the heating section to a temperature sufficient to raise the temperature of the sheets above their normalizing temperature during passage of the sheets therethrough, and for heating the reheating section to a temperature below the normalizing temperature but sufficiently to materially affect the grain structure of the sheets during passage through said reheating section, and means to maintain a non-oxidizing atmosphere throughout said furnace.

In testimony whereof, we hereunto affix our signatures.

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