

Sept. 29, 1959

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2,906,652

METHOD OF MAKING BRIGHT-FINISHED STEEL STRIP

Filed June 20, 1956

2 Sheets-Sheet 1

FIG. 1

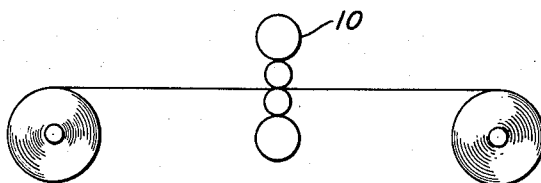


FIG. 2

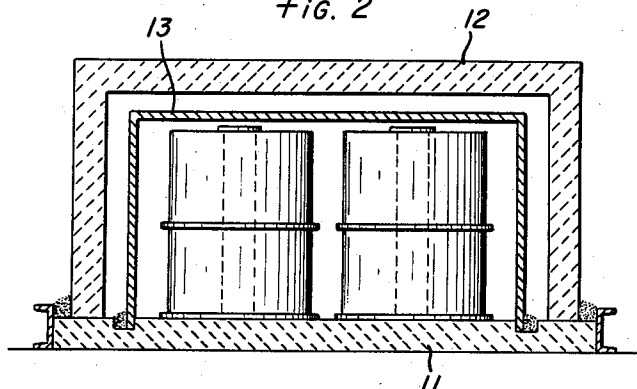


FIG. 3

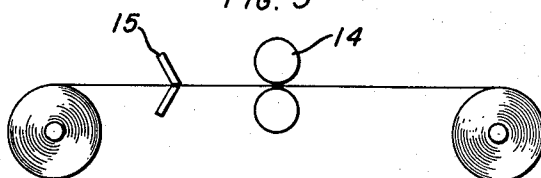
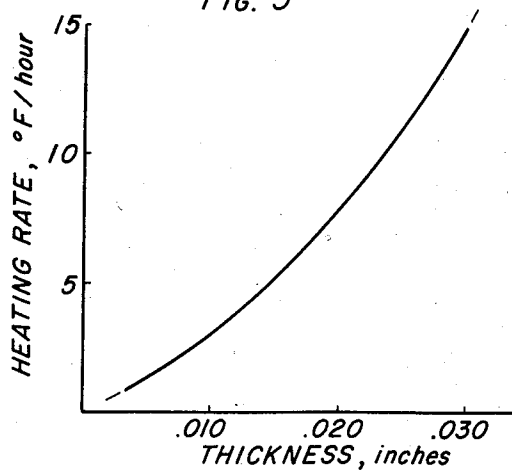


FIG. 5



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FIG. 4

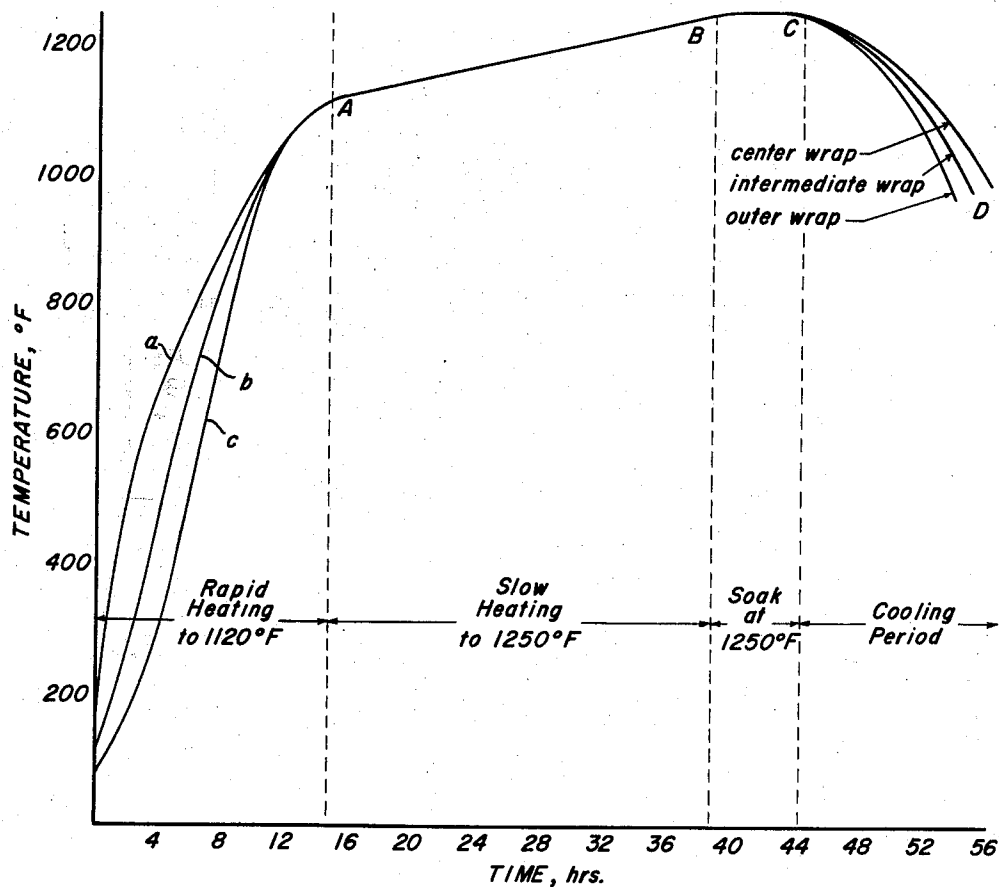
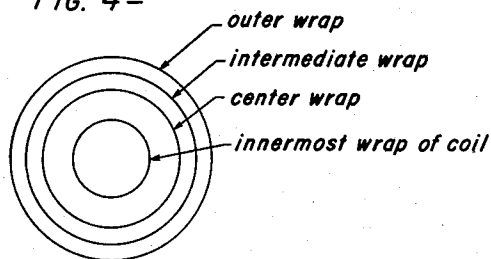


FIG. 4a



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METHOD OF MAKING BRIGHT-FINISHED
STEEL STRIP

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2 Claims. (Cl. 148—12)

This invention relates to the manufacture of sheet or strip steel and, in particular, to the production of thin-gage sheets or strip of low-carbon steel having a bright, lustrous finish on the surface thereof, in the "as-rolled" condition.

Bright-finished or "mirror"-finished sheets of low-carbon (less than .15% C.) steel are used in certain applications where appearance is of major importance. In the production of such sheets by the best practice known heretofore, serious difficulty has been experienced continually for several years because of the development of a wavy, irregular pattern, particularly adjacent the edges of the strip from which the sheets are sheared, after the annealing and temper-rolling thereof. The pattern is usually present after annealing but may be obscured until the strip is given its final finish by temper-rolling between polished rolls. This treatment brings out any difference in surface texture, even though not previously noticeable. While the exact cause of the pattern which appears has not been established with certainty, its presence is readily observable. The pattern effect cannot be removed and, since it impairs the appearance, it is often sufficient cause for rejection because prime sheets must have a uniform, unmarred, lustrous appearance.

I have invented a method of manufacture whereby the formation of a pattern effect on the surfaces of bright-finished steel sheets is entirely prevented. In a preferred practice I cold-roll cleaned hot-rolled steel strip substantially to final gage and then anneal it. I control the rate of heating of the material during the latter part of the heating portion of the annealing cycle, so that the entire mass comes up to temperature at the same time, i.e., without substantial temperature differentials between various parts of each coil. This requires that the temperature of the coil be increased at a very low rate between a borderline temperature such as 1100° F. and the final temperature of around 1250° F. After reaching final temperature the coils are held there for several hours and are then permitted to cool substantially to atmospheric temperature. The entire annealing operation is conducted as usual under a non-oxidizing atmosphere.

A complete understanding of the invention may be obtained from the following detailed description and explanation which refer to the accompanying drawings illustrating the present preferred embodiment. In the drawings:

Figures 1-3 are diagrammatic showings of the several steps of my improved method;

Figure 4 is a time-temperature curve showing the progress of the annealing cycle, according to my invention;

Figure 4a is an explanatory diagram related to Figure 4; and

Figure 5 is a curve showing the maximum permissible rate of temperature rise during the last stage of the heating portion of the cycle, for various thicknesses of material.

Referring in detail to the drawings and, for the present particularly to Figures 1-3, the three steps of my overall

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method are as there shown and described. Hot-rolled strip of low-carbon steel, say .12% carbon, at a gage of from .075 to .120", say .083", is cleaned in the usual manner and reduced by passing it through a single-stand reversing cold mill 10, to cold-rolled strip of from .012" to .035" in thickness, say about .020" or even .015" depending on the desired final gage. The thickness of the strip after cold-rolling should be within from 3 to 5% of this final gage. The cold-rolled strip is then annealed in coils under a non-oxidizing atmosphere, in about the usual manner, except for the modification now to be described, using conventional apparatus, i.e., a base 11, a heating cover 12 and an inner cover 13.

The particular novelty of my invention resides in the heating-up portion of the annealing cycle, shown graphically in Figure 4. In the usual case, when a coil is heated from atmospheric temperature, the temperature of the outer and innermost wraps rises most rapidly, i.e., along curve (a) of Figure 4. The temperature of the intermediate wraps inwardly of the interior and exterior wraps rises next most rapidly, i.e., along curve (b). The temperature of the center wraps rises most slowly along curve (c). I effect this part of the heating stage so as to raise the temperature of all portions of the coil as rapidly as possible to an intermediate temperature of between 1075 and 1175° F., say about 1120° F. When this temperature has been reached, I reduce the supply of heat to the cover 12 so that further increase in temperature will occur at a lower rate. As a result, curves (a), (b) and (c) merge at point A and continue as one thereafter. This portion of the cycle will take perhaps 14 hours, at a heating rate of about 75° F. per hour, averaged over the entire time.

When the temperature of the coils has become substantially uniform throughout at 1120° F., I continue to supply heat at a reduced rate so that the temperature of the coils will rise at a much lower rate; the temperature of all portions of the coil rising substantially simultaneously at a definite increase per hour. The rate of increase will vary with the thickness of the strip and may be from 2 to 8° per hour for .010" strip, 8 to 10° per hour for .020" strip and 12 to 17° per hour for .030" strip. The curve of Figure 5 gives the maximum permissible heating rates during the final portion of the heating-up stage for 20" diameter coils of strip of various thicknesses weighing from 4,000 to 7,500 pounds. For strip .020" thick the maximum rate is 7.5° per hour. As will be noted from the curve of Figure 5, the maximum heating rate in degrees per hour is about one-third the thickness of the strip in thousandths of an inch, but this ratio may be as high as one-half or as low as one-quarter.

The criterion for the maximum heating rate is that it should be low enough to insure that the heat flow from both the upper and lower sides of the coil is sufficient to keep the center wraps of the coil at substantially the same temperature as the inner and outer wraps.

Heating at this low rate causes all portions of the coil to come up in temperature substantially simultaneously to the required final value, i.e., from 1200 to 1300° F., say 1250° F. At the rate typified by the curve of Figure 4, the rise from 1120 to 1250° F. will, of course, require about 24 hours. The slow rise in temperature is indicated in Figure 4 by the portion of the curve between points A and B. I prefer to circulate the atmosphere inside the inner cover by known means, throughout the heating stage, to aid the convection of heat to the coils. When the coils have reached the final temperature, they are held there from 4 to 10 hours, say about 6 hours, this part of the heating stage being represented by the portion of the curve of Figure 4 between points B and C, which is parallel to the time axis.

After holding the coils for several hours at the final annealing temperature, the input of heat is cut off by removing the heating cover 12 and the coils are allowed to cool while still in the protective atmosphere within the inner cover 13. The cooling is permitted to progress as rapidly as it will, along portion C—D of the curve of Figure 4, the rate of cooling preferably being at least 50° per hour. This may easily be maintained by continued circulation of the atmosphere in the inner cover after removal of the heating cover. The existence of a differential between temperatures of various portions of the coil is not objectionable at temperatures below 1100° F. Natural cooling causes the time-temperature curve to branch, with curve (a) dropping most rapidly, curve (b) next and curve (c) last, i. e., the same order in which they ascended to level A.

When the coils have cooled to a safe temperature, i. e., such that they may be removed from the protective atmosphere without being oxidized in the air, say 300° F., the strip is subjected to temper-rolling between the highly polished rolls of a mill 14 which effects a reduction in gage of from 3 to 5%. The strip should be wiped thoroughly before entering the mill as by wipers 15 and for best results, the mill rolls should be super-finished and free from any surface blemish. As a result, a bright, lustrous or mirror finish is imparted to the strip. By virtue of the special annealing cycle described, furthermore, it remains free from the objectionable wavy pattern observed in bright-finished strip as made heretofore, even after temper-rolling.

Although the reason for the appearance of the pattern which occurred prior to my invention remains obscure, I believe it results from non-uniform annealing and, more specifically from vaporization of iron at the crystal or grain boundaries in the edge portions of the strip when temperatures above 1100° F. are reached during the annealing as ordinarily conducted. The edge portions of the coil, being heated to a higher temperature than the mid-portion, exhibit the results of this vaporization to a greater degree than the latter, giving rise to the pattern effect. In practicing my invention, I avoid this by carefully maintaining all portions of the coil at substantially the same temperature at all times when at a temperature above 1100° F. Thus, any vaporization which may occur is substantially uniform throughout the surface of the strip and the development of a pattern effect is thereby obviated.

It will be apparent that my invention affords a simple, easily practiced yet effective method of eliminating pat-

tern for bright-finished sheet steel and makes it possible to produce material having a uniform bright appearance throughout.

Although I have disclosed herein the preferred practice of my invention, I intend to cover as well any change or modification therein which may be made without departing from the spirit and scope of the invention.

I claim:

1. A method of making bright-finished steel strip comprising cold-rolling cleaned hot-rolled steel strip substantially to the desired finished gage, then annealing the cold-rolled strip in coils under a protective atmosphere in four distinct stages, i. e. (1) heating at a rate of about 75° F. per hour to from 1075 to 1175° F., (2) heating to a final temperature between 1200 and 1300° F. at a maximum rate equal to one-half the strip thickness in inches times 1000° F. per hour, (3) holding at said final temperature from 4 to 10 hours and (4) cooling to a temperature of 300° F. while still under said atmosphere, then temper-rolling the strip between polished rolls to effect a gage reduction of from 3 to 5%.

2. A method of making bright-finished steel strip comprising cold-rolling cleaned hot-rolled steel strip substantially to the desired finished gage, then annealing the cold-rolled strip in coils under a protective atmosphere by heating the coils at a rate of about 75° F. per hour to an intermediate temperature from 1075 to 1175° F., then after all portions of the coils have reached substantially a uniform temperature, further heating the coils to a final annealing temperature between 1200 and 1300° F. at a rate of about 10 degrees F. per hour, whereby the temperature of all portions of the coils continues to be substantially uniform, holding the coils at said final temperature for several hours, then cooling the coils to a temperature of 300° F. while still under said atmosphere, and temper-rolling the strip between polished rolls to effect a gage reduction of from 3 to 5%.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,906,652

September 29, 1959

John M. Kiefer, Jr.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 19, for "cure" read -- curve --; line 69, before "from" insert -- for --; column 4, line 1, for "for" read -- from --.

Signed and sealed this 15th day of March 1960.

(SEAL)

Attest:

KARL H. AXLINE

Attesting Officer

ROBERT C. WATSON

Commissioner of Patents