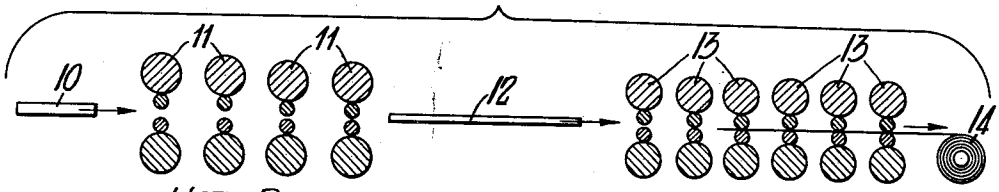
July 1, 1952 J. C. ECKEL 2,602,034

METHOD OF MAKING ENAMELING SHEETS

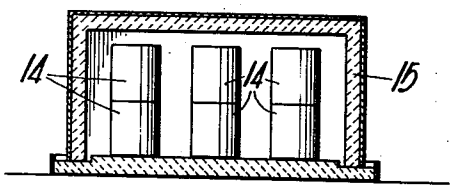
Filed Jan. 18, 1950

FIG. 1.



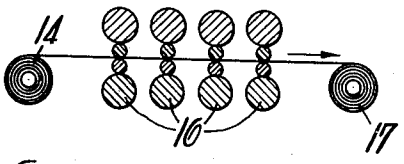
HOT ROLLING AND LOOSE COILING.

FIG. 2.



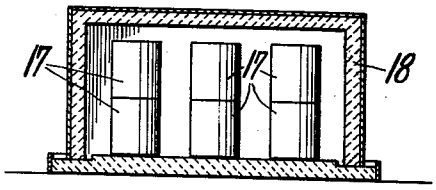
BOX ANNEALING (1500 - 1650°F.) LOOSE COILS.

FIG. 3.



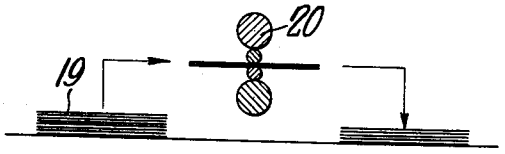
COLD ROLLING TO GAUGE.

FIG. 4.



BOX ANNEALING (1200 - 1275°F.)

FIG. 5.



TEMPER ROLLING.

Inventor:
JOSEPH C. ECKEL,
by: Donald G. Dalton
his Attorney.

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METHOD OF MAKING ENAMELING SHEETS

Joseph C. Eckel, Pittsburgh, Pa., assignor to United States Steel Company, a corporation of New Jersey

Application January 18, 1950, Serial No. 139,195

1 Claim. (Cl. 148—12)

1

This invention relates to the processing of ferrous sheets after the hot-rolling thereof, to impart thereto the properties desired for their ultimate use and, in particular, to the processing of enameling stock.

The past experience of the industry indicates that a normalizing treatment of ferrous sheets produces the best enameling stock, the normalizing treatment being followed by pickling. Such treatments, however, are very costly and there has consequently been a demand for a less expensive processing which would produce material of substantially the same characteristics. Box-annealing has been viewed hopefully in this connection because it is lower in cost than normalizing and eliminates pickling. The maximum temperature permissible for thus treating stacked low-carbon sheets or tight coils of strip suitable for the application of a porcelain enameling coating, however, is from 1200 to 1275° F., because of the tendency of the sheets or coil wraps to stick or weld together if heated to a higher temperature and the danger of causing defects such as blisters in the enamel coating. Box-annealing at the maximum temperature stated, as previously attempted, has consistently failed to produce material having the desired mechanical or physical characteristics. Despite much effort, furthermore, no commercially feasible modification of the usual or standard practice of box-annealing yet proposed has given any such favorable results as to indicate that the solution of the problem of the high cost of normalizing and pickling might lie in this direction.

I have discovered that if hot-rolled ferrous sheets be subjected to appropriate heat treatment before cold-rolling to gauge, they will exhibit such improved response to subsequent box-annealing that the final product, for enameling purposes, is practically equivalent to normalized sheets. More particularly, I have found that the box-annealing of ferrous stock having a chemical composition suitable for enameling, at temperatures from 1500 to 1650° F., before cold-rolling to gauge will cause the material when subsequently box-annealed according to the usual practice, to develop properties comparable to those of normalized enameling stock. Preferably the material is in the form of loose coils of strip during the initial annealing, so that cold-rolling to gauge may be carried on in the customary manner.

In order to afford a complete understanding of the invention, I shall describe in detail hereinbelow a typical procedure in the manufacture of

2

enameling sheets in accordance with my invention. This description refers to the accompanying drawings, the several figures of which illustrate the several successive steps of my new method. In the drawings,

Figure 1 shows the roughing and finishing strands of a continuous hot-strip mill;

Figure 2 shows a cover-type annealing furnace;

Figure 3 shows a continuous cold-rolling mill;

Figure 4 shows a furnace similar to that of Figure 2; and

Figure 5 shows a single-stand temper-rolling mill.

A slab 10 of steel having an analysis suitable for enameling stock and specifically a low carbon content, i. e., less than .10% and preferably around .03%, is passed through the roughing stands 11 of a hot-strip mill and converted into a breakdown 12. A typical analysis is:

Carbon	.03–.05%
Manganese	.03–.12%
Silicon	.05% max.
Phosphorus	.10% max.
Sulphur	.04% max.
Fe	Balance

The breakdown 12 is then sent through the finishing stands 13 and the resulting hot-rolled strip, finished at from 1520 to 1600° F. and about .080" thick, is formed into a coil as at 14. The coil is formed so that the successive wraps thereof are relatively loosely coiled, i. e., they do not have intimate contact with each other throughout more than a small portion, say 25%, of their area.

The loose coils 14 are immediately placed on the base of a cover-type annealing furnace 15 with as little opportunity for cooling as may be convenient. The cover is lowered thereover and the coils are heated to a temperature between 1500 and 1650° F. in from five to ten hours and held there for from ten to twenty hours. This box-annealing of the hot-rolled strip can be carried out in a neutral atmosphere, an oxidizing decarburizing atmosphere, or a non-oxidizing decarburizing atmosphere as desired, those skilled in the art of making enameling sheets being familiar with such atmospheres and their reactions. When the coils have cooled substantially to atmospheric temperature, they are removed from the furnace 15, pickled and then cold-rolled substantially to gage by passing them through the several stands 16 of a cold-rolling mill and recoiling. Should the lubricant used on the strip

during cold-rolling be of the type which leaves a carbonaceous deposit on the sheets after box-annealing, the strip should be cleaned after cold-rolling by suitable treatment as already well known.

The coils 17 of cold-rolled strip are placed on the base of a furnace 18 similar to that shown at 15, heated to a temperature between 1200 and 1275° F. and held there for from ten to twenty hours in accordance with conventional box-annealing practice, utilizing a non-oxidizing atmosphere in the furnace to obviate scaling and the resulting necessity for pickling. When cooled substantially to atmospheric temperature, the coils are removed from the furnace, temper-rolled in coil form or as sheets 19 on a single-stand temper mill 20. Alternatively, the strip may be sheared into sheets before the final anneal. After temper-rolling the material is ready for shaping and enameling.

The following table shows the comparison between material produced by the method disclosed herein (column A) and material made by the conventional process of normalizing (column B):

	A	B
Yield Point, lbs./in.	24,600–27,000	25,000–30,000
Ultimate Strength, lbs./in.	43,000–45,300	40,000–43,000
Elongation in 2", per cent	35–38	33–38
Hardness, Rockwell B	42–43	32–42
Grain Size	6	5–6

It will be apparent that the characteristics of the sheets produced by the two methods are closely similar. Sheets made by normalizing after cold-rolling and without the previous heat treatment contemplated by my invention, show a higher hardness and yield point and an irregular grain size.

The cost of the method of my invention is substantially less than the cost of normalizing, even though two box-annealings are required, because of the economy characteristic of the latter treatment and the elimination of a pickling operation which is necessary after normalizing.

Annealing before cold-rolling possesses several collateral advantages besides producing enameling sheets with mechanical properties substantially equal to those of normalized stock. If the annealing of loose-wound coils before cold-rolling be conducted in a decarburizing atmosphere, preferably with a vigorous circulation of the atmosphere, the annealed metal is freed to a considerable extent from carbon. This results in enameling sheets showing substantially no gas evolution during the firing of the porcelain enamel coating and, therefore, possessing superior enameling properties, particularly in the application of single white or light-colored coats of porcelain enamel without the use of a conventional ground coat. Carbon reduction effected in the box-annealing at 1500–1650° F. in a decarburizing atmosphere decreases the potential amount of distortion on firing of the enamel coat by increasing the critical points of the metal to temperatures above the maturing temperature of the enamel and, at the same time, reducing the distortion and warpage of the articles shaped from the sheets.

I claim:

In a method of making enameling stock, the steps including winding hot-rolled low-carbon ferrous strip about .080" thick into loose coils, box-annealing the coils before further reduction in strip thickness, at a temperature of from 1500 to 1650° F., cooling the strip to atmospheric temperature, pickling the strip, cold-rolling the strip substantially to final gauge, and again box-annealing the cold-rolled strip at a temperature between 1200 and 1275° F., whereby the resulting sheet metal is substantially free from gas evolution on firing a vitreous enamel coat applied thereto and exhibits reduced distortion and warpage as a result of such firing.

JOSEPH C. ECKEL.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,536,663	Cunningham	May 5, 1925
1,723,152	Grafton	Aug. 6, 1929
1,857,215	Ruder	May 10, 1932
2,084,336	Goss	June 22, 1937
2,127,388	Canfield et al.	Aug. 16, 1938
2,381,435	Burns et al.	Aug. 7, 1945
2,495,167	Horstman et al.	Jan. 17, 1950