Feb. 13, 1934. A. H. SHONKWILER ET AL 1,946,766

FINISHING FERROUS SHEET MATERIAL

Filed April 8, 1933

Fig. 1.

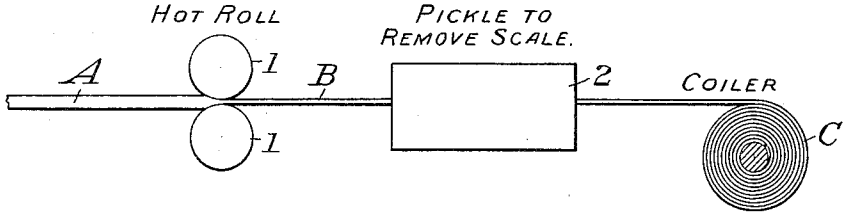
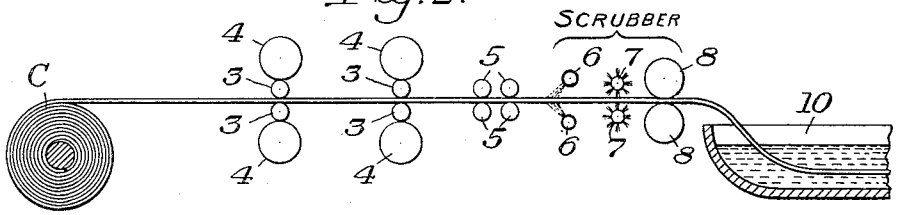


Fig. 2.



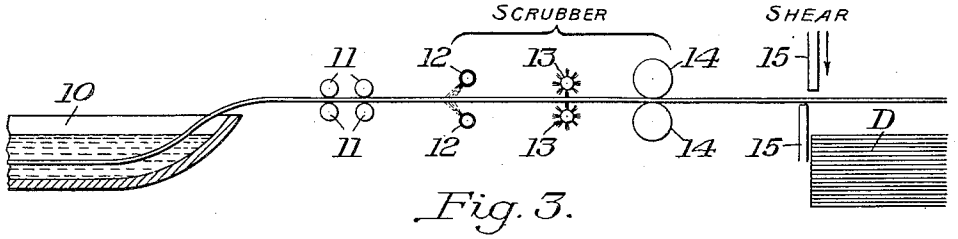


Fig. 3.

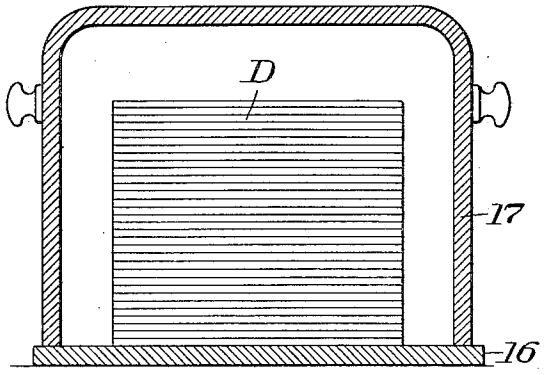
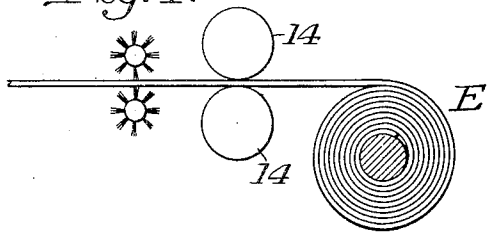


Fig. 4.



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Patented Feb. 13, 1934 1,946,766

UNITED STATES PATENT OFFICE

1,946,766

FINISHING FERROUS SHEET MATERIAL

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Application April 8, 1933. Serial No. 665,186

11 Claims. (Cl. 148—4)

This invention relates to the finishing of cold rolled ferrous sheet material. More particularly, the invention relates to steps in the process of producing ferrous sheet material by a cold rolling method which shall result in the production of ferrous sheet material which takes paints or lacquers readily and whose surface has characteristics rendering it less liable to be scratched and marred.

We use the expressions "ferrous sheet material" and "sheets" as terms of general definition and not of limitation, and intend to include thereby any ferrous sheet-like materials, such as those known to the trade by the technical terms "strip sheet", "strip", "sheets", "plates", etc.

As cold rolled sheet material has come into more extensive use, particularly in the automobile trade, difficulty has arisen in its use due to the unusually bright glossy surface which will not retain paint or lacquer. A dull finish is particularly desirable for several reasons. The dull finish sheet does not show scratches in handling, neither is it susceptible to marks resulting from being drawn by dies. The dull finish sheet has better drawing qualities, due to a better gripping of the sheet when drawing with dies. Moreover, due to the dull finish, lacquer adheres better to a sheet whose surfaces have a dull finish.

As is well known, the usual cold rolling procedure imparts to the ferrous sheet material a bright glossy surface. To do away with this hard glossy surface, two procedures have been resorted to.

In the first of these known procedures, the cold rolled strip in a coil is open annealed at about 1650° F. and air-quenched. This process is commonly known as "normalizing", since it results in a so-called normalized fine grain structure. As a result of this open annealing, oxide scale is formed on the surface of the material; and when this oxide scale is removed in the subsequent pickling operation, a dull finish results. The pickled coil is then sheared into lengths, and the sheets are given two passes in a cold mill under light pressure to flatten the sheet. The sheets are then given a box annealing and are then given two light passes in a cold mill.

The second procedure is to shear the cold rolled strip into lengths, and then open anneal the sheets to above the critical temperature to form a coating of oxide on the surface of the sheets, and then air-quench, or normalize. This oxide or scale is removed by pickling in sulphuric acid. The sheets are then given two passes through a cold mill to straighten them, after which the sheets are box annealed and subjected to two passes in a cold mill to slightly harden the surface so that it draws without slippage of the grain of the surface.

We have discovered that cold rolled ferrous sheet material may be finished with surfaces having improved qualities for receiving paint or lacquer by a procedure which is less costly than the two procedures above outlined. In accordance with our preferred process, the cold rolled strip is passed through an etching bath, then sheared into lengths and box annealed.

Following the box annealing, the lengths of material are subjected to two cold roll passes to slightly compact the surface. As a modification of this procedure, the cold rolled strip may be sheared into lengths before the etching step. The sheared sheets are etched, box annealed, and subjected to two cold roll passes as is the procedure with the embodiment first described.

Our invention results in a considerable reduction in the cost of producing dull finished sheets from cold rolled sheet material. Both of the procedures above described as known heretofore involve open annealing which costs about $3.50 per ton. This open annealing is followed by pickling in sulphuric acid which costs about $3.00 per ton. The two passes in the cold mill to straighten the sheets cost about 90¢ per pass or $1.80 per ton for the two passes.

In our process, the cost of the etching step is about $1.90 per ton. The open annealing, the expensive pickling, and the straightening are done away with, with the result that a saving of about $6.50 per ton is effected over the old practice.

In order to present a clear and complete teaching of our invention, we have shown diagrammatically in the accompanying drawing a succession of steps which may be carried out in accordance with our invention. In the drawing which is intended merely as illustrative and not as limiting the invention to the precise details shown,

Fig. 1 shows the hot rolling process by which ferrous sheet material is produced;

Fig. 2 shows the cold rolling steps followed by the treatment of the surfaces of the sheet material to etch the same;

Fig. 3 shows in section an annealing box in which the annealing step may be performed; and

Fig. 4 indicates an alternative manner in which annealing may be carried out.

Fig. 1 shows strip steel B being hot rolled by

passing heated metal A between hot rolls 1, 1. The rolled strip B is passed through a pickling bath 2 to remove the scale formed at this high temperature on the hot strip, and is coiled as indicated at C. It will be understood that the hot rolling is so carried out that the thickness of the strip B is greater by at least a third than that desired in the finished product, and generally the strip B is twice as thick.

The coil of pickled strip is then cause to travel through the passes of two cold rolling mill stands arranged in tandem. As is customary, a pair of comparatively small cylindrical alloy rolls 3, 3 of great hardness are backed up by larger rolls 4, 4 by which the smaller rolls are maintained in contact with the strip. In the embodiment shown in the drawing, feed rolls 5, 5 are arranged beyond the cold rolling mills to advance the strip at the desired speed. Sufficient pressure is exerted by the rolls 3, 3 so that the original grains which are fairly large in the hot rolled strip are stretched out and broken up into small grains.

Subsequent to the cold rolling, the oil which is generally applied to the surface of the strip at the time of cold rolling is removed. A scrubber may be employed which, as shown in Fig. 2, comprises spray pipes 6, 6 for spraying the upper and lower surfaces of the strip with alkali and/or water, followed by brushes 7, 7 for scrubbing the surfaces of the sheet, and wringer rolls 8, 8 of soft rubber for removing excess moisture.

The cleaned strip is now ready to have its surfaces treated to remove the high gloss. As shown in Fig. 2, the strip is passed into a tank containing in solution nitric acid or a nitric acid compound which will break up when dissolved in a bath of sulphuric acid, freeing nitric acid by the reaction. On a basis of cost, the preferred etching solution contains sodium nitrate and sulphuric acid. As a specific example, we have employed a water solution containing 2% by weight of sodium nitrate and 5% by volume of 60° Bé. sulphuric acid. The etching bath is preferably employed at room temperatures. The temperature should not be allowed to exceed about 100 to 110° Fahrenheit, since the valence and chemical activity of iron increase with increase in temperature, and accordingly a large amount of acid would be wasted at high temteratures in oxidizing the iron into ferric form.

The etching solution must be such as will actively attack the steel. Sulphuric acid or hydrochloric acid is not sufficiently energetic to attack the hard cold rolled surface. The action of the nitric acid is apparently to oxidize the material to form an iron oxide which is soluble in sulphuric acid. This is indicated by the fact that the etching bath has to be enriched almost entirely with sulphuric acid and there is a very slight consumption of nitric acid.

Other source of nitric acid such as potassium nitrate is usable; but as market conditions now exist, sodium nitrate is the cheapest. Picric acid likewise is usable and will etch the surface of the sheets; but the cost at present is prohibitive. The same is true of ferric chloride, or ferric chloride together with sulphuric acid.

The time allowed for immersion in the bath is governed so as to permit sufficient etching to remove the gloss or hard polish from the strips or sheets, while avoiding sufficient attack on the surfaces to waste metal and acid, or impair the surface. With the strip travelling at a speed of 125 feet per minute, a tank 25 feet long will afford an immersion of the strip for ten seconds. The amount of etching can be varied by varying the time of immersion of the strip in the etching bath, or by varying the strength of the etching acid employed.

After the strip emerges from the tank 10, the the strip passes between additional feeder rolls 11, 11 and is washed for the purpose of removing the adherent etching solution. If desired, an alkali solution (such as sodium carbonate) may be applied either as a second bath or as a spray. As shown in Fig. 2, a second scrubber is employed comprising spray pipes 12, 12, brushes 13, 13 and wringer rolls 14, 14.

After the etching solution is removed by the second scrubber, the strip passes either through the shears 15, 15, being severed into sections which are deposited in a pile D, or is delivered to a coiling machine and fashioned into a coil E as shown in Fig. 4.

Subsequently, the pile D or the coil E as the case may be, is laid on a bottom plate 16, covered by a suitable box top 17, and the whole placed in a furnace where it is raised gradually to such temperature as to soften the ferrite without producing objectionable grain growth, for example, a temperature of about 1200° to 1300° F. Sufficient time is allowed for the heat to penetrate into the interior of the pile or coil. For instance, annealing for forty hours at a furnace temperature of approximately 1300° F. is sufficient to take out the strains caused by cold rolling and to somewhat round out the small grains produced as a result of the crushing effect of the rolls 3, 3. The annealing at 1300° does not, however, interfere with the fineness of the grain produced by the cold rolling; and a finer ultimate grain structure is obtained than has been possible with the two procedures above described as already known, in which the heat treatment at above 1650° F. completely eliminates the fine grain structure and forms a new normalized grain structure due to the heating and air quenching.

After the box annealing, the sheets should ordinarily be given two cold roll passes to slightly compact the surfaces of the sheets. The effect of these passes is sufficient merely to harden the surface while leaving the interior fully annealed; and accordingly, strains in subsequent operations are avoided. The cold rolled effect is very superficial and reduces the thickness from a quarter-thousandth to two-thousandths of an inch.

In preparing sheets for the application of vitreous enamel, a sheet with a sufficiently matte surface to hold the vitreous enamel is desired. The usual procedure which has been employed has been to hot roll the thin sheets in packs. Sheets which are thus hot rolled in packs can be pickled and the oxide removed so as to give a matte surface. Our procedure described above may be employed for obtaining the desired matte surface for sheets to be coated with vitreous enamel by prolonging the time allowed for the etching of the sheets somewhat beyond the time required for the dull finish for lacquered sheets and sheets for automobile bodies. The sheets thus produced are superior to the sheets obtained by the pack rolling procedure, in that they are free from deep surface pits; and moreover, the procedure entails considerably less expense. The sheets produced in accordance with our process have the advantages in drawing with dies of the favorable grain structure imparted by the cold

rolling; and at the same time, the surface of the sheet has been sufficiently roughened to give the "sharp teeth" required for holding the vitreous enamel. Not only does the old procedure, involving pickling with sulphuric acid of the sheets hot rolled in packs, lead to marring of the sheets by deep surface pits; but this old procedure causes losses in the enameling process due to boiling of the enamel (probably due to some foreign inclusions on the surface which have not been entirely removed by the sulphuric acid pickle). Sheets produced in accordance with our process do not give rise to this difficulty (nitric acid seemingly being effective to completely remove such surface inclusions).

Our process for finishing ferrous sheets for general utility, such as automobile bodies, has this same advantage, namely, that the sheets produced have surfaces which are free of the small pits quite generally formed on the surfaces of sheets subjected to the open anneal and sulphuric acid pickle in accordance with known procedures. These known procedures result in the rejection of a considerable percentage of sheets because of this objectionable pitting of the surfaces; and often sheets which are not rejected have some tendency to show small objectionable pits.

The dull finish sheets produced by our process may also be advantageously used for galvanizing where a tightly adherent zinc coating is desired, since the surface etching furnishes an exceptionally good anchorage for the zinc coating to the steel. Our dull finish sheets can also be advantageously employed for terne coats.

There is a further decided advantage in our procedure over the known procedures in that sheets produced in accordance with the old procedure are very soft, having a Rockwell of 40 to 55 on the B scale as they come from the open anneal; and are likely to be scratched in handling prior to the box annealing. Sheets produced in accordance with our process are full hard, having (following the etching step) a Rockwell of about 88 to 93 on the B scale, so that danger of scratching prior to box annealing is eliminated. This freedom from scratches is particularly advantageous where paint or lacquer is to be applied to the finished product. In the case of sheets produced by the old procedures, these scratches show through the paint or lacquer; and consequently polishing of the steel before applying of the paint or lacquer must be resorted to in order to take out the blemish due to the sub-surface scratches and pits. The necessity for polishing after painting or lacquering has been practically eliminated with the dull finish sheets produced in accordance with our invention.

A further advantage resulting from the use of the etching bath is the readiness with which the stack of sheets may be unpacked after the box annealing. If a pile of cold rolled sheets with the hard polished surfaces resulting from the cold rolling be box annealed, the adjacent faces of the material adhere so tenaciously at the end of the annealing step that it is sometimes an arduous task, if not altogether impossible, to separate the surfaces due to the sheets welding to each other. The dull surfaces resulting from the etching step of our process entirely eliminate any tendency on the part of adjacent surfaces to adhere together.

The dull finish cold rolled sheets produced in accordance with our invention have a further quality which is of importance in connection with drawing of the sheets in dies. The Olson ductility tests for 20 gauge sheets show about .400 to .420 on sheets produced in accordance with our invention, as against .385 to .400 on the sheets made in accordance with the old process in which the sheets were normalized. The greater ductility in the sheets which are etched and box annealed in accordance with our process is, we believe, due to the crushed grain resulting from the cold rolling of the strip. During the box anneal at a relatively low temperature, the cold working strains within the grain structure are eliminated, but no objectionable grain growth results; and improved ductility of the sheet is a consequence of the series of steps taught herein. Experience has shown that sheets having the crushed grain structure resulting from cold rolling have greater ductility than sheets having the fine grain structure resulting from a normalizing treatment.

Low carbon steels constitute the material usually used for the production of drawing steel or sheets used for automobiles or for vitreous enameling. It will be understood, however, that our invention is not limited to application of the steps set forth to steel which are low in carbon. It is contemplated that various steels including those in which other metals are alloyed with iron come within the contemplation of the process constituting our invention.

This application is a continuation-in-part of our copending application Ser. No. 539,698, filed May 25, 1931.

While we have specifically described certain preferred embodiments of our invention, including specific formulæ for the etching bath in which etching of the polished surfaces may be carried out, it is to be understood that the invention is not so limited, but may be otherwise embodied and practiced within the scope of the following claims.

We claim:

1. In the process of producing ferrous sheet material by first hot rolling, then cold rolling, and then finishing, the finishing steps consisting in etching the cold rolled material by treatment with a solution containing the nitric acid radical in active form, and then annealing the etched material.

2. In the process of producing ferrous sheet material by first hot rolling to substantially twice the desired gauge, then cold rolling substantially to the desired gauge, and then finishing, the finishing steps consisting in etching the cold rolled material by treatment thereof with a solution containing sulphuric acid and sodium nitrate, and box annealing the material.

3. In the process of finishing cold rolled ferrous sheets, strips or the like material, the steps consisting in etching or corroding the cold rolled material by treatment with a solution containing the nitric acid radical in active form, and then annealing the etched material at a temperature below that at which objectionable grain growth occurs.

4. In the process of finishing cold rolled ferrous sheets, strips or the like material, the steps consisting in etching or corroding the cold rolled material in a bath containing sodium nitrate and sulphuric acid in solution, and then box annealing the material at a temperature of about 1200° to 1300° F.

5. The process of producing ferrous sheet material, comprising the steps of hot rolling the material into sheet form, pickling the sheets to remove the scale produced in hot rolling, cold rolling the pickled sheets to produce a fine crushed grain structure and a highly finished glossed surface, immersing the sheets in an acid etching bath to produce a dull surface finish, and so annealing the dull finished sheets as to remove the cold rolling strains without causing objectionable grain growth.

6. The process of producing ferrous sheet material, comprising the steps of hot rolling the material into sheet form, pickling the sheets to remove the scale produced in hot rolling, cold rolling the pickled sheets to produce a fine crushed grain structure and a highly finished glossed surface, immersing the sheets in an acid etching bath containing sulphuric acid and the nitric acid radical to produce a dull surface finish, and so annealing the dull finished sheets as to remove the cold rolling strains without causing objectionable grain growth.

7. The process of producing ferrous sheet material, comprising the steps of hot rolling the material into sheet form, pickling the sheets to remove the scale produced in hot rolling, cold rolling the pickled sheets to produce a fine crushed grain structure and a highly finished glossed surface, immersing the sheets in an acid etching bath to produce a dull surface finish, so annealing the dull finished sheets as to remove the cold rolling strains without causing objectionable grain growth, and lightly cold rolling the thus annealed sheets.

8. The process of producing ferrous sheet material, comprising the steps of hot rolling the material into sheet form, pickling the sheets to remove the scale produced in hot rolling, cold rolling the pickled sheets to produce a fine crushed grain structure and a highly finished glossed surface, etching the sheets to produce a dull surface finish, and so annealing the dull finished sheets as to remove the cold rolling strains without causing objectionable grain growth.

9. The process of producing ferrous sheet material, which comprises the steps of hot rolling the material into sheet form, pickling the sheets to remove the scale produced in hot rolling, cold rolling the pickled sheets to produce a highly finished glossed surface, etching the sheets to produce a dull surface finish, and annealing the dull finished sheets.

10. The process of producing ferrous sheet material, which comprises the steps of hot rolling the material into sheet form, pickling the sheets to remove the scale produced in hot rolling, cold rolling the pickled sheets to produce a highly finished glossed surface, immersing the sheets in an acid etching bath to produce a dull surface finish, and annealing the dull finished sheets.

11. The process of producing ferrous sheet material, which comprises the steps of hot rolling the material into sheet form, pickling the sheets to remove the scale produced in hot rolling, cold rolling the pickled sheets to produce a highly finished glossed surface, immersing the sheet in an etching bath containing the nitric acid radical in active form to produce a dull surface finish, and annealing the dull finished sheets.

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