Dec. 16, 1941. J. S. NACHTMAN 2,266,330

PROCESS FOR ELECTROPLATING STRIP STEEL

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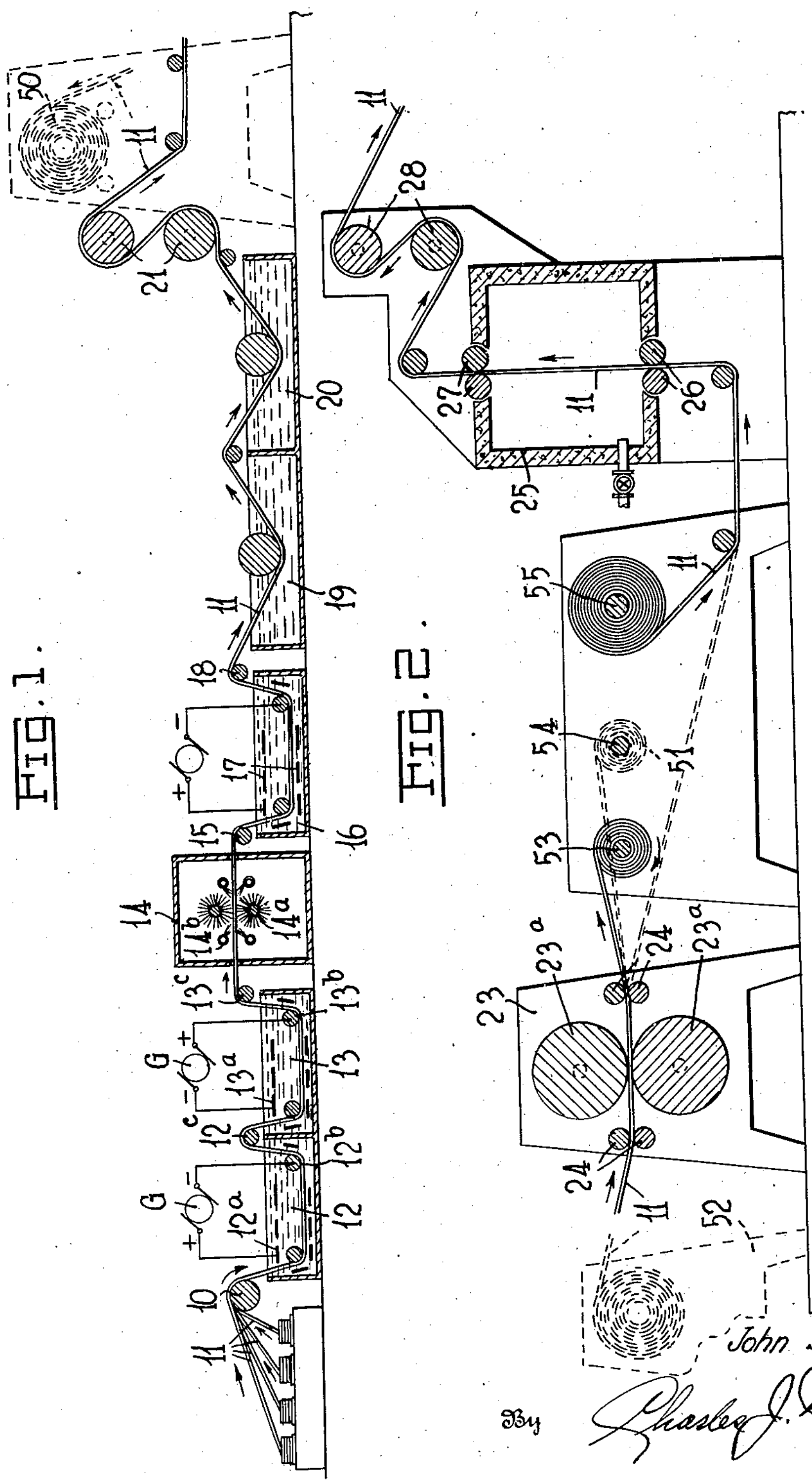

Fig. 1.

Fig. 2.

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FIG. 3.

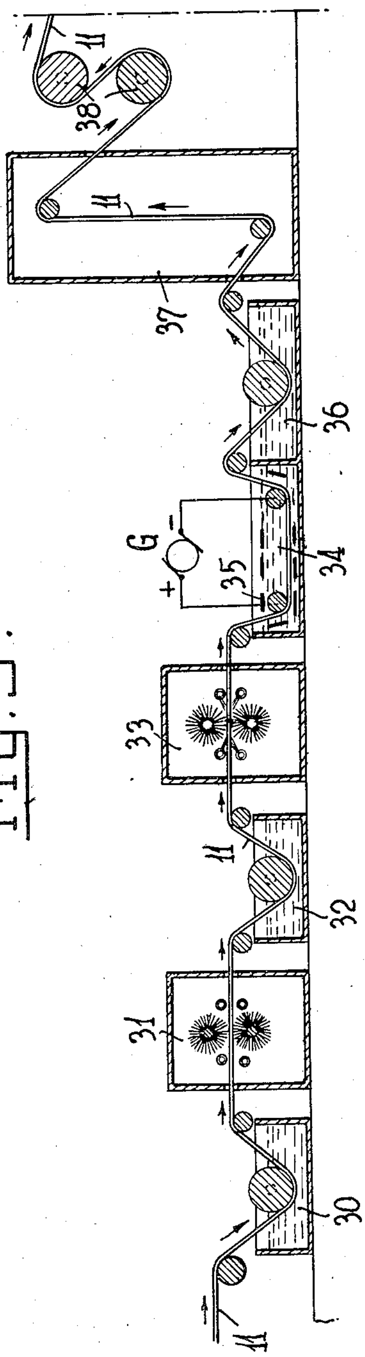
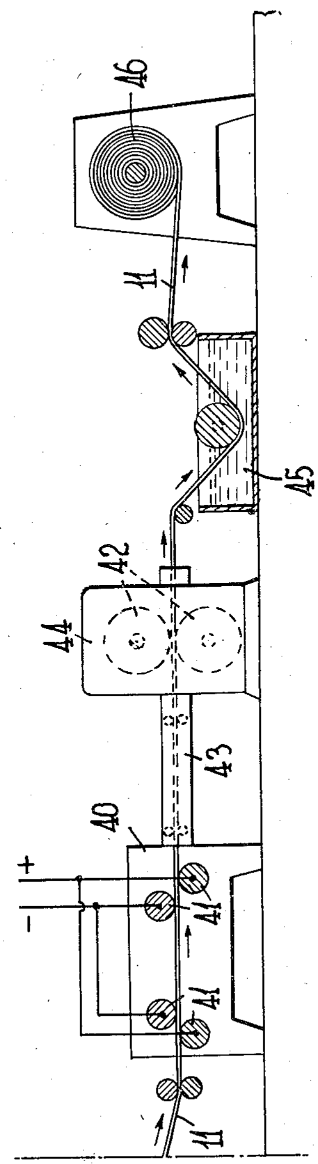


FIG. 4.



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PROCESS FOR ELECTROPLATING STRIP STEEL

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Application February 25, 1937, Serial No. 127,776

5 Claims. (Cl. 204—28)

This invention relates to a new and improved method of producing tin-plated ferrous metal stock and is particularly directed to the production of improved tin coatings upon steel stock in the form of strips, sheets or wire of extensive length.

A principal object of the invention is the production of improved tin-plated ferrous metal, and especially the production of tin-plated steel strip stock which is more suited to the manufacture of cans or containers for food products than the tin-plated stock heretofore available.

A further object of the invention is to provide a more economical method for the production of tin-plated ferrous metal than the so-called "hot tin coating" method.

Another object of the invention is the provision of a method for the rapid and economical plating of steel or other ferrous metal in the form of strips or sheets of greatly extended length which may be coiled or reeled.

It is important that cans or containers, such as for food products, shall be highly rust resistant and free from surface defects and pinholes, whereby the plated product is given a longer life and the contents of the containers are protected against deterioration and contamination; and it is also desirable that the plated product have a lustre finish exterior, rendering it more attractive.

It has been found that the above-mentioned objects and other desirable advantages may be attained by the method of the invention which comprises electro-plating the base stock with a ferrous or non-ferrous metal or alloy and thereafter electroplating the stock with tin. It is further particularly advantageous to subject the plated stock after the final plating to a temperature sufficient to alloy the final plating with the earlier plating. The plated stock may also advantageously be subjected to a heating operation before the final plating, whereby the earlier plating or platings are caused to alloy with the ferrous metal base.

It is desirable to subject the base metal to thorough cleaning before submitting it to the plating operations. Preferably this cleaning includes an electrical cleaning operation whereby the base stock is passed in immediate succession through a plurality of electrical pickling baths in one of which the base stock is the cathode and in the other the base stock is the anode.

The finally plated stock is also preferably subjected to a smoothing operation after it has been heated to effect alloying in order to improve the quality and appearance of the coating.

The preliminary plating may be effected with any electrolytically depositable ferrous or non-ferrous metal or alloy of such metal, preferably including at least one metal other than tin. Among the metals which may be used in the first plating are copper, nickel, chromium, cobalt, tungsten, iron and the like or alloys thereof such as copper-tin, copper-nickel, nickel-iron, nickel-cobalt, and the like.

The base metal stock may in general be any suitable ferrous metal in sheet, strip wire or other extended form. Thus, when I speak of "strip," I have reference to any suitable extended form such as previously mentioned. Rolled steel is particularly suitable and may be utilized in hot rolled condition, or after cold rolling or annealing or both. Summarized briefly, for obtaining the same final quality product in the case of hot rolled stock, I prefer the following sequence of operations: (1) pickle to remove scale and oxides; (2) wet mechanically clean the strip to remove particles, film, etc., left by the pickle; (3) plate with an under coat of metal; (4) roll the strip to reduce it to proper gauge, thus hardening it; (5) anneal the strip to remove the hardness produced in (4) above and to alloy the metal under coat to the base strip; (6) clean the annealed strip for further plating; (7) plate with a metal having a low melting point such as tin or an alloy such as terne; (8) heat the strip to fuse the last applied coating and to alloy such coating with the metal under coating. It is apparent that the process can be applied to the strip in any condition between hot rolled and completely cold rolled.

For the purpose of illustration a specific embodiment of the principles of the invention will be more particularly described with reference to the accompanying drawings which are diagrammatic representations of a typical embodiment of the invention.

In the drawings:

Fig. 1 shows the cleaning and preliminary plating of ferrous metal strip;

Fig. 2 shows the steps of rolling the preliminarily plated strip to gauge and alloying the plating with the base metal;

Fig. 3 shows further cleaning and tin-plating of the strip; and,

Fig. 4 shows the steps of alloying the tin plating with the previous plating and subjecting the strip to a smoothing or gauging operation.

The practice of my invention will be particularly described with reference to the plating of hot rolled strip steel. The strip steel to be plated is unwound from a payoff reel 10 from which the strip 11 is pulled, by pull rolls at the different stations along the line, as hereinafter explained. The strip 11 passes in succession through tanks 12 and 13, each of which contains a pickling electrolyte which may be like that described in my Patent No. 1,950,689 or may be a neutral salt, such as ammonium fluoride or sodium nitrate. In the pickling tank 12, the pickling is cathodic and in tank 13 it is anodic.

In the case of the pickling tank 12 the positive side of generator G is connected to plates 12a submerged in the electrolyte, and the negative side of the generator is connected to one or both of the metallic guide rollers 12b also submerged in the electrolyte and over which the strip 11 passes.

From the tank 12 the strips 11 pass over a guide roller 12c into a tank 13 where the positive side of the generator G is connected to one or more of the guide rollers 13b and the negative side is connected with the plates 13a submerged in the electrolyte.

While generators G are shown for purpose of illustration, any suitable source of current for this purpose may be employed. This treatment is especially efficacious in producing chemically clean surfaces on the strip or strips 11 for electro-depositing or plating by removing all oxides rolled into the strip by the hot rolling process.

From the tank 13 the strip stock 11 passes over a guide roller 13c and there is subjected to a mechanical cleaning. This mechanical cleaning may be performed by the apparatus 14 which may comprise rotary brushes 14a which will contact both sides of the strip stock 11 and also spray devices 14b arranged for spraying either water or steam on the surfaces of the strip stock. However, other forms of mechanical cleaning may be found desirable.

From the brushing and spraying apparatus 14, the cleaned strip passes over a roll 15 that directs it through the plating tank 16 containing any suitable electrolyte according to the metal or alloy to be plated, but which, for the plating of copper, may consist of copper cyanide, sodium cyanide, sodium sulphite and water. The strip is electrically connected with the negative pole of a direct current generator and is therefore the cathode. The copper anodes 17 above and below the strip, as shown, are connected to the positive side of the direct current generator, and thus plate each side of the strip.

It is preferred in the present process to only plate a thin or flash coating at the tank 16, which is usually sufficient for the purposes of the invention. However, heavier coatings may be plated and for some purposes may be desirable.

From the plating tank or station 16, the strip passes from a roll 18, first to a water rinsing tank 19 containing cold water and then to and through a tank 20 containing hot water which, due to the rapid evaporation of the hot water, may sufficiently dry the strip stock. However, if found desirable, a drier, not shown, but which may be the same as the drier 36 shown in my U. S. Patent No. 1,991,817, may be employed. From this drying step the strip stock 11 passes over drums 21 by which the pulling action on the strip is effected.

Referring to Fig. 2 it will be seen that the copper plated strip stock 11 is passed to one or more cold rolling machines 23, whose construction need not be described in detail, by which it is cold rolled to the desired thickness. The strip stock 11, leaving the rolling rolls 23a, is kept under tension by pinch rolls 24 from which it is passed to a vertical furnace 25 by feed rolls 26 which eliminates marking or scratching the stock and conserves horizontal space in the plant. In such furnace 25 a reducing atmosphere is maintained and the strip stock is subjected to a temperature approximately the melting point of the metal deposited at 16, but below the melting point of the base metal, which in the case of copper is about 1950° F. This heat treatment produces an alloy between the contiguous surfaces of the plating metal and of the base strip stock 11, thereby at least providing three distinct layers, consisting of the base metal, the alloy and the plated metal, and rendering the plated strip stock almost free from pinholes when thin plating is done at 16. Of course, it is understood that heavier plating would eliminate all pinholes. Satisfactory results may be obtained by using lower temperatures in the furnace 25. The temperature is selected according to the depth of alloying desired. The higher the temperature, the greater the alloy depth.

From the furnace the strip passes between rolls 27 and is delivered to pulling drums 28 (corresponding to the similar drums 21 of Fig. 1) by which the strip is pulled onward.

After the above-described three layer alloying step the plated strip stock is subjected to a cleaning treatment, shown by way of example, by first passing it through the cleaning tank 30 containing, preferably, an alkaline bath and, then, to the mechanical cleaner 31 comprising a water spray and brushing means similar to the cleaner 14 in Fig. 1. After being thus cleaned, the strip may be next subjected to a "brightening dip" in tank 32 containing chromic acid and sulphuric acid, and after being etched it is again water sprayed and brushed by apparatus 33 similar to 31. The plated strip stock is now prepared for the tin-electro-plating bath to which it is next subjected for tin plating.

The tin electrolyte bath is contained in a tank 34 of usual construction and similar to the tank 16 of Fig. 1. The strip is the cathode and is therefore connected with the negative side of the generator and there are tin anodes 35 above and below the strip, as shown, connected to the positive side of the generator. Thus each side of the strip is tin plated. An example of a suitable tin electrolyte is as follows:

	Gms./liter
Stannous sulphate	60–130
Sulphuric acid	3–6
Aloin	5
Succinic acid	1–2

Other acids may be used than succinic acid, such as malic acid, lactic acid, diphenyl sulphonated acid, hydro-fluosilicic acid and cresol sulphonic acid, or phenol sulphonic acid. Other suitable tin electrolytes may also be used for electro-depositing the tin.

The amount of tin deposited may be varied in accordance with the use to which the product is to be put. In general, the weight of the deposit may be varied from one-quarter pound to three pounds of tin per base box which is a coating or deposit upon each side of the product of from .000015" to .00018" thick.

After leaving the tin plating bath, the strip is water rinsed in a tank 36 and may also be dried, if desirable, in heat chamber 37 from which the strip stock is drawn onward by pulling drums 38 and from the latter delivered to the subsequent steps shown in Fig. 4, if desired.

The steps of the invention next to be described, with reference to Fig. 4, are for hardening the plating and to give the plated product a more satisfactory appearance.

Platings of non-ferrous metals on ferrous metals have, in most cases, a white or non-metallic appearance, and in some cases are objectionably soft, both of which characteristics are objectionable to the trade which makes use of plated strip steel as stock material for working up into a great variety of products by such operations as stamping, deep-drawing, etc. It is also desirable to alloy the different metals to one another. By the following steps non-ferrous coatings are given the desired hardness, an alloy is formed, and the coating is given the required bright metallic appearance, so that it looks like buffed nickel or buffed stainless steel.

Describing what is shown in Fig. 4 of the drawings, the plated strip stock is passed through a heater 40 which subjects the strip to a temperature just below the melting point of the last-plated non-ferrous coating on the strip stock 11. In practice, I use temperatures ranging from five to twenty-five degrees F. below the melting point. Such heater as shown is electrical and includes a chamber within which are two sets of copper rolls 41, each set being in pairs, one above the other, and the two sets being spaced apart in the direction of travel of the strip horizontally through the chamber of the heater 40.

In the heater 40 the strip is heated in a reducing atmosphere by electrically heating to a temperature just below the melting point of the last deposited coating. This acts as a pre-heating step ahead of the heater 44 and permits the plated coating to be quickly melted and smoothed and alloyed by the action of the reducing rolls 42 in heater 44. The temperature in heater 44 is above the melting point of the last coated metal. The contact between the strip and rolls 42 is for only a short interval of time and due to the rolling action of the heater rolls 42, the coating is smoothed and fused as it passes between the rolls 42 and solidifies as it passes out of heater 44. The strip then is cooled in the cooling bath 45.

I find that a highly lustrous coating may be produced if the temperature in the heater 40 is above the melting point of the last deposited coating. Where the hot oil or low melting salt above is used in place of the electric heater the rollers 41 will be omitted; the strip is heated above the melting point of the last deposited coating and then quenched without coming in contact with guiding rolls.

The copper rolls 41 are connected in pairs with the opposite poles of a 12 to 18 volt D. C. variable speed generator, the two upper rolls of the two sets being, as shown, connected to the positive side of the generator. Thus, by the heating of the rolls, the temperature above stated is produced and maintained in the chamber of the heater 40. Suitable means, not necessary to be described, are provided to control the temperature of the copper rolls, 41, such means comprising no part of my invention. The chamber 40, heated by the rolls 41, is maintained at reducing atmosphere.

From the heater 40 the strip is passed (preferably through a closed conduit 43 between suitable guide rolls) to the heating means 44, which subjects the strip to a temperature above the melting point of the last deposited non-ferrous coating, such heating means including a reducing stand which has upper and lower heat resisting reducing rolls 42 internally heated by electrical units, and between which rolls 42 the strip is passed. The temperature of these rolls in practice is from ten to fifty degrees F. above the melting point of the coating. The rolls 42 contacting the melted coating act to smooth out and solidify it and form the alloy, with its contiguous metal surface.

The reducing rolls 42 are made of a metal which does not oxidize at the high temperatures to which they are subjected, and thus discoloration from oxidation is avoided. Such rolls may be of a steel nickel chrome alloy that is heat resisting. The heating means may be electrical.

As a result of the treatment or treatments by which the plating on the strip is subjected to a melting temperature, and while melted acted on by reducing rolls 42, I secure the results herein before set forth of giving the desired metallic luster to the non-ferrous coating and the production of an alloy between the metal layers. After leaving the rolls 42, the strip is cooled, as by being passed through a tank 45 containing oil or water at a temperature between 60° F. and 150° F.

The finished product is wound into a roll upon a drum or reel 46 driven by a variable speed motor in order to compensate for the increasing diameter of the roll or coil.

The plating accomplished by the process exemplified in Figs. 1, 2 and 3 secures results satisfactory for many uses, without carrying the process further. However, better results are secured for some uses by the proper selection of the metal to be first plated on the strip stock 11, at 16, and continuing the process in accordance with the treatment shown and described with respect to Fig. 4.

Of course, a number of strips, 11, may be simultaneously subjected to my process by being run through the apparatus side by side, but not in contact with one another, and may have dimensions of from ¼ inch to 84 inches in width, and from 1/1000 inch to ¼ inch in thickness, and a length so great, sometimes several thousand feet long, that, for convenience in handling, it is wound into a coil.

It will, of course, be understood that where, because of limitations of space, it is not possible or practical to have the above-described process run continuously without a break, the strip stock may be wound on reels following each of the draw-drums 21, 28, and 38, as indicated in dotted lines at 50 and 51 in Figs. 1 and 2 or at any other convenient point in the process. A fully wound reel is then placed on an unreeling stand 52 (as in Fig. 2) at any break in the process so that the process may continue as described. In Fig. 2, it may be found desirable to reel up the strip stock alternately on reels 53 and 54, after passing through the pinch rolls 24; and then transfer the full reel to an arbor 55 to pay-off to the feeding rolls 26 of the furnace 25. Therefore, the word "continuous," as used herein and in the appended claims contemplates and includes such breaks as above mentioned where strips of great length are employed.

The tin-plated stock produced by the above process is superior to any hot tin coated strip or stock or any electro-tin-plated stock or sheet produced by known processes, yet is cheaper to produce. This is true because the plating can be accomplished by a continuous process in continuous strips or sheets delivered in roll or coil form instead of single sheets, thus reducing the cost of handling and operating costs to both the producer of the plated product and to the manufacturer of containers or other articles to be made from the plated product; the plated product requires less tin than hot tin coated stock; the plated stock is more rust resistant than any tin plate available at present and is free of pinholes and other defects, due to the chemical cleaning of the surfaces of the base stock above-described and the duplex plating of the base stock with dissimilar metals preferably alloyed as above-described; and finally the product has a more lustrous finish than the present tin-plated product and is, therefore, more attractive.

The process of making satisfactory tin plate for can manufacturers or for other purposes may be modified by rolling hot rolled ferrous metal stock to desired gauge before electroplating the initial coating rather than afterwards as described herein in detail with reference to hot rolled stock.

The term "electroplating" in the specification and claims is intended to include only electrodeposition in which an electric potential is applied from an external source between a bath of electrolyte and the material to be plated upon.

This application is a continuation-in-part of my application Serial No. 55,917, filed December 23, 1935.

I claim:

1. In a method of coating strip steel with tin the steps of electroplating a thin coating consisting essentially of a metal selected from the class consisting of copper, nickel, chromium, cobalt, tungsten, and iron directly upon each side of a clean steel strip; then heating the thus-plated strip in a reducing atmosphere to a temperature not in excess of 1950° F. to provide at least three layers, consisting of the strip steel, an alloy of the steel and plating metal, and the plating metal; controlling the thickness of said alloy layer by controlling the heating temperature; then electroplating a tin coating between .000015'' and .00018'' thick upon each side of the thus-plated heat-treated strip; and then heating the tin plated strip in a reducing atmosphere to a temperature at least as high as the melting point of tin whereby a tin coating alloyed to the previously plated heat-treated strip is secured.

2. In a method of coating strip steel with tin the steps of electroplating a thin coating consisting essentially of a metal selected from the class consisting of copper, nickel, chromium, cobalt, tungsten, and iron directly upon each side of a clean steel strip; then heating the thus-plated strip in a reducing atmosphere to a temperature not in excess of 1950° F. to provide at least three layers, consisting of the strip steel, an alloy of the steel and plating metal, and the plating metal; controlling the thickness of said alloy layer by controlling the heating temperature; and then electroplating a tin coating between .000015'' and .00018'' thick upon each side of the thus-plated heat-treated strip.

3. In a method of coating strip steel with tin the steps of electroplating a thin coating consisting essentially of a metal selected from the class consisting of copper, nickel, chromium, cobalt, tungsten, and iron directly upon each side of a clean steel strip; then cold rolling the thus-plated strip; then heating the thus-plated strip in a reducing atmosphere to a temperature not in excess of 1950° F. to provide at least three layers, consisting of the strip steel, an alloy of the steel and plating metal, and the plating metal; controlling the thickness of said alloy layer by controlling the heating temperature; and then electroplating a tin coating between .000015'' and .00018'' thick upon each side of the thus-plated heat-treated strip.

4. In a method of coating strip steel with tin the steps of electroplating a thin coating consisting essentially of a metal selected from the class consisting of copper, nickel, chromium, cobalt, tungsten, and iron directly upon each side of a clean steel strip; then cold rolling the thus-plated strip; then heating the thus-plated strip in a reducing atmosphere to a temperature not in excess of 1950° F. to provide at least three layers, consisting of the strip steel, an alloy of the steel and plating metal, and the plating metal; controlling the thickness of said alloy layer by controlling the heating temperature; then electroplating a tin coating between .000015'' and .00018'' thick upon each side of the thus-plated heat-treated strip; and then heating the tin plated strip in a reducing atmosphere to a temperature below the melting point of tin, and then without exposing the thus-plated strip to the atmosphere, further heating the strip to a temperature above the melting point of tin whereby a tin coating alloyed to the previously plated heat-treated strip is secured.

5. In a method of coating strip steel with tin, the steps of electroplating a thin coating of copper directly upon each side of a clean steel strip; then heating the thus-plated strip in a reducing atmosphere to a temperature not in excess of 1950° F. to provide at least three layers, consisting of the strip steel, an alloy of the steel and copper, and copper; controlling the thickness of said alloy layer by controlling the heating temperature; then electroplating a tin coating between .000015'' and .00018'' thick upon each side of the thus-plated heat-treated strip; and then heating the tin plated strip in a reducing atmosphere to a temperature at least as high as the melting point of tin, whereby a tin coating alloyed to the previously plated heat-treated strip is secured.

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