

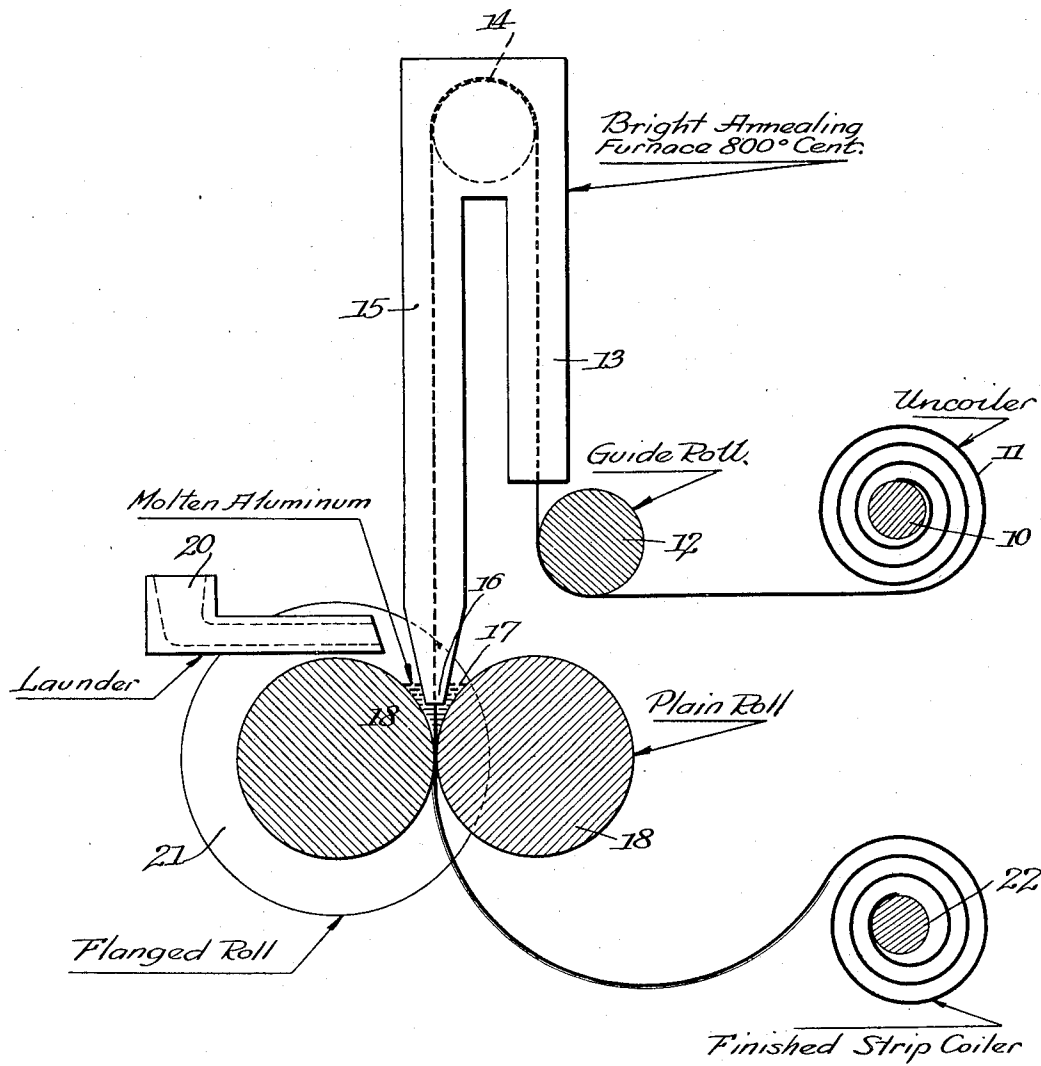
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METHOD OF COATING METAL

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METHOD OF COATING METAL

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This invention relates to a continuous method for annealing strips and sheets of steel and coating the same with aluminum.

It is an object of the invention to produce coated steel sheet or strip having a smooth and uniform coating of aluminum firmly united to the base metal and possessing an attractive silvery appearance.

Another object of the invention is to produce an aluminum coated steel in sheet or strip form which may be commercially worked as by stamping, pressing or drawing without cracking or loosening of the coating. The coated metal is useful in the manufacture of containers such as cans and bottles and container closures, e. g., crown caps.

The coating is non-corrosive, abrasion resistant and as distinguished from the usual tin plate, will take decorating lacquers and enamels which require a high baking temperature.

A further object of the invention is to produce aluminum coated steel in gauges comparable to that of the usual tin plate employed for making containers and caps but possessing superior advantages, and which may be commercially manufactured by a continuous method, rapidly and at a substantial saving over the cost of tin plate.

An important feature of the method employed in the invention is the step of conducting the annealing operation in a reducing atmosphere and passing the annealed metal directly to the molten bath of aluminum without opportunity for oxidation and under the influence of the reducing atmosphere. In addition to avoiding objectionable oxidation and resultant poor coating, this step eliminates the necessity for any cleaning or pickling treatment of the annealed metal between the annealing and coating operations and enables them to be immediately consecutive and continuous. The annealing is preferably accomplished at heating and cooling temperatures to produce a bright anneal which I find enables a very effective coated product to be achieved.

Another important step in the method of the invention is the introduction of the steel in annealed condition to a bath of molten aluminum at such a temperature relative to the temperature of the molten aluminum that the coating metal and the base metal will rapidly unite and form a smooth and firmly adhered coating. That is, the steel is preferably introduced to the molten bath at a temperature above the melting point (about 1250° F.) of aluminum, for example about 1500° F., under which conditions (1) a rapid and even union of the base and coating metals takes place,

and (2) a desirably thin uniform coating is obtained which may have a thickness below .0012" if desired.

I have discovered that by observing the above considerations and conducting the coating operation rapidly in an aluminum bath of relatively small volume, that a minimum of opportunity is presented for chemical reaction between the aluminum and the iron present in the steel whereby formation of a brittling reaction product (Fe_2Al_3) either beneath or at the surface of the aluminum coating is reduced to a point where the product is commercially workable without cracking or loosening the coating and the coating is smooth, uniform in appearance and non-corrosive.

Heretofore, the presence of such reaction product has mitigated against satisfactory commercial use of aluminum coated strip or sheet, since the excessive amount of Fe_2Al_3 rendered the product brittle, and the coating spotty and its union with the base metal weak. In accordance with the present method, however, wherein a preferably bright annealed steel sheet or strip free from oxidation is directly introduced at a high temperature to the molten aluminum bath, which I find need be of but small volume, and conducted through the bath at rapid rate, an aluminum coated steel product free of the aforementioned objections is obtained, i. e., the opportunity for reaction of the iron and aluminum to form a brittling compound is reduced to a negligible minimum.

In addition to the above steps of the method an equally important factor consists in rolling the coating metal on the sheet or strip. This not only enables the continuous method to be efficiently achieved, but, in addition, aids in producing a smooth and continuous coating of desired thickness. The nip between the coating rolls affords a means of supporting the aluminum bath, and the rolls are adjustable to control the thickness of the coating, and are also regulable to propel the strip or sheet through the several instrumentalities of the apparatus at the desired rate of speed.

In the drawing, I have illustrated a preferred apparatus for carrying out the invention, but this may be modified, or various other constructions may be utilized for practicing the method which will now be described in detail.

The numeral 10 indicates a suitable coiler carrying a coil of strip steel 11 in connection with which the method will be explained, but it is to be understood that the invention may be op-

erated with sheets or strips of any desired length. This steel has a low carbon content, e. g., .05 to .10%, and is of a customary thin gauge of about .005" to .015" comparable to the usual tin plate employed for making metal containers and container caps. The steel strip is traveled continuously from the coiler 10 under the guide roll 12 into the heating chamber 13 of the annealing furnace, over the roll 14 and through the cooling leg 15.

The lengths of the heating chamber and the cooling leg, the speed of the travel of the strip, and the temperatures maintained within the furnace and the leg are preferably such that the steel is (1) given a bright anneal, and (2) is cooled to a temperature, preferably in the neighborhood of 1472° F., i. e., the strip leaves the lower end 16 of the leg 15 at a high temperature, preferably above the melting point (about 1250° F.) of aluminum.

The lower end 16 of the leg 15 terminates below the level of a bath of molten aluminum 17 which as shown is wholly confined and supported between the coating rolls 18 and 19. The coating rolls also act to propel the strip through the several instrumentalities of the apparatus.

The annealing operation may be conducted at temperatures above 1500° F. and is preferably conducted in a reducing atmosphere such as hydrogen whereby its surface is cleansed of scale and oxide in accordance with well known practice from which the present invention departs, however, in that I find it to be an absolute requirement that this cleansing step be carried on at a temperature of at least 1000° F. to secure a satisfactory coating and preferably high enough so that the strip will be bright annealed and will have an initial temperature when entering the bath, above that of the bath in accordance with the method hereindescribed. By having the strip enter the bath 17 directly from the leg 15 of the annealing furnace, and below the surface of the bath, no opportunity for oxidation of the annealed strip is presented and, moreover, the hydrogen atmosphere in the leg 15 is available to act upon the aluminum in the bath and prevent any formation of objectionable oxide slag about the strip.

It is an important feature of the invention as above set forth, that the temperature of the base metal when introduced into the bath is relatively high, namely, around 1500° F., i. e., higher than that of the temperature of the molten aluminum in the bath 17 which is usually about 1250 to 1325° F. I find by continuously passing the annealed metal strip at such a temperature into the bath, for a relatively short distance and at a rapid rate with consequent reduction in the time period of contact between the base and coating metals, and coating the aluminum upon the base metal by means of rolls, that a very complete union between the base metal and the aluminum takes place in which the Fe_2Al_3 is not objectionably present and a smooth and uniform coating is produced.

The coating rolls 18 are operable at various speeds to control the rate of travel of the strip through the apparatus and are adjustable relative to each other to vary the thickness of the coating. The molten aluminum is fed to the bath from a suitable launder 20. One of the rolls 18 is formed with end flanges 21 cooperating with the nip of the rolls to form side walls for confining the bath. The bath may be provided with

means for coating the metal on one side only of the strip. By confining the bath in the nip of the rolls i. e. wholly supported by the rolls, a relatively small volume of molten aluminum is necessary and, consequently, only a short time period is required for effecting the coating operation.

Therefore, the initial temperature of the annealed base metal entering the bath, and the speed of travel of the strip is so controlled in cooperation with the relatively short distance required for the strip to traverse the bath, as to afford a very brief time period of contact between the strip and the aluminum. This reduces substantially the opportunity for reaction between the iron and aluminum, which is important, since aluminum coated steel heretofore produced has been objectionably characterized by the presence of an alloy or reaction product of the iron and aluminum (Fe_2Al_3) to the extent that the metal is brittle, and hence not commercially workable for drawing, stamping or pressing of metal products.

The coated product may be drawn, stamped or pressed to form a variety of shaped articles, for example, containers such as cans or bottles and metal closures such as crown caps without cracking of the metal or loosening of the coating, and is generally superior to the usual tin plate employed for this purpose. Moreover, the coating is free of spots and is corrosion resistant indicating the absence of an appreciable amount of Fe_2Al_3 in the coated surface. Also since the metal base is introduced at a high temperature, very thin coatings are obtainable, e. g., less than .0012", which are highly desirable.

The strip is ejected by the coating rolls 8 into the atmosphere and the molten coating is hardened by the reduced temperature thereof, the strip being coiled by a coiler 22 into a roll.

If desired, a suitable polishing and smoothing means may be employed to treat the coated strip after the coating is hardened and before it is coiled, i. e., during its passage from the coating rolls to the coiler.

In some cases, the hardening is produced by a quick cooling through the medium of a conduit having a cooling coil and preferably in a non-oxidizing atmosphere. Also, the molten coating strip may be first passed through a non-oxidizing atmosphere at elevated temperature and then into a cooling zone having a non-oxidizing atmosphere. Such treatments in a non-oxidizing atmosphere will avoid the effects of oxidation while the positively applied cooling or chilling will afford a quick hardening, thereby permanently preserving the brilliant mirror-like appearance of the molten coating as it issues from the coating rolls.

While I have described the invention in connection with the coating of steel strip with aluminum, it is equally useful for applying a coating of tin to the base metal. Where tin is used as the coating metal, the bath will have a temperature of about 600° F. and the strip will be heated so as to insure a proper adherence, being preferably introduced to the tin bath at a temperature of about 700° F.

Although I have described the method in considerable detail, it will be understood that the apparatus illustrated and the details of the method disclosed are merely illustrative and that such variations in the method and apparatus are within the invention as come within the scope of the appended claims.

I claim:

1. The continuous method of annealing and coating steel with one of a group of metals consisting of tin and aluminum comprising annealing the base metal and traveling the same, without opportunity for oxidation, into a molten bath of the coating metal wholly confined and supported between a pair of coating rolls, and rolling the coating metal on the surface of the base metal as it passes between said rolls.

2. The continuous method of annealing and coating steel with aluminum comprising annealing the base metal and traveling the same directly from the annealing treatment and without opportunity for oxidation, into a molten bath of the coating metal wholly confined and supported between a pair of coating rolls, and rolling the coating metal on the surface of the base metal as it passes between said rolls.

3. The method of coating steel with aluminum which comprises introducing steel at a temperature above the melting point of aluminum into a bath of aluminum wholly confined and supported between a pair of coating rolls, and coating the steel as it passes between said rolls therewith by rolling the aluminum upon the steel.

4. The method of coating steel with aluminum which comprises introducing steel at a temperature of about 1500° F. into a bath of aluminum wholly confined and supported between a pair of coating rolls, and coating the steel therewith by rolling the aluminum upon the steel as it passes between said rolls.

5. The continuous method of annealing and coating steel with aluminum comprising annealing the base metal and traveling the same, without opportunity for oxidation at an initial temperature above the melting point of aluminum to and through a molten bath of the coating metal wholly confined and supported between a pair of coating rolls, and rolling the coating metal on the surface of the base metal as it passes between said rolls.

6. The continuous method of annealing and coating steel with aluminum comprising annealing the base metal and traveling the same, without opportunity for oxidation, at an initial temperature of about 1500° F. to and through a molten bath of the coating metal wholly confined and supported between a pair of coating rolls, and rolling the coating metal on the surface of the base metal as it passes between said rolls.

7. The continuous method of annealing and coating steel with aluminum comprising bright annealing the base metal and traveling the same, without opportunity for oxidation at an initial temperature of about 1500° F. in and through a molten bath of the coating metal wholly confined and supported between a pair of coating rolls, and rolling the coating metal on the sur-

face of the base member as it passes between said rolls.

8. The method of coating steel with aluminum which comprises annealing the steel and introducing the same at a temperature above the melting point of aluminum into a bath of the coating metal wholly confined and supported between a pair of coating rolls, and coating the steel by rolling the aluminum upon the steel as it passes between said rolls.

9. The method of coating steel with aluminum which comprises annealing the steel and introducing the same at a temperature of about 1500° F. into a bath of aluminum wholly confined and supported between a pair of coating rolls and having a temperature of about 1250° F. to 1325° F. and coating the steel by rolling the aluminum upon the steel as it passes between said rolls.

10. The continuous method of annealing and coating steel with aluminum comprising annealing the steel and controlling the cooling thereof to a temperature above the melting point of aluminum, introducing the annealed steel at such temperature and without opportunity for oxidation into a bath of molten aluminum wholly confined and supported between a pair of coating rolls, and coating the aluminum on the steel by rolling the aluminum upon the steel as it passes between said rolls.

11. The continuous method of annealing and coating steel with aluminum comprising annealing the base metal in a reducing atmosphere at a temperature above 1000° F. and traveling the same, without opportunity of oxidation, into a molten bath of the coating metal wholly confined and supported between a pair of coating rolls, and rolling the coating metal on the surface of the base metal.

12. The continuous method of annealing and coating steel with aluminum comprising annealing the base metal at a temperature above 1500° F. and traveling the same in a non-oxidizing atmosphere into a molten bath of the coating metal wholly confined and supported between a pair of coating rolls, and rolling the coating metal on the surface of the base metal as it passes between said rolls.

13. The continuous method of annealing and coating steel with aluminum comprising annealing the base metal and traveling the same without opportunity for oxidation to a molten bath of the coating metal wholly confined and supported between a pair of coating rolls, introducing the steel at a temperature of substantially 1500° F. below the surface of the coating metal in a non-oxidizing atmosphere, and rolling the coating metal on the surface of the base metal as it passes between said rolls.

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