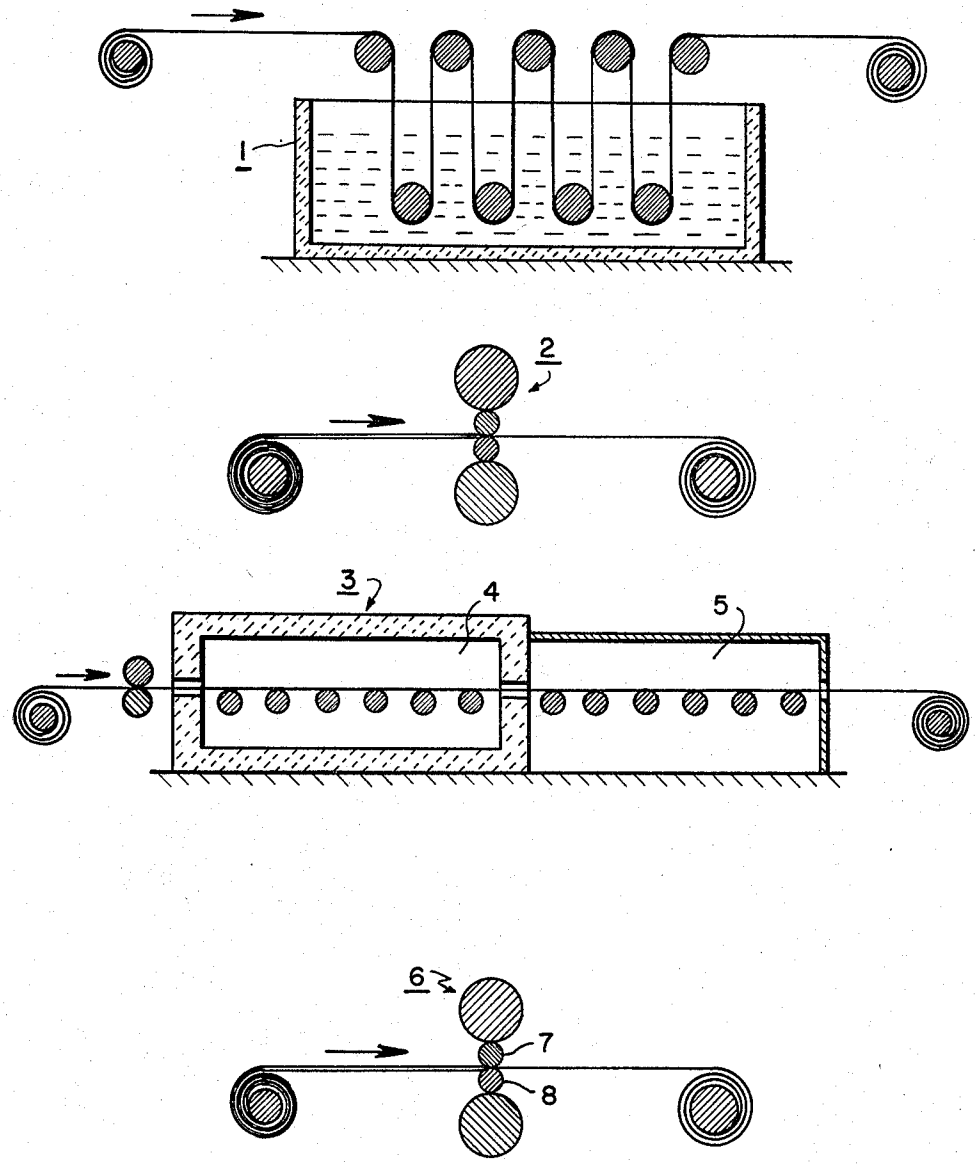
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PROCESS FOR PRODUCTION OF TIN PLATE

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PROCESS FOR PRODUCTION OF TIN PLATE

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This invention relates to a process for production of tin plate, and, more particularly, to production of ductile tin plate and tin plate of a given temper in gauges 0.001" to 0.0088", especially gauges under 0.005".

Cost factors render it impractical to tin steel strip in gauges under 0.005", for production of a given weight of tin coating on steel strip 0.005" thick requires as much time from a standpoint of lineal speed of the strip through the tinning apparatus as placing an equivalent weight of tin coating on strip 0.010" thick. The cost of tinning strip becomes higher and higher as thinner gauges are tinned, and, specifically, the cost of tinning the 0.005" gauge strip is about twice that of coating the 0.010" strip with cold rolling practices in the thinner gauges as well as tinning operations contributing to these high costs. Accordingly, ability to tin the heavier gauges such as 0.0077"–0.0153" and market this tin plate in the 0.0011"–0.0088" gauge range can realize material savings in production costs.

Manufacturers of tin cans desire a bright finish tin plate, so that if the tin plate is cold rolled with steel rolls after tinning, the rolled tin plate has a dull, matte finish with poor reflection properties. Containers made from such tin plate are unattractive from a sales standpoint.

Heretofore, production of thin tin plate in gauges about 0.005" to 0.006" included cold rolling low carbon steel strip on a 5- or 6-stand tandem mill, followed by annealing it and then a further cold rolling on a 2- or 3-stand tandem mill to a minimum gauge of 0.005". Following this second cold rolling, the steel strip is tinned and then is ready for shipment to a fabricator. However, such tin plate has limited use and cannot be employed for containers or other articles which require a ductile tin plate. The product from the 2- or 3-stand tandem mill has received a 30%-40% reduction after annealing and has sufficient ductility to withstand a crimping or forming operation which forms can ends without breakage. However, a greater amount of cold rolling than about 37% after annealing renders the material too hard for this crimping or forming operation, and such material encounters objectionable fracturing during fabrication.

Accordingly, production of tin plate under 0.005" gauge with required ductility has not been achieved on a practical production basis, and that tin plate under about 0.005" which has been made has been both objectionably hard and unsatisfactory for most forming procedures.

My invention produces ductile tin plate and tin plate of a given temper in gauges between 0.001" and 0.0088", with a bright finish, so that the tin plate of my process has wide application in many farbrication methods. Specifically, my process resides in production of tin plate in which steel strip is plated with a coating of tin to form tin plate, and comprises cold rolling this tin plate which has not been heat treated after tinning thereof to reduce its thickness at least 40% and to obtain a thickness between substantially about 0.0088" and 0.001". Thereafter, this cold rolled tin plate is heated in a non-oxidizing atmosphere and maintained at a temperature of substantially 1200° F. to substantially 1800° F. to effect one of annealing or normalizing the tin plate. Preferably, this heating is carried out for 2 to about 10 seconds. Then, after this heating, the tin plate may be given a further cold rolling to obtain a given temper from about T–1 to T–6,

inclusive. The amount of this further cold rolling may range between 1% and 50% to obtain the desired amount of temper in the tin plate. Preferably, the cold rolling of the tin plate and the further cold rolling are carried out with at least one work roll made from tungsten carbide.

In practice of my process, the starting material generally is low carbon steel strip or sheet which has been cold rolled from hot strip gauge to a gauge between 0.007" and 0.0153", with selection of the particular gauge dependent upon the total amount of cold rolling made after tinning and prior to heating, which preferably is a continuous heat treatment, and a second cold rolling, if any, after the continuous heat treatment. This steel strip is then either annealed and thereafter coated with tin to form the tin plate, or is simply coated with tin without being first annealed, then temper rolled to form the tin plate. Application of the tin coating to the low carbon steel strip may be an electrotytic method, or by a hot dip procedure in which the strip is dipped into a bath of molten tin or is run through such a bath. The above describes the processing of the starting material prior to its subjection to the process of my invention.

Usually, the amount of tin applied to the steel strip falls into a range between 0.10 pound per base box to 1.00 pound per base box, and provides a thickness of coating as set forth in the following table:

Tin coating in pounds per base box:	Thickness of coating
.10	.000006
.25	.000015
.50	.00003
.75	.000045
1.00	.00006

Following the tinning and before any continuous heat treatment, the tin plate is cold rolled to effect a reduction in thickness of at least 40% and may be as much as 80% or more, after which it is continuously heat treated to a temperature between about 1600° F. and about 1800° F. This cold rolling is performed without first heat treating the tin plate. I have found that reducing the tin plate at least 40% before the heating renders it quickly responsive to the heating or normalizing temperature of 1600° F.–1800° F. and transformation to small equiaxed grains is rapid. Where the amount of rolling is less than 40% before this heating, response of the tin plate to the normalizing temperature is slower and a greater length of time in the furnace is required, so that in a continuous normalizing operation, the length of the furnace and its cost make the process economically unfeasible.

This cold rolling reduces the tin plate either to a final desired gauge between 0.001"–0.0088", or to a gauge from which a further cold rolling is made after the heating to obtain a tin plate of a given temper such as a temper within the range T–1 to T–6. This further cold rolling amounts to between 1% and 50% reduction and the particular amount selected is that required to obtain a desired temper.

To assure a bright finish on the tin plate where there is no further cold rolling after the heating, the cold rolling before the heating is carried out with at least one, and preferably both work rolls of the mill made from tungsten carbide. Of course, where only one work roll is tungsten carbide, only one side of the strip has the bright finish. However, where there is further cold rolling after the heating, then the rolling before the heating need not be made with tungsten carbide rolls, but may be made with steel or iron rolls. Accordingly, where there is further cold rolling after the heating, obtention of bright

finish tin plate includes rolling the heated or normalized tin plate with at least one, and preferably two tungsten carbide work rolls.

In the heating or normalizing operation, it is preferable that the tin plate be so heated that it is at a temperature in the range 1600° F.–1800° F. for a short time, such as 2–10 seconds, depending upon the thickness of the tin plate. However, times longer than 10 seconds can be tolerated. When the tin plate has been reduced at least 40%, then it needs to be at the temperature 1600° F.–1800° F., 2–3 seconds for normalizing and obtention of the small equiaxed grains and of the same physical properties both across and in the direction of rolling. For example, 0.002" tin plate which had been cold rolled more than 40% after tinning, obtained a completely normalized structure after traverse at a speed of 400 f.p.m. through a continuous annealing furnace which had a heating zone 35 feet in length, wherein the tin plate reached a temperature of 1700° F.–1750° F. for the required time. Thus, this 0.002" tin plate was in the furnace about 5¼ seconds.

Exposure of the tin plate to the normalizing temperature longer than required for normalizing is avoided because it may cause buckles or distortion in shape, or may not lie as flat as if it escaped subjection to the normalizing temperature longer than needed. Additionally, the longer the tin plate is maintained at the normalizing temperature, the greater is the penetration of the tin into the steel to form an iron-tin alloy. While there is a rapid penetration of some of the tin into the steel and an initial formation of an iron-tin alloy upon subjection to the normalizing temperature, additional penetration of the tin and subsequent growth of the iron-tin alloy is slower and can be reduced by minimizing time of exposure of the tin plate to this temperature. Furthermore, this iron-tin alloy is very hard and brittle and does not withstand bending well, so that it is highly desirable that the length of time during which the tin plate is subjected to the normalizing temperature be minimized, but be sufficient to effect transformation into the small equiaxed grains.

The rate of heating is as rapid as practical, and is dependent upon the length of the heating zone of the furnace, so that the longer the heating zone of the furnace, the more rapid the travel of the tin plate therethrough.

The heating of the tin plate to the normalizing temperature is made in a non-oxidizing atmosphere, i.e., a neutral or reducing one, because an oxidizing atmosphere produces an oxide film on the surface of the tin plate which is detrimental for soldering work and which lacks a bright finish. Tin plate which has been subjected to oxidizing atmosphere at such temperature has an unattractive dull, greenish-brown appearance. Likewise, the normalized tin plate is cooled in a non-oxidizing atmosphere to a temperature less than that at which occurs visible oxidation of the tin, i.e., a discoloration of the tin when exposed to air. In most cases, the tin plate is cooled in the non-oxidizing atmosphere to a temperature of 325°–300°–250° F., or less. This cooling is quite rapid.

In one specific example of my invention, cold rolled steel strip 0.0061" gauge and 6½" wide was coated with tin equivalent to ½ pound per base box to form tin plate. Next, this tin plate was cold rolled to 0.002" gauge and then subjected to normalizing temperature of 1700° F. for about 33 seconds. This normalizing was carried out by passing the tin plate through a continuous annealing furnace with a non-oxidizing atmosphere at a speed of 72 feet per minute. Following the normalizing, the tin plate was subjected to physical testing and the following results obtained:

Elongation, percent	9.5–11.0
Yield strength, p.s.i	34,200–39,500
Rockwell hardness	53

This tin plate was bent flat upon itself both in the direction of rolling and across the direction of rolling without any fracture, and was further subjected to soldering tests with satisfactory results.

A modification of my process includes subjecting the cold rolled tin plate to the same foregoing described procedure except that the heating temperature is 1200° F.–1325° F., which effects a stress relief anneal wherein only the ferrite is affected. Tin plate so processed is not as good ductilitywise as that subjected to 1600° F.–1800° F. temperatures, but is suitable for certain drawing and fabrication operations.

In the accompanying drawing, I have shown schematically one embodiment of apparatus for production of tin plate in accordance with my process. In this embodiment, cold rolled low carbon strip such as 0.0083" gauge traverses a conventional electrolytic tinning unit **1** which places a coating of tin, such as ½ pound per base box, on the steel strip to form tin plate. Then, without any heat treatment thereto, this tin plate is cold rolled on a 4-high mill **2**, to 0.002", after which this 0.002" tin plate is passed through a continuous normalizing furnace **3**, which contains a heating zone **4** and a cooling zone **5**, each with a reducing atmosphere, and interconnected for travel of the tin plate from the heating zone into and through the cooling zone. The heating zone is 35 feet long and is at a temperature such that during traverse of the tin plate therethrough, it reaches a temperature of 1700° F. for about 2–4 seconds to effect complete transformation to small equiaxed grains. The rate of travel of the tin plate through the heating zone is about 400 feet per minute, and the tin plate exists from the cooling zone at about 300° F.

Finally, the normalized tin plate undergoes a further cold reduction on a second 4-high mill **6** with tungsten carbide work rolls **7** and **8** engaging the metal to produce a given temper such as quarter hard tin plate.

My invention has important advantages which include production of fully ductile tin plate in the thin gauges 0.001"–0.0088", and of tin plate of such gauges in specified tempers such as one-quarter hard, half hard, and full hard. This tin plate is satisfactory for a wide range of fabrication operations, some of which have severe deformation procedures and require fully ductile metal, while others of which utilize quarter hard, half hard, and even full hard tin plate. Additionally, the tin plate of my process not only has a bright finish and presents no soldering problems, but also substantially retains its rolled shape.

While I have shown and described preferred embodiments of my invention, it may be otherwise embodied within the scope of the appended claims.

I claim:

1. In a process for production of tin plate in which steel strip is plated with a coating of tin to form tin plate, the invention comprising cold rolling said tin plate which has not been heat treated following formation thereof to reduce its thickness at least 40% and obtain a thickness between substantially about 0.0088" and 0.001", heating said cold rolled tin plate in a non-oxidizing atmosphere to and maintaining same at a temperature of substantially 1200° F. to substantially 1800° F. to effect heat treating of said tin plate.

2. The invention of claim **1** characterized by carrying out said heating and maintaining for substantially about 2 to 10 seconds.

3. The invention of claim **1** characterized by after said heating and maintaining, cooling said tin plate in a non-oxidizing atmosphere to a temperature less than that at which occurs visible oxidation of tin.

4. The invention of claim **1** characterized by heating said cold rolled tin plate to a temperature between substantially 1600° F. and 1800° F. to normalize same and produce a ductile tin plate.

5. The invention of claim 1 characterized by after said heating, further cold rolling said tin plate a given amount to obtain a given temper therein.

6. The invention of claim 1 characterized by heating said cold rolled tin plate to a temperature between substantially 1600° F. and 1800° F. to normalize same and produce a ductile tin plate, and by after said heating and maintaining, cooling said tin plate in a non-oxidizing atmosphere to a temperature less than that at which occurs visible oxidation of tin.

7. The invention of claim 4 characterized by after said heating, further cold rolling said tin plate a given amount to obtain a given temper therein.

8. The invention of claim 1 characterized by heating said cold rolled tin plate to a temperature between substantially 1200° F. and substantially 1325° F. to effect annealing of same.

9. The invention of claim 8 characterized by after said heating and maintaining, cooling said tin plate in a non-oxidizing atmosphere to a temperature less than that at which occurs visible oxidation of tin.

10. The invention of claim 1 characterized by carrying out said heating by passing said tin plate through a continuous furnace.

11. The invention of claim 1 characterized by carrying out said cold rolling with at least one work roll made from tungsten carbide.

12. The invention of claim 5 characterized by in said further cold rolling, effecting a reduction in thickness of said tin plate between 1% and 50% to obtain a given temper in said tin plate, and by carrying out said further cold rolling with at least one work roll made from tungsten carbide.

13. The invention of claim 12 characterized by said first-mentioned cold rolling being carried out with at least one work roll made from tungsten carbide.

14. The invention of claim 1 characterized by said steel strip being substantially about 0.007" to 0.0153" thick.

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