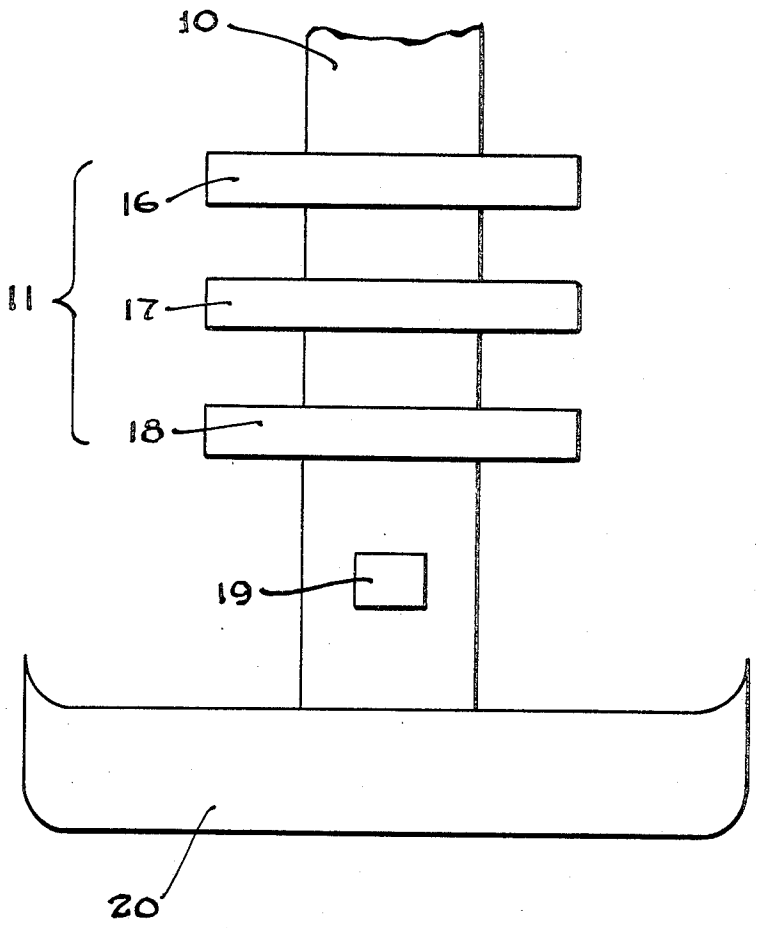
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TIN PLATE TREATING PROCESS TO IMPROVE CORROSION RESISTANCE

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Inventors
Coy S. Ham
Lyle Raub
Jack E. Joyce
Robert Lozano
By Hibben, Noyes & Bicknell
Attorneys

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TIN PLATE TREATING PROCESS TO IMPROVE CORROSION RESISTANCE

Coy S. Ham, Munster, Lyle Raub, Gary, Jack E. Joyce, Chesterton, and Robert Lozano, Griffith, Ind., assignors to Inland Steel Company, Chicago, Ill., a corporation of Delaware

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The present invention relates generally to the production of electrolytic tin plate and more particularly to an improved method of producing electrolytic acid tin plate having improved corrosion resistance.

Electrolytic tin plate made on an alkaline tin plate line consistently exhibit superior corrosion resistance, such that even a highly corrosive food packed in containers made from alkaline tin plate generally has a shelf life in excess of twelve months. An electrolytic tin plate made on an acid line, however, only sporadically exhibits superior corrosion resistance, and electrolytic acid tin plate made on a halogen line practically never exhibits superior corrosion resistance.

A fairly accurate indication of the corrosion resistance of electrolytic tin plate can be obtained by determining the alloy-tin couple current (ATC) value of the tin plate. Low ATC values are indicative of high corrosion resistance and generally predict a long shelf life for foods packed in containers made from tin plate exhibiting low ATC values. Conventional tin plate exhibits ATC values ranging between about 0.15 to about 0.65 microamp per square centimeter, while tin plate having superior corrosion resistance and classified as Grade A or Grade K exhibits ATC values of 0.12 microamps per square centimeter or below.

Heretofore many special heat treating processes have been developed for improving the corrosion resistance of tin plate generally and for electrolytic acid tin plate specifically. Certain of these processes require maintaining the tin plate at a temperature slightly below the melting point of tin for a relatively prolonged period to initiate iron-tin alloy crystal nucleation and thereafter heating the tin plate preferably to a temperature (about 450° F.) only slightly above the melting point of tin to complete formation of a thin layer of iron-tin alloy crystals and fusion of the tin to provide a smooth, reflective outer tin coating. Other processes have required heating the tin plate rapidly to effect fusion and maintaining the fused tin at a constant temperature only slightly above its melting point so that the iron-tin formation takes place at a constantly relatively low temperature. In accordance with a very recent process, a very thin coating of tin is applied and heated to the relatively high temperature of about 1000° F. in order to effect formation of a special iron-tin alloy (FeSn) which does not form at temperatures below 925° F. and thereafter providing heavier outer coating of metallic tin. None of these prior art processes, however, are entirely satisfactory from an overall economical and operational standpoint, and there remains a need for an improved process for producing electrolytic tin plate and particularly electrolytic acid tin plate having superior corrosion resistance.

It is therefore an object of the present invention to provide an improved method of producing electrolytic tin plate having improved corrosion resistance properties.

It is a further object of the present invention to provide a more economical process of producing electrolytic acid tin plate consistently having superior corrosion resistance.

It is still another object of the present invention to provide a process of producing electrolytic tin plate which can be incorporated in a conventional acid electrolytic tin plating line without requiring major changes therein.

Other objects of the present invention will be apparent to those skilled in the art from the following detailed description and claims to follow when read in conjunction with the accompanying drawing which is a schematic diagram illustrating the process of the present invention.

It has now been discovered that an electrolytic acid tin plate product having superior corrosion resistance equal to that of high grade alkaline tin plate can be consistently produced by rapidly heating acid electrolytic tin plate above the fusion point of tin (450° F.) without preheating or holding at a temperature below the melting point of the tin to a temperature substantially above 600° F. and maintaining the fused tin plate at a temperature of between about 600° F. and 800° F. for a period of at least 0.5 second, and thereafter rapidly quenching the tin plate to below 212° F.

In practicing the process of the present invention a dry strip **10** of low carbon steel preferably having a gauge of between about 0.0030 inch and 0.0120 inch covered with an electrolytically deposited acid tin coating weighing between 0.25 pound to 1.00 pound per base box is passed continuously through a heating means **11** disposed at the end of a conventional electrolytic acid tin plating line. The heating means **11** is adjusted to rapidly heat the tin plate from its ambient base temperature of about 150° F. to fusion (i.e. about 450° F.), preferably within about 0.2 to about 0.5 second after the strip enters the heating means. Heating of the strip is continued to rapidly raise the temperature of the strip to above 600° F. and maintain the temperature between 600° F. and 800° F. for a period of at least 0.5 second and preferably for about one second to effect conversion of not more than 50% of the tin coating and preferably only about 20% thereof to iron-tin alloy ($FeSn_2$). Thereafter the strip is rapidly quenched in an aqueous bath **20**.

The maximum temperature to which the strip is heated in the heating means **11** is such that the strip temperature, as determined by a surface temperature measuring device **19** positioned at a point spaced about 3 feet from the outlet end of the heating means **11**, is between 600° F. and 800° F. and preferably about 630° F.

In the preferred embodiment of the invention the heating means **11** employed consists of three ten-turn, high frequency electric induction heating coils which are spaced about fifteen inches. The first two coils **16**, **17**, rapidly heat the strip to a temperature above the melting point of tin (i.e. 450° F.) and while the strip remains in coil **17** and in coil **18** it is rapidly raised to a temperature above 600° F. to between 600° F. and 800° F. and remains at the latter temperature for at least 0.5 second before the strip reaches the water quench **20**.

The foregoing prolonged high temperature heat treatment to which the tin plate strip is subjected forms a substantially continuous coating of iron-tin alloy ($FeSn_2$) which is comprised of a major proportion of large iron-tin alloy crystals which merge into each other in such fashion as to substantially cover the base metal.

The ATC values and standard pack test results of tin plate produced in accordance with the present invention have shown that the tin plate is unusually resistant to corrosion and consistently exhibits superior corrosion resistant properties. For example, where a tin plate strip is subjected to a standard fusion and reflow treatment exhibits an ATC value of about 0.3 microamp per square centimeter, the same tin plate strip heat processed according to the present invention exhibits ATC values of 0.03 and 0.04 microamp per square centimeter. In order to further illustrate the present invention, the following spe-

cific example is given without, however, limiting the invention to the specific conditions used therein.

EXAMPLE 1

A low carbon steel strip having a thickness of about 0.008 inch with an electrolytic acid in coating weighing about 0.50 pound per base box, after conventional alkaline cleaning, water rinsing and drying, and while traveling at a line speed of about 1200 feet per minute, is passed successively through three ten-turn, high frequency electrolytic induction heating coils formed of water-cooled copper tubing and maintained at between 111–116 kilocycles and up to 15 kilovolts. The tin coating is rapidly heated from a temperature of about 150° F. to 450° F. within about 0.5 second after entering the first heating coil and before leaving the second heating coil. The strip is further heated in the second and third heating coils to a temperature in excess of 600° F. but not appreciably above 800° F., and preferably at a temperature of 630° F., said temperature being determined by an infra-red surface temperature measuring device placed in-line about three feet beyond the third heating coil. The tin coating is maintained at a temperature of between 600° F. and 800° F. for at least 0.5 second but not substantially longer than about one second to effect conversion of not more than 50% and preferably only about 20% into an iron-tin alloy coating which is characterized by having a large portion of macro iron-tin alloy crystals which defuse into each other to substantially completely cover the base steel strip.

The tin plate produced in the above manner has an ATC value of 0.03 microamp per square centimeter without applying any additional tin coating and exhibits superior corrosion resistant properties when subjected to standard pack tests.

It will be understood by those skilled in the art that the rate of heating in the heating means **11** will vary with the thickness of the base steel strip, the thickness of the tin coating, and the rate at which the strip is traveling through the heating means. The induction heating coils or other heating means can, of course, be adjusted to effect the required temperature in any particular electrolytic acid tin plate strip being processed.

We claim:

1. A method of making Grade A and Grade K electrolytic acid tin plate which comprises; rapidly heating in a heating zone a clean dry low carbon steel strip having directly in contact with the surface of said strip an electrolytic acid tin plate coating weighing at least 0.25 pound per base box from a temperature of about 150° F. to a temperature above the melting point of tin within a period of about 0.2 to 0.5 second, continuing said heating of the fused tin plate to a temperature range of between about 600° F. and 800° F. and maintaining said tin plate at said temperature range for a period of at least 0.5 second, and thereafter rapidly cooling said strip by immersing in a water bath; thereby forming a substantially continuous layer of macro-crystals of $FeSn_2$ alloy comprising between about 20% and 50% by weight of said tin coating.

2. A process as in claim **1**, where said fused tin plate remains at a temperature between 600° F. and 800° F. for a period of between 0.5 second and about 1.0 second.

3. A process as in claim **1**, where the temperature of said strip as it leaves said heating zone is about 630° F.

4. A method of making Grade A and Grade K electrolytic acid tin plate as in claim **1**, wherein said strip has a gauge between about 0.0030 inch and 0.0120 inch with said coating having between about 0.25 lb. and about 1.00 lb. tin per base box is heated from about 150° F. to above the fusion point of said coating, and continuing heating at the foregoing rate to raise the temperature of said strip to between about 600° F. and 800° F. and maintaining said strip at said temperature for a period of between about 0.5 second and 1 second.

5. A method of making Grade A and Grade K electrolytic acid tin plate which comprises rapidly heating in a heating zone a clean dry low carbon steel strip having directly in contact with the surface of said strip an electrolytic acid tin plate coating weighing at least 0.25 lb. per base box from a temperature of about 150° F. to a temperature above the melting point of tin within a period of about 0.2 to 0.5 second, continuing said heating of the fused tin coating in said heating zone within a temperature range of between about 600° F. and 800° F. and maintaining said tin coating within said temperature range for a period of at least 0.5 second and removing said strip from said heating zone when a substantially continuous layer of macro-crystals of $FeSn_2$ alloy is formed on said surface of said strip which comprises between about 20% and 50% by weight of said tin coating, and rapidly cooling said strip by immersing in a water bath.

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JOHN H. MACK, Primary Examiner

W. B. VANSISE, Assistant Examiner

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