

RESERVE CCOPY PATENT SPECIFICATION

1,116,222

DRAWINGS ATTACHED.

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Int. Cl.:—C 23 c 1/02.

COMPLETE SPECIFICATION.

Improvements relating to the Coating of Metals.

We, NATIONAL STEEL CORPORATION, a Corporation organised and existing under the laws of the State of Delaware, United States of America, of 2800, Grant Building, Pittsburgh 19, Pennsylvania, United States of America, (Assignee of JOHN THOMAS MAYHEW), do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to continuous strip galvanizing methods and apparatus.

The invention provides a continuous strip coating process for producing iron-zinc alloy coated steel strip comprising heating steel strip to a temperature substantially above the melting temperature of galvanizing spelter, introducing the heated strip into a molten galvanizing bath so as to add heat to molten galvanizing spelter in the bath, the molten galvanizing bath being maintained at a temperature above 900°F, forming an iron-zinc alloy coating on the steel strip by submerging the heated strip beneath the surface of the molten galvanizing bath, moving the heated strip through the molten galvanizing spelter towards an exit side of the bath while submerged beneath the bath surface, delivering the steel strip from the molten galvanizing bath, the steel strip having an inner iron-zinc alloy coating and an outer molten galvanizing spelter coating, and directing gas under pressure against at least one face of the coated steel strip upon delivery from the molten galvanizing bath to remove molten galvanizing spelter coating from said face of the iron-zinc alloy coated strip.

The invention includes continuous strip coating apparatus for producing iron-zinc alloy coated steel strip comprising means for heating steel strip to a temperature of

about 1000°F. or higher, hot-dip galvanizing means including a galvanizing bath, means for delivering the heated steel strip through a non-oxidizing atmosphere into the galvanizing bath including means for maintaining strip temperature near 1000°F. means for submerging the heated steel strip beneath the surface level of the galvanizing bath and for moving the submerged strip through the galvanizing bath to impart heat to molten spelter in the galvanizing bath and maintain the temperature of the spelter above 900°F, means for cooling a portion of the galvanizing bath to produce a zone of cooled galvanizing spelter at 800°F. to 860°F inclusive, means for delivering strip from the galvanizing bath upon passage through the zone of cooled spelter, so that the delivered steel strip has an inner iron-zinc alloy coating and an outer molten galvanizing spelter coating, and means for directing gas under pressure against at least one face of the coated steel strip to remove molten galvanizing spelter coating from that face of the iron-zinc alloy coated steel strip.

The invention is further described, by way of example, with reference to the accompanying drawings in which:

Figure 1 is a schematic diagram of a continuous strip line constructed in accordance with the invention, and

Figure 2 is a schematic diagram of a portion of the continuous-strip line,

Referring to Figure 1, steel from coils 12 and 14 is formed into continuous strip 16 at a welder 18. Ordinarily, the strip is cleaned or otherwise treated at a unit 20 and then heated in a furnace heater 24 which can be a continuous annealer.

The heated strip is fed through an atmosphere-controlled chute 26 to a coating pot 28. The chute 26 leads into and extends beneath the surface of a bath 30 so that the

strip 16 enters the bath from a controlled atmosphere. The bath 30 can be conventional galvanizing spelter with up to 0.30% aluminum additions, impurity level percentages of lead, tin, antimony, cadmium etc., and the balance zinc about 99% (by weight).

A controlled iron-zinc alloy is formed having a uniform, smooth finish suitable for painting without bonderizing or other treatment and formable to the same extent as the base metal without cracking. In order to meet this objective and produce the desired type of coating, iron from the steel must be alloyed with zinc out of contact with an oxidizing atmosphere and the alloy produced must be brought to the surface of the finished product. Existing continuous-strip galvanizing lines may be modified to permit manufacture of this coating and product on these lines.

Referring to Figure 1, the strip 16 and the bath 30 are raised in temperature above what is ordinarily considered optimum coating temperatures. This is practicable because of special cooling apparatus, specially located. The bath 30, except for a defined minor portion specially located at its exit side, is maintained at a temperature of approximately 900°F. to 950°F. or higher. This temperature is maintained by the strip 16 or by the strip 16 and other heat sources.

Iron-zinc alloy is formed primarily while the strip 16 is submerged in the bath 30, roughly between entry of the strip 16 into the bath 30 and its passage around a sink roll 32. One theory is that desirable alloy is produced primarily during the period that the temperature of the strip 16 approaches and reaches the temperature of the major portion of the bath 30. Alloying is controlled mainly by the heat content of the strip 16 which is influenced by the gauge of the strip. Heavy-gauge materials generally carry more heat and produce heavier coating weights, e.g. around 0.3 to 0.35 ounce per square foot of surface. The light-gauge materials produce alloy coatings around 0.15 to 0.2 ounce per square foot of surface.

The strip 16 should be introduced into the bath 30 at a temperature around 1000°F. or higher. The strip is brought to required temperature on the line in the heater 24. Strip transfer into the pot 28 is controlled in the chute 26. This includes control of atmosphere in the chute 26 to prevent oxidation of the strip 16; atmosphere control means, such as conduits 34 and 36, are provided for this purpose. Control of strip transfer also includes control of heat losses; the chute 26 can be insulated for this purpose and can include heat control means 38. The temperature of the strip 16 as measured at temperature sensors 40 and 42 is maintained around 1000°F or higher. The strip

16 travels around the sink roll 32 towards a cooled spelter zone 44. Upon passage through the zone 44, the strip travels through coating control means 46 towards a top roll 48.

Reviewing the embodiment described thus far, strip is heated in a continuous-strip line to a temperature around 1000°F. or higher. The strip is transferred from the line heating means to the coating pot through a controlled atmosphere and is introduced into molten galvanizing spelter at a temperature around 1000°F or higher. The temperature of the bath is maintained at 900°F. to 950°F. These steps combine to control alloy formation of bath zinc with strip iron while the steel strip is submerged beneath the surface of the bath.

Iron-zinc alloy formation is controlled quantitatively by control of temperature factors to produce coating weights between 0.15 and 0.35 ounce per square foot, inclusive, on each surface of the steel strip. Alloy formation is controlled qualitatively by such factors as production out of contact with an oxidizing atmosphere, temperature and substantial termination of alloying before contact with an oxidizing atmosphere.

Referring to Figure 2, after passage of the strip around the sink roll 50, iron-zinc alloy coated strip 52 travels into a cooled spelter zone 54. Galvanizing bath cooler 56, 58, 60 and 62 cool the spelter in the zone 54 and are used to control the temperature of this zone. Details of a suitable bath cooler may be found in the copending British Patent Application No. 25063/65 (Serial No. 1,116,221). Briefly, however, one or more submerged coolant conduits, positioned near the travel path of strip approaching exit from the bath, are used to cool a portion of the bath contiguous with the travel path of the strip in the exit zone.

The cooled spelter zone is ordinarily held to a temperature around 840°F. to 860°F. with any variations below this range being dependent on the product. This zone is ordinarily not cooled below 800°F. and a temperature around 820°F. can be used when cooling requirements dictate, e.g. for the heavier gauges. The remainder of the bath 56 is maintained at a temperature around 900°F. to 950°F.

An important function of the galvanizing bath cooler is to cool the molten spelter applied to iron-zinc alloy coated strip and to cool the steel base metal. In this way, iron-zinc alloying is terminated before contact of the coated strip with ambient atmosphere.

With termination of alloying the iron-zinc alloy coating must be exposed as a finished surface of the product. The strip 52, upon exit from the cooled galvanizing spelter zone 54 is coated with an inner iron-zinc alloy

coating and an outer galvanizing spelter coating. The iron-zinc alloy is made the finished surface of the product by precisely controlling removal of the molten galvanizing spelter coating from the solid iron-zinc alloy coating. Such removal is controlled by gas barrier (jet) coating control elements 66 and 68 which, in accordance with one embodiment of the invention, remove the galvanizing spelter coating entirely from both surfaces of the iron-zinc alloy coated strip.

The gas barrier or jet coating control elements and process use heated gas which is directed against the moving strip so as to act as a barrier to passage of molten coating. The process and apparatus are described in detail in copending British Patent Application No. 20966/64 (Serial No. 1,071,572). Substantially all the galvanizing spelter is removed by the gas barrier. Iron-zinc alloy shows on the entire surface after passage through gas barrier apparatus. Mechanical rolls, wipers, or scrapers, as presently developed, leave marks on the strip and patches of galvanizing spelter which cause commercial rejects and produce a differing coating while the gas barrier (jet) method and apparatus leave a smooth-finish, uniform, galvanize spelter-free, iron-zinc alloy surface.

The bath cooling apparatus serves other important functions such as reducing iron dissolution in the galvanizing spelter applied to the strip 52. The temperature of the galvanizing spelter on strip 52 upon exit from the zone 54 is at or near the temperature of the zone 54. If high temperature galvanizing spelter were present in the zone 54, iron dissolution and dross formation would make it impossible to produce a smooth coat. Without this cooling feature, a gritty, uneven, unacceptable surface would be formed and it would not be practicable to maintain the remainder of the bath at the temperature level required to produce the desired alloy.

With certain gauges of steel strip, especially among the lighter gauges, heat is required to be added to the bath from one or more heat sources, such as a bath heater unit 63. Bath temperature can be maintained at the desired level near 900°F. to 950°F. by a control 64 which may be coordinated automatically with the temperature of the strip and/or the temperature of the galvanizing bath spelter.

Iron content in the iron-zinc alloy coating formed varies around 10% to 15% by weight of the alloy. Corrosion tests on this coating for steel strip rate this coating above other commercially available steel strip coatings of equal and heavier coating weights. Salt spray tests of over 100 hours and up to 165 hours have been held without show-

ing rust. It is believed that 0.6 ounce per square foot of steel strip of this coating is the equal of 1.5 ounces per square foot of regular galvanized spelter coating.

This coating is uniform and very smooth. None of the rough surface associated with conventional galvanized and related commercially available product is present. The coating is adherent throughout its depth, is solid, and is not powdery.

The coating adhesion is excellent. The coating can be formed to the same extent as the base metal without crumbling or cracking. All standard tests, such as the Pittsburgh Lockseam Test, have been performed on this product without in any way disturbing coating adhesion.

Also, this coated product can be welded like uncoated steel. All standard welding tests show little or no difference in weldability between this product and uncoated steel. None of the disadvantages of electrode tip pick-up, experienced with other coated steel products, are present. Spot welding is facilitated by a quicker concentration of heat than with conventional coated steel product.

Further, as produced on the line, this coated product takes most conventional painting or coating treatments applied to cold rolled steel so that it can be worked in conjunction with cold rolled stock. Another advantage of the product is its ability to take heat treatment. For example, in production of drawing stock for automotive uses, this product can be heated to temperatures up to 1000°F. and higher without damage to the protection provided by the coating or damage to the coating itself. This alloy coating has a melting temperature above 1000°F.

Differentially coated steel strip is another product available by means of the illustrated apparatus. Upon exit of the strip from a cooled spelter zone, the jet process is used to remove the galvanizing spelter coating entirely from one surface of the strip and to control the coating weight of galvanize spelter on the remaining surface of the iron-zinc alloy coated steel strip. A thin controlled coating of galvanizing spelter on one side of the iron-zinc alloy coated strip is produced which presents a bright, smooth surface.

The iron-zinc alloy inner surface coating of the differentially coated product is as described earlier. That is, between 0.15 and 0.35 ounce per square foot, inclusive, of iron-zinc alloy coating is present. A galvanizing spelter coating between 0.10 and 0.50 ounce per square foot, inclusive, is produced on one surface of the product while the iron-zinc alloy finish is produced on the remaining surface. This can be carried out by setting the hot gas pressure

for the jet nozzle 66 to remove all coating from one surface of the strip 52 and by setting the hot gas pressure for the jet nozzle 68 to leave a controlled amount of molten galvanizing spelter.

The galvanize spelter finish on the differentially coated product is unusually smooth for galvanized product. The roughness associated with spangle boundaries is not present. This smoothness is believed to be due, at least in part, to the thinness of the galvanized spelter coating. Such thin coating is made possible because of the previously described cooling feature. Without this feature such a thin coating would alloy, more than desired, in the atmosphere after exit from the coating control means.

WHAT WE CLAIM IS:—

1. Continuous strip coating process for producing iron-zinc alloy coated steel strip comprising heating steel strip to a temperature substantially above the melting temperature of galvanizing spelter, introducing the heated strip into a molten galvanizing bath so as to add heat to molten galvanizing spelter in the bath, the molten galvanizing bath being maintained at a temperature above 900°F, forming an iron-zinc alloy coating on the steel strip by submerging the heated strip beneath the surface of the molten galvanizing bath, moving the heated strip through the molten galvanizing spelter towards an exit side of the bath while submerged beneath the bath surface, delivering the steel strip from the molten galvanizing bath, the steel strip having an inner iron-zinc alloy coating and an outer molten galvanizing spelter coating, and directing gas under pressure against at least one face of the coated steel strip upon delivery from the molten galvanizing bath to remove molten galvanizing spelter coating from said face of the iron-zinc alloy coated steel strip.

2. Coating process as claimed in claim 1 in which the molten galvanizing bath is maintained at a temperature of not more than 950°F.

3. Coating process as claimed in claim 1 or 2 wherein the steel strip is heated to a temperature above 1000°F, and is thereafter introduced to the molten galvanizing bath at a temperature of about 1000°F.

4. Coating process as claimed in claim 1, 2 or 3 wherein a portion of the molten galvanizing bath at the exit side of the bath is cooled to form a zone of cooled spelter at a temperature between 800°F. and 860°F., inclusive, the zone of cooled spelter being contiguous with the travel path of strip approaching exit from the galvanizing bath with the steel strip being delivered from the molten galvanizing bath upon passage through the cooled spelter zone.

5. Coating process as claimed in claim

4 in which the cooled spelter zone is maintained at a temperature between 840°F and 860°F, inclusive.

6. Coating process as claimed in claim 5 wherein the steel strip is coated with an inner iron-zinc alloy coating and an outer molten galvanizing spelter coating, and the inner iron-zinc alloy coating on each face of the steel strip has a weight between 0.15 and 0.35 ounce per square foot of steel strip, inclusive, and wherein the molten galvanizing spelter coating is removed from one face of the coated steel strip and the coating weight of molten galvanizing spelter coating remaining on the other face of the coated steel strip is controlled by directing gas under appropriate respective pressures against both faces of the strip.

7. Coating process as claimed in claim 1, 2 or 3 wherein the gas under pressure is directed against both faces of the coated steel strip upon delivery from the galvanizing bath to simultaneously remove the molten galvanizing spelter coating from one face of the coated steel strip while controlling the coating weight of molten galvanizing spelter coating remaining on the other face.

8. Continuous strip coating processes substantially as herein described with reference to the accompanying drawings.

9. Steel strip when coated by the process claimed in any of claims 1 to 8.

10. Steel strip when coated by the process claimed in any of claims 1 to 5 and 8 and having a uniform outer coating of iron-zinc alloy having a total coating weight on both faces of the steel strip of 0.3 to 0.7 ounce per square foot of steel strip, inclusive.

11. Steel strip when differentially coated by the process claimed in claim 6, 7 or 8 and having an iron-zinc alloy coating on both faces of the strip and a uniform galvanizing spelter coating on only one face of the iron-zinc alloy coated steel strip, the iron-zinc alloy coating on the strip having a coating weight between 0.15 and 0.35 ounce per square foot on each face of the steel strip, inclusive.

12. The differentially coated steel strip as claimed in claim 11 in which the uniform galvanizing spelter coating on said one face of the iron-zinc alloy coated strip has a bright spangled finish and a coating weight between 0.1 and 0.5 ounce per square foot, inclusive of steel strip.

13. Steel strip as claimed in claim 10, 11 or 12 wherein the iron-zinc alloy has an iron content between 10% and 15% by weight, inclusive.

14. Continuous-strip coating apparatus for producing iron-zinc alloy coated steel strip comprising means for heating steel strip to a temperature of about 1000°F. or higher, hot-dip galvanizing means including a galvanizing bath, means for delivering the

for the jet nozzle 66 to remove all coating from one surface of the strip 52 and by setting the hot gas pressure for the jet nozzle 68 to leave a controlled amount of molten galvanizing spelter.

The galvanize spelter finish on the differentially coated product is unusually smooth for galvanized product. The roughness associated with spangle boundaries is not present. This smoothness is believed to be due, at least in part, to the thinness of the galvanized spelter coating. Such thin coating is made possible because of the previously described cooling feature. Without this feature such a thin coating would alloy, more than desired, in the atmosphere after exit from the coating control means.

WHAT WE CLAIM IS:—

1. Continuous strip coating process for producing iron-zinc alloy coated steel strip comprising heating steel strip to a temperature substantially above the melting temperature of galvanizing spelter, introducing the heated strip into a molten galvanizing bath so as to add heat to molten galvanizing spelter in the bath, the molten galvanizing bath being maintained at a temperature above 900°F, forming an iron-zinc alloy coating on the steel strip by submerging the heated strip beneath the surface of the molten galvanizing bath, moving the heated strip through the molten galvanizing spelter towards an exit side of the bath while submerged beneath the bath surface, delivering the steel strip from the molten galvanizing bath, the steel strip having an inner iron-zinc alloy coating and an outer molten galvanizing spelter coating, and directing gas under pressure against at least one face of the coated steel strip upon delivery from the molten galvanizing bath to remove molten galvanizing spelter coating from said face of the iron-zinc alloy coated steel strip.

2. Coating process as claimed in claim 1 in which the molten galvanizing bath is maintained at a temperature of not more than 950°F.

3. Coating process as claimed in claim 1 or 2 wherein the steel strip is heated to a temperature above 1000°F, and is thereafter introduced to the molten galvanizing bath at a temperature of about 1000°F.

4. Coating process as claimed in claim 1, 2 or 3 wherein a portion of the molten galvanizing bath at the exit side of the bath is cooled to form a zone of cooled spelter at a temperature between 800°F. and 860°F., inclusive, the zone of cooled spelter being contiguous with the travel path of strip approaching exit from the galvanizing bath with the steel strip being delivered from the molten galvanizing bath upon passage through the cooled spelter zone.

5. Coating process as claimed in claim

4 in which the cooled spelter zone is maintained at a temperature between 840°F and 860°F, inclusive.

6. Coating process as claimed in claim 5 wherein the steel strip is coated with an inner iron-zinc alloy coating and an outer molten galvanizing spelter coating, and the inner iron-zinc alloy coating on each face of the steel strip has a weight between 0.15 and 0.35 ounce per square foot of steel strip, inclusive, and wherein the molten galvanizing spelter coating is removed from one face of the coated steel strip and the coating weight of molten galvanizing spelter coating remaining on the other face of the coated steel strip is controlled by directing gas under appropriate respective pressures against both faces of the strip.

7. Coating process as claimed in claim 1, 2 or 3 wherein the gas under pressure is directed against both faces of the coated steel strip upon delivery from the galvanizing bath to simultaneously remove the molten galvanizing spelter coating from one face of the coated steel strip while controlling the coating weight of molten galvanizing spelter coating remaining on the other face.

8. Continuous strip coating processes substantially as herein described with reference to the accompanying drawings.

9. Steel strip when coated by the process claimed in any of claims 1 to 8.

10. Steel strip when coated by the process claimed in any of claims 1 to 5 and 8 and having a uniform outer coating of iron-zinc alloy having a total coating weight on both faces of the steel strip of 0.3 to 0.7 ounce per square foot of steel strip, inclusive.

11. Steel strip when differentially coated by the process claimed in claim 6, 7 or 8 and having an iron-zinc alloy coating on both faces of the strip and a uniform galvanizing spelter coating on only one face of the iron-zinc alloy coated steel strip, the iron-zinc alloy coating on the strip having a coating weight between 0.15 and 0.35 ounce per square foot on each face of the steel strip, inclusive.

12. The differentially coated steel strip as claimed in claim 11 in which the uniform galvanizing spelter coating on said one face of the iron-zinc alloy coated strip has a bright spangled finish and a coating weight between 0.1 and 0.5 ounce per square foot, inclusive of steel strip.

13. Steel strip as claimed in claim 10, 11 or 12 wherein the iron-zinc alloy has an iron content between 10% and 15% by weight, inclusive.

14. Continuous-strip coating apparatus for producing iron-zinc alloy coated steel strip comprising means for heating steel strip to a temperature of about 1000°F. or higher, hot-dip galvanizing means including a galvanizing bath, means for delivering the



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heated steel strip through a non-oxidizing atmosphere into the galvanizing bath including means for maintaining strip temperature near 1000°F., means for submerging the

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- 5 heated steel strip beneath the surface level of the galvanizing bath and for moving the submerged strip through the galvanizing bath to impart heat to molten spelter in the galvanizing bath and maintain the temperature of the spelter above 900°F., means for cooling
- 10 a portion of the galvanizing bath to produce a zone of cooled galvanizing spelter at 800°F. to 860°F., inclusive, means for delivering strip from the galvanizing bath upon
- 15 passage through the zone of cooled spelter, so that the delivered steel strip has an inner iron-zinc alloy coating and an outer molten

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galvanizing spelter coating, and means for directing gas under pressure against at least one face of the coated steel strip to remove molten galvanizing spelter coating from that face of the iron-zinc alloy coated steel strip. 20

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15. Continuous strip coating apparatus constructed substantially as herein described with reference to and as illustrated in Fig. 1 or Fig. 2 of the accompanying drawings. 25

16. Steel strip when coated in the apparatus claimed in claim 14 or 15.

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