

[54] METHOD FOR CONTINUOUSLY GALVANIZING STEEL STRIP

[72] Inventors: Theodore H. Krengel, Flossmoor; Arthur E. Ostrowski, Alsip; Anthony J. Raymond, Olympia Fields, all of Ill.

[73] Assignee: Allied Tube & Conduit Corporation, Harvey, Ill.

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[51] Int. Cl.B23p 17/00

[58] Field of Search....29/527.1, 527.4, 527.2, 527.3; 72/47; 117/130, 131

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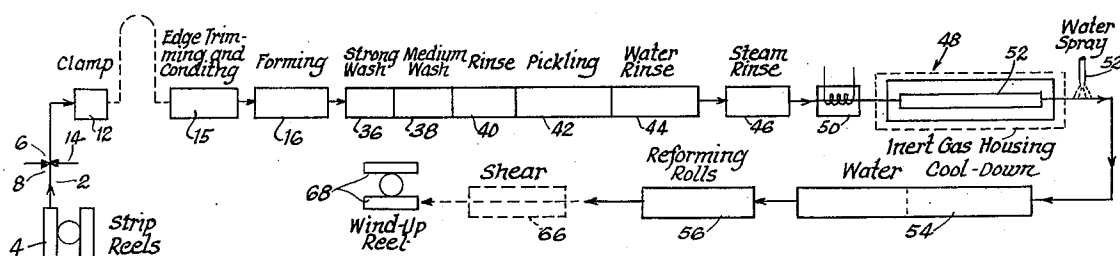
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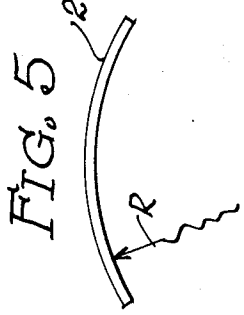
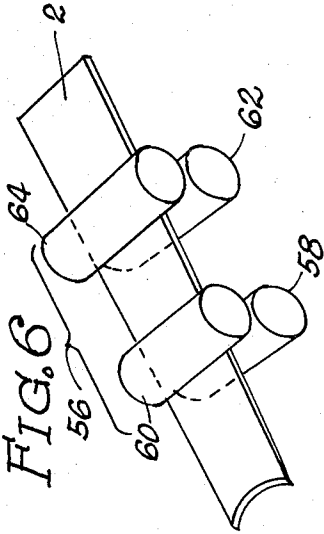
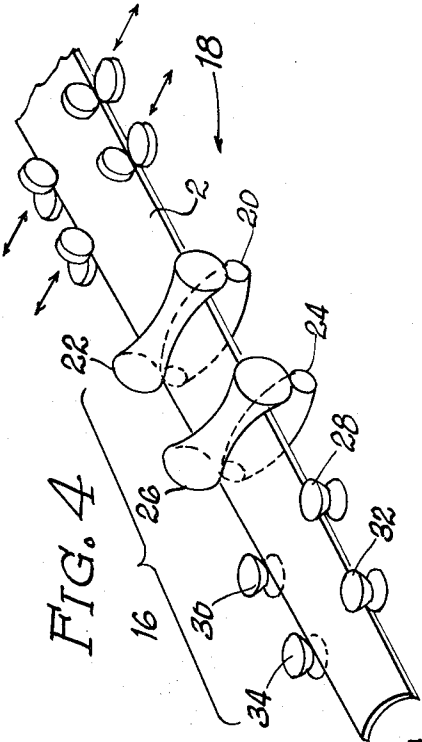
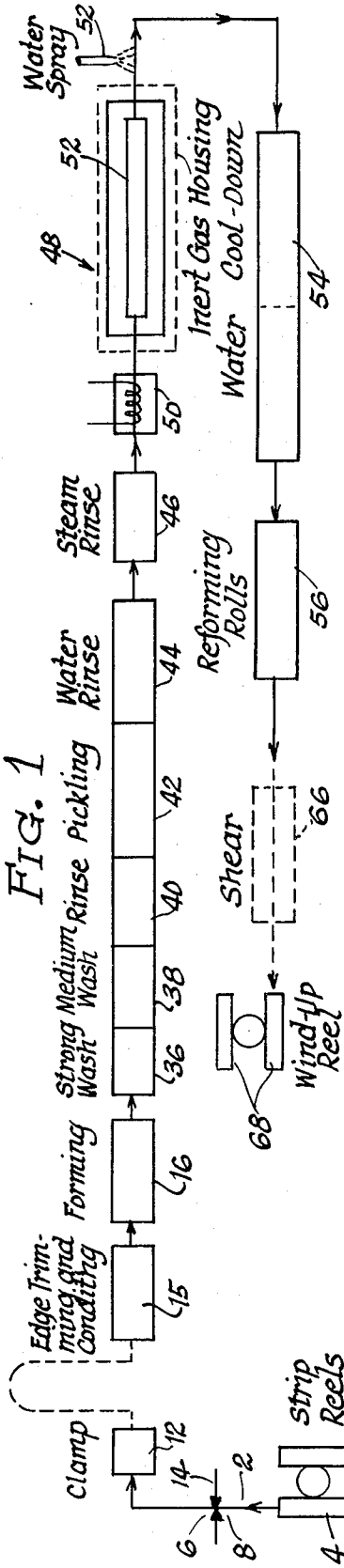
Primary Examiner—John F. Campbell
Assistant Examiner—Donald P. Rooney
Attorney—McDougall, Hersh & Scott

[57] ABSTRACT

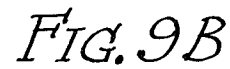
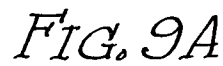
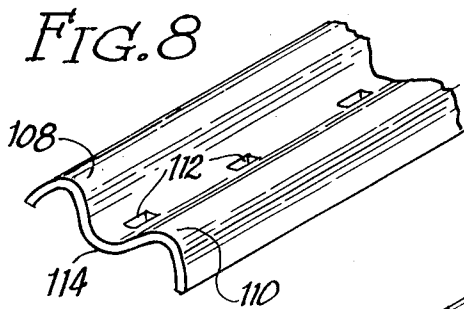
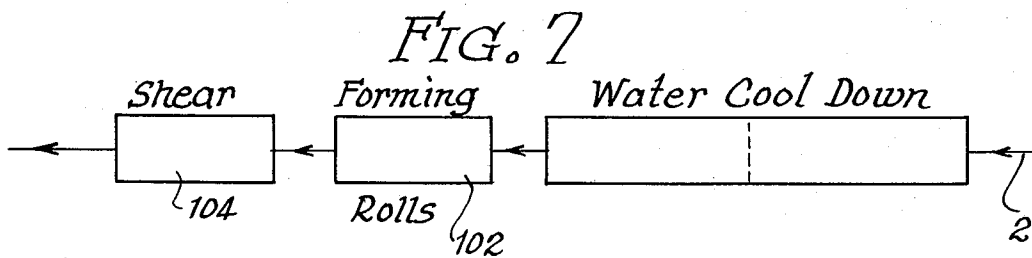
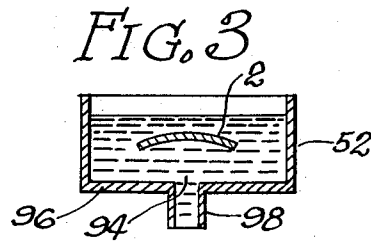
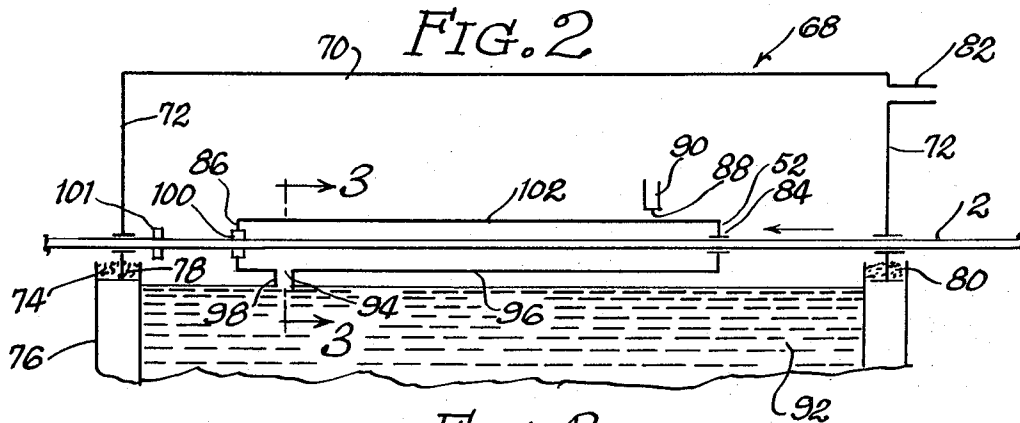
A method of galvanizing strip steel is disclosed in which a continuous strip moving in a horizontal plane, after passing through preparation steps, is caused to enter a bath of molten zinc below the level of the surface of that bath. The strip still moving in a horizontal plane passes through the bath and exits therefrom from a location below the surface. After cooling, the strip may be coiled or partially roll-formed and cut to desired lengths. The disclosure includes the steps of forming or partially forming the strip prior to its entry into the bath.

8 Claims, 10 Drawing Figures





INVENTORS
Theodore H. Krengel
Arthur E. Ostrowski
Anthony J. Raymond
by McDougall, Hersh, Scott
and Ladd Attys



METHOD FOR CONTINUOUSLY GALVANIZING STEEL STRIP

The galvanizing of flat strip has been accomplished in the prior art with which we are familiar by the use of baths or tanks of molten zinc of substantial depth. The strip is fed into the bath by causing it to enter its top surface from above and after passing over one or more guide rolls to exit from the bath from the top surface. With this basic apparatus and method satisfactory results using appearance, resistance to rust and corrosion, as criteria have been achieved. The strip steel galvanized is almost never a finished product in itself but rather constitutes material to be shaped into a desired configuration. In order to do this, it has been the practice heretofore to galvanize strip material of fairly large width and then slit the material. Usually, the slit material is coiled and then transported elsewhere for shaping as by roll forming, cutting or punching. When slit or cut or punched after galvanizing, the side or other edges are exposed and when exposed may rust. It is generally agreed that in order to achieve a product which exhibits good resistance to edge rusting over long periods of time there is a limitation on the thickness of the material that can be galvanized. For instance, in one report of tests by Frank J. Cole of the Republic Steel Corp. in Cleveland, Ohio, delivered at a meeting of The Galvanizers Committee in October of 1963, it was concluded that the degree of protection afforded by zinc galvanizing was dependent on steel gauge and zinc thickness. In his report, he stated that it was the usual view of the industry that galvanic cathodic protection will protect the edges of galvanized steel on only 0.036 inch. gauge and lighter and that his data confirmed that view.

In considerable measure, the prior art method is necessary because it has not been considered practical to shape strip material either partially or completely in a galvanizing line. One reason is that the length of the line required for the galvanizing methods of the prior art are such that the addition of roll forming to the line becomes uneconomical or otherwise not feasible.

Consequently, the generally accepted industry view has been, as noted above, that 0.036 inch is the limit on the thickness of the strip that can be galvanized in a continuous process where the edges are exposed as slitting after galvanizing. When it is possible, as is the case with this invention to eliminate the slitting operation following galvanizing, to effect that operation before galvanizing, then strip greater than 0.036 inch may be galvanized and effective coating of all surfaces provided. This result is obtained by an aspect of this invention which permits strip material galvanized in a continuous process to be formed or partially formed as by rolls, punches or the like so that a finished or partially finished product with its exposed edges galvanized is produced. Generally, roll forming of galvanized strip is done up with strip up to 36 inches in width, and it is contemplated that this invention may be used in continuous galvanizing lines capable of processing strip of at least that dimension.

Therefore, it is an object of this invention to provide a novel method of galvanizing strip steel of any desired width so that the edges will be adequately protected even with a strip thickness greater than 0.036 inch.

Other problems of the prior art method and apparatus have the effect of increasing their cost of

operation by limiting their flexibility as to the kind of strip that can be galvanized without time consuming and expensive changeover procedures. Other cost increasing factors are the need for periodic downtime for maintenance of such elements, guides, sinker rolls and other submerged moving parts. Further, it is necessary to periodically remove dross on the top of the bath for instance. Also, complicated means to maintain a desired bath temperature and dispersion of alloying materials are required. In addition, if it is desired to produce a galvanized steel product wherein the quality of the surface finish is important, as for instance, where a consumer product is desired, the use of post coating devices such as planishing rolls is required thus further adding to the cost and complexity of the system.

Accordingly, it is another object of this invention to provide a novel method for the continuous galvanizing of strip steel which is relatively easier and less costly to construct and maintain.

A further object of this invention is to provide a novel method for the continuous galvanizing of strip steel which may more easily than the prior art be threaded when it is desired to change from one width of strip to another.

It is still another object of this invention to provide a novel method for the continuous galvanizing of strip steel which is capable of producing smooth spangle free finishes.

A still further object of this invention is to provide a novel method for the continuous galvanizing of strip steel which will coat strip material which has been roll-formed to a desired shape or has been partially roll-formed before galvanizing and may be finish roll-formed after galvanizing.

It is another object of this invention to provide a novel method and apparatus for continuously galvanizing the surfaces of strip steel which is not wasteful of the zinc used for galvanizing.

SUMMARY OF THE INVENTION

The above and other objects of the invention are achieved by a novel method of strip galvanizing which includes the step of moving the strip material in substantially a horizontal plane through a zinc bath. In another aspect of the invention, the strip may be processed while flat or partially formed.

BRIEF DESCRIPTION OF THE FIGURES

The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the concluding portion of this specification. Embodiments of the invention, both as to their structure and manner of operation, together with further objects and advantages thereof may be best understood by reference to the following description taken in connection with the accompanying drawings in which:

FIG. 1 is a diagrammatic illustration of a machine embodying the invention and useful in carrying out the method thereof;

FIG. 2 is a schematic illustration of a zinc bath structure useful in carrying out the method of the invention;

FIG. 3 is a view along the lines 3—3 of FIG. 2;

FIG. 4 is a diagrammatic illustration of forming rolls forming a part of a machine incorporating the invention and useful in carrying out the method thereof;

FIG. 5 is an end view of strip material after it has passed through the forming rolls of FIG. 3;

FIG. 6 is a diagrammatic illustration of reforming rolls which may form a part of a machine embodying the invention and be useful in carrying out the novel method thereof;

FIG. 7 is a diagrammatic illustration of a portion of apparatus which may be used to practice an alternate embodiment of the invention;

FIG. 8 is a perspective view of one type of steel strip that may be galvanized in accordance with the invention;

FIG. 9A is a perspective view of a partially formed shape which may be galvanized in accordance with the invention; and

FIG. 9B is a perspective view of the shape that may be formed from the partially formed shape of FIG. 9A after galvanizing.

DETAILED DESCRIPTION

FIG. 1 illustrates a galvanizing machine which is fed with strip steel 2 supplied from a strip reel 4. The machine is arranged as a series of in line stages to operate in a continuous manner for providing a galvanizing coat to all surfaces of the strip material 2. Advancement of the strip 2 is effected primarily by engagement between the strip and the forming rolls rotating at relatively constant speed whereby the strip is drawn into the machine for processing. Since the lengths of the steel strip from the strip reel 4 come to an end after a relatively short period of operation by the machine and since the strip is taken up continuously by the machine in its continuous operation, it is necessary to provide means for splicing the end 6 of the strip from one reel 4 with the leading end 8 of another reel for joiner of the strip into continuous lengths without stoppage of the machine in its continuous operation. For this purpose a loop 10 is taken in the strip 2 and dimensioned to have a length sufficient to continuously feed the strip to the mill while the trailing end 6 of the strip is held stationary for splicing, as by welding, onto the leading edge 8 of a new reel which has been moved into a position for use. The loop 10 may be placed about a roller riding on a carriage in turn riding on a track similar to that shown in the U.S. Pat. to Krengel et al. No. 3,122,114. To the same end a clamp 12 may be provided to hold the end 6 while the end 8 is welded to it by the welder illustrated diagrammatically by reference numeral 14.

Generally, it is necessary to trim or condition the edges of the strip from the reel 4 for it is relatively rough and uneven. In order to accomplish this edge trim or conditioning, means 15 may be provided. This may be constituted by a rotary side trimmer which removes a small portion of each edge or scarfing tools on each side which will remove projections from the edges.

Likewise, prior to forming a slit may be provided which cuts the strip unwinding from the reel 4 into a plurality of strips, not necessarily of the same width, which may then be processed including forming, partially forming and galvanizing in parallel to produce a product having all exposed surfaces galvanized.

In one embodiment of the invention in order to galvanize or coat the surface of the strip 2 with zinc in ac-

cordance with this invention, the strip is first passed through a series of forming rolls 16 which have a configuration and number sufficient to form the flat strip into an arcuate shape as shown in FIG. 5. By way of illustration the forming rolls may be arranged through the machine in the direction of the arrow 18. A first pair of forming rolls engage the upper and lower surfaces of the strip and are constituted by a bottom roll 20 having a slightly convex shape and an upper roll 22 having a slightly concave shape to begin the deformation of the strip to the desired shape. These rolls are provided to have their axis of rotation extend transversely to the direction of movement of the strip and are rotatable in the direction shown by the arrows on the ends thereof. As noted above, these rolls engaging the upper and lower surfaces of the strip in addition to partially forming it to the desired shape also act to drive or advance the strip through the machine.

A second set of transverse rolls comprising a lower convex roll 24 and an upper concave roll 26 may be provided. These rolls would have radii of curvature greater than those of the rolls 20 and 22 in order to further form the strip to the desired arcuate shape. Further forming rolls may be provided by a pair of opposed vertical rolls 28 and 30 driven about axes perpendicular to the axis of rotation of the rolls 20, 22, 24 and 26. These rolls are provided with concave surfaces engaging the lateral edges of the strip 2 forcing it further toward the desired arcuate shape. A similar set of vertical rolls 32 and 34 are provided to engage the lateral edges of the strip in the same manner. These rolls are mounted in the machine with their axis of rotation closer together than the axis of rotation of the rolls 28 and 30 in order to further form the strip 2 to the desired arcuate shape. By using various combinations of forming rolls of which the arrangement in FIG. 4 is intended only as representative of one combination that may be used the strip may be gradually formed from its flat configuration as shown in the right-hand portion of FIG. 3 to the arcuate configuration as shown in the left-hand portion of that figure. In addition to rolls actually forming or partially forming the strip, the forming stage 16 may also include stock guides 35 consisting of guide rollers engaging the edge and top and bottom of the strip adjacent the edges on both sides thereof and movable inwardly and outwardly as indicated by the arrows. When provided with such stock guides, the roll may by adjustment inwardly or outwardly accommodate strip material of different widths without the necessity to change the forming rolls.

Referring again to FIG. 5, it will be seen that the strip 2 has been formed into an arcuate shape having a radius of curvature R. By forming the strip in the manner shown the amount of zinc which will adhere to the surface will be that necessary to obtain a coating that will be strongly bonded to the surface of the strip, have a desired thickness, good coverage of the entire surface and good appearance. These results will be achieved without the use of excessive zinc for the excess will be provided with a path to be easily wiped off down the downwardly sloping sides of the arcuate strip back into the bath for reuse. Likewise, the concave undersurface of the strip will be similarly coated with the excess returning to the bath. The limitation on R are related to the thickness of the strip, it being important not

to exceed a minimum value for a given thickness in order that the strip not be deformed beyond a point where reforming into its flat form is no longer possible. On the other hand, a maximum value of R is determined by the need to a surface curved downwardly sufficient to permit the excess zinc to run off.

After being formed to the arcuate shape, the strip is advanced to elements linearly aligned therewith for washing and pickling the surfaces of the strip in preparation for continuous galvanizing. The washing and pickling of the machine may be similar to that disclosed in the U.S. Pat. to Kregel et al. No. 3,122,114 and comprise a first stage 36 for providing a strong wash of that surface and a second stage 38 for providing a medium wash. As in the disclosure in the patent to Kregel et al., these washes may take the form of solutions of alkali in hot water. From the alkali washes the strip is advanced to a rinse stage 40 where it is sprayed with rinse water to remove the alkali from the surface. After rinsing, the strip may be pickled at the stage 42 using a solution of hydrochloric acid. After a water rinse by a stage 44 and a steam rinse by a stage 46, the strip is advanced to the entrance to an inert gas housing 48.

In the interior of the housing 48 there is first provided means to preheat the strip to a temperature in the range of 650° to 950° F. in order that the galvanizing operation may be carried out more rapidly. The preheat means is illustrated as being constituted by an induction heating device comprising an induction heating coil 50 encompassing the strip and connected to a suitable source of electrical energy (not shown). Also included within the inert gas housing is a bath of molten zinc, a portion of which is in a trough 52 disposed within the housing. This construction may be the same as that disclosed in the Kregel et al. patent referred to above, it being noted that suitable means shaped to conform to the surfaces of the strip and engaging therewith may be provided at the exit end of the trough to wipe off the excess zinc as the strip leaves the housing 48.

In order to prevent flow and bead formation, it is desirable to freeze the metal as soon after wiping as possible. For this purpose use can be made of a water quench as in the form of a water spray or flow coat 54 following substantially after the strip emerges from the housing.

From the galvanizing section the galvanizing strip is advanced sequentially through a series of water spray sections 54 to cool down the galvanized strip if it has not otherwise been sufficiently cooled in the freezing step.

If it is desired to produce flat strip, the machine will include a series of reforming rolls 56. These reforming rolls may be arranged as shown in FIG. 6. In this figure, there is shown a first pair of transverse rolls 58 and 60 wherein the roll 58 is positioned beneath the strip 2 while the roll 60 is positioned above it. Engaging the surfaces of the strip the rolls have the effect of forcing the arcuately shaped strip back toward its flat configuration. Whatever number of rolls are necessary may be provided and in this figure there is included an additional set of rolls 62 and 64 which are arranged for rotation in the same direction as the rolls 58 and 60 but which have their axis of rotation closer together than the axis of rotation of the rolls 58 and 60.

After being reformed into flat strip, the strip 2 may either be cut into desired lengths by a shear 66 or wound on a storage reel 68 depending on the needs and the desires of the user.

Rather than use the forming and reforming rolls just described the strip may be passed through the galvanizing bath flat but with its longitudinal axis tilted slightly from the horizontal. In this manner, a sloping surface for excess run-off may be provided without bending the strip. Roller guides may be provided in lieu of the forming rolls 16 for this purpose.

An important concept of this invention resides in the method for continuously galvanizing the strip material as a continuous operation. For this purpose it is desirable to contact the cleaned surface of the strip 2 with molten zinc for a sufficient time to enable the desired reactions to take place to form the desired thickness of galvanize on its surface, and it is important to carry out the reactions under non-oxidizing conditions. Otherwise undesirable oxides of the metal will form at the elevated temperatures under which the reactions are carried out.

The desired reducing or non-oxidizing atmosphere can be maintained by the enclosure of the galvanizing zone within a sealed housing into which an inert or reducing gas can be introduced with a maintenance of a non-oxidizing atmosphere. This can be accomplished by a sealed enclosure but it is preferable to make use of an enclosure which is capable of removal to gain access to the interior of the galvanizing zone but without interfering with the ability to achieve atmospheric control when in position of use.

The desired characteristics have been achieved in the construction illustrated in FIG. 2 of the drawings by the use of a rectangular hood 68 having a horizontally disposed top wall 70, side and end walls 72 which extend perpendicularly downwardly from the edges of the top wall into a trough 74 facing upwardly from a frame 76 which extends all about the galvanizing zone. The bottom edges 78 of the side walls are received within the trough for support of the hood. The trough is at least partially filled with a material 80 such as fine sand into which the lower edge of the side walls becomes embedded to effect a sealing relationship all around which militates against the flow of free gases all around for atmospheric control. One or more inlets 82 for the inert or reducing gas are provided in the walls of the hood for introduction of such inert or reducing gas in the amounts to maintain a non-oxidizing atmosphere therein.

Referring more particularly to FIGS. 2 and 3, the galvanizing means comprises an elongated horizontally disposed housing 52 in the form of a trough aligned axially with the line of travel of the sheet 2 for passage of the sheet horizontally through an intermediate section of the trough from an inlet 84 at one end and to an outlet 86 at the opposite end. The trough is provided with one or more inlets 88 which are connected by a passage 90 to a reservoir 92 of molten zinc with means for displacement of the molten zinc from the reservoir to the inlets at a rate sufficient to maintain the trough substantially filled with molten zinc to cover the strip advancing therethrough. The inlet 88 may be adjacent the inlet 84 through which the strip is introduced for concurrent flow of the molten zinc through the trough with the strip and in position to overlie the strip so as to

direct the stream or streams of molten zinc onto the strip. Alternatively, the location of the inlet 88 and outlet 86 may be reversed to provide for counter flow of the molten zinc with the moving strip.

The trough 52 is further provided with a drain opening 94 in the bottom wall 96 thereof with a downpipe 98 leading from the drain to the reservoir. The drain opening is of small dimension to enable a thin stream of molten zinc constantly to flow therethrough but at a rate that is considerably less than the rate of introduction of molten zinc into the trough less the amount that escapes through the openings so that there will be an overflow of molten zinc over the sides of the trough forming the inlet to the trough, but insuring an amount of molten zinc in the trough to cover the strip passing therethrough. It is preferable to provide that the ends of the trough be higher than the sides in order that the overflow occur at the sides. In this manner, the entry of the strip below the surface of the bath in the trough without its prepared surface having previously been contacted by overflow zinc is insured.

A wiper means such as the element 100 may be provided in the outlet 86 to control the thickness of the zinc coating without bead formation and to provide for removal of excess for return to the reservoir while in a molten state and while still in a protective atmosphere. A similar element may be provided in the inlet 84 to engage the surface of the strip. These two elements may be constituted by guide blocks shaped to conform to the surface of the strip and may be constructed out of materials to which molten zinc will not adhere. An alloy of tungsten and aluminum have been found useful for this purpose.

Following the element 84 a conduit provided with outlets to supply a sharp blast of heat encompasses the strip to remove excess zinc and in this manner control the thickness of the zinc coating, provide a luster finish and ensure a uniformity of the coating.

As may be seen from FIGS. 2 and 3, the strip 2 enters the bath of molten zinc in the trough 52 below the level of its surface 102. During its passage through the bath, it travels in the same horizontal plane and exits similarly. This method of galvanizing results in a number of advantages. The most important advantage is that a complete high quality coating is obtained on all surfaces including the edges of the strip. As pointed out above, that by so doing it becomes possible to continuously galvanize strip steel normally slit from wide coil stock in thickness greater than 0.036 inches and produce a product which exhibits a resistance to corrosion including rust on all exposed surfaces including edges and the sides of punched holes for periods longer than heretofore possible. In addition, a shiny smooth finish is obtained free of flaws such as wrinkles or spots where the galvanizing is incomplete.

There seems to be a number of reasons why these results are obtained. First, by entering the galvanizing bath below the level of its top surface the strip material is constantly exposed to fresh bath material inasmuch as it does not have to pass through the dross that forms on the top of the baths such as found in the prior art. Second, the fact that the bath is continuously circulating provides the advantage of a good dispersion throughout the bath of any alloying materials that may be used. Further, because of the circulation optimum

temperature distribution is achieved enabling easier control of the temperature and a better ability to maintain the bath at a desired temperature.

A further advantage is that it becomes easier to remove foreign materials which tend to rise to the top of the bath and contaminate which are heavier and fall to the bottom. Other advantages which are obtained include an ability to control the length of the trough 52. Heretofore, this has been done by the use of additional guide rolls in the bath or by providing deeper baths. Further, it becomes easier to put the continuous galvanizing line in operation as there is no longer any need to thread the strip over guide rolls in the bath.

As described above, the method and apparatus may be used to continuously galvanize flat strip by the use of forming and reforming rolls. However, it is also possible to galvanize formed or partially formed strip material. Thus, in FIG. 7 an alternative embodiment is illustrated wherein the strip 2 after leaving the housing 48 and the quenching or cooling stage 54 may pass through a series of forming rolls 102 to be formed to any desired shape such as rectangular sections or angular constructions. After forming, a shear 104 may be provided to cut the formed strip to desired lengths.

FIG. 8 illustrates a formed strip which may be continuously galvanized using the method and apparatus of this invention. This is a more complex shape and comprises a strip having two curves 108 and 110 which may be used for guard rails of the type installed along highways. In this case, the machine could include a punch at a point prior to the surface preparation stages to form holes 112 in the trough 114 formed by the double curve of such a strip. This punch could be provided prior to the forming stage so that the holes are in the formed strip prior to galvanizing. This arrangement permits excess zinc draining into the trough 114 from the sloping sides of the curves to reenter the bath and yet at the same time the sides of the holes 112 are galvanized so that corrosion protection is thereby provided. Alternatively, prepunched strip could be used when the shape which may be galvanized using the method and apparatus of this invention is illustrated in FIGS. 9A and 9B.

FIG. 9B illustrates the desired end product, that is, a rectangular section 116 in which all the exposed surfaces are galvanized. Such a shape could be formed by first partially forming the strip material into the angular shape 118 shown in FIG. 9A, and then after surface preparation, passing this shape in the same manner as described above through the galvanizing bath. After galvanizing and cooling, additional forming rolls could complete fabrication of the strip 118 into the rectangular configuration 116.

When it is desired to galvanize flat strip which is to be reeled for further processing elsewhere, a loop such as that shown by the reference numeral 10 in the upstream part of the machine may also be used between the shear 66 and the wind up reel 68 in order to permit continuous operation. The process of such a loop would provide storage for galvanized strip while an empty reel is being exchanged for a reel which has just been filled.

It will be understood that changes may be made in the details of construction, arrangement and operation as well as in the materials employed without departing

from the spirit of the invention, especially as defined in the following claims.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A method of continuously galvanizing steel strip comprising the steps of:
continuously feeding flat steel strip from a source of such material;
passing the strip with all of its surfaces exposed, whereby all of said surfaces will be galvanized while moving in a horizontal plane into an agitated bath of molten zinc at a location below the upper surface thereof so as to avoid passage through any dross on the surface of the bath and to produce a zinc coating substantially free from flaws;
maintaining the strip moving through the bath in the same horizontal plane; and
passing the strip while moving in the same horizontal plane out of the bath of molten zinc at a location below the surface thereof.
2. The method of continuously galvanizing steel strip as set forth in claim 1 in combination with the step of preparing the surface of said strip by washing and pickling prior to its passage into the bath.

3. The method of continuously galvanizing steel strip as set forth in claim 1 in combination with the step of preheating the strip prior to entry into the bath.

4. The method of continuously galvanizing steel strip as set forth in Claim 1 including the step of forming said flat strip so as to have downwardly sloping sides and exposed edges prior to its entry into the bath.

5. The method of continuously galvanizing steel strip as set forth in claim 4 in combination with the step of reforming the strip so as to be flat after its exit from the bath.

6. The method of continuously galvanizing steel strip as set forth in claim 1 in combination with the step of partially forming said strip to a desired configuration with exposed edges prior to its entry into the bath.

7. The method of continuously galvanizing strip steel as set forth in claim 6 in combination with the step of forming the partially formed strip to a desired configuration after its exit from the bath.

8. The method of continuously galvanizing steel strip as set forth in claim 1 wherein the strip is passed into an agitated bath of molten zinc maintained in a non-oxidizing atmosphere.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,696,503 Dated October 10, 1972

Inventor(s) Theodore H. Krengel et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, after the title of the application, the first paragraph of the specification has been omitted. It should read as follows:

--This invention relates to a method and apparatus for galvanizing strip material. More specifically, it relates to a method and apparatus for continuously galvanizing such material which is flat or shaped or partially shaped by roll forming.--

Signed and sealed this 6th day of March 1973.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents