

June 19, 1951

R. F. RENKIN
METHOD OF COATING STRIP STEEL WITH A
PROTECTIVE METAL COATING

2,557,764

Filed March 6, 1947

2 Sheets-Sheet 1

Fig. 1a

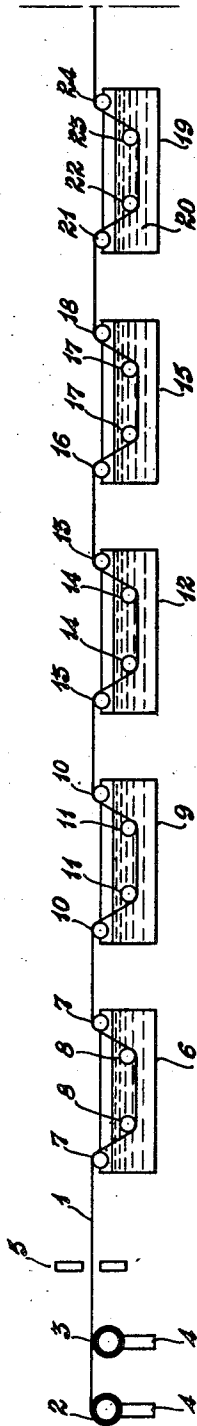
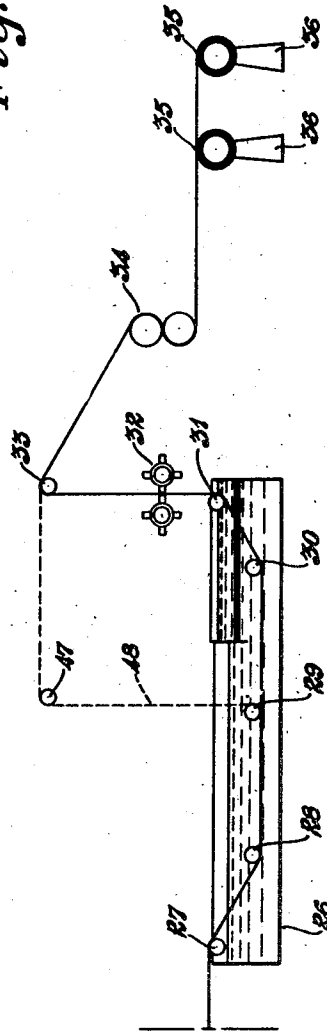


Fig. 1b



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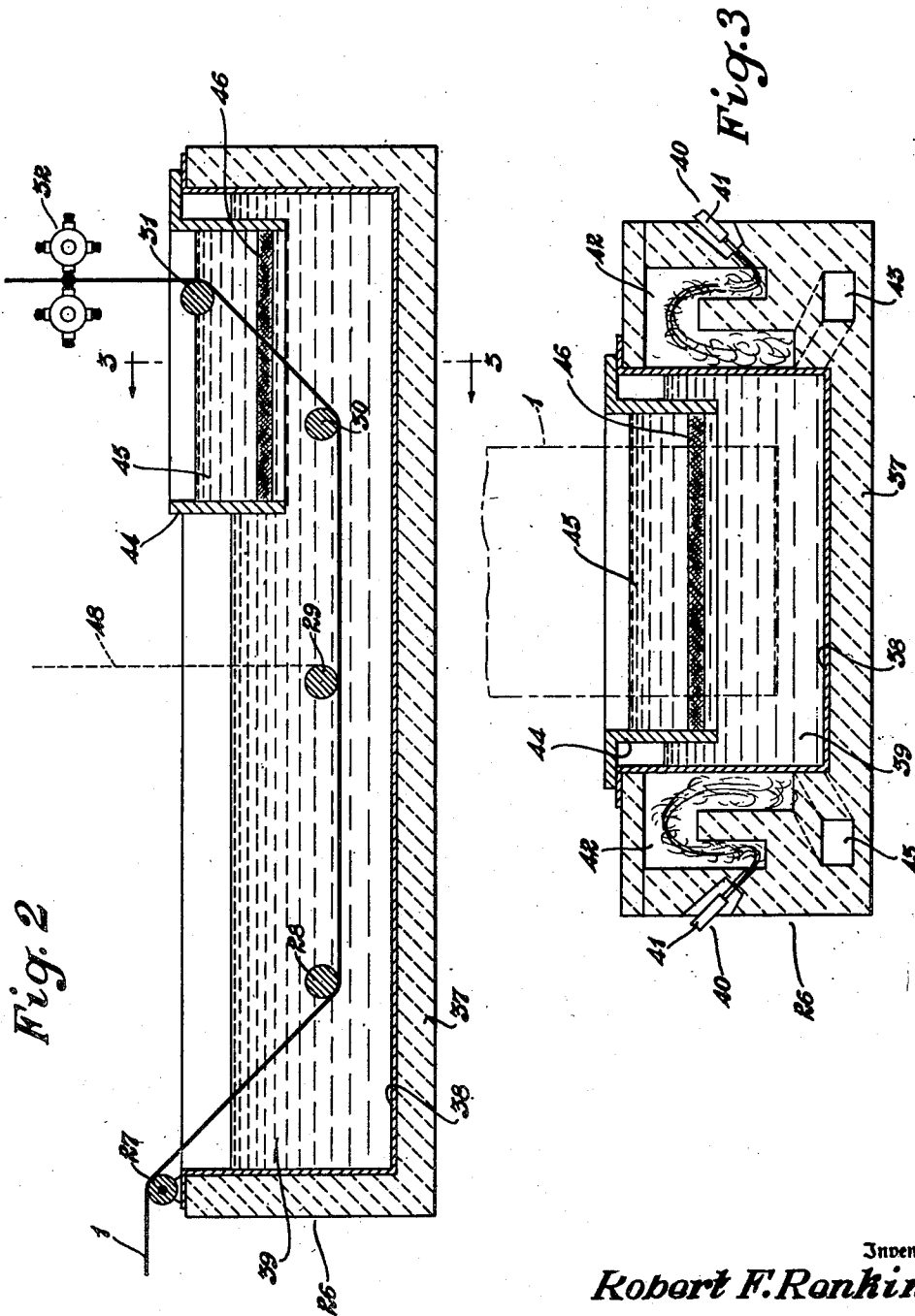
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METHOD OF COATING STRIP STEEL WITH A
PROTECTIVE METAL COATINGRobert F. Renkin, Sharon, Pa., assignor of one-
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1 Claim. (Cl. 117-64)

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The invention relates broadly to coated metal products and methods of making the same, and more particularly to the hot coating of steel sheets, strips, stripsheets, wire, and the like with a protective metallic coating, similar in some respects to and totally different in other respects from a galvanized or zinc coating, and having properties comparable to an electro-galvanized coating, so as to produce at low cost a hot coated, corrosion resisting product having an extremely thin, ductile, metallic coating thereon.

It has been customary to galvanize by employing a molten metal bath of zinc, or zinc alloys such as zinc and tin; zinc, lead and tin; zinc, lead, tin and aluminum; zinc, tin and aluminum; or zinc and aluminum. Steel products hot coated in such baths sometimes are subsequently heated or rolled or both to produce a galvanized heat and corrosion resisting product which will withstand forming at right angles without flaking the coating thereof.

However, the use of each of such customary zinc containing baths results in the formation of a layer of zinc-iron alloy at each of the zones between the steel surfaces being coated and the coating metal. Such layers of zinc-iron alloy are very brittle and affect to a considerable degree the ductility of the coated metal product.

My prior Patent No. 2,069,658 indicates a manner in which the zinc-iron alloy in a zinc coated steel product may be greatly reduced or substantially eliminated. This patent further indicates how a zinc-tin-iron alloy which is ductile and cohesive may be formed by using a molten zinc-tin coating bath operated in certain critical percentage and temperature ranges.

The method of my prior Patent No. 2,069,658 produces a ductile zinc containing coating, but a coating weight of at least 0.3 to 1 ounce per square foot of material coated must be produced in order to obtain satisfactory corrosion resisting properties in the coated product; and from 85 to 97% of the coating metal on the coated product is zinc.

Under economic conditions which have prevailed for some years and are likely to prevail for many years, there is a shortage of zinc, and material and labor costs are high. Thus, a complex problem exists as to how to substantially reduce the amount of zinc used in making steel products having a zinc containing coating thereon; as to how to obtain a thinner coating; as to how to provide such a thinner coating with less zinc and which may be subjected to the most extreme deep drawing or forming operations with-

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out disturbing, fracturing flaking or otherwise harming the coating; and as to how to reduce the cost of making zinc containing coated products.

Electro-galvanized steel products have been made in which a comparatively small amount of zinc by weight is present in the coating for obtaining satisfactory corrosion resistance, but the cost of making electro-galvanized products is relatively high.

Terne coated steel sheets have customarily been made by passing sheets through a molten terne bath in an otherwise standard tinning machine, but the sheets so coated have a relatively heavy terne coating thereon which is uneven and non-uniform in thickness and appearance. When it has been attempted to wipe a terne coated sheet or strip as it emerges from a molten terne bath between stationary wiper pads, the resultant terne coating is relatively thin, but it does not have uniform surfaces because scratch-like lines appear or occur on the surfaces of the coating.

The prior Roemer and Renkin Patent No. 2,126,578 indicates a manner in which the foregoing difficulties in terne coating may be overcome to provide smooth, uniform finished terne coated surfaces; but such terne coated materials do not have the corrosion resistance that is obtained when zinc containing coatings are used.

Accordingly, a problem has existed and still exists as to how to substantially reduce the amount of terne metal (lead and tin) used in providing a satisfactory coating containing terne metal on steel products; as to how to obtain a satisfactory corrosion resisting coating containing terne metal when wiping the coating between stationary wipers under pressure so as to substantially reduce the amount of coating metal used; as to how to provide an extremely thin terne containing coating on steel products which may be subjected to the most extreme deep drawing or forming operations without injuring the corrosion resisting properties of the coating; and as to how to substantially reduce the cost of making terne containing coated products.

I have discovered how these complex and long standing problems in the art may be solved, how the cost of making hot coated metal products may be materially reduced, how the amount of zinc and terne metal used in making hot coated steel products having a zinc and terne containing coating thereon may be materially reduced, and how a ductile materially thinner hot coated zinc and terne containing coating than heretofore made

may be produced having the same or better corrosion resisting properties than present with electro-zinc coatings.

These results in accordance with the present discoveries may be obtained by passing steel strip material and the like, first through a molten terne metal bath, then through a molten zinc containing bath floating on top of a portion of the molten terne metal bath, and by then wiping the coated metal between stationary wipers under pressure to form a coating thereon containing zinc and terne metal without the formation of any substantial amount of zinc-iron alloy, and particularly without the formation of a layer of brittle zinc-iron alloy between the coating and base metal usually found in hot galvanized sheets.

Accordingly, it is a general object of the present invention to improve the art of making hot metallic coated steel sheets, strips, strip-sheets, wire, and the like.

Furthermore, it is an object of the present invention to provide methods of making hot coated steel products having metallic coatings thereon with properties comparable to electro-galvanized coatings in respect of ductility of coating metal and having the same or better corrosion resistance.

Moreover, it is an object of the present invention to provide methods of making hot coated steel products with zinc containing coatings thereon without forming any substantial amount of zinc-iron alloy in the coating or at its bond with the steel base.

Also, it is an object of the present invention to reduce the cost of making hot metallic zinc containing coatings on steel sheets, strips, strip-sheets, wire, and the like.

Furthermore, it is an object of the present invention to provide new methods of making hot coated corrosion resisting steel products having extremely thin, ductile, zinc containing coatings thereon as thin as 0.2 ounce per square foot of material coated.

Moreover, it is an object of the present invention to provide new methods of making hot metallic coatings containing zinc, tin, and lead, and alloys of said three metals on steel sheets, strips, stripsheets, wire, and the like.

Furthermore, it is an object of the present invention to provide new methods of making extremely thin hot zinc containing coatings on steel sheets, strips, stripsheets, wire, and the like which coated materials may be subjected to the most extreme deep drawing or forming operations without disturbing, fracturing, flaking, or otherwise harming the coating.

Also, it is an object of the present invention to provide new methods of making hot coated steel products having metallic coatings thereon containing zinc and terne metal with a wiped, smooth, uniform fine-grained coating metal structure which has a characteristic slipperiness similar to terne coatings or electrogalvanized coatings as distinguished from the more porous, coarser grained structure of usual wiped or heat treated hot dipped zinc coatings.

Moreover, it is an object of the present invention to provide new methods of making, at reduced costs and with reduced amounts of zinc and terne metal, improved extremely thin and ductile zinc and terne containing coatings on steel sheets, strips, stripsheets, wire, and the like having satisfactory corrosion resisting properties.

In addition, it is an object of the present in-

vention to provide a new hot coated steel product having a zinc containing metallic coating thereon similar in ductility to electro-galvanized metal and having better corrosion resisting properties.

Moreover, it is an object of the present invention to provide a new hot coated steel product having a zinc containing coating thereon substantially free of zinc-iron alloy.

Also, it is an object of the present invention to provide a new hot coated steel product having an extremely thin, ductile, corrosion resisting, zinc containing coating thereon as thin as 0.2 ounces per square foot of material coated.

Moreover, it is an object of the present invention to provide a new hot coated steel product having a coating thereon containing zinc, tin and lead, and alloys of said three metals.

Furthermore, it is an object of the present invention to provide a new hot coated steel product having a wiped zinc and terne metal containing coating thereon.

Likewise, it is an object of the present invention to reduce the cost of gross losses in forming hot zinc containing coatings on steel products.

Also, it is an object of the present invention to provide a new method of making hot dipped zinc containing coatings on steel products which enables a much longer pot life to be realized than is obtained in hot dip zinc coating steel products in accordance with prior practice.

Furthermore, it is an object of the present invention to provide a new method of making zinc and terne containing hot dip coatings on steel sheets, strips, stripsheets, wire, and the like, of either high or low carbon steel, either annealed or unannealed, which method can be carried out in conjunction with any usual procedure of preparatory cleaning, pickling, and fluxing, and which method does not require special fluxes or special pickling or cleaning treatment.

Finally, it is an object of the present invention to materially improve zinc and terne coating methods and products; to reduce the cost and amount of coating metal used in making zinc and terne containing metal coatings; to avoid the prior art zinc and terne coating difficulties; to generally advance the art of making hot metallic coated steel products; to solve long standing problems in the art; and to obtain the foregoing advantages and desiderata in a simple, effective and inexpensive manner.

These and other objects and advantages apparent to those skilled in the art from the following description and claim, may be obtained, the stated results achieved, and the described difficulties overcome, by the products, methods, steps, operations, and procedures which comprise the present invention, the nature of which are set forth in the following general statements, preferred embodiments of which—illustrative of the best modes in which applicant has contemplated applying the principles—are set forth in the following description and shown in the drawings, and which are particularly and distinctly pointed out and set forth in the appended claim forming part hereof.

The nature of the improvements in hot coated steel products of the present invention may be stated in general terms as comprising a steel sheet, strip, stripsheet, wire, and the like having a hot dipped metallic coating thereon containing zinc, lead and tin and alloys of said three metals, and being substantially free of zinc-iron alloy.

The nature of the improvements in methods of making coated steel products may be stated in general terms as preferably including the steps of pickling, cleaning and fluxing the material to be coated in any desired usual manner, then passing the material through a molten bath of **terne metal**, then passing the material through a molten bath of zinc containing metal floating on top of a portion of said molten **terne metal** bath, and then wiping the coated material between stationary wipers under pressure to remove excess coating metal and to finish the coated steel product.

By way of example a preferred embodiment of apparatus which may be used to carry out the improved method in the coating of strip steel is shown somewhat diagrammatically in the accompanying drawings forming part hereof wherein:

Figs. 1a and 1b are diagrammatic side elevations of a continuous line of apparatus which may be used in carrying out the improved method to make the improved product;

Fig. 2 is an enlarged diagrammatic longitudinal section through the hot coating pot shown in Figs. 1a and 1b; and

Fig. 3 is a cross section taken on the line 3—3, Fig. 2.

Similar numerals refer to similar parts throughout the various figures of the drawings.

In carrying out the improved method, a strip of annealed or unannealed, high or low carbon steel, generally indicated at 1, is continuously pulled from a coil 2 or 3 thereof located on uncoiling stands 4, through a welder 5 and into an alkali cleaning tank 6 in a usual manner. The strip 1 in passing through the cleaning tank 6 passes over entry and exit rolls 7 and hold-down rolls 8; and the cleaning tank 6 may contain any desired or usual alkali cleaning solution.

The strip 1 then preferably passes through wash tank 9 containing a desired washing solution, usually water, and again passes over entry and exit rolls 10 and hold-down rolls 11.

The strip 1 then passes into pickling tank 12 containing any usual pickling solution, over entry and exit rolls 13 and hold-down rolls 14 therein; and then through water wash tank 15 and over entry and exit rolls 16 and 18 and hold-down rolls 17 therein.

The purpose of passing the strip 1 through the cleaning tank 6, wash tank 9, pickling tank 12, and wash tank 15 is to properly, adequately, uniformly and completely clean the surfaces of the strip and eliminate all impurities therefrom so as to provide coating receptive surfaces.

However, any usual kind or type of cleaning or pickling steps or apparatus may be used, including a gas pickling operation, for removing impurities and for providing a coating receptive surface.

The strip 1 then is passed through a flux tank 19 containing a usual liquid flux 20 and provided with an entry roll 21, hold-down rolls 22 and 23, and an exit roll 24. The liquid flux contained in flux tank 19 may be a bath of zinc chloride, or other commercial flux, or may comprise zinc ammonium chloride containing either nickelous chloride or aluminum chloride or both. If desired, the liquid flux in flux tank 19 may be electrolyzed.

Immediately after the flux tank 19, the strip 1 passes into a coating pot, generally indicated at 26, provided with the usual entry roll 27, hold-down rolls 28, 29 and 30, and an exit roll 31.

After passing through the coating pot 26, the strip 1, as it emerges therefrom, is passed between preferably stationary wipers 32, such as shown in my Patent No. 1,932,229. Beyond the wipers 32, the strip 1 passes over roll 33 and through pull tensioning rolls 34 which supply the pull to feed the strip through the foregoing apparatus. The strip may then be wound into coils 35 on any of wind up reels 36.

Only one strip 1 is shown in the drawings as being continuously hot coated. However, it is to be understood that one wide strip or a plurality of narrow strips may be simultaneously hot coated, depending upon the width and length of the apparatus.

Coils 2 and 3 are fed from reels 4, in accordance with common strip handling practice. As one coil is used up the end thereof is welded to the end of another coil. When the welded joint reaches a coiler 36, the same may be cut out, the coil of coated strip metal removed from the coiler, and a new coil started.

As previously stated, the pull tensioning rolls 34 pass the strip continuously through the treating apparatus so that the strip is maintained taut between the various entry, exit, hold-down, and pullover rolls of the various devices.

Referring more particularly to Figs. 2 and 3, the coating pot 26 generally may be of usual construction comprising a suitable foundation or shell 37 upon and within which is supported a metal tank or container 38 containing a molten **terne bath** 39. The bath 39 is heated and maintained molten by any usual heating means, generally indicated at 40, preferably in the side walls of the foundation 37 and comprising suitable burners 41, discharging into combustion chambers 42, and out through flues 43.

At the exit end of the molten **terne bath** 39, box-like walls 44 open at their upper and lower ends are supported on the pot foundation 37, the box-like walls 44 extending down into the molten **terne bath** 39. A bath of molten zinc 45 is provided within the compartment formed by the box-like walls 44, and the molten zinc bath 45 floats on top of the molten **terne bath** 39 somewhat as shown, because of its lower specific gravity. In operation, when dross is formed, it collects at 46 between the molten zinc bath 45 and molten **terne bath**, and within the box-like compartment 44.

The composition of the molten **terne bath** 39 may be 2 to 50% tin and the balance lead and other commercial residuals of a lead-tin alloy. Preferably, however, the **terne metal** bath 39 is composed of about 5% tin and the balance lead and other commercial residuals of a lead-tin alloy. Similarly, the **terne bath** may comprise 10% tin and 90% lead or 15% tin and 85% lead.

The zinc bath 45 preferably comprises pure or commercially pure zinc, or zinc with an addition of a small amount of aluminum such as .05 to .1% aluminum, forming a zinc-aluminum alloy; or zinc with the addition of aluminum containing silicon, forming a zinc-aluminum-silicon alloy.

The zinc bath 45, in order to be maintained molten, must be heated to and maintained at a temperature of approximately 800° F. to 840° F. The source of heat for maintaining the zinc bath 45 molten is the **terne bath** 39 upon which the zinc bath 45 floats; and therefore the **terne bath** 39 must be maintained heated to approximately 800° F. to 840° F. This temperature is considerably higher than the usual bath tem-

perature for terne coating, which may be 600° F. to 750° F., depending upon the particular composition of the bath.

A very tight coating having excellent adherence is obtained by thus passing the strip 1 through a molten terne bath 33, then up through a molten zinc bath 45 and by then wiping the surfaces of the strip between wipers 32 to remove excess coating metal adhering thereto. In addition, the resultant wiped coating is extremely thin, as thin as two-tenths ounces per square foot of material coated.

It is difficult, because of its extreme thinness, to obtain an exact analysis of the composition and proportions of alloys and metals in the coating produced in accordance with the present invention. However, there seems to be zinc on top and zinc-tin-lead alloy below. There also seems to be certain amounts in varying proportions of zinc-tin alloy and zinc-lead alloy below the zinc along with the zinc-tin-lead alloy which tightly adheres to the steel base.

Microscopic examination of the coating discloses some alloying of the coating metal and the base metal at a layer between the coating metal and base metal. This layer has a far finer grain structure than that of the regular brittle zinc-iron alloy present between the coating and base metal in usual hot zinc coatings. Moreover, this alloy layer is far thinner than the usual zinc-iron alloy layer. It approaches the thinness but is heavier than the bonding alloy layer between terne coating metal and the base metal. The alloy bonding layer in the new product made in accordance with the present invention is so thin that it has been impossible to determine its composition.

Undoubtedly, some iron is alloyed at this bonding layer with some or all of the coating metals because a bond is formed; and therefore there must be minute quantities of zinc-iron alloy present. However, the amount of zinc-iron alloy that may be present is so small as to be inconsequential because tests by forming, stamping or bending disclose an absence of brittleness usually found in hot zinc coatings and attributed to the presence of zinc-iron alloy. Therefore, for all practical purposes, the new coating is free of zinc-iron alloy; and when the coating is designated herein as being "free of zinc-iron alloy" the above factors are intended to be recognized.

Accordingly, the wiped coating produced on the hot coated steel products made in accordance with the present invention is much thinner than any zinc containing coating heretofore produced by known methods. This thin coating characteristic gives rise to several important advantages or new results. First, much less coating metal is used. Second, since much less coating metal is used, the cost of the coating metal is considerably reduced.

Nevertheless, from the standpoint of corrosion resistance and coating ductility, the thinner, cheaper and metal conserving coating of the present invention is equal to or better than standard electro-zinc or terne coated materials. Thus, steel strip having the improved coating thereon may be subjected to severe forming, rolling and deep drawing operations without cracking, flaking, fracturing, or otherwise harming the coating. Similarly, the improved coating is comparable if not superior to electro-galvanized coatings in corrosion resistance. As a result the new hot coated steel products may be used for the fabrication of many types and kinds of

formed or deep drawn parts. In this connection, it is believed that the ability of the new coated product to be readily subjected to severe deep drawing is assisted by the slipperiness characteristic of the new coating.

There is another important feature of the improved method. When it is desired to produce heavy terne coated steel products, it is only necessary to by-pass the zinc bath 45 in compartment 44 and to pass the strip through the coating pot 37 beneath hold-down rolls 28 and 29 and then out of the terne bath and over roll 47 to roll 33 as shown by dot-dash lines 48 in Figs. 1b and 2. Alternately, the material passing out of the terne bath at 48 may be wiped to produce thin terne coatings. When the equipment is so operated to make terne coatings alone, the temperature of the terne bath 33 may if desired be reduced to the usual terne bath operating temperatures which depend upon the particular bath composition.

This feature of dual operation of the equipment to make either terne coated products, or zinc-containing coated products, is of great economic advantage. Thus, with the same line of equipment and without even changing coating baths, two different products can be made. Furthermore, the two different coated products can be made at the same time by threading one or more strips through the terne bath 33 and then through the zinc bath 45, and by threading another or other strips through the terne bath 33 and out at 48.

As far as I am advised, there has never been any hot coating lines known, built or operated in which two different hot coated products could be made selectively or concurrently on one line of equipment with one coating pot and without changing coating metals.

Another important and advantageous feature of the present invention is the substantial reduction in dross loss that is affected. In normal operation of the improved method, the amount of dross formed is approximately five pounds per ton of material coated, and indications are that when prime western spelter is again available, the dross loss will be considerably lower. Normal dross losses in making zinc containing coatings in accordance with the prior art have been from fifteen to eighteen pounds of dross per ton of material coated.

Dross forms when molten zinc and iron are in contact, and it has numerous phases. However, because no substantial amount of zinc-iron alloy is produced in the resultant coating, it is believed that most of the iron causing dross formation at 46 must be iron in the walls 44 which form the zinc containing compartment. Because these walls have a relatively small area in contact with zinc, including the absence of a bottom wall, the amount of dross formed is relatively small.

A further advantage in connection with the decreased dross loss which characterizes the present invention is that it is unnecessary to shut down the equipment at intervals for drossing operations, heretofore always required in making zinc containing coated products. Because the amount of dross formed is so small and because of the location of the dross at 46 within the zinc compartment 44, it is possible to dip and skim the dross from the zinc containing compartment during continuous operation of the equipment. The avoidance of shut downs for drossing accordingly further reduces coating costs.

Still another important advantage from a cost

and operating standpoint is the fact that zinc does not contact the main side walls 38 of the coating pot but only contacts the box-like walls 44 of the zinc containing compartment. This results in greatly increased pot life. The walls 44 may be made somewhat heavier than the usual pot walls, and when replacement thereof is necessitated, it is a simple matter to substitute a new box-like structure 44. If zinc were in the main pot 26 it would attack the walls 38, and when these walls fail it is necessary to completely rebuild the coating pot 37 and 38, which is normally required at relatively frequent intervals when coating with zinc.

The pressure wipers used may be adjusted to control the pressure exerted by the wiper pads and to thereby control the thickness of the resultant coating on the coated material.

Specific examples of the coating conditions and coated products produced in accordance with the improved method are as follows:

Example A

An annealed steel strip of .065 gauge, 4" wide having an approximate analysis of 0.06 to 0.08 carbon was cleaned and then passed through the coating pot illustrated in Figs. 2 and 3 at a speed of 70 feet per minute and then wiped under pressure. The terne bath composition was 5% tin and the balance lead, and the zinc bath composition was commercially pure zinc. Analysis of the coating on the resultant product indicated the amount of coating metal to be 0.3 ounces per square foot (approximately 0.15 ounces per square foot on each side) of material coated, composed of approximately 98.5% zinc, 0.5% lead, and 1% tin.

When the same type of .065 gauge, 4" wide strip steel is cleaned and passed through a zinc coating pot at a speed of 70 feet per minute and then wiped under pressure, an all zinc coating results weighing about 0.6 ounces per square foot of material coated.

Thus, in accordance with the present invention, only one-half as much coating metal is used in forming a zinc containing coating on strip steel as is used in accordance with standard galvanizing practice.

Example B

When an annealed low carbon steel strip of .065 gauge, 4" wide is cleaned and passed through the coating pot illustrated in Figs. 2 and 3 at a speed of 70 feet per minute and then wiped under pressure with a terne bath composition of 20% tin and the balance lead, the resultant coating on the product is again approximately 0.3 ounces per square foot of material coated; as compared with a resultant coating of about 0.6 ounces per square foot when the same material is coated under the same conditions in a straight zinc galvanizing bath as indicated in Example A.

In other words, variations in the relative percentages of tin and lead in the terne bath do not seem to affect to any marked degree the relative thinness of the resultant zinc containing coating. The reason for changes in the proportions of tin and lead in the terne bath is to change the proportions of these metals when desired in carrying out a straight terne coating operation selectively or concurrently with the operation of the line for forming the improved zinc containing coating.

Example C

When an annealed low carbon steel strip of

.012 gauge, 2½" wide is passed through the coating pot of Figs. 2 and 3 at a speed of 130 feet per minute and then wiped under pressure, and with the terne bath composition being 5% tin and the balance lead, the resultant coating weighs 0.2 ounce per square foot of metal coated.

When similar material is galvanized at the same speed in an all zinc pot, the resultant coating weighs 0.4 ounce per square foot of material coated.

Here again, the amount of coating metal used in accordance with the present invention to form a zinc containing coating on steel strips is approximately one-half of the amount used in making straight galvanized coatings.

Fundamentally, the present invention provides a new coated product having a thin, ductile, corrosion resisting coating thereon, containing zinc, tin and lead, and free of zinc-iron alloy.

Furthermore, the improved method provides a protective coating containing tin, lead and zinc on steel products at extremely low cost, taking into consideration the cost of coating metals, pot maintenance and replacement costs, fuel costs, dross losses, and the resultant coating thickness. Thus, an improved product is produced at a substantially reduced cost as compared with usual galvanizing costs.

In the foregoing description, certain terms have been used for brevity, clearness and understanding; but no limitations are to be implied therefrom beyond the requirements of the prior art, because such words are used for descriptive purposes herein and not for the purpose of limitation, and are intended to be broadly construed.

The terms "zinc" and "spelter" used herein and in the appended claim refer to pure zinc, or to commercially pure zinc which may contain slight amounts of impurities such as iron, lead, cadmium, tin, copper and arsenic.

Likewise, the term "tin," used herein and in the appended claim, refers to pure tin, or to commercially pure tin which may contain slight amounts of impurities such as iron, copper and bismuth.

Moreover, in referring herein and in the appended claim to percentages of tin or lead in the terne bath, or of tin, lead and zinc in the coating on the product, percentages by weight are meant.

It is not intended to limit the scope of the present invention to the coating of strip steel, or to the continuous coating of a continuous strip, since it is clear that sheets, stripsheets, wire, and the like may be coated in the same manner; so that the terms "ferrous strip metal," "strip," "strip steel," and "steel products" when used herein and in the appended claim, refer to steel sheets, strips, stripsheets, wire, and the like. Similarly, the terms "hot coated steel product," and "hot coated steel products," when used herein and in the appended claim, are intended to include hot coated steel sheets, hot coated steel strips, hot coated steel stripsheets, hot coated steel wire, and the like.

While there is diagrammatically shown and described certain specific forms of apparatus to be used in carrying out the new methods to make the new products claimed, it is to be understood that the invention is not limited exactly to such particular apparatus, since various modifications may be made in the types and kinds of apparatus used, which will be apparent to those skilled in the art, without departing from the scope

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of the invention, as defined in the appended method and product claim.

Having now described the features of the invention, the manufacture of the improved hot coated steel products, the preferred steps of the methods of making the same, the characteristics of the new method and product, and the advantageous new and useful results attained by the invention; the new and useful products, methods, steps, operations and procedures, and reasonable mechanical equivalents thereof, obvious to those skilled in the art, are set forth in the appended claim.

I claim:

The method of providing a hot coated steel product with a ductile, corrosion resistant, adhesive coating such that the coated product may be subjected to extreme deep drawing or forming operations without fracturing or flaking the coating, and which coating has a smooth, uniform, fine-grained structure and a slippery surface, said coating consisting of approximately 98.5% zinc, 1% tin and 0.5% lead and being free of zinc-iron alloy and weighing 0.2 to 0.3 ounce per square foot of coated material; which consists in passing cleaned strip steel through a molten terne bath consisting of 2 to 50% tin and the remainder lead at a speed of 70 to 130 feet per minute, said bath being maintained at a temperature

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of approximately 800° F. to 840° F., then passing the strip from said terne bath directly into and through a molten bath of commercially pure zinc floating on top of a portion of the molten terne bath, said zinc bath being maintained heated to a temperature of approximately 800° F. to 840° F. by the heat of the molten terne bath, and then pressure wiping the coated strip.

ROBERT F. RENKIN.

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