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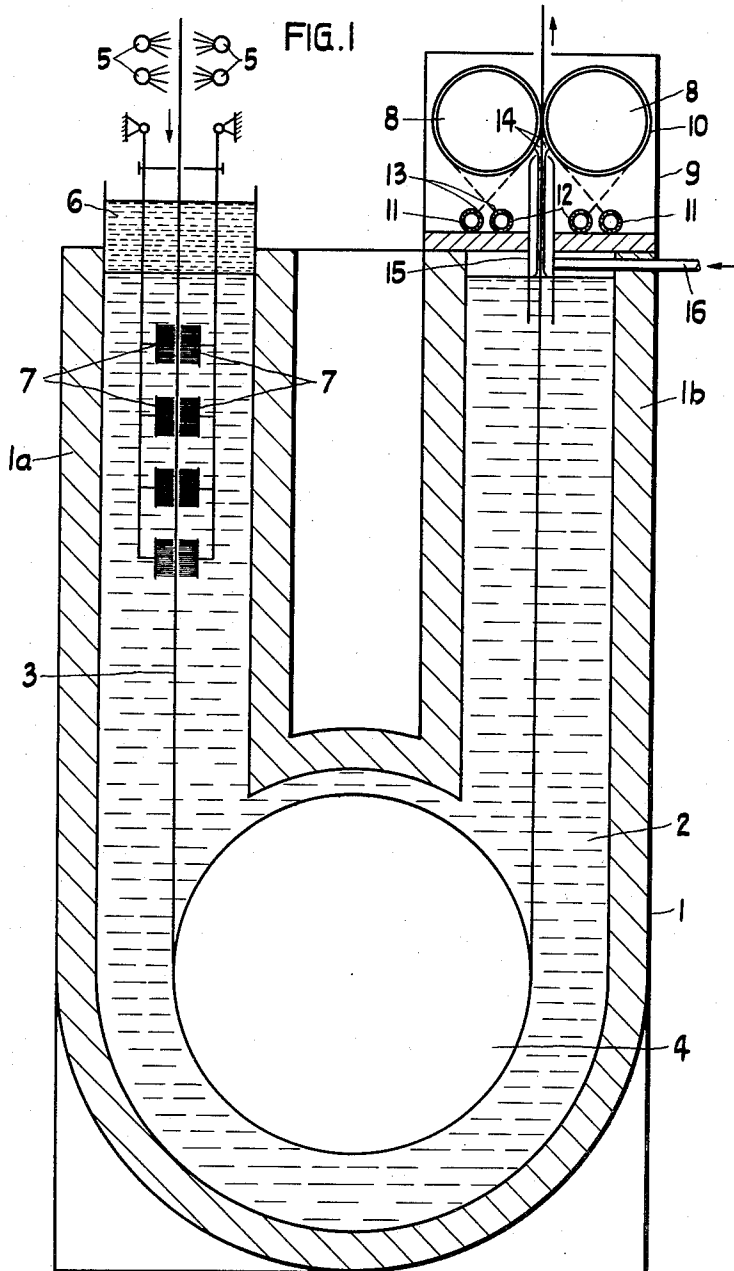
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METHOD AND APPARATUS FOR COATING METALS

Filed Nov. 19, 1957

2 Sheets-Sheet 1



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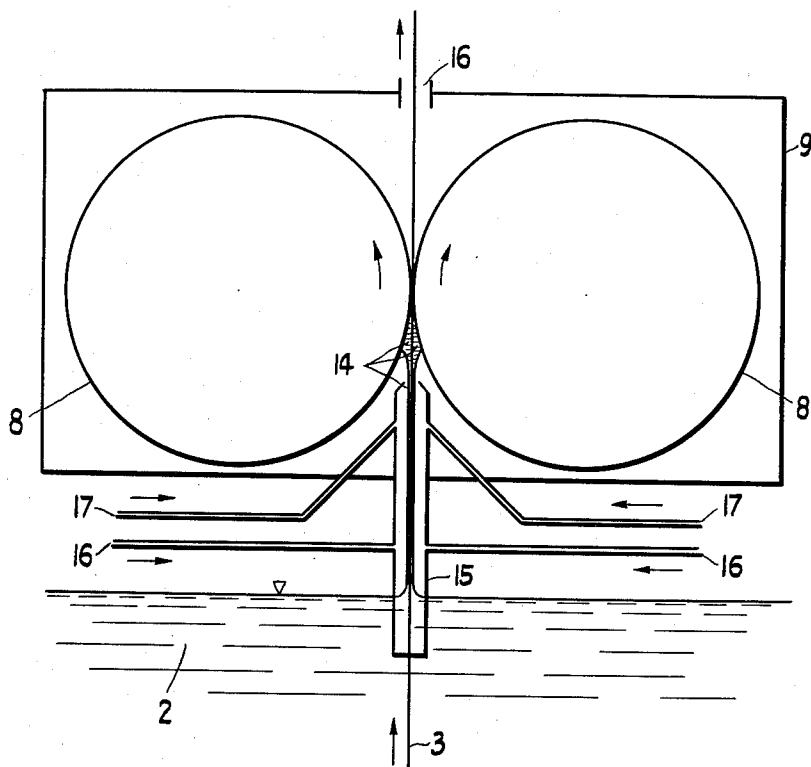
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FIG. 2



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## METHOD AND APPARATUS FOR COATING METALS

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This invention relates to process and apparatus for metal-coating elongated metal strips and like products.

In a known process for metallising steel and/or metal strips by hot-dipping, more particularly by hot-dip tinning, the strip of steel or sheet metal is first passed through a bath containing a flux and then through a metal melt, for instance tin, surplus metal being thereafter removed by means of squeeze rolls running in a grease bath disposed immediately above a metal boiler. This known process has considerable disadvantages, in respect to hot-dip tinning. The output is very low, since the speed of a strip or plate passing through the tinning bath cannot exceed more than 2.4 meters per minute and 12 meters per minute, respectively. These rates cannot be increased, for if they are the thickness of the tin coating on the respective product becomes excessive. The thickness of the tin cannot be controlled accurately and reliably. The tin layer becomes relatively thick and varies from 25-40 grammes per square meter. Also, the tin is of uneven thickness and there is a variation, for instance,  $\pm 3$  grammes per square meter in a strip. The tin layer is non-uniform and porous, so that the strips or plates produced by the known hot-dip tinning process do not withstand corrosion satisfactorily. Another disadvantage is that several pairs of treatment rolls are necessary. They must be made of steel and their peripheries become covered with a tin film, the thickness of which determines the thickness of the tin layer on the strip. In the known aforesaid hot-dipping process the steel strip or metal plate must first be pickled and then degreased after tinning, which ensues a complicated process.

This invention obviates all the above considerable disadvantages of the known hot-dip metallising processes. In the process according to the invention, the surplus tin is squeezed off not in a grease bath but above the metal bath in a protective gas atmosphere, and a small amount of cleaning agent which simultaneously acts as a lubricant is supplied continuously to the treatment rolls, conveniently before the entry of the strip into the roll gap, the cleaning agent serving to remove any undesirable metal compounds formed on the strip due to reduction or oxidation. Advantageously, a reducing agent or flux such as, for instance, hydrogen chloride, is supplied.

Advantageously, the treatment or squeeze rolls used have a metal-repellent contact surface or surface layer. Detailed experiments have shown that a very satisfactory and even metallising action takes place when squeeze rolls are employed having a contact surface of rubber-like material, more particularly silicone rubber.

The process according to the invention, which differs from any conventional method, has considerable advantages, more particularly so far as hot-dip tinning is concerned. The tin deposit is reduced considerably, to approximately 15 grammes per square meter on both sides. The thickness of the covering is more uniform, thus helping to improve the quality of the finished product considerably, and the covering is more uniform and denser,

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that is, it has less recesses or pores, so that it withstands corrosion much more satisfactorily. Since the kind of surface used on the aforesaid rolls governs the thickness of the tin layer, the density of the tin layer can be controlled simply and reliably between approximately 15-60 grammes per square meter by appropriate design of the roll surfaces. With this novel method, the rates at which the strip travels can be increased to approximately 100 meters per minute. Because of this high rate the thickness of the iron-tin alloy layer can be considerably reduced so that further processing of the strips is greatly facilitated. The first costs and running costs of a tinning plant according to the invention are very low.

It is therefore an important object of the present invention to provide means redounding to a highly economical and efficacious process and treatment plant for lengthy metal products to be metallized in a continuous and rapid operation, whereby the final product shows markedly improved properties and qualities, is free from porous spots and has a uniform and dense metal coat throughout its length.

It is another object of the invention to provide means contributing to a positive control of the metal deposit or layer to be applied to the surface of a lengthy strip and like product without resorting to complicated process steps, which would otherwise impair speedy and accurate handling of said product and would be a hindrance to a considerable reduction of cost contemplated by the present invention.

Yet a further object of the present invention resides in the provision of means ensuring considerable reduction in maintenance, repair and replacement of the squeeze or smoothing rolls employed in the novel process, which remain out of contact with the hot metal bath, are kept clean and aid in the equalization of a relatively thin and even metal coat on the product, while said rolls are simultaneously lubricated and eased in regard to undue pressures.

A still further object of the present invention is to provide means envisaging ready changes of heretofore existing installations of the aforesaid type, which will now bring about a highly lustrous and non-porous strip or like product, whose metallized strata may differ in thickness at opposed surfaces of said strip, as each stratum may be reliably and accurately predetermined and checked despite high operational speeds heretofore not experienced.

These and other objects of the invention will become further apparent from the following detailed description, reference being made to the accompanying drawings, showing a preferred embodiment of the invention.

In the drawings:

Figure 1 is a cross-section through a hot-dip tinning installation embodying the invention and over which squeeze rolls are disposed in a reservoir, and

Figure 2 is a view drawn to an enlarged scale of a special reservoir for the aforesaid rollers running in an atmosphere of a protective gas.

Referring now more specifically to the drawings, reference numeral 1 denotes a heatable boiler or reservoir for the metal melt, that is, for the tin bath 2. Conveniently, the steel or metal strip 3 enters and leaves the bath vertically and is drawn therethrough under tension, being guided over a guide roller 4. Before entering the bath, the strip is preferably heated by known heating devices 5, for instance, approximately to the temperature of the bath 2. The previously degreased strip (pickling is unnecessary), before entering the tin bath 2, passes, in this instance, through a flux bath 6 which can be conventional, for instance zinc chloride and ammonium chloride. A small quantity of water is continuously supplied downwards to this flux bath 6 so that the top layers

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thereof are relatively thinly liquid and the entering strip 3 is well wetted. Those parts of the flux which are carried into the bath 2 by the strip, as well as reduction residues, can be removed by a number of scrapers 7 and retained thereon, which scrapers are disposed in series one behind another and on both sides or surfaces of the strip. The scrapers comprise, for instance, brushes made of chrome alloy steel wires.

As can be seen in Fig. 1, the boiler 1 is U-shaped in section so that two legs 1a and 1b are formed the one constituting an entry channel and the other an exit channel. As compared with the relatively wide and long tin baths of known type, the U-shaped boiler or bath requires a considerably smaller charge of tin. As can be seen in the drawings, squeeze rolls 8 disposed in a protective gas reservoir 9 are provided immediately above and out of contact with the tin boiler, that is, above the exit channel or conduit 1b.

In contrast to the known tin baths having a number of pairs of squeeze rolls disposed one above another in the bath, a single pair of such rolls located beyond the bath of melt is sufficient for the process according to the invention. Experiments have shown that, if required, tinned steel rolls can be used as squeeze rolls. On these steel rolls there is then formed a film of tin which is much thinner than heretofore so that the density of the tin coating on the strip is about 20-25 grammes per square meter.

However it is advantageous to use smoothing rolls having a tin-repellent surface layer or covering. If such rolls are used, the thickness of the tin covering on the strip can be considerably reduced. As tin-repellent rolls there can be used diffusion-chromed steel rolls or rolls of carbon, porcelain or quartz glass. The best result was obtained with rolls having a rubber-like resilient covering 10, advantageously made of silicone rubber. If this resilient and tin-repellent substance is used for the aforesaid rolls, the roll gap can be smaller than is the case with rollers made of a non-resilient material and the thickness of the tin is constant over the whole width of the strip. In contrast to the high roll pressures used with the steel rolls of the known tin baths, rolls 8 are applied to one another only with a very reduced pressure, for instance, as little as approximately 20 kg. for a strip or roller width of 600 mm.

For the smoothing rolls 8 to operate satisfactorily, they must be supplied with a cleaning or reducing agent which simultaneously acts as a lubricant. In the construction shown in Figure 1, tubes 11 and 12 disposed below the rolls 8 are provided with facing rows of apertures 13 from which the gas supplied issues in the crossing directions shown by dotted lines. The apertures 13 of these tubes are about 10 mm. apart and of relatively small diameter, for instance, 0.4 mm., the gas pressures also being relatively low, for instance, 5-50 mm. water column, so that the gas issues at a low speed, that is, very small quantities of reducing agent are supplied continuously to the rolls 8.

Referring further to Figure 1, moist hydrogen chloride is supplied, for instance, through the tubes 11 and ammonia through the tubes 12 so that ammonium chloride is produced and reaches the rollers 8 in very finely divided form. The supply of this reducing agent, for which a flux such as ammonium chloride or hydrogen chloride or possibly even a mixture of tallow and salamoniac or killed spirits can advantageously be used, keeps the roller surface and roller gap free of disturbing metal compounds, that is, the metal compounds formed on the strip 3 due to influences of reduction or oxidation are removed. Hence, not only are the rolls kept constantly clean but a tinned strip is produced which has a very uniform non-porous and highly lustrous tin layer.

As already stated, the surplus tin 14 carried along by the strip is squeezed off in a protective gas atmosphere and may flow back to the bath 2 via conduit 15.

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To this end, said conduit 15 is disposed below the rolls, dips into the metal bath, extends to near the roll gap and protects the moving strip 3. As can be seen in Figure 1, an inert protective gas, for instance, nitrogen, is supplied to the conduit 15 through a pipe 16. In the advantageous construction shown in Figure 2, gas supply pipes 16 and 17 are provided, the pipes 16 opening into the bottom of the conduit 15 and the pipes 17 opening into the top of the conduit 15. Inert gas is thus supplied to both faces or sides of the strip through the pipes 16 and the reducing agent is supplied through the pipes 17. Good results were obtained by supplying hydrogen chloride through the pipes 17. If ammonium chloride is used as in the construction shown in Figure 1, condensation occurs in undertempered regions and may lead to jamming.

To ensure satisfactory tinning, the flux must be supplied to the rolls 8 or to the roller gap in correct quantities.

If no reducing agent, that is, flux, is supplied to the rolls 8, the same run dry and the entire pure tin layer is squeezed off completely. If too little flux is supplied, the resultant tin layer is too thin and of irregular thickness and the strip looks patchy. If an excess of flux is supplied, a thick layer of tin is produced and the strip surface is uneven due to pickling of the strip by the flux which the strip carries with it.

If required, instead of using hydrogen chloride as a flux, a salamoniac stone can be pressed against the squeeze rolls or the same can be wetted with hydrochloric acid.

There can be used, in addition to the fluxes mentioned, oils, waxes, lacquers, lubricants in general and even water provided that their surface tension at the temperature of working is low enough. Fluxes clean the roller surface by chemical action, whereas oils, waxes or the like provide purely mechanical cleaning, the residues being either covered or lifted and removed. These lubricants may not be supplied in excess because at the high speeds prevailing the lubricant also acting as a pressure medium, as in cold rolling, and squeezes off the whole (soft) pure tin coating.

The tinned strip 16 issuing out of the protective gas reservoir 9 and shown in Figure 2 has a highly lustrous surface and is given the after treatment conventional in tin galvanising, that is, it is provided with a protective layer (oil film or chrome film). In the novel process, the thickness of the tin layer can be controlled accurately and reliably. If the surfaces of the squeeze rolls are polished, the density of the tin layer can be reduced to approximately 15 grammes per square meter. The thickness of the tin layer can differ on each side of the strip if the surface smoothness of the two co-operating rolls 8 is appropriately varied.

The novel process is not limited to the embodiments hereinbefore described for tin but can be used similarly for the coating of strips with zinc or aluminium by hot dipping.

Various changes and modifications may be made without departing from the spirit and scope of the present invention and it is intended that such obvious changes and modifications be embraced by the annexed claims.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent, is:

1. The process of metallizing a metal strip, including steel strip, by means of hot dipping; comprising the steps of preheating said strip, contacting said strip with flux means, passing said strip through a bath of metallic melt, then feeding said strip between squeezing rollers at a location out of contact with said melt and in the presence of an inert protective gaseous medium, to rid said strip of surplus metal, and simultaneously supplying to the strip surfaces predetermined small quantities of a reducing and lubricating agent, respectively.

2. The process according to claim 1, including the step

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of supplying said reducing and lubricating agent to opposite sides of said metal strip prior to its entry between said squeezing surfaces.

3. The process according to claim 1, wherein a flux is employed as the reducing and lubricating agent.

4. The process according to claim 1, wherein the reducing and lubricating agent comprises hydrogen chloride.

5. The process of metallizing a metal strip, including steel strip, by means of hot dipping; comprising the steps of preheating said strip, contacting said strip with flux means, passing said strip through a bath of metallic melt, supplying a reducing and lubricating agent to the opposite sides of said metal strip prior to its entry between said squeezing surfaces, then feeding said strip between squeezing rollers at a location out of contact with said melt and in the presence of an inert protective gaseous medium, to rid said strip of surplus metal, and simultaneously supplying to said surfaces predetermined small quantities of a reducing and lubricating agent, respectively, said inert protective gaseous medium is introduced to said sides of said metal strip immediately above said melt and guided on said sides of said strip up to the entry of the latter between said squeezing surfaces, said reducing and lubricating agent being supplied to said sides of said metal strip prior to its entry between said squeezing surfaces.

6. An apparatus for producing metal-coated strips made from steel and similar metals; comprising a bath for holding a metal coating, flux means above said bath, means for heating said bath, means for feeding said strip into and out of said bath, a pair of squeezing rolls located beyond said bath, where said strip leaves said bath and out of contact with same, thereby to remove surplus metal coating from said strip, a reservoir surrounding said rolls and said strip upon leaving said metal bath, means for supplying a reducing and lubricating agent in predetermined small quantities to said rolls, and means for supplying an inert gas into said reservoir.

7. An apparatus according to claim 6, including a conduit extending from the gap between said squeezing rolls into the bath, whereby said strip passes through said conduit, and a plurality of gas ducts opening into said conduit and serving to supply an inert protective gaseous medium and reducing agent, respectively, to the faces of said strip.

8. An apparatus according to claim 6, said squeezing rolls being made of non-resilient material and being provided with a resilient, metal-repellent covering.

9. An apparatus according to claim 6, said squeezing rolls having surfaces made from metal-repellent material.

10. An apparatus according to claim 9, said squeezing rolls being provided with surfaces formed of silicone rubber.

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11. An apparatus for producing a coated metal strip comprising a bath for holding a metal coating, means for heating said bath, means for feeding metal strip into and out of the bath in substantially vertical direction, a roller located in the bath for guiding said strip during its traverse of said bath, a pair of squeezing rolls located above and out-of-contact with the bath and adapted to remove surplus metal coating from said strip, a reservoir encasing said squeezing rolls and containing an inert protective gaseous medium for treating said coated strip prior to its passage through said rolls, a conduit extending from a location between said squeezing rolls into said bath, said strip being adapted to pass through said conduit, and duct means opening into said conduit and through the latter into said reservoir and serving to supply said inert protective gaseous medium to said strip and to direct a cleaning agent to said squeezing rolls, respectively.

12. An apparatus for manufacturing a metal-coated strip and like lengthy product made of metal, including steel; comprising a first reservoir holding a metal coating substance, means for heating said metal coating substance in said reservoir, means for feeding said metal strip through said first reservoir and in substantially vertical direction to the surface of said metal coating substance therein, roller means located in said first reservoir and for guiding said strip in the latter, a pair of squeezing rolls located above said first reservoir and out-of-contact with said metal coating substance, a second reservoir encasing said squeezing rolls and for containing an inert gaseous medium for treating said coated strip when passing out of said first reservoir into said squeezing rolls in said second reservoir, a conduit extending from a location adjacent said squeezing rolls through said second reservoir into said metal coating substance of said first reservoir, said conduit being adapted to direct said medium to and along said strip, said strip being adapted to pass through said conduit and between said squeezing rolls for squeezing off from said strip surplus coating substance whereby the latter is returned via said conduit to said first reservoir, and heating means located adjacent said first reservoir for heating said strip prior to its passage of said first reservoir.

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