

Dec. 12, 1944.

J. D. KELLER

2,364,904

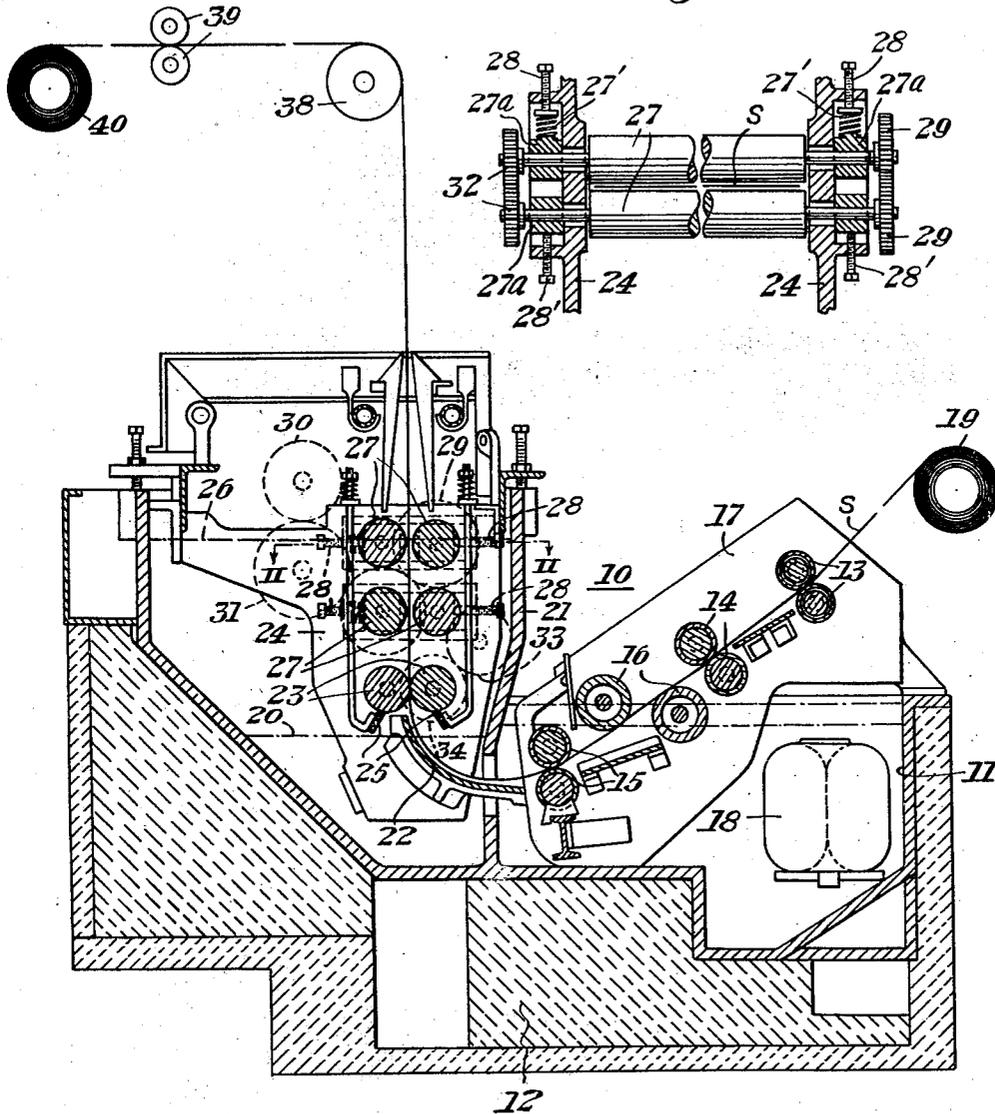
METHOD FOR TINNING STRIP

Filed Nov. 13, 1940

3 Sheets-Sheet 1

Fig. 1.

Fig. 2.



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3 Sheets-Sheet 2

Fig. 3.

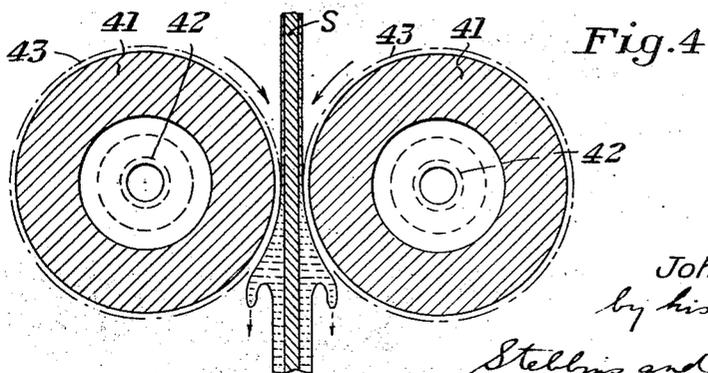
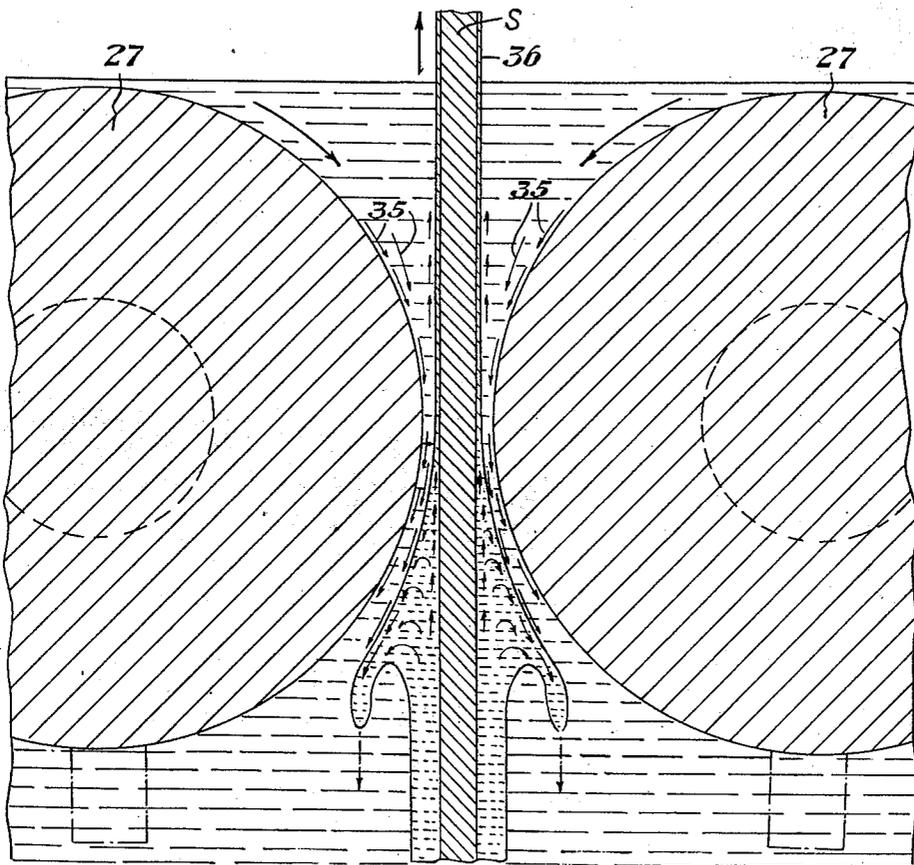


Fig. 4

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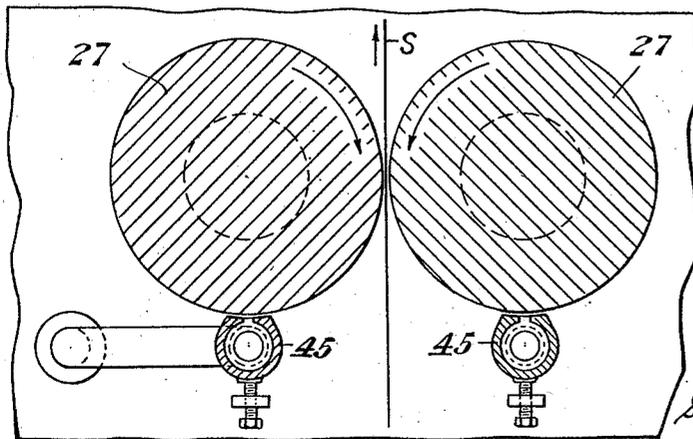
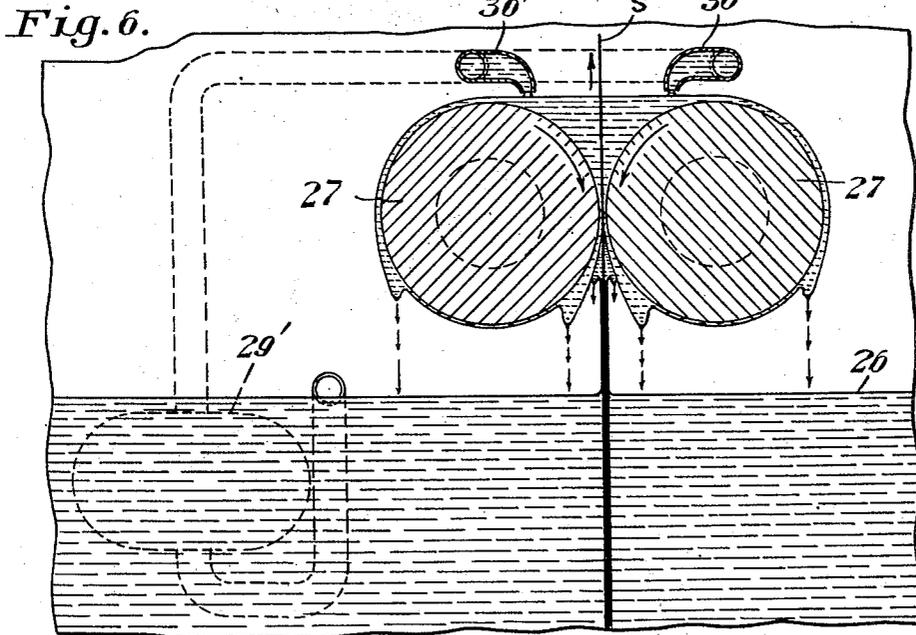
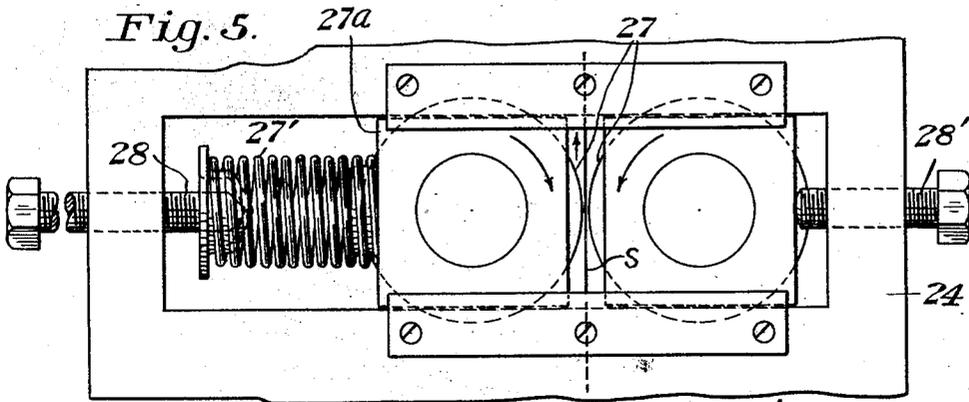
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3 Sheets-Sheet 3



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# UNITED STATES PATENT OFFICE

2,364,904

## METHOD FOR TINNING STRIP

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Application November 13, 1940, Serial No. 365,495

10 Claims. (Cl. 117—102)

This invention relates to the coating of strip material and, in particular, to the application of a protective coating such as tin to a metallic base such as steel strip.

Numerous attempts have been made heretofore to tin steel strip continuously. All such attempts which have utilized the hot-dip method in which the strip is passed through a bath of molten tin, have proved unsuccessful because so-called scruff marks show up in the material after a relatively short period of operation and it has not been possible to eliminate such marks. Their presence, of course, prevents sale of the product as prime material and it must, therefore, be scrapped.

I have invented a novel method and apparatus for the continuous tinning of strip which eliminate the difficulties heretofore encountered and make it possible to turn out tinned strip all of which is saleable as prime sheets, at a lower cost than has been possible previously. In a preferred embodiment and practice of the invention, I pass the strip through a bath of molten tin and withdraw it therefrom through a bath of palm oil or the like floating on the tin. I remove surplus tin adhering to the strip by drawing it between rolls immersed in or fed with palm oil and driving said rolls in such directions and at such speeds as to induce a movement of the palm oil adjacent the strip between the rolls which effectively wipes the surfaces of the strip and at the same time maintains an oil film between the rolls and the strip and keeps their surfaces entirely out of mechanical contact. By this process, it is possible to reduce the average thickness of the tin coating on the finished strip much below what is possible with the conventional tin pot utilizing exit rolls which have mechanical contact with the material, and at the same time to distribute the tin much more uniformly and to produce a bright coating. An increased economy in the consumption of tin is effected by this means.

The details of the method and apparatus of my invention will be described and explained fully herebelow with reference to the accompanying drawings illustrating the preferred embodiment and practice. In the drawings:

Fig. 1 is a diagrammatic view showing a tinning apparatus according to the invention in longitudinal, vertical section;

Fig. 2 is a partial sectional view along the line II—II of Fig. 1;

Fig. 3 is a diagrammatic view to enlarged scale showing the rolls which set up the wiping flow

of the palm oil and the coating strip emerging therebetween;

Fig. 4 is a view similar to Fig. 3 to reduced scale showing a modification;

Fig. 5 is a partial side elevation showing the construction of the bearings for the rolls;

Fig. 6 is a transverse section through the rolls illustrating diagrammatically a modified arrangement; and

Fig. 7 is a similar section showing suction scrapers adjacent the rolls.

Referring in detail to the drawings and for the present to Figs. 1 and 2, a tinning machine indicated generally at 10 comprises a pot 11, positioned in a setting 12 and provided with feed-in rolls 13, 14, and 15 and guide rolls 16 journaled in spaced side frames 17 positioned in the entry side of the pot. An immersion heater 18 is also mounted in the entry side. Steel strip *s* is unwound from a coil 19 and, after passing through any suitable preliminary processing apparatus, is introduced between the feed-in rolls and thereby passed downwardly into a bath of molten tin in the pot, the level of which is indicated at 20.

The strip is directed through an opening in the cross wall 21 of the pot by a guide 22 and passes upwardly between feed rolls 23, journaled in spaced side frames 24. The rolls 23 are adjustable so as to grip the strip in the manner of pinch rolls and are provided with wiper pads 25 effective to remove accumulations of particles from the surface thereof. The rolls 23 are analogous to the conventional exit rolls of a tin machine, and preferably are positioned at about the level of the tin in the exit side of the pot.

A palm oil bath, the level of which is indicated at 26, floats on the tin in the exit side of the pot and the strip passes upwardly therethrough on leaving the rolls 23.

Above the rolls 23, I provide one or more pairs of spaced rolls 27, and the strip emerging from the tin bath passes upwardly between the pair of rolls, or between the pairs in succession, when more than one pair is used. The rolls 27 are journaled in bearing blocks 27a at their ends and a light but adjustable force is applied to these blocks through springs 27' and adjusting screws 28 as shown in Fig. 5. The rolls may thus be sprung apart slightly by the pressure of the oil film between the rolls and the strip. Adjusting screws 28' provide accurate lateral adjustment of the rolls with respect to the strip. Instead of the springs 27' and adjusting screws 28, I may utilize cylinders with pistons or diaphragms acted upon by adjustable pressure of air, oil or

other fluid, to exert the desired force on the rolls 27. As an alternative, I may omit springs 27' and position the bearing blocks by screws 28 acting directly thereon, but in general this is not desirable, because of variations of thickness of the strip along its length.

In one embodiment of the invention, the rolls 27 are immersed in the bath of palm oil, the level of which is indicated at 26. In a preferred embodiment shown in Fig. 6, in order to reduce the churning of the oil bath and the power consumed by oil friction, I maintain the level of the palm oil bath slightly below the rolls 27, and by means of a pump 29', I supply palm oil through feed pipes 30' to the V at the top of the rolls between them and the strip, keeping the V full of oil and allowing the excess to run over the outside of the rolls and drop down into the bath. The oil in its passage to or from the pump may be heated or cooled or maintained constant in temperature, as desired, by well known means.

The rolls 27 are driven at a high speed in such directions that if they engaged the strip, they would tend to pull it backward. That is to say, the rolls on the right-hand of the strip as viewed in Fig. 1 are driven counterclockwise and the rolls on the left-hand side clockwise. Meshing gears 29 at one end of one roll 27 of each pair are driven by a motor (not shown) through gears 30 and 31. At the other ends of the rolls 27, meshing gears 32 on the two rolls of each pair drive the remaining rolls 27. A separate drive is provided for the rolls 23 and includes gears 33 and 34 and a suitable motor (not shown).

The rolls 27 are driven at a speed much greater than that at which the exit rolls of a conventional tinning machine are driven, and preferably about ten times that speed. The high speed rotation of the rolls 27, as best shown in Fig. 3, induces a circulation of the palm oil downwardly along the strip *s* ascending between the rolls. This circulation is illustrated diagrammatically by the arrows 35 and is effective to exert a strong wiping action on the tin coating of the strip *s* indicated at 36. This coating is relatively thick as the strip leaves the rolls 23 and remains molten as it passes upwardly through the palm oil. The wiping action of the palm oil reduces the thickness of the tin coating materially as the strip passes between the rolls 27. The palm oil serves as a lubricant between the strip and the rolls and maintains an oil film which prevents actual contact of the rolls with the strip, or (usually) with the tin. Thus, the rolls, so far as the strip is concerned, are completely oil-borne, being carried on a liquid film, the same as the shaft in a turbine or automobile engine bearing. The extent of the wiping action produced depends on the viscosity of the palm oil and its speed relative to the strip. It will be apparent that after passing through one or two sets of the rolls 27, the tin coating on the strip *s* will be reduced to a thickness only slightly greater than that of the alloy layer which forms next to the base metal, corresponding to a total weight of tin per base box of considerably less than the minimum of 1.35 pounds which it is possible to obtain under the previous practice without producing scruff marks. The tin coating, furthermore, is much more uniformly distributed because, by running the rolls at sufficiently high speed, it is possible to have the oil film of the order of .001" thick (the same as in a bearing) and hence, ten to twenty times as

thick as the tin film. This means that the slight, unavoidable inaccuracies of the strip surface or of the roll surface, which are of the same order of magnitude as the thickness of the tin film, are only  $\frac{1}{16}$  to  $\frac{1}{20}$  of the thickness of the palm oil film. Since the variations in thickness of the tin film are proportional to, or even less in proportion than, the variations in the thickness of the palm oil film, the tin film thus produced while very thin is almost uniform in thickness, especially in comparison to the thickness variations of 100% produced in present conventional tinning practice.

As the strip emerges from between rolls 27, the coating thereon rapidly solidifies as the strip moves upwardly. The strip finally passes around a guide roll 38 and between pinch rolls 39, which serve to draw the strip through the tinning machine and thence after passing through any desired further processing apparatus to a coiler indicated diagrammatically at 40. The strip may, of course, be sheared to length, instead of being recoiled.

A modification of the invention illustrated in Fig. 4 provides for internal cooling of the rolls which cause circulation of the palm oil to effect the desired wiping action. Hollow rolls 41 are mounted in the same manner as the rolls 27 and are provided with connections 42 at their ends whereby cooling fluid such as water or air may be passed through the rolls. By cooling the interior of the rolls, the viscosity of the palm oil layer 43 next to the surface of the rolls is greatly increased and a stronger wiping action is thereby exerted on the strip *s* ascending between the rolls, or the same wiping action may be obtained at a lower speed of the rolls. At the same time, the cool oil film exerts a certain amount of quenching action on the liquid tin layer. The thickness of the tin layer on the finished strip may be controlled to a certain extent by varying the cooling effect to which the rolls 41 are subjected.

In the modification illustrated in Figs. 1 through 3, the thickness of the tin coating applied may be varied either by adjusting the yielding pressure on the rolls 27 or by changing their speed. By analogy with bearing practice, it will be understood that the wiping force exerted on the tin layer will vary with the thickness of the oil film and with the speed of the rolls 27.

By means of rolls 23 and pinch rolls 39, only sufficient tension is ordinarily exerted on the strip to keep it from vibrating while between rolls 27. When an especially adherent coating is desired, however, by means of these rolls, I increase the tension in the strip between 23 and 39 or by means of other rolls (not shown), I maintain the strip under high tension during the entire time of its passage through the tin pot. The tension may be increased almost to the elastic limit of the strip material or may even slightly exceed it. The tin is thus caused to enter the crevices of the strip surface when stretched by the tension, and thereby to bond itself tightly to the strip, the bonding being increased after the tension is released by the elastic reaction of the strip material.

Scrapers are ordinarily provided acting on rolls 27, but their pressure must be very light because of the high speed. Since any particles which adhere to these rolls are usually only loosely attached, a suction scraper as shown at 45 in Fig. 7 is preferably used. In one form, it consists of an elongated head having a narrow slot

extending along the length of the roll and connected to a suction pump. The surfaces of the head on either side of the slot are adjusted in close proximity to, but out of actual contact with, the roll surfaces.

The rolls 27 may be made of either tinning or non-tinning material, the only requirement being that it must be capable of being wetted by the palm oil or other liquid flux. Non-tinning material is preferable because the formation of tin-iron crystals on the roll surfaces is avoided.

In the foregoing, reference has been made to palm oil, but the use of other suitable fluxing oils or non-oily fluxing liquids in place of the palm oil is within the scope of the invention. While I have shown a bath of tin for coating the base metal by immersion, furthermore, any other suitable method may be utilized for applying the tin coating.

In another embodiment of the invention (which, with suitable modifications can be applied to severed sheets as well as to continuous strip), instead of the rigid rolls 27, I may use hollow, flexible-walled rolls backed up with rigid rolls as shown in my copending application, Serial No. 363,652, filed October 31, 1940, for Method and apparatus for coating sheet metal. I drive the flexible-walled rolls in such direction that they tend to pull the strip backward, but at a comparatively low speed. For example, the surface speed of the rolls in one direction may be about the same as the speed of the strip in the opposite direction. The rolls may be immersed in palm oil, but in some circumstances the level of the palm oil may be below the bottom of the rolls. The strip is pulled between the rolls against the frictional force exerted by the latter which is sufficient to effect a good wiping action on the strip and remove surplus tin.

The invention is characterized by numerous advantages which will be obvious to those skilled in the art. In the first place, the tinning of strip in continuous lengths constitutes a marked improvement over the practice of tinning individual sheets, from the standpoint of both the quantity produced and the time required. A more important advantage of the invention is the ability to turn out coated strip without scuff marks having a bright tin coating thinner, but more uniform than it has been possible to produce heretofore. This represents an obvious economy in the amount of tin consumed. Still further advantages reside in the fact that conventional tinning machines may be readily converted for the practice of the invention and no additional complications are introduced into the tinning operations. The invention is useful in coating metals other than steel and with coatings other than tin.

Although I have illustrated and described but a preferred embodiment and practice of the invention, it will be recognized that changes in the construction and procedure disclosed may be made without departing from the spirit of the invention or the scope of the appended claims.

I claim:

1. In a method of coating metal strip, the steps including advancing the strip along a predetermined path, applying liquid coating metal in contact with the strip, passing the strip between smooth surfaces traveling in a direction opposite to that of the strip and yieldably held as regards their lateral location with respect to the strip, maintaining a liquid film wetting said sur-

faces and in contact with the coating on the strip, and moving the surfaces at a speed such as to draw in between the surfaces and the strip a liquid film of sufficient thickness to urge the surfaces away from the strip and prevent solid contact of said surfaces with the strip and simultaneously to remove surplus coating material from the strip by the motion of said film relative to the strip induced by the movement of said surfaces.

2. In a method of tinning metal strip, the steps including applying to the strip a coating of molten tin, drawing the strip through oil and between smooth surfaces traveling in a direction opposite that of the strip, maintaining a liquid film wetting said surfaces and in contact with the coating on the strip, and moving the surfaces at a speed such as to draw in between the surfaces and the strip a liquid film of sufficient thickness to urge the surfaces away from the strip and prevent solid contact of said surfaces with the strip and simultaneously to remove surplus coating material from the strip by the motion of said film relative to the strip induced by the movement of said surfaces.

3. In a method of tinning metal strip, the steps including applying to the strip a coating of molten tin, drawing the strip between smooth metallic surfaces moving in a direction opposite that of the strip, maintaining a liquid film wetting said surfaces and in contact with the coating on the strip, and moving the surfaces at a speed such as to draw in between the surfaces and the strip a liquid film of sufficient thickness to urge the surfaces away from the strip and prevent solid contact of said surfaces with the strip and simultaneously to remove surplus coating material from the strip by the motion of said film relative to the strip induced by the movement of said surfaces.

4. In a method of tinning metal strip, the steps including feeding the strip through a bath of molten tin, drawing the strip upwardly through a bath of palm oil floating on the tin between smooth metallic surfaces traveling in a direction opposite that of the strip, maintaining a liquid film wetting said surfaces and in contact with the coating on the strip, and moving the surfaces at a speed such as to draw in between the surfaces and the strip a liquid film of sufficient thickness to urge the surfaces away from the strip and prevent solid contact of said surfaces with the strip and simultaneously to remove surplus coating material from the strip by the motion of said film relative to the strip induced by the movement of said surfaces.

5. In a method of coating sheet metal, the steps including applying a liquid coating to base metal, passing the coated metal between a pair of smooth metallic surfaces disposed closely adjacent each other and traveling in a direction opposite that of the strip, maintaining a liquid film wetting said surfaces and in contact with the coating on the strip, and moving the surfaces at a speed such as to draw in between the surfaces and the strip a liquid film of sufficient thickness to urge the surfaces away from the strip and prevent solid contact of said surfaces with the strip and simultaneously to remove surplus coating material from the strip by the motion of said film relative to the strip induced by the movement of said surfaces.

6. The method as defined by claim 1 characterized by the further step of cooling said sur-

faces, thereby producing a progressive increase in the viscosity of said film from the strip toward said surfaces.

7. In a method of coating metal strip, the steps including advancing the strip along a predetermined path, applying liquid coating metal in contact with the strip, passing the strip between smooth surfaces traveling in a direction opposite to that of the strip, preventing the surfaces from making solid contact with the strip, maintaining a liquid film wetting said surfaces, and in contact with the coating on the strip and moving the surfaces at a speed sufficient to remove surplus coating material from the strip by the motion of said film relative to the strip induced by the movement of said surfaces.

8. In a method of tinning metal strip, the steps including bringing the strip into contact with molten tin, and inducing a flow of an oily liquid along and in contact with the strip in a direction opposite to the direction of strip motion and at a velocity much greater than the velocity of the strip, thereby removing excess tin therefrom, and cooling the liquid to increase its viscosity and thereby enhance the wiping action thereof.

9. In a method of coating metal strip, the steps

including feeding the strip into a bath of molten coating metal and drawing the strip upwardly from said bath, maintaining the strip free from mechanical contact between a point adjacent the surface of the bath and a point thereabove at which the coating on the ongoing strip has solidified, causing an oily wiping liquid to move downwardly and at a velocity much greater than the velocity of the strip onto the strip at a point where the coating is still molten, thereby removing excess coating metal, and cooling the liquid to increase its viscosity and enhance the wiping action thereof.

10. In a method of tinning metal strip, the steps including progressively bringing the strip into contact with molten tin, maintaining a supply of a viscous oily liquid adjacent the strip at a point where the tin applied to the strip is still molten, continuously moving a surface in said liquid adjacent the strip to induce a flow of the liquid along and in contact with the strip in a direction opposite to the direction of strip motion and at a velocity greater than that of the strip, thereby removing excess tin therefrom, and cooling the liquid to increase its viscosity and thereby enhance the wiping action thereof.

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