Jan. 2, 1951 J. D. KELLER 2,536,186

METHOD OF WIPING LIQUID METAL COATINGS

Filed May 2, 1946 3 Sheets-Sheet 1

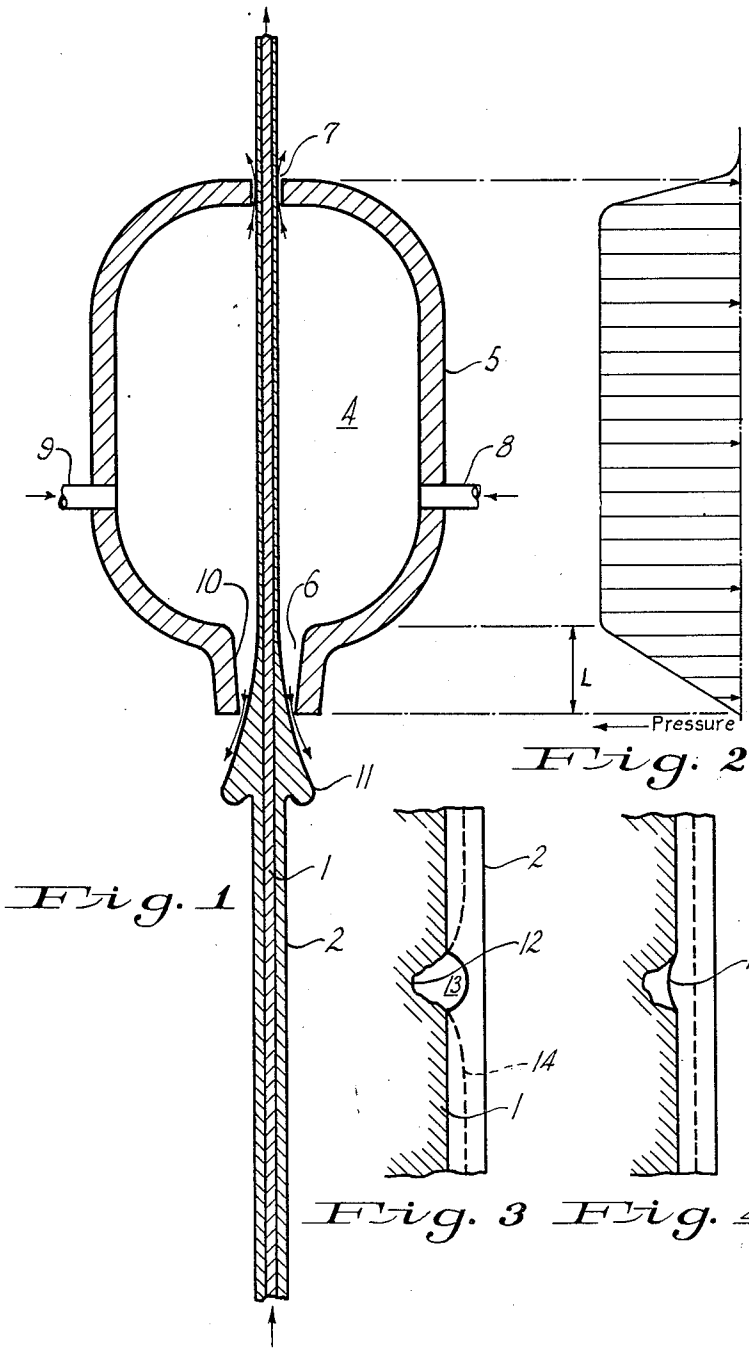


Fig. 1

Fig. 2

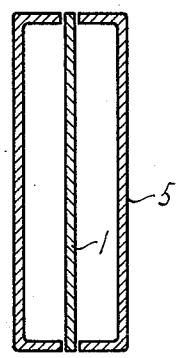


Fig. 6

Fig. 3

Fig. 4

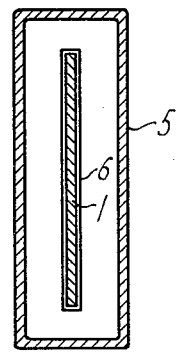


Fig. 5

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METHOD OF WIPING LIQUID METAL COATINGS

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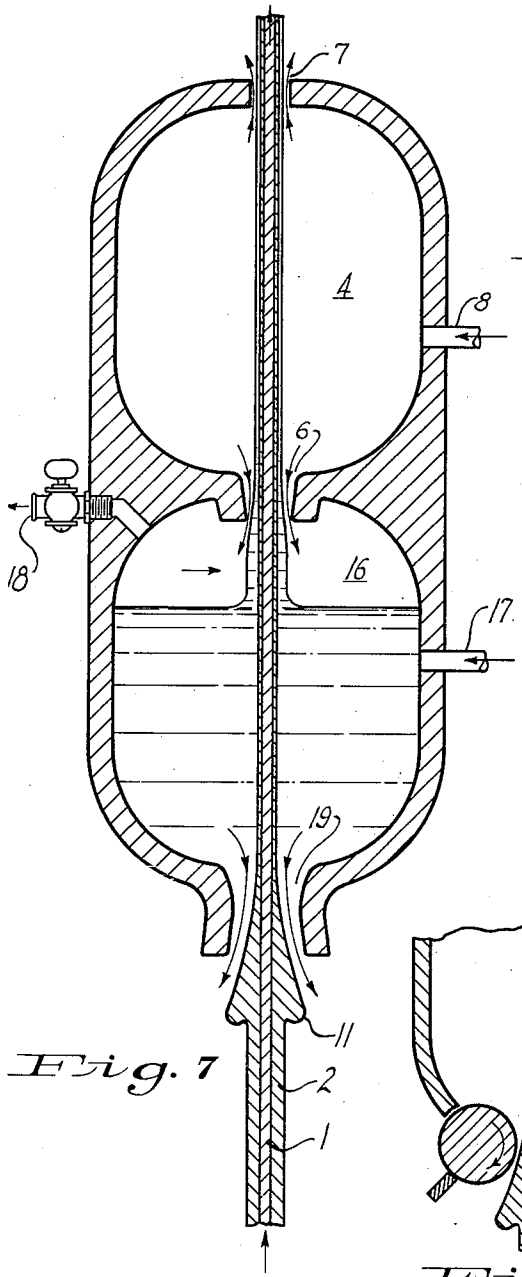


Fig. 7

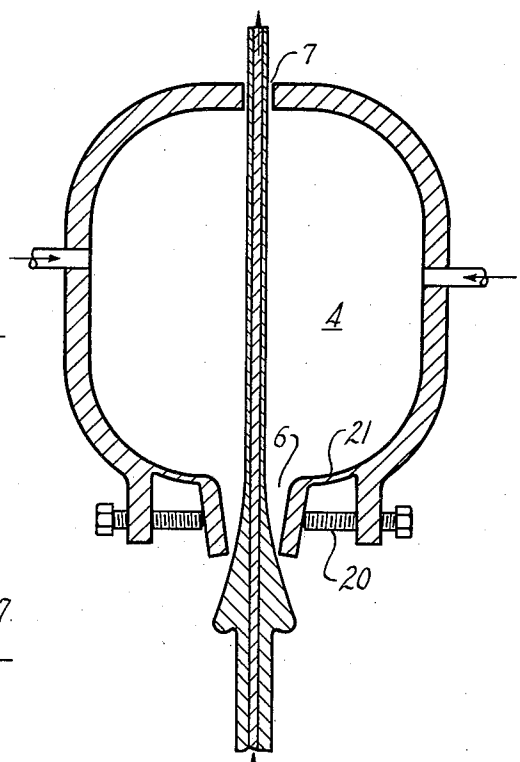


Fig. 8

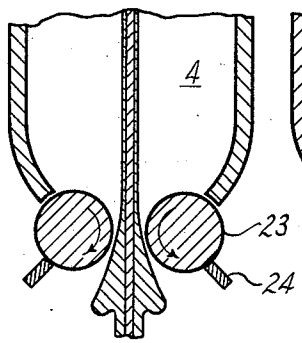


Fig. 9

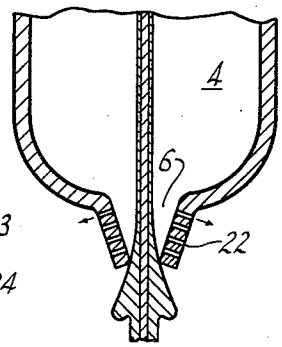


Fig. 10

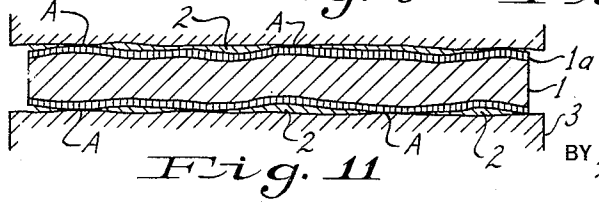


Fig. 11

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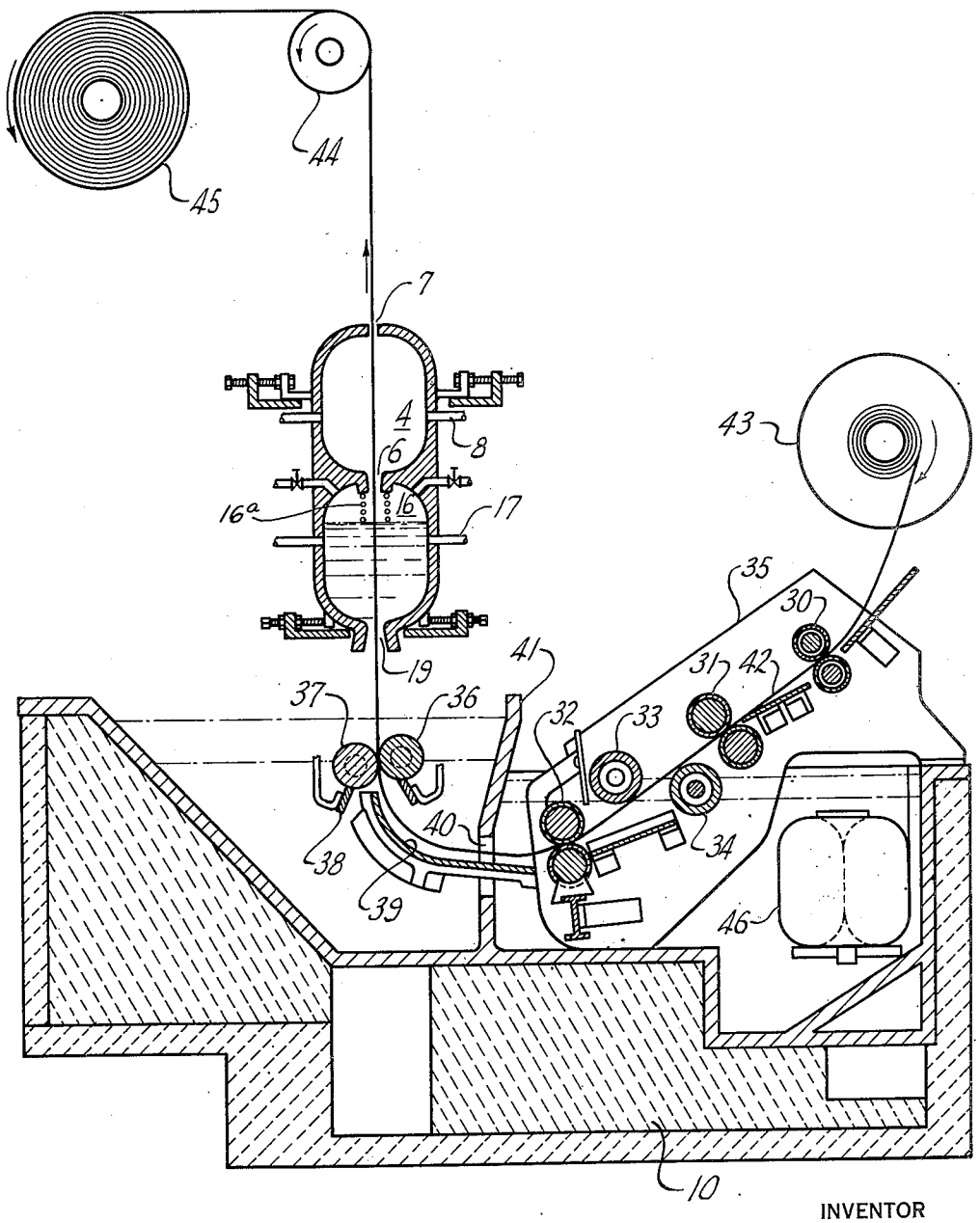


Fig. 12

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2,536,186

METHOD OF WIPING LIQUID METAL COATINGS

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Application May 2, 1946, Serial No. 666,543

2 Claims. (Cl. 117—64)

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This invention relates to a method of and apparatus for producing and controlling liquid coatings on sheets or rounds by the employment of a pressure fluid gradient, and it is among the objects thereof to control the thickness of a liquid coating film on materials without solid contact of the coated surface. More specifically, the invention deals with a method particularly adapted to control the coating of tin on metal sheets or wires to any desired thickness and free of pin holes or other flaws, the invention being particularly suited where the body to be coated is continuously drawn through a tinning bath and coiled or otherwise gathered at the completion of the tinning operation.

A further object of the invention is the provision of means of reducing the loss of palm oil or the like which is employed on the surface of the tin by means of the same method employed in controlling the thickness of the tin coating, the two operations being carried out in sequence.

Still another object of the invention is the provision of apparatus for applying fluid pressure to the tin surface in a manner to establish a pressure gradient that constitutes the film coating a membrane upon which the pressure acts to wipe off excess tin or other coating fluid.

In the conventional method of coating sheet or strip metal with tin, pressure rolls have been employed to squeeze off the excess coating material, and by this method it is impractical to reduce the amount of tin applied to the sheets below about 1.25 pounds per base box because of the fact that by the roll pressure method the tin layer is in spots wiped down to the alloy layer, which produces a dull and streaky condition in the finished product, and increasing the roll pressure then produces no appreciable reduction of the coating thickness.

As an improvement of this method I have utilized a method of reducing the tin coating by the employment of flexible wiping walls for which United States Letters Patents No. 2,338,438 was granted to me January 4, 1944. While the flexible wall method of wiping the tin was an improvement over the contact roll method, there were still disadvantages, due to the wiping contact of the walls, which are eliminated by the method of my present invention, in which no

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physical contact of any solid member is effected with the coated surface.

The present invention will become more apparent from a consideration of the accompanying drawings, constituting a part hereof, in which like reference characters designate like parts, and in which

Fig. 1 is a vertical cross-sectional view of a fluid pressure chamber and a coated sheet strip embodying the principles of this invention;

Fig. 2 a pressure diagram of the pressure gradient in the pressure chamber of Fig. 1;

Fig. 3 a vertical section of a greatly enlarged portion of a tinned surface;

Fig. 4 a similar view;

Fig. 5 a vertical cross-sectional view of an enclosed pressure chamber with the strip material passing therethrough having openings at both ends thereof illustrating one form of the apparatus employed;

Fig. 6 a vertical cross-sectional view of a two-part pressure chamber with the strip material passing therethrough which is another form of the pressure chamber;

Fig. 7 a vertical cross-sectional view diagrammatically illustrating a modification of the form of apparatus shown in Fig. 1 which is employed to control both the tin film and oil film of the tinned sheet in the tinning operation;

Fig. 8 a vertical cross-sectional view diagrammatically illustrating a pressure chamber having an adjustable inlet passage;

Fig. 9 a vertical cross-sectional view of a portion of a pressure chamber illustrating the use of rollers in the inlet passage of the chamber;

Fig. 10 a vertical cross-sectional view of a portion of a pressure chamber in which the inlet passage walls are provided with air vent perforations;

Fig. 11 a cross-sectional view of a tinned sheet and pressure rolls greatly magnified; and

Fig. 12 a longitudinal central, vertical section through a tin pot with which my invention is combined.

The function and utility of the proposed method of controlling the thickness of tin coating is best illustrated with reference to Fig. 11 of the drawing in which the numeral 1 is the sheet strip to be coated, 1a the alloy layer, 2 the coating of liquid tin and 3 the contacting surfaces in con-

ventional use which may be squeeze rolls or wiping surfaces. The thickness of the sheet and coating is greatly exaggerated to show the irregularity of the surface to demonstrate that the thickness of the tin film is limited because of the point contact with the squeezing or wiping members. In hot-dip tinned sheet or strip steel, for a coating of 1.35 pounds per base box, the alloy layer is found to have a thickness of about $\frac{1}{10}$th of one ten-thousandth of an inch, while the pure tin coating above it has an average thickness of $\frac{7}{10}$ths of one ten-thousandth of an inch. Even with the very flat strip or sheet made by the modern cold-reduction methods, and with accurately machined wiping rolls contacting the strip in the conventional tinning machine, the unavoidable unevenness of the contacting surfaces is of an order of magnitude greater than the average tin film thickness. Consequently the high spots of the rolls made solid contact with the alloy layer at the high spots of the strip, as at A, A in Fig. 11, exerting concentrated pressure at these points, in some cases crushing the alloy layer and squeezing off all the liquid tin, leaving these spots dry so that they appear as rough, dull patches or streaks in the finished tin plate. The remaining liquid tin in the hollows between the solid surfaces, as at 2 in Fig. 11, is however, sufficient to form an average coating of 1 to 1¼ pounds of tin per base box of plate, and this cannot be appreciably reduced by increasing the pressure on the rolls, since the increased roll pressure is taken up by the solid contact at A, A.

By means of the present invention this point contact of the wiping medium with the tin layer is eliminated by use of apparatus such as shown in Fig. 1 in which the sheet 1 may be coated with a heavy layer of tin, for example, by the hot dip method, and passed upwardly into a pressure chamber 4 constituted by the walls 5 which may be a closure as shown in Fig. 5 with openings 6 and 7, or a two-piece wall member as shown in Fig. 6. If the latter, air or other gaseous fluid or vapor under pressure is continually supplied to the chamber 4 through inlets 8 and 9, whereas in the form of Fig. 5 a single fluid pressure supply source is sufficient.

As shown in Fig. 1, the inlet passage is preferably divergent as shown at 10 in the direction of movement of the sheet strip 1 which is upward in a vertical direction passing into the chamber at the opening 6 and exiting therefrom at 7. The arrows in the openings 6 and 7 indicate the air flow from chamber 4 which, because of the shape of the opening 6, produces a pressure gradient as illustrated in Fig. 2 of the drawings, in which the height of the curve corresponds to the constant pressure maintained in chamber 4, and the gradients at both ends represent a gradually reducing air pressure resulting from the escape of the air from the chamber through the inlet and outlet, the length L of the gradient corresponding to the dimension of the length of the opening 6.

The strip as it passes through the chamber 4 is taut, it being supported by pinch rolls (not shown) below and above the chamber 4, and if the two-piece construction of Fig. 6 is used the chamber walls are so held as to maintain fixed positions laterally with respect to the strip. As the strip passes toward the chamber 4 it is coated with the molten tin to a desired film section by any desired means, and as it is drawn steadily upward into and through the pressure chamber 4 it begins to be subjected to increasing lateral pressure which becomes greater and greater, as shown by the gradient in Fig. 2. The surface of the liquid tin film may be considered a skin or membrane on which the air pressure is exerted laterally, and since, in fluids, pressure acts equally in all directions, the pressure within the tin film also acts in the direction parallel to the strip motion.

As the tin film tries to follow the solid strip into the passage 6, it is subjected to continually increasing pressure forcing it backward, with the result that the film is thinned to the desired thickness by forcing the excess tin back where it is sloughed off as diagrammatically illustrated at 11, Fig. 1 of the drawings.

In this form of the invention the motion of the strip is not necessarily vertical, although preferably so; and the tin coating may be applied by other means than the hot dip method, for example, by spraying on the liquid tin.

The dimension of chamber 4 is preferably such with respect to the speed of movement of the strip therethrough to allow the tin coating to cool off sufficiently to solidify before passing out of the chamber at 7, and suitable accelerated cooling means may be employed in the chamber, for example, by control of the temperature of the pressure medium.

As contrasted with the conventional process of attempting to squeeze off the excess tin by solid rolls, it is a characteristic of wiping by pressure-gradient that a coating of very uniform thickness is produced over the entire surface of the strip, since the pressure is entirely uniform across the strip width, and at each point of the strip travel the pressure is contant with respect to time, and in accordance with the laws of viscous flow in thin layers of fluid, the final thickness is therefore practically constant at all points of the strip surface.

By means of the above-described method of controlling the film thickness of the tin, pin holes that occur in the conventional method of squeezing or wiping the tin surface are eliminated. As shown in Fig. 3 a cavity 12 in the base metal covered with a tin coat may form gas bubbles when heated either by vaporization of water from the pickling bath remaining in the cavity or from hydrogen occluded in the steel. The gas bubble is expanded as shown at 13, Fig. 3, to a convex form, and as the tin film is wiped down thinner and thinner the thickness of the film at the convexity of the bubble becomes so small that it ruptures and leaves an open pin hole, the surface of the tin film taking the form shown by the broken lines 14, Fig. 3.

By means of the present invention, on the contrary, the effect of the excess pressure in chamber 4 is to compress the gas contained in the cavity forcing some of the liquid inward, as shown at 15, Fig. 4, making the gas-tin interface concave instead of convex. The tin layer when wiped down in chamber 4, no matter how thin, will not rupture in the cavity and no pin holes will result as the tin surface is preferably allowed to solidify while in the pressure chamber 4.

In present hot dip tinning practice a bath of palm oil is maintained on top of the tin bath at the outlet side of the tinning machine and the outgoing sheets emerge from this oil film and carry a film of oil outside of the tin film. The continued presence of this palm oil film until the tin has solidified is generally considered desirable, but thereafter the greater part of the oil must be removed.

In the modified form of apparatus shown in Fig. 7, such a bath of palm oil may be maintained in a separate chamber 16, the oil being maintained at a desired level by an inlet supply line 17, preferably having a liquid-level regulator of well-known type (not shown), and a bleeder passage 18 may be provided above the liquid level to maintain the pressure at a predetermined value which is lower than the gas pressure maintained through inlet 8 in chamber 4. As shown at the bottom of the chamber 16, the inlet passage 19 is divergent in the direction of motion of the strip to establish a pressure gradient as in the divergent passage 6 of the upper pressure chamber 4. The excess tin sloughs off before passing into the oil chamber 16.

In operation the oil in chamber 16, being under pressure, flows downward through the passage 19 increasing in velocity and decreasing in pressure as it does so. This creates a gradient of increasing pressure as the tin and oil coated material passes into chamber 16, thus forcing back the excess tin in the manner previously described, the interface between the oil and the liquid tin corresponding to a membrane on which the pressure is applied. The pressure acts in all directions within the tin film in accordance with the laws of hydraulics.

The chamber 16 is so proportioned with respect to the speed of the strip that the tin coating preferably cools sufficiently to solidify before reaching the top of this chamber; and auxiliary cooling means such as a cooling coil 16*a*, Fig. 12, may, if desired, be provided in the chamber to insure solidification before the tin reaches the top of the chamber.

As the strip continues its upward movement through passage 6 into the upper chamber 4, the counter-flow of the gas or vapor downward in passage 6 increases in velocity and again creates a gradient of pressure. The solidified tin layer is unaffected by the pressure gradient in passage 6 which acts on the palm oil forcing back the excess into chamber 16. In this manner the oil film adhering to the tin may be wiped down to almost any desired extent, depending upon the pressure differential between chambers 4 and 16.

The pressure gradient at the lower passage 19 is determined by the pressure on the liquid in chamber 16 which is maintained by the bleeder 18 and the pressure differential of the liquid supply at 17 and the air or gas supply pressure at 8 in chamber 4.

As shown in Fig. 8, the walls of the divergent inlet passage 6 may be adjustable by set screws 20, the section 21 of the pressure chamber 4 being flexible for that purpose. By this adjustment the pressure gradient in the inlet passage may be regulated. The mouth of the passage 6 may be no larger than to afford suitable operating clearance for the tin sheet passing therein, although even if the opening were so small as to close the inlet passage 6 the inlet walls of the opening 6 could be provided with perforations 22 to permit the progressive escape of the fluid pressure from the passage 6, and thus produce the desired pressure gradient along said passage.

In cases where it is important to eliminate the adherence of dross or other foreign particles to the surface of the tin, rollers 23 may be provided instead of the walls of the divergent passage 6, and scrapers 24 of well-known type would wipe off any particles carried by the rolls, the rolls being driven at a suitable speed by means well known in the art, in such directions of rotation

that their surfaces adjacent to the strip move in direction opposite to the strip motion.

Instead of the shape of inlet walls shown in the drawings, they may be of any suitable form and may be rounded at the ends if desired, and any suitable shape of pressure chamber or means for supplying pressure and establishing and maintaining a pressure gradient may be employed. The passages 6 or 19 may be replaced by sharp-edged orifices, and the natural contraction of the fluid stream depended upon to produce the pressure gradient. Also it is evident that the invention may be adapted for regulating the thickness of liquid coating films in other arts to obtain a uniform quality product.

For the purpose of demonstrating the application of my method and apparatus for reducing the tin coatings to tin pots in conventional use, I have shown in Fig. 12 a plurality of pressure chambers of substantially the form shown in Fig. 7 in combination with a tin pot. In Fig. 12 numeral 10 designates a tin pot including feed rolls 30, 31 and 32 and guides rolls 33 and 34, the rolls being journaled in spaced side frames 35. Feed rolls 36 and 37 are similarly journaled in the exit end of the tin pot. Wipers 38 engage the rolls 36 and 37 to remove any solidified particles or crystals which may adhere thereto. A curved guide plate 39 extends through an opening 40 in the center wall 41 of the pot to direct a sheet 42 from the rolls 32 to the rolls 36 and 37. The sheet to be coated is drawn from a coil 43 and passes through the feed rolls into the lower opening 19 of chamber 16 in which the excess tin and oil is removed after which it passes over guide roll 44 to be rewound on coil 45. An immersion heater 46 is disposed in the entry side of the tin pot.

Although several embodiments of the invention have been herein illustrated and described, it will be evident to those skilled in the art that various modifications may be made in the details of construction without departing from the principles herein set forth; for example, while the pressure chambers are illustrated as adapted to vertical movement of the sheet or strip, the process may be carried out with the sheet or strip disposed in a horizontal plane.

I claim:

1. The method of producing uniform relatively thin coatings of tin on metal surfaces having melting temperatures higher than tin, which comprises passing the metal previously coated with molten tin in any suitable manner into and through a wiping liquid maintained under a gradient of pressure increasing in the direction of motion of the coated metal to a predetermined maximum sufficient to provide a thin, uniform coating of tin on such metal surfaces, then maintaining the coated metal in said wiping liquid maintained substantially at such predetermined maximum pressure, then passing the coated metal into and through a gas which is maintained under a gradient of pressure increasing in the direction of movement of the coated metal to a predetermined maximum sufficient to remove the liquid from the coated metal, then maintaining the coated metal in said gas maintained substantially at said last mentioned predetermined maximum pressure, and cooling the tin coating to solidify the tin while subjected to the last named gas pressure.

2. The method of producing uniform relatively thin metal coatings on strip metal having a melting temperature higher than that of the metal

coating which comprises continuously passing the strip metal to be coated through a molten metal bath, and thereafter passing such coated metal strip through a fluid medium maintained at a sufficiently high pressure to force the molten metal into the minute cavities in said strip metal surfaces, the temperature of the fluid pressure medium and the speed of travel of the coated metal strip being maintained so as to solidify the coating during passage of such coated metal strip through the fluid pressure medium while maintained at said pressure.

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