June 5, 1945. J. D. KELLER 2,377,632

METHOD AND APPARATUS FOR COATING STRIP

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Fig. 1.

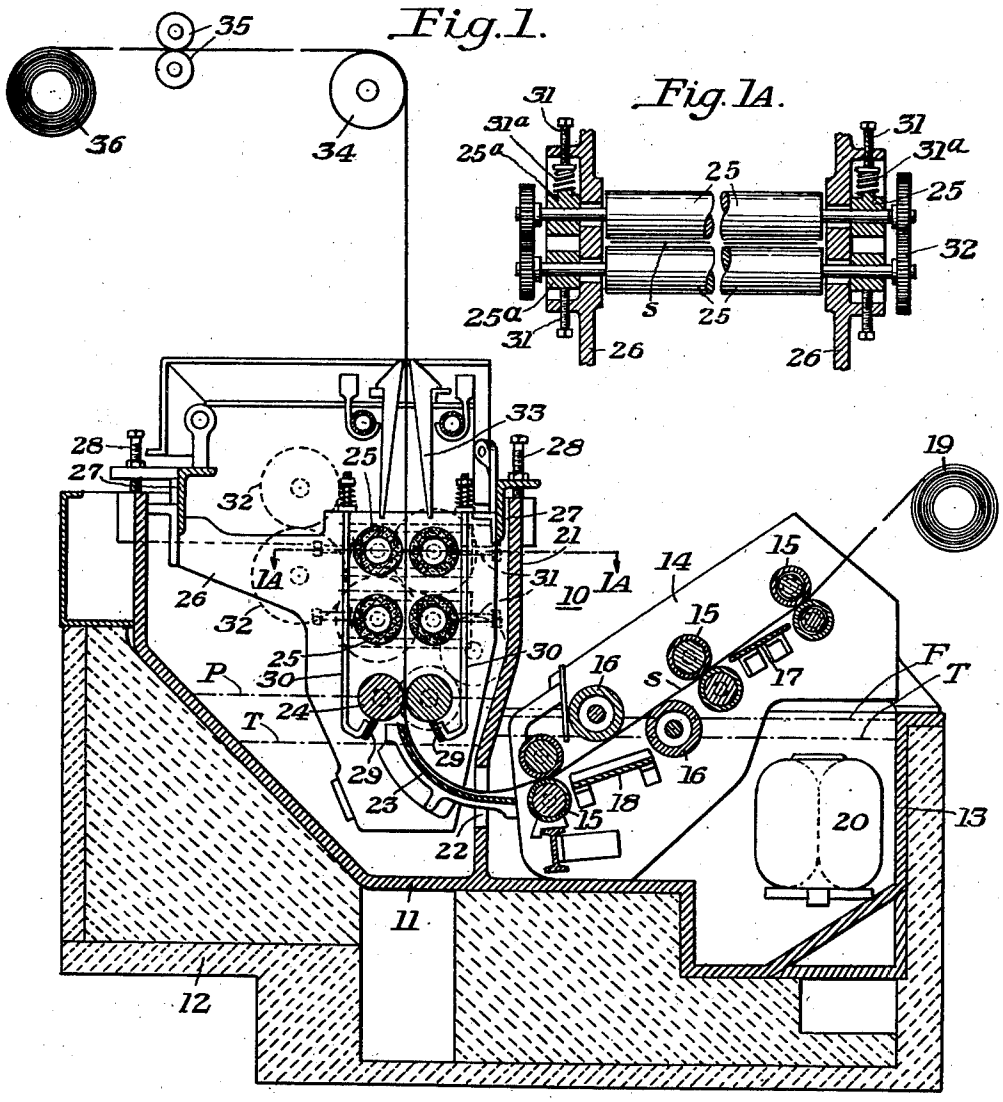

Fig. 1A.

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Fig. 2.

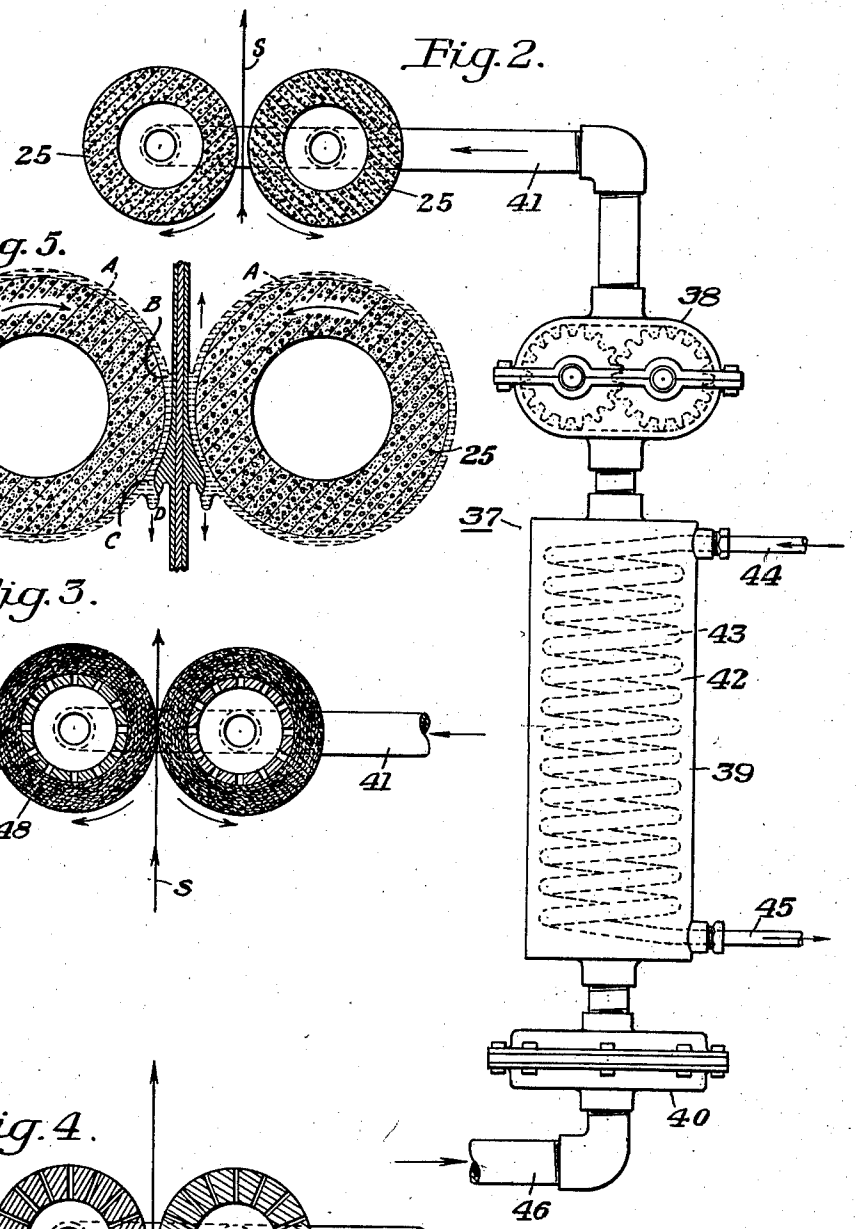
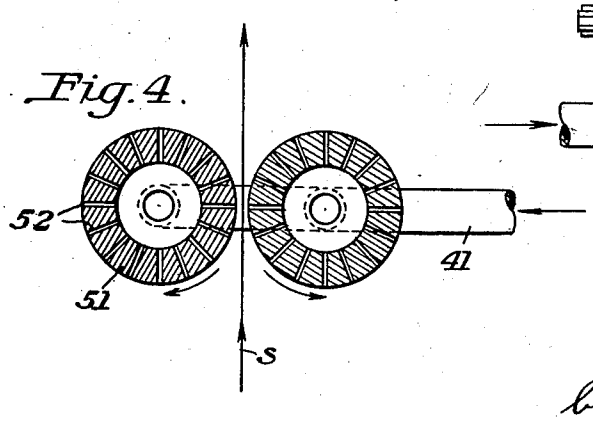


Fig. 5.

Fig. 3.

Fig. 4.



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METHOD AND APPARATUS FOR COATING STRIP

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Application September 16, 1942, Serial No. 458,523

8 Claims. (Cl. 117—114)

This invention relates to the coating of sheet metal and, in particular, to the tinning of ferrous strip.

The tinning of ferrous sheets by the hot-dip process has been carried on successfully for many years. Improved methods of tinning, e. g., the electrolytic method, have come into use recently because their tin consumption is less for a given area of sheet metal coated. I have invented an improvement in the hot-dip process whereby I am able to produce a coating of tin almost as thin as that resulting from the electrolytic treatment, using conventional apparatus to a large extent, and thereby obviating the large capital investment represented by a complete electrolytic tinning line. The present invention, furthermore, is an improvement over the practice and apparatus disclosed in my copending Patents 2,338,438 and 2,364,904.

In a preferred practice of my invention, I pass ferrous strip through a coating bath such as molten tin having a flux layer floating thereon adjacent the point of entry and a layer of palm oil or the like floating thereon at the point where the strip emerges from the tin. The strip is drawn vertically from the tin bath through the palm oil and between a plurality of pairs of wiping rolls. According to my invention, at least the upper pair or pairs of wiping rolls are of such construction as to permit the flow of palm oil radially thereof, either by virtue of the porosity of the material of which they are composed or by the provision of radial passages therethrough. The rolls are hollow and are provided with means for supplying palm oil under pressure to the interior whence it flows outwardly onto the strip passing between the rolls of successive pairs. The upper pair or pairs of rolls are yieldably urged together and are preferably driven in such directions that they would tend to restrain or reverse the ascending strip if they actually had contact with it. This creates moving films of oil by fluid friction which prevent actual contact between the rolls and the strip.

The oil flowing out radially from the porous wiping rolls effects a strong wiping action on the tin coating applied to the strip before it solidifies and thus removes any excess tin beyond the barest minimum which adheres to the strip by surface tension and the alloying action which occurs at the tin-iron interface. In order to control the wiping effect, I provide means for regulating the temperature of the palm oil delivered to the rolls. I thus maintain the viscosity of the oil at the value necessary to produce the desired wiping action. As a result, I am able to apply a continuous coating to the base metal, using but little, if any, more tin for a given area of metal coated than required by the electrolytic process, for example.

Further details, novel features and advantages of the invention will be pointed out during the following detailed description and explanation which refer to the accompanying drawings illustrating the embodiment and practice briefly described above, with certain modifications. In the drawings,

Figure 1 is a longitudinal vertical section through a strip-tinning apparatus embodying my invention, the auxiliary apparatus associated therewith being shown diagrammatically;

Figure 1A is a partial horizontal, transverse section along the plane of line IA—IA of Figure 1;

Figure 2 is a diagrammatic illustration showing the course of the palm oil delivered to the wiping rolls for radial flow therefrom, the rolls being shown in transverse section, as in Figure 1;

Figure 3 shows wiping rolls of a modified construction in transverse section;

Figure 4 is a view similar to Figure 3 showing another modified form of rolls; and

Figure 5 is a diagram showing the action of the wiping rolls.

Referring now in detail to the drawings and, for the present, to Figure 1, I utilize a so-called tinning machine 10 which is largely of known construction, including a tin pot 11 supported in a suitable foundation or setting 12. The lower or entering side 13 of the pot is provided with spaced side plates 14 in which successive pairs of feed rolls 15 and guide rolls 16 are journaled. The plates 14 are supported at one end on the bottom thereof. Fixed guides 17 and 18 cooperate with the rolls to direct therebetween the entering end of a strip *s* delivered into the apparatus from a coil 19 disposed in a suitable uncoiler.

An immersion heater 20 comprising a gas-fired combustion tube is disposed in the lower part of the pot to maintain the tin therein in molten condition, the level of the tin bath being designated T. A layer of flux F floats on the tin bath in accordance with the customary practice.

The higher portion 21 of the tin pot communicates with the lower portion through an opening 22. A curved guide 23 directs material

passing through the opening 22 upwardly between a plurality of pairs of feed rolls 24 and wiping rolls 25 journaled in spaced side plates 26. The side plates are suspended from the edges of the pot on cross members 27. The latter have adjusting screws 28 bearing on the edges of the pot.

The bottom rolls 24 serve to feed the strip *s* upwardly. As the strip emerges from the tin bath, the level of which is indicated at T, it traverses a layer of palm oil or the like, the level of which is indicated at P. The rolls 24 are provided with conventional wipers 29 carried on spring-urged rods 30 which are mounted on the side plates 26. The rolls 24 may be driven in the proper directions by any convenient driving means.

The rolls 25 are provided with adjustable bearings 25*a* and adjusting screws 31, and are normally urged together by springs 31*a*. The rolls are preferably driven in such directions that if they engage the strip, they would tend to restrain or reverse its upward movement. While any convenient drive may be utilized for actuating the rolls 25, I have indicated a gear drive therefor at 32. Suitable scrapers bearing lightly on the rolls may be provided if desired.

After passing beyond the rolls 25, the strip passes between guides 33 and thence upwardly to a guide roller 34 positioned at a sufficient distance above the apparatus to permit freezing of the tin coating on the strip before it engages the roller. Traction or pinch rolls 35 spaced beyond the roller 34 aid in drawing the strip through the apparatus and deliver it to any suitable recoiler such as indicated at 36 or to apparatus for further processing or fabrication.

Referring now more particularly to Figure 2, the rolls 25 are hollow and have a porous or permeable wall of such character that fluid such as palm oil delivered to the interior under suitable pressure flows radially outward through the wall of the rolls in all directions. The rolls may be composed of any suitable material having the characteristics mentioned. They may, for example, be formed from powdered metal by sintering. As is well known, this method of fabrication results in a porous metallic mass which is readily permeable by fluids. Rolls may be made by this method to exact dimensions and with a smooth surface which are, of course, desirable.

In order to deliver wiping fluid such as palm oil to the interior of the rolls 25, I provide a fluid-circulating system indicated generally at 37 including a pump 38, a heat exchanger 39 and a filter 40. The pump 38 is illustrated as of the gear type but may be of any suitable construction. It delivers wiping fluid through suitable pipe connections 41 and swivel fittings (not shown) to the interior of the rolls 25 through the journals of the latter. The heat exchanger 39 may be of any suitable type but, as illustrated, is of the surface type, including a chamber 42 having a coil 43 therein through which heating or cooling fluid such as steam or water may be circulated at will, the inlet and outlet connections for the coil being shown at 44 and 45.

The filter 40 may be of any suitable type. It is connected by piping 46 to the higher portion 21 of the tin pot below the level of the palm oil therein designated P.

It will be apparent that with the fluid-circulating system shown in Figure 2, palm oil is drawn from the exit side of the tin pot where it is maintained at a temperature above the melting point of tin by direct contact with the tin bath and, after being filtered in the filter 40, is passed through the heat exchanger 39. Ordinarily, the temperature of the palm oil floating on the tin bath will be above the value at which the oil has sufficient viscosity to serve effectively as a wiping medium to remove excess tin from the coated strip. The function of the heat exchanger 39, therefore, will usually be to cool the oil and cooling fluid such as water is circulated through the coil to this end. There may be occasions, however, when the oil from the bath will have to be heated and, under such conditions, a heating fluid such as steam may be delivered to the coil 43.

The pump 38 delivers oil after filtering and cooling or heating to the interior of the rolls 25 under sufficient pressure to cause it to flow outwardly therethrough. The rolls are preferably driven at high speed, i. e., at a peripheral speed several times the linear speed of the strip *s*. The radial flow of oil through the walls of the rolls resulting from the applied pressure aided by such centrifugal force as may be developed subjects the strip to a highly effective wiping action produced by the oil film leaving the rolls 25 tangentially. It will readily be apparent that this film has the effect of uniformly removing any excess from the still-molten coating of tin on the strip, the excess tin removed being caused to run down the ascending strip and return to the bath.

As above stated, the rolls 25 are positioned relative to the bath so that the tin coating on the strip is still molten when passing between the rolls. By this arrangement, the wiping action is effective to remove all the tin from the strip except an exceedingly thin layer sufficient to cover the first layer which actually alloys with the iron of the strip. As a result, the method and apparatus of my invention are characterized by an economy in the use of tin approaching that of the electrolytic process in which the tin coating is only a relatively few atoms thick.

As explained and illustrated in my copending Patent 2,364,904, the rotation of the rolls 25 at high speed in the direction indicated by the arrows in Figs. 2 and 5, causes the film of palm oil adhering to the surface of the rolls to exert a strong wiping action on the liquid tin film adhering to the surface of the ascending strip. The palm oil, which in the present invention has oozed out through the pores of roll 25 and formed a uniform film (as at A, Fig. 5) over the surface of said roll, acts in the same manner as the lubricating oil film in a journal bearing, for example, an automobile engine bearing. In the present case, the roll corresponds to the rotating shaft and the strip corresponds to the shell of the bearing. The rolls are not rigidly fixed in position but are urged toward the strip by the force of springs, as shown in Fig. 1A. As is well known from the theory and practice of bearing lubrication, in such a case if the speed of the roll and the viscosity of the oil are sufficient, the roll "floats" on the oil film and is carried entirely by said film, without any solid contact whatsoever between the strip and the roll. The oil film not only positively prevents solid contact between the roll and the strip, and (normally) between the roll and the tin film, but from point B to point C in Fig. 5 it exerts a very effective wiping action on the tin film, due to the strong adhesion of palm oil to tin and to the strong shearing forces in the oil and the tin films resulting from the

rapid motion of the roll surface. This action wipes off the excess tin which adheres to the strip as it leaves the tin bath. The excess tin and oil collect at C and D and drop back into the bath. All that is left on the strip as it ascends from between the rolls is an extremely thin but uniform film of relatively pure tin sufficient to cover the base layer which has actually alloyed with the iron of the strip.

Instead of rolls composed of porous metal, I may employ rolls **48** shown in Figure 3, composed of a tube **49** having radial holes therein, with a surface layer **50** of fibrous material bonded thereto. The layer **50** might, for example, be composed of felted asbestos fibers with sufficient porosity to permit the flow of oil radially therethrough as a result of the pressure maintained within the tube **49**. In the case of the rolls **48**, it is permissible for them to have actual contact with the ascending strip *s*, thereby producing a more pronounced wiping action, since the material of which the surface of the rolls is composed is such that it will not mar the coating applied to the strip.

A further modified form of wiping rolls is illustrated in Figure 4. As there shown, rolls **51** composed of metal have very small radial passages **52** therethrough whereby oil supplied to the interior thereof may flow radially under the combined effect of centrifugal force and the pressure inside the rolls, producing a tangential film in somewhat the same manner as the rolls **25** and **50**.

It will be apparent from the foregoing that the invention is characterized by numerous advantages. In the first place, it makes possible the use of existing tinning apparatus, with but slight modification, to produce tinned strip with an economy in tin consumption almost as great as that of the electrolytic process which involves a wholly new installation of expensive equipment. The invention, furthermore, does not introduce any additional complications either in construction or maintenance nor require the training of new personnel, since the general mode of operation is sufficiently similar to the previous, practically universal hot-dip tinning method as to be readily carried out by those familiar with the latter.

A further advantage is the ability to control the wiping action and thereby the thickness of the tin coating on the finished product, by varying the viscosity of the palm oil or other wiping fluid as well as the speed of rolls and the roll pressure.

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. The wiping rolls, for example, instead of being driven in directions such that they tend to reverse the strip, may be driven in opposite directions. They may also be operated at peripheral speeds but little if any greater than that of the strip, instead of at much higher speeds.

I claim:

1. Apparatus for coating strip comprising a container for holding a coating bath, means for feeding strip through said bath, a pair of rolls between which the strip passes on emerging from the bath, said rolls being permeable, and means supplying wiping fluid to the interior of the rolls for radial flow therefrom onto said strip.

2. Apparatus for coating strip comprising a container for holding a coating bath, means for feeding strip through said bath, a pair of rolls between which the strip passes on emerging from the bath, said rolls being permeable, means supplying wiping fluid to the interior of the rolls for radial flow therefrom onto said strip and means driving said rolls in such directions that the surfaces of the rolls nearest the strip move in a direction opposite to that of the strip movement.

3. Apparatus for coating strip comprising a container for holding a coating bath, means for feeding strip through said bath, a pair of rolls between which the strip passes on emerging from the bath, said rolls being permeable, means supplying wiping fluid to the interior of the rolls for radial flow therefrom onto said strip and heat-exchange means through which the fluid passes before entering said rolls.

4. The apparatus defined by claim 1 characterized by said rolls being composed of porous material mounted on a perforated metal tube.

5. The apparatus defined by claim 1 characterized by said rolls being hollow metal cylinders with radial holes therethrough.

6. In a method of coating strip, the steps including applying a coating fluid to the strip, wiping off the surplus coating fluid by forcing wiping fluid under pressure through permeable surfaces into contact with the strip, and moving said permeable surfaces in such directions that they tend to oppose the forward movement of the strip on engagement therewith.

7. In a method of coating strip, the steps including applying a coating fluid to the strip, wiping off the surplus coating fluid by forcing wiping fluid under pressure through permeable surfaces into contact with the strip, moving said permeable surfaces in such directions that they tend to oppose the forward movement of the strip on engagement therewith, and subjecting the wiping fluid to a heat-exchange treatment before passing it through said surfaces.

8. In a method of coating strip, the steps including applying a coating fluid to the strip, wiping off the surplus coating fluid by supplying wiping fluid through permeable surfaces into contact with the strip, yieldably holding such surfaces adjacent the strip, and moving them in such direction that they would tend to oppose the forward movement of the strip if in contact therewith, and at such a speed as to maintain films of said wiping fluid between the surfaces and the strip thereby separating the latter from the former.

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