Feb. 27, 1934. J. L. BRAY 1,948,505

METHOD OF COATING IRON AND STEEL

Filed Jan. 18, 1932

Fig. 1

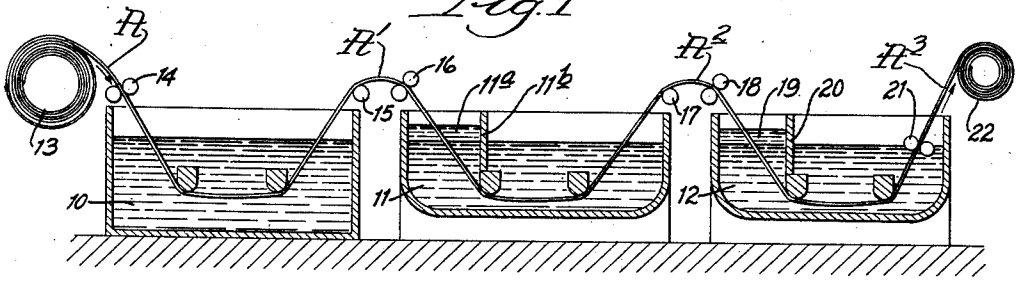


Fig. 2

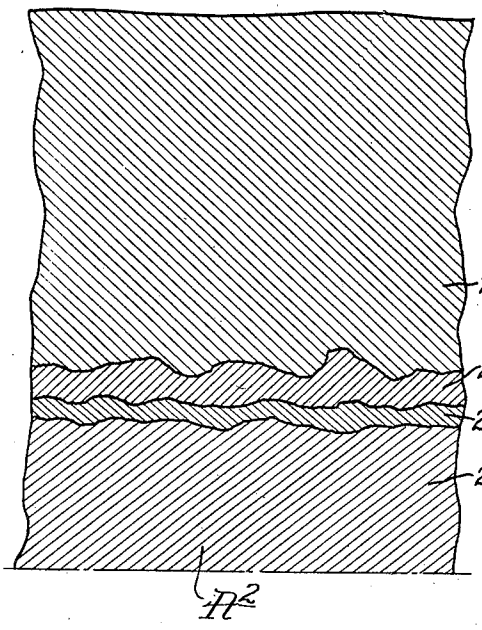
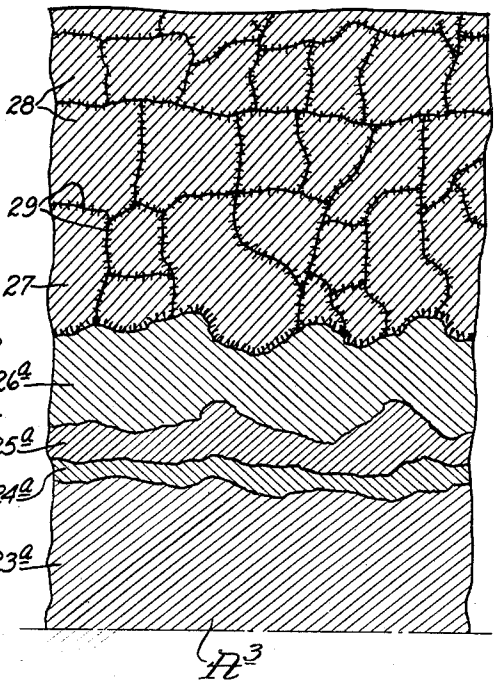


Fig. 3



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METHOD OF COATING IRON AND STEEL

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6 Claims. (Cl. 91—70.2)

An object of the invention is to provide an improved coating for sheet steel, steel wire, and irregular shapes, and an improved method for making the same.

Heretofore various processes for coating iron or steel sheets with lead and zinc have been suggested, but these processes have in all cases possessed certain defects which rendered the results uncertain, and in many cases valueless. The present invention, however, overcomes these difficulties and provides a method of forming a firmly adhering coat of an alloy of lead and zinc which possesses great flexibility without cracking or scaling, and which at the same time is highly resistant to the action of water, and other liquid corroding or dissolving agents, as well as resistant to the action of atmospheric corrosion.

Another object is to provide a method which will insure uniform coatings of this character when the process is run continuously. By the methods now in use a satisfactory coating can be obtained for a short time, but the later results are very uncertain and unsatisfactory when the attempt is made to run the process continuously.

The invention is fully described in the following specification and shown in the accompanying drawing, in which—

Figure 1 is a diagrammatic view showing apparatus for carrying out the invention;

Fig. 2 is a greatly enlarged transverse section through a sheet of iron coated with zinc after passing through the zinc bath of the coating process; and

Fig. 3 is a similar view showing the sheet after it passes the lead-zinc bath.

The apparatus for carrying out this process is shown diagrammatically in Fig. 1, and comprises a pickling tank 10, a bath of molten zinc 11, a molten lead-zinc alloy 12, together with means for carrying the sheet or other iron object from one of these tanks to the next in the order stated. These baths are heated by any well known means (not shown). The bath 12 may also be lead-cadmium, or lead-zinc-cadmium.

This apparatus, as illustrated, is intended primarily for coating a continuous iron strip, wire or sheet A which is fed from a roll 13 through a pair of feed rolls 14, the strip A passing down through the pickling solution in the tank 10, thence emerging as a cleaned and pickled strip A′ passing over a roll 15 then through another pair of feed rolls 16, thence down through molten zinc in the tank 11. On top of the entering end of the zinc tank 11 is a suitable flux 11^a floating on the surface of the molten zinc and retained by a partition 11^b. The strip or sheet next emerges from the tank 11 as the galvanized strip A^2 which passes over a roll 17, and thence between a pair of feed rolls 18. From this point the strip passes down into the lead-zinc bath through a flux 19 which is held in the entering end of the tank 12 by means of a partition 20. The strip then passes on through the molten lead-zinc alloy in the tank 12, and out through a pair of feed rolls 21 or similar means for wiping or smoothing the lead from the sheet. The finished and coated sheet is then wound on the roll 22.

The pickling solution in the tank 10 may be any of the well known solutions for preparing an iron or steel sheet for galvanizing. Having been thus cleaned, the sheet passes into the tank of molten zinc, the temperature of which should be kept as near the freezing point of zinc as may be found suitable in operation. By keeping the temperature of the molten zinc as low as may conveniently be possible the zinc is prevented from oxidizing rapidly, and forms a firm bond with the iron, as will later be described.

On passing from the zinc bath 11, the zinc on the surface quickly hardens and passes in a solid state through the flux 19 floating on top of the molten metal in the tank 12. This flux may consist, for example, of a thin molten layer of zinc chloride, to which has been added a small amount of ammonium chloride. It is necessary to prevent this flux from entering the main body or outlet side of the lead alloy bath or tank 12, and this is accomplished as has been previously stated by means of the partition 20.

Fig. 2 shows a partial cross section of one surface at a sheet of iron, enormously magnified, coated by this process with zinc in the condition of the sheet A^2 as it emerges from the galvanizing tank 11. The sheet then consists of the iron or steel base 23, a very thin layer 24 consisting of a solid solution of the intermetallic compound $FeZn_3$ in zinc. This compound has a very firm attachment to the iron sheet 23. Just beyond the compound 24 is another layer 25 consisting of a solid solution of the intermetallic compound $FeZn_7$ in zinc. These two solid solutions are firmly united by the common bond, zinc. Beyond these lie a coating of zinc 26 which in turn is firmly united to the layer 25.

The thickness of these layers of zinc and zinc-iron compounds depends upon several factors, such as the temperature of the zinc bath, the

time of immersion of the iron sheet therein, etc. It is important, however, as will presently be seen, that the coating of zinc should be very thin. This is particularly true of the thickness of the outer layer of substantially pure zinc crystals 26.

As the sheet of galvanized iron A^2, as shown by Fig. 3, passes into and through the tank 12 containing an alloy of molten lead with from 0.1% to 1.2% zinc, the outer layer of zinc 26 becomes partially melted and begins to diffuse into the molten lead-zinc alloy. This is shown in Fig. 3 in which the sheet 23^a and the layers 24^a and 25^a correspond to the sheet 23 and layers 24 and 25 of Fig. 2 substantially without change. It will be seen, however, that much of the layer of zinc 26 of Fig. 2 has diffused into the bath, and only a small portion consisting of a relatively thin layer 26^a remains.

Instead, some of the outer portion of the original layer 26 is now replaced with a layer 27 of a lead and zinc alloy which, on examination under a powerful microscope, reveals lead 28 with minute needles of zinc 29 therein. These needles of zinc coming in contact with the layer 26^a of zinc are seen to be firmly welded thereto, and these needles, extending as they do throughout the mass of lead, tie the lead together in much the same way as barbed or roughened reinforcing rods tie concrete together.

The thickness of the zinc layer 26^a remaining in the finished article will depend upon several factors, such as the temperature of the lead-zinc alloy bath, the time of immersion of the sheet therein, etc. This time of immersion, for ordinary work will be from three to twenty seconds, and the temperature of this bath should be from 345° C. to 400° C. (653° F. to 752° F.), with the preferred working temperature of about 370° C. When too high there is likelihood of an imperfect coating (color) resulting from oxidation.

The actions of lead and zinc in protecting iron are quite different. Zinc acts as a chemical protector for iron, while lead affords only mechanical protection. This is to be expected from the fact that zinc is more electronegative than iron, while lead is less electronegative than iron. Iron coated with zinc alone will be protected from the corroding liquids so long as any of the zinc coat remains, for the reason that zinc tends to go into solution much faster than iron. Lead, on the other hand, serves only in a mechanical way to hold the corroding or dissolving agent out of contact with the iron and goes into solution in water more slowly.

The strength of the finished lead-zinc alloy coating and its resistance to corrosion or solution depends principally on the size of the zinc needles, and this in turn depends largely on the percentage of zinc present. If these needles are too small the strength of the coating is impaired, and the protective layer is full of pinholes, as shown by tests. If the zinc needles are too large, as happens when too much zinc is present in the lead-alloy bath, they become absorbed by the corroding agent and thus leave relatively large passages through the lead through which the iron may be reached and corroded.

If, however, the proportion of zinc is carefully selected, the needles of zinc will be of a zinc which will give sufficient mechanical strength to the coating, and which will at the same time be so small as to leave only minute passages through the coating in case the zinc does become dissolved, and these passages are so fine as to prevent the further progress of the corroding agent therethrough. In other words, the only way the corroding agent can reach the iron is by dissolving out the zinc needles and following in along the passages thus made so long as the alloy coating is otherwise intact and free from pinholes. Careful tests conducted over a long period indicate that in the alloy the zinc must be between about 0.1% and 1.2% with the balance lead. I have obtained the best results so far between the limits 0.35% and 0.7% zinc, with an ideal proportion having about 0.5% zinc.

I have conducted careful and extended tests to determine the saturation point of zinc in lead in the lead-rich end of the mixture for the range of temperatures at which it is desirable to operate this process, namely, 345° C. to 400° C. (653° F. to 752° F.). As a result I have determined that the saturation point of zinc in lead at 345° C. is approximately 2.0% and at 400° C. is approximately 4.7%, and that it is approximately 3.25% at what I consider the best operating temperature, namely, 370° C. By comparing this data with the amounts stated in the foregoing paragraph, it will be seen that the proportion of zinc which I use is materially below the saturation point of zinc in lead at the operating temperature of the bath.

Having determined the proper proportion of zinc and lead in the alloy bath, the question arose how to maintain the proper mixture in the alloy bath. One of the difficulties of doing this will be seen by comparing Figs. 2 and 3. The coated sheet of Fig. 2 bearing a large amount of zinc 26 enters the lead-zinc alloy bath and much of the zinc coat 26 diffuses therein, the sheet emerging from this bath with only a small amount of zinc 26^a, and the zinc needles 29 scattered throughout the lead coat 27, as shown in Fig. 3.

Thus the lead-zinc bath will tend constantly to increase in its proportion of zinc due to the above cause. At the same time, however, the zinc in the molten lead-zinc bath tends constantly to decrease due to its loss by drossing, by volatilization, and the like. Under some operating conditions the zinc will increase, and under others it will decrease. In order to determine just what the proportions are I test the bath at intervals of say thirty minutes, or longer. For this purpose I have devised a special method of quickly determining the zinc content of the bath so that corrections can be made soon after a sample is taken.

If a given test shows the zinc in the bath to be above 0.5% and increasing, some of the bath is withdrawn and a suitable amount of lead added to hold the bath at approximately 0.5% zinc. If, however, the test shows the proportion of zinc in the bath to be below 0.5% and decreasing, some zinc is added to keep the proportion near the ideal of 0.5% zinc. Thus is assured a uniformly good coating for iron or steel which heretofore has not been possible, because no means has previously been devised to insure a uniform lead-zinc bath of the proper proportions.

It will be understood that while this process is shown in connection with a continuous strip, wire, or the like running through the various baths, but this is illustrative only, and sheets or other articles of iron or steel may be similarly coated by passing them first through a bath of zinc, and then through a bath of zinc lead which is maintained between the limits as above described.

While I have described and shown but a few

embodiments of my invention, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and arrangement may be made which do not depart from the spirit and scope of the invention as disclosed in the appended claims.

I claim:

1. The method of coating the surface of an iron or steel body comprising dipping the body in a bath of molten zinc, removing and cooling said body below the solidifying point of zinc, dipping said body in a bath consisting of molten lead containing zinc materially below the saturation point at the operating temperature of the bath, removing a portion of this lead-zinc bath from time to time, and adding lead so as to maintain said bath with a desired percentage of zinc below the saturation point.

2. The method of coating the surface of an iron or steel body comprising dipping the body in a bath of molten zinc, removing and cooling said body below the solidifying point of zinc, dipping said body in a bath consisting of molten lead containing zinc materially below the saturation point at the operating temperature of the bath, testing the bath at frequent intervals to determine the zinc content, and adding metal to maintain the desired proportion of lead and zinc in the bath.

3. The method of coating the surface of an iron or steel body comprising dipping the body in a bath of molten zinc, removing and cooling said body below the solidifying point of zinc, dipping said body in a bath consisting of molten lead containing between the limits of 0.1% and 1.2% of zinc, testing said bath at frequent intervals to determine the zinc content, and adding metal to hold the zinc content within said limits.

4. The method of coating the surface of an iron or steel body comprising dipping the body in a bath of molten zinc, removing and cooling said body below the solidifying point of zinc dipping said body in a bath consisting of molten lead containing approximately 0.5% zinc, and maintaining the zinc content at approximately 0.5%.

5. The method of coating the surface of an iron or steel body comprising dipping the body in a bath of molten zinc, removing and cooling said body below the solidifying point of zinc, dipping said body in a bath consisting of molten lead containing approximately 0.5% zinc, testing the bath at frequent intervals to determine the zinc content, and adding zinc or lead as required to maintain the zinc content at approximately 0.5%.

6. The method of coating the surface of an iron or steel surface comprising dipping the body in a bath of molten zinc, removing and cooling said body below the solidifying point of zinc, dipping said body in a bath consisting of molten lead containing approximately 0.5% zinc, removing a portion of this lead-zinc bath from time to time, and adding lead so as to maintain said bath at approximately 0.5% of zinc.

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