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P. E. SCHNEDLER
STEEL BODY HAVING ALLOYED ZINC COATING AND
METHOD OF PRODUCING SUCH COATING
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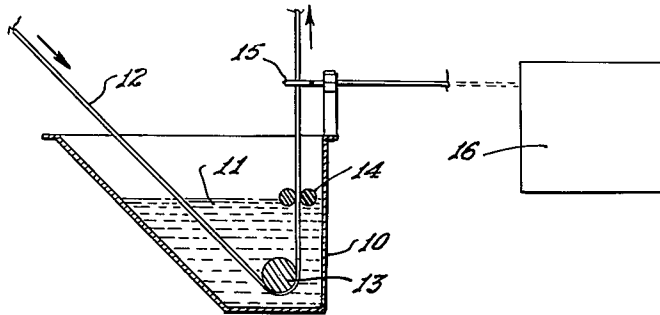


FIG. 1.

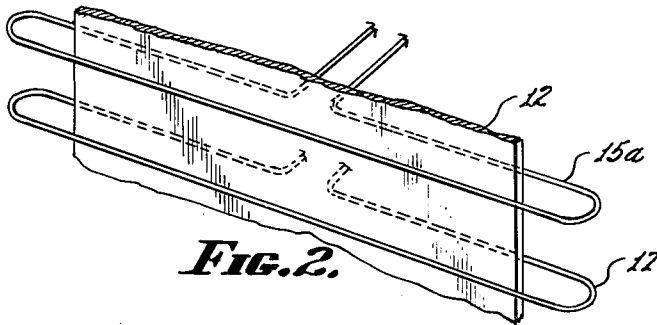


FIG. 2.

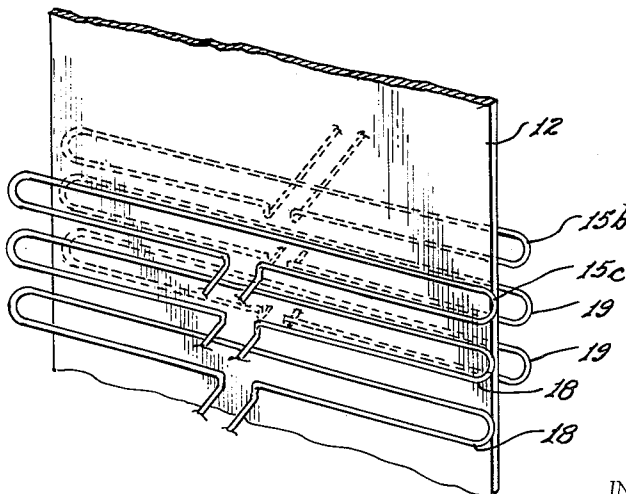


FIG. 3.

INVENTOR.

PAUL E. SCHNEDLER,

BY

Allen & Allen

ATTORNEYS.

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STEEL BODY HAVING ALLOYED ZINC COATING AND METHOD OF PRODUCING SUCH COATING

Paul E. Schnedler, Middletown, Ohio, assignor to Armco Steel Corporation, Middletown, Ohio, a corporation of Ohio

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8 Claims. (Cl. 29—196.2)

This invention relates to a steel body having an alloyed zinc coating and to a method of producing such a coating. Generally speaking, when a steel body is coated with zinc by the hot dip method, it has been considered desirable to conduct the operation in such a manner that alloying of the coating was minimized and preferably substantially avoided. For certain particular purposes, however, it has been desired to produce a zinc coating wherein the zinc was alloyed with iron. The production of an alloyed zinc coating has been very difficult to accomplish in a homogenous and even manner. Photomicrograph studies of cross-sections of alloyed coatings have shown that the coatings not only are non-uniform in the degree of alloying from one area to another, but that they are not homogenous from the base metal out to the surface and often consist of a plurality of "phases" wherein different proportions of the alloying metals are found in different strata. The principal difficulty however has been that where alloying of the coating has proceeded to the surface, the alloying action has tended to accelerate while in areas where the alloying was slower in starting, the alloying has proceeded less rapidly so that a very uneven and blotchy appearance resulted.

With the foregoing considerations in mind, it is an object of the present invention to provide a steel body having essentially a one-phase iron zinc alloy coating wherein the alloy is homogeneous substantially from the interface between the alloy and the iron base metal out to the surface of the coating. It is another object of the invention to provide such a body having a uniform alloy coating over its entire area whereby the appearance of the coated body is uniform and smooth.

It is still another object of the invention to provide a body having an alloyed zinc essentially one-phase coating containing from about eight percent to about twelve percent iron whereby to produce a coating which is ductile and will not chip, peel, or flake in a forming or drawing operation and which will provide an excellent paintable surface. It is still another object of the invention to provide a method of treating metal bodies and particularly steel strip to produce thereon a coating of the character described herein and further to provide such a method whereby the alloying step can be carried on at the normal speed at which the strip passes through the zinc coating apparatus.

These and other objects of the invention which will be pointed out in more detail hereinafter or which will be apparent to one skilled in the art upon reading these specifications are accomplished by that method and in that form of which the following is an exemplary embodiment.

Reference is made to the drawing forming a part hereof and in which:

FIGURE 1 is a semi-diagrammatic cross-sectional view of a typical zinc coating pot showing an apparatus for practicing the method and producing the article herein described.

FIGURES 2 and 3 are fragmentary enlarged perspective views showing two different embodiments of heating element for carrying out the method.

While all the factors involved are not fully understood it is believed that the difficulties heretofore encountered

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have stemmed primarily from the fact that an unalloyed zinc coating is highly reflective to heat while an alloyed coating has a very low reflectivity. To state the above proposition in the converse, a black body has an absorptivity or emissivity of one hundred percent. In other words, a black body will absorb one hundred percent of the heat impinging upon it or if heated internally will emit one hundred percent of the heat. The absorptivity of an alloyed zinc iron coating having a rather dull mat finish is approximately seventy-eight percent. The absorptivity of a molten unalloyed zinc coating is approximately 8.5 percent.

When an unalloyed zinc coating is placed upon a steel strip it requires heat to carry out the alloying step. In the past, this heat has always been externally applied as by passing the strip through a furnace or by causing a direct flame to impinge upon the coating. When heat is applied in this manner to an unalloyed zinc coating, as soon as alloying takes place in a given area, the absorptivity of the coating increases dramatically. The result of this is that more heat is absorbed by those areas where alloying has been effected and therefore the alloying action speeds up, and if allowed to continue, develops a multi-phase structure. Conversely, in those areas where alloying has not begun to take place, the high reflectivity or low absorptivity of the surface minimizes the heat supplied so that alloying action in these areas is retarded. It might be said that non-uniformity of the coating is multiplied substantially nine fold.

Briefly, in the practice of the present invention, the heating of the strip necessary to produce the alloying action is applied from within. This may be accomplished by heating the strip by electric resistance, or by induction heating, or a combination of induction and resistance heating. In the claims the terms "electrically heating", "electrical heating" and "heating electrically" are used to specify a heating from within either by electrical resistance or by a combination of induction or resistance heating. It is a well understood fact that when an object is heated by induction, ferromagnetic materials will heat much more rapidly and readily than non-ferrous materials. And, it is known that induced currents tend to flow on the surface of ferromagnetic materials. In this instance, with a sandwich type construction where a non-ferrous metal encloses a ferrous metal, the induction heating will cause a heat concentration at the non-ferrous-ferrous interface causing alloying between the two metals. When this well known concept is applied to the problem at hand, the highly divergent absorptivities of alloyed zinc and unalloyed zinc, instead of compounding the non-uniformity of the coating, actually operate in favor of a uniform coating. Thus, when the composite body is heated from within as by induction heating, as soon as alloying proceeds to the surface in a given area the reflectivity decreases and the emissivity increases so that the heat supplied to that area is emitted from that area to the ambient atmosphere more rapidly, while the heat applied to an unalloyed portion where the reflectivity is high and the emissivity is only about 8.5 percent, is retained since such portions are in a manner of speaking insulated; and with more heat applied the alloying proceeds at a greater rate. The general effect is that the entire coating is uniformly alloyed and a non-uniform or mottled appearance is avoided.

Furthermore, where induction heating is used as above outlined, heating can be much more rapid and the heat input can be controlled very accurately to maintain the strip at the desired temperature for the desired length of time. In a conventional zinc coating operation, the strip issues from the coating pot at a temperature of about 860° F. The maximum rate of alloying of zinc and iron occurs at temperatures of 900° F. to 950° F. By means

of an induction coil, the temperature of the strip must be raised from about 860° F. to between 900° and 950° F. and held there for a sufficient time for iron molecules to migrate out to the surface of the coating. By induction heating this can be accomplished in a matter of a few feet of travel of the strip and over a period of a few seconds. An advantage of this method is that it can be applied to existing zinc coating lines where space limitations are a factor. Because of the rapidity with which the body may be heated, the alloying operation may be carried out at the speed of the zinc coating apparatus.

Generally, it will be advantageous to accomplish the heating immediately above the coating pot, so that the alloying will be initiated before the molten coating begins to freeze in the conventional spangled pattern. Spangled coatings can of course be reheated and alloyed, but the outlines of the spangles will tend to persist and the oxide impurities at the spangle boundaries will be retained in the alloyed coating.

In the drawing there is shown a conventional zinc pot 10 containing the molten zinc 11. The strip 12 enters the pot from a source of supply (not shown) after having been given a desired pretreatment and after passing over a pot roll 13 it issues from the pot between the exit rolls 14.

At 15 there is indicated an inductive heating loop powered from a suitable source of electric power diagrammatically indicated at 16.

As shown in FIGURE 2, the inductive heating device may comprise a single loop 15a through which the strip 12 passes or as shown in FIGURE 3 it may comprise two flat loops 15b and 15c between which the strip 12 passes.

If desired, it is of course possible to provide additional loops 17 as shown in FIGURE 2, or additional loops 18, 19, as shown in FIGURE 3, as necessitated by the gauge and speed of the strip, so as to produce the required heating within the available time.

It will be within the skill of the electrical engineer to determine the physical dimensions of the loops and the power to be applied as well as the frequency in order to achieve the required degree of heat within the required space of time. Experimentally when using zinc coated strip previously given an unalloyed zinc coating and now at room temperature, perfect alloying of the zinc coating was achieved with a single turn coil as shown in FIGURE 2, supplied with ten kilowatts power at a frequency of 185 kilocycles. It must be borne in mind that in this experiment the inductive heating apparatus is required to raise the temperature of the strip from room temperature to about 950° F. Of course, where the alloying operation follows immediately the coating operation, the temperature of the strip need be raised less than 100° F. so that the power requirements are of course less.

It will be understood that conventional cooling means, such as blowers and the like, (not shown), may be provided to cool the alloyed coating after it has been sufficiently heated.

By the procedure described above, perfect essentially one-phase alloyed coatings have been produced on steel strip, the coating containing from about eight to twelve percent iron. The word "essentially," as used in the specification and claims, indicates that although undoubtedly one or more phases are present at the interface between the alloy and the iron base metal, these are practically impossible to identify, and that to all intents and purposes, the alloy coating is a one-phase alloy. The surface of this coating has an excellent paintable surface and appears to have good corrosion resistance. If desired, a phosphate coating may be applied to the alloyed surface but this is not considered to be necessary to give it paintable qualities. The coating is very ductile and does not flake, crack or chip during a forming operation.

Where a zinc coating bath containing a small percentage of aluminum is used, the alloy coating tends to fall

more readily within the range of 8 percent to 12 percent iron, although this range can easily be achieved without aluminum if overheating is avoided. It has been known for many years (as for instance as disclosed in U.S. Patent 2,197,622) that the addition of aluminum in small percentages to molten zinc coating baths will facilitate the production of galvanized sheet and strip having superior adherence of the coating. In this instance the coating will be composed primarily of free zinc with very little alloy formation at the interface between the base metal and the coating. Now it has been determined that if this type of zinc coated steel strip (which includes about .001-.35% aluminum in the coating) is heated, before the zinc freezes on the strip, until the coating is completely alloyed, the coating will be smooth and non-spangled and have particularly desirable properties as regards ductility, adherence, and paintability. The iron content of this zinc coating which contains a small amount of aluminum will be on the order of 812 percent. Excessive heating will cause additional diffusion of iron into the alloyed zinc coating layer, which tends to destroy these desirable properties. These high iron content alloys may reach 20-35% iron.

It is to be understood that while the above mentioned examples have included references to induction heating, resistance heating means or other internal heating means are equally well adapted to supply the necessary heat, as long as these heating means afford a heat concentration to the ferrous metal core or the interface, rather than to the non-ferrous surface layer. There are certain advantages to each heating method. It is possible to add the induction heating equipment to existing coating facilities without alteration of existing equipment. Resistance heating means are sometimes considered to be more economical, but adaptations to existing equipment must be made so that power sources can contact the strip, preferably in the coating bath and at a second point above the coating bath after the coating metal has solidified and the alloying is completed.

It will be clear that various modifications may be made without departing from the spirit of the invention and that details described herein have been by way of example only.

What is claimed is:

1. A steel body having essentially a one-phase coating of a substantially iron-zinc alloy containing from about .001% to about .35% of aluminum, said alloy coating being ductile and having good paintability and produced by coating said body with zinc containing said percentage of aluminum, and subjecting said coated body to electrical heating from within and maintaining said body in said heated condition for a time sufficient to permit iron molecules to migrate to the outer surface of the coating.

2. A steel strip having essentially a one-phase coating of a substantially iron-zinc alloy containing from about .001% to about .35% of aluminum, said alloy coating being ductile and having good paintability and produced by coating said strip with zinc containing said percentage of aluminum, and subjecting said coated strip to electrical heating from within and maintaining said strip in said heated condition for a time sufficient to permit iron molecules to migrate to the outer surface of the coating.

3. A steel strip having a coating of a substantially iron-zinc alloy containing from about .001% to about .35% of aluminum, said alloy coating containing from about 8% to about 12% iron, said coating being non-spangled, ductile, and having good paintability, said coating being produced by coating said strip with zinc containing said percentage of aluminum, and subjecting said coated strip to electrical heating from within and maintaining said strip in said heated condition for a time sufficient to permit iron molecules to migrate to the outer surface of the coating.

4. The method of producing on a steel body an alloyed coating of zinc containing from about .001% to about

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.35% of aluminum, which includes the steps of electrically heating said coated body to a temperature of from about 900° F. to about 950° F., and maintaining said body at said temperature for a time sufficient to permit iron molecules to migrate to the outer surface of the coating.

5. The method of producing on a steel strip essentially a one-phase alloyed coating of zinc containing from about .001% to about .35% of aluminum, which includes the steps of electrically heating the zinc coated strip, from within, to a temperature of from about 900° F. to about 950° F., and maintaining said strip at said temperature for a time sufficient to permit iron molecules to migrate to the outer surface of the coating.

6. The method of producing on a steel strip essentially a one-phase alloyed coating of zinc containing from about .001% to about .35% of aluminum, which includes the steps of heating the strip, after it emerges from the coating pot, by electrical heating, to a temperature of from about 900° F. to about 950° F., and maintaining said strip at said temperature for a time sufficient to permit iron molecules to migrate to the outer surface of the coating.

7. The method of producing on a steel strip an alloyed coating of zinc containing from about .001% to about .35% of aluminum, which includes the steps of electrically inducing in said strip, after it emerges from the coating pot, an increase in temperature to from about 900° F. to about 950° F., and maintaining said strip at said temperature for a time sufficient to permit iron molecules to migrate to the outer surface of the coating.

8. The method of producing a non-spangled, alloyed coating of zinc containing from about .001% to about

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.35% of aluminum on a ferrous metal strip, which includes the steps of applying to said strip said zinc-aluminum alloy coating internally heating the coated strip electrically, while the coating metal is still molten, to a temperature of from about 900° F. to about 950° F., and maintaining said strip at said temperature for a time sufficient to diffuse iron from the base metal into the coating whereby to develop a homogeneous, substantially single phase coating of iron-aluminum-zinc alloy of an iron content between 8 and 12%, said alloy being ductile and having good paintability.

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