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METHOD OF TINNING COPPER WIRE

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This invention relates to the art of tinning metals, and has for its principal object to provide an improved method of forming on metal articles, such as wires, a thin, substantially uniform, continuous, adherent metallic coating. This application is a continuation-in-part of our copending application, Serial No. 462,002, filed October 14, 1942, now abandoned.

It has long been common practice to coat various metal articles with thin films of metallic tin or tin alloys to protect the article from corrosion or discoloration, to facilitate soldering, and for other purposes. For example, large quantities of thin steel sheet or strip have been coated with metallic tin for the purpose of making various sheet metal containers, and copper wire very commonly is coated with metallic tin to facilitate soldering of the wire, to prevent corrosion or discoloration by the sulphur or other components of rubber insulation subsequently applied thereto, and to prevent such insulation from adhering too tightly to be easily removed.

The tinning metal heretofore used for tinning these and other metal articles has been either commercially pure tin, or a lead-tin alloy containing a high percentage of tin. In recent years much effort has been directed to finding a suitable tinning alloy containing only a small proportion of tin, or none at all, but to a large extent only indifferent success has heretofore resulted from these efforts. For example, lead-base alloys containing no tin have been proposed as substitutes for tin for this purpose, but such alloys for the most part do not adhere well to wire or other metal article. In other cases, where lead alloys containing a relatively small percentage of tin have been used, the coating on the wire or other metal base is sticky in the sense that it tends to bind frictionally in steel dies through which the wires are passed, or in which other metal articles are formed, in the course of fabricating the tinned metal into finished articles.

We have discovered that it is possible to produce very excellent metallic coatings, having many of the desirable properties of pure tin coatings, using a lead-base alloy containing but a small proportion of tin, together with small proportions of cadmium and antimony. The coatings produced in accordance with the invention are for the most part not subject to the disadvantages of heretofore proposed tinning compositions of low tin content.

The method of the invention for forming on a metal article a substantially uniform, continuous, adherent, metallic coating capable of inhibiting corrosion or discoloration of the article and of facilitating soldering thereof involves the operation of bringing the article in contact with a molten alloy maintained at a composition of about 0.25% to 10% tin, about 0.35% to 1.5% cadmium, about 0.05% to 0.75% antimony, and the balance substantially all lead.

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The composition of the coating formed on a copper wire or other metal article by passing it through a molten metal bath of the above-described composition differs substantially from the composition of the bath itself. The coating on the wire or other article contains substantially more tin and cadmium, and substantially less lead, than the bath. This results in a greater depletion of the bath with respect to tin and cadmium than with respect to lead. The invention consequently involves the step of maintaining approximately constant the volume and composition of the bath described above which comprises replenishing depletions of said bath by adding thereto a lead-base alloy containing from about 0.75% to about 5% more tin, about 0.65% to 3.5% more cadmium, and from about the same amount to 0.25% more antimony than the average amounts of such metals maintained in the bath.

The wire or other metal article produced according to the invention carries a thin coating composed of about 1.5% to 12% tin, about 0.7% to 1.75% cadmium, about 0.1% to 0.6% antimony, and the balance substantially all lead.

For the purpose of affording a better understanding of the invention, it is described in detail below as embodied in an operation for tinning a copper wire. It is understood, however, that the scope of the invention is not limited to the following specific description.

The mechanical steps for tinning copper wire in accordance with the invention are substantially the same as have heretofore been employed in commercial wire-tinning operations. Briefly, these steps involve passing the wire from a reel through a body of flux, which may be a conventional soldering flux such as acidified zinc chloride solution. Excess flux is wiped from the wire, and it is then drawn through a bath of the coating metal maintained in the molten state in a suitably heated pot. The wire is of course submerged below the surface of the molten coating metal in the pot as it is passed therethrough. Upon emerging from the pot, the wire is passed through one or more wipers or wiping dies to remove excess coating metal, and then through a water bath or spray to insure cooling of the wire and of the coating metal to well below the melting point of the latter. The wire is then thoroughly dried and wound on a take-up reel.

In accordance with the invention, the coating metal maintained in the pot is an alloy consisting of about 0.25% to 10% tin, about 0.35% to 1.5% cadmium, about 0.05% to 0.75% antimony, and the balance substantially all lead. The presence of a small proportion of tin in the alloy is necessary to insure firm adherence of the coating to the wire. As the wire is drawn through the bath of the coating alloy, there is a tendency for the tin to adhere to the wire in substantially greater proportion than its concentration in the molten alloy in the pot. This tendency results in depleting the tin content of the bath more rapidly than the lead content and unless controlled it will result in a wire having a coating undesirably high in tin content. Excessive accumulation of tin in the coating (up to 25%, more or less) not only results in high tin consumption, but also results in a coating which is sticky in the sense that it binds frictionally in steel dies through which the tinned wire may be passed in stranding, compacting and other fabricating operations.

The presence of cadmium in the coating alloy serves to prevent an unduly large proportion of the tin in the molten pot alloy from adhering to the wire and thus entering the coating composition on the wire. Thus it reduces the tin consumption and prevents the coating on the wire from binding frictionally in steel dies. The cadmium also hardens the coating on the wire substantially. Another important function of the cadmium is that it enables the coating film to be applied evenly and with ease. An alloy containing tin and antimony within the ranges stated, but with too little cadmium (less than 0.35% in the bath, giving less than about 0.7% in the coating on the wire), produces a coating that tends to bunch up when the wire is wiped as it leaves the molten alloy pot, and so results in a coating of uneven thickness. If the cadmium content is within the range given, this difficulty is not experienced. To date we have obtained the best results when the alloy in the pot contains from 1.5% to 3% tin to insure firm and uniform adherence of the coating to the wire, and from 0.75% to 1.0% cadmium to insure against excess accumulation of tin in the wire coating.

The small proportion of antimony present in the alloy serves to increase its fluidity and to aid in the formation of a thin, smooth, and uniform coating film on the wire. Within the range of antimony content stated above, and with the above-given best concentrations of tin and cadmium, very satisfactory results have been secured using from 0.2% to 0.4% antimony.

Even when the tin and cadmium concentrations in the molten alloy in the pot are balanced to produce a good coating on the wire, a somewhat higher proportion of both tin and cadmium is found in the wire coating than is present in the molten alloy in the pot. For example, the coating composition on the wire generally contains 1.5% to 12% tin, 0.7% to 1.75% cadmium, and 0.1% to 0.6% antimony. A wire drawn through a molten alloy containing the particularly satisfactory proportions of 1.5% to 3% tin, 0.75% to 1% cadmium, 0.2% to 0.4% antimony, and the balance substantially all lead will acquire a coating containing about

4% tin, slightly more than 1% cadmium, and about 0.25% antimony with the balance lead.

The formation of such alloys relatively richer in tin and cadmium on the wire than in the pot results in the gradual depletion of tin and cadmium relatively to the lead in the pot. There may also be some relatively greater depletion of antimony. Accordingly, it is the practice according to the invention to replenish depletions of the coating metal in the pot with an alloy containing from 0.75% to 5% more tin, from 0.65% to 3.5% more cadmium, and from about the same amount to about 0.25% more antimony than the average amounts of such metals maintained in the pot alloy. Within this range, it is ordinarily advantageous for the replenishing alloy to contain from about 2% to about 3.5% more tin, from about 1.5% to about 1.75% more cadmium, and perhaps slightly more antimony than the average analysis of the alloy in the pot. In the case of the exemplary pot alloy containing 1.5% to 3% tin, 0.75% to 1% cadmium, and 0.2% to 0.4% antimony with the balance substantially all lead, a satisfactory replenishing alloy contains about 5% tin, about 2.5% cadmium, and about 0.3% antimony, the balance being substantially all lead. By periodic additions of this replenishing alloy, the volume and composition of the metal in the pot may be maintained approximately constant, and a wire carrying a coating of uniform composition and physical characteristics may be produced.

A simple and convenient way for testing the alloy in the pot to make sure that its composition is about right to produce a good wire coating is to cast and solidify a small sample of the pot alloy and test it for hardness. The Brinell hardness of such a sample should be at least about 8, and preferably about 8.5 to 9. It may occasionally happen that notwithstanding additions to the pot of a replenishing alloy as described above, the hardness of the pot alloy will drop below 8.25 or 8 Brinell, indicating that the replenishing alloy has not fully made up the depletions of tin, cadmium, and antimony. In such a case, these depletions may be made up, independently of the regular additions of the above-described replenishing alloy, by adding to the metal in the pot about 5 pounds of tin, about 5 pounds of cadmium, and about 1¼ pounds of antimony for each 10,000 pounds of metal in the pot and for each 0.25 Brinell number below the hardness sought to be maintained.

For example, if the pot contains 20,000 pounds of tinning alloy and the hardness drops ¼ Brinell number below the value sought to be maintained, or if the pot contains 10,000 pounds of coating alloy and the hardness drops ½ Brinell number below that sought to be maintained, then in either case about 10 pounds of tin, about 10 pounds of cadmium and about 2.5 pounds of antimony should be added to the pot metal, supplemental to the usual additions of replenishing alloy. Small pigs of an alloy containing the correct proportions of tin, cadmium, and antimony (about 45% tin, about 45% cadmium, and about 10% antimony) of known weights may be kept on hand for making these supplemental additions to the pot whenever the hardness drops undesirably below the hardness sought to be maintained.

The temperature of the alloy in the pot should be above the melting point of the alloy (about 620° F.), and preferably from about 750° F. to 800° F. to insure that the alloy is completely melted and sufficiently fluid to form a uniform and thin coating on the wire. If the temperature is allowed to rise very much above 800° F., there is some danger that tin and cadmium may be lost in a dross, but a higher temperature may be maintained in cases where such losses are not considered objectionable. To guard against such losses, it is sometimes advantageous not to skim the molten metal in the pot, but to retain whatever dross forms as a protective coating over the molten alloy to guard against further losses. A further protective covering of charcoal may be maintained over the metal in the pot, if desired.

Although the foregoing specific description is presented with particular reference to the coating of cooper wire, it is understood that metals other than copper and articles other than wire may be coated with the alloy and by the method herein described. The coating formed on the metal article is thin, continuous and uniform, and adheres well. It does not tend to bind in the steel dies or other forming tools which may be used in fabricating the coated metal. It provides excellent protection against discoloration and corrosion, and when applied to a copper wire which is subsequently covered with rubber, it provides an intermediate film between the rubber and the copper which both protects the copper from discloration and corrosion and prevents the rubber insulation from adhering too tightly. It further provides an excellent base for solder, thereby facilitating the making of soldered joints.

We claim:

1. The method of tinning copper wire to produce on the surface of the wire a continuous, adherent metallic coating capable of inhibiting corrosion and of facilitating soldering and capable of being passed through a steel fabricating die without frictionally binding in the die, said method comprising passing the wire through a molten bath of an alloy composed of about 0.25% to 10% tin, about 0.35% to 1.5% cadmium, about 0.05% to 0.75% antimony, and the balance substantially all lead, and maintaining the volume and composition of the bath approximately constant by periodically replenishing depletions of said bath by adding thereto a lead-base alloy containing from about 0.75% to 5% more tin, from about 0.65% to 3.5% more cadmium, and from about the same amount to 0.25% more antimony than the average amounts of such metals maintained in the bath.

2. The method of tinning copper wire to produce on the surface of the wire a continuous, adherent metallic coating capable of inhibiting corrosion and of facilitating soldering and capable of being passed through a steel fabricating die without frictionally binding in the die, said method comprising passing the wire through a molten bath of an alloy composed of about 1.5% to 3% tin, about 0.75% to 1% cadmium, about 0.2% to 0.4% antimony, and the balance substantially all lead, and maintaining the volume and composition of the bath approximately constant by periodically replenishing depletions of said bath by adding thereto a lead-base alloy containing from about 2% to 3.5% more tin, from about 1.5% to 1.75% more cadmium, and slightly more antimony than the average amounts of such metals maintained in the bath.

3. The method of tinning copper wire to produce on the surface of the wire a continuous, adherent metallic coating capable of inhibiting corrosion and of facilitating soldering and capable of being passed through a steel fabricating die without frictionally binding in the die, said method comprising passing the wire through a molten bath of an alloy composed of about 1.5% to 3% tin, about 0.75% to 1% cadmium, about 0.2% to 0.4% antimony, and the balance substantially all lead, and maintaining the volume and composition of the bath approximately constant by periodically replenishing depletions of said bath by adding thereto a lead-base alloy containing about 5% tin, about 2.5% cadmium, about 0.3% antimony, and the balance substantially all lead.

4. The method of tinning copper wire to produce on the surface of the wire a continuous, adherent metallic coating capable of inhibiting corrosion and of facilitating soldering and capable of being passed through a steel fabricating die without frictionally binding in the die, said method comprising passing the wire through a molten bath of an alloy composed of about 0.25% to 10% tin, about 0.35% to 1.5% cadmium, about 0.05% to 0.75% of antimony, and the balance substantially all lead, replenishing depletions of said bath by periodically adding thereto a lead-base alloy containing from about 0.75% to 5% more tin, from about 0.65% to 3.5% more cadmium, and from about the same amount to 0.25% more antimony than the average amounts of such metals maintained in the bath, and also maintaining the hardness of said bath metal above Brinell No. 8 by adding thereto as required and independently of said replenishing additions about 5 pounds of tin, about 5 pounds of cadmium, and about 1¼ pounds of antimony for each 10.000 pounds of metal in the bath and for each 0.25 Brinell number below the hardness to be maintained, whereby the volume of the bath is maintained approximately constant and its composition is maintained within the limits for producing a satisfactory coating.

5. The method of tinning copper wire to produce on the surface of the wire a continuous, adherent metallic coating capable of inhibiting corrosion and of facilitating soldering and capable of being passed through a steel fabricating die without frictionally binding in the die, said method comprising passing the wire through a molten bath of an alloy composed of about 0.25% to 10% tin, about 0.35% to 1.5% cadmium, about 0.05% to 0.75% antimony, and the balance substantially all lead, and maintaining the hardness of the bath metal above that corresponding to Brinell No. 8 by adding thereto as required and independently of normal replenishing alloy additions about 5 pounds of tin, about 5 pounds of cadmium, and about 1¼ pounds of antimony for each 10,000 pounds of metal in the bath and for each 0.25 Brinell number below the hardness to be maintained, whereby the composition of the bath metal is maintained within suitable limits for producing a satisfactory coating.

6. The method of tinning copper wire to produce on the surface of the wire a continuous, adherent metallic coating capable of inhibiting corrosion and of facilitating soldering and capable of being passed through a steel fabricating die without frictionally binding in the die, said method comprising passing the wire through a molten bath of an alloy composed of about 0.25% to 10% tin, about 0.35% to 1.5% cadmium, about 0.05% to 0.75% antimony, and the balance substantially all lead, and maintaining the hardness of the bath metal above that corresponding to Brinell No. 8 by adding thereto and independently of normal replenishing alloy additions an alloy containing about 45% by weight tin, about

45% by weight cadmium, and about 10% by weight antimony in an amount sufficient to yield about 5 pounds of tin, about 5 pounds of cadmium, and about 1¼ pounds of antimony for each 10,000 pounds of molten metal in the bath and for each 0.25 Brinell number below the hardness to be maintained.

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