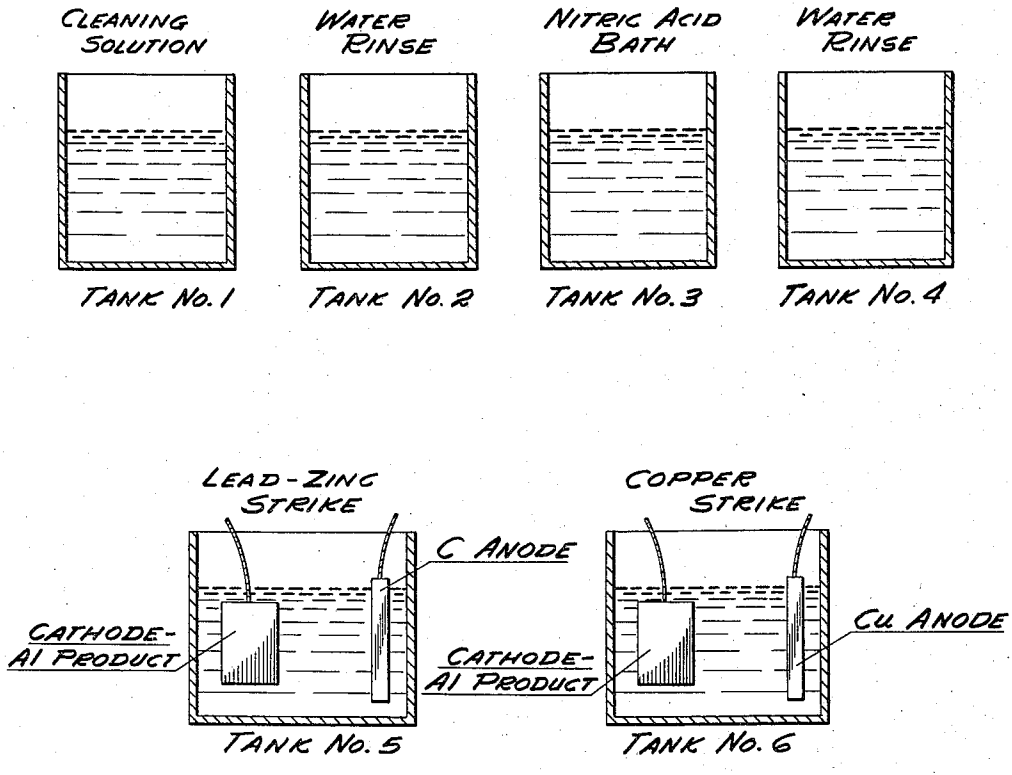
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PROCESS OF ELECTROPLATING ON ALUMINUM

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PROCESS OF ELECTROPLATING ON ALUMINUM

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This invention relates to a process of electroplating on aluminum products whether the products be wire, strip, sheet, or in cast or forged states.

The invention relates particularly to a process for the direct electroplating on commercially pure aluminum, and aluminum base alloys, and to the electroplating baths employed in the process.

A primary object of the invention is to provide an electroplating process which will have a widespread usage in commercial plating and which changes the electroplating art from guess work to an exact science as relating to the plating on aluminum. The process avoids the heretofore employed zincate immersion solution. Furthermore the process is highly adaptable to time cycles which makes it possible to electroplate continuously on aluminum wire or strip materials.

One of the great advantages of the present invention resides in the fact that the plating is actually bonded to the aluminum in such strength that regardless of how the aluminum may be manipulated such as in wire form or strip form, the bond is not easily broken, a result particularly desirable in handling aluminum wire where it is to be plated with a solderable coating as a replacement for copper wire.

Any porosity of the electroplating coating of metals or alloys of metals having a relatively low temperature melting point can be substantially eliminated by re-flowing of the coating in a bath of heated oil, the temperature being such that the coating actually flows. Furthermore the bond-strength of the electroplated coating in this process is greater than the tensile strength of a eutectic tin-lead solder.

In the accompanying drawing, seven separate tanks are illustrated and designated, and the usages of them will become apparent in the following description.

The initial step in approaching the process of the present invention is to clean the aluminum product by soaking in a water solution of partially inhibited caustic solution wherein the concentration would run from 8 to 12 ounces per gallon of a caustic material such as sodium hydroxide. In this tank No. 1 containing the cleaning solution, the temperature ranges from 160 to 200 degrees F. and the time period for the soaking of the aluminum product in this solution will range from 5 to 30 seconds depending of course upon the size, contour, shape and surface condition of the material. Where the material is wire, or strip, the wire and strip may be continuously moved through the bath at a predetermined speed so that when the surface condition shows a lightly etched effect, it is time to remove the aluminum material from the tank No. 1, that is from the caustic material. By lightly etched, it is meant that the aluminum assumes a light gray color and has not been pitted or roughened. The aluminum material is taken from the tank No. 1 and then thoroughly rinsed in a water bath at substantially room temperature, such a dwell of the material in the water bath ranging from 2 to 5 seconds for wire form, or from 10 to 20 seconds for shaped

aluminum products. The timing as indicated by the range of time is not critical. It is the intent in this bath simply to remove adhering caustic material.

In the tank No. 3, there is carried an nitric acid bath also at room temperature, wherein the concentration ranges from 40 to 60 percent by volume of 40 degree nitric acid in water. There is a time range of from approximately 3 to 30 seconds of the dwell of the aluminum material in this nitric acid bath, entirely dependent upon the time required to remove "smut" which has been raised in the alkaline bath in tank No. 1. Also in this nitric acid bath, the nitric acid removes alloying elements from the surface layer at least of the aluminum material. It is the intent in the process to have a chemically clean aluminum surface on which to plate. Again it is pointed out that the time dwell of from 3 to 30 seconds in this nitric acid bath depends not only on the removing of the smut, but also upon the size and shape and surface condition of the aluminum products.

From this nitric acid bath, the aluminum product is then taken through the No. 4 tank which contains simply a flowing bath of rinse water maintained substantially at room temperature, wherein the aluminum is subjected to the rinsing of the water for from 3 to 5 seconds for wire form or from 10 to 30 seconds for shaped aluminum products. These time ranges are indicated as minimums since there is no harm done in allowing the aluminum products to remain over and above that time limit.

The next step of carrying the aluminum products through the bath in the tank No. 5 is quite important, particularly in the make up of the bath.

The concentration of this bath in tank No. 5, is not critical, but it is all important that there be lead ions present in this bath or the electroplating process will not operate. The bath must always contain enough lead in solution to be blackened with a sodium sulfide test solution.

The electrolyte bath composition in tank No. 5 is as follows—aqueous solution containing caustic soda; a chelating compound, sodium cyanide and zinc and lead ions.

The chelating compounds may be one or more of the sodium salts of closely related polyhydroxy acids such as the hexahydroxyheponates or the sodium salts of hydroxycarboxylic acids such as sodium lactate, sodium salt of malic acid, sodium tartrate, sodium potassium tartrate, sodium citrate, or sodium succinate or the di, tri or tetra sodium salts of ethylene diamine tetraacetic acid or the trisodium salt of N-hydroxy-ethylethylene-diamine triacetic acid. These last salts give the best results although the others operate satisfactorily. The important characteristic of the chelating compound is that it must form a stable complex with the lead ions so as to keep the lead ions in solution in a highly alkaline solution. Specifically, this electrolytic bath in the tank No. 5 may have the specific ingredients and proportions as follows; 16 ounces per gallon of sodium cyanide; 0.134 ounce per gallon of lead acetate where the lead as a metal is about 1.0 gram per liter, this amount being the optimum, but the amount may vary from 0.4 to 2.0 grams per liter; 1.35 ounces per gallon of zinc cyanide wherein the zinc as a metal will range from 5 to 15 grams per liter with the optimum at 10 grams. The bath will be allowed to remain at room temperature. The aluminum product will of course constitute the cathode and carbon will be used for the anodes. The voltage employed in the electroplating process will be 6 volts and the current density may range from 50 to 1,000 amperes per square foot depending again upon the shape and form of the aluminum product, with approximately 500 amperes per square foot density for wire. It is desirable to maintain a slight

agitation during current flow. It will require from 5 to 10 seconds dwell in this bath No. 5 for wire products and strip products, and from 5 to 20 seconds for formed or cast aluminum products. Electrical contact is made prior to the placing of the aluminum product in the bath. Now to that bath before the aluminum product is immersed and electrical circuit is established, there is added the chelating compound. Selecting out of the group above indicated, as an example, the sodium potassium tartrate (Rochelle salt) in the proportion of one pound per gallon is employed. For the lead acetate, there may be substituted any soluble lead salt, and likewise for the zinc cyanide there may be substituted any soluble zinc salt. As previously indicated, the optimum concentration is at room temperature.

In the absence of lead ions, zinc will not work, and in the absence of zinc ions, lead will not work. Also it is to be pointed out that if the aluminum product is allowed to remain in this tank No. 5 in this bath, too long, such as moving a wire or strip through it too slowly, or in an attempt to get a thicker coating, the lead may build up in a spongy form which is not usable.

The result of the electroplating in this bath in tank No. 5, is that there is a plating or strike on the aluminum which approaches molecular thickness only, the thickness being in the order of from 2 to 3 millionths of an inch in thickness.

From tank No. 5, the aluminum product is carried into or through the bath in the tank No. 6. Here the purpose is to give the zinc-lead struck aluminum a coating of copper in the nature of a copper strike.

The composition of the electrolytic bath in tank No. 6 is as follows—copper cyanide where the copper as a metal will range from 6 to 8 ounces per gallon; free potassium cyanide, 1 to 2 ounces per gallon; and potassium carbonate of about 2 ounces per gallon as a starter and a pH increaser. The pH range of this bath can be 10.5 to 13.5. The temperature of this bath will be maintained within a range of from 160 to 180° F., and the anodes will be copper with the aluminum product constituting the cathode. It is necessary to maintain a slight agitation in this bath during the plating process, that is during the current flow. The current density will range from 20 to 200 amperes per square foot, depending again upon the nature or shape of the aluminum product. For wire the density will range from 150 to 200 amperes per square foot. Voltages will range from 4 to 6. The time of dwell of the aluminum product in this bath in tank No. 6 will range from 2 to 5 seconds, or at least be sufficient to electroplate on the aluminum until it has a very definite copper color, the coating of the copper approaching 50 millionths of an inch in thickness. It is essential in this procedure relating to tank No. 6, that electrical contact be made prior to the placing of the aluminum in the bath, otherwise the copper film will be non-adherent.

Following removal of the aluminum product from the tank No. 6, the product is rinsed in water, preferably in flowing water, such as in tank No. 7 at room temperature, for at least 2 to 5 seconds for wire and strip products, and from 10 to 20 seconds for formed or cast products. Again the exact time in this water rinsing tank No. 7 is not critical.

The product thus containing the resultant copper strike over the zinc-lead strike is then ready for any subsequent plating of a metal to be desired. This subsequent plating may follow any of the well known plating processes from acid or alkaline plating solutions for plating over copper.

There are on the market a number of compounds of a chelating nature comprising essentially flake caustic soda, and a chelating agent plus some material which acts as an accelerator, it being assumed that such proprietary compounds embody the compounds previously indicated as being useful in the chelating compound of the process.

As above indicated, the purpose of the chelating compound is to produce a stable complex with the lead ions so as to keep them in solution in a highly alkaline solution.

It is believed that the high degree of success of the process constituting the invention resides in the facts that the original strike of zinc and lead directly on the aluminum constitutes a barrier between the aluminum and the copper preventing alloying therewith, so that the copper will be directly available for the subsequent plating operations as may be desired. Also it is to be pointed out again that there is no immersion coating to secure the deposition of a metal on the aluminum or over an original coating, but to the contrary the electroplating process is used in both of the strikes.

While there may be variations in times of dwell of the aluminum products in the various baths, slight changes in proportions of the various ingredients of the baths, substitutions in the chelating agents, and variations in the current densities employed all from those above set out, and without departing from the spirit of the invention, I therefore do not desire to be limited to the precise bath compositions beyond the limitations which may be imposed by the following claims.

I claim:

1. In a continuous process of preparing elongated aluminum in wire or strip form preliminary to a final plating, the steps comprising cleaning the aluminum to obtain a substantially chemically pure surface thereon; continuously passing the aluminum as a cathode through a first aqueous alkaline solution consisting essentially of lead and zinc ions in the ratio of from 0.4 to 2.0 grams of lead to 5 to 15 grams of zinc per liter, a chelating compound, and sodium cyanide in the presence of a carbon anode while passing an electric current between the cathode and the anode, producing a lead-zinc strike directly on the aluminum; and continuing the travel of the aluminum directly from said solution immediately into and continuously through, while connected with said current as a cathode, a second solution containing copper cyanide to receive a copper strike over said lead-zinc strike in the presence of a copper anode while passing an electric current between the cathode and the anode; the dwell period of the aluminum in said first solution ranging from approximately five to ten seconds, and providing a lead-zinc strike limited to from two to three millionths of an inch.

2. The method of claim 1 in which the current density for the aluminum in the first solution is approximately 500 amperes per square foot at approximately six volts.

3. The method of claim 1 in which the dwell period of the aluminum in the second solution ranges from approximately two to five seconds giving a copper coating approaching fifty millionths of an inch.

4. The method of claim 3 in which the current density for the aluminum in the second solution is approximately from 150 to 200 amperes per square foot with a voltage range of from four to six.

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