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(54) **PROCESS FOR CONTINUOUS ELECTROCHEMICAL TINNING OF AN ALUMINIUM WIRE**

(57) A process for continuous electrochemical tinning of an aluminum wire (1), comprises the steps of: providing an aluminum wire (1), performing the pickling of the aluminum wire (1), by passing it through a pickling tank (4) containing a pickling solution, performing carburization of the aluminum wire (1) by passing it through a carburization tank (5) containing a carburization solution, performing the alkaline copper plating of the aluminum wire (1) by passing it through an alkaline copper plating tank 6 containing an alkaline copper plating solution, performing acid copper plating of the aluminum wire (1) by passing it through an acid copper plating tank (7) containing an acid copper plating solution, performing tinning of the aluminum wire (1) by passing it through a tinning tank (8) containing tinning solution.

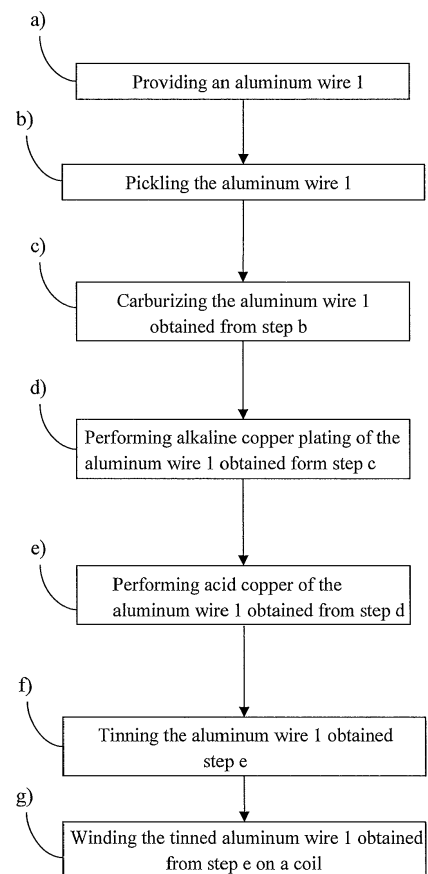


Fig. 1

Description

FIELD OF APPLICATION

[0001] The object of the present invention are a process for continuous electrochemical tinning of an aluminum wire and a plant for performing the aforementioned process.

Description of the prior art

[0002] In the prior art it is known to use copper as an electrical conductor, in particular for making electrical wires and cables. Thanks to its conductive properties, copper is used in numerous fields, especially where high performance is required in the transmission of electric current.

[0003] In detail, ETP copper used in the electrical field has the following electrical characteristics: IACS conductivity >99%, specific weight of 8.93 Kg/dm³. Considering the continuous increase in the cost of copper, there is a need to seek alternative materials capable of offering a good compromise between cost and conductive properties.

[0004] In the state of the art, aluminum is the material considered most suitable due to its electrical characteristics (IACS 50-63.8% depending on the alloy), its mechanical characteristics, its workability, its low specific weight (2.7 Kg/dm³), its low cost, its abundance and wide availability in nature. Therefore, currently aluminum is the only commercial alternative to copper in the electrical field.

[0005] Aluminum is used as conductor in high and medium power busbars, where the conductors consist of bars. In low power busbars, where wires are generally used as conductors, the material used is copper.

[0006] Given that copper and aluminum have a different electrical conductivity, it is necessary to correctly size the conductive aluminum wire in order to obtain the same performance as an equivalent copper wire. For example, in order to obtain an aluminum wire with the same performance as a copper wire, it is necessary to increase the diameter of the aluminum wire by 30% with respect to the diameter of the copper wire. Such an increase in diameter is, however, compensated by the lower specific cost of aluminum. Indeed, the linear weight of an aluminum conductor is roughly half that of a copper conductor having the same diameter.

Problem of the prior art

[0007] In the prior art, the difficulty of using aluminum wire is linked to the need to treat the wire itself in order to avoid problems of oxidation especially in contact areas. Indeed, although aluminum is a highly corrosion-resistant material, it reacts very easily with oxygen due to its position in the electrochemical series.

[0008] The resistance of aluminum to corrosion is

linked to the formation of a very compact layer of aluminum oxide Al₂O₃, known as alumina, which protects the material from further corrosion attacks. Such an oxide constitutes a very stable layer that coats the aluminum providing a passivating effect that impedes the attack of the oxide with regard to the underlying metal.

[0009] In order to improve contact resistance and prevent it from raising because of the formation of the aluminum oxide, which has low electrical conductivity, it is possible to tin the contact area. Indeed, tinning protects the material from oxidation and makes it possible to have a better interface in the contact area.

SUMMARY OF THE INVENTION

[0010] The aim of the subject invention is to make an aluminum wire for applications in the electrical field that has suitable electrical and mechanical characteristics and that allows a copper wire to be replaced.

[0011] Such an aim is accomplished by a process according to claim 1 and by a plant according to claim 10.

Advantages of the invention

[0012] Thanks to an embodiment, it is possible to make an aluminum wire that has a tinning over its entire surface, protects the material from oxidation and makes it possible to have a better interface in the electrical contact area.

[0013] Thanks to an embodiment, it is possible to make a process that allows the aluminum wire to be treated continuously.

[0014] Thanks to an embodiment, the process of the present invention makes it possible to make an aluminum wire that can also be used in low power ducts.

[0015] Thanks to an embodiment, it is possible to make an aluminum wire that is sized and treated suitably to ensure electrical performance comparable to that of a copper wire. Thanks to an embodiment, it is possible to make an aluminum wire whose performance has been verified through overheating tests pursuant to product standard EN61439-6. Thanks to an embodiment, it is possible to make an aluminum wire that offers comparable performance to that of a copper wire, and that allows the production costs to be reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The features and advantages of the present disclosure will become clearer from the following detailed description of a possible practical embodiment, illustrated as a nonlimiting example in the set of drawings, in which:

- figure 1 shows a flow diagram of the steps of the process according to the present invention,
- figure 2 shows a block diagram of the components of a plant able to be used to perform the process of

figure 1.

[0017] The device illustrated in the attached figures must be considered to be schematically represented, not necessarily to scale and not necessarily with the represented proportions between the various constituent elements.

DETAILED DESCRIPTION

[0018] Even where not explicitly highlighted, the single characteristics described in reference to the specific embodiments should be considered as accessory and/or interchangeable with other characteristics, described in reference to other embodiments.

[0019] The object of the present invention is a process for continuous electrochemical tinning of an aluminum wire 1.

[0020] The process comprises a step of providing an aluminum wire 1, and in particular a first coil 2 of aluminum wire 1 and a second coil 3 configured to rotate and to be operatively coupled with the aluminum wire of the first coil 2. In detail, when the second coil 3 (or winder) rotates, it pulls the aluminum wire 1 making it run from the first coil 2 towards the second coil 3, thus winding the aluminum wire on the second coil 3. In this way, the first coil 2 (or unwinder) rotates through the effect of the traction force exerted on the aluminum wire 1 by the second coil 3 (or winder), thus unwinding the aluminum wire 1 from the first coil 2.

[0021] In other words, the aluminum wire is in traction between the first coil 2 and the second coil 3. The second coil 3 winds the wire that is thus unwound from the first coil 2. Alternatively, both the first coil 2 and the second coil 3 can be set in rotation simultaneously to make the aluminum wire 1 run.

[0022] The process comprises the step of performing a pickling of the aluminum wire 1. In particular, the aluminum wire is made to pass through a pickling tank 4 containing a solution comprising caustic soda and gluconate, and having a temperature comprised between 40°C and 80°C. Preferably, the pickling tank 4 is configured to allow the aluminum wire 1 to run through it, keeping the aluminum wire 1 immersed in the solution of caustic soda and gluconate.

[0023] In accordance with a preferred embodiment of the present invention, the solution of caustic soda and gluconate has a concentration comprised between 25g/l and 35g/l and a temperature comprised between 50°C and 70°C. As specified earlier, the aluminum wire 1 is completely immersed in the solution of caustic soda and gluconate when it runs through the pickling tank 4. It should be specified that the aluminum wire 1 runs through the pickling tank 4 thanks to the synergic movement of the first coil 2 and of the second coil 3. This step allows both the cleaning and the activation of the material of which the aluminum wire 1 consists.

[0024] Preferably, the pickling tank 4 comprises means

configured for measuring and regulating the temperature of the pickling solution contained in it. Even more preferably, the means comprise pulleys and guides adapted for keeping the aluminum wire 1 immersed in the solutions contained in each treatment tank, and for allowing the aluminum wire 1 to run through the plurality of tanks.

[0025] In accordance with a preferred solution, the pickling step of the aluminum wire 1 is followed by a washing step, this washing step in turn preferably preceded by a pre-washing step of the aluminum wire 1.

[0026] Advantageously, the pickling step of the aluminum wire 1 makes it possible to remove the oxide layers present on the surface of the wire, so as to make the surface suitable for coating with successive metallic layers (e.g. copper, tin) by electrolytic galvanization.

[0027] The process also comprises a step of carburizing the aluminum wire 1 obtained from the pickling step, carried out by passing the aluminum wire 1 through a carburization tank 5 containing a solution comprising zinc, caustic soda, and preferably additives, and having a temperature comprised between 15°C and 50°C. Preferably, the carburization tank 5 is configured to allow the aluminum wire 1 to run through it, keeping the aluminum wire 1 immersed in the solution of zinc, caustic soda and additives.

[0028] In accordance with a preferred embodiment, the solution of zinc, caustic soda and additives has a concentration comprised between 18% and 22% in volume and a temperature comprised between 20°C and 45°C.

[0029] Preferably, the aluminum wire 1 is completely immersed in the solution of zinc, caustic soda and additives when it runs inside the carburization tank 5.

[0030] In accordance with a preferred solution, the step of carburizing the aluminum wire is followed by a washing step, this washing step in turn preferably preceded by a pre-washing step of the aluminum wire 1.

[0031] Preferably, the carburization tank 5 comprises means configured for measuring and regulating the temperature of the carburization solution contained in it. Advantageously, the step of carburizing the aluminum wire 1 allows the surface of the wire itself to be prepared for the application of successive galvanic coating layers. The process comprises a step of performing alkaline copper plating (i.e. by electrolytic galvanization) of the aluminum wire 1 obtained from the carburizing step, by making the aluminum wire 1 pass through an alkaline copper plating tank 6 containing a solution comprising copper and conducting salts, and having a temperature comprised between 50°C and 70°C and an applied voltage value comprised between 2V and 4V. Preferably, the alkaline copper plating tank 6 is configured to allow the aluminum wire 1 to run through it, always keeping the aluminum wire 1 immersed in the solution of copper and conducting salts.

[0032] In accordance with a preferred embodiment, the solution of copper and conducting salts has a temperature comprised between 60°C and 65°C and an applied voltage value comprised between 2.7V and 3.2V, and

has a concentration comprised between 14g/l and 17g/l and a pH comprised between 8 and 9.5.

[0033] Preferably, the aluminum wire 1 is completely immersed in said solution of copper and conducting salts when it runs inside the alkaline copper plating tank 6.

[0034] In accordance with a preferred solution, the step of performing alkaline copper plating is followed by a washing step, this washing step in turn preferably preceded by a pre-washing step of the aluminum wire 1.

[0035] Preferably, the alkaline copper plating tank 6 comprises means configured for measuring and regulating the temperature of the alkaline copper plating solution contained in it.

[0036] The process also comprises the step of performing acid copper plating (i.e. by electrolytic galvanization) of the aluminum wire (1) obtained from the alkaline copper plating step, by moving the aluminum wire 1 through an acid copper plating tank 7 containing a solution comprising copper sulfate, sulfuric acid and preferably additives, and having a temperature comprised between 20°C and 40°C and an applied voltage value comprised between 0.8V and 2V. Preferably, the acid copper plating tank 7 is configured to allow the aluminum wire 1 to run through it, always keeping the aluminum wire 1 immersed in the solution of copper sulfate, sulfuric acid and additives.

[0037] In accordance with a preferred embodiment, the solution of copper sulfate, sulfuric acid and additives has a temperature comprised between 25°C and 35°C and an applied voltage value comprised between 1V and 1.5V, and has a concentration of copper sulfate comprised between 180g/l and 220g/l, a concentration of sulfuric acid comprised between 60g/l and 70g/l and a concentration of additives comprised between 2cm³/l and 3cm³/l.

[0038] Preferably, the aluminum wire 1 is completely immersed in the solution of copper sulfate, sulfuric acid and additives when it runs inside the acid copper plating tank 7. In accordance with a preferred solution, the step of performing acid copper plating of the aluminum wire 1 is followed by a washing step, this washing step in turn preferably preceded by a pre-washing step of the aluminum wire 1.

[0039] Preferably, the acid copper plating tank 7 comprises means configured for measuring and regulating the temperature of the acid copper plating solution contained in it.

[0040] The method also comprises the step of performing tinning (i.e. by electrolytic galvanization) of the aluminum wire 1 obtained from the acid copper plating step, by moving the aluminum wire 1 through a tinning tank 8 containing a solution comprising methanesulfonic acid, methanesulfonic tin and preferably brightener, and having a temperature comprised between 15°C and 35°C and an applied voltage value comprised between 0.5V and 2.7V. Preferably, the tinning tank 8 is configured to allow the aluminum wire 1 to run through it, always keeping the aluminum wire 1 immersed in the solution of meth-

anesulfonic acid, methanesulfonic tin and brightener. In accordance with a preferred embodiment, the solution of methanesulfonic acid, methanesulfonic tin and brightener has a temperature comprised between 20°C and 30°C and an applied voltage value comprised between 1.2V and 1.6V, and has a concentration of methanesulfonic acid comprised between 90g/l and 100g/l and a concentration of methanesulfonic tin comprised between 20g/l and 55g/l and a concentration of brightener comprised between 1cm³/l and 2cm³/l.

[0041] Preferably, the aluminum wire 1 is completely immersed in the solution of methanesulfonic acid, methanesulfonic tin and brightener when it runs inside the tinning tank 8.

[0042] In accordance with a preferred solution, the step of tinning the aluminum wire 1 is followed by a washing step, this washing step in turn preferably preceded by a pre-washing step of the aluminum wire 1.

[0043] Preferably, the tinning tank 8 comprises means configured for measuring and regulating the temperature of the tinning solution contained in it.

[0044] In accordance with a preferred embodiment, the aluminum wire 1 is made to move continuously through the series of tanks comprising the pickling tank (4), the carburization tank (5), the alkaline copper plating tank (6), the acid copper plating tank (7) and the tinning tank 8 at a speed comprised between 30m/min and 70m/min. Preferably, after each treatment tank 4-8 there is a washing tank L, and a pre-washing tank (if foreseen) arranged before the washing tank L. Both the washing tank and the pre-washing tank are passed through by the aluminum wire that runs immersed in the respective washing and pre-washing solutions contained in them.

[0045] In accordance with a preferred embodiment, the alkaline copper plating tank 6, the acid copper plating tank 7 and the tinning tank 8 each comprise at least one electrode. Preferably, each electrode is an anode arranged on a basket containing copper or tin depending on the treatment tank. An electric current is passed through the electrodes (e.g. anodes) and the predetermined voltage values are applied for the electrochemical treatment of the respective solutions contained in the treatment tanks.

[0046] Preferably, the process comprises the step of circulating a current of intensity comprised between 120A and 220A in the electrode (e.g. anode).

[0047] Preferably, the intensity of the electrical current in the electrodes (e.g. anodes) is dependent on the advancing speed of the wire. For example, for advancing speeds of the wire of 40m/min, there is an intensity of electric current in the anodes that varies between 130A and 150A, whereas for speed values of the wire of 60m/min, there is an intensity of electric current that varies between 190A and 210A.

[0048] With reference to the example given in figure 1, the process is in the succession of the following steps carried out in the following order: a) providing an aluminum wire 1; b) performing the pickling of the aluminum

wire 1; c) performing the carburization of the aluminum wire 1 obtained from step b; d) performing the alkaline copper plating of the aluminum wire 1 obtained from step c; e) performing the acid copper plating of the aluminum wire 1 obtained from step d; f) performing the tinning of the aluminum wire 1 obtained from step e; g) winding the aluminum wire 1 obtained from step f) onto the second coil 3. The wire continuously passes through the plurality of tanks in series in which the steps of the process listed above are performed in sequence. In a preferred embodiment of the invention, each step is followed by at least one washing step that is performed in suitable washing tanks L arranged downstream of each treatment tank (figure 2).

[0049] The present invention also refers to a plant 9 able to be used to perform the process described above (figure 2).

[0050] The plant 9 comprises a plurality of tanks that are mutually distinct and arranged in series. The plurality of tanks comprises: a pickling tank 4 containing a pickling solution, a carburization tank 5 containing a carburization solution, an alkaline copper plating tank 6 containing an alkaline copper plating solution, an acid copper plating tank 7 containing an acid copper plating solution and a tinning tank 8 containing a tinning solution. The alkaline copper plating tank 6, the acid copper plating tank 7 and the tinning tank 8 comprise at least one electrode each, preferably at least one anode each.

[0051] The plant 9 also comprises a first coil 2 of aluminum wire 1, and a second coil 3 operatively coupled with the first coil 2. The second coil 3 is configured to rotate so as to pull and make the aluminum wire 1 move from the first coil 2 to the second coil 3, so as to unwind the aluminum wire 1 from the first coil 2 to wind it up on the second coil 3. The first coil 2 and the second coil 3 are configured to move the aluminum wire 1 continuously through the plurality of tanks arranged in series. Preferably, the second coil 3 is set in rotation through an electric motor. As an example, the first coil 2 is the coil with which the aluminum wire 1 to be treated with the process of the present invention is supplied, whereas the second coil 3 is the coil onto which the tinned aluminum wire according to the process of the present invention is wound. Preferably, the plurality of tanks comprises means adapted for keeping the aluminum wire 1 always immersed in the respective solutions contained in them. In other words, the plurality of tanks comprises treatment tanks that are mutually separate and arranged in series. Each treatment tank is filled with a predetermined volume of a respective solution, and is configured both to allow the aluminum wire 1 to run inside it, and to keep the aluminum wire 1 immersed in the solution.

[0052] Advantageously, the speed of movement of the aluminum wire 1 can be adjusted during the operation of the plant 9 to determine the exposure time of the aluminum wire 1 to each solution.

[0053] In accordance with a preferred embodiment, the process foresees to perform a washing step of the alu-

minum wire 1 after each of the steps of the aforementioned process. Preferably, the liquids used in the washing steps are treated and purified through a demineralizing apparatus for example made up of a plurality of demineralisers (e.g. for tin, acid copper, alkaline copper, pickling and carburization) arranged near to the single washing tanks L. Preferably, each washing step is preceded by a pre-washing step of the aluminum wire 1. Advantageously, the washing step carried out after each treatment makes it possible both to eliminate the deposit of liquids on the aluminum wire 1, and to avoid carrying substances and consequently polluting the solutions contained in the subsequent tanks. Indeed, the washing step of the aluminum wire 1 is a critical aspect for the process, particularly relative to the first two pickling and carburization tanks 4,5. As stated above, a preferred embodiment of the plant 9 foresees the presence of a pre-washing tank arranged in series before each washing tank L, so as to optimize the washing step itself.

[0054] Preferably, the pre-washing water of the first two baths, being particularly critical, are replaced frequently.

[0055] In accordance with an embodiment of the plant 9, the solutions are kept in separate storage tanks from the plurality of tanks of the plant 9. When the plant 9 is started up, the solutions are taken from the storage tanks through a system of pipes and valves, and taken into the respective treatment tanks. In this step, the treatment tanks of the plant 9 are filled so that both the aluminum wire 1 to be treated and the anodes are perfectly immersed in the solutions contained in them.

[0056] Advantageously, the process object of the present invention makes it possible to make an aluminum wire 1 that is tinned uniformly, which has the following characteristics: good adherence of the copper-tin applied layer, adequate thickness of the coating and uniformity of the surface.

[0057] Periodically, the process comprises a step in which the copper-tin applied layer is controlled with metallographic section.

[0058] Preferably, the thickness of the copper layer that coats the aluminum wire 1 is comprised between 1 μm and 2 μm , whereas the thickness of the tin layer is comprised between 1 μm and 3 μm .

[0059] Advantageously, it is possible to determine the exposure time of the aluminum wire 1 to the solutions contained in the tanks, both by varying the advancement speed of the wire (i.e. through the rotation speed of the coils 2 and 3), and by suitably sizing the treatment tanks. In other words, it is possible to determine the thickness of the copper and tin layer by suitably adjusting the aforementioned parameters.

[0060] It should be noted that the Applicant has carried out adhesion tests through rubbing, in accordance with the standard UNI EN ISO 2819, with a positive outcome on aluminum wires treated with different advancement speeds.

[0061] Accelerated corrosion tests were also carried

out through the Machu test, also in this case on aluminum wires coated with copper-tin treated with different advancing speeds, obtaining positive results.

[0062] Furthermore, a corrosion resistance test in a humid chamber was also performed according to the standard UNI EN ISO 6270-1, with a positive outcome.

[0063] Advantageously, the plant 9 operates continuously. Indeed, before the first coil 2 to be treated has completely run out, it is possible to proceed to join the aluminum wire with a sacrificial wire or with an aluminum wire of the next coil through brass joins or through cold welding. In this way, it is possible to stable join the two ends of the two wires, aluminum-sacrificial or aluminum-aluminum. For example, during the passage of the sacrificial, the speed of the wire is reduced. In the case of the plant 9 being switched off for a medium-long time period (e.g. 2-3 days), the aluminum wire can be completely replaced by a sacrificial wire, so as to never lose the continuity of the production process. Advantageously, it is possible to make a process that allows the aluminum wire to be treated continuously, allowing different stationed timed in the various tanks and in the washing steps without ever interrupting the process.

[0064] Advantageously, it is possible to make an aluminum wire 1 that has tinning over the entire surface thereof, which protects the material from oxidation and makes it possible to have a better interface in the electrical contact area.

[0065] Advantageously, it is possible to make an aluminum wire 1 that is suitably sized to ensure comparable electrical performance to that of a copper wire, by performing a sizing of the diameter of the wire and of the thickness of the copper and tin coating layers. Advantageously, it is possible to make an aluminum wire 1 the performance of which has been verified through overheating tests foreseen by the product standard EN61439-6. Thanks to an embodiment, it is possible to make an aluminum wire 1 that offers comparable performance to that of a copper wire, and which makes it possible to reduce the costs both thanks to the lower price per kilo of aluminum with respect to copper, and thanks to the smaller amount of material necessary (for example, roughly half of the material is need for the same length of wire, with increased aluminum wire diameter with respect to that of copper).

[0066] Of course, those skilled in the art can bring numerous modifications to the variants described earlier, in order to satisfy contingent and specific requirements, all of which are in any case covered by the scope of protection as defined by the following claims.

Claims

1. Process for continuous electrochemical tinning of an aluminum wire (1), comprising the steps of:

a) - providing an aluminum wire (1),

b) - performing pickling of said aluminum wire (1) by moving said aluminum wire (1) through a pickling tank (4) containing a solution comprising caustic soda and gluconate, and having a temperature comprised between 40°C and 80°C,

c) - performing carburization of said aluminum wire (1) obtained from said step b) by moving said aluminum wire (1) through a carburization tank (5) containing a solution comprising zinc and caustic soda, and having a temperature comprised between 15°C and 50°C,

d) - performing alkaline copper plating of said aluminum wire (1) obtained from said step c) by moving said aluminum wire (1) through an alkaline copper plating tank (6) containing a solution comprising copper and conducting salts, and having a temperature comprised between 50°C and 70°C and an applied voltage value comprised between 2V and 4V,

e) - performing acid copper plating of said aluminum wire (1) obtained from said step d) by moving said aluminum wire (1) through an acid copper plating tank (7) containing a solution comprising copper sulphate and sulfuric acid, and having a temperature comprised between 20°C and 40°C and an applied voltage value comprised between 0,8V and 2V,

f) - performing tinning of said aluminum wire (1) obtained from said step e) by moving said aluminum wire (1) through a tinning tank (8) containing a solution comprising methanesulfonic acid and methanesulfonic tin, and having a temperature comprised between 15°C and 35°C and an applied voltage value comprised between 0,5V and 2,7V.

2. Process according to claim 1, wherein

- said solution of caustic soda and gluconate has a concentration comprised between 25g/l and 35g/l and a temperature comprised between 50°C and 70°C,

- said aluminum wire (1) is completely immersed in said solution of caustic soda and gluconate.

3. Process according to claim 1 or 2, wherein

- said solution of zinc and caustic soda comprises additives,

- said solution of zinc, caustic soda and additives has a concentration comprised between 18% and 22% in volume and a temperature comprised between 20°C and 45°C,

- said aluminum wire (1) is completely immersed in said solution of zinc, caustic soda and additives.

4. Process according to any one of the preceding claims, wherein

- said solution of copper and conducting salts has a temperature comprised between 60°C and 65°C and an applied voltage value comprised between 2,7V and 3,2V, and has a concentration comprised between 14g/l and 17g/l and a pH comprised between 8 and 9,5,
- said aluminum wire (1) is completely immersed in said solution of copper and conducting salts.

5. Process according to any one of the preceding claims, wherein

- said solution of copper sulphate and sulfuric acid comprises additives,
- said solution of copper sulphate, sulfuric acid and additives has a temperature comprised between 25°C and 35°C and an applied voltage value comprised between 1V and 1,5V, and has a concentration of copper sulphate comprised between 180g/l and 220g/l and a concentration of sulfuric acid comprised between 60g/l and 70g/l and a concentration of additives comprised between 2cc/l and 3cc/l,
- said aluminum wire (1) is completely immersed in said solution of copper sulphate, sulfuric acid and additives.

6. Process according to any one of the preceding claims, wherein

- said solution of methanesulfonic acid and methanesulfonic tin comprises brightener,
- said solution of methanesulfonic acid, methanesulfonic tin and brightener has a temperature comprised between 20°C and 30°C and an applied voltage value comprised between 1,2V and 1,6V, and has a concentration of methanesulfonic acid comprised between 90g/l and 100g/l and a concentration of methanesulfonic tin comprised between 20g/l and 55g/l and a concentration of brightener comprised between 1cc/l and 2cc/l,
- said aluminum wire (1) is completely immersed in said solution of methanesulfonic acid, methanesulfonic tin and brightener.

7. Process according to any one of the preceding claims, wherein each step of said process is followed by at least one washing step of said aluminum wire (1).

8. Process according to any one of the preceding claims, wherein said aluminum wire (1) is made to move continuously through a plurality of tanks arranged in series at a speed comprised between

30m/min and 70m/min, said plurality of tanks comprising said pickling tank (4) and said carburization tank (5) and said alkaline copper plating tank (6) and said acid copper plating tank (7) and said tinning tank (8).

9. Process according to any one of the preceding claims, wherein

- said alkaline copper plating tank (6) and said acid copper plating tank (7) and said tinning tank (8) comprise at least one electrode each,
- said process comprises the step of circulating in said at least one electrode a current of intensity comprised between 120A and 220A.

10. Plant (9) for carrying out a process for continuous electrochemical tinning of an aluminum wire (1) according to any one of the preceding claims, said plant (9) comprising:

- a plurality of tanks distinct from each other and placed in series,
- a first coil (2) of aluminum wire (1) and a second coil (3) operatively coupled with said first coil (2) and configured to rotate so as to move said aluminum wire (1) from said first coil (2) to said second coil (3), so as to unwind said aluminum wire (1) from said first coil to wind it on said second coil (3),
- said first coil (2) and said second coil (3) are configured to move said aluminum wire (1) continuously through said plurality of tanks placed in series and containing respective solutions,
- said plurality of tanks comprises a pickling tank (4) containing a pickling solution, a carburization tank (5) containing a carburization solution, an alkaline copper plating tank (6) containing an alkaline copper plating solution, an acid copper plating tank (7) containing an acid copper plating solution and a tinning tank (8) containing a tinning solution, said alkaline copper plating tank (6) and said acid copper plating tank (7) and said tinning tank (8) comprise at least one electrode each,
- said plurality of tanks comprises means adapted to keep said aluminum wire (1) immersed in the respective solutions contained therein.

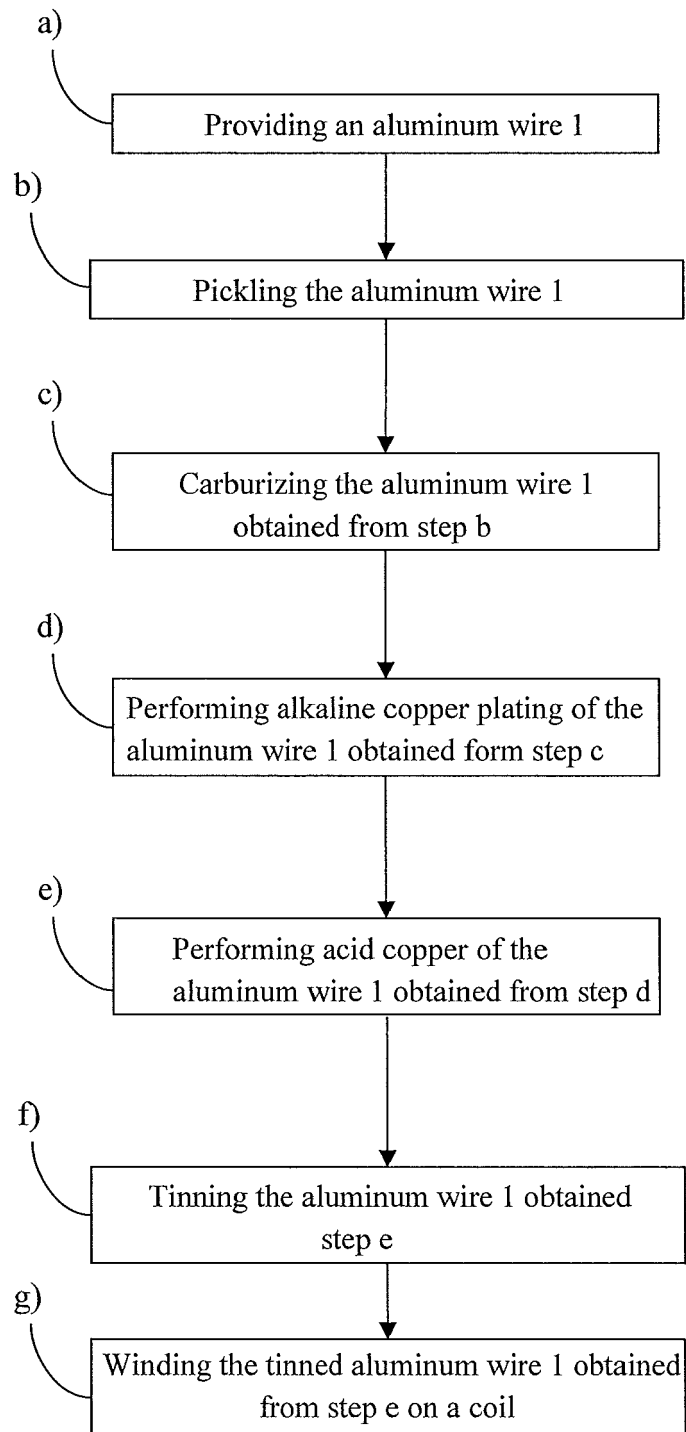


Fig. 1

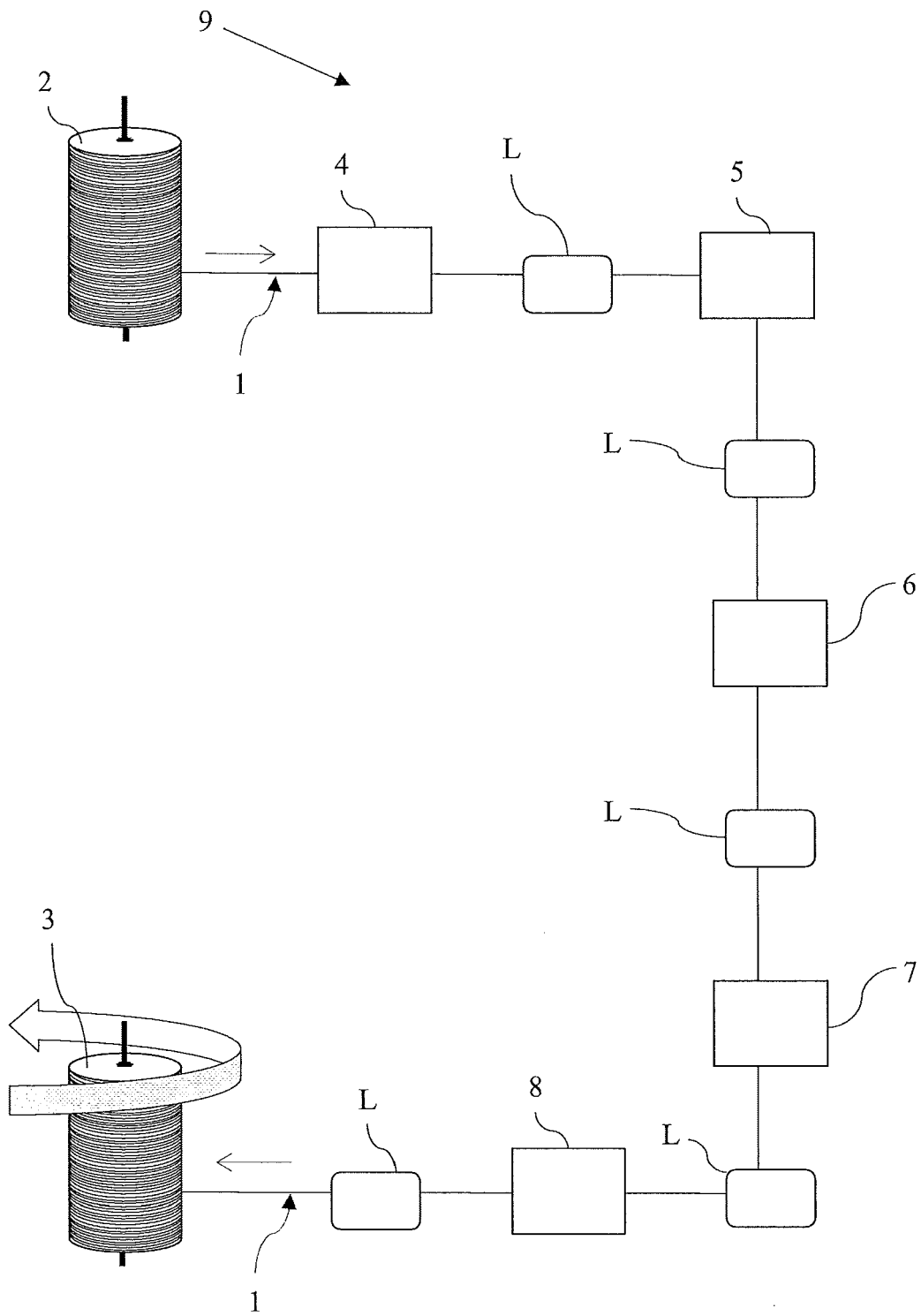


Fig. 2



EUROPEAN SEARCH REPORT

 Application Number
 EP 16 16 2541

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 94/13866 A1 (AXON CABLE SA [FR]; YU NING [FR]) 23 June 1994 (1994-06-23) * abstract * * page 5, line 4 - page 7, line 18 *	1-9	INV. C25D5/10 C25D5/44 C25D7/06
X	GB 1 464 048 A (ASS ELECT IND) 9 February 1977 (1977-02-09) * claim 14 *	10	
A	* page 3, lines 1-76 *	1-9	
X	US 2 509 117 A (WALLACE EDWARD H) 23 May 1950 (1950-05-23) * figure 2 *	10	
X	US 3 622 470 A (GOWMAN LAWRENCE P) 23 November 1971 (1971-11-23) * figure 1 *	10	
			TECHNICAL FIELDS SEARCHED (IPC)
			C25D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 27 May 2016	Examiner Haering, Christian
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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