

[54] ONE-SIDE ELECTROCOATING

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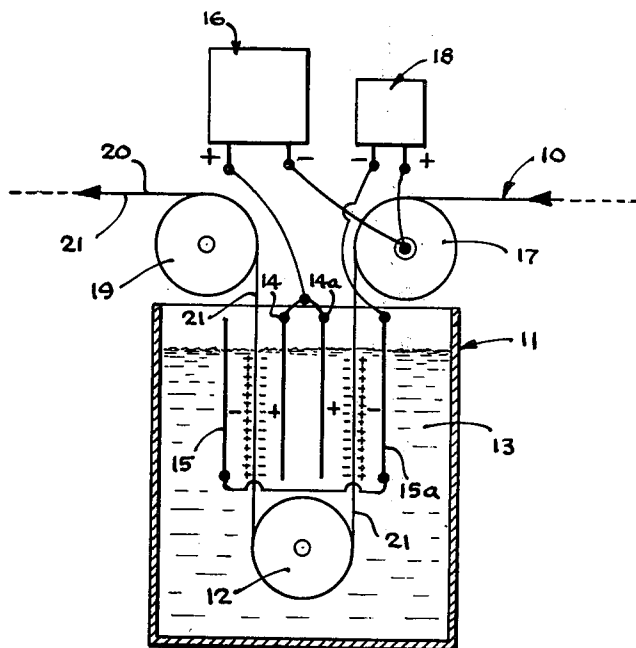
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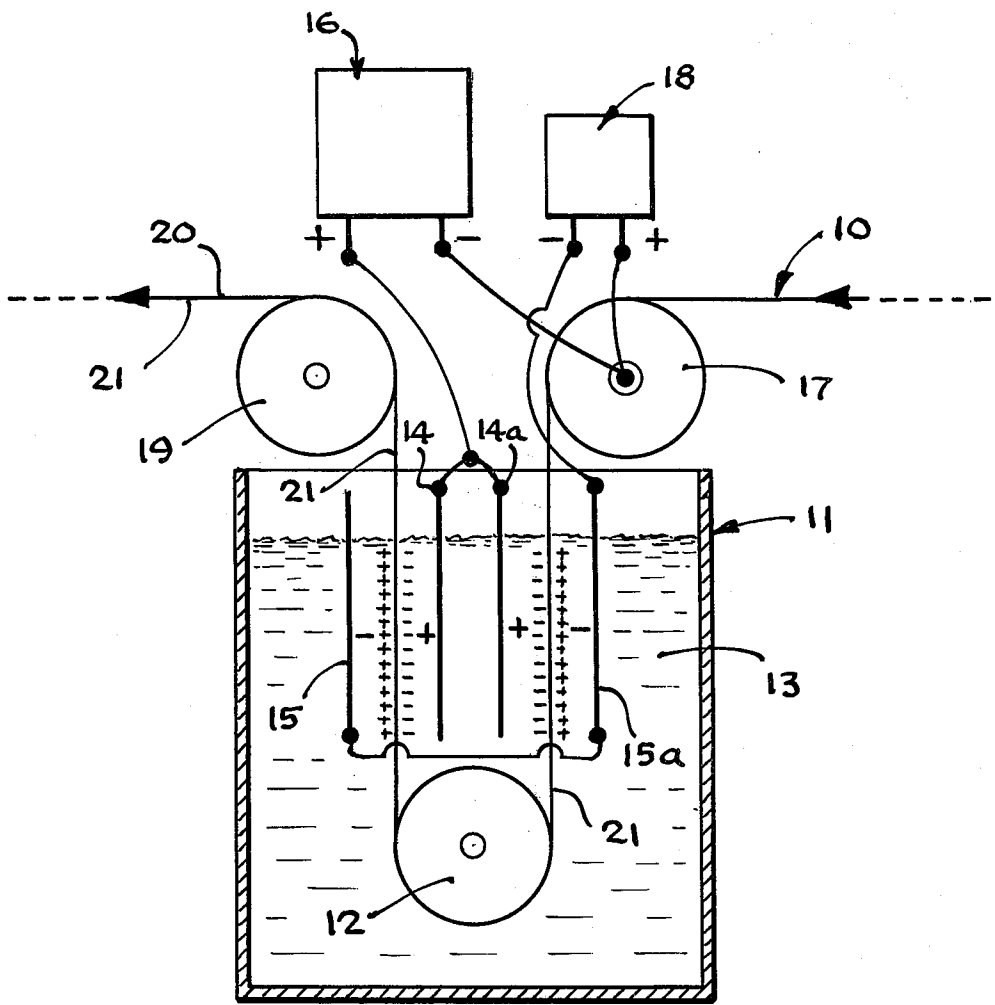
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ABSTRACT

A process of continuously electrolytically coating a metal strip on one-side-only while immersed in electrolyte containing the coating material by connecting the strip to the negative terminal of a plating rectifier with the positive terminal of the rectifier being connected to an anode disposed adjacent the one side of the strip to be plated, maintaining the other side of the strip which is not to be plated anodic by connecting the strip to the positive terminal of an etching rectifier with the negative terminal of the etching rectifier being connected to a cathodic electrode disposed in the electrolyte adjacent the side of the strip which is not to be plated, and setting the output of the plating rectifier at a level sufficient to deposit the required coating weight on the one side of the strip while the strip is moved continuously through the electrolyte, and regulating the output of the etching rectifier to a level below the output of the plating rectifier but sufficient to prevent objectionable "wrap-around" of coating material along the longitudinal edges of the strip and preferably at a level about one-tenth to one-third that of the plating rectifier. Any metal capable of being electrolytically deposited on a metal strip can be one-side-coated by the present process, and the strip can also be electropainted using a conventional electropaint bath.

5 Claims, 1 Drawing Figure





ONE-SIDE ELECTROCOATING

The present invention relates generally to a process of electrocoating an electrically conductive strip on only certain portions of the surface thereof, and more particularly to a process of continuously electrolytically applying a protective or decorative coating to an electrically conductive metal strip by electroplating a metal or electropainting an organic coating material on only one side thereof.

It is frequently desirable to coat a metal strip, such as an endless steel strip, with a protective or decorative coating on one-side-only so that the opposite side of the strip remains free of the coating material. For example, where steel sheet material is to be used for making automobile bodies, it is desirable to provide one side of the sheet material with a coating of zinc to reduce corrosion, while the other surface of the material remains free of zinc so that the surface can be satisfactorily painted or lacquered.

When a steel strip is continuously electroplated in accordance with presently available one-side electroplating procedures, however, it is difficult to avoid depositing zinc on both sides of the steel strip, particularly along the longitudinal edges of the strip, and producing what is called the "wrap-around" effect. Many attempts have been made to overcome or minimize the "wrap-around" effect, such as using various types of current shields or barriers to limit the flow of electroplating current. Processes which rely on inducing a bipolar charge on the strip, such as disclosed in Japanese Pat. No. 8957 of 1963 issued Hitachi, have objectionable features which preclude certain commercial applications thereof.

It is therefore an object of the present invention to provide an improved process of electrolytically depositing metal or an organic electropainting material on limited portions of the surface of an electrically conductive metallic strip without requiring the use of current shields or barrier coatings.

It is a further object of the present invention to provide a continuous process of electroplating a metal strip on a continuous electroplating line which coats only a limited portion of the surface thereof without effecting substantial changes in the electrolyte composition or requiring extensive changes in the operating conditions and apparatus conventionally used on a continuous electroplating line.

It is a still further object of the present invention to provide a continuous process of electrodepositing an organic electropainting material on only a limited portion of the surface of an electrically conductive strip in a continuous electrolytic painting line without effecting substantial changes in the electropainting bath composition or requiring extensive changes in the operating conditions and apparatus conventionally used on a continuous electropainting line.

Other objects of the present invention will be apparent to those skilled in the art from the following detailed description and appended claims when read in conjunction with the accompanying drawing showing a schematic vertical sectional view of a continuous in-line electrolytic coating apparatus for continuously coating an electrically conductive strip in accordance with the present invention.

In achieving one of the objects of the present invention a metal sheet, such as a strip of cold rolled low car-

bon steel conventionally used for electrogalvanizing, after cleaning and treating in any conventional manner to prepare the strip for electroplating, is electroplated on one-side-only by immersing the metal strip in an aqueous electrolyte having disposed therein means for electrically connecting the strip and spaced anodic and cathodic electrodes disposed on opposite sides of the strip with two separate electrical power sources so as to provide a "plating circuit" which maintains the one surface of the strip to be electroplated cathodic and an "etching circuit" which maintains the opposite surface of the strip which is not to be plated anodic.

In order to provide the required "plating circuit" in which only the surface of the metal strip to be plated is made cathodic, the metal strip is electrically connected by any suitable means with the negative terminal of a plating rectifier providing a source of direct cathodic electroplating current, as in a conventional electroplating process, and the positive terminal of the plating rectifier is connected with an anodic electrode disposed adjacent but spaced from the surface which is to be electroplated. The "etching circuit" which delimits the surface area electroplated by the plating circuit is established by connecting the positive terminal of an etching rectifier with the metal strip, and the negative terminal of the etching rectifier is connected to a cathodic electrode disposed in spaced relationship with the strip on the side of the strip opposite to that on which the anodic electrode is placed. Thus, the complete "plating circuit" in the present process comprises: (1) the plating rectifier negative terminal electrically connected with the metal strip, (2) the one lateral surface of the said metal strip which is electroplated, (3) the anodic electrode facing the lateral surface of the strip which is electroplated, (4) the positive terminal of the plating rectifier which is electrically connected with the anodic electrode, and (5) the plating electrolyte in which the strip and electrode are immersed. And, the complete "etching circuit" comprises: (1) the etching rectifier positive terminal which is connected with the metal strip, (2) the other lateral surface of the said metal strip which is opposite to the surface electroplated, (3) the cathodic electrode which faces the lateral surface of the strip which is not electroplated, (4) the etching rectifier negative terminal electrically connected with the cathodic electrode, and (5) the plating electrolyte in which the strip and electrode are immersed. Each of the foregoing plating and etching circuits can be varied independently, as will be described hereinafter, for controlling the amount of electroplating "wrap-around" and etching of the unplated surface of the strip.

In the process of the present invention the surface of the metal strip facing the anodic electrode is maintained negatively charged (i.e. cathodic) by the plating circuit and is readily electroplated, as a result of the positive metal ions in the electrolyte being attracted to the negatively charged (i.e. cathodic) surface of the strip. The opposite surface of the strip facing the cathodic electrode is maintained positively charged (i.e. anodic) by the etching circuit and repels the positively charged metallic ions in the electrolyte so that this surface remains free of plating metal, and is etched as a result of withdrawal of ferric metal ions from the surface of the metal strip during the electroplating process.

The electrolyte in the present process preferably has the same compositions as in a conventional cathodic

electroplating process, and the electrolyte is allowed to circulate freely about the metal strip in the electroplating chamber without the necessity of providing two baths having different compositions contacting the opposite sides of the metal sheet. The concentration of the plating metal ions in the electrolyte can be most conveniently maintained at a desirable level by forming the anodic electrode of material having the same composition as the metal coating to be plated on the sheet. The cathodic electrode can be of any electrically conductive material which is non-reactive in the electrolyte bath and can be formed of carbon, lead, stainless steel or a like metal which is inert to the electrolyte.

As an illustration of a specific application of the present invention and using the apparatus illustrated in the drawing, a cold rolled low carbon thin endless steel strip 10 is one-side electrogalvanized continuously bypassed the strip 10 continuously through an electroplating tank 11 and around a sink-roll 12 the surfaces of which are formed of electrical insulating material and with the tank 11 containing a conventional zinc plating electrolyte 13. Immersed in the electrolyte 13 are two spaced planar anodic (+) electrodes 14, 14a disposed facing one of the lateral surfaces of the strip, such as the upper surface 20 which is to be electroplated, and two planar cathodic (−) electrodes 15, 15a are disposed on the other side of the strip 10 directly opposite the anodic electrodes 14, 14a, respectively, facing the opposite or lower surface 21 which is not electroplated. Each of the electrodes is spaced sufficiently from strip 10 to allow free circulation of the electrolyte so as to maintain a uniform composition throughout the electrolyte 13, and preferably each electrode is spaced uniformly between about one and one-half to five inches from the surfaces of the steel strip 10.

The anodic electrodes 14, 14a are connected with the positive terminal of a source of direct current, such as the plating rectifier 16, while the negative terminal thereof is connected with roll 17 which forms an electrical contact with the strip 10. The cathodic electrodes 15, 15a are connected with the negative terminal of an etching rectifier 18 which provides an independent source of direct current which has the positive terminal thereof connected with the contact roll 17.

The anodic electrodes 14, 14a are preferably formed of the metal being plated, and the cathodic electrodes 15, 15a are formed of lead but can be formed of carbon, stainless steel or like electrically conductive material inert toward the electrolyte. All the electrodes are of the same width and have a width substantially equal to the width of the steel strip 10 being electroplated. The oppositely disposed surfaces of the electrodes have substantially equal areas, and the electrodes 14, 14a and 15, 15a, respectively, and the steel strip 10 are preferably parallel with the mid-points thereof in substantially the same vertical plane. The sink roll 12, the electrical contact roll 17, and guide roller 19 maintain the strip 10 midway between the electrodes 14, 14a and 15, 15a as the strip is passed through the tank 11.

An electrical current sufficient to provide a current density corresponding to that employed in a conventional cathodic continuous electroplating process which provides the desired coating weight is applied to the strip 10 by the plating rectifier 16 through the electrical contact roll 17. The current output of the etching rectifier 18 is adjusted to a level substantially lower

than the ampere output of the plating rectifier 16 so that substantially less electric current is applied by the etching circuit to the strip 10 than is applied to the strip 10 by the plating rectifier 16. Metal is electrodeposited on the negatively charged upper surface 20 which comprises one of the elements in the plating circuit. The lower surface 21 which comprises one of the elements of the etching circuit remains entirely free of zinc, because the surface 21 is positively charged, repelling the positively charged metal ions in the electrolyte, and is also etched as a result of having ferrous metal ions removed from the surface thereof by means of an etching or reverse electroplating current.

The ampere output of the etching rectifier 18 is varied to control the degree of "wrap-around" formed on the strip. For example, if in a particular electroplating process where no etching rectifier current is applied (i.e. the etching circuit is inactive) and the "wrap-around" on the surface 21 were relatively large, such as a strip ½ inch wide extending along the longitudinal edges of the metal strip 10, the "wrap-around" can be means of the present process be reduced to a vary narrow unobjectionable band extending along the longitudinal edges or can be restricted precisely to the edge of the strip by applying sufficient electric current by means of the etching rectifier 18 so as to activate the etching circuit to the degree required to reduce or eliminate the "wrap-around."

It will be evident in the above described process that by varying the magnitude of the etching current relative to the plating current, but always maintaining the etching circuit amperage substantially below the amperage of the plating circuit, it is possible to control the amount of iron removed from that surface of the strip which is maintained anodic by the etching circuit in addition to controlling the extent of "wrap-around" on the strip. Thus, when the etching current is maintained, for example, at a level one-tenth the plating current, the amount of iron removed from the anodic surface of the strip will be substantially one-tenth the amount of metal plated on the cathodic surface of the strip. In this way, iron contamination of the plating bath is substantially reduced and controlled.

Tests were conducted on an experimental continuous electroplating line using apparatus having the above described structure and arrangement to simulate production continuous electroplating line operating conditions and using an endless strip of cold rolled low carbon steel about 9 inches wide, wherein the strip was subjected to alkaline cleaning, water rinsing, acid pickling, and water rinsing to prepare the strip for electroplating. In each of the tests the strip was electroplated in accordance with the present invention with the anode being formed of the metal being electroplated and the cathode being formed of lead.

EXAMPLE I

One-Side-Only Zinc Plating

Electrolyte Composition	Oz/gal.	Temp. °F	Range of pH
Zinc sulfate ($\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$)	32-48	75-140	3.5-4.2
Ammonium Chloride (NH_4Cl)	2-4		
Aluminum Sulfate ($\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$)	4		

The endless low carbon steel strip was one-side electroplated using the above described apparatus by having the plating rectifier output adjusted to provide a current density of 30 amp/ft² (asf) with the etching circuit output being controlled to provide 10 asf. A coating of zinc 0.05 mils thick was deposited on only one side of the strip in a total of 1.43 minutes treating time.

In another test run with the foregoing bath and apparatus the plating circuit current was set to provide 300 asf and the rectifier circuit set to provide 30 asf with like results. A zinc coating 0.05 mils thick was electro-deposited on the strip on one side only in a total treating time of 0.145 minutes.

EXAMPLE II

One-Side-Only Nickel Plating

Electrolyte Composition	Oz/gal.	Temp. °F	Range of pH
Nickel Sulfate (NiSO ₄ ·6H ₂ O)	40	90-160	2.0-5.2
Nickel Chloride (NiCl ₂ ·6H ₂ O)	6		
Boric Acid	4-5		

The endless low carbon steel strip was plated in the above described electrolyte and continuous electroplating apparatus, wherein the plating rectifier circuit output was set to provide a current density on the surface to be plated of 60 asf with the etching circuit output set to provide 10 asf. A 0.05 mil thick coating of nickel was deposited on only one side of the strip in a total treating time of 1 minute.

EXAMPLE III

One-Side-Only Nickel Plating

Electrolyte Composition	Oz/gal.	Temp. °F	Range of pH
Nickel Chloride (NiCl ₂ ·6H ₂ O)	32	100-145	0.9-1.1
Boric Acid	4		

The endless low carbon steel strip was plated in the above described electrolyte and continuous electroplating apparatus wherein the plating rectifier output was set to provide a current density of about 500 asf while the etching rectifier output was set to provide about 50 asf. A 0.05 mill thick coating of nickel was plated on only one side of the strip in a total treating time of 0.12 minutes.

In the process of the present invention, the output of the plating rectifier in the preferred embodiments is set at a conventional current output level to provide a current density on the surface to be plated which will effect electrodeposition of the desired coating weight of the metal during the period the strip is immersed in the electrolyte, and the etching circuit is then adjusted to a substantially lower level, preferably at between about 10 to 30% of the output of the plating rectifier, as required in order to effect the desired control of "wrap-around" and etching. The voltage used will vary depending on the current density, the efficiency of the bath, and the spacing, size and configuration of the electrodes. The line speed and the electrolyte temperature can be varied depending on the coating thickness and finish desired. However, in certain embodiments of

the present invention the voltage is preferably controlled, as is the case when electropainting an organic coating material on a ferrous metal surface using the present process.

The foregoing test data are typical of the results obtained when electroplating a steel strip on one-side-only in accordance with the present invention and show that highly satisfactory one-side-only metal electroplating results without "wrap-around" can be produced on a continuous electroplating line using the etching circuit with the electrolyte composition and the cathodic plating circuit in accordance with the operating conditions of a conventional cathodic continuous electroplating line employing only the minor additions and modifications described herein.

Other protective metal coatings and decorative coating materials can be applied to a limited portion of the surface of an electrically conductive article by the process of the present invention in addition to those set forth in the specific examples. Thus, any other metal which is capable of being electroplated from an aqueous bath can be used, including such metals as tin, cadmium, copper, lead, chromium, the noble metals, the rare earth metals, and alloys of any of the foregoing metals. A satisfactory electrolyte composition for electroplating any of the foregoing metals or others can be obtained by referring to a standard electroplating handbook, such as *Electroplating And Related Processes* by J. B. Mohler; publisher: Chemical Publishing Co., NYC, NY; 1969 Ed. It should be also understood that the surface on which the coating metal is electroplated does not have to be a ferrous metal surface, but can be any other metallic surface. Thus, a ferrous metal sheet or strip can be provided with a coating of a non-ferrous metal before one-side electroplating in accordance with the present invention. For example, a ferrous metal strip in one embodiment of the present invention can first be coated on one-side-only or on both sides by any procedure with copper and then the strip can be coated on one-side-only with nickel by the process of the present invention. It will also be understood that any electrically conductive material in addition to a ferrous metal strip, and including chromium plate, aluminum and the like metals, can be one-side coated by the present process whether formed of one electrically conductive metal or of a plurality of layers of electrically conductive metals. Any of the conventional procedures for preparing the surface of the metal for electroplating can be used.

While the specific examples illustrating the present invention show electrolytically coating a strip with a metal, the present invention can also be used to electrodeposit on only one-side of a metal strip an organic electropaint material, such as a water soluble acrylic or epoxy resin, from a conventional electropainting bath composition.

We claim:

1. In a process of continuously electrolytically depositing a coating material on only one lateral surface of a pre-formed elongated flexible metallic strip of electrically conductive material while preventing said coating material depositing on the other lateral surface of said strip as said strip is moved continuously through an electrolyte bath which circulates freely about all surfaces of said strip, the improvement which comprises:

- maintaining the one lateral surface of said strip to be electrolytically coated cathodic by electrically

connecting said strip with a negative terminal of a plating rectifier providing a first source of direct electrical current and connecting the positive terminal of said plating rectifier with an anodic electrode immersed in said electrolyte bath and having said anodic electrode disposed in spaced relationship with and adjacent the said one lateral surface, and adjusting the electrical output of said plating rectifier to a current density level sufficient to maintain said one lateral surface completely cathodic and electrolytically deposit a coating of predetermined thickness on said one lateral surface while said strip remains immersed in said electrolyte bath; and

- b. maintaining the said other lateral surface of said strip anodic by electrically connecting a positive terminal of an etching rectifier providing a second source of direct electrical current with said strip and connecting the negative terminal of said etching rectifier with a cathodic electrode immersed in said electrolyte bath and having said cathodic electrode disposed in spaced relationship with and adjacent said other lateral surface of the said sheet, and adjusting the electrical output of said etching rectifier to a current density level which is sufficient to maintain the said other lateral surface completely anodic and at a current density level below that of said plating rectifier;

whereby said one lateral surface is electrolytically coated with said coating material and said other lateral surface remains electrolytically uncoated by said coating material during the electrodeposition process.

2. A process as in claim 1, comprising adjusting the ampere output of said etching rectifier to a level between about one-tenth and one-third the ampere output of said plating rectifier.

3. A process as in claim 1, wherein said strip is a ferrous metal strip and said electrolyte contains metallic ions selected from the group consisting of zinc and nickel.

4. A process as in claim 1, wherein said strip is a ferrous metal strip and said electrolyte comprises a water

soluble organic resin.

5. In a process of continuously electrolytically treating a pre-formed elongated flexible metallic strip of electrically conductive material in an electrolyte bath which prevents any of the electrolyte bath material depositing on more than one lateral surface of said strip and which etches the other surface of said metallic strip as said strip is moved continuously through a said electrolyte bath circulating freely about all surfaces of said strip, the improvement comprising;

- maintaining the one lateral surface of said strip cathodic by electrically connecting said strip with a negative terminal of a plating rectifier providing a first source of a direct electrical current and connecting the positive terminal of said plating rectifier with an anodic electrode immersed in said electrolyte bath, having said anodic electrode disposed in spaced relationship with and adjacent said one lateral surface, and adjusting the electrical output of said plating rectifier to a current density level sufficient to maintain said one lateral surface completely cathodic while said strip remains immersed in said electrolyte bath; and
- maintaining the said other lateral surface of said strip anodic by electrically connecting a positive terminal of an etching rectifier providing a second source of direct electrical current with said strip and connecting the negative terminal of said etching rectifier with a cathodic electrode immersed in said electrolyte bath, having said cathodic electrode disposed in spaced relationship with and adjacent said other lateral surface of the said sheet, and adjusting the electrical output of said etching rectifier to a current density level which is sufficient to maintain the said other lateral surface completely anodic,
- and controlling the amount of metal ions removed from said other surface during the said etching thereof by controlling the current density level of said etching rectifier relative to the current level of said plating rectifier.

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