

PATENT SPECIFICATION

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(54) ELECTROLYTIC TREATMENT OF METAL SHEET

(71) I, WAI KWANG SHANG, of 501 Wellington House, 3A Wyndham Street, Hong Kong, of British nationality, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method of electrolytically treating a metal sheet, and to apparatus for use in this method. In particular, but not solely, it relates to tin-plating a steel sheet.

Hot dip tinning has been virtually superseded by electrolyte tin plating, which can produce thinner tin coatings of excellent quality. Typical of modern tin plating are the "Halogen" process and the "Ferrostan" process. Both of these processes treat steel strip at the rate of 1,400-2,000 ft/min (totalling 140,000 to 200,000 tons per year) and involve large capital investment.

However, particularly in the developing countries, there are many circumstances in which it would be desirable to be able to tin-plate individual sheets continuously (rather than batch-wise) at the rate of, say, 10,000 to 20,000 tons per year with comparatively simple and inexpensive equipment. It would also be desirable to be able to electrolytically treat individual sheets continuously, but up to now no satisfactory technique has been developed, despite considerable research.

The present invention provides apparatus for use in electrolytic treatment of a ferromagnetic metal sheet, comprising a tank for containing an electrolyte and a conveyor for transporting the sheet across the surface of the electrolyte, the conveyor comprising a series of rollers, each roller having means for producing a magnetic field so that the sheet will be held against the underside of the conveyor by the resulting magnetic force acting on the sheet.

The invention also provides a method of electrolytically treating a ferromagnetic metal sheet, in which the sheet is transported across the surface of a bath of

electrolyte by means of a conveyor comprising a series of rollers, a magnetic field being produced in each roller so that the sheet is held against the underside of the conveyor by the resulting magnetic force acting on the sheet, the lower surface of the sheet being in contact with the electrolyte.

The above-described method and apparatus can be used for electroplating, particularly for plating steel sheet with tin, chromium, or zinc, electrolytic de-greasing, or electrolytic pickling.

The magnetic field producing means may comprise electromagnets or, preferably, permanent magnets. Preferably each roller is tubular and contains permanent magnets spaced along it. Alternatively, some or all of the rollers could be solid and permanently magnetised.

The rollers are preferably exposed at the underside of the conveyor so that the sheet is in contact with the series of rollers. The axes of the rollers should preferably be spaced apart by a distance which is less than one-third of the length of the sheet. It is convenient for the surface of at least one roller to be electrically conductive and to be electrically connected, in use, to a source of electrical power.

Alternatively, the conveyor may include an endless flexible strip passing along the underside of the series of rollers in order to cover the upper surface of the sheet, in order to prevent electrolyte from contaminating the upper surface. In this case it is convenient for the strip to be electrically conductive and to be electrically connected, in use, to a source of electrical power.

The invention will be described further, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 diagrammatically shows a longitudinal section through an apparatus forming part of an electrolytic tin-plating installation;

Figure 2 is an electrical circuit diagram of the apparatus;

Figure 3 is an axial section through part of the length of a roller;

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Figure 4 is a view, similar to Figure 1, of an alternative embodiment of apparatus, and

Figure 5 is a schematic view on line V—V in Figure 4, in conjunction with an electrical circuit diagram.

In the apparatus shown in Figure 1, a rectangular tank 1 contains a conventional electrolyte (stannous chloride solution) as used in the "Halogen" process for tin-plating. The surface 2 of the bath of electrolyte is maintained at a constant level by allowing the electrolyte to overflow from the tank 1. A series of rollers 3 to 9, constituting a conveyor 10, are rotatably mounted transversely of the tank 1 and are equally spaced. The rollers 3 to 9 comprise tubes of titanium or a stainless steel which resists electrodeposition of tin (e.g. 300 series stainless steel). The surface of the middle roller 6 is connected by a sliding contact 14 to the negative pole of a d.c. source 11, whose positive pole is connected to a tin anode 12 immersed in the electrolyte. Each tubular roller 3 to 9 contains permanent magnets 13 comprising barium ferrite ($\text{BaCO}_3/\text{Fe}_2\text{O}_3$) cores 15 mounted between soft iron armatures 20 (Figure 3). The rollers 3 to 9 carry sprockets 16 and are rotatable anticlockwise (as seen in Figure 1) by a chain 17 driven by a drive sprocket 18 and acted on by a tensioning sprocket 19.

A mild steel sheet 21 to be tin-plated, when inserted into the left-hand (Figure 1) end of the tank 1, will be held against the rollers 3 to 9 by the magnetic force acting on the sheet 21 as a result of the magnetic fields produced by the magnets 13. The length of the sheet 21 is preferably more than three times the spacing between the axes of the rollers so that the sheet is maintained horizontal. The rollers 3 to 9 are just above and tangential to the surface 2 of the electrolyte, and therefore only the lower surface of the sheet 21 is in contact with the electrolyte. The rotation of the rollers 3 to 9 forwards the sheet 21 along the underside of the conveyor 10 to the right-hand end of the tank 1, where it is directed out of the tank 1 by a ramp 22. As long as the sheet 21 is in contact with the middle roller 6, the sheet acts as a cathode, so that tin is deposited on its lower surface.

In the complete installation there are, for example, six or twelve (or more) apparatuses as described above, arranged in series. One side of the sheet 21 is plated in the first three or six apparatuses; then the sheet 21 is turned over, and its other side is plated in the last three or six apparatuses.

The electroplated sheet is subjected to a conventional process known as reflowing (or flow-brightening), in which the sheet is passed through a furnace having a temperature of 500—600°C for 1—2 seconds

and immediately quenched in cold water. Reflowed tinplate is mirror bright.

The alternative apparatus illustrated in Figures 4 and 5 has a conveyor 30 which includes chain-driven rollers 26 comprising electrically conductive tubes (e.g. of titanium or stainless steel) each containing magnets 13 as described above with reference to Figure 3. The conveyor 30 also includes a flexible strip 27 which runs on an endless path defined by the driven rollers 26 and two idle rollers 28, the strip being of titanium or of a stainless steel which resists electrodeposition of tin. The strip 27 is tangential to the surface 2 of the electrolyte and is driven across the surface 2 by the rotation of the rollers 26.

On the underside of the conveyor 30, the mild steel sheet 21 is held against the strip 27 by the magnetic force acting on the sheet as a result of the magnetic fields of the magnets 13. The two end rollers 26 (and optionally one or more of the intermediate rollers) are electrically connected, via sliding contacts 29, to the negative pole of the d.c. source 11. Since the strip 27 is electrically conductive, the steel sheet 21 acts as a cathode and tin is deposited on its lower surface.

WHAT I CLAIM IS:—

1. Apparatus for use in electrolytic treatment of a ferromagnetic metal sheet, comprising a tank for containing an electrolyte and a conveyor for transporting the sheet across the surface of the electrolyte, the conveyor comprising a series of rollers, each roller having means for producing a magnetic field so that the sheet will be held against the underside of the conveyor by the resulting magnetic force acting on the sheet.

2. Apparatus as claimed in claim 1, in which the magnetic field producing means comprise electromagnets.

3. Apparatus as claimed in claim 1, in which the magnetic field producing means comprise permanent magnets.

4. Apparatus as claimed in any of claims 1 to 3, in which the rollers are exposed at the underside of the conveyor.

5. Apparatus as claimed in claim 4, in which the surface of at least one roller is electrically conductive.

6. Apparatus as claimed in any of claims 1 to 3, in which the conveyor includes an endless flexible strip passing along the underside of the series of rollers in order to cover the upper surface of the sheet.

7. Apparatus as claimed in claim 6, in which the strip is electrically conductive.

8. A method of electrolytically treating a ferromagnetic metal sheet, in which the sheet is transported across the surface of a bath of electrolyte by means of a conveyor comprising a series of rollers, a magnetic field being produced in each roller so that

Figure 4 is a view, similar to Figure 1, of an alternative embodiment of apparatus, and

Figure 5 is a schematic view on line V—V in Figure 4, in conjunction with an electrical circuit diagram.

In the apparatus shown in Figure 1, a rectangular tank 1 contains a conventional electrolyte (stannous chloride solution) as used in the "Halogen" process for tin-plating. The surface 2 of the bath of electrolyte is maintained at a constant level by allowing the electrolyte to overflow from the tank 1. A series of rollers 3 to 9, constituting a conveyor 10, are rotatably mounted transversely of the tank 1 and are equally spaced. The rollers 3 to 9 comprise tubes of titanium or a stainless steel which resists electrodeposition of tin (e.g. 300 series stainless steel). The surface of the middle roller 6 is connected by a sliding contact 14 to the negative pole of a d.c. source 11, whose positive pole is connected to a tin anode 12 immersed in the electrolyte. Each tubular roller 3 to 9 contains permanent magnets 13 comprising barium ferrite ($\text{BaCO}_3/\text{Fe}_2\text{O}_3$) cores 15 mounted between soft iron armatures 20 (Figure 3). The rollers 3 to 9 carry sprockets 16 and are rotatable anticlockwise (as seen in Figure 1) by a chain 17 driven by a drive sprocket 18 and acted on by a tensioning sprocket 19.

A mild steel sheet 21 to be tin-plated, when inserted into the left-hand (Figure 1) end of the tank 1, will be held against the rollers 3 to 9 by the magnetic force acting on the sheet 21 as a result of the magnetic fields produced by the magnets 13. The length of the sheet 21 is preferably more than three times the spacing between the axes of the rollers so that the sheet is maintained horizontal. The rollers 3 to 9 are just above and tangential to the surface 2 of the electrolyte, and therefore only the lower surface of the sheet 21 is in contact with the electrolyte. The rotation of the rollers 3 to 9 forwards the sheet 21 along the underside of the conveyor 10 to the right-hand end of the tank 1, where it is directed out of the tank 1 by a ramp 22. As long as the sheet 21 is in contact with the middle roller 6, the sheet acts as a cathode, so that tin is deposited on its lower surface.

In the complete installation there are, for example, six or twelve (or more) apparatuses as described above, arranged in series. One side of the sheet 21 is plated in the first three or six apparatuses; then the sheet 21 is turned over, and its other side is plated in the last three or six apparatuses.

The electroplated sheet is subjected to a conventional process known as reflowing (or flow-brightening), in which the sheet is passed through a furnace having a temperature of 500—600°C for 1—2 seconds

and immediately quenched in cold water. Reflowed tinplate is mirror bright.

The alternative apparatus illustrated in Figures 4 and 5 has a conveyor 30 which includes chain-driven rollers 26 comprising electrically conductive tubes (e.g. of titanium or stainless steel) each containing magnets 13 as described above with reference to Figure 3. The conveyor 30 also includes a flexible strip 27 which runs on an endless path defined by the driven rollers 26 and two idle rollers 28, the strip being of titanium or of a stainless steel which resists electrodeposition of tin. The strip 27 is tangential to the surface 2 of the electrolyte and is driven across the surface 2 by the rotation of the rollers 26.

On the underside of the conveyor 30, the mild steel sheet 21 is held against the strip 27 by the magnetic force acting on the sheet as a result of the magnetic fields of the magnets 13. The two end rollers 26 (and optionally one or more of the intermediate rollers) are electrically connected, via sliding contacts 29, to the negative pole of the d.c. source 11. Since the strip 27 is electrically conductive, the steel sheet 21 acts as a cathode and tin is deposited on its lower surface.

WHAT I CLAIM IS:—

1. Apparatus for use in electrolytic treatment of a ferromagnetic metal sheet, comprising a tank for containing an electrolyte and a conveyor for transporting the sheet across the surface of the electrolyte, the conveyor comprising a series of rollers, each roller having means for producing a magnetic field so that the sheet will be held against the underside of the conveyor by the resulting magnetic force acting on the sheet.
2. Apparatus as claimed in claim 1, in which the magnetic field producing means comprise electromagnets.
3. Apparatus as claimed in claim 1, in which the magnetic field producing means comprise permanent magnets.
4. Apparatus as claimed in any of claims 1 to 3, in which the rollers are exposed at the underside of the conveyor.
5. Apparatus as claimed in claim 4, in which the surface of at least one roller is electrically conductive.
6. Apparatus as claimed in any of claims 1 to 3, in which the conveyor includes an endless flexible strip passing along the underside of the series of rollers in order to cover the upper surface of the sheet.
7. Apparatus as claimed in claim 6, in which the strip is electrically conductive.
8. A method of electrolytically treating a ferromagnetic metal sheet, in which the sheet is transported across the surface of a bath of electrolyte by means of a conveyor comprising a series of rollers, a magnetic field being produced in each roller so that



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the sheet is held against the underside of the conveyor by the resulting magnetic force acting on the sheet, the lower surface of the sheet being in contact with the electrolyte.

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9. A method as claimed in claim 8, in which the sheet is in contact with the series of rollers.

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10. A method as claimed in claim 9, in which the axes of the rollers are spaced apart by a distance which is less than one-third of the length of the sheet.

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11. A method as claimed in claim 9 or 10, in which the surface of at least one roller is electrically conductive and is electrically connected to a source of electrical power.

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12. A method as claimed in claim 8, in which the conveyor includes an endless flexible strip passing along the underside of the series of rollers and covering the upper surface of the sheet.

13. A method as claimed in claim 12, in

which the strip is electrically conductive and is electrically connected to a source of electrical power.

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14. A method of electrolytically treating a ferromagnetic metal sheet, substantially as described herein with reference to Figure 1 or Figure 4 of the accompanying drawings.

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15. A ferromagnetic metal sheet treated by a method according to any of claims 8 to 14.

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16. Apparatus for use in electrolytic treatment of a ferromagnetic sheet, substantially as described herein with reference to, and as shown in, Figure 1 or Figure 4 of the accompanying drawings.

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