March 4, 1958 S. S. JOHNSTON 2,825,681

ELECTROPLATING

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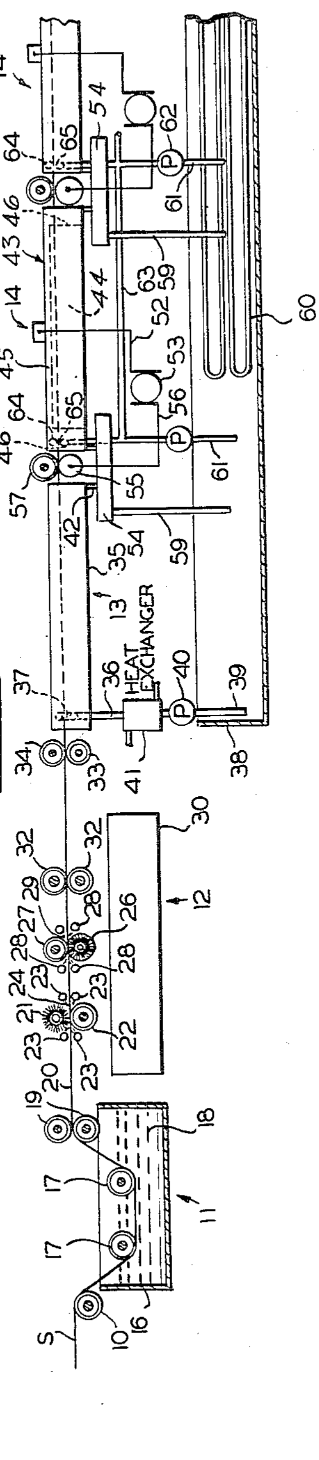

FIG. 1.

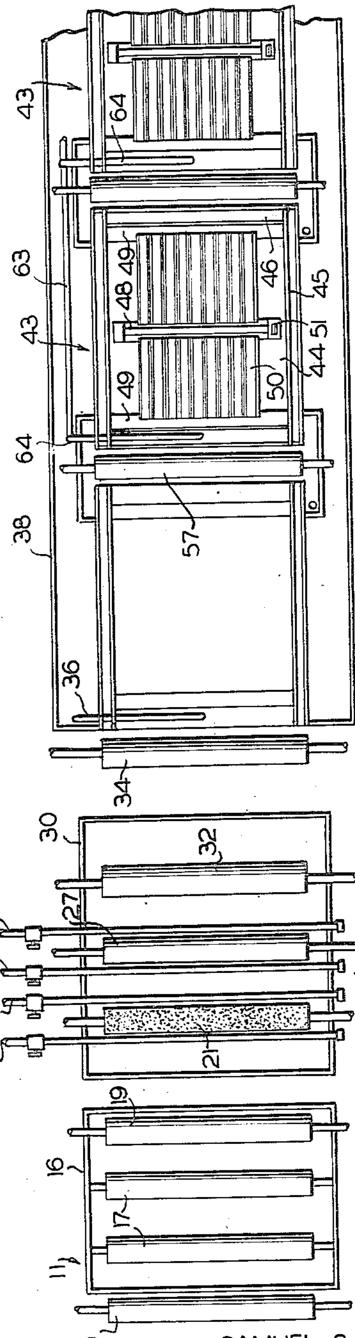

FIG. 2.

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1

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ELECTROPLATING

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3 Claims. (Cl. 204—28)

This invention relates to a method of electroplating strip material with a coating of metal and is primarily concerned with electroplating ferrous metal strip, such as black plate, with a coating of protective metal, such as tin, while the strip is moving at a high speed.

When continuously and progressively electroplating strip steel with tin, the strip is continuously moved through a long electroplating line at speeds of about 1,000 feet per minute to 2000 feet per minute and higher. The electroplating line includes a large number of units disposed along the path of the strip for treating and electroplating the strip while traveling at such high speeds. These units include a unit for cleaning the strip and a unit for scrubbing and washing the cleaned strip to remove any cleaning solution dragged out of the cleaning unit by the strip. In addition, the electroplating line includes a unit for pickling the cleaned and washed strip and a unit for scrubbing and washing the pickled strip with cold water to remove any residual pickle liquor dragged out of the pickling apparatus. This wet, washed strip is then passed through the electroplating unit in which at least one surface of the strip is maintained in contact with a bath of electroplating solution. The electroplating unit may include one, and usually a plurality, of electroplating cells in each of which there is provided one or more tin anodes. As the strip moves across or through the electroplating cells, current is passed from the anodes through the electroplating solution to the strip to deposit thereon a layer of anode metal. The electroplating solution will include at least one electrolyte of the metal which is to be plated. Usually, only a thin film of tin is deposited by the electroplating process and for the tin plated product to have sufficient resistance to attack it is necessary that the coating be of the best quality that can be deposited. Accordingly, it is necessary that the units of the electroplating line including the electroplating unit all be operated at peak efficiency in order to produce satisfactory electro-tinplate. Further, it is difficult to operate such a line at peak efficiency so that at times the quality of the coating will not be satisfactory for reasons which can not be determined. As a result, there is a need for an improved electroplating method and apparatus which will produce better coatings and which will not be as difficult to operate at peak efficiency as has been the case heretofore.

The value of a metal coating such as tin on a base metal depends in a general way on the uniformity of the thickness of coating obtained. Lack of uniformity in the thickness of a metal coating not only adversely affects its protective value but also contributes to a product of poor appearance and renders it unsatisfactory for many uses. Although the exact cause of ununiform thickness of coating is not known in many instances, there are several known types which may be classified by physical appearance. One such type is known as "striation." Striation is a striped or streaked effect running the length of the strip, having no particular fixed pattern, but being of different width along the

2

length of the strip. Striations occur in the center two-thirds portion of the strip, the outer limits of the width of the strip usually being free of striation. Another effect often occurring is one which is referred to as "anode pattern." Anode pattern is a striped effect, the stripes being parallel, fairly uniform in width and running along the length of the strip.

Both striation and anode pattern effects may occur at the same time with the result that the product is highly unsatisfactory from the standpoint of both protective value and appearance.

Accordingly, it is an object of the present invention to provide an improved method of electroplating the conductive surface of material with a metallic coating which may include one or a plurality of metals.

Another object of the present invention is to provide an improved electrodeposited coating of protective metal.

A further object of the present invention is to provide an improved method of electroplating ferrous metal strip with tin.

It is also an object of the present invention to provide an improved method of electroplating strip material at a high rate of speed with a protective coating of metal of superior quality.

A further object of the present invention is to provide an improved method of electroplating strip materials at a high rate of speed with a protective coating of metal of uniform thickness.

Another object of the present invention is to provide an improved method of electroplating strip materials at a high rate of speed with a protective coating of metal relatively free of striation and anode pattern.

These and other objects and advantages will become more apparent when considering the following detailed description, taken with the accompanying drawing, in which:

Figure 1 is a side view, partially in section, diagrammatically showing a portion of a strip plating line embodying the principles of the present invention; and

Figure 2 is a plan view of the apparatus of Figure 1.

In accordance with the present invention, the quality of an electroplated tin coating is improved if, before the wet-washed strip is electroplated, the strip is heated to a temperature of 120 through 160° F. by bringing a heated aqueous solution containing at least one of the electrolytes and preferably all of the electrolytes of tin present in the electroplating solution into intimate contact with the surface to be plated.

It is to be understood that the present invention is not limited to any particular theory but apparently the very thin aqueous film which is present on the washed strip reduces the effectiveness of the electroplating action in the electroplating unit and causes striation. It is not known whether the aqueous film insulates the strip to reduce the current passing to the strip from the anodes, or whether the aqueous film dilutes the electroplating solution adjacent the strip, or whether the aqueous film reduces the quality of the electrodeposit for some other reason. Whatever the exact cause is, it has been discovered that the quality of the plated tin can be improved and striation eliminated by replacing the aqueous film on the washed strip with a film solution that is more nearly like or is substantially the same as the electroplating solution. Film replacement is obtained by physically propelling the tin electrolyte containing solution against the surfaces to be plated. The aqueous rinsing solution is preferably substantially the same as the electroplating solution in so far as the electrolyte or electrolytes of tin are concerned. A rinsing solution containing only a very small amount of tin electrolyte can be used but better results are obtained if the rinsing solution contains about the same amount of the same tin electrolyte present in the tin electroplating solution.

If the aqueous film on the washed strip is simply replaced by a tin electrolyte containing film and the strip is not at a temperature between 120 through 160° F., an anode pattern will result although striation is eliminated. This does not means that the replacement film is the cause of anode pattern as is evident by the fact that this effect occurs without film replacement if the strip temperature is not within the range of 120 through 160° F. It does mean, however, that in order to obtain uniformity of coating thickness, both temperature control of the strip and film replacement are necessary.

Referring to the drawings, the strip S which usually will have been previously cleaned and washed by apparatus, not shown, progressively passes over the rotatably supported, rubber-covered roll **10** to a pickler **11** where the strip is treated in a suitable pickling solution containing one or more acids. The pickled strip then moves to a scrubbing and washing apparatus **12** where the residual pickling solution is washed off by water. The washed strip passes from the scrubber **12** through the rinsing unit **13** and then to the electroplating unit **14** which may be of any suitable type. The electroplating unit **14** may be of the type in which the strip is passed through a bath so that both surfaces are simultaneously electroplated. As is shown in the drawings, electroplating unit **14** is of the type in which the strip is passed across a plurality of electroplating cells in which the lower surface of the strip is in contact with the electroplating bath in each cell so that the lower face is plated with tin. If the opposite surface of the strip is to be plated, the direction of travel is reversed and the strip is brought back across a second series of electroplating cells with the opposite surface facing downwardly and in contact with the electroplating solution in the cells so that this opposite surface is plated with tin. Such an electroplating line is shown in the book entitled "Tinplate" by Hoare and Hedges, 1945, page 263. After the strip has been electroplated with tin, the plated strip may be treated in any desired manner.

The pickling apparatus **11** includes a tank **16** in which there are mounted a pair of rotatable, rubber-covered rolls **17** for depressing the strip S and causing it to pass through the body of pickling solution **18** in the tank **16**. A pair of rotatable, rubber-covered wringer rolls **19** are provided to remove the excess pickle liquor and prevent the strip from dragging an excessive amount of pickling solution out of the tank **16**. When the strip leaves the wringer rolls **19** at **20**, it has thereon a film of pickling solution and it then passes through the scrubber **12** which removes this residual pickling solution. The scrubber includes a first brush **21** and a cooperating lower back-up roll **22**. A plurality of spray pipes **23**, each connected to a source of wash water, are arranged to direct water sprays **24** against the strip as it passes the brush **21**. The scrubber **12** includes a second brush **26** and a cooperating upper back-up roll **27**. A plurality of pipes **28** are each connected to a source of wash water and are arranged to direct streams or sprays of water **29** against the strip as it passes between the brush **26** and the back-up roll **27**. The brushes **21** and **26** may be driven and rotated in a direction opposite to the direction of strip travel. Any suitable means may be provided for driving the brushes. A tank **30** is provided for collecting the excess wash water. A pair of wringer rolls **32** are provided for removing excess liquid from the strip.

Guide rolls **33** and **34** are provided adjacent the rinsing unit **13**. The rinsing unit **13** includes a tank **35** and a source of supply **36** of rinsing solution. The source of supply **36** of rinsing solution is arranged for directing jets or streams of rinsing solution **37** against both sides of the central portion of the strip S as it enters the tank **35**. Rinsing solution **45** is preferably fed to supply means **36** from a recirculating tank **38**. This is done by means of pipeline **39** and pump **40**. The rinsing solution from pump **40** passes through a heat exchanger **41** to the supply means **36**. Heat exchanger **41** will be described more fully hereinafter. An outlet pipe **42** is provided for tank **35** and preferably is valve controlled so as to maintain the body of solution in tank **35** at the proper level. Excess rinsing solution is removed from strip S after passing through the rinsing unit **13** by contact roll **55** and back-up roll **57**.

Electroplating unit **14** includes a plurality of similar electroplating cells **43**, only one of which will be described in detail. The electroplating cell **43** includes a tray **44** having side troughs **45** and end troughs **46** for collecting the overflowing electroplating solution. Electroplating solution is continuously supplied to the tray **44** from a source **38** of electroplating solution by means described hereinafter. The sides of the tray **44** are of such a height as to maintain a body or bath of electroplating solution in the tray with the upper surface at or slightly above the level of the lower surface of strip S. Electroplating solution is constantly fed to the tray to replenish the bath and the solution continuously flows over the sides of the tray **44** into the collecting troughs **45** and **46**. In the tray there is a center anode support **48** and spaced side supports **49** on which are mounted a plurality of anodes **50**, each formed of tin. The center support is provided with electrically conductive surfaces which engage the ends of the anodes **50** and these surfaces are connected through a bus bar **51** and a wire **52** to one side of the generator **53**. Such an arrangement of anodes is shown and described in Patent No. 2,399,254, issued April 30, 1946 to Rieger et al. Below each end of the tray **44** there is a collecting pan **54** and these pans **54** collect the electroplating solution dragged out of the electroplating trays by the strip and also collect the solution from the overflow troughs. At the entrance side of tray **44**, there is a conductive contact roll **55** connected through wire **56** to the other side of generator **53**. A rotatable back-up roll **57** is provided for holding the strip in contact with the contact roll **55**. The sides of the tray **44** are so arranged that the strip is in contact with the upper surface of the body of electroplating solution in the tray so that electrical current flows from the anodes through the electroplating solution to the strip to deposit a layer of tin on the bottom surface of the strip.

The electroplating solution may be of any particular type, for example, the stannous sulphate acid type or any other suitable type which contains one or more tin electrolytes (see United States Patents 2,512,719 and 2,598,-486). The stannous sulphate acid bath, for example, contains stannous sulphate which is an electrolyte of the metal being plated. As the tin ions migrate to and are deposited on the strip which is the cathode, the bath is replenished with tin dissolved from the anodes. Normally, the electroplating solution flows from the collecting trays **54** through drain pipes **59** to a common collecting or recirculating tank **38** which is replenished when necessary with chemicals to maintain the electroplating solution in the proper condition. Tank **38** preferably is located below and extends the combined length of washing unit **13** and the electroplating units **14**. Heat exchanger coils **60** are provided for controlling the temperature of the electroplating solution in tank **38**. The temperature of this electroplating solution will vary in accordance with such conditions as length of time that the line has been in operation since the last shut down, current density being employed for electroplating, ambient temperature, temperature of make-up solution added to the electroplating solution, etc. Consequently, heat exchanger coils **60** may be used either for heating or cooling the electroplating solution as required. Lines **61**, pumps **62**, manifold **63** and jet or spray orifices **64** are provided for supplying electroplating solution to the individual cells **14** at the forward end thereof and physically propelling the same against the central area of both surfaces of the strip.

The rinsing solution **37** contains an electrolyte of tin which is the same as at least one of the tin electrolytes in the electroplating solution. The character of the final coating is improved when the rinsing solution contains tin electrolyte and apparently the reason is that the aqueous film on the strip is replaced with a film of rinsing solution which is more nearly like the electroplating solution. The greatest degree of improvement is obtained when the rinsing solution is the same as the electroplating solution in the electroplating unit **14**. Consequently, the preferred embodiment of the present invention utilizes electroplating solution from tank **38** and receives it through line **36** via line **39**, pump **40** and heat exchanger **41**. If it were desirable to provide rinsing solution containing at least one tin electrolyte from another source, this could be accomplished by directing the line **39** to that source and providing for the return of overflow from tank **35** through line **42** to that same source. Heat exchanger **41** provides the heat necessary for the rinsing solution to obtain a strip temperature of 120 through 160° F. Steam or hot water may be used for this purpose.

If the strip is electroplated when it is at a temperature below 120° F., anode pattern effects result. If, on the other hand, the strip is heated to a temperature above 160° F., decomposition of certain components in the electroplating solution, such as ferro-cyanide compounds will occur. These factors therefore determine the upper and lower temperature ranges of the strip at the time of commencing the electroplating operation. Although the pickling solution **18** is maintained at a temperature of approximately 180° F., the rinse water in tank **12** is at the prevailing water supply temperature because of the fact that cold rinse water removes the pickling acid better and prevents the strip from drying. Therefore, upon emergence from roll **32**, the strip is at a temperature below 120° F. Thus, in order to obtain the benefits of the present invention, it is necessary to heat the strip prior to electroplating.

Although the preferred temperature of the strip upon commencing electroplating is somewhat dependent upon the coating weight of the tin to be applied, it has been found that a more important factor is the current density being used. For example, when using a current density of 200 amperes per square foot, it has been found that the temperature of the strip should be at least 125° F. for preferred results. Similarly, at current densities of 300 and 600 amperes per square foot, the minimum temperature should be 135 and 145° F., respectively. In no case should the strip temperature exceed 160° F.

The present invention has been described in connection with the electroplating of tin on ferrous metal strip, but may be used for plating other metals onto other strip materials. Although the rinsing solution preferably is substantially the same as the electroplating solution, it need not be the same and it does constitute an improvement when the rinsing solution contains only a small amount of the same electrolyte as the electroplating solution.

I claim:

1. The method of eliminating striation and anode pattern in the progressive electrotinplating of a surface of ferrous metal strip at strip speeds of about 1000 feet per minute and higher, comprising the steps of progressively passing the strip at a speed of at least about 1000 feet per minute through a washing zone, a rinsing zone and an electrotinplating zone, washing the surface of the strip to be plated with relatively cold water in the washing zone, passing a stream of hot aqueous rinsing solution into the rinsing zone, heating the strip in the rinsing zone in the absence of electrolytic treatment of the strip to a temperature within the range 120° Fahrenheit to 160° Fahrenheit by continuously bringing the hot aqueous rinsing solution into intimate contact with the surface to be plated, and electrotinplating the surface of the heated strip in the electroplating zone while the surface to be plated is in contact with a bath of aqueous electrotinplating solution, the electrotinplating solution containing at least one tin electrolyte and the rinsing solution containing said one tin electrolyte.

2. The method of eliminating striation and anode pattern in the progressive electrotinplating of a surface of ferrous metal strip at strip speeds of about 1000 feet per minute and higher, comprising the steps of progressively passing the strip at a speed of at least about 1000 feet per minute through a washing zone, a rinsing zone and an electrotinplating zone, washing the surface of the strip to be plated with relatively cold water in the washing zone, passing a stream of hot aqueous rinsing solution into the rinsing zone, heating the strip in the rinsing zone in the absence of electrolytic treatment of the strip to a temperature within the rang 120° Fahrenheit to 160° Fahrenheit by continuously bringing the hot aqueous rinsing solution into intimate contact with the surface to be plated, and electrotinplating the surface of the heated strip in the electroplating zone while the surface to be plated is in contact with a bath of aqueous electrotinplating solution, the electrotinplating solution containing at least one tin electrolyte and the rinsing solution containing substantially the same percentage of said tin electrolyte as the electrotinplating solution.

3. The method of eliminating striation and anode pattern in the progressive electrotinplating of a surface of ferrous metal strip at strip speeds of about 1000 feet per minute and higher, comprising the steps of progressively passing the strip at a speed of at least about 1000 feet per minute through a washing zone, a rinsing zone and an electroplating zone, washing the surface of the strip to be plated with relatively cold water in the washing zone, passing a stream of hot aqueous rinsing solution into the rinsing zone, heating the strip in the rinsing zone in the absence of electrolytic treatment of the strip to a temperature within the range 120° Fahrenheit to 160° Fahrenheit by continuously bringing the hot aqueous rinsing solution into intimate contact with the surface to be plated, and electrotinplating the surface of the heated strip in the electroplating zone while the surface to be plated is in contact with a bath of aqueous electrotinplating solution, the electrotinplating solution containing at least one tin electrolyte and the rinsing solution and the electrotinplating solution being substantially the same.

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U. S. DEPARTMENT OF COMMERCE

PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,825,681

March 4, 1958.

Samuel S. Johnston

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 43, for "wet-washed" read -- wet, washed --; column 6, line 24, for "rang" read -- range --.

Signed and sealed this 29th day of April 1958.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents