Aug. 2, 1966 A. F. WELLS 3,264,198

CONTINUOUS ELECTROPLATING METHOD

Filed May 31, 1962

FIG. 1

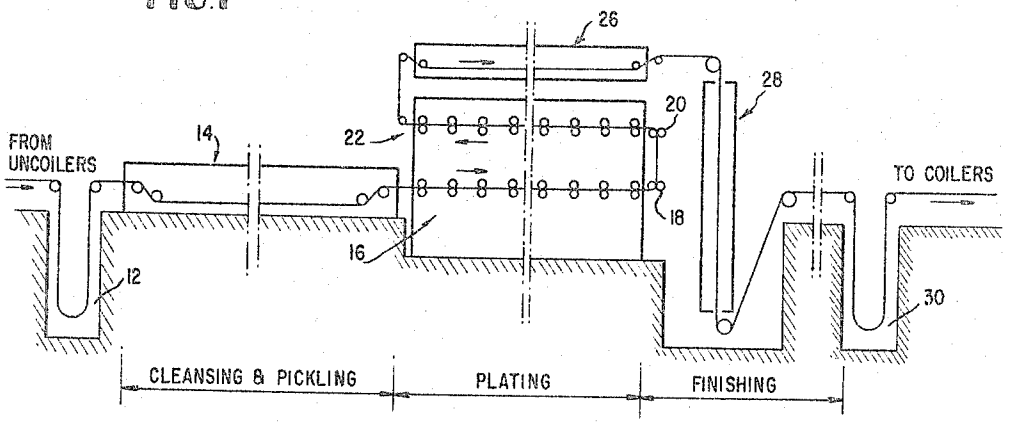
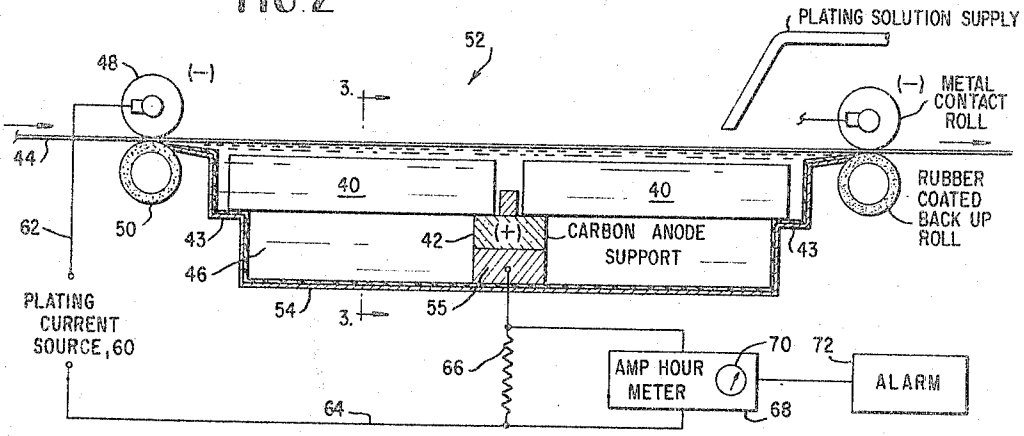


FIG. 2



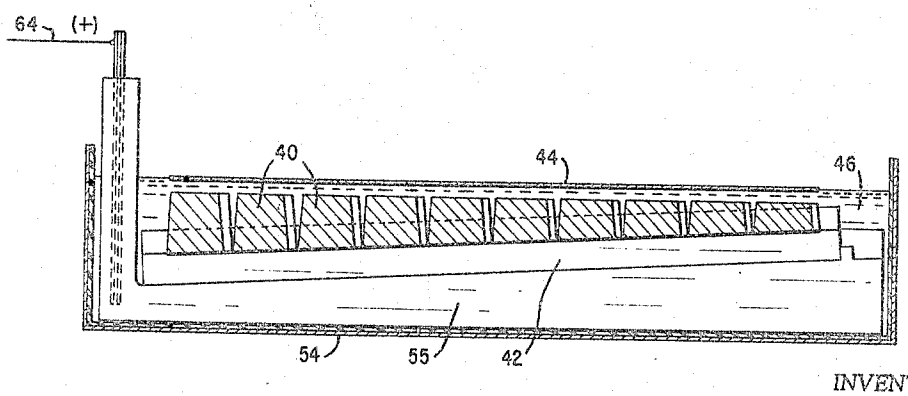


FIG. 3

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CONTINUOUS ELECTROPLATING METHOD

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This invention is concerned with methods and apparatus for obtaining improved uniformity in the electroplating of a continuously moving base metal.

In continuous electroplating, the material to be plated is passed in immediate succession through a series of plating cells and the desired coating weight is built up progressively in each cell. Some of the main objectives of continuous electroplating operations are accurate control of coating weight and uniformity of the coating. To a large degree both of these objectives are dependent on maintaining uniform spacing between the anode (plating metal) and the cathode (base metal) in each cell. The importance of uniform spacing between the anode and cathode is accentuated in plating continuous strip since it is desired to have coating weight and appearance uniform across the entire width of the strip. Also, the continuous nature of these operations adds difficulties not found in batch processing for example. The continuous operation cannot be interrupted to measure or adjust the anode position or to change anodes. Further, plating characteristics affecting anode erosion differ from cell to cell and anode erosion differs with differing coating weights, strip speeds, etc. Prior to the present invention, attempts were made to calculate erosion time for an anode so that uniform spacing between anode and cathode could be maintained. Because of the different characteristics of each cell and the effects of changing coating weights, changing line speeds, variations in the current source, etc., it was impossible to calculate anode erosion with any accuracy. With some calculation, trial and error, and a good deal of experience the operator could attempt to guess the proper time to change anode bars in a continuous operation. With the teachings of this invention these problems are eliminated since the above mentioned variables affecting anode erosion are automatically integrated and a precise measurement is made which accurately indicates the proper time to change anode bars in each cell of a continuous electroplating line.

The invention will be described in relation to a Halogen Process line for continuous electro-tinplating of steel strip although its teachings are applicable to other continuous operations using other plating metals and other base metals.

In the drawings:

FIGURE 1 is a schematic diagram of a continuous tinplating line of the Halogen type;

FIGURE 2 is a schematic diagram of a plating cell embodying the invention; and

FIGURE 3 is a sectional view of a portion of FIGURE 2 taken along the line 3—3.

Referring to FIGURE 1, coils of steel strip are formed into continuous strip at uncoilers and fed through looping pit **12** and cleansing and pickling means **14** preparatory to plating. In the Halogen Process, the strip is plated on one surface at a time, first in a series of plating cells in plating tier **16**, then after inversion of the strip by rolls **18** and **20**, on the opposite surface in a second tier of plating cells **22**. Solution recovery and wash rinses are provided at **26** in a third tier above the plating cell tiers **16** and **22**. Thereafter the strip is passed through a fusion tower **28** where the plated tin is brightened by melting and subsequent quenching. After passage through looping pit **30** the finished strip

is formed into coils or may be sheared into desired lengths.

In a Halogen type line each plating tier may contain twelve, sixteen, or more, plating cells and the strip passes in immediate succession from one cell to the next. The speed of the line may vary up to about 2100 feet per minute, or more. Under these conditions it is essential to accurately control plating in each cell. Further, uniform plating across the full width of the strip requires that the distance between the tin anode and the steel strip cathode be kept uniform across the full width of the strip. Since the operation is continuous, the line cannot be stopped to change anodes; therefore the anode is in the form of bars disposed side by side on guides so that they can be moved progressively across the line of travel of the strip. Referring to FIGURES 2 and 3, anode bars **40** are shown supported on anode support bar **42** and tank guides **43**. Anode bars **40** extend across the full width of strip **44** and the distance separating the anode bars **40** and strip **44** is kept uniform by moving the bars along the inclined plane provided by the anode support bar **42** and guides **43**. As the anode bars erode they are moved progressively up the inclined plane by periodically removing the uppermost anode bar and adding a bar at the opposite end of the inclined plane.

Ordinarily it is not possible to see the anode bars because of the strip **44** and the near opacity of plating solution **46**; nor is it conveniently possible to physically measure the distance between the anode **40** and the strip **44**. As previously indicated, changing of anode bars has been based largely on a matter of experience. The skill required was of the highest order and, considering the complexity of the problem stemming from changing coating weights during production runs, changing line speeds, differing resistances in the various plating cells, etc., precision was not to be expected and seldom obtained. The problems are similar in vertically oriented continuous electroplating lines and the invention similarly provides methods and apparatus for accurately determining when an anode bar should be changed in such lines with improved coating control and uniformity similarly resulting.

Referring in particular to FIGURE 2, strip **44** passes between contact roll **48** and backup roll **50** onto plating cell **52**. A continuous electroplating line includes a plurality of substantially identical plating cells, such as that shown schematically in FIGURE 2, arranged in immediate succession. Strip **44** is the cathode in each cell and electrical contact is completed through a metal contact roll such as cathode contact roll **48**. For purposes of explanation, the plating circuit of cell **52** can be considered as including plating current source **60**, anode conductor **55**, anode support **42**, anode means **40**, plating solution **46**, strip (cathode) **44**, and cathode contact roll **48**. Plating current source **60** is joined to cathode contact roll **48** by connector **62** and to anode conductor **55** by connector **64**.

In accordance with the teachings of the invention, a quantitative measurement of the electricity delivered to the plating solution **46** by anode **40** is made and this measurement provides a quantitative measurement of the amount of anode **40** which has entered into the solution. To effect such quantitative measurements, impedance **66** is connected in the plating circuit to serve as a meter shunt. Ampere hour meter **68** is connected across the shunt represented by impedance **66**. Ampere hour meter **68** is an integrating meter which sums up the current in the plating circuit with respect to time. In this way the anode erosion effects of the variables which are nearly impossible to calculate or estimate, such as changing line speeds, changing coating thicknesses, differing plating efficiencies in the various cells, etc., are taken into account

by ampere meter **68** and a single output produced for each cell which totalizes these effects. Dial **70** of ampere hour meter **68** can be calibrated to read directly in ampere hours or in anode erosion so that a reading from ampere hour meter **68** can be used to indicate when an anode bar should be changed. Ampere hour meter **68** can also be utilized to actuate a visual and/or audio alarm **72** to indicate when an anode bar should be changed. The operation of an ampere hour meter is well known in the art and no further description of the instrument itself is necessary to an understanding of the invention. A suitable ampere hour meter for continuous electro-tinplating operation available on the market is the Standard D.C. Sangamo Ampere Hour Meter #9518234, ampere rating 12,000 amperes.

In the specific embodiment described, a Halogen Process line, tin is plated from its bivalent ion. Each plating tier includes sixteen plating cells. The anode in each cell includes two banks of anode bars with sixteen bars in each bank. The anode bars weigh approximately ninety pounds apiece when added to a cell after the line is in operation. At the start of a new line, anode bars are cast in special molds with the weight of each anode bar varying with its position in the bank. In this way the parallel relationship between the strip and the top surfaces of the anode bars is obtained initially. After the line is in stabilized operation this parallel relation is maintained by periodically removing the uppermost bar in each bank and adding a bar to each bank at the lower end of the inclined plane formed by the anode support and guides. Anode bars when removed weigh approximately twenty-nine pounds. An ampere hour meter is connected at each plating cell and a total of twenty-five thousand ampere hours is required between changes of anode bars. The anode efficiency of these plating cells is held constant at about 100% so that a total of approximately one hundred and twenty-two pounds of tin is plated out by the twenty-five thousand ampere hours. From these figures, those skilled in the art will be able to calculate the required number of ampere hours between anode bar changes for other types of electro-tinplating lines or lines for electroplating other types of metals.

In this description the anode means has been designated as electrically positive and the cathode means as electrically negative. This nomenclature is in accordance with electrical theory which considers current flow to be from positive to negative in circuit analysis. In electrical theory which considers electron flow to be from negative to positive, the polarity designation or electrode names could be reversed. Therefore, for purposes of defining the invention in the claims, the term "anode" refers to the element providing plating metal and "cathode" to the element being plated, without limitation to the polarity or other designation employed in practice. The invention has been described with particular reference to a continuous electro-tinplating line of the Halogen Process type. Further details of this type of line can be found in "Apparatus for Electrocoating Striplike Material," Reissue Patent 23,456 to E. W. Rieger, issued January 22, 1952 or in "Electrotinning Steel Strip," Metal Finishing, February 1944, pages 77–79, both of which are incorporated herein by reference.

While the invention has been described with particular reference to a line for plating continuous steel strip, the teachings of the invention are applicable to the plating of other elongated, continuously moving, metallic materials; reference being had to the appended claims for defining the limits of the invention.

What is claimed is:

1. Continuous strip electroplating process in which plating metal supply is continuously maintained within a plating cell comprising the steps of

passing continuous strip longitudinally through a plating cell having an anode made up of a plurality of individual elongated anode elements arranged in side by side relationship with predetermined spacing between the anode elements and the continuous strip across its full width,

supplying plating current to the plating cell,

quantitatively measuring plating current delivered to the cell as a measure of anode erosion, and

adding a new anode element to the cell and progressively moving partially eroded anode elements in a direction across the width of the continuous strip responsive to the quantitative measurement of plating current delivered to the cell to maintain the predetermined spacing between the anode elements and the continuous strip.

2. Continuous steel strip electroplating process in which plating metal supply is continuously maintained within a plating cell comprising the steps of

passing continuous steel strip longitudinally through a plating cell having an anode made up of a plurality of individual elongated anode elements arranged in side by side relationship with predetermined spacing between the anode elements and the continuous strip across its full width,

supplying plating current to the plating cell,

quantitatively measuring the plating current delivered to the cell as a measure of anode erosion, and

adding a new anode element to the plating cell and progressively moving partially eroded anode elements in a direction across the width of the continuous steel strip responsive to the quantitative measurement of plating current delivered to the cell to maintain the predetermined spacing between the anode elements and the continuous steel strip.

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