Sept. 28, 1954

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APPARATUS FOR REDUCTION OF HEAVY EDGE COATING IN ELECTROPLATING

2,690,424

Filed Nov. 20, 1950

3 Sheets-Sheet 1

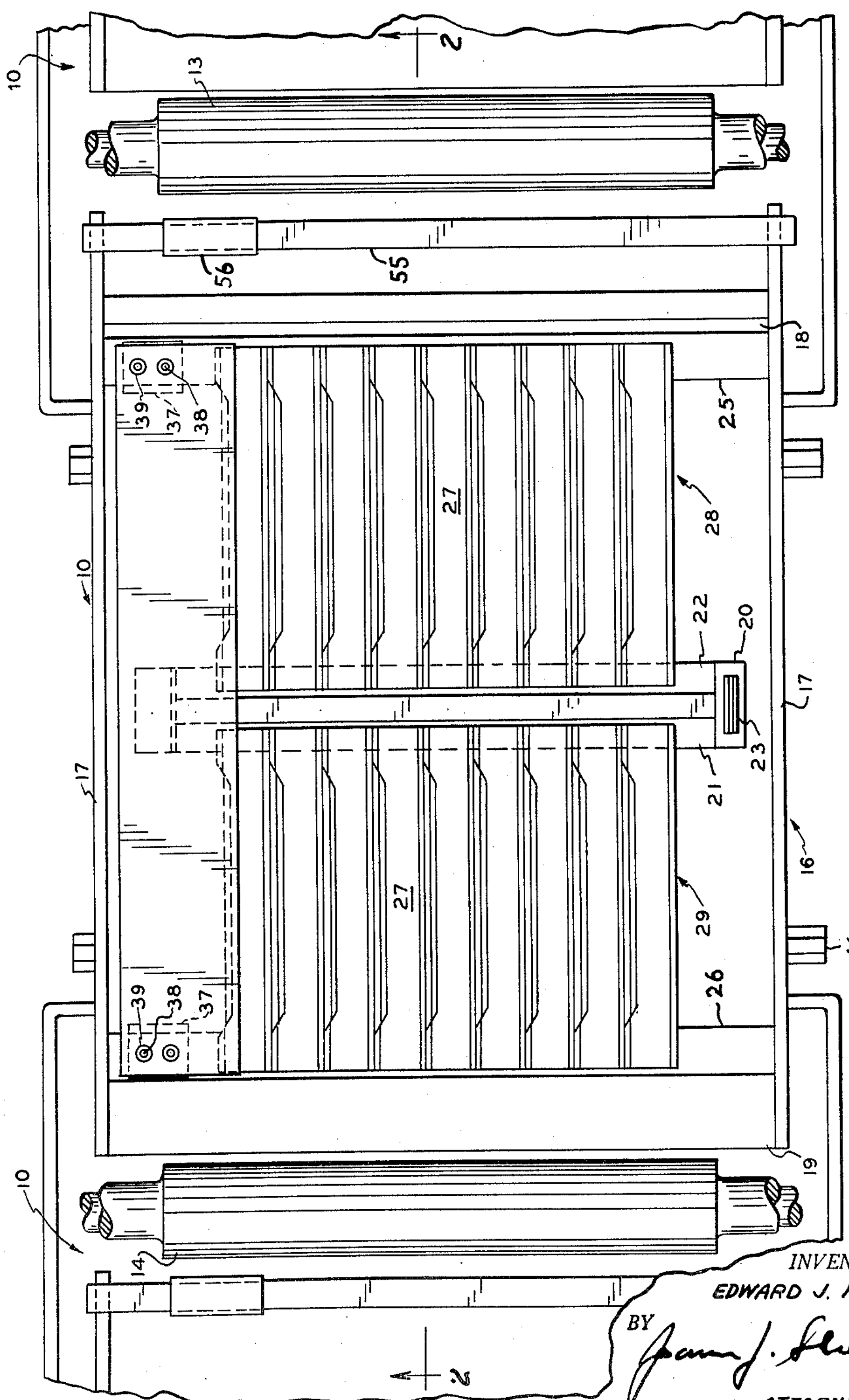

Fig. 1

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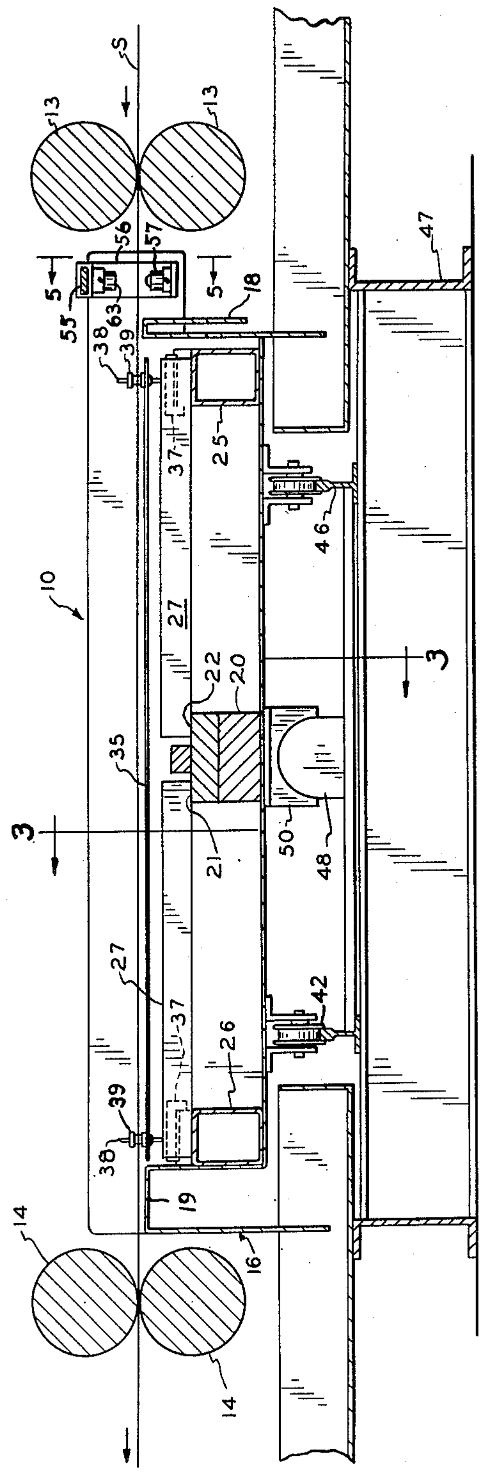

Fig. 2

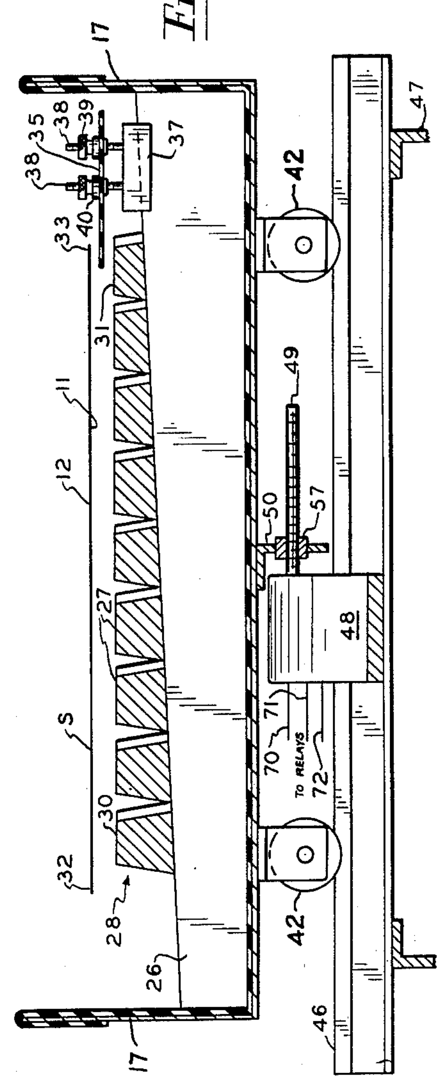

Fig. 3

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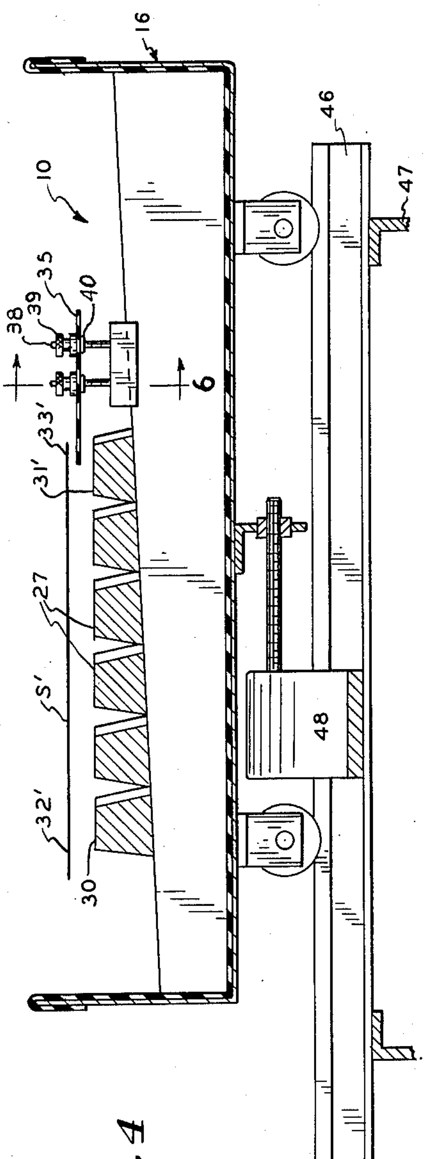

Fig. 4

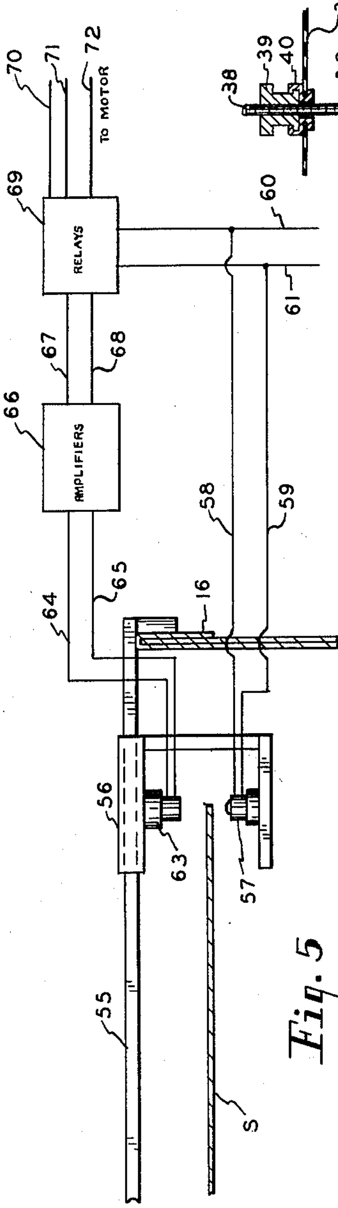

Fig. 5

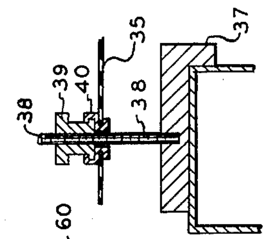

Fig. 6

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UNITED STATES PATENT OFFICE

2,690,424

APPARATUS FOR REDUCTION OF HEAVY EDGE COATING IN ELECTROPLATING

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Application November 20, 1950, Serial No. 196,589

2 Claims. (Cl. 204—206)

The present invention relates to improvements in a method of and apparatus for electroplating strip material and more particularly relates to improvements in the electroplating of a conductive surface of elongated strip, such as metal strip, with a protective coating of metal while the strip is being moved continuously and progressively along a predetermined path.

When electroplating strip metal, the strip is progressively moved across one or a series of electroplating cells past a soluble anode of electroplatable metal while the surface to be plated is in contact with an electroplating bath in the cell. The anode is wide enough to extend across the path of the strip from one edge to the opposite edge of the surface being plated. In the type of system with which the present invention is concerned the anode is made up of a series of elongated anode elements or bars arranged side by side with their length parallel to the direction of strip travel. These anode bars are supported on a surface extending across the path of the strip, and this surface is inclined so that the surface is farther away at one side than at the other side of the strip. As plating continues, the anode bars are eroded, and to compensate for this erosion, a fresh anode bar is periodically inserted at the side of the anode which is farther away from the strip. When this new anode bar is added, the other bars are pushed up the inclined surface and the anode bar previously adjacent the opposite edge of the strip is pushed out beyond the strip. This last mentioned eroded anode bar is then removed from the electroplating bath and scrapped. With this arrangement, the width of the anode is equal to the total width of the anode bars. In the past, it has been very difficult, if not impossible, to produce an electrodeposited layer of metal on the surface of the strip that has the same or substantially the same thickness along the edges as along the central portion of the strip surface. The coating along the edges tends to be considerably thicker than on the remainder of the strip. The edge coating can be maintained at or substantially at the same thickness only by accurately positioning the anode bars that define the lateral edges of the anode in the correct positions relative to the corresponding edges of the strip. If the bars along the anode edges extend outwardly beyond such positions, a heavier coating is deposited as a result of the concentration of plating current at the edges of the strip, and this phenomenon is commonly termed "edge effect." With the width of the anode

being a multiple of the width of the anode bar, it is usually impossible to obtain the exact width of the anode which will be the correct or best width for the strip being plated. Another problem encountered in practice is that successive lengths of strip vary in width. If this variation in width is relatively large, the width of the anode is varied by increasing or decreasing the number of anode bars in the anode. Here again, it is often impossible to vary the width of the anode by the proper amount as normally only one size of anode bar is carried in stock so that it is only possible to vary the width of the anode by predetermined amounts. These amounts of variation in the anode width quite often do not coincide with the amounts of variation in strip width. Where the variations in strip width are relatively small, the manufacturer often will not attempt to vary the width of the anode because it is realized that it will be impossible to make a worthwhile improvement. Accordingly, the anode bars are arranged to provide an anode as wide as or slightly wider than is required for the widest strip and narrower strips will be plated with the same arrangement of anode bars. Accordingly, most if not all, electroplated strip is excessively coated along the edges which is undesirable and which constitutes a waste of valuable metal.

Accordingly, it is an object of the present invention to provide an improved method of and apparatus for electroplating a strip with a layer of protective metal that is more nearly uniform in thickness, particularly along the edge portions of the strip.

Another object of the present invention is to provide a method of and apparatus for continuously electroplating strip material of varying width.

Another object of the present invention is to provide an improved method of and apparatus for electroplating strip with a layer of metal of uniform thickness that will not require the carrying in stock of a large number of different size of anode elements or bars to obtain an anode having the proper width.

In accordance with my invention, the fresh anode bar is positioned along one edge of the anode. At the opposite edge of the anode, there is a mask interposed between the eroded anode bar and the opposite edge portion of the strip. This mask is positioned so as to reduce the effective width of the anode whereby a more nearly uniform layer of metal is deposited on the strip, particularly along the opposite edge portion of the strip. The eroded anode bar can extend beyond the strip and the mask prevents the depositing of excess metal on the adjacent edge of the strip. The manufacturer of electroplated strip need not carry a large stock of different sizes of anode bars to obtain an anode of the proper width. In addition, when successive lengths of strip of different width are to be plated, the anode is automatically moved laterally of the strip to maintain the fresh anode adjacent the same edge of the successive lengths. This is particularly important as the eroded or partially eroded anode bar at the opposite side has its shape deformed as a result of the mask being present so that when the width of the strip changes, this eroded or partially eroded anode bar that has been partially masked must be discarded. By maintaining the fresh anode bar in the proper electroplating position adjacent the same edge of the strip regardless of the width of the strip, the waste anode metal is greatly reduced.

These and other objects and advantages of the present invention will become apparent from the following description, taken with the accompanying drawings, in which:

Figure 1 is a plan view with the strip removed of a portion of an electroplating line including an electroplating cell embodying the principles of the present invention;

Figure 2 is a view in cross-section taken along line 2—2 of Figure 1;

Figure 3 is a view in cross-section taken along line 3—3 of Figure 2;

Figure 4 is a view in cross-section similar to Figure 3 showing a different arrangement of the parts;

Figure 5 is a fragmentary sectional view taken along 5—5 of Figure 2 and diagrammatically illustrating an electrical control means; and,

Figure 6 is a fragmentary sectional view taken along line 6—6 of Figure 4.

In electroplating lines of the type in which a preferred embodiment of the present invention is applicable, metal strip after being cleaned and pickled is continuously moved along a path across a series of electroplating cells or a single long electroplating cell with the surface or surfaces to be plated in contact with an electroplating bath in the cell. Both surfaces of the strip may be plated simultaneously or only one surface may be plated at a time. In the system, a part of which is shown in the drawings, a strip S is progressively moved horizontally across a series of similar electroplating cells 10 and the bottom surface 11 is plated with anode metal. When desirable, the strip S may be brought back across a second series of cells (not shown) to electroplate the other surface 12 of the strip. The cells 10 are similar and only one cell will be described in detail, it being understood that one or any number of cells may be used.

Referring to the drawings and more particularly to Figures 1 and 2, adjacent the entry end of cell 10 there are a pair of rolls 13, and adjacent the exit end of cell 10 there are a pair of rolls 14. The rolls 13 and 14 are rotatable and the strip S passes between the rolls and across the cell. One roll of each pair, preferably the upper roll, is a contact roll and is adapted to connect the strip S as a cathode to one side of a source of electric current. The other roll of each pair is a back-up roll which holds the strip against the contact roll to grip the strip therebetween.

The cell 10 is arranged along the path of the strip S and includes a tray 16 having side walls 17, an entry end wall 18 and an exit end wall 19. The tank or tray 16 is adapted to confine a body of electroplating solution and bottom surface 11 of the strip S contacts the bath of solution as the strip moves across the tray. An anode supporting guide 20 provides a pair of shoulders 21 and 22 and has a conductive member 23 extending above tray 16. At the entry end of the tray 16, there is an anode support 25 and a similar anode support 26 at the exit end of the tray. The upper surfaces of supports 25 and 26 and of shoulders 21 and 22 are parallel and are supporting and guiding surfaces for the anode elements 27. The upper surfaces of guides 22 and 25 support a series of elongated, parallel anode bars or elements 27 which together constitute an anode 28. The upper surfaces of shoulder 21 and support 26 support a similar series of elongated, anode elements 27 which together constitute a second anode 29. The anodes 28 and 29 are identical. Each shoulder 21 and 22 is electrically connected to conductive member 23 for connecting each series of anode elements to the opposite side of a source of electroplating current.

Referring to the drawings and particularly to Figure 3, the elongated anodes 27 of anode 28 are arranged side by side in parallel relationship with their length or longitudinal axes extending substantially parallel to the direction of strip travel. Each anode element extends longitudinally of the strip. The upper anode contacting and supporting surface of support 25 extends transversely across and from one side to the other side of the path of the strip and this surface is inclined from one side of the strip path upwardly toward the path of the strip and the opposite side of the strip path. The anode supporting surfaces of shoulders 21, 22, 25 and 26 are parallel so that the ends of each anode element are supported on parallel inclined surfaces. The angle of inclination is such that the surfaces of the elements facing the path of the strip are located in a common plane that is substantially parallel to the bottom surface of the strip. This last-mentioned plane may be inclined a few degrees so that the upper surface of the anode element in position 30 and the upper surface of the anode element in position 31 are slightly differently spaced from strip to compensate for anode erosion. The relationship of the anode elements constituting either anode will best be understood from a description of the operation.

Assuming that the electroplating line is in continuous operation, anode metal, for example, tin, zinc or other metal, is being continuously deposited on the bottom surface of the moving strip and metal is being continuously dissolved from the anode elements so that the anode elements are continuously eroded. Periodically, a new anode element corresponding to the anode element in position 30 is inserted in this position. In order to place the anode element 30 into this position, the remainder of the anode elements are moved up the inclined supporting surface so that the one previously occupying the position indicated at 31 is moved up the inclined supporting surface and out of electrolytic relation with the strip. This last-mentioned eroded anode element is then removed from the electroplating cell. A fresh anode element is inserted at 30 each time the previously introduced anode element and the other anode elements have been subjected to a predetermined amount of erosion due to the electrodeposition of anode metal on the bottom surface of the strip. It will be apparent that each anode element as it is moved up the inclined supporting surface by the introduction of a fresh anode element at 30 approaches the position of anode element 31. During the time that each anode element is in the cell, erosion reduces the dimensions of the anode element so that by the time the anode element reaches the position at 31, the anode element has been sufficiently eroded so that it should be removed from the electroplating cell.

As previously described, the electroplating cell 10 and the anode elements extending longitudinally of the strip are supported and arranged substantially in the same manner as shown and described in Patent No. 2,399,254 which issued on April 30, 1946, to E. W. Rieger et al.

One of the problems in producing electroplated strip is to deposit a coating that is substantially uniform in thickness across the width of the strip surface. In order to do this, it is necessary to properly position the anode element at 30 adjacent the corresponding edge 32 of strip S and to properly position the anode element at 31 adjacent the corresponding edge 33 of the strip S. The anode elements are formed by casting and produced in one size. An electroplating line requires a large number of anode bars and producing these bars in a variety of sizes would be prohibitive in cost. The width of the anode is determined by widths of all of the anode elements. Thus, the width of the anodes depends on the number of anode elements and the widths of the anode can only be changed by adding or subtracting one or more anode elements. Accordingly, it frequently happens that the anode is too wide so that excessive metal is deposited along one or both edges of the strip.

In accordance with the present invention, the width of the of the anode is infinitely varied in accordance to the width of the strip. As shown in Figure 3, the anode element at 30 is correctly positioned adjacent the corresponding edge 32 of the strip so that the coating metal will be substantially uniform in thickness. The anode element 31 is incorrectly positioned and extends beyond the edge of the strip so that normally excessive metal would be deposited along the strip edge portion 33. A mask 35 is mounted adjacent the edge 33 between strip S and anode 31 and edge 33 in position to inhibit the electroplating of anode metal onto the edge portion of the strip. The mask 35 which is made of non-conductive material extends part way into the electrical field between the anode element 31 and the strip so as to reduce the current concentration along the edge portion of the strip. The mask preferably does not prevent the plating of metal along the corresponding edge of the strip but only inhibits the electrodeposition of metal. The anode element adjacent the strip edge is preferably positioned so that the strip extends outwardly beyond the anode a short distance to reduce edge effect. The edge 32 extends beyond anode element 30. In order to produce the same effect along the opposite side of the strip, the mask 35 preferably extends part way beneath the strip S, although the mask would inhibit electroplating if the edge of the mask did not extend beneath the strip because the mask would reduce the width of the path of the electroplating current.

The mask 35 is adjustable transversely of the strip surface. On each support 25 and 26, there is mounted a member 37, each carrying a pair of threaded posts 38. A nut 39 is threaded onto each post 38 and each nut carries a collar 40 engaging the mask 35. The nuts 39 can be adjusted to raise or lower the mask 35 and the members 37 are slidable along the upper surfaces of supports 25 and 26 for adjusting the mask transversely of the path of the strip surface 11. Thus, the mask 35 can be adjusted back and forth transversely of the strip path in a plane parallel to the strip surface to vary the effective width of the anode.

It is important that the mask be interposed between the strip and the eroded anode at 31. As electroplating proceeds, metal is removed from that portion of anode bar 31 which is not blanked out or covered by the mask 35 while less metal or no metal is dissolved from that portion of anode bar 31 which is beneath the mask. Accordingly, once the mask is interposed between the anode bar 31 and the edge 33 of the strip and if the mask is subsequently removed, the anode 31 must be discarded as there will be present a raised portion of metal on the anode bar. The raised metal would deposit a streak of heavier metal along the strip surface which is highly undesirable. For this and other reasons, masks have never been used with the present type of anode arrangement. Accordingly, the electroplating operation is carried out in such a manner that a mask can be used and can be used without discarding excessive quantities of partially eroded anode bars.

The tank 16 is supported for movement across the path of the strip in a plane parallel to the strip surface so that the relatively fresh anode at 30 can be correctly positioned adjacent the edge or side 32 of strip S and so that the anode 30 can be positioned adjacent the same relative side or edge of successive lengths of strip of different widths. A pair of rails 46 are mounted on the framework 47 beneath tank 16. Flanged wheels 42 are carried by tank 16 and mounted on rails 46. A reversible motor 48 is mounted on framework 47 and is connected to a long lead screw 49 for rotating the screw in either direction. A bracket 50 is connected to tank 16 and bracket 50 carries a nut 51 which extends screw 49. When the motor 48 is energized, tank 16 and the anode are moved transversely of the strip. The direction of movement depends upon the direction of flow of the current supplied to motor 48.

Preferably, the control circuit for motor 48 includes means responsive to the strip for energizing motor 48 so as to maintain anode 30 adjacent the side 32 of the strip.

Referring more particularly to Figure 5, a bar 55 is mounted on tank 16 and extends across the tank above the strip and adjacent the entry end of the tank. A bracket 56 is slidably mounted on bar 55. The bracket 56 carries a light 57 connected through wires 58 and 59 to wires 60 and 61 which are in turn connected to a source of electric current. Above the light 57 there is a photoelectric cell 63 mounted on bracket 56 and connected through wires 64 and 65 to amplifiers 66. The amplifiers 66 are connected through wires 67, 68 to relays 69. The relays 69 are interposed between the power lines 61, 60 and wires 70, 71 and 72 which are connected to the motor 48. The amplifiers and relays 66 and 69 are so arranged that when a predetermined portion of the field of photoelectric cell 63 is covered by strip S, no current is supplied to the motor. If the strip S moves to the left so that more light from lamp 57 reaches photoelectric cell 63, then the motor is energized to move the tray and the photoelectric cell 63 toward the left until the strip intercepts a portion of the light reaching cell 63. If the strip S moves toward the right so as to further reduce the amount of light reaching the photoelectric cell 63 from the lamp 57, then the motor is energized and rotated in the opposite direction to move the tray and photoelectric cell 63 toward the right so that the strip again intercepts the predetermined amount of light. Thus, if the strip weaves laterally, the photoelectric cell 63 automatically moves the tray 16 along the rails 46 to maintain the anodes in their correct position relative to the surface of the strip.

In operation, and assuming that a relatively wide strip, such as strip S, is to be plated, the tray 16 is moved along the rails into alignment with the path of the strip, and enough anode bars 27 are placed in position so that the anode will have a width sufficient to electroplate the entire bottom surface of the strip. The tray 16 is so positioned that the anode bar in position 30 is adjacent the edge 32 of the strip and the anode bar 31 is adjacent the opposite edge of the strip 33. Normally, the width of the anode should be slightly less than the width of the strip surface to prevent the so-called edge effect. After the anode bars have been positioned, the mask 35 and its holder are adjusted to position the edge of the mask between the edge 33 of the strip and the eroded anode 31. The strip S is progressively continuously moved across the cells and anode metal is uniformly deposited on the bottom surface. When the anode bars 27 have been sufficiently eroded, a new anode bar is inserted at 30. The insertion of this new anode bar pushes the anodes 27 up the inclined surface of the anode supporting means. Prior to the insertion of a new anode bar, the mask mounted on the slidable supports 37 is moved up the inclined surface of the anode supporting means out of the way so that the eroded anode bar at position 31 can be pushed out beyond the strip and removed. After this eroded anode bar has been removed, the mask 35 is moved back into position between the edge 33 of the strip and the partially eroded anode bar now in position 31.

If a succeeding length of strip is relatively narrow, such as strip S′, Figure 4, then some of the anode bars 27 are removed so that the width of the anode is as near to the width of the strip as it is possible to make it. The relatively fresh anode bar 30 is positioned adjacent the same corresponding edge 32′ of strip S′. The eroded anode bar at 31′ is positioned adjacent the opposite edge 33′ of the strip. After the width of the anode has been varied, the mask 35 is moved into position so that the effective width of the relatively narrower anode is reduced to the width required for the relatively narrower strip. Customarily, successive lengths of strip of different widths are moved along a path with the center of the various lengths of strip moving along a common line. Thus, when a narrower strip is to be plated, it is necessary to energize motor 48 to move the tray 16 toward the right to position the anode bar 30 adjacent the edge 32′. If a subsequent wider length is to be plated, the tray 16 is moved back toward the left.

Before proceeding to plate the strip and after the tray 16 has been properly positioned, the bracket 56 is moved along 55 so that the edge of the strip intercepts part of the light emitted by lamp 57. In other words, the photoelectric cell is positioned adjacent the edge of the strip so that the motor will not be energized except when the strip moves laterally from its normal position. Then if the strip weaves or moves laterally from this normal position in either direction, the photoelectric cell 63 will automatically energize the motor 48 to move the tray and the anode into alignment with the strip.

The present apparatus is primarily intended for electroplating tin onto strip steel, such as black plate. Where the electrodeposited coating is tin, the anode bars are formed of tin and these bars are slowly dissolved or eroded to replenish the electroplating bath with tin. The present invention is not limited to the plating of tin but may be utilized for plating other electrically conductive strip materials with other protective metals.

I claim:

1. In an apparatus for progressively electroplating a surface of an elongated metal strip, the combination comprising an electroplating cell including a tank adapted to contain a body of electroplating solution, roller means mounted at the ends of the tank for moving the strip progressively along a path across the tank from end to end with the surface of the strip in contact with the electroplating solution, an anode supporting means located in the tank below the path of the strip and presenting an inclined surface facing the path of the strip, the inclined surface extending transversely across the tank and across the path of the strip with the lower end of the inclined surface at one side of the path of the strip being farther away from the path of the strip than the upper end of the inclined surface at the opposite side of the path of the strip, an anode supported in the tank by the anode supporting means, the anode being below the path of the strip and spaced from the path of the strip, means for connecting the anode to a source of electroplating current, the anode including a plurality of elongated soluble anode elements movably mounted side by side on the inclined surface, each element being mounted on the inclined surface with its length dimension parallel to the path of the strip and being movable along the inclined surface laterally of the path of the strip in a direction toward the upper end of the inclined surface to compensate for erosion of the anode elements, one of the anode elements being adjacent the one side of the path of the strip and another anode element being adjacent the opposite side of the path of the strip, means for adjusting the lateral position of the one anode element on the one side of the path of the strip, a mask positioned at the upper end of the inclined surface adjacent the opposite side only of the path of the strip, the mask extending longitudinally of the path of the strip, and means for mounting the mask in spaced relation between the path of the strip and the other anode element, the last-named means including a mask supporting member mounted for movement along the inclined surface laterally of the path of the strip, and means for mounting the mask on the mask supporting member including means for vertically adjusting the mask with respect to the mask supporting member.

2. In an apparatus for progressively electroplating a surface of an elonagted metal strip, the combination comprising an electroplating cell

including a tank adapted to contain a body of electroplating solution, roller means mounted at the end of the tank for moving the strip progressively along a path across the tank from end to end with the surface of the strip in contact with the electroplating solution, an anode supporting means located in the tank below the path of the strip and presenting an inclined surface facing the path of the strip, the inclined surface extending transversely across the tank and across the path of the strip with the lower end of the inclined surface at the one side of the path of the strip being farther away from the path of the strip than the upper end of the inclined surface at the opposite side of the path of the strip, an anode supported in the tank by the anode supporting means, the anode being below the path of the strip and spaced from the path of the strip, means for connecting the anode to a source of electroplating current, the anode including a plurality of elongated soluble anode elements movably mounted side by side on the inclined surface, each element being mounted on the inclined surface with its length dimension parallel to the path of the strip and being movable along the inclined surface laterally of the path of the strip in a direction toward the opposite side of the path of the strip to compensate for erosion of the anode elements, one of the anode elements being adjacent the one side of the path of the strip and another anode element being adjacent the opposite side of the path of the strip, means for supporting the tank for movement transversely of the path of the strip for adjusting the lateral position of the one anode element on the one side of the path of the strip, a mask positioned at the upper end of the inclined surface adjacent the opposite side only of the path of the strip, the mask extending longitudinally of the path of the strip, and means for mounting the mask in spaced relation between the path of the strip and the other anode element, the last-named means including a mask supporting member mounted for movement along the inclined surface laterally of the path of the strip, and means for mounting the mask on the mask supporting member including means for vertically adjusting the mask with respect to the mask supporting member.

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