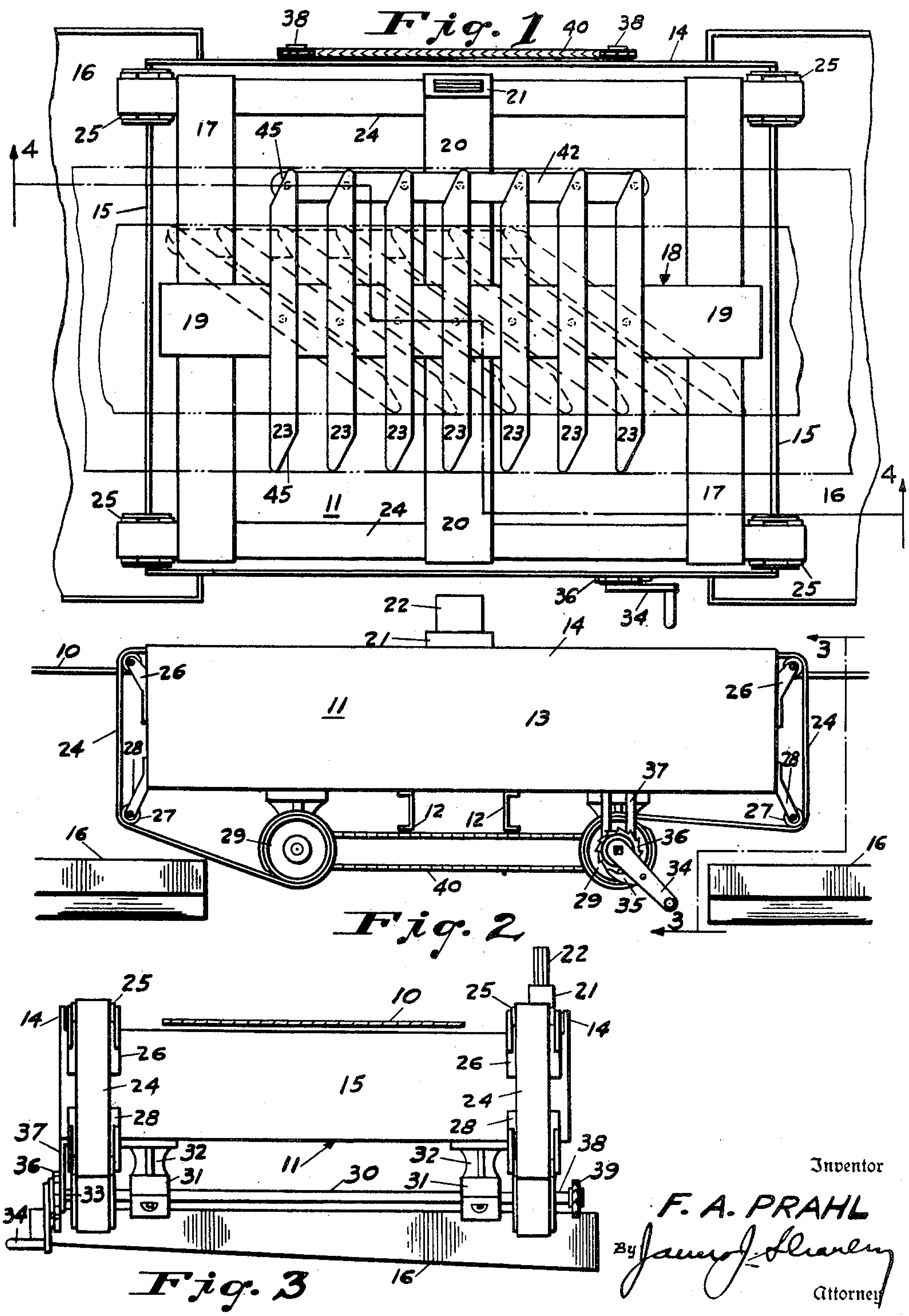
March 6, 1951 F. A. PRAHL 2,544,510

APPARATUS AND METHOD FOR PLATING STRIPS

Filed Oct. 23, 1943 2 Sheets-Sheet 1



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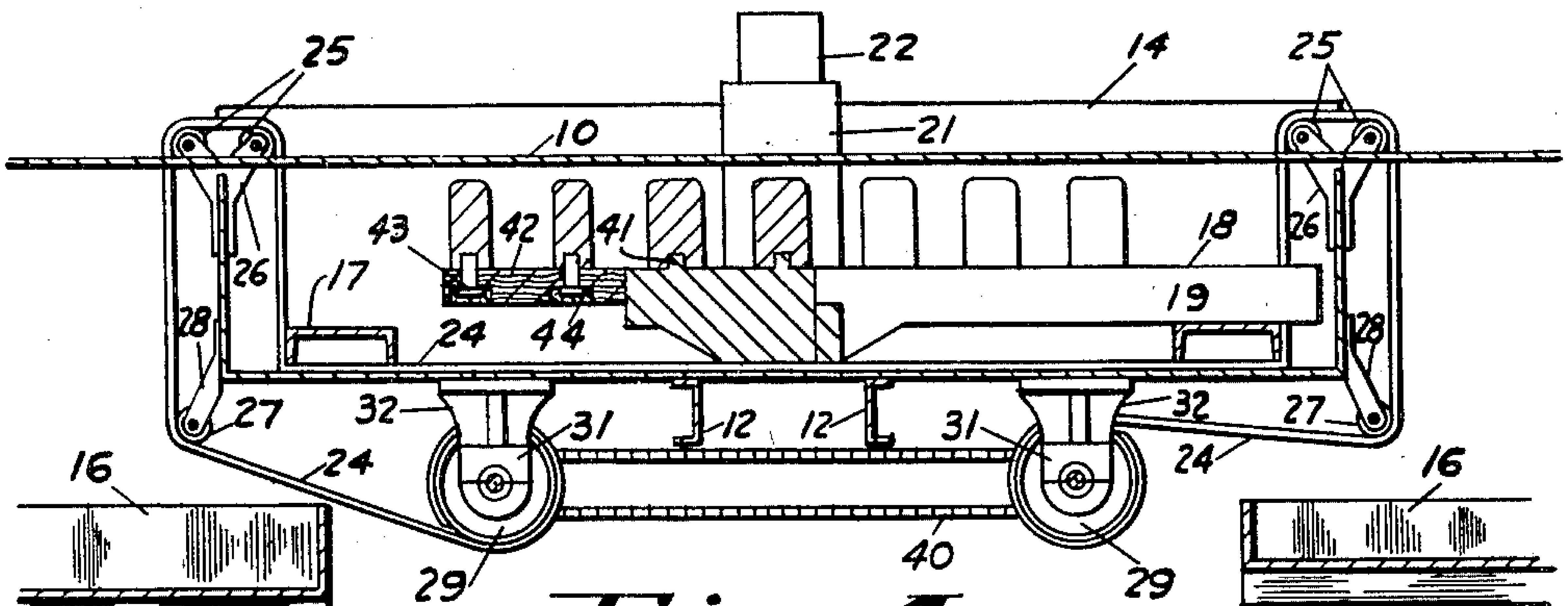

Fig. 4.

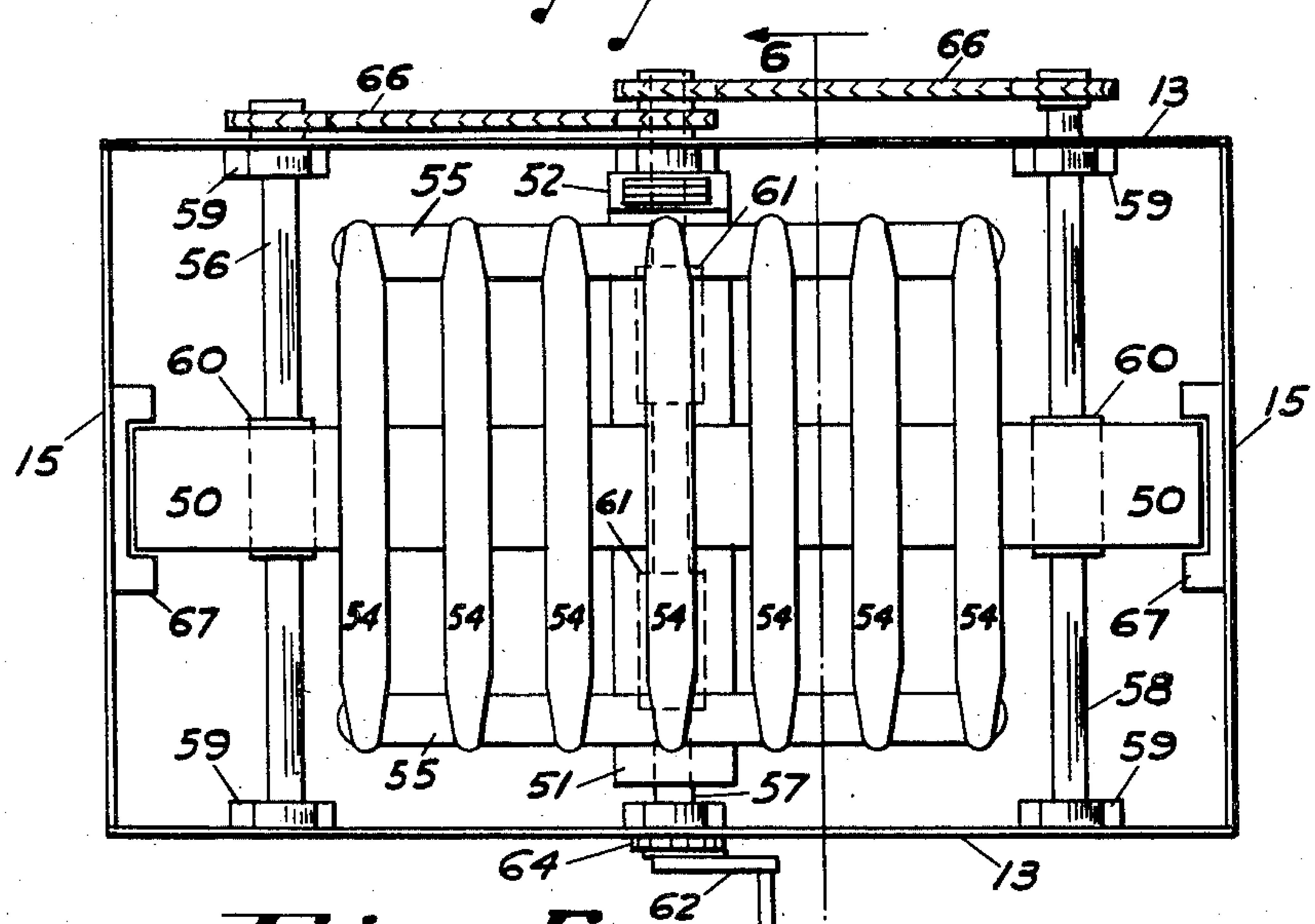

Fig. 5

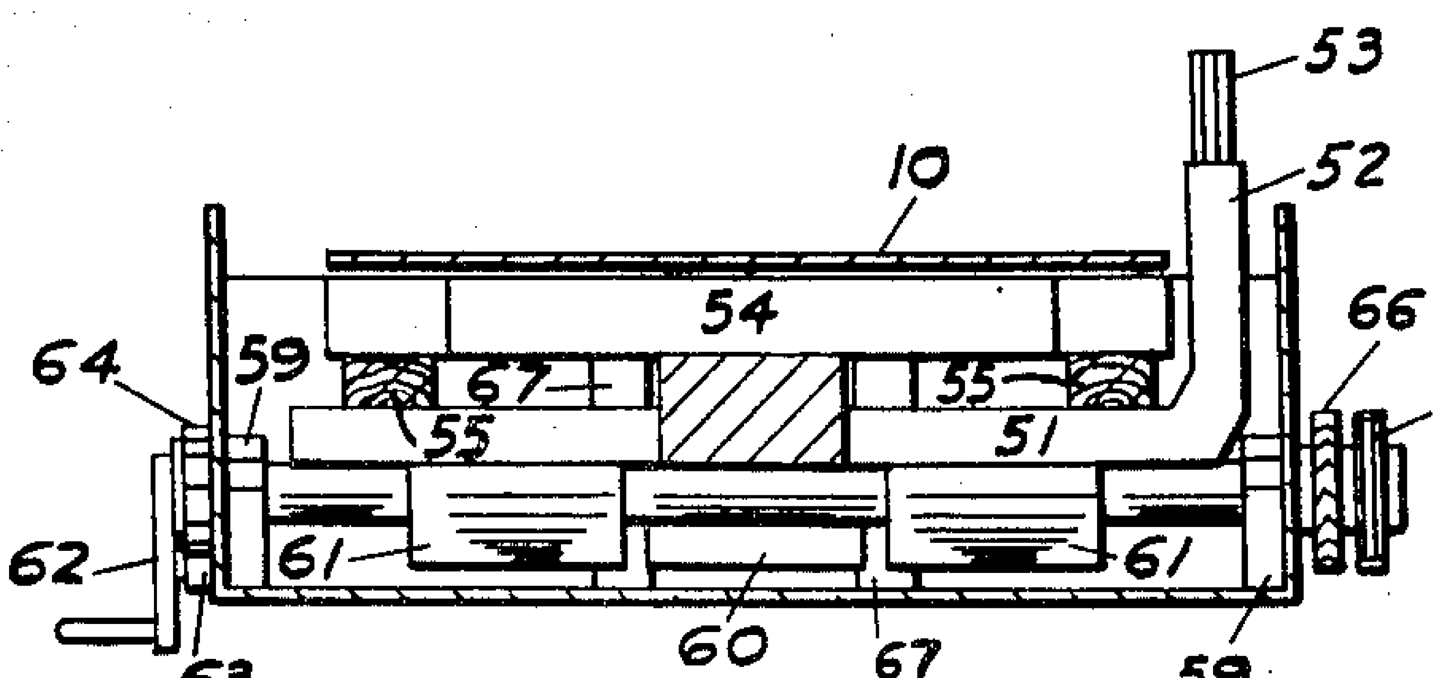

Fig. 6

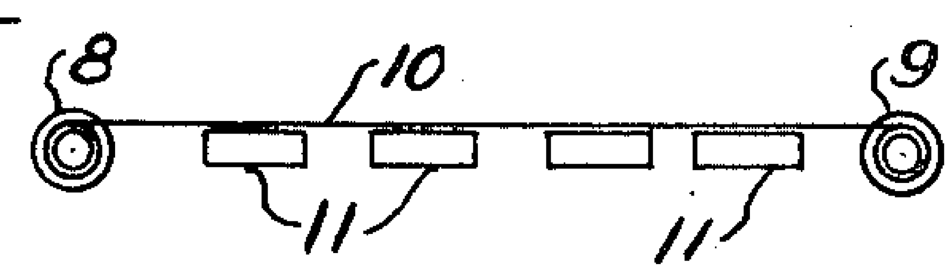

Fig. 7

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APPARATUS AND METHOD FOR PLATING STRIPS

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22 Claims. (Cl. 204—28)

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The present invention relates to improvements in continuous electroplating of a moving strip having a conductive face. More particularly, the present invention relates to the continuous electroplating of strip metal such as steel with a coating metal such as tin, zinc, nickel, chromium, etc. in which a soluble anode of the coating metal is replaced periodically with a fresh anode, the optimum electrolytic relationship between the strip and the anode being maintained during the operating period.

The continuous electroplating of strip material has developed along several lines. Some systems plate both sides of the strip at the same time while others plate only one side, subsequently plating the other where desirable. Still baths and circulating electrolytic solutions have been used. In some systems the soluble anodes of coating material are continuously replenished by the addition of fresh anode elements at one side of an anode and the withdrawal of corroded anode elements at the other side of the anode. Such systems were evolved to remove the disadvantages of the earlier systems in which the anodes were placed adjacent the strip to be plated and were removed when corrosion affected the efficiency of the plating action. In the latter systems herein termed "periodic electroplating systems," the corrosion of the soluble anode resulted in electroplating current paths of increasing length between the anode surface and the strip. To compensate for this phenomenon, the electroplating voltage was raised to maintain substantially constant current density of the plating current. In a few cases where the anode was not exposed on both sides to electrolytic action, crude means was provided for maintaining the distance between the anode surface and the face of the strip being plated within the limits of practical operation.

I have found that during operation of a continuous electroplating line, the formation of sludge and deposition of undesirable substances on the operating parts make periodic shutdowns necessary. Additionally, for most satisfactory labor conditions a limited period of continuous operation is essential. Finally, when producing tin plated steel strip, for example, the amount of tin deposited on the strip during continuous operation over a 24-hour period is such that it is entirely possible to make one anode last for a period of several days so long as compensation is made for corrosion of the anode and the resulting change in electrolytic relationship to the strip. Combining these factors, I have evolved an anode system in which the anodes may be designed to supply sufficient coating metal for a period corresponding to that over which objectionable chemical deposition on the apparatus takes place. Under certain conditions this period, which of

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course is rather elastic, may be made to conform to the period of most satisfactory continuous labor operation. I have thus evolved a system having none of the undesirable factors of the old periodic systems and which is much simpler and more efficient than the present electroplating systems, having provision for continuously replenishing the anodes.

In the usual operation of a plating line, for example a line for plating tin on steel strip, the apparatus must be designed to take strips of different width. The tin plate industry, which can be considered representative of sheet or strip plated material, has been developed along lines which require products of different dimensions. For this reason a tin plating line may be called upon to turn out an order of several thousand base boxes of tin plate having dimensions such that a steel strip 32" wide must be run through the line. The next order to be supplied may call for a coil of strip only 24" wide. With most electroplating systems either the anodes must be changed to accommodate the various widths of strip or the orders must be scheduled so that the widest strip is plated first with orders requiring narrower strips being plated in the order of decreasing width. If this is not done, a narrow strip being plated from wide anodes will result in a "dishing" of the top surfaces of the anodes. When a wide strip follows such a narrow strip, the dished configuration of the anode results in an uneven deposit of the coating metal on the strip. Even when the orders are scheduled so as to run through in decreasing widths, an objectionable heavy deposit of the coating metal appears on the edges due to an unequal disposition of the plating current at those points. In order to produce a satisfactory plating system in which the anodes are replaced at the end of a given period and not before, I have evolved an anode arrangement in which varying widths of strip within practical limits can be accommodated. By forming each anode of a plurality of spaced anode elements and supporting these anode elements pivotally in the plane of the anode, an anode structure of variable width results.

As mentioned above an "edge effect" is present when strip is being plated from an anode wider than the strip. If the width of the anode is decreased, a point is arrived at where coating at the edge of the strip is reduced below that of the remainder of the strip. The current density of the electroplating current across the face of the strip controls the thickness of the deposit of coating metal. The number of possible paths for the electroplating current between the anode and the strip increases at the edge when the anode projects beyond the edge of the strip. The plating current at the anode does not terminate along the line of the edge of the strip but decreases over the projecting portion of the anode in accordance with the length of the path and the resulting increasing resistance of the path. Since the current leaving the anode directly under the edge of the strip should be about the same as that across the face of the strip, the current leaving the projecting portion of the strip is what deposits the objectionable thickness of coating at the edges. As the width of the anodes is decreased, a point is reached where the end surfaces of the anode furnish electroplating action supplemental to that of the top surface so an anode exactly the same width as the strip usually does not give the desired uniform coating. I have developed an anode which gives ready control of the coating at the edge. This anode is made up of anode elements arranged transversely of the strip, the surface of each anode element which is in electrolytic relation to the strip presenting a tapered configuration at the ends. This tapered configuration is such that the variation in current density adjacent the end of the anode element is gradual, making the relative position of the end of the anode element and the edge of the strip less critical.

Although the specific embodiment of the present invention disclosed herein relates to an electroplating system in which one side of the strip is plated while passing over a horizontal tray or cell, it will be apparent that certain features and advantages of the present invention are equally applicable to any other electroplating system and all the features and advantages are especially applicable to any electroplating system where each anode has only one surface in electrolytic relation with the strip being coated. Although separate trays or cells are shown it would be obvious that one continuous bath having a plurality of anodes or a continuous anode would be within the scope of the present invention. In general in the present specification the word "strip" is utilized but it will be apparent that sheets or wire could be treated just as readily and for this reason the term "strip" is intended to include such forms.

An important object of the present invention is the provision of a method and apparatus for continuously electroplating moving strip having a conductive face in which a soluble anode is supplied of sufficient capacity to furnish coating metal for a period of time coincident with other operating features.

A further important object of the present invention is the provision of a system for continuously electroplating moving strip having a conductive face in which the electrolytic relationship between a soluble anode and the face is maintained substantially constant despite corrosion of the anode.

A further important object of the present invention is the provision of a system for continuously electroplating moving strip having a conductive face in which strips of varying width can be readily accommodated.

A further important object of the present invention is the provision of an anode arrangement for plating strips of different width in which the width of the anode can be varied.

A further important object of the present invention is the provision of an anode element designed to facilitate maintenance of uniform plating current distribution across the face.

These and other objects and advantages of the

present invention will be apparent from the following description and accompanying drawings which disclose a preferred embodiment of the present invention.

Figure 1 is a plan view of apparatus incorporating the present invention, the strip being removed but the position of two widths of strip being shown in broken lines.

Figure 2 is a view in side elevation of the apparatus shown in Figure 1.

Figure 3 is a view in end elevation of the apparatus of Figures 1 and 2 with the strip to be plated shown in section taken on line 3—3 of Figure 2.

Figure 4 is a view in section taken on the line 4—4 of Figure 1.

Figure 5 is a plan view of apparatus similar to Figure 1 incorporating a modification of the invention.

Figure 6 is a view in section taken on the line 6—6 of Figure 5.

Figure 7 is a diagrammatic view illustrating the path of travel of the strip across a series of cells.

In electroplating lines of the type in which the present invention is especially applicable, a continuously moving metal strip which has been previously cleaned and pickled is passed through a series of electrolytic trays or cells or a long electrolytic bath in which soluble anodes incorporating coating material are arranged on the underside of the moving strip. In one form the horizontally disposed strip moves along in contact with the surface of the electrolytic solution in the cell or bath. In case both sides of the strip are to be plated the moving strip is then reversed and passed through a similar section in which the other face is opposed in electrolytic relation to the anodes. As diagrammatically shown in Figure 7, strip metal 10 to be electroplated is mounted in rolled condition on a reel 8 from which it passes across a series of cells 11 to where it is rewound on reel 9 which, if desired, may serve as the pulling means for drawing the strip of metal continuously through the line. Since the electroplating portion of the line normally includes identical cell structure whether with separate baths or one elongated bath, the present detailed disclosure is confined to one cell and associated structure. In the apparatus herein disclosed the strip travels through the electroplating section in a straight line. Electroplating potential is supplied to the strip 10 by means of contact rolls (not shown) between cells 11.

Referring to the modification shown in Figures 1 to 4 inclusive, the tray or cell is shown at 11 supported in any suitable manner on channels 12, a plurality of these cells constituting the electroplating section of the line. Each cell is filled with electrolytic solution to form the bath, fresh solution being supplied to the bath continually or periodically to maintain the proper chemical composition. The side walls 13 of the tray have side boards 14 making their height greater than that of end walls 15. Excess solution overflows end walls 15 into collecting pans 16 located between cells. Solution is withdrawn from collecting pans 16 and by means of a circulating system not shown is treated and returned to the cells as fresh solution.

Resting on the bottom of the tray are a pair of base channels 17 for an anode support indicated generally at 18. Anode support 18 may be in the form of a spider having longitudinal crossarm or bar 19 and lateral crossarm or bar 20.

The spider is preferably designed so that the extremities of the longitudinal crossarm 19 rest on base channels 17 and the extremities of lateral cross arm 20 have lower surfaces in the same plane as that of the bottom of the base channels. This makes the base channels and anode support a stable structure with six supporting points in the same plane for engagement with the suspension means to be described later. At one end of lateral bar 20 there is a vertical member 21 incorporating a bus bar of electrically conductive metal protruding at 22 for connection to a source of electroplating potential. The anode support is so constructed that bus bar 22 is in electrical connection with the surface of longitudinal bar 19, which may be formed of carbon in accordance with the invention disclosed in copending applications Serial No. 79,150 filed March 2, 1949 by Abram B. Wilson and Serial No. 156,693 filed April 18, 1950 by Walter W. Kompart, which are divisional applications of application Serial No. 488,866 filed May 28, 1943 by Kompart and Wilson, now abandoned. The remaining parts of anode support 18 and, in fact, all other parts of the apparatus exposed to the action of the electrolytic solution may be either formed of chemically resistant material or are coated with rubber or the like. Supported on longitudinal bar 19, herein termed an electrical contact member, is an anode formed of a plurality of spaced anode elements 23. In resting on contact member 19 the anode elements are placed in electrical connection with the source of electroplating potential connected to bus bar 21, and in view of the fact that this entire top surface may be formed of carbon the anode elements may be moved relative thereto while still maintaining electrical connection. The spacing between anode elements allows for circulation of the electrolyte around each anode element and also angular movement of the group of anode elements forming each anode, as later herein described.

In order to move the anode toward the strip during plating to compensate for corrosion of the anode elements a suspension system is provided incorporating a pair of flexible straps or suspension members 24 which go around and under the end portions of base channels 17 and transverse bar 20. Strap 24 may be formed of chemically resistant metal, webbing, or metal having a rubberlike covering. The ends of each strap 24 are passed around guide rolls 25 supported on brackets 26 and thence around additional guide rolls 27 supported on brackets 28 to winding drums 29. Similar ends of the two straps are wound on a pair of winding drums 29 rigidly mounted on the same axle 30. Axles 30 rotate in bearings 31 suspended under the base of the cell by supports 32. An extension 33 on one of these axles terminates in a hand operable crank 34. A dog or pawl 35 on crank 34 engages a stationary rachet 36 mounted on cell 11 by means of bracket 37. On the end opposite crank 34 each of the axles 30 has an extension 38 carrying a sprocket 39, a chain drive linking the two sprockets to synchronize movements of all four winding drums.

In operation the parts are so related and the initial size of the anode elements is so designed that under the normal plating conditions expected, the anode elements will contain the necessary coating material for the expected period of operation and still leave enough cross-sectional area to carry the plating current toward the end of the period. Thus, for example, if it is planned to operate the line for six days and to clean up on the seventh, with a coating having a thickness equal to one-half pound to the base box, a strip having an average width over the operating period of 28″, and an average strip speed through the line of 800 feet per minute, we arrive at about 36,950 pounds as the weight of coating metal needed with 100% operation. Assuming the line is down 10% of the time for changing coils, making running repairs, etc., 33,355 pounds of anode capacity will satisfy the production of output. Assuming there are 24 anodes, 12 to each side of the strip, and that each anode is made up of 10 anode elements, it will be apparent that each anode element must have about 140 pounds of coating metal to supply the coating requirements. The maximum plating current required and the conductivity of the anode metal will determine the additional anode weight necessary. Where desirable, contact member 19 may be so shaped that it carries the major portion of the plating current to thereby reduce the total weight of each anode element. Anode elements of required weight would be cast and set up on the anode support as shown in Figures 1 to 4 inclusive. As the soluble anodes are corroded due to the plating of the coating metal on the strip, the operator turns crank 34 thereby winding straps 24 onto winding drums 29. Each anode element will corrode away on its top surface and the shortening of strap 24 will move the whole anode support together with the anode elements toward the strip to make up for this corrosion. At the end of the operating period the anode elements will be reduced to thin flat shape and they can be remelted and cast into new anode elements.

In order to accommodate strips of varying width the anode arrangement of the present invention is designed to be adjustable so that the width of each anode can be varied without adding or withdrawing anode elements. Contact member 19 in the preferred embodiment incorporates pivot lugs 41 and each of the anode elements is cast with a complementary pivot hole for engagement therewith to space and pivotally mount the anode elements. In order to arrive at the most efficient anode, the anode elements should be maintained spaced from each other throughout their lengths. A parallel relationship is preferred for group movement. To this end a spacing bar 42 is slidably supported on the upper surface of lateral arm 20. A plurality of equally spaced pins 43 are positioned in bar 42, held in place by a plastic insert 44. Each anode element adjacent one end is cast with a socket registering with each of the pins 43 when the anode elements are in parallel position. By engaging each anode element with a pivot lug 41 and a spacing bar pin 43, the weight of the anode elements unites the structure into an integral adjustable anode, the width of which can be changed by changing the angular relationship of the anode elements to the longitudinal contact member 19. Due to the action of spacing bar 42 in this arrangement, an operator can attain the desired width of anode by pushing any part thereof, spacing bar 42 sliding along on lateral bar 20 to maintain a parallelogram relationship.

In operation with the anode bars normal to the path of movement of the strip, the maximum width of strip can be plated. When it is necessary to run an order of narrow strip through the line the operator merely pushes the anode elements to a position like that shown in dotted lines in Figure 1. Since the same amount of anode area is present whether the strip be wide or narrow, it will normally be desirable to reduce the amount of plating current when running narrow strip. So long as a constant line speed is desirable a reduction in the overall current would be a necessary feature with any anode arrangement when running a narrower strip.

The present invention contemplates shaping the anode element itself so as to make possible constant deposition of the coating material across the width of the strip at all times. With a rectangular anode element having an end surface parallel to the edge of the strip, deposition of the coating material on the edge of the strip will vary from that in the intermediate portions across the width. Current leaving the anode at the end of the anode element has a plurality of possible paths to reach the edge of the strip. The path having the shortest electrical resistance is the straight line path, but the longer paths out beyond the end of the anode element will also carry a portion of the current roughly inversely related to the length of each path; thus the edge portion of the strip would have more coating metal deposit on it than the intermediate portions across the width. This would be a phenomenon confined to the period of operation following the introduction of new anode elements. Since a greater deposit of coating metal on the edges of the strip would mean a greater corrosion of the anode elements at the ends, the situation would remedy itself as the surface of the anode elements at this point became farther away from the strip, thus introducing a higher resistance in the circuit at this point and reducing the current density. The present invention seeks to remove this initial fault in operation and for this purpose the anode elements are tapered at the ends so that less anode element surface is placed in juxtaposition to the surface of the strip adjacent the edges. The current density will not be affected, but the total current passing from the anode element to the strip at this point will. The angle of taper can be so designed that the total current flowing between the anode element and the strip throughout the length of the anode element will be substantially the same despite the phenomenon described above. Although more paths are available for the current at the end of the anode element, the reduced surface of anode element tends to offset this feature and equalize total current conditions.

Each anode element 23 is defined at each end by an angular end surface 45 to give the anode element a tapering top surface in opposed relation to the strip. These angular surfaces are on opposite sides of the anode element at each end so that as the anode element is pivoted to form a narrower anode as indicated in dotted lines in Figure 1, the tapering will have maximum effect.

Referring now to Figures 5 and 6, a modification of the anode support suspension means will be seen. As in the modification shown in Figures 1 to 4 inclusive the anode support is in the form of a spider having a longitudinal bar or arm 50 and a lateral bar or arm 51. The lateral bar includes a vertical member 52 incorporating a bus bar of electrically conductive metal protruding at 53. Here again the anode support is so constructed that bus bar 53 is in electrical connection with the surface of longitudinal bar 50 for applying plating potential to the anode. In this modification anode elements 54 rest on bar 50 with no positive connection thereto. Spacing bars 55 identical with that shown at 42 in Figures 1 to 4 inclusive extend along both ends of the anode elements, the weight of the anode elements maintaining the parts together. There is thus formed a unitary anode which rests on and is slidable relative to bar 50 and which can have its width varied to meet changing requirements as to strip width. In this form the anode can be moved laterally of the path of the strip in case the strip is not centered in the line.

The tray or cell structure is the same as in the previously described modification and is identified by the same reference numerals.

The anode support is movably mounted on a structure incorporating three rotatable shafts 56, 57 and 58 rotatably mounted in bearing members 59 carried by the side walls 13 of the tray. Shafts 56 and 58 each have a cam 60 centrally disposed thereon and in supporting contact with the end portions of longitudinal bar 50. Shaft 57 has a pair of cams 61 disposed on either side of its center portion and in supporting engagement with the side portions of lateral bar 51. Shaft 57 extends through the side wall 13 of the tray and is rigidly connected to a crank 62 which has rigidly associated therewith a dog or pawl 63 for coaction with a ratchet 64 rigidly mounted on the side of the tray. Shafts 56, 57 and 58 all extend through the side wall 13 of the tray on the side opposite the crank and have rigidly mounted thereon sprockets 65 connected by sprocket chains 66 so as to synchronize movement of all three shafts. Since the shafts are submerged in the electrolyte, suitable packing glands are used where the shafts go through the side walls of the tray. The extreme ends of longitudinal bar 50 are movably received by guides 67 to restrain the spider from movement other than in a vertical direction.

In operation all four cams are arranged in the same position so that when crank 62 is rotated, the shafts rotate in synchronism and the entire support moves vertically while remaining in a horizontal plane. As in the previously described modification, all the parts submerged in the electrolyte except the upper surface of bar 50 and the anodes are either made of material resistant to the chemicals present or they may be covered with a rubber-like material. It will be apparent that corrosion of the anodes 54 is compensated for by movement of the anode support on the rotating cams.

I claim:

1. Apparatus for electroplating a longitudinally moving strip having a conductive face in contact with the electrolyte comprising an anode support having a conductive surface submerged in the electrolyte; means for connecting a source of electroplating potential to the conductive surface of the anode support; an anode submerged in the electrolyte and including a plurality of elongated anode elements extending transversely of the strip and supported by the anode support, said anode elements being in contact with the conductive surface of the anode support so that electroplating of the anode metal on the conductive face of the strip progressively corrodes the anode elements and reduces them in size; and adjustable cam means including rotatable cams submerged in the electrolyte and operatively associated with the anode support, said cams being rotatable to move the anode support and the anode elements toward the conductive face of the strip to compensate for corrosion of the anode elements and to maintain the anode support and anode elements in the proper operative position adjacent the conductive face of the strip.

2. Apparatus for electroplating a longitudinally moving strip having a conductive face in contact with the electrolyte comprising an anode support having a conductive surface submerged in the electrolyte; means for connecting a source of electroplating potential to the conductive surface of the anode support; an anode submerged in the electrolyte and including a plurality of elongated anode elements extending transversely of the conductive face of the strip and supported by the anode support, said anode elements being in contact with the conductive surface of the anode support so that electroplating of the anode metal on the conductive face of the strip progressively corrodes the anode elements and reduces them in size; and adjustable cam means including rotatable cams submerged in the electrolyte and operatively associated with the anode support, said cams being rotatable to move the anode support and the anode elements toward the conductive face of the strip to compensate for corrosion of the anode elements and to maintain the anode support and anode elements in the proper operative position adjacent the conductive face of the strip, said adjustable cam means including actuating means external of the electrolyte for rotating the cams to move the anode support.

3. Apparatus for electroplating a surface of an elongated strip comprising, in combination, an adjustable anode, means for longitudinally moving the strip along a path across the anode with a surface facing the anode, said anode being in electrolytic relation to the surface and being formed of a plurality of spaced parallel anode elements of equal length extending transversely of the path of the strip surface with the ends falling in two straight lines parallel to the direction of strip travel across the anode, and pivotal means mounting each anode element for rotational movement about a point on the anode element and about a predetermined axis extending in a direction normal to the path of the strip surface across the anode, such points being similarly located on each anode element and falling in a straight line parallel to the lines formed by the ends of the anode elements.

4. Apparatus for electroplating a surface of an elongated strip comprising, in combination, an adjustable anode, means for longitudinally moving the strip along a path across the anode with a surface facing the anode, said anode being in electrolytic relation to the surface and being formed of a plurality of spaced parallel anode elements of equal length extending transversely of the path of the strip surface with the ends falling in two straight lines parallel to the direction of strip travel across the anode, and spacing means having pivotal connection with each anode element, the axes of rotation of the connections falling in a straight line parallel to the lines formed by the ends of the anode elements and each axis extending in a direction normal to the path of the strip surface across the anode.

5. Apparatus for electroplating a surface of an elongated strip comprising, in combination, an adjustable anode, means for longitudinally moving the strip along a path across the anode with a surface facing the anode, said anode being in electrolytic relation to the surface and being formed of a plurality of spaced parallel anode elements of equal length extending transversely of the strip with the ends falling in two straight lines parallel to the direction of strip travel across the anode, and spacing means including two members each having a pivotal connection with each anode element, the axes of rotation of the connections with the members falling in two parallel lines, respectively, which are in turn parallel to the lines formed by the ends of the anode elements and each axis extending in a direction normal to the path of the strip surface across the anode, one of the members being movable relative to the other member for varying the width of the anode in accordance to the width of the strip surface.

6. The method of electroplating a surface of elongated strip of varying width comprising longitudinally moving the strip along a path, supporting an integral adjustable anode parallel to the surface of the moving strip in electrolytic relationship to the surface with the ends of the anode adjacent opposite edges of the strip surface, and angularly adjusting the anode with respect to the length of the strip about a predetermined axis normal to the strip surface to vary the width of the anode in accordance with variations in the width of the strip and maintain the ends of the anode adjacent said opposite edges.

7. The method of electroplating a surface of elongated strip comprising longitudinally moving the strip along a path, supporting an integral adjustable anode parallel to the surface of the moving strip in electrolytic relationship to the surface with the ends of the anode adjacent opposite edges of the strip surface, angularly adjusting the anode with respect to the length of the strip about a predetermined axis normal to the strip surface to vary the width of the anode in accordance with variations in the width of the strip and maintain the anode ends adjacent said opposite edges, and moving the anode toward the strip to compensate for corrosion of the anode.

8. The method of electroplating a surface of elongated strip comprising longitudinally moving the strip along a path, supporting a series of anode elements along the strip path in a plane parallel to the strip surface with each anode element arranged at an angle to the path of the strip such that a controlled thickness of coating is supplied from the anode element across the entire width of the strip, and changing said angle when the width of the strip is changed to maintain such control.

9. The method of electroplating a surface of elongated strip comprising longitudinally moving the strip along a path, supporting a series of elongated anode elements along the strip path in a plane parallel to the strip surface, each anode element arranged at an angle to the path of the strip such that the entire length of the anode element is in substantially uniform electrolytic relation with the strip surface across the entire width of the same, and changing said angle when the width of the strip is changed to maintain such relationship.

10. The method of electroplating a surface of elongated strip comprising longitudinally moving the strip along a path, supporting and arranging a series of anode elements along the strip path in a plane parallel to the strip surface with each anode element arranged at an angle to the path of the strip with opposite ends adjacent opposite edges of the strip surface, the ends of each anode element having original tapered ends so that a controlled thickness of coating is supplied from the anode element across the entire width of the strip surface, and changing said angle when the width of the strip is changed and positioning the tapered ends adjacent the

opposite edges of the strip to maintain such control.

11. Apparatus for electroplating a surface of strip comprising means for moving the strip along a path, an anode support, and an anode formed of a plurality of elongated anode elements of rectangular cross-section extending transversely of the path of the strip supported by the anode support in electrolytic relation to the path of the strip surface with a top surface of each anode element in opposed parallel relation to the path of the strip surface, each anode element having original side surfaces and an original end surface along the edges of the top surface, the original end surface at one end of the anode element making an acute angle with a side surface to provide a top surface tapering inwardly toward the end.

12. Apparatus for electroplating a surface of strip comprising means for moving the strip along a path, an anode support, and an anode formed of a plurality of elongated anode elements of rectangular cross-section extending transversely of the path of the strip supported by the anode support in electrolytic relation to the path of the strip surface with a top surface of each anode element in opposed parallel relation to the path of the strip surface, each anode element having original end surfaces and original side surfaces along the edges of the top surface, one end surface making an acute angle with one side surface and the other end surface making an acute angle with the other side surface to provide a top surface tapering inwardly toward each end of the top surface, the angular end surfaces being on opposite sides of the anode element.

13. Apparatus for electroplating a conductive face of an elongated strip comprising, in combination, an anode support, an anode supported by the anode support, means for longitudinally moving the strip along a path across the anode with the conductive face toward the anode, said anode being formed of a plurality of spaced anode elements extending transversely of and from side to side of the path of the conductive face in a plane parallel to the path of the conductive face, said anode elements being movable in said plane relative to the anode support about axes located in a plane normal to the path of the conductive face and parallel to the direction of strip travel for adjusting the width of the anode to accommodate strips of different transverse width, and restraining means movable relative to the anode support having a pivotal connection with each anode element and acting on the anode elements to maintain them in parallel relationship upon movement of the anode elements relative to the anode support, the axes of the pivotal connections being located along a line parallel to the direction of strip travel.

14. Apparatus for electroplating a conductive face of an elongated strip comprising, in combination, an anode supporting means, an anode having opposite ends and being supported by the anode supporting means, means for moving the strip along a path across the anode with the conductive face toward the anode, said anode extending transversely of and from edge to edge of the path of the conductive face, and a pivotal connection connecting the anode and said anode supporting means for rotational movement of the anode relative to the anode supporting means about an axis normal to the path of the conductive face for adjusting the anode so that the anode ends are in proper operative position adjacent the corresponding edges of the conductive face.

15. Apparatus for electroplating the conductive face of an elongated strip comprising, in combination, an anode supporting and spacing means, an anode supported by the anode supporting and spacing means, means for longitudinally moving the strip along a path across the anode with the conductive face toward the anode, said anode being formed of a plurality of spaced parallel anode elements extending transversely of and from side to side of the path of the conductive face in a plane parallel to the path of the conductive face, and pivotal connections connecting each of the anode elements and said anode supporting and spacing means for rotational movement of the anode elements relative to the anode supporting and spacing means about individual axes normal to the conductive face and located along a line parallel to the direction of strip travel for adjusting the width of the anode to accommodate strips of different transverse width.

16. Apparatus for electroplating the conductive face of an elongated strip comprising, in combination, an anode support, an anode supported by the anode support, means for longitudinally moving the strip along a path across the anode with the conductive face toward the anode, said anode being formed of a plurality of spaced anode elements extending transversely of the path of the conductive face in a plane parallel to the path of the conductive face, pivotal means connecting each of the anode elements and said anode support for rotational movement of the anode elements relative to the anode support about individual axes normal to the path of the conductive face and located along a line parallel to the direction of strip travel for adjusting the width of the anode to accommodate strips of different transverse width, and restraining means including pivotal connections acting on the anode elements confining the same to group movement on rotational movement of the anode elements relative to the anode support.

17. Apparatus for electroplating a conductive face of an elongated strip comprising, in combination, an anode support including a conductive surface, an anode supported by the anode support, means for longitudinally moving the strip along a path across the anode with the conductive face toward the anode, said anode being formed of a plurality of spaced anode elements extending transversely of and from side to side of the path of the conductive face, said anode elements being supported by the anode support with the anode elements in contact with the conductive surface and in a plane parallel to the path of the conductive face and said anode elements being movable in a plane parallel to the path of the conductive face and relative to the anode support about individual axes normal to the path of the conductive surface and located along a line parallel to the path of the strip while maintaining contact with the conductive surface for adjusting the width of the anode to accommodate strips of different transverse width, and restraining means movable relative to the anode support having a pivotal connection with each anode element and acting on the anode elements confining the same to group movement about said axes on movement of the anode elements relative to the anode support, the axes of the pivotal connections being located along a line parallel to the direction of strip travel.

18. Apparatus for electroplating a conductive face of an elongated strip comprising an anode element, and means for longitudinally moving the strip along a path across the anode with the conductive strip face opposed to a surface of the anode element, said anode element being disposed across and parallel to the path of the conductive face and being rotatable about a point on the anode element and about an axis normal to the path of the conductive face and movable angularly with respect to the length of the strip path so that the entire anode element may be maintained in electrolytic relation to the strip path across the entire width of the path of the conductive face despite variations in the width of the strip, the anode element having a first surface in opposed parallel relation to the path of the conductive face, the original ends of the anode element being tapered and the original middle portion of the anode element between the ends being of uniform size to maintain substantially uniform controlled density of the plating current across the entire width of the strip, each tapered end having an original side surface and an original end surface along edges of the first anode element surface, the end surface making an acute angle with the side surface so that the first surface at each end tapers inwardly toward the end.

19. Apparatus for electroplating a surface of elongated strip moving along a path comprising, in combination, means for moving the strip along a path, an anode support, a pivotal anode element carried by the anode support and extending across and from side to side of the path of the strip surface, and means having a pivotal connection with the anode element mounting the anode element on the anode support for angular movement with respect to the direction of strip movement and for rotational movement about a point on the anode element and about a predetermined axis normal to the path of the strip surface so that the entire anode element may be maintained in electrolytic relation to the strip across the entire width of the strip despite variations in the width of the strip.

20. Apparatus for electroplating a surface of elongated strip moving along a path comprising, in combination, means for moving the strip along a path, an anode supporting means, a pivotal anode element carried by the anode supporting means and extending across and from side to side of the path of the strip surface, and means having a pivotal connection with the anode element mounting the anode element on the anode supporting means for angular movement with respect to the direction of strip movement and for rotational movement about a point on the anode element and about a predetermined axis normal to the path of the strip surface so that the entire anode element may be maintained in electrolytic relation to the strip across the entire width of the strip despite variations in the width of the strip, the original ends of the anode element at the opposite sides of the path of the strip surface being tapered to maintain controlled density of the plating current across the width of the strip.

21. Apparatus for electroplating a surface of elongated strip moving along a path comprising, in combination, means for moving the strip along a path, an anode supporting means, a pivotal anode element carried by the anode supporting means and extending across and from side to side of the path of the strip surface, and means having a pivotal connection with the anode element mounting the anode element on the anode supporting means for regular movement with respect to the direction of strip movement and for rotational movement about a point on the anode element and about a predetermined axis normal to the path of the strip surface so that the entire anode element may be maintained in electrolytic relation to the strip across the entire width of the strip despite variations in the width of the strip, an original end surface at each end of the anode element making an acute angle with an original side surface of the anode element such that angular movement of the anode element in the direction toward which the end surfaces face will result in controlled density of the plating current across the width of the strip.

22. Apparatus for electroplating a conductive face of an elongated strip comprising, in combination, an anode support, an anode supported by the anode support, means for longitudinally moving the strip along a path across the anode with the conductive face toward the anode, said anode being formed of a plurality of spaced parallel anode elements extending transversely of and from side to side of the path of the conductive face in a plane parallel to the path of the conductive face, said anode elements being movable in said plane relative to the anode support about axes located in a plane normal to the path of the conductive face and parallel to the direction of strip travel for adjusting the width of the anode to accommodate strips of different transverse width, and restraining means having elements engaging the parallel anode elements at points equidistant from said axes and acting on the anode elements confining the same to parallel group movement about said axes on rotational movement of the anode elements relative to the anode support in said plane.

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Certificate of Correction

Patent No. 2,544,510 March 6, 1951

FREDERICK A. PRAHL

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 14, line 5, for the word "regular" read *angular*;

and that the said Letters Patent should be read as corrected above, so that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 12th day of June, A. D. 1951.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.