

**March 31, 1936.**

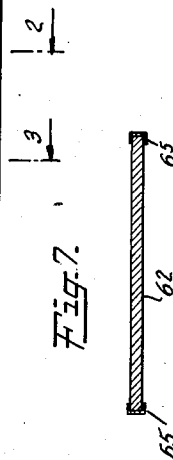
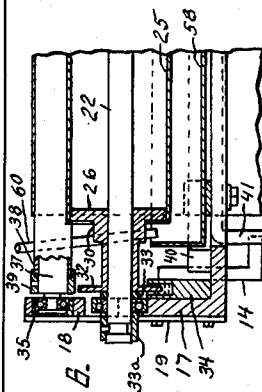
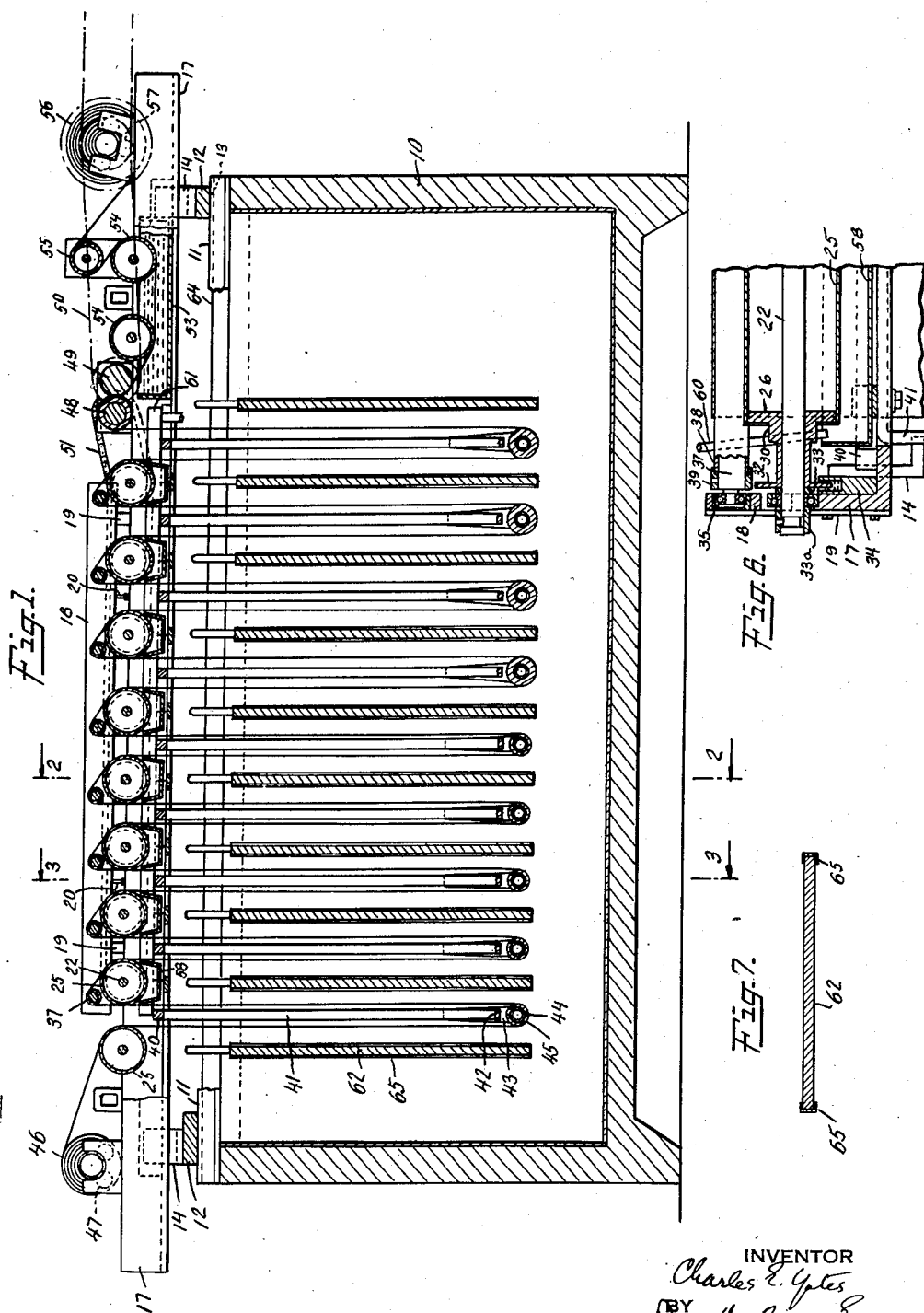
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**2,035,517**

# APPARATUS FOR ELECTRODEPOSITION

Filed April 13, 1933

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 2.

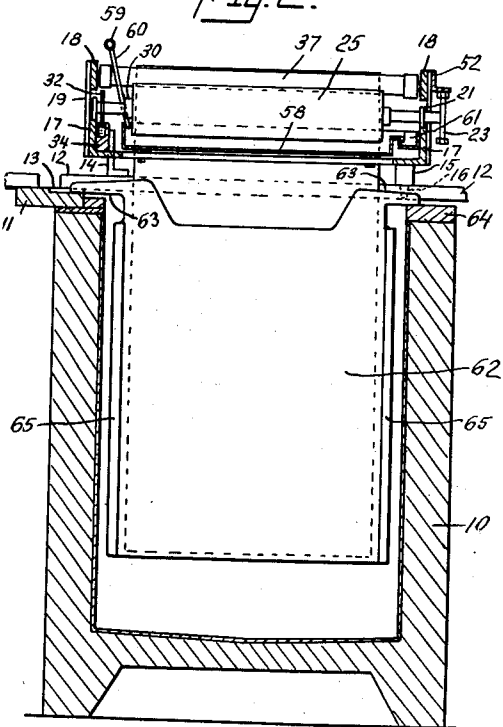


Fig. 3.

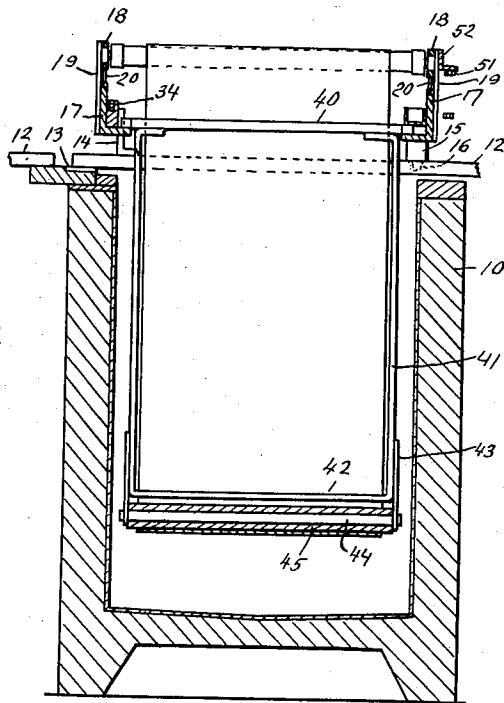


Fig. 4.

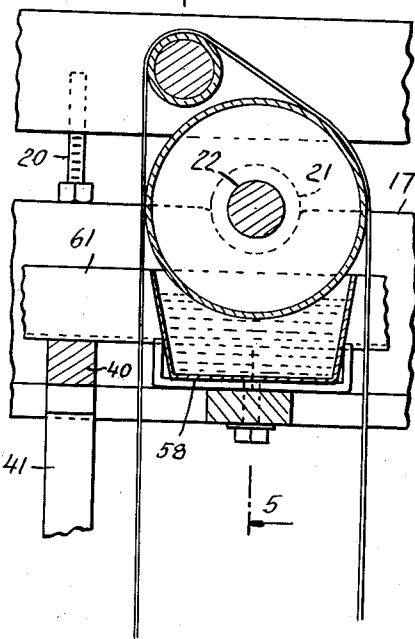
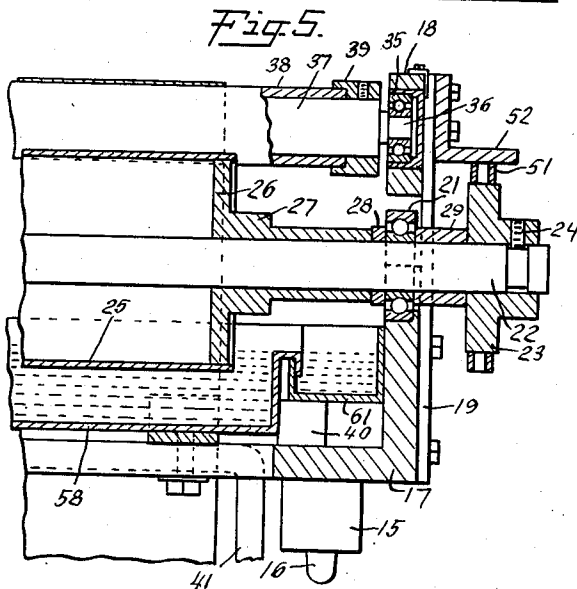


Fig. 5.



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## UNITED STATES PATENT OFFICE

2,035,517

## APPARATUS FOR ELECTRODEPOSITION

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Application April 13, 1933, Serial No. 665,888

29 Claims. (Cl. 204-5)

This invention relates to the production of metallic sheets by electrodeposition, and is concerned more particularly with a novel apparatus in which a thin sheet or foil may be built up to final thickness by the deposition of metal thereon. The new apparatus may be employed to especial advantage in the deposition of copper, and, to explain the principles involved, a form of the device suitable for use in connection with the plating of copper on a sheet of indefinite length will be described in detail, though it is to be understood that the utility of the invention is not limited to the deposition of that particular metal.

In the copending application of Solomon Levy, Charles E. Yates, and William M. Shakespeare, Serial No. 507,126, filed January 7, 1931, now Patent No. 1,952,762, issued March 27, 1934, there is disclosed a method and apparatus for the production of metallic sheets or foils by electrodeposition, and according to the method of that application, metal is deposited on a rotating drum cathode, stripped therefrom, and then built up to final thickness in another plating tank. In the building-up tank, the foil is guided in the form of depending loops between anodes which are mounted face to face in a series extending lengthwise of the tank, and, during its movement, the foil passes in opposition to both faces successively of each of the anodes except the first and last in the series, although if desired additional loops may be used at the ends of the group of anodes, so that the foil opposes each face of each anode in the group. In its travel, the foil receives a deposit on one face only, and, by placing the first and last anodes of the series with their faces parallel, it is possible to produce a sheet of uniform thickness.

In the apparatus disclosed in that application, the foil moves through the tank in such manner that it never passes beneath an anode. As a result, a smooth sheet may be produced, even though soluble anodes are used, since the sludge which is formed when the anodes dissolve and which would cause roughening of the surface of the deposit sheet, if it came in contact with the sheet, falls freely to the bottom of the tank. However, the sheet may be guided to pass alternately under and over the anodes, in which case the sludge may be prevented from falling on the sheet by suitable expedients, if a smooth sheet is desired, or devices for this purpose may be dispensed with, if the smoothness of the sheet is not considered important.

The present invention is directed to the provision of apparatus generally similar to that disclosed in the patent mentioned but is concerned more specifically with improved means for moving the foil through the tank and regulating the tension on it and for withdrawing the plating

current therefrom. In the new apparatus, the means for advancing the foil permits the tension thereon to be regulated and controlled to an extent such that wrinkling of the sheet is prevented, and the contact means by which the foil is connected to the negative side of the source of energy, is continuously treated so that crystallization thereon of the metal salts from the electrolyte with consequent roughening and sprouting, is avoided.

For a better understanding of the invention, reference may be made to the accompanying drawings in which,

Fig. 1 is a view of one form of the apparatus in vertical longitudinal section;

Fig. 2 is a view of the apparatus on the line 2-2 of Fig. 1;

Fig. 3 is a view of the apparatus on the line 3-3 of Fig. 1;

Fig. 4 is a longitudinal sectional view on an enlarged scale of a part of the apparatus shown in Fig. 1;

Figs. 5 and 6 are sectional views on the line 5-5 of Fig. 4, showing opposite end constructions; and Fig. 7 is a sectional view through an anode.

Referring now to the drawings, the apparatus is illustrated in a form resembling that disclosed in application Serial No. 507,126, in the respect that the foil is guided to take the form of loops lying between the anodes and not passing beneath an anode.

The apparatus comprises a tank 10 of any suitable material through which electrolyte is circulated in the usual manner, and extending along the tank at one side of the top is a positive bus bar 11. Negative bus bars 12 extend across the top of the tank at its ends and these bus bars are separated from the positive bus bar on which they rest by strips of insulation 13. Resting on the negative bus bars is a frame structure of any suitable material, preferably of metal, and this frame includes legs 14 at one side and supports 15 at the other side, the supports 15 having dowel pins 16 entering openings in the bus bars, so that the frame may be maintained in proper position on the tank.

Attached to the upper ends of the legs 14 and supports 15, respectively, are longitudinal frame members 17, shown in the form of angle irons, and bars 18 extending along the frame are supported above the frame members 17 on straps 19. The bars are connected to the upper ends of the straps by means permitting vertical adjustment of the bars, effected by adjusting screws 20.

The upper edges of the vertical limbs of the frame members 17 are recessed for the reception of suitable bearings 21, such as ball bearings, for shafts 22, and at one end each shaft carries a sprocket wheel 23 outside the frame member.

Each sprocket wheel is provided with a set screw 24 in its hub by which it can be connected fast to the shaft for a purpose presently to be described.

5 Mounted on each shaft 22 is a hollow roll 25 of conductive material, preferably copper, and the roll has end plates 26 with hubs 27 forming elongated sleeves fitting the shaft loosely. At the end of the sleeve at one end of the roll is a collar 28 engaging one member of the ball bearing 21, and beyond the ball bearing, the shaft carries another collar 29 spacing the bearing and sprocket wheel 23. At the other end, the end plate 26 has a hub 30, provided with a circumferential flange serving as a contact disc 32, and the shaft carries a spacing collar 33 between this disc and bearing and an end collar 33a beyond the bearing. The frame member 17 mounted on legs 14 carries a bus bar 34, the top of which is channeled at intervals to form cavities in which mercury may be placed with the discs 32 entering the mercury, and bus bar 34 is preferably in direct contact with the legs 14.

25 The bars 18 at the top of the frame are provided with recesses for the reception of bearings 35 in which are mounted the shafts 36 of rolls 37, the rolls 37 extending across the frame structure parallel to the shafts 22 and rolls 25. Each roll 37 is formed of suitable material, such as metal, and it is provided with a covering 38, centered between end collars 39. The coverings of the rolls 37 are of different materials depending on the location of the rolls along the frame in the direction of movement of the sheet through the apparatus, the first group of rolls having relatively soft coverings and the second group having coverings of harder material.

40 Extending across the frame below each space between the rolls 25 are bars 40, which are secured rigidly to the frame members 17. Bars 41 attached to bars 40 extend downward therefrom and are connected by a crosspiece 42. Straps 43 are attached to the bars 41 and carry a rod 44 on which is loosely mounted a hollow sleeve 45 which may be of soft rubber. The bars 41, crosspiece 42, straps 43, and shaft 44 are lead-coated to protect them against corrosion from the electrolyte. The structure described serves as one of a lower series of guiding means for the sheet passing through the tank.

50 The supply of foil to receive the plating may take the form of a roll 46 mounted on rolls in a suitable support 47 at one end of the frame and the foil passes over a roll, then down into the tank, around a roll 45, and then upward toward the frame. As the foil leaves the electrolyte, it is wet, and when thin lightweight foil is being plated, it has been found that wrinkling difficulties are encountered if the foil is passed at once to a roll 25 and makes contact therewith for an arc of substantially 180°. To prevent the light foil from becoming wrinkled in this manner, the auxiliary rolls 37 are used, these rolls being placed so that the sheet may pass from a roll 45, around an auxiliary roll 37, and then around a roll 25 and down into the tank to the next roll 45 in the series. When the material being produced weighs 2 oz. per square foot or less, each of the auxiliary rollers will be used, but when a 3 oz. material is being produced, only two or three of the auxiliary rollers at the feed end of the apparatus are used while the others are by-passed with the sheet passing directly from a roll 45 to a roll 25.

75 As mentioned above, it has been found that

for best results, the coverings or surfaces of the auxiliary rolls 37 should be of different materials with the rolls at the feed end of the apparatus surfaced with a soft material, such as soft rubber, and the remainder with harder materials, such as hard rubber, although copper may be substituted for hard rubber on some of the rolls at the discharge end of the apparatus. Where only a few auxiliary rollers are used, as for example, when 3 oz. material is being produced, only soft rubber rolls are used and these rolls are located at the feed end of the tank. In the production of such material, it appears to be best to place the auxiliary rolls so that the sheet passes over a main roll first and then over an auxiliary roll, but in making 2 oz. material, the auxiliary rolls may be disposed in the manner shown in Figure 1 with the sheet passing over an auxiliary roll before it is led to a roll 25. For general purposes, it is perhaps best to place the auxiliary rolls so that the sheet contacts with them after passing over the main rolls.

As an example of one form of the apparatus, there may be eight rolls 25 with their associated auxiliary rolls 37. Of the auxiliary rolls, the first four are surfaced with soft rubber and the remainder with hard rubber, although copper may be substituted for the hard rubber at the discharge end of the apparatus.

At the rear end of the apparatus, driven rolls 48, 49 are mounted on the frame structure, the roll 48 being surfaced with rubber and the surfaces of the rolls contacting. The rolls 48 and 49 which are positively driven by any suitable means, such as a chain 50, positively control the speed of movement of the sheet through the apparatus, and the shaft of roll 48 carries the sprocket wheel about which is led a chain 51. This chain passes over the tops of all the sprocket wheels 23 on the shafts 22 and is held down in contact therewith by any suitable means, such as an angle bar 52 carried on the straps 19. When the apparatus is operating, the feed rolls 48, 49 are continuously rotating, as are also the sprocket wheels 23, and the sprocket wheels are driven in the same direction as the rolls 25 on shafts 22 and at a slightly higher speed. The sprocket wheels 23 may be either fast or loose on the shafts 22, but the rolls 25 are always loose on the shafts. Accordingly, the rolls 25 are never positively driven but are always rotated by the moving foil contacting with them. However, the resistance opposed to the movement of the foil by a roll 25 depends on whether its shaft 22 is being positively driven by its sprocket wheel 23 or is running idly, and thus by setting selected sprocket wheels tight on their shafts, the resistance to foil movement may be cut down to the degree desired, and localized conditions of high tension may be corrected.

Beyond the feed rolls 48, 49, the frame carries a washing pan 53 continuously supplied with water and the sheet passes into the pan under idle guide rolls 54 and then up and over a suitably mounted roll 55, which is made of a hollow copper tube and steam heated so that it dries the sheet. From the roll 55, the sheet may be rolled up as indicated at 56. For this purpose, it is wound on a tube, the ends of which rest on rollers 57 and the tube is rotated in any suitable manner through a friction clutch.

In order that the contact rolls 25 may continuously make a clean contact with the sheet, the frame structure is provided with pans 58, one beneath each roll, and these pans are supplied with fluid through pipe 59 with a separate branch 70

60 leading to each pan and the pans overflow into a trough 61 along one side of the frame. The fluid used may be water, in which case the trough is provided with a waste discharge pipe, but if desired, electrolyte may be supplied to the pans, in which event the trough discharges into the circulating system for the electrolyte.

The anodes 62 used in the tank are preferably of plate form and provided with supporting lugs 63 at the top. One of these lugs rests on and makes contact with the positive bus bar 11 while the other may rest on a piece of wood 64 or other suitable material along the top of the other side of the tank. In order to prevent thickening of the edges of the deposit sheet, the anodes may be provided along their vertical edges with edge shields 65 of channel section, these shields being non-conductive under the conditions of operation. If soluble anodes of copper are employed, the shields may be made of antimonial sheet lead, since with such anodes, the voltage between the anode and cathode may be under 1.7 volts, which is the voltage required to cause current to flow from the lead to the electrolyte. When insoluble anodes are employed, the shields should be of insulating material, such as rubber, wood, etc. In either case, the shields reduce the current density on the sheet along its edges and thus prevent thickening of the edges. If shields are not used, the thickened edges of the sheet are removed by trimming knives acting on the sheet before it is rolled up.

It will be seen that in the apparatus described, the foil supplied for plating is drawn through the apparatus by the feed rolls 48, 49, and if no provision were made to prevent, the tension on the foil would build up from one end of the apparatus to the other, and serious wrinkling of the foil would result. Also, differences in friction at different points would produce localized points of high tension resulting in wrinkling. It has not been possible heretofore to correct these conditions in practical operation as, for example, by causing all the rolls to be positively driven, since they must be rotated at exact relative speeds to obtain the desired result. However, with the present apparatus in which the resistance to movement of the sheet offered by the rolls 25 may be varied and controlled by causing the shafts of more or less of these rolls to be driven, the difficulties are entirely overcome. The driving of the shafts on which the rolls are mounted for free rotation entirely eliminates the friction of the journals for these rolls and thus reduces the tension in the sheet. If the tension of the sheet is high, with a consequent increase of pressure of the rollers against their shafts, some driving action may also be obtained, since the shafts are rotated at a somewhat higher speed than that of the feed rolls 48, 49. When the shaft of a roll is not driven, a certain amount of friction between the shaft and roll develops and this serves to prevent the formation of slack in the sheet. Since the shafts of the rolls can be driven selectively, a close approximation of the desired conditions of tensions throughout the sheet is obtained in a simple and convenient manner and this control of tension does not require constant attention from the operator making adjustments of driving speeds, etc.

In order to insure that the rolls will function in the manner described, they are made hollow and a quantity of lubricating oil introduced into the interior of each roll. This serves to lubri-

cate the bearing of the roll on the shaft and prevents the roll from becoming stuck to the shaft.

Difficulties arising from wrinkling caused by adherence of the thin wet sheet to the contact rolls 25 are avoided by the use of the auxiliary rolls which reduce the area of contact of the sheet and contact rolls and thus reduce the adherence and difficulties in obtaining a proper contact between the sheet and the rolls 25 are overcome by continually maintaining the rolls wet by supplying fluid to the pans beneath the rolls.

While the apparatus illustrated is of a form in which the sheet being plated is guided to provide loops between adjacent anodes with the sheet never passing beneath an anode, it will be apparent that the utility of the invention is not limited to that particular type of equipment. In all forms of plating apparatus in which the deposit sheet passes through the tank along a tortuous course, difficulties arise from variations in the tension of the sheet, from the adherence of the wet sheet to contact rolls outside the solution, and in obtaining a proper contact between the sheet and the contact rolls, and these difficulties may be overcome by the use of the present invention regardless of whether or not the sheet passes beneath the anodes.

The apparatus described may be used to produce sheet material of a wide range of thicknesses and has been used in regular operation in the production of material ranging from 2 to 8 oz. in weight per square foot. It has also been used successfully in the production of material having a weight of 17 oz. per square foot.

I claim:—

1. Apparatus for the electrolytic production of sheet metal, which comprises a plating tank containing a plurality of anodes mounted in the tank in spaced relation with their faces opposed, means for advancing a foil to be plated through the tank, means for guiding the foil in a tortuous course among the anodes, and means for controlling the resistance to movement of the foil offered by said guiding means.

2. Apparatus for the electrolytic production of sheet metal, which comprises a plating tank containing a plurality of anodes mounted in the tank in spaced relation with their faces opposed, means for advancing a foil to be plated through the tank, means for guiding the foil in a tortuous course among the anodes, said means including rotatable elements contacting with the foil, and means for controlling the resistance to movement of the foil offered by said guiding means.

3. Apparatus for the electrolytic production of sheet metal, which comprises a plating tank containing a plurality of anodes mounted in the tank in spaced relation with their faces opposed, means for advancing a foil to be plated through the tank, means for guiding the foil in a tortuous course among the anodes, said means including rotatable elements in upper and lower series with which the foil contacts alternately, and means for controlling the resistance to movement of the foil offered by the elements of the upper series.

4. Apparatus for the electrolytic production of sheet metal, which comprises a plating tank containing a plurality of anodes mounted in the tank in spaced relation with their faces opposed, means near one end of the group of anodes for drawing a foil through the tank to receive a deposit therein, means for guiding the foil in a tortuous course among the anodes, and means for controlling the resistance to movement of the foil offered by the guiding means.

5. Apparatus for the electrolytic production of sheet metal, which comprises a plating tank containing a plurality of vertical anodes, means for advancing a foil through the tank to receive a deposit, means for guiding the foil along a vertical zig-zag path through the tank with the foil opposing the faces of the anodes, and means for controlling the resistance to movement of the foil offered by the guiding means.
6. Apparatus for the electrolytic production of sheet metal, which comprises a plating tank containing a plurality of vertical anodes, means for advancing a foil through the tank to receive a deposit, means for guiding the foil along a vertical zig-zag path through the tank with the foil opposing the faces of the anodes, said means including a plurality of rotatable elements contacting with the foil and rotated thereby, and means for controlling the resistance to rotation offered by said elements.
7. Apparatus for the electrolytic production of sheet metal, which comprises a plating tank containing a plurality of anodes, means for advancing a foil through the tank to receive a deposit, means for guiding the foil along a tortuous path through the tank with the foil opposing the faces of the anodes, said means including a plurality of rotatable elements contacting with the foil and rotated thereby and shafts on which said elements are mounted for free rotation, and means for rotating said shafts to control the resistance to the movement of the foil offered by said elements.
8. Apparatus for the electrolytic production of sheet metal, which comprises a plating tank containing a plurality of anodes, means for advancing a foil through the tank to receive a deposit, means for guiding the foil along a tortuous path through the tank with the foil opposing the faces of the anodes, said means including a plurality of rotatable elements contacting with the foil and rotated thereby and shafts on which said elements are mounted for free rotation, and means for rotating selected shafts to control the resistance to the movement of the foil offered by said elements.
9. Apparatus for the electrolytic production of sheet metal, which comprises a plating tank containing a plurality of anodes, means for advancing a foil through the tank to receive a deposit, means for guiding the foil along a tortuous path through the tank with the foil opposing the faces of the anodes, said means including a plurality of rotatable elements contacting with the foil and rotated thereby and shafts on which said elements are mounted for free rotation, continuously operating driving means, and means for connecting selected shafts to said driving means to control the resistance to the movement of the foil offered by said elements.
10. In apparatus for electrodeposition, the combination of a plating tank, a plurality of rolls mounted for rotation above the solution level in said tank, means for advancing a foil through said tank with said foil in its movement engaging and rotating said rolls, and means for controlling the resistance to movement of said foil offered by said rolls.
11. In apparatus for electrodeposition, the combination of a plating tank, a plurality of rotatable shafts mounted above the solution level in said tank, a roll mounted for free rotation on each shaft, means for advancing a foil through said tank with said foil in its movement engaging and rotating said rolls, and means for rotating selected shafts in the direction of rotation of said rolls.
12. In apparatus for electrodeposition, the combination of a plating tank, a plurality of rotatable shafts mounted above the solution level in said tank, a roll mounted for free rotation on each shaft, means for advancing a foil through said tank with said foil in its movement engaging and rotating said rolls, continuously operating driving means, and means for connecting selected shafts to said driving means to be rotated thereby in the direction of rotation of said rolls.
13. In apparatus for electrodeposition, the combination of a plating tank, a plurality of rotatable shafts mounted above the solution level in said tank, a negative bus-bar, a roll mounted for free rotation on each shaft, means for advancing a foil through said tank with said foil engaging said rolls on its movement and rotating them, and an electrical connection between each roll and said bus-bar.
14. In apparatus for electrodeposition, the combination of a plating tank, a plurality of rolls mounted above the solution level in the tank, means for advancing a foil through the solution to receive a deposit, said foil passing out of the solution and over the rolls successively, and means for continuously wetting the surfaces of said rolls to provide clean contact surfaces thereon.
15. In apparatus for electrodeposition, the combination of a plating tank, a plurality of rolls mounted above the solution level in the tank, means for advancing a foil through the solution to receive a deposit, said foil passing out of the solution and over the rolls successively, a vessel beneath each roll containing a liquid into which the roll dips, and means for changing the liquid.
16. In apparatus for electrodeposition, the combination of a plating tank, a plurality of rolls mounted above the solution level in the tank, means for advancing a foil through the solution to receive a deposit, said foil passing out of the solution and over the rolls successively, a vessel beneath each roll, and means for causing a flow of liquid through the vessel in contact with the surface of the roll.
17. In apparatus for electrodeposition, the combination of a plating tank, a plurality of guides disposed within the solution in the tank, a plurality of rolls disposed in a series along the tank, means for advancing a sheet through the tank to receive a deposit, said sheet passing beneath the guides and up and over the rolls successively, and means for varying the arcs of contact of the sheet with the rolls.
18. In apparatus for electrodeposition, the combination of a plating tank, a plurality of guides disposed within the solution in the tank, a plurality of rolls disposed in a series along the tank, means for advancing a sheet through the tank to receive a deposit, said sheet passing beneath the guides and up and over the rolls successively, and means for varying the arcs of contact of the sheet with the rolls, said means comprising rolls lying parallel to said rolls.
19. In apparatus for electrodeposition, the combination of a plating tank, a plurality of guide elements in a series lying within said tank, a plurality of main rolls disposed in a series along said tank above the level of the series of guide elements, means for advancing a sheet through the tank to receive a deposit, said sheet passing beneath the guide elements and over the main rolls alternately, and auxiliary rolls mounted adjacent certain main rolls and contacting with the sheet, each auxiliary roll being so disposed as to lessen the extent to which said sheet would con-

tact with its main roll but for the action of said auxiliary roll.

20. In apparatus for electrodeposition, the combination of a plating tank, a plurality of guide elements in a series lying within said tank, a plurality of main rolls disposed in a series along said tank above the level of the series of guide elements, means for advancing a sheet through the tank to receive a deposit, said sheet passing beneath the guide elements and over the main rolls alternately, and auxiliary rolls mounted adjacent certain main rolls and contacting with the sheet, each auxiliary roll being so disposed as to lessen the extent to which said sheet would contact with its main roll but for the action of said auxiliary roll and said auxiliary rolls having surfaces of different materials.

21. In apparatus for electrodeposition, the combination of a plating tank, a plurality of guide elements in a series lying within said tank, a plurality of main rolls disposed in a series along said tank above the level of the series of guide elements, means for advancing a sheet through the tank to receive a deposit, said sheet passing beneath the guide elements and over the main rolls alternately, and auxiliary rolls mounted adjacent certain main rolls and contacting with the sheet, each auxiliary roll being so disposed as to lessen the extent to which said sheet would contact with its main roll but for the action of said auxiliary roll, said auxiliary rolls near the entrance end of the tank having surfaces which are softer than the surfaces of the rolls near the exit end of the tank.

22. In apparatus for electrodeposition, the combination of a plating tank, a plurality of guide elements in a series lying within said tank, a plurality of main rolls disposed in a series along said tank above the level of the series of guide elements, means for advancing a sheet through the tank to receive a deposit, said sheet passing beneath the guide elements and over the main rolls alternately, and auxiliary rolls mounted adjacent certain main rolls and contacting with the sheet, each auxiliary roll being so disposed as to lessen the extent to which said sheet would contact with said main roll but for the action of said auxiliary roll and said auxiliary rolls adjacent the entrance end of the tank having surfaces of soft rubber.

23. In apparatus for electrodeposition, the combination of a plating tank, a plurality of guide elements in a series lying within said tank, a plurality of main rolls disposed in a series along said tank above the level of the series of guide elements, means for advancing a sheet through the tank to receive a deposit, said sheet passing beneath the guide elements and over the main rolls alternately, and auxiliary rolls mounted adjacent certain main rolls and contacting with the sheet, each auxiliary roll being so disposed as to lessen the extent to which said sheet would contact with said main roll but for the action of said auxiliary roll and said auxiliary rolls adjacent the exit end of the tank having surfaces of hard rubber.

24. In apparatus for electrodeposition, the combination of a plating tank, a plurality of guide elements in a series lying within said tank, a plurality of main rolls disposed in a series along said tank above the level of the series of guide elements, means for advancing a sheet through the tank to receive a deposit, said sheet passing beneath the guide elements and over the main

rolls alternately, and auxiliary rolls mounted adjacent certain main rolls and contacting with the sheet, each auxiliary roll being so disposed as to lessen the extent to which said sheet would contact with said main roll but for the action of said auxiliary roll, said auxiliary rolls adjacent the entrance end of the tank having surfaces of soft rubber, those adjacent the exit end of the tank having surfaces of metal, and those between the entrance and exit ends of the tank having surfaces of hard rubber.

25. In apparatus for electrodeposition, the combination with a plating tank having a positive and a negative bus-bar thereon, of a frame supported above the tank and having a conductive portion engaging said negative bus-bar, a plurality of negative contact elements supported on said frame and electrically connected to said conductive portion, a plurality of guide elements attached to said frame and lying in a series within said tank, and means for advancing a sheet through said tank, said sheet passing beneath guide elements and over contact elements alternately.

26. In apparatus for electrodeposition, the combination with a plating tank, having a positive and a negative bus-bar thereon, of a frame supported above the tank and having a conductive portion engaging said negative bus-bar, a plurality of rotatable negative contact elements supported on said frame and electrically connected to said conductive portion, a plurality of guide elements attached to said frame and lying in a series within said tank, means for advancing a sheet through said tank, said sheet passing beneath guide elements and over contact elements alternately, said contact elements being rotated by the movement of the sheet in contact therewith, and means for varying the resistance to the movement of the sheet offered by said contact elements.

27. Apparatus for electrodeposition, which comprises a plating tank containing a plurality of anodes mounted in the tank in spaced relation with their faces opposed, means for advancing a foil to be plated through the tank, means for guiding the foil so that it forms loops between adjacent anodes without passing underneath an anode, and means for varying the resistance to movement of the foil offered by said guiding means.

28. A method of depositing metal upon a sheet in an electrolytic cell containing a plurality of anodes which comprises advancing the sheet through the tank by pulling on it at one point, guiding it in its movement to cause it to follow a tortuous path among the anodes, said guiding operation offering resistance to the movement of the sheet at the places where it changes direction, and controlling the tension on the sheet by varying said resistance at certain of said places.

29. In apparatus for electrodeposition, the combination of a plating tank, a plurality of anodes mounted in said tank in spaced relation with their faces opposed, means for advancing a foil to be plated through said tank, means for guiding the foil so that it follows a tortuous course among said anodes, and shields on the vertical edges only of said anodes, said shields being non-conductive under the conditions of operation in said tank and preventing increased plating along the edges of said foil.

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