ELECTROPLATING APPARATUS

Filed March 8, 1965 5 Sheets-Sheet 1

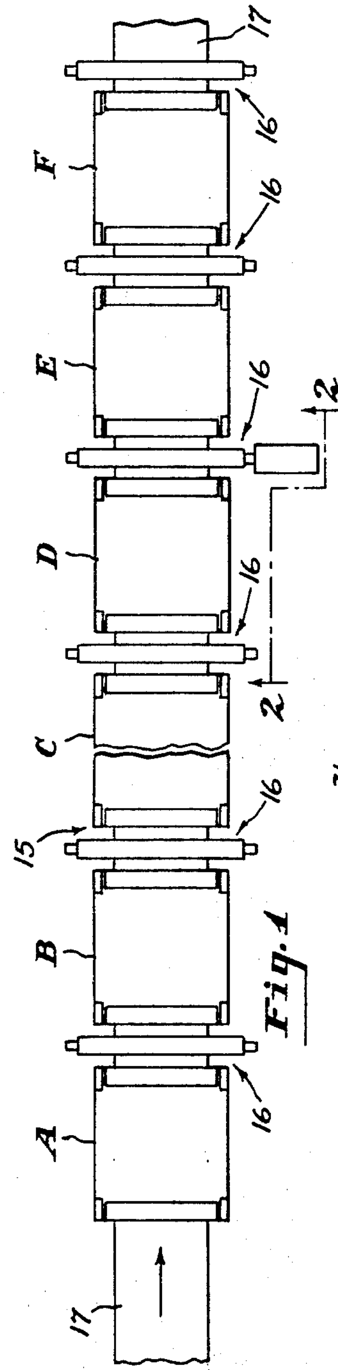

Fig. 1

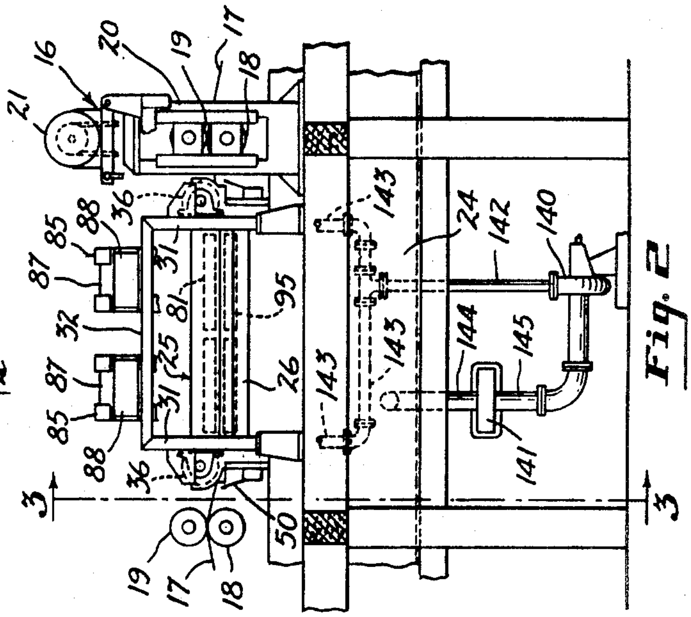

Fig. 2

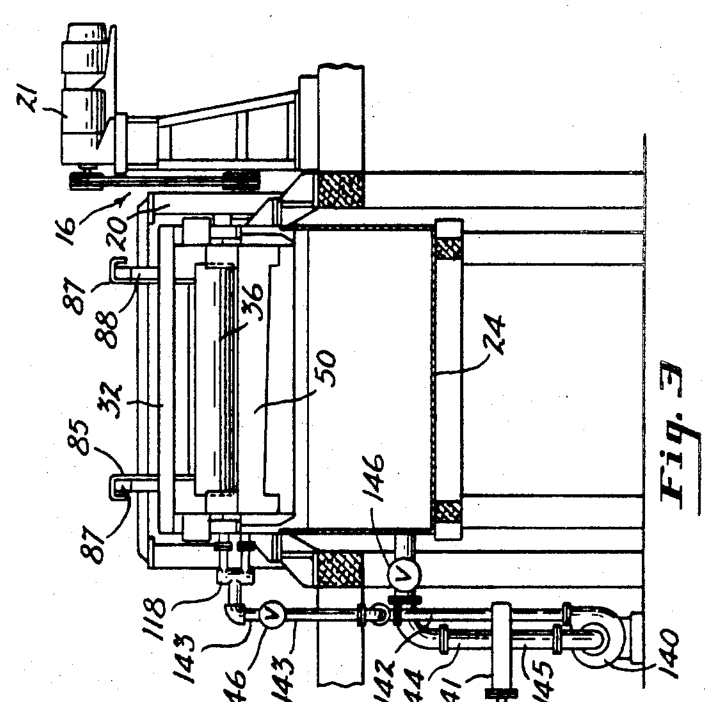

Fig. 3

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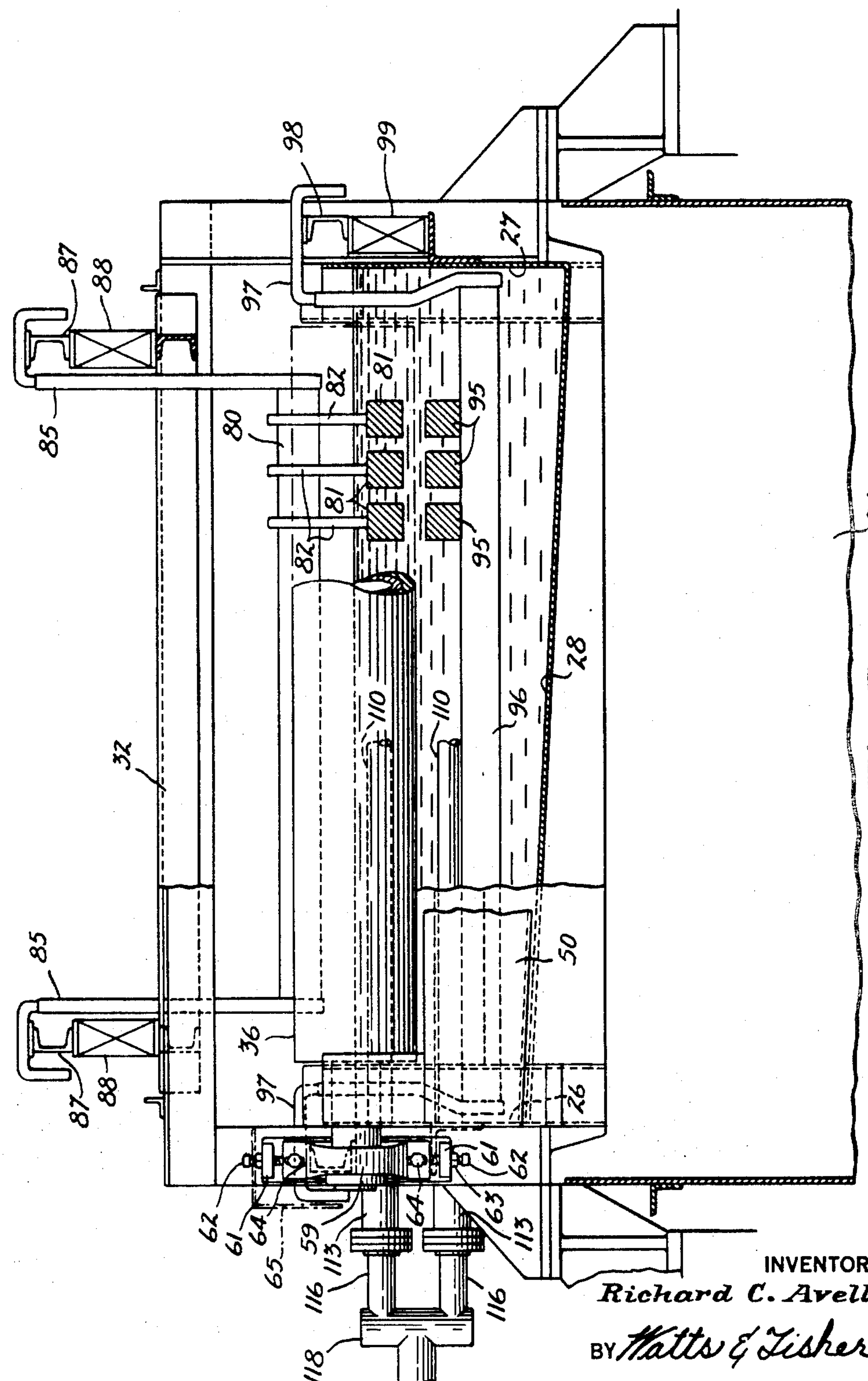

Fig. 5

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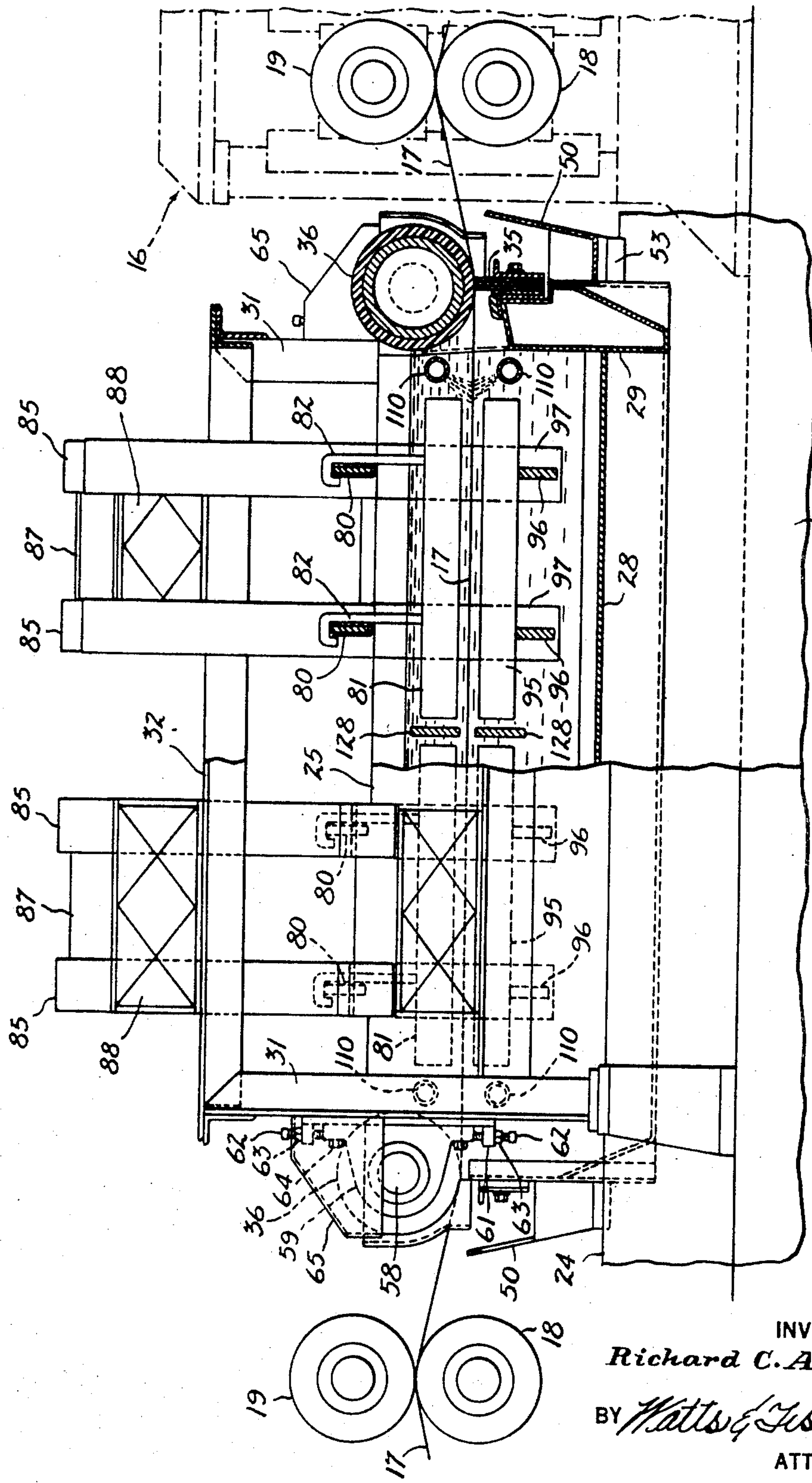

Fig. 4

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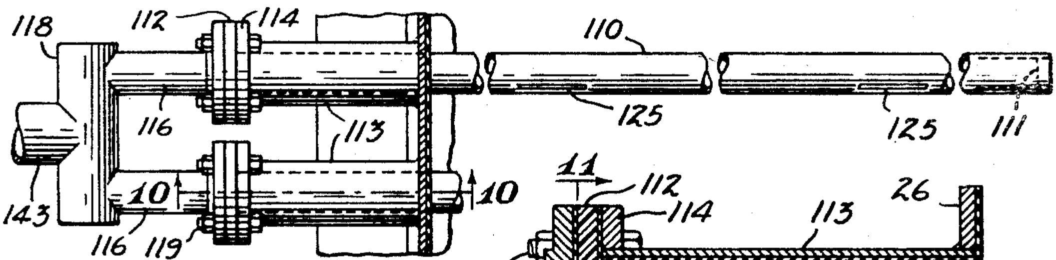

Fig. 9

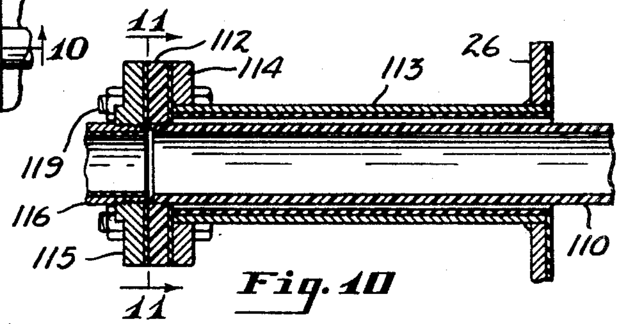

Fig. 10

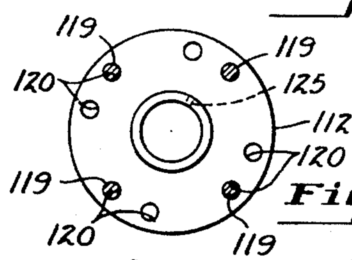

Fig. 11

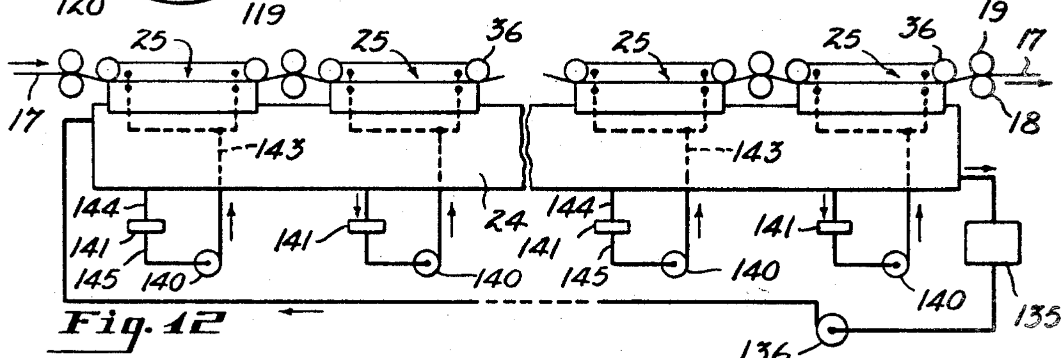

Fig. 12

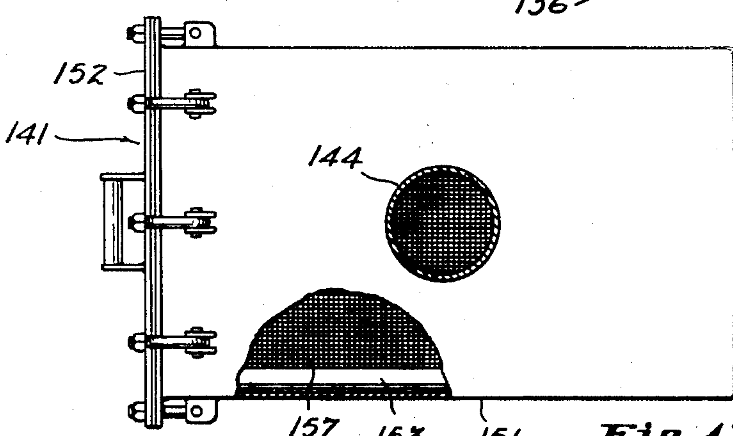

Fig. 13

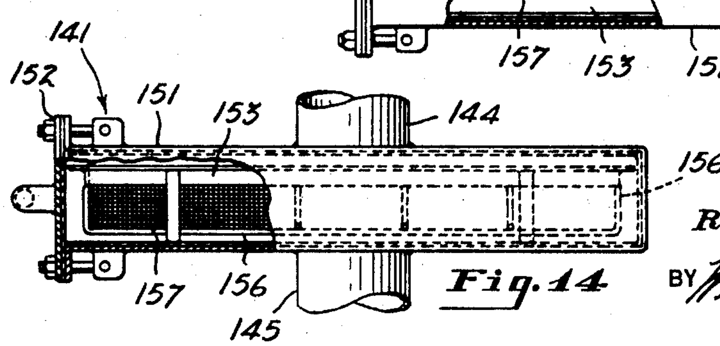

Fig. 14

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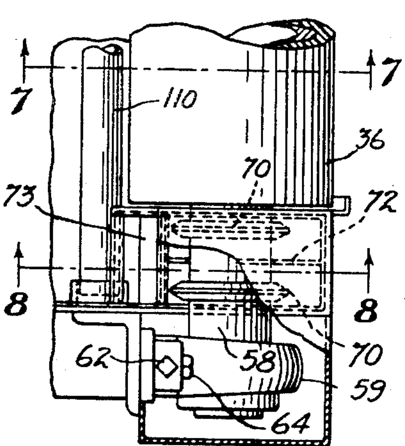

Fig. 6

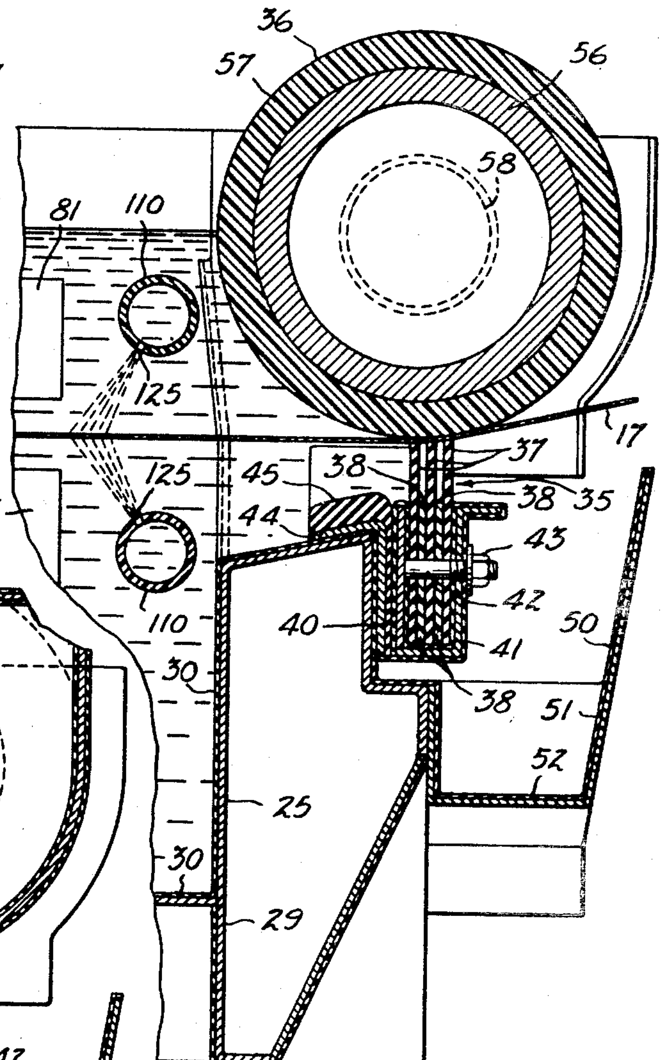

Fig. 7

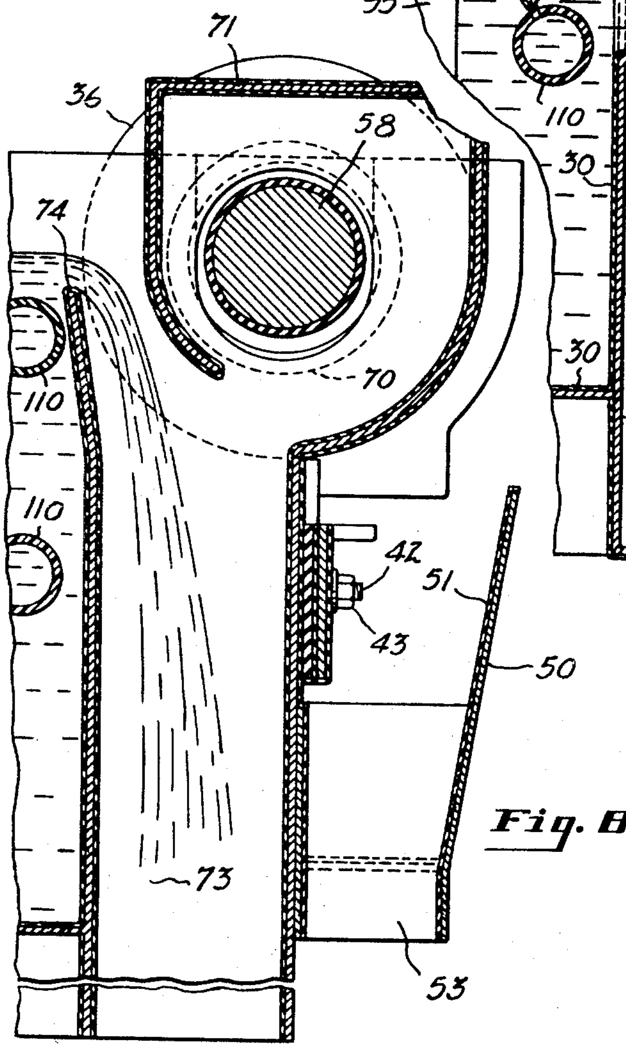

Fig. 8

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United States Patent Office

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ELECTROPLATING APPARATUS

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Int. Cl. C23b 5/58, 5/70
U.S. Cl. 204—207 13 Claims

ABSTRACT OF THE DISCLOSURE

An electroplating cell for high speed continuous strip plating lines comprises a tray for holding the plating solution having end walls through which the strip passes. A pair of entry and exit dam members cooperate to hold the strip on a pass line as it travels through the tray and in conjunction with the end and side walls of the tray, contain the plating solution at a predetermined level above the pass line. At least one of the exit dam members comprises a resilient wiping strip in uniform contact across the width of the strip which serves to wipe the plating solution from a surface of the strip. A distributor tube submerged in the tray ahead of the wiping strip adjacent the pass line delivers jets of plating solution preferably counterflow to the direction of strip movement to agitate the plating solution which otherwise tends to be dragged out of the cell on the strip surface.

Field of the invention

This invention relates generally to the electroplating art, and more specifically to apparatus for electrodepositing a layer of metal such as zinc from a plating bath on a continuously moving base material. It is particularly concerned with new and useful improvements in the construction of the plating cells in a continuous strip plating line and a system for agitating, circulating and purifying the plating bath of each cell so as to obtain a high quality product at maximum production rates.

In the continuous electroplating of strip material, it is usual to move the strip through a series of cells, each comprising a tray containing the plating solution and a number of suitably disposed soluble anodes. Electrical contact to the strip is made at intervals by electric contact rolls which are mounted between the trays, whereby the strip is connected as the cathode in the electroplating circuit. The strip thus receives a metallic deposit as it is progressively moved through the several plating cells.

The thickness of the deposit depends upon the current and the immersion time, and, in a continuous strip plating operation, can be controlled by adjusting the strip speed in relation to the current available for plating and the number of plating cells in the line. Consequently, when producing a deposit of a desired thickness, maximum current and high current densities are required for high line speeds. It is therefore important in a strip plating operation to control the conditions affecting current efficiency.

In order to make full use of the available current and achieve a high rate of production, it is essential to provide effective circulation and agitation of the plating solution in each cell. Maximum solution agitation reduces anode polarizations which restrict current flow. Proper circulation of the solution between the anodes and the cathodic strip is also necessary to assure an adequate supply of the coating metal ions to the strip and thereby improve the plating efficiency, and to prevent deposit burning at the desired high current densities.

Another factor which is important in obtaining high uniform quality of the product at maximum production rates is the control and removal of metal and organic

contaminations from the plating bath. Contamination may result from tree growths on the anodes and strip edges, from zinc flakes on the strip surface due to poor adhesion of the deposit, and from damaged equipment such as cell dams, rolls, polishers and the like. Other debris, such as rust, dirt, solid soils and metal chips may drop into the bath from overhead structures or be introduced into the bath on the strip surfaces.

Such contaminants affect the bath performance by contributing to anode polarizations, reducing cathode or strip efficiency, and reducing strip and anode current density ranges. They also affect the quality of the product. For example, deposits at high current densities have aboreal, burnt or powdery structures, while deposits produced at medium current density ranges are hard, have poor adhesion, no ductility, and poor continuity and appearance. In addition, when solid contaminants are carried to the processing rolls, they cause defects in the strip surface which have been one of the main reasons for product rejection and scrappage.

It is particularly important to provide an efficient filtering system in a high speed, high current operation where both sides of the strip are plated because of the desirability of making maximum use of the available current and the fact that any contaminants in the solution have more chance to affect the surface of the strip when it is plated on both sides.

Continuous strip plating operations present the further problem of preventing solution drag-out or loss of the electrolyte due to movement of the strip out of the cells of the plating line. It is customary to provide dams at the exit ends of the cells in an attempt to inhibit solution flow in the direction of strip travel and to prevent loss due to splashing, but the prior arrangements have not been entirely satisfactory, particularly at high line speeds which magnify the problem. Excessive solution flow to the contact rolls contributes to roll plating and to the formation of dried sludges, both of which adversely affect the surfaces of the strip. Moreover, the bath losses which result are costly, since considerable quantities of chemicals are required for make-up additions.

The present invention provides new and improved electroplating apparatus which overcomes the problems discussed above and obtains an efficient plating line operation in which a continuously moving substrate or base metal strip can be uniformly coated simultaneously on both sides at high line speeds. These advantages are obtained in part by improved solution agitation and circulation of the electrolyte in each plating cells. The new system includes the provision of novel solution distributor tubes. These tubes are preferably mounted near the ends of each cell above and below the strip pass line to provide strip washing, to supply fresh solution to the electrodes in an improved manner, and to create a turbulent circulation of the solution between the anodes and the strip. As discussed above, these conditions are necessary to permit full use of available current and particularly to reduce electrode polarizations and deposit burning at high current densities. With the preferred construction and arrangement, it is therefore possible to obtain thicker coatings on the substrate than has been possible in the past at the same production rates and to obtain coatings of the same thickness as in the past at higher production rates.

Another feature of the invention resides in a new and improved plating cell construction which includes a novel dam arrangement designed to reduce drag out and consequent bath losses. In the preferred embodiment, the cell construction comprises a rubber lined steel tray having slotted ends to permit the passage of the strip. A damming roll is used as the upper portion of each cell end wall and serves to return and hold the strip on a pass line as it travels through the cell. The damming rolls also help to prevent electrical shorting of the strip to the upper anodes. The bottom dams at each end of the cell are preferably in the form of thin squeegees sandwiched between suitable separator plates. These bottom dams or squeegees lie directly below the upper damming rolls and prevent excessive solution flow externally of the cell to the contact rolls. Cell gutters are used across each cell and below the dam assemblies to reduce solution splashing and overflow weirs are located in each corner of the cell. These weirs are constructed to permit usage of full pump capacity so as to obtain proper solution coverage of the upper anodes and to obtain removal of suspended bath contaminants.

The invention further contemplates the provision of a new and improved system for removing bath contaminants and supplying the electrolyte to the plating cells. In the preferred arrangement, a separate pump is used for each plating cell in the line continuously to recirculate plating solution between a reservoir and the cells. These pumps in conjunction with the solution distributor tubes provide the necessary agitation and rapid change of the solution that is required for high speed plating operations. A filter unit also is provided in connection with each cell pump to prevent larger bath debris and contaminants from being recirculated to the strip surfaces and from clogging the solution distributor tubes. The filter units preferably include a removable basket covered with a suitable screen for trapping bath debris. The outlet of each filter unit is connected to the pump intake line and the inlet of each unit is connected to an opening near the base of the reservoir tank. With this arrangement, solution from the reservoir is cleaned prior to its entrance into each pump and plating cell. In addition to the individual cell filter units, large filter presses may be used continuously during operation of the line for removing minute, as well as larger bath contaminants and for removing carbon and zinc dust materials used in bath purification treatments.

All of the foregoing improvements are obtained in an arrangement which minimizes detrimental line stops. In particular, it is possible to replace the cell dams and anodes and to clean the filter units without stopping the strip.

Other advantages and a fuller understanding of the invention will be had by reference to the following detailed description and the accompanying drawings.

In the drawings:

FIGURE 1 is a schematic top plan view of a portion of a plating line embodying the apparatus comprising the present invention;

FIGURE 2 is a side elevational view taken on the line **2—2** of FIG. 1 showing one cell of the illustrated plating line;

FIGURE 3 is an end elevational view of the plating cell taken on the line **3—3** of FIG. 2;

FIGURE 4 is an enlarged side elevational view, partially in cross-section, of a portion of the plating cell;

FIGURE 5 is an enlarged end elevational view, partially in cross-section, of a portion of the plating cell;

FIGURE 6 is a fragmentary top plan view of a portion of the cell assembly;

FIGURE 7 is a vertical cross-sectional view taken on the line **7—7** of FIG. 6;

FIGURE 8 is a vertical cross-sectional view taken on the line **8—8** of FIG. 6;

FIGURE 9 is a fragmentary top plan view of another portion of the apparatus;

FIGURE 10 is a cross-sectional view taken on the line **10—10** of FIG. 9;

FIGURE 11 is a view taken on the line **11—11** of FIG. 10;

FIGURE 12 is a view diagrammatically illustrating the preferred filtering and solution circulating system for cells of the plating line;

FIGURE 13 is a fragmentary top plan view of a portion of the filtering and circulating system; and

FIGURE 14 is a side elevational view, partially in cross-section, of the structure shown in FIG. 13.

The invention is hereinafter specifically described in connection with the formation of a zinc coating on both sides of a ferrous metal strip. However, it is to be understood that the improvements which are provided can be used in electrodepositing other metals on various conductive materials, including tubes, wires and the like. It will also be understood that the invention is not limited to the plating of both sides of the base material simultaneously, although it has particular utility in such an operation.

Referring now to the drawings, and to FIG. 1 in particular, the illustrated strip plating line embodying the present invention is indicated generally by reference numeral **15**. The plating line **15** is comprised of a desired number of individual plating cells designated by the letters A–F. Roll assemblies **16** which are preferably positioned between each pair of adjacent cells of the plating line are used to move the strip **17**. As shown in FIGS. 2, 3 and 4, each of the assemblies **16** includes a contact roll **18** by which electric current is supplied to the strip **17** and a cooperating back-up roll **19**. The rolls **18, 19** may be suitably mounted in a roll stand **20** for adjustment toward and away from each other as is well understood in the art and the contact roll driven by a motor **21**.

The cells A–F are shown mounted above a plating solution reservoir tank **24**. This tank may be of a sufficient size to hold the total volume of plating solution required for all of the cells. It is also possible to use a multiple number of reservoir tanks, if desired. As described in greater detail below, each of the plating cells A–F is connected to the reservoir **24** so that the solution is individually pumped through each cell and is filtered to remove solution contaminants.

Referring now more particularly to FIGS. 2–8, the preferred construction of each of the plating cells A–F is shown to comprise a tray **25** having side walls **26, 27**, a bottom wall **28** which slopes downwardly from the side wall **26** to the opposite side wall **27**, and end walls **29**. As is conventional, the tray **25** has a rubber coating **30** on its inner surfaces. The tray **25** is mounted within a structural framework comprised of vertical members **31** and horizontal top members **32**.

Each of the opposite end walls **29** is slotted to provide entrance and exit openings for the strip **17** so that it can be moved through the tray **25**. In the preferred embodiment of the invention, each of the slotted end walls **29** is comprised of a lower dam in the form of a squeegee **35** and an upper dam in the form of a roll **36**. The squeegee **35** and the roll **36** at each end of the tray cooperate to establish a pass line (see particularly FIG. 4) along which the strip **17** is moved through the cell. The bottom dams **35** also prevent excessive flow of the plating solution externally of the cell to the reservoir **24** and the roll assemblies **16**.

As shown most clearly in FIG. 7, the squeegee **35** is an assembly comprised of three adjacent strips **37** that are held between separator plates **38**. The strips **37** are preferably formed of a non-corrosive, flexible material, such as polyurethane or the like. The strips **37** and the intermediate separator plates **38** are secured between a rubber coated clamp bar **40** and a rubber coated dam support bracket **41** by means of studs **42**. The studs **42** are secured to the clamp bar **40** along its length and extend through the assembly of the strips and separator plates. Nuts **43** are threaded on the outer ends of the studs against the outside of the dam support bracket **41**. The squeegee assemblies are each secured to an end of the cell by a bumper **44** which comprises a steel plate and a rubber coating **45** between the plate and the clamp bar **40**. The bumper **44** is secured to a portion of the tray **25** by accessible bolts (not shown). With this arrangement in which the nuts **43** and the bolts for the bumper **44** are on the outside of the tray the dam or squeegee **35** can be easily removed for repair or replacement without stopping the strip **17**.

A gutter **50** is provided across each cell end directly below the lower dam assembly **35** in order to reduce solution splashing and to return to the reservoir the solution that passes between the squeegee and the upper dam roll **36**. The gutter **50** is in the form of a metal trough which is secured to the cell ends and is coated on its inside surface with rubber **51**. The bottom wall **52** of the gutter slopes from one end to the opposite end which is provided with a downspout **52** that communicates with the reservoir **24**. The downspout **52** is also formed of rubber coated metal.

The upper dam roll **36** comprises a metal shell **56** having a soft rubber-like coating **57** formed of polyurethane resin or the like. The metal shell **56** is provided at its ends with roll necks **58**. Each of the roll necks **58** is bearinged in pillow blocks **59**. These pillow blocks **59** are secured to the vertical framework members **30** for limited vertical adjustment to accommodate roll wear. As shown most clearly in FIGS. 4, 5 and 6, the pillow blocks **59** are each mounted by a bracket **60** that includes adjusting blocks **61** above and below the pillow blocks. The adjusting blocks **61** are tapped to receive vertical adjustment screws **62** which are provided with jam nuts **63**. The adjusting screws **62** extend into engagement with the pillow blocks which are secured to the bracket plate **60** by means of cap screws **64**. These cap screws **64** are engaged through slots formed in the pillow blocks (FIG. 5) so that the cap screws can be loosened and the pillow block and roll assembly adjusted up and down by means of the adjustment screws **62**. The pillow block and bearing assemblies are preferably shielded within bearing covers **65** which are also secured to the vertical frame members **30**. As is the case with the lower dam **35**, it will be apparent that the roll **36** can be conveniently removed from the cell when necessary.

A pair of slingers **70** in the form of rubber disks are mounted on the roll necks **58** between each pillow block and bearing assembly **59** and the ends of the metal shell or cylinder **56**. These slingers **70** spin off the film of solution which tends to run along the roll necks into the bearing assemblies. As shown in FIGS. 6 and 8, the slingers **70** on each roll neck are mounted in a housing **71** and are separated by a housing partition **72**. Each housing **71** communicates with a rubber coated overflow weir **73**. The solution which tends to creep outward of the roll necks **58** is spun off by the slingers **70** into the housing **71** and runs down into the overflow weir **73** which communicates with the reservoir **24**. The overflow weirs **73** are preferably located at each corner of the tray **25** and have upper open ends **74**. Thus arranged, the overflow weirs establish a solution height which is above the pass line of the strip **77** and the anodes mounted in the tray.

In the preferred embodiment of this invention, two banks of zinc anodes are mounted above and below the pass line of the strip **17** in the cells for plating the strip with zinc on both sides in a continuous operation. The top bank of anodes are adjusted up and down from the strip surface and are contained in a conductor bar assembly rack or framework to permit the removal and/or replacement of the top anodes in one operation. The lower anodes are mounted on conductor bars and means are provided for raising and loweirng the anodes from the strip surface.

Referring particularly to FIGS. 4 and 5, there is shown two pairs of upper conductor bars **80** which carry anodes **81**. The anodes **81** are suitably spaced across the width of the tray **25** above the pass line of the strip and are preferably supported on the bars **80** by hanger arms **82**. Suitable hold-down structure (not shown) may be provided to assure good contact between the hanger arms **82** and the conductor bars. Each pair of the conductor bars is mounted in a separate framework or rack. The rack comprises two arms **85** that project upwardly at each side of the tray **25** and are connected by members **86**. The bars **80** extend transversely of the tray and are secured between the lower ends of the arms **85**. The upper ends of members **85** are engaged over anode bed supports **87**. Suitable jacks or the like, which are diagrammatically illustrated at **88**, may be provided between the bed supports **87** and the structural members **32** for positioning the anodes **81** relative to the upper surface of the strip **17**.

The lower anodes **95** are supported on two pairs of lower conductor bars **96**. Each pair of the bars **96** also forms part of a removable rack that includes arms **97**. These arms **97** are engaged over lower anode supports **98**. Jack mechanisms **99** similar to the upper jacks **88** may be disposed below the supports **98** for positioning the anodes **95**.

A suitable source of D.C. current, for example, two rectifiers (not shown), is provided for each cell. The positive lead from one rectifier is connected to the top anode conductor bars **80** and the positive lead of the other rectifier is connected to the bottom anode conductor bars **96**. The negative leads of the rectifiers are connected to the contact rolls **18** for each cell.

As generally described above, an important feature of this invention resides in the provision of a pair of novel solution distributor tubes **110** (FIGS. 4 and 7) which are mounted above and below the pass line of the strip **17** adjacent each cell end wall **29**. The tubes **110** are preferably formed of a non-corrosive material, such as polyvinyl chloride or the like, and extend across the width of the tray **25** below the bath level established by the weirs **73**. In FIGS. 9, 10 and 11, the construction of each tube is shown to include a closed end **111** and an opposite open end having a flange **112**. The flanged end portion of each tube extends within a rubber coated sleeve **113** which projects externally of the side wall **26** of the tray **25**. The tube flange **112** is secured between a flange **114** on the outboard end of the sleeve **113** and a flange **115** of a pipe **116**. The pipes **116** for each pair of tubes form part of a cell header connection **118**. In the preferred construction, the flanges **112**, **114** and **115** are secured together by bolts **119** that project through circumferentially spaced bolt holes **120** in the flange **112**. The tubes **110** can be rotatably adjusted about their axes for a purpose to be described by selectively locating the bolts **119** in the proper bolt holes **120**.

The solution distributor tubes **110** are also formed with slotted openings **125** which are spaced along the lengths of the tubes. In use, the tubes are oriented as shown in FIG. 7 to spray the plating solution from the openings **125** in jet stream patterns that converge on the strip pass line toward the center of the cell. The jet streams fan across the full width of the strip **17** to provide improved strip washing and an adequate supply of electrolyte to the electrode surfaces. The arrangement also obtains optimum solution turbulence around the anodes as is necessary to permit the use of high current densities and reduce anode polarizations. With the preferred construction, it is possible to change the angle of the solution spray by rotatably adjusting the tubes about their axes in the manner described above.

If desired, a vertical plate **128** (FIG. 4) may be provided above and below the pass line of the strip **17** near the center of the tray **25**. These plates **128** serve as baffles for the solution sprayed from the tubes **110** and further increase the turbulence of the bath. The plates also function as guards to prevent electrical shorts between the strip **17** and the anodes.

Reference is now made to FIG. 12 which illustrates the preferred solution pumping and circulation system contemplated by this invention. As thereshown, the main solution reservoir **24** is connected to one or more conventional filter presses **135** suitable for removing minute as well as larger bath contaminants and for removing carbon and zinc dust materials used in bath purification treatments. The solution in the reservoir **24** is continuously circulated through the filter press or presses **135** by a pump **136**.

The preferred circulation system also includes a separate pump **140** and a filter unit **141** for each cell which prevents larger bath debris and contaminants from being recirculated to the strip surfaces and from clogging the solution distributor tubes **110**. Each cell pump **140** has its intake side connected to the reservoir **24** and its discharge side connected to the cell headers **118** by pipes **142** and **143** (also see FIGS. 2 and 3). The filter unit **141** for each cell is connected to the intake side of the pump **140** by a pipe **145** and to the base of the tank **24** by a pipe **144**. Suitable valves **146** may be provided in the pipes **143** and **145**.

Referring to FIGS. 13 and 14, the preferred construction of each filter unit **141** is shown to include a housing **151**. The housing **151** is normally closed by a removable plate **152**. Within the housing **151** there is mounted a removable filter basket **153**. The basket **153** in its preferred form comprises a wire frame **156** which supports a filter screen **157**. The basket may be disposed on either an upright or an inverted position. However, for convenience, the basket is upright and the screen **157** is located on the inside of the frame **156** so that the pressure flow of the solution forces the screen against the frame. In this manner, the contaminants in the solution are trapped in the basket **153** as the solution is pumped through the filter unit from the reservoir **24**. The basket can be periodically removed from the housing **151** for cleaning or replacement.

The operation of the apparatus comprising this invention will be largely apparent from the foregoing description. In summary, the several plating trays **25** are filled with the electrolyte to a level above the upper anodes **81** and the solution distributor tubes **110**, the level being established by the weirs **73**. The upper and lower banks of anodes are suitably positioned in the trays and electric connections are made to contcat rolls **18** and the conductor bars **80, 95**. Actuation of the power driven roll assemblies **16** serves to move the strip **17** through the cells, whereby the strip is simultaneously plated on both sides.

The positioning of the solution distributor tubes **110** and the manner of spraying the solution on the strip **17** maintains maximum circulation and agitation of the electrolyte between the strip and the anodes. Consequently, it is possible to employ high current densities and obtain a high line speed. In the preferred embodiment, the plating current supply and the line speed are synchronized and can be raised or lowered simultaneously for control of the deposit thickness.

During operation of the line, the solution is continuously circulated through the large filter presses to remove the minute as well as larger bath contaminants. At the same time, the individual filter units for each cell serve to remove the large bath contaminants and prevent such debris and contaminants from being recirculated to the strip surfaces and from clogging the solution distributor tubes **110**. With the illustrated circulation arrangement, the solution from the reservoir **24** is effectively cleaned prior to its entrance into the pumps **140** and the plating cell trays **25**.

When it is necessary to remove the cell dams for replacement or repair, the solution level in the individual cells can be lowered below the pass line of the strip **17** by turning off the pump **140** which is connected to the cell. The squeegees **35** and/or the rolls **36** can then be easily disconnected by means of the accessible, externally located bolts and nuts without stopping the strip. It is also possible to remove the dams without lowering the solution level, the solution simply being allowed to run into the gutters **50**. The upper and lower banks of anodes can be easily removed by lifting the supporting racks with a crane or the like.

Many modifications and variations of the invention will be apparent to those skilled in the art in view of the foregoing detailed description. Therefore, it is to be understood that, within the scope of the appended claims, the invention can be practiced otherwise than as specifically shown and described.

What is claimed is:

1. An electroplating cell comprising:

(a) a tray for containing a plating solution through which stock is passed,

(b) said tray including two pairs of dam members each being electrically non-conductive with respect to the plating solution and stock,

(c) said dam members cooperating to hold stock on a pass line as it travels through said tray,

(d) one of said dam members in each pair being formed by a roll having a non-conductive surface rotatably engageable with one side of the stock and the other of said dam members being formed by a resilient element having a non-conductive surface continuously engageable with the opposite side of the stock for stripping the plating solution therefrom;

(e) a pair of contact rolls each making electrical contact with the stock beyond opposite ends of the tray so that the stock is subjected to a plating potential as it travels through the tray independently of said dam members.

2. An electroplating cell comprising:

(a) a tray containing a plating solution through which stock is passed,

(b) said tray including slotted wall portions,

(c) each of said wall portions being formed by first and second dams, each dam being electrically non-conductive with respect to the plating solution and stock,

(d) one of said dams being a roll having a non-conductive surface rotatably engageable with one side of the stock and the other of said dams being formed by a resilient element having a non-conductive surface continuously engageable with the opposite side of the stock for stripping the plating solution therefrom,

(e) said dams cooperating to establish a pass line along which stock is moved through said tray,

(f) means for establishing a solution level in said tray above said pass line,

(g) means mounting said dams so that they can be released and removed without stopping the stock, said mounting means being located in accessible positions externally of said tray, and

(h) a pair of contact rolls each making electrical contact with the stock beyond opposite ends of the tray so that the stock is subjected to a plating potential as it travels through the tray independently of said dams.

3. The cell as claimed in claim **2** wherein the other of said dams in each pair comprises a squeegee mounted below said roll.

4. An electroplating cell comprising:

(a) a tray,

(b) said tray including opposed wall openings for permitting stock to be moved through said cell, and first and second dam members on opposite sides of each opening,

(c) one of said dam members being formed by an assembly of squeegee elements continuously engageable with one side of the stock for stripping the plating solution therefrom,

(d) the other of said dam members being formed by a roll,

(e) said dam members cooperating to define a pass line along which stock can be moved through said cell,

(f) solution distributor tubes disposed on opposite sides of the pass line adjacent each opposed wall opening,

(g) each of said tubes including openings spaced along its length, said tubes being oriented to spray solution from said openings in jets converging on the pass line toward the center of said cell,

(h) means mounting each of said tubes for movement about its longitudinal axis so that the spray angle can be selectively adjusted,

(i) anode means mounted in said tray on opposite sides of the pass line, and

(j) overflow means mounted in said tray to establish a solution height above the pass line, said tubes and said anodes.

5. A plating cell as claimed in claim **4** wherein said anode means on each side of the pass line comprises a plurality of conductor bars, a plurality of anodes connected to said conductor bars, and a removable rack in which said bars are mounted.

6. A tray for an electroplating cell having side and bottom walls and comprising:

(a) a pair of dam members defining entry and exit openings at opposite ends of the tray through which the strip travels and cooperating with said side walls to contain a plating solution above the strip pass line,

(b) at least one of said dam members in each pair comprising a resilient wiping strip essentially normal to the plane of the strip and having one edge extending transversely in uniform wiping contact with the surface of the strip being free to bend in the direction of strip movement, and,

(c) means for mounting said wiping strip.

7. A tray according to claim **6** in which the means for mounting the wiping strip comprises:

(a) a bracket removably securable to the tray having studs projecting outwardly so as to be accessible from the outside of said tray, and

(b) a clamp bar received on said studs holding the lower portion of said wiping strip between said bracket and clamp bar.

8. A tray according to claim **6** in which each said dam member comprises:

(a) a roll journaled at each end in the side walls of the tray having a non-conductive surface in rolling contact with the upper surface of the strip, and

(b) said resilient wiping strip extending upwardly into wiping contact with the lower surface of said strip opposite the roll.

9. A tray according to claim **8** comprising:

(a) a pair of aligned pillow block members for receiving the opposite ends of each roll projecting through the side walls of the tray,

(b) mounting means for each pillow block member including adjusting screws accessible from the outside of said tray for adjusting the vertical position of each with respect to the strip pass line, and

(c) sealing means at each end of the rolls for inhibiting the escape of solution into the pillow block members.

10. A tray according to claim **6** having an overflow weir in each corner formed by a partial enclosure extending vertically from the bottom wall of the tray defining a vertical channel, the upper end of said enclosure extending above the pass line of the strip and establishing the solution level in the tray and the lower end opening through the bottom wall.

11. An electroplating line apparatus having a series of cells through which continuous strip material is passed, each cell comprising:

(a) a tray for maintaining a plating solution above the pass line of the strip while moving through the tray,

(b) said tray including side and bottom walls, the side walls extending vertically to a height substantially above the pass line and including overflow weir means for establishing the proper height of plating solution above the pass line, said height being sufficient to allow the solution to rise throughout the tray substantially above the pass line before overflowing through said overflow wier means,

(c) a pair of dam members at each end of the tray for damming the plating solution in cooperation with the side walls to a height at least equal to the height established by said overflow wier means,

(d) one of said dam members in each pair being formed by a roll and being rotatably mounted so as to roll in tangentially continuous contact with the strip traveling through the tray, each said roll being electrically non-conductive with respect to the strip and plating solution,

(e) the other dam member in each pair of dam members extending transversely across the tray opposite the roll dam member and having a resilient, non-conductive surface continuously engageable with the surface of the strip opposite the roll dam member for stripping the plating solution therefrom,

(f) said electroplating line apparatus including anode and cathode means associated with each cell, the anode means being immersed in the plating solution in each cell adjacent the strip pass line and the cathode means comprising,

(g) a pair of contact rolls each making electrical contact with the strip beyond opposite ends of the cell so that the strip is subjected to a plating potential as it travels through the cell independently of said dam members whereby cathode roll plating is minimized.

12. An electroplating line apparatus according to claim **11** wherein the other dam member positioned at the strip exit end of the cell is formed by a resilient wiper element having a wiping edge engageable with the strip which is free to bend in the direction of strip movement and said cathode roll beyond the strip exit end of the cell is engageable with the strip on the same side of the strip as said resilient wiper element.

13. An electroplating line apparatus according to claim **11** wherein each cell comprises:

(a) a forced circulation system including a pump for delivering plating solution to the tray and return circuit means for recirculating the plating solution to the pump, and

(b) jet means in the tray submerged in the plating solution adjacent the pass line for directing streams of plating solution against the strip.

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