July 12, 1960 R. P. YECK 2,944,954

ELECTROLYTIC PRODUCTION OF METAL SHEET

Filed Feb. 6, 1959 2 Sheets-Sheet 1

Fig. 1.

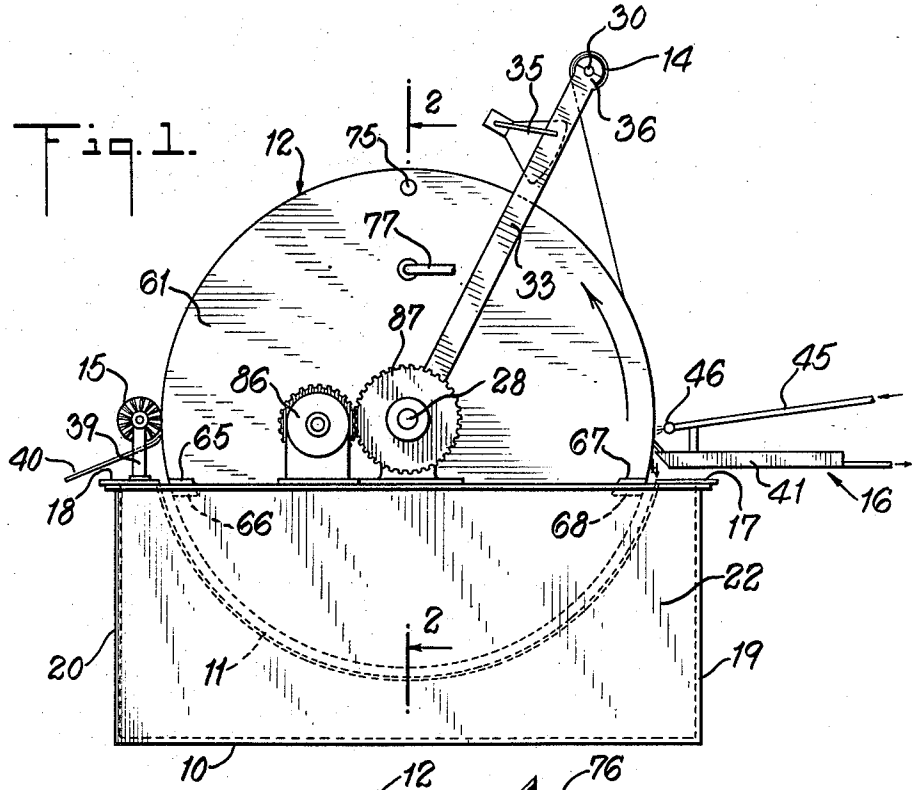
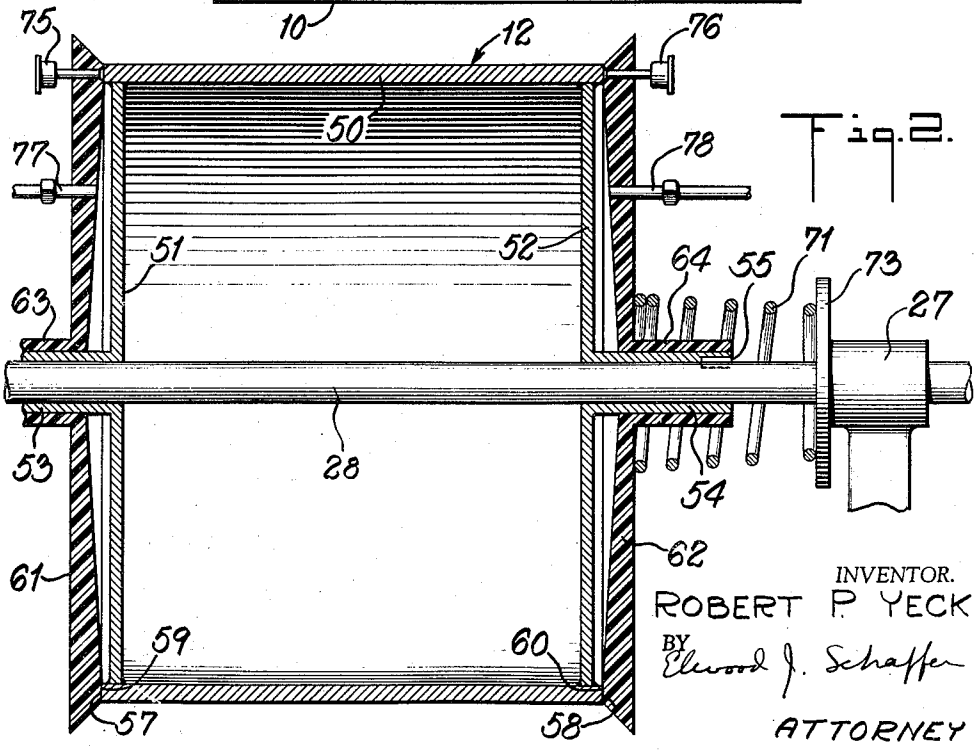


Fig. 2.



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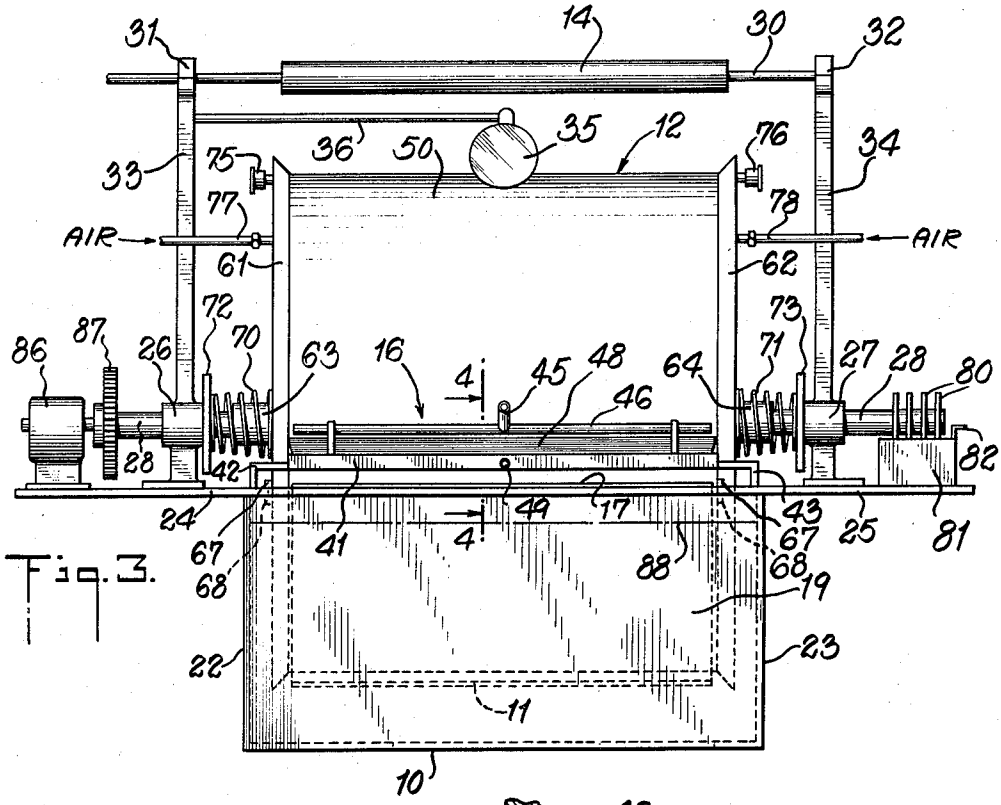


Fig. 3.

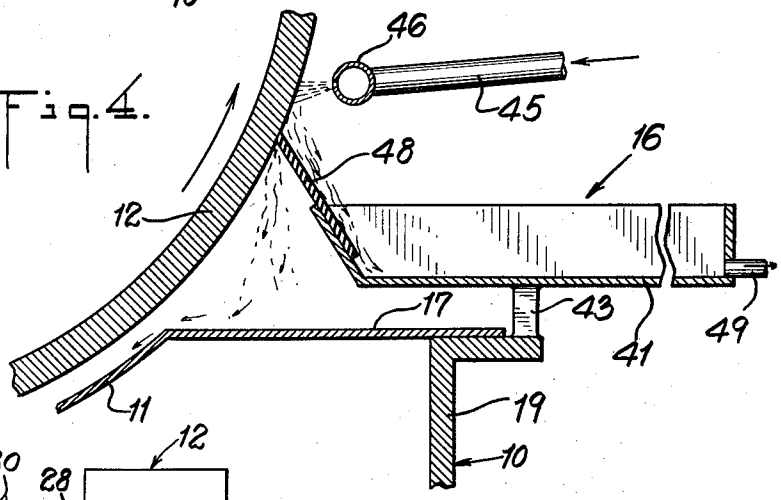


Fig. 4.

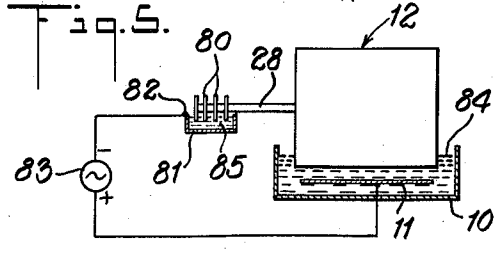


Fig. 5.

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ELECTROLYTIC PRODUCTION OF METAL SHEET

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2 Claims. (Cl. 204—216)

This invention relates to method and apparatus for the electrolytic production of metal sheet. More particularly, it relates to method and apparatus for continuously depositing metal from an electrolyte upon a moving cathodic surface and stripping the thus deposited metal as a sheet from said surface without tearing.

In the production of metal sheet by electrolytically depositing metal on a moving cathodic surface such as a drum and stripping the thus deposited metal as a sheet from the drum, it has been found to be essential that edge sticking be avoided or reduced to a minimum in order to avoid tearing of the sheet during stripping. Ideally to avoid tearing during stripping, the metal should be deposited on the surface of the drum but not on the side edges of the drum. However, since the drum itself is a conductor, deposition of metal on the drum edges, which are surfaces normal to the surface of the drum itself, is difficult to avoid.

Attempts have been made to overcome the above difficulties by employing a method and apparatus in which an anodic polarity was maintained on the edge of the cathodic drum by means of a secondary power supply and auxiliary cathodes were disposed adjacent the drum edges. The secondary current in this "current thief" arrangement was separately controlled to control the deposition on the drum edges. Tearing, however, still occurred to an undesirable extent with this procedure and could not be eliminated. In addition, the procedure was unsatisfactory in that it was cumbersome, wasteful of electrical power as well as of deposited metal, and presented serious maintenance problems.

Attempts were made to attach and seal insulating plates, such as plastic plates, to the sides of the drum. All attempts to form a seal between the drum and the insulating side plates failed in that the seal developed leaks in a comparatively short period of time, with the result that electrolyte crept into the cracks between the drum and the side plates thereby causing deposition of metal to take place on the drum edges which, in turn, caused the edge of the sheet to stick to the edges of the drum and resulted in tearing of the sheet when it was stripped from the drum.

The principal object and advantage of the present invention is that it overcomes the above described difficulties. Another object and advantage is that the invention provides a comparatively simple method and apparatus in which tearing of the metal sheet while it is stripped from a moving cathodic surface is prevented. A further object and advantage is that the invention provides method and apparatus in which electrodeposition of metal on the sides of the moving surface is avoided. These and other objects and advantages will become apparent from the following more detailed description of the invention.

Broadly, the invention comprehends a method and apparatus in which plates are held in contact with the sides of the moving cathodic surface while providing relative motion between the plates and the cathodic surface during the electrodeposition of metal on the moving surface. The relative motion between the side plates and the moving surface may be obtained in any suitable manner. Thus the side plates may be moved in the same direction as the cathodic surface but at a higher or lower speed than the cathodic surface or the side plates may be moved at a desirable speed in a direction opposite to that of the cathodic surface. Preferably, however, the relative motion is obtained by holding the side plates stationary. It was discovered quite unexpectedly that, when these features of the invention were practiced, tearing of the metal sheet during stripping was eliminated or drastically reduced. It was observed that the relative movement between the plates and the cathodic surface provided a cutting action at the contact between the plates and the cathodic surface; and, it is believed, that the cutting action accounts for these unexpected results.

Preferably, and for best results—especially in simplicity of design in the apparatus, the plates are fabricated of an electrically insulating material. Any insulating material which is inert or substantially inert to the electrolyte may be used. Thus, for example, the plates may be composed of wood, inorganic matter, plastics, etc. With aqueous electrolytes such as cyanide, acid or alkaline aqueous electrolytes, the plates are most preferably composed of a solid plastic such as any of the commercially available polymerized or co-polymerized, thermo-plastic or thermo-setting resins—for example, an acrylate, ethylene, styrene, vinyl, epoxy, urethane resin or co-polymers thereof. However, if desired for any reason, the plates may be composed of an electrically conducting material of the same or different composition of the moving surface—for example, the moving surface may be composed of one metal and the plates may be composed of the same or different metal. Where the plates are composed of a conductor material, the "current thief" procedure referred to earlier, is preferably also employed. In this latter procedure, an anodic polarity is maintained on the plates by means of a secondary power supply, auxiliary cathodes are disposed adjacent to the plates and the current flowing in this secondary system is controlled to control deposition of metal on the plates, especially during the starting of the sheet producing system.

In accordance with another feature of the invention, improved results as to tearing of the sheet during stripping are obtained by maintaining a coating of a sealant material on the moving surface, either or both on or adjacent the sides of the moving surface. For best results, a moving sealant is employed on the sides of the moving surface, preferably by introducing and maintaining sealant material between the contacting surfaces of the moving cathodic surface and the plates. The sealant may be a solid, semi-solid or liquid material. Preferably, the sealant is a lubricant which, for best results, is a non-conducting material which is inert or substantially inert to the electrolyte. The lubricant may be an inorganic or organic material. Preferably, however, the lubricant is comprised of an organic material and may, for example, comprise a hydrocarbon, hydrocarbonaceous, or substituted hydrocarbon or hydrocarbonaceous material or mixtures thereof; the most preferred lubricant of this type being a grease. Of the commercially available lubricants, a so-called silicon grease, i.e. a grease comprised of an organic silicon compound, or a grease comprised of a fluorinated hydrocarbon are most preferred. In the preferred procedure, a sufficient amount of lubricant is introduced and maintained between the moving surface and the plates to seal any interstitial space between these elements. In general, in the preferred procedure, continuous application of lubricant to these elements is not necessary to maintain the sides of the cathodic surface sealed from the electro-

lyte, after a seal on said sides has been established. In most instances, intermittent introduction of lubricant is sufficient to maintain the seal. A further enhancement of results is obtained by employing machined surfaces on the plates and the moving surface where these elements are in contact with each other during the electrodeposition.

The invention may be practiced to produce continuously any metal sheet in any metal electrodeposition process or apparatus. It may be practiced in connection with any aqueous, non-aqueous, simple or complex electrolyte. It is particularly useful in connection with the production of metal sheet from an aqueous electrolyte such as, for example, a cyanide or an acid or an alkaline aqueous electrolyte. It is especially useful in the production of copper or zinc sheet using an aqueous acid electrolyte, especially a sulphuric acid electrolyte. It will be understood that the term "sheet" as used herein includes in its scope thin metal sheet or so-called metal foil.

The invention is further illustrated in the accompanying drawings and examples. It should be understood, however, that the drawings and the examples are given for purposes of illustration and the invention in its broader aspects is not limited thereto.

In the drawings:

Fig. 1 is a side view of a preferred embodiment of the apparatus employing the invention;

Fig. 2 is an enlarged view of the drum of Fig. 1 taken along the line 2—2 of Fig. 1 in the direction of the arrows;

Fig. 3 is a front view of the apparatus of Fig. 1;

Fig. 4 is an enlarged view of the sheet washing means taken along line 4—4 of Fig. 3 in the direction of the arrows; and

Fig. 5 is an illustration, diagrammatic in nature, showing the electric circuit employed during the electrodeposition.

Referring now to the drawings, there is shown on electrolytic tank 10 fabricated of a suitable electrical insulating material, provided with semi-circular anode 11, cathodic drum 12, sheet take-up roll 14, drum polishing brush 15, and sheet washing means 16. Anode 11, which is disposed in the tank in close proximity but out of direct contact with the drum, is supported in position by means of anode flanges 17 and 18 which rest upon the top edge of the front and rear walls 19 and 20, respectively, of the tank. Mounted on the side walls 22 and 23 of the tank are plates 24 and 25 which carry pillow blocks 26 and 27 upon which is mounted shaft 28 of the drum.

The shaft 30 of sheet take-up roll 14 is supported in bearings 31 and 32 carried by support members 33 and 34 which respectively are mounted on pillow blocks 26 and 27. Infra-red lamp 35 for drying the sheet is connected to a suitable source of electric power not shown and is supported in position by support member 36 attached to member 33. Drum polishing brush 15 driven by a suitable driving means not shown is mounted on and supported in position against the drum by blocks 39 carried by plates 24 and 25 and is provided with shield 40 also supported by blocks 39.

The pan 41 of sheet washing means 16 is supported in position by supports 42 and 43 attached respectively to plates 24 and 25. T-shaped water conduit 45 is mounted on pan 41. The transverse element 46 of conduit 45 is co-extensive with the width of the drum and is provided with a plurality of orifices along its length. Attached to the back of pan 41 is flexible element 48 which extends across the width of the drum with its upper edge bearing against the drum. As shown in Fig. 4, the metal sheet on the drum which has emerged from the electrolyte in tank 10 is washed by water from the T-shaped conduit 46. The wash water emerges from the orifice in conduit 46 and plays against the sheet in the drum after which it runs down flexible element 48 and collects in pan 41 from which it is discharged through outlet 49. As will be seen from Fig. 4, the element 48 which, as shown, is a rubber element, functions as a so-called "squeegee" which wipes electrolyte from the outer surface of the sheet and returns the removed electrolyte to tank 10. At the same time element 48 prevents wash water from leaking into the electrolyte.

As illustrated in the drawings, the drum 12 is preferably a hollow member. As shown in Fig. 2, the outer surface of the hollow cylinder 50 provides the electrolytic plating surface on which the metal sheet is formed. The open ends of the cylinder are closed by metallic discs 51 and 52 which are inset slightly from the ends of the cylinder and are suitably attached and sealed to the under surface of the cylinder, as by welding. The discs 51 and 52 are provided respectively with hub members 53 and 54 in which the shaft 28 is disposed; at least one of the hubs being keyed to the shaft as by key 55 for hub 54.

The edges 57 and 58 of cylinder 50 are machined surfaces which are adapted to receive corresponding machined surfaces 59 and 60 respectively on stationary end plates 61 and 62 which are fabricated of electrically insulating material. End plates 61 and 62 are provided respectively with hub members 63 and 64 which respectively ride on hub members 53 and 54. The end plates 61 and 62 are respectively held stationary by projections on their outer surfaces which engage plates 24 and 25 on the sides of tank 10 as illustrated in Fig. 1 by projection 65 through 68 on plate 61.

The respective machined surfaces on plates 61 and 62 are held tightly against the machined edges 57 and 58 of cylinder 50 by means of springs 70 and 71 which are under compression. The inner ends of springs 70 and 71 bear respectively against stationary plates 61 and 62 while their outer ends respectively bear against flanges 72 and 73 which are attached to pillow blocks 26 and 27 respectively. The machined surfaces on the sides of cylinder 50 as well as those on the end plates 61 and 62 are lubricated and sealed by means of grease cups 75 and 76 provided respectively on plates 61 and 62. These latter may also be provided with air conduits 77 and 78 respectively for introducing air under a slightly elevated pressure into the space between the plate 61 and disc 51 and between plate 62 and disc 52 to assist in sealing the joints between the machined surfaces and prevent electrolyte from leaking into the space between these discs and plates. In addition, the inner faces of plates 61 and 62 preferably are tapered toward their centers, as by undercutting these faces. This latter construction further enhances the seal on and between the machined surfaces in that it permits maximum spring pressure to be exerted against plates 61 and 62 without causing the outer end of the machined surface on these plates to bow away from the upper edges of cylinder 50.

Cylinder 50, discs 51 and 52, and shaft 28 are fabricated of a suitable electrically conductive material—for example, a metal or metal alloy. The shaft 28 is also provided with an appropriate electrical contact. Preferably, this contact is provided by a plurality of discs 80 attached to shaft 28 which discs dip into a pool of mercury contained in box 81; the latter being provided with stationary electrical contacts 82 which also dip into the mercury. The electrical circuit of the system is illustrated in Fig. 5. The anode 11 is connected to the positive outlet of a direct current source 83 while the plating cylinder 50 of drum 12 is connected to the negative terminal of the power source. In electrolytically depositing metal from the electrolyte onto the surface of cathodic cylinder 50 of the drum, the current flows from source 83 to anode 11 through the electrolyte 84 into cylinder 50 from whence it flows through discs 51 and 52 into shaft 28. The current then flows from the shaft through disc 80 into the mercury pool 85 from whence it returns to the source 83.

In operation, the cylinder 50 is rotated in the direction

indicated by the arrows by a motor 86 connected to gear 87 which is mounted on shaft 28. Prior to introducing electrolyte into tank 10, sufficient lubricant is applied to the machined surfaces on plates 61 and 62 and to the edges of cylinder 50 by means of grease cups 75 and 76 to lubricate and seal these surfaces and the interstitial space therebetween. Thereafter, during the course of operating the apparatus, additional lubricant is introduced intermittently as needed to preserve the seal. During the electrodeposition, electrolyte is preferably maintained in the tank at a fixed level indicated by lines 88 in Fig. 3 and air at slightly elevated pressure may be introduced and maintained in the spaces behind end plates 61 and 62.

Inasmuch as the thickness of the deposited metal sheet in any given apparatus is governed by the current density on the cylindrical surface 50 and the latter's rate of revolution, these two factors are controlled so that sufficient metal is deposited on each portion of the cylinder during its immersion in the electrolyte to obtain a sheet of the desired thickness. The sheet, still adhering to the cylinder, emerges from the electrolyte and passes under squeegee element 48 which wipes off most of the electrolyte clinging thereto. Above element 48 the outside surface of the sheet is washed with water from conduit 45 as described earlier. Above the washing means 16, the sheet which is stripped from the cylinder is dried by lamp 35 and is wound upon takeup roll 14. As described earlier, the relative motion between the cylinder 50 and end plates 61 and 62 provides a self-cutting action at the edge of the sheet which prevents edge sticking and tearing of the sheet during shipping. In addition, the seal provided by the lubricant between the machined contacting surfaces on the end plates 61 and 62 and the cylinder 50 prevents leakage of electrolyte between these contacting surfaces and prevents electrodeposition of metal on the edges 57 and 58 of cylinder 50 thereby further insuring against edge sticking of the sheet and tearing of the latter during stripping.

The anode 11 may be a soluble anode composed of the metal to be plated as the sheet. In most instances, and especially in the production of copper or zinc sheet, an insoluble anode is employed and the electrolyte is refortified in a conventional manner to restore the depleted metal value. The cathodic plating cylinder or the surface it presents to the electrolyte may be fabricated of any electrically conductive material to which the metal sheet does not adhere excessively and which would not otherwise adversely affect the physical properties of the sheet. Thus, for example, in producing zinc sheet the cylinder 50 preferably is fabricated of aluminum or aluminum alloy and the anode 11 is fabricated of lead or a lead alloy while in the case of copper sheet both the anode and the cathode are fabricated of lead or a lead alloy. In both cases the electrolyte is preferably an acid electrolyte, most preferably a sulphuric acid electrolyte.

Zinc sheet was continuously produced in the apparatus of the drawing. Cylinder 50 was 26 inches wide and was fabricated of aluminum containing .8 to 1.2% Mg, .4 to .8 Si, .15 to .4 Cu, .15 to .35 Cr. The side plates 61 and 62 were fabricated from commercially available slabs of an acrylate resin. The plating surface of cylinder 50 which was polished without buffing to a satiny finish before use was also polished continuously during use by means of brush 15 to maintain the satiny finish thereon. A fluorinated hydrocarbon grease was employed in grease cups 75 and 76 to lubricate the machined surfaces on the plates and the edges of the cylinder and to seal the clearance between these machined surfaces. The anode 11 was an insoluble anode fabricated from a silver-lead alloy containing 1% silver. The electrolyte was a conventional acid zinc sulphate electrolyte employed in the electrowinning of zinc. It comprised 30–100 grams per liter of zinc, 100–200 grams per liter of sulphuric acid together with conventional addition agents such as gum arabic, glue and sodium silicate. The electrolyte was refortified by recirculation through a refortification step in the manner conventional in the electrowinning of zinc.

In starting the apparatus, drum 12 was held stationary until a metallic deposit of sufficient thickness was formed on the submerged portion of cylinder 50 which could easily be stripped therefrom. The drum was then rotated at a desired speed. When the leading edge of the initial sheet moved above the washing means 16, it was stripped from the drum and lead to takeup roll 14. During the operation of the apparatus, air under slight pressure was admitted and maintained in the spaces between the end plates and the discs of the drum. Before the electrolyte was introduced to tank 10, drum 12 was rotated while applying grease through cups 75 and 76 until the machined surfaces on plates 61 and 62 and the edges of cylinder 50 were lubricated and the space between these machined surfaces was sealed. Thereafter, additional grease was applied intermittently as required to maintain the seal.

In a series of runs the drum was rotated at a rate which corresponded to a linear advance of 7 inches per minute employing current densities from 180 to 588 amperes per square foot to produce continuous length of sheet which in each particular run were of uniform thickness. Individual runs were made in which continuous sheets were made which were .0010, .0012, .0016, .0021, and .0030 inch thick. Sheets of such thickness were also produced employing drum rotational speeds corresponding to a linear advance of from 1.75 to 10 inches per minute. In all of these tests the sheets produced had excellent physical characteristics and no edge sticking or tearing of the sheet took place during the stripping of the sheet from the cylinder 50.

What is claimed is:

1. Apparatus for the electrolytic production of metal sheet comprising an electrolyte tank, a rotatable drum having a portion of its circumference disposed in said tank, means to rotate said drum, an anode disposed in said tank in proximity to the drum, means connecting said drum and said anode to a source of direct current, side plates for the sides of the drum, said side plates being fabricated of an electrically insulating and machinable material, yieldable means urging said plates in contact against the sides of the drum, the contacting surfaces between said plates and the sides of said drum being machined contacting surfaces, means to provide relative rotative motion between said side plates and said drum, and means on said side plates for supplying a sealant to said machined contacting surfaces.

2. Apparatus according to claim 1 in which said drum is a hollow cylinder provided with internal support means for mounting the cylinder on a shaft, said side plates are stationary circular plates of a diameter greater than that of said cylinder, each of said plates on their inner surface being tapered from their perimeter toward their center.

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