

July 24, 1956

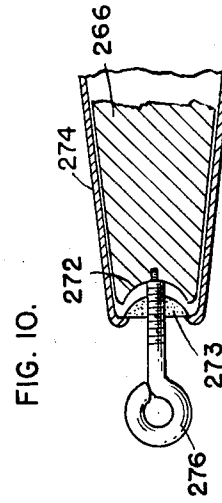
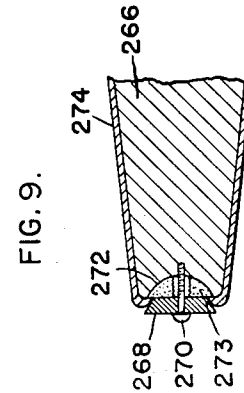
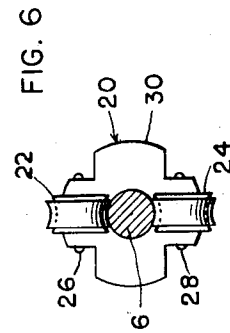
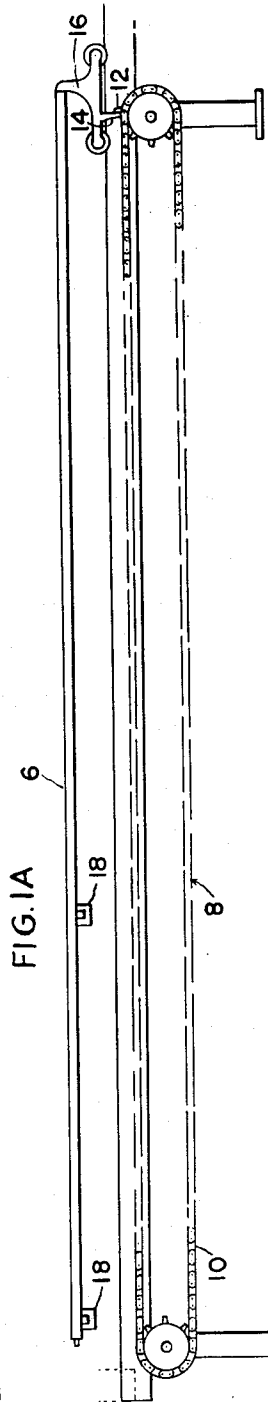
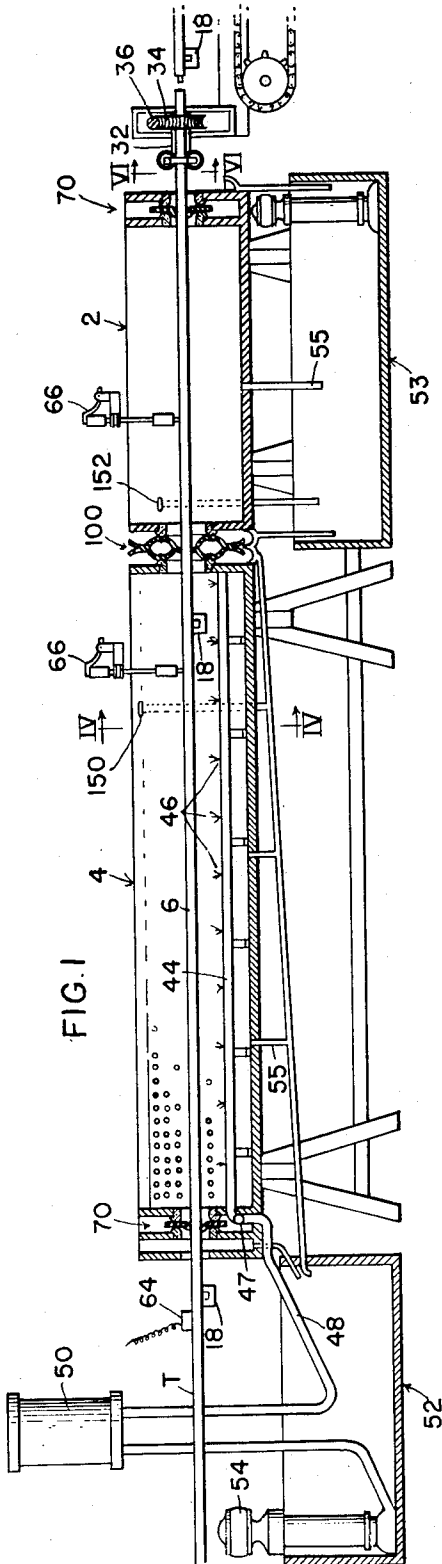
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2,756,205

APPARATUS FOR MAKING TUBING CONTINUOUSLY BY ELECTRODEPOSITION

Filed Nov. 15, 1950

4 Sheets-Sheet 1



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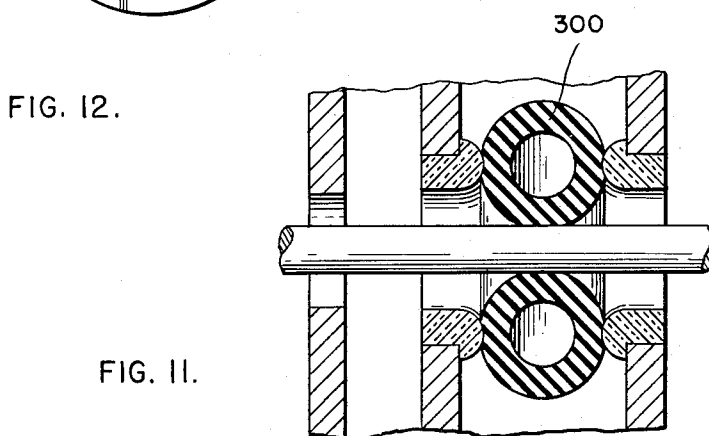
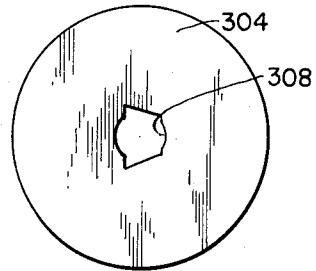
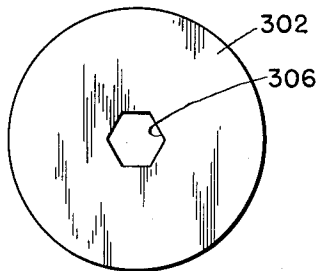
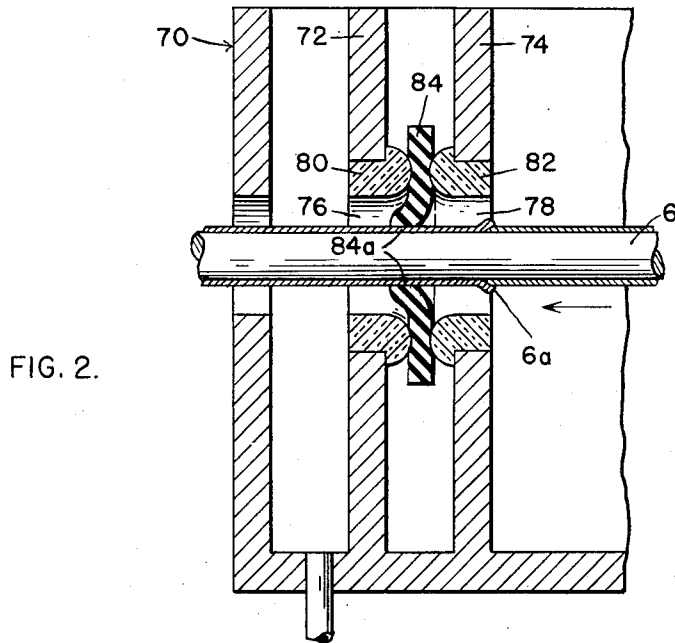
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APPARATUS FOR MAKING TUBING CONTINUOUSLY BY ELECTRODEPOSITION

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4 Sheets-Sheet 2



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APPARATUS FOR MAKING TUBING CONTINUOUSLY BY ELECTRODEPOSITION

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4 Sheets-Sheet 3

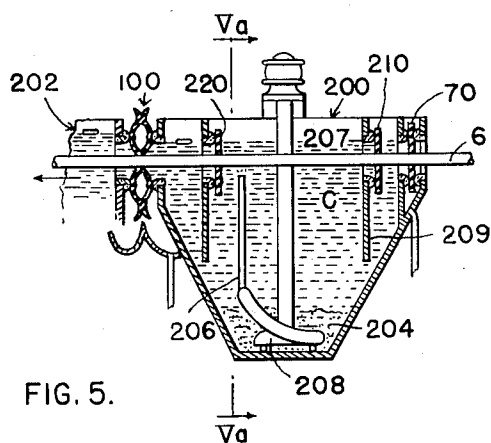


FIG. 5.

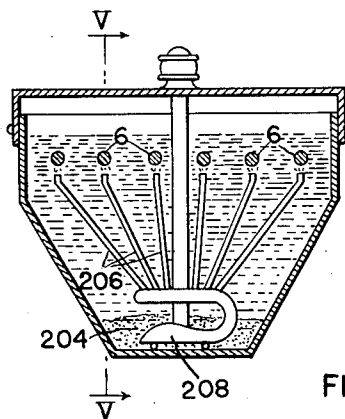


FIG. 5a

FIG. 4.

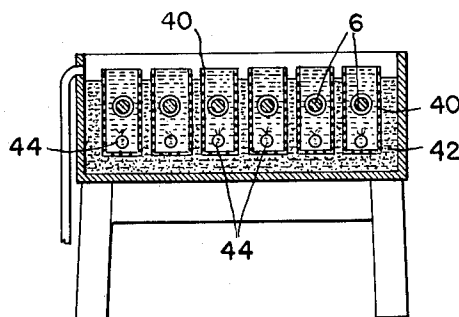


FIG. 3.

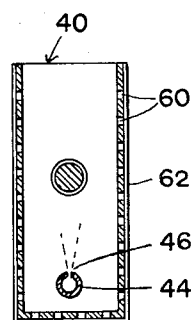
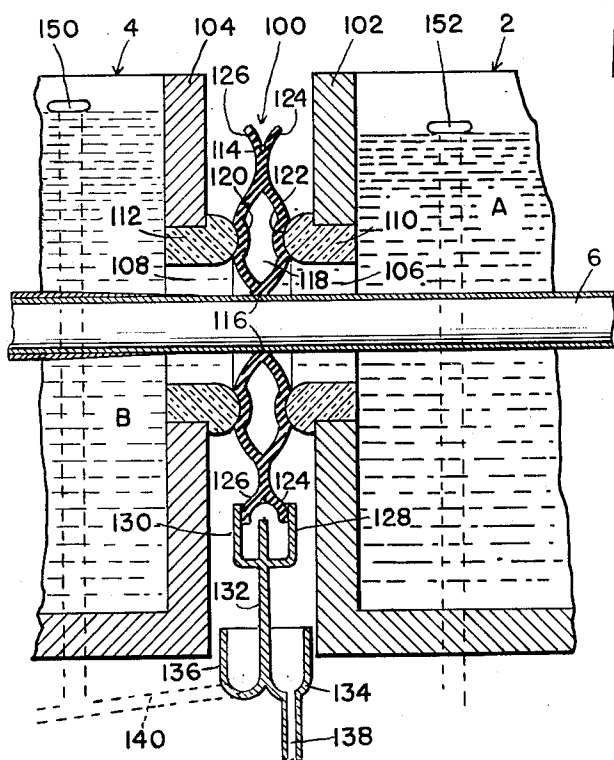


FIG. 4a

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FIG. 7.

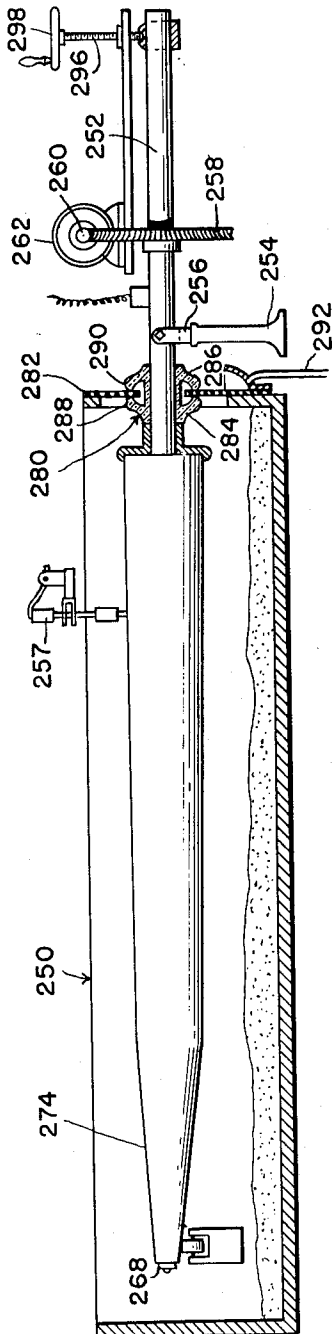
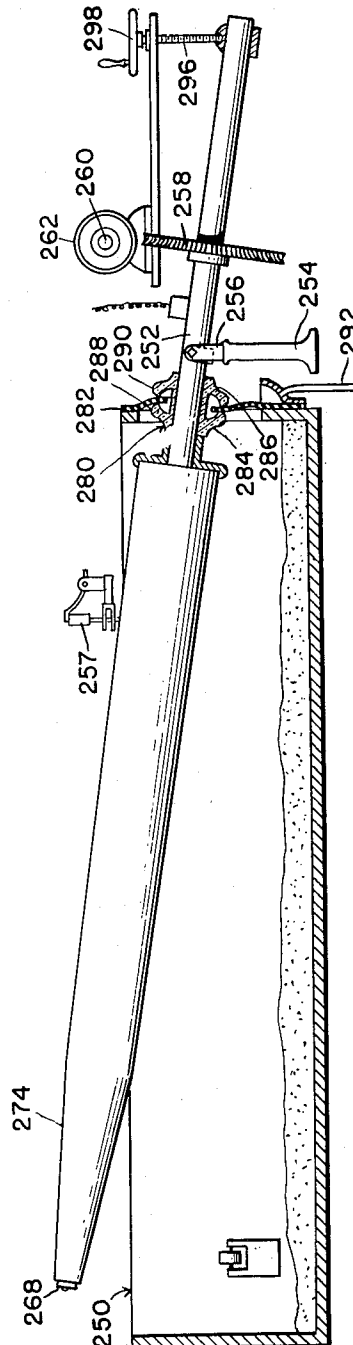


FIG. 8.



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APPARATUS FOR MAKING TUBING CONTINUOUSLY BY ELECTRODEPOSITION

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Application November 15, 1950, Serial No. 195,828

6 Claims. (Cl. 204—209)

This invention relates to the manufacture of metal articles by electrodeposition and particularly to sealing the electrolyte against leakage from the tank around the cathodic mandrel on which the metal is deposited. This application is a continuation-in-part of my prior application, Serial No. 727,793, filed February 11, 1947, now Patent Number 2,540,175.

The problem of sealing which, so far as I am aware, has not been solved prior to my invention, arises primarily from the need to move the cathodic mandrel relative to a wall of the tank through which it protrudes, during the process of electrodeposition as, for example, where, in the manufacture of tubing in continuous lengths, the mandrel enters the tank at one end and leaves it at the other and is continuously rotated as it advances through the end walls of the tank during the process of electrodeposition. Not only must the seal effectively guard against leakage of electrolyte, but it must be so highly resistant to wear that it need not be changed except at long intervals, despite the lateral relative motion between the mandrel and the tank wall which is frequently of the order of several hundred thousand inches per day.

It is the primary objective of the present invention to provide sealing method and means which effectively fill this need. It is my further purpose to adapt the seal provided by my invention to suit specific operating requirements such as to avoid the admixture of liquids in a number of tanks through which the mandrel passes in succession as, for example, where the mandrel is passed first through a cleaning bath and then through an electroplating bath or where the mandrel receives first an electrodeposit of one metal and then the electrodeposit of another by means of successive tanks, between which the mandrel passes without exposure to oxidizing atmosphere. Other embodiments of my invention will appear as the description proceeds.

In the drawings:

Fig. 1 is a side elevation view of electrodeposition apparatus in which different forms of my sealer have been incorporated to meet specific operating requirements.

Fig. 1A is a side elevation of that portion of the apparatus which extends to the right of Fig. 1.

Fig. 2 is an enlarged detail vertical section of one form of sealer, adapted for use particularly at the entrance or exit end walls of apparatus of this character.

Fig. 3 is a view similar to Fig. 2 of another form of sealer, adapted particularly for use between successive tanks.

Fig. 4 is a vertical section of the line IV—IV of Fig. 1.

Fig. 4a is a detail of one of the baskets shown in Fig. 4.

Fig. 5 is a vertical section of a cleaning tank embodying my invention, as taken on the line V—V of Fig. 5a.

Fig. 5a is a vertical section taken on the line Va—Va of Fig. 5.

Fig. 6 is a vertical section of the chuck for rotating the mandrel, taken on the line VI—VI of Fig. 1.

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Fig. 7 is a side elevation view partly in section of a different type of electrodeposition apparatus.

Fig. 8 is a view showing the parts of Fig. 7 in a different position.

Fig. 9 is a detail vertical section through the tip of the mandrel of Fig. 7.

Fig. 10 is a view similar to Fig. 9, showing the insulating shield removed and the eye-hook inserted for withdrawal of the metal article from the mandrel of Figs. 7 and 8.

Fig. 11 is a vertical section showing a further modification of the sealer.

Figs. 12 and 13 are views of the sealer disc as modified for use with molded bars of two special shapes.

In the present application, Figs. 1 and 1A, is shown two tanks, 2 and 4, through which the mandrel 6 advances in succession. The tank 2 may contain copper-depositing electrolyte and the tank 4 may be adapted for nickel electrodeposition. The mandrel 6, which may be sectional, is advanced successively through the two tanks by feeding mechanism 8 having an endless conveyor chain 10 carrying an upwardly extending lug 12 which engages a corresponding lug 14 depending from the carriage 16 which supports one end of the mandrel 6. The mandrel is supported at intervals by bearings 18.

To assure uniformity of electrodeposition and also to aid in effective working or hammering of the metal as it is deposited, as will be referred to, the mandrel is continuously rotated as it advances through the tanks. This is accomplished by means of the chuck 20 having upper and lower rubber lined rolls 22, 24 (see also Fig. 6), peripherally grooved to conform to the cylindrical contour of the mandrel and grippingly engaging the mandrel. The rolls are mounted on bearing pins 26, 28, carried in a boss 30, which has an integral sleeve 32 (Fig. 1) to which is splined or keyed the worm gear 34. Worm 36 is power-driven to rotate chuck 20 and hence mandrel 6 during the electrodeposition.

Fig. 4 shows six mandrels 6 passing through the tank simultaneously. For each mandrel there is provided a perforated lead basket 40 which extends the length of the tank. Anode nickel shot 42 for tank 4 surrounds the baskets, virtually filling the tank except for the areas located by the baskets. Electrolyte is admitted to the tank through pipes 44, apertured periodically at 46 (Fig. 1) and leading to a manifold 47 which communicates with an inlet pipe 48, leading from filter 50 to which electrolyte is pumped by pump 54 from the storage tank 52. An identical system is provided for supplying copper electrolyte to tank 2, containing copper shot.

The baskets 40, of lead, are perforated at 60 (Fig. 4a) and covered over with porous cloth 62.

The current is led out of the apparatus by one or more brushes 64 forming the cathodic contact outside the tank in engagement with the tubing T which has been formed on the mandrel 6. The anodic elements are connected to the nickel and copper shot in several places, not shown. The lengths of tanks 2 and 4 depend upon the desired comparative thickness of copper and nickel.

During the electrodeposition, the electrodeposited metal is worked by hammers 66 which are mounted on a reciprocating carriage to traverse the rotating mandrel in the manner described in my prior application above referred to.

Fresh electrolyte admitted through pipes 44 enters the baskets at a rate greater than the seepage through the porous cloth 62, so that the solution rises above the basket walls and flows over into the anodic metal shot occupying the space surrounding the baskets. By circulating the solution in this manner, I secure not only a very rapid circulation adjacent to the cathode surfaces, thus permitting a relatively very high current density,

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but by means of the porous cloth 62 I also prevent any anode sludge from reaching the cathode compartments. The cathode compartments receive only freshly filtered electrolyte from filters 50, for nickel and copper, through pipes 48, 47 and 44. The solution returns to the storage tanks 52, 53 through suitable bottom outlets 55 and overflow outlets 150, 152 (Fig. 3).

Disposed at the outlet end of tank 4, and also at the inlet end of tank 2, is a sealer 70 of the form shown in detail in Fig. 2. Taking the sealer at the exit end as typical, the tank has a double exit wall composed of partition 72, 74, axially apertured at 76, 78 in alignment, the aperture 76 being lined with a glass ring 80 and the aperture 78 being similarly lined with a glass ring 82. Embracing the mandrel 6 and extending radially between the opposed glass rings 80, 82, is an elastic disc 84, of rubber, natural or artificial, or of other suitable elastic material, having a central aperture of a diameter somewhat less than that of the mandrel, so that it fits snugly on the mandrel as indicated by the compressed margin on the aperture 84a. The disc engages the glass rings on both sides but slides freely between the discs by virtue of the rubber-to-glass contact which has a very low coefficient of friction, particularly when the rubbing glass and rubber ring surfaces are wet.

In practice, the elastic disc 84, snugly fitting the mandrel 6, rotates therewith so that the mandrel has no rotary motion relative to the disc. All friction and wear from rotary movement occurs between the disc and the glass rings which it lightly engages. Axial movement of the mandrel does not displace the elastic ring in an axial direction as it is held axially between the opposed glass rings. Thus, the only relative movement between the elastic disc and the mandrel is due to the movement of the mandrel in an axial direction. In an hour's typical operation, this relative axial movement amounts to only a fraction of a foot as compared with a rotary movement of the mandrel of many hundreds of feet. Thus, by restricting the relative movement between mandrel and elastic disc to the movement in an axial direction, I greatly reduce the possibility of wear between the parts and in practice the wear occasioned by relative rotary movement between the elastic disc and the glass rings is so slight that that portion of the seal usually far outwears the portion of the disc in engagement with the mandrel. Thereby the sealer afforded by my invention greatly outlasts any sealers that have been suggested by the prior art, so far as I am aware, and this durability is reflected in continuous operation of the machine over long periods of time without need for shut-downs to change sealers, with consequent loss of production time and material.

In instances where an enlarged joint 6a occurs between successive tubes, as explained in my prior application, or in the event of a possible though unlikely protruding flaw, the rubber disc 84 readily yields so that it may pass through.

I have shown glass rings on both sides of the elastic disc in Fig. 2 because two rings are employed where the mandrel is retracted at intervals during the process, as in my said prior application. Where the mandrel is not retracted, but is moved axially only in one direction, the glass ring behind the disc may be omitted.

At 100 in Fig. 1 and on an enlarged scale in Fig. 3 I have shown a sealer of modified form, especially well adapted for use where a cathodic mandrel passes from one tank to another in succession during the electrodeposition process.

The problem in the use of successive tanks arises in part from the need to convey the mandrel from one tank to another without exposure to atmosphere which would cause oxidation of the electrodeposition which has taken place in the first tank. The best way to accomplish this result is to conduct the solutions from the two successive tanks into near proximity to each other, so that

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the mandrel passes from one solution immediately into the next succeeding solution. And yet the sealer interposed between the solutions must effectively prevent leakage of one solution into the other. Thus, Figs. 1 and 3 show mandrel 6 passing from tank 2 through end wall 102 thereof into tank 4 through entrance end wall 104 of the latter. In a typical operation, tank 2 is filled with copper plating solution A and tank 4 is filled with nickel plating solution B. According to my invention, juxtaposed end walls 102 and 104 are apertured in alignment with each other at 106 and 108 respectively and these apertures are lined with annular glass rings 110 and 112 respectively. Interposed between the rings 110 and 112 is an elastic disc 114 apertured at 116 for snug fit on the mandrel to rotate therewith, as described with reference to the embodiment of Fig. 2. The disc 114 is channeled internally at 118 to receive gas or liquid under pressure so that the side wall 120 of the disc is pressed against ring 112 and side wall 122 of the disc is pressed against ring 110. The outer periphery of the disc 114 is split and deformed in manufacture to provide diverging marginal edges 124 and 126 which, on rotation of the disc with the mandrel, wipe against pins 128 and 130, respectively. The pins are mounted on wall 132 which separates the collecting cups 134 and 136. Cup 134 drains into tube 138, returning the copper solution to the supply and similarly cup 136 drains through outlet 140 to the nickel plating solution supply.

In practice, electrolyte A from tank 2 extends through the bore of ring 110 in the end wall 102 of the tank, to immerse the mandrel up to the point where it is engaged by the inner edge 116 of the elastic seal 114. Similarly, solution B in tank 4 extends through the bore of ring 112 as far as the seal 114. Thus the mandrel passes from one electrolyte to the other through the seal without exposure to atmosphere so that oxidation is effectively prevented.

Despite the close proximity of one electrolyte to the other, there is virtually no leakage from one tank to the other and very little leakage from either tank to the outside. The close fit of the disc 114 on mandrel 6 minimizes the leakage of solution by way of the mandrel surface. The pressure of the side walls of the disc against the corresponding glass rings minimizes leakage between the disc and either ring so that very little electrolyte escapes to be collected in cups 134 and 136 and returned to the supply. The axial movement of the mandrel relative to the disc tends to urge the disc against the forward ring 112 with greater pressure than that between the disc and the ring 110 behind it. However, by virtue of the fluid pressure within the channel 118, the pressure of the disc is substantially equalized against both rings and this condition contributes to effective sealing.

As indicated in Fig. 3, the level of electrolyte B in tank 4 is slightly higher than the level of electrolyte A in tank 2. This is achieved by the use of overflow outlets 150 and 152 respectively of different elevations. Thus, there is a slightly greater hydrostatic pressure of liquid B against one side of the seal than is exerted by liquid A on the other side. My purpose in providing for such difference in pressure is to assure against any possibility of leakage of electrolyte A into tank 4 containing electrolyte B and I have found this to be a useful arrangement in situations where leakage from tank 4 to tank 2 is of considerably lesser importance than leakage in the opposite direction, such, for example, as where A is copper plating solution and B is a solution for nickel plating.

As typical of a further operation in which my novel sealer is well adapted for use, is the apparatus illustrated in Fig. 5 and Fig. 5a wherein is shown a tank 200 for cleaning and degreasing the mandrel immediately prior to its introduction into a tank 202 for electrolytic deposition. The tank 200 is filled with an electrolytic cleaning solution C in which the mandrels 6 are immersed as

they advance through the tank. A supply 204 of an abrasive is forced through pipe 206 against the mandrel 6, by pump 208, as aid in cleaning and degreasing. Fig. 5a shows a series of six mandrels being so operated on by six corresponding pipes 206 leading from pump 208. At the inlet end of tank 200 is a seal 70 constructed as above described with reference to Fig. 2. To assure against any access of finely divided abrasive to the seal 70, a second seal 210 is provided consisting of an elastic disc, tightly mounted on mandrel 6 to rotate therewith and urged against a glass ring which lines the aperture of a partition 209, as shown. At the outlet of tank 200 and immediately preceding entrance to tank 202 is a seal 100 which is constructed as described above with reference to Fig. 3. To assure against contamination of seal 100 by finely divided abrasive, a guard seal 220 is provided, which may be identical with the seal 210 above described.

In Figs. 7 and 8 I have shown a still further modification of my invention adapting it for use in the manufacture of lengths of tubing on a mandrel which rotates during electrodeposition but does not advance axially. Tank 250 containing electrolyte receives mandrel 252 mounted on a stand 254 in a trunnion 256 which is adapted to tilt relative to the stand as indicated by a comparison of Figs. 7 and 8. The mandrel is rotated during the deposition for effective action of the hammers of which the one shown at 257 is typical, the rotation being effected by worm gear 258 meshing with worm 260, power-driven at 262.

The mandrel is tapered at its forward end 266 (Fig. 9) and the forward end is solid, terminating in a cup 272. Fitting into the cup is a member 273 having an aperture screw threaded internally for a purpose which will appear. An insulating washer 268 holds member 273 in place by screw 270 threaded into the end 266 of the mandrel. After the electrodeposition has been completed, the deposit 274 covers the edge of member 273. To loosen the tubing, washer 268 and screw 270 are removed and a larger eye screw 276 (Fig. 10) is threaded through the aforesaid screw threaded aperture in member 273. Advance of the screw causes the screw to press against the mandrel 266 and to break the tubing loose therefrom, after which it may readily be removed.

The sealer is designated generally by the numeral 280 in Figs. 7 and 8. The end wall 282 of the tank in this embodiment is composed of a heavy elastic material, such as rubber, natural or artificial, apertured for passage of the mandrel. Glass discs 284 and 286, secured to the mandrel on opposite sides of the end wall, have annular rims 288 and 290 which press against opposite sides of the elastic end wall 282. During the electrodeposition leakage is effectively prevented although any slight leakage which may occur is collected and drained off at 292. There is no axial motion of the mandrel and the seal will therefore wear almost indefinitely.

When the deposition is completed, the mandrel is tilted on its stand 254 by depression of the extreme outer end of the mandrel, by means of screw 296, manually rotated by hand wheel 298. Such inclination of the mandrel is permitted by the elasticity of the end wall 282 as shown in Fig. 8.

In the embodiment of Fig. 11, the disc of Fig. 2 is in the form of a toroidal ring 300, circular in cross section and with an internal diameter for snug fit of the mandrel. In operation, the ring rolls on the mandrel as the latter advances so that substantially the only wear takes place at the rubber to glass contact so that this form of sealer is exceptionally long-lived.

In Figs. 12 and 13 the disc 302 or 304 has its aperture for reception of the mandrel specially shaped to conform to special mandrel shapes, which need not be circular in cross section as indicated by the hexagonal aperture 306 of Fig. 12 and the intricately shaped aperture 308 of Fig. 13.

I claim:

1. Apparatus for sealing leakage of electrolyte around a rotating cathode protruding through an orifice in the wall of a tank for electrodeposition of metal, comprising the combination of a seal element extending radially from the cathode to occupy the free area of the orifice around the cathode and obstruct the orifice against substantial leakage of electrolyte, the margins of the tank wall surrounding the orifice being formed as annular protuberances engaging the element in an axial direction, the element being adequately secured to the cathode to rotate therewith and being held against axial movement with the cathode in either direction by abutment against said protuberances on opposite sides thereof, and fluid pressure means expanding the seal element axially substantially to equalize the pressure of the element against said opposite protuberances.

2. Apparatus for sealing leakage of electrolyte around a rotating cathode protruding through an orifice in the wall of a tank for electrodeposition of metal, comprising the combination of a seal element extending radially from the cathode to occupy the free area of the orifice around the cathode and obstruct the orifice against substantial leakage of electrolyte, the margins of the tank wall surrounding the orifice being formed as annular protuberances engaging the element in an axial direction, the element being adequately secured to the cathode to rotate therewith and being toroidally shaped to roll on the mandrel as the mandrel advances axially while the element is held against axial movement by abutment against said protuberances.

3. Apparatus for making tubing continuously by electrodeposition, including a tank having end walls at least one of which end walls has an opening, a mandrel within the tank presenting a cathodic surface on which the tubing is formed and projecting outwardly of the tank through said opening, the said opening being of a size substantially larger than the outer diameter of that portion of the cathodic surface projecting through it, means for rotating the mandrel in said opening, and means for preventing leakage of solution through said opening around the mandrel, comprising an annular seal embracing and secured to the cathode surface to rotate therewith, an annular abutment surrounding the opening, mounted in fixed position relative to the seal and abutting the seal to exclude the passage of liquid between the seal and the abutment, the said seal and said abutment presenting contiguous rubber to glass surfaces which minimize friction therebetween resulting from rotation of the seal relative to the abutment.

4. Apparatus for making tubing continuously by electrodeposition, including a tank having end walls, a cathodic mandrel within the tank on which the tubing is formed, an opening in an end wall of the tank of a size larger than the outer diameter of the tubing formed on the mandrel, means for simultaneously rotating the mandrel and advancing it axially outwardly of the tank through said opening, and means for preventing leakage of solution as the tubing passes through said opening, comprising an annular seal having an aperture smaller than the outer diameter of the tubing embracing the tubing to rotate therewith, annular stop means inside the tank surrounding the opening and mounted in fixed position relative to the seal, abutting the seal to hold it against movement with the tubing in a direction axially of the tubing, the said seal and said stop means presenting contiguous smooth surfaces which minimize friction therebetween resulting from rotation of the seal.

5. Apparatus for making tubing continuously by electrodeposition, including a tank having end walls, a cathodic mandrel within the tank on which the tubing is formed, an opening in an end wall of the tank of a size larger than the outer diameter of the tubing formed on the mandrel, means for simultaneously rotating the mandrel and advancing it axially outwardly of the tank

through said opening, and means for preventing leakage of solution as the tubing passes through said opening, comprising an annular seal having an aperture smaller than the outer diameter of the tubing, embracing the tubing to rotate therewith, annular stop means inside 5 the tank surrounding the opening and mounted in fixed position relative to the seal, abutting the seal to hold it against movement with the tubing in a direction axially of the tubing, the said seal and said stop means presenting contiguous rubber to glass surfaces which minimize friction therebetween resulting from rotation of the seal. 10

6. In apparatus for electroplating two superimposed layers of electrolytic metal, the combination of two tanks, containing different plating solutions, disposed in close proximity to each other end to end, the adjacent tank 15 ends having aligned tubular glass-lined openings, a cathode freely passing through the opening from one tank to the other, means for rotating the cathode, means for moving the cathode in an axial direction from one tank to the other, and means for preventing leakage between 20 tanks consisting of a hollow annular elastic disc filled with fluid and having an aperture therein smaller than

the diameter of the cathode member embracing the cathode and rotating therewith, said elastic disc being interposed between the glass linings and adapted to slidingly press on both the glass linings.

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