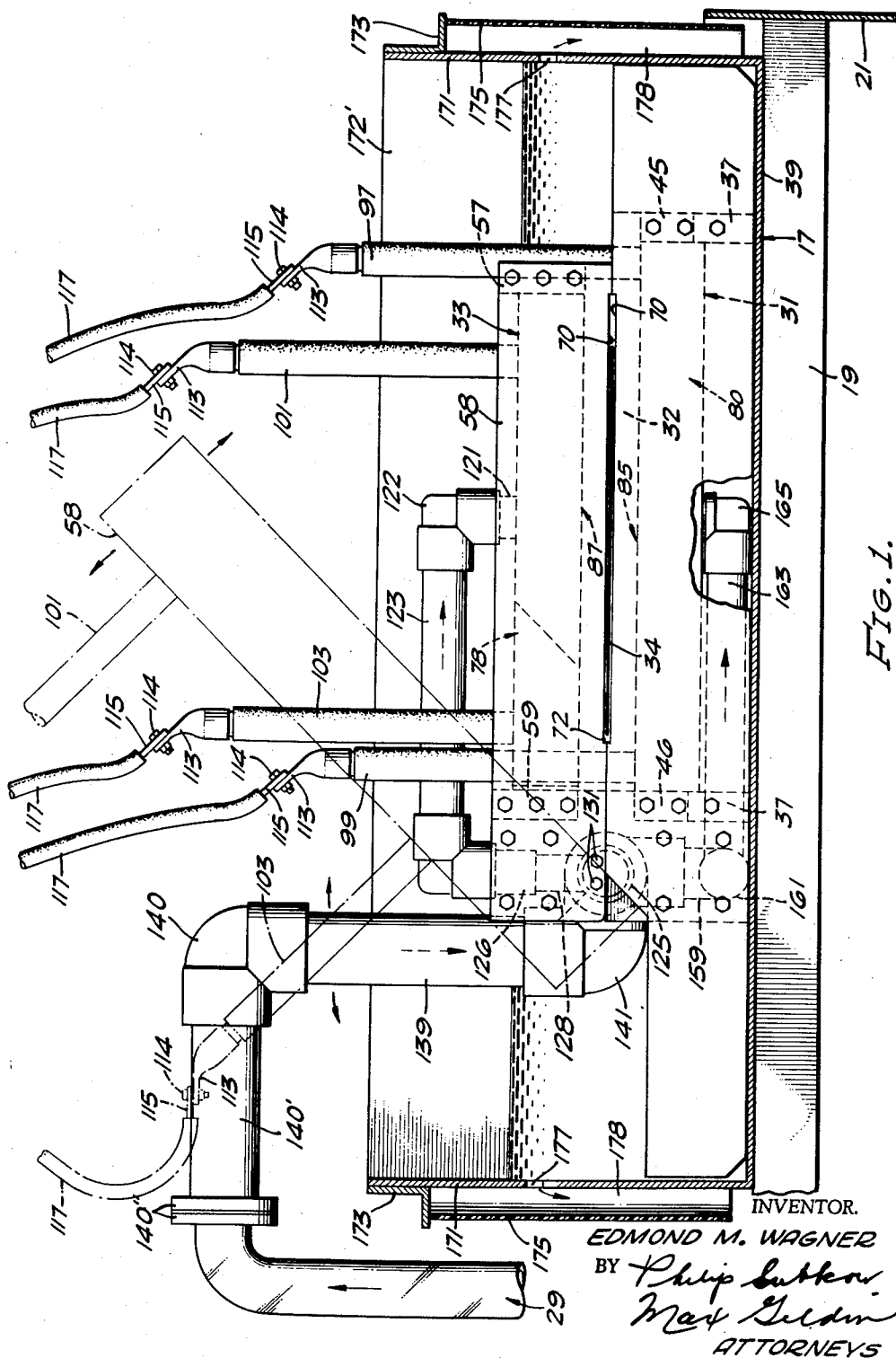


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# APPARATUS FOR ANODIZING ALUMINUM

Filed March 17, 1958

7 Sheets-Sheet 1



Aug. 29, 1961

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2,998,372

APPARATUS FOR ANODIZING ALUMINUM

Filed March 17, 1958

7 Sheets-Sheet 2

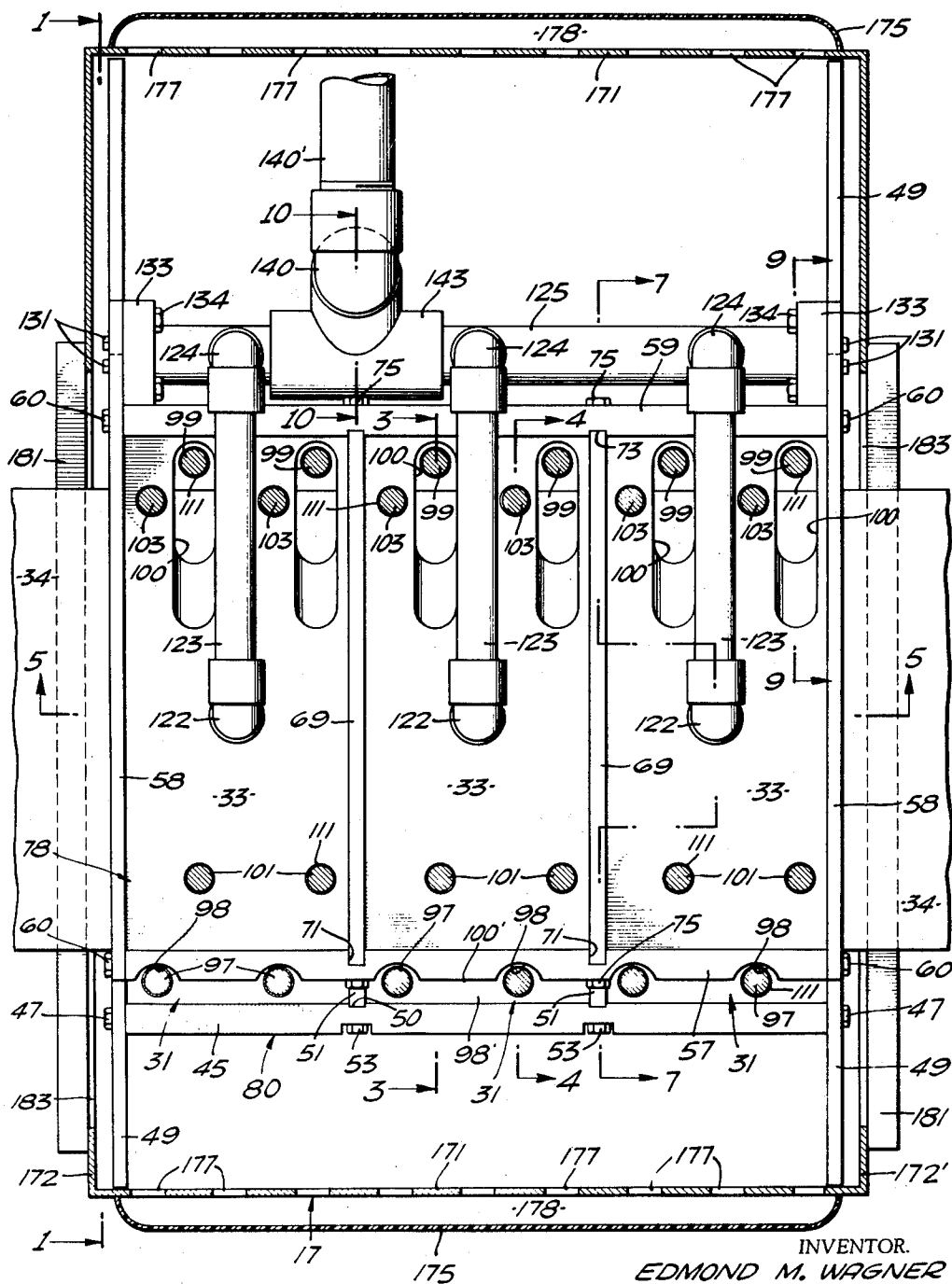


FIG. 2.

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APPARATUS FOR ANODIZING ALUMINUM

Filed March 17, 1958

7 Sheets-Sheet 3

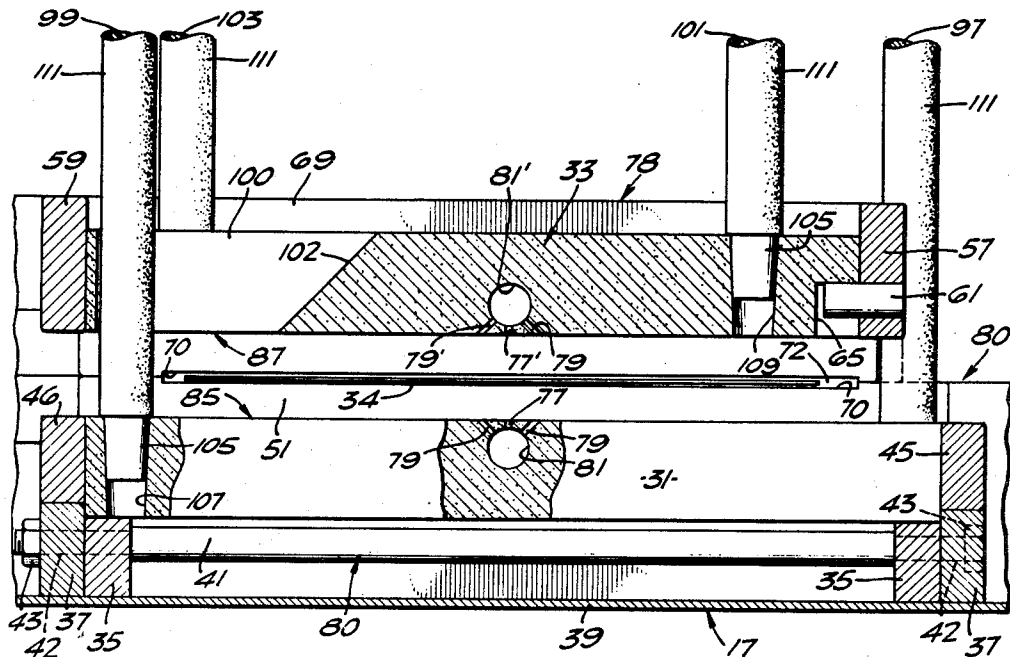


FIG. 3.

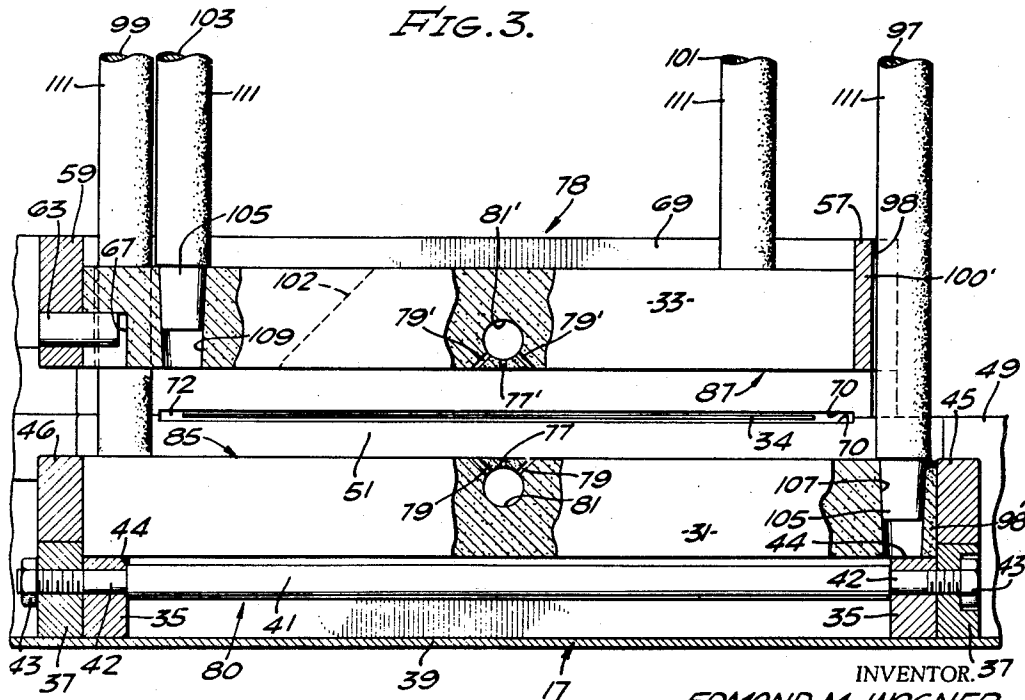


FIG. 4.

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**Aug. 29, 1961**

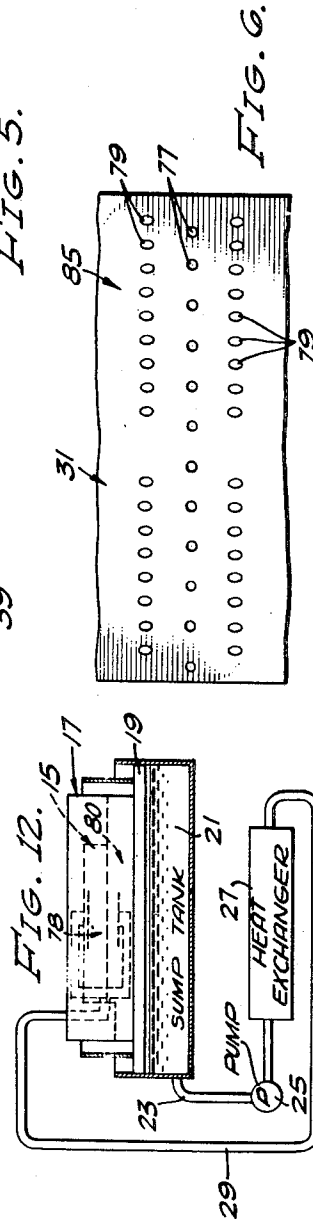
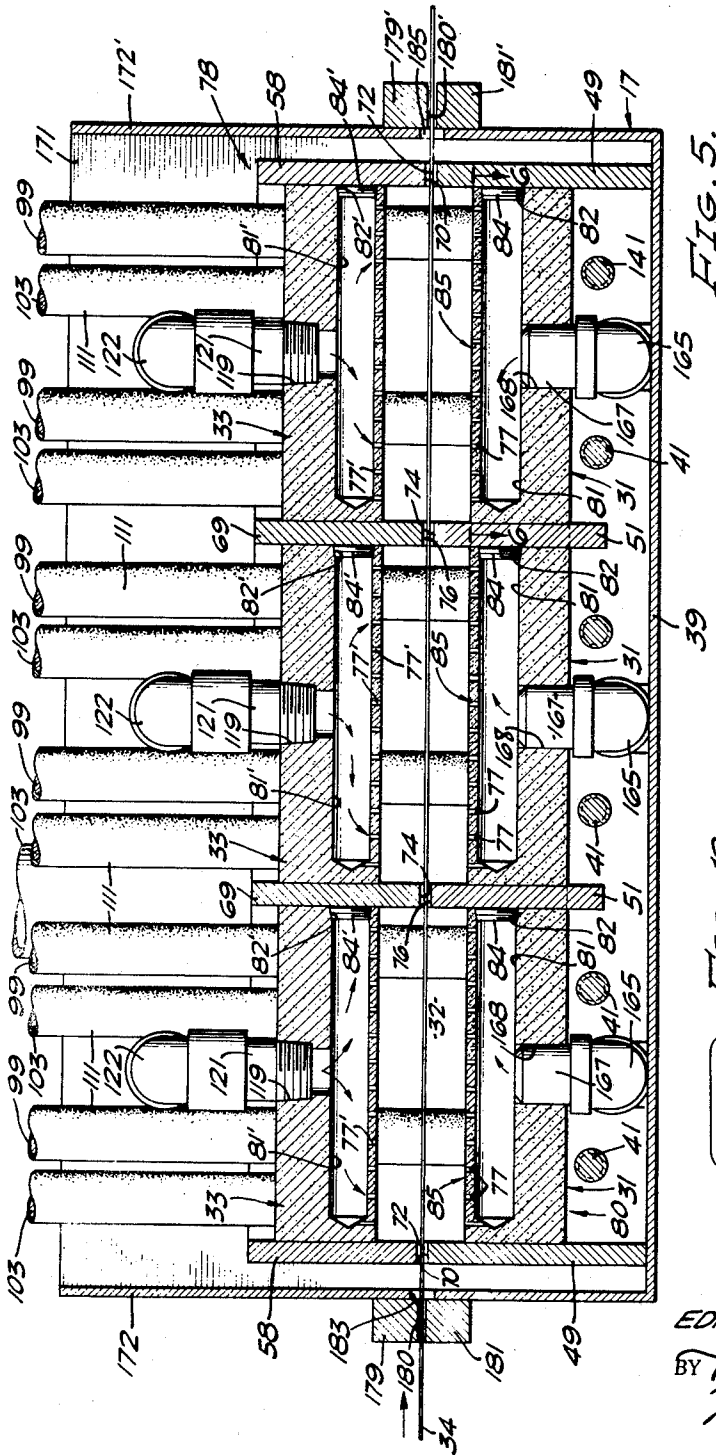
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**2,998,372**

# APPARATUS FOR ANODIZING ALUMINUM

Filed March 17, 1958

7 Sheets-Sheet 4



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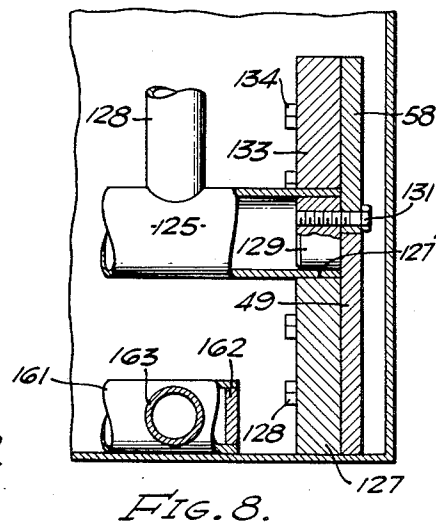
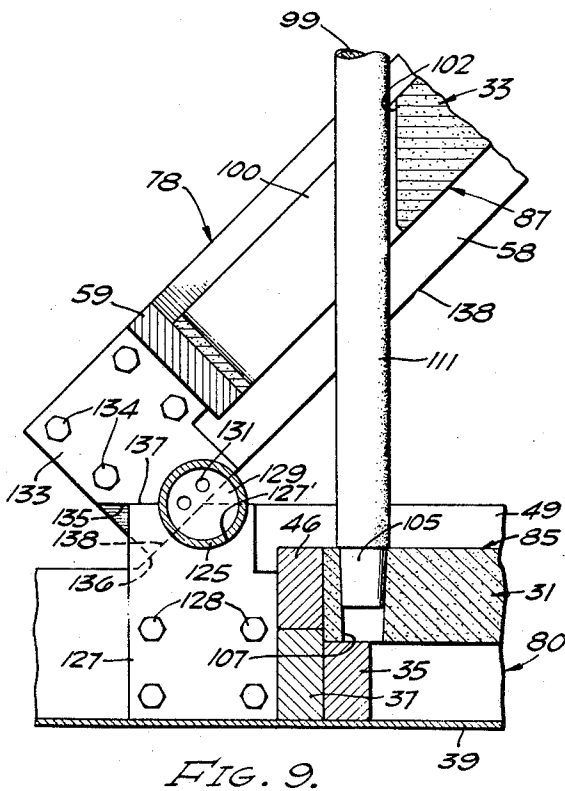
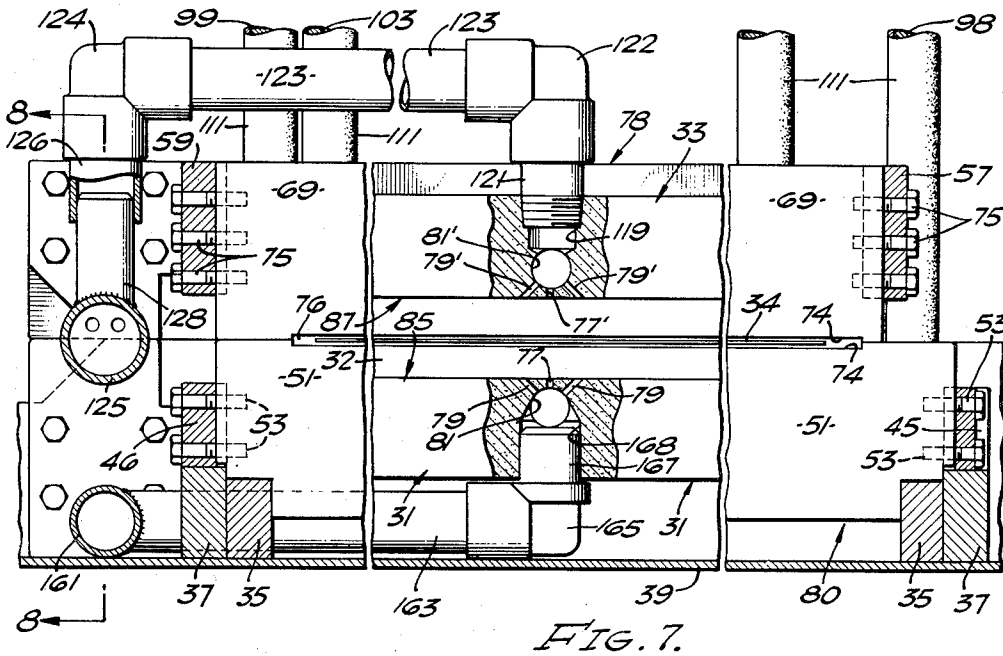
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APPARATUS FOR ANODIZING ALUMINUM

Filed March 17, 1958

7 Sheets-Sheet 5



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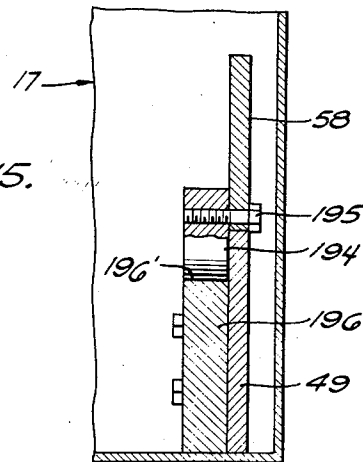
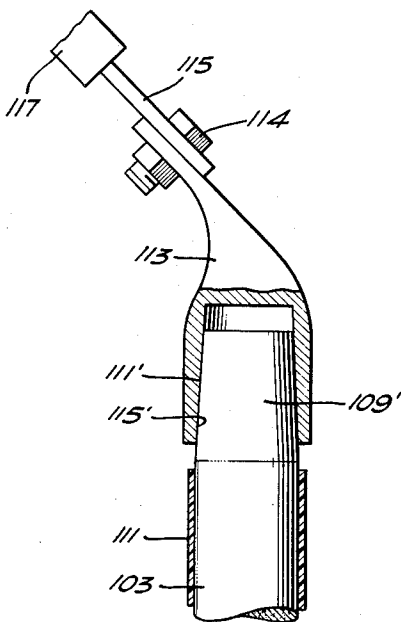
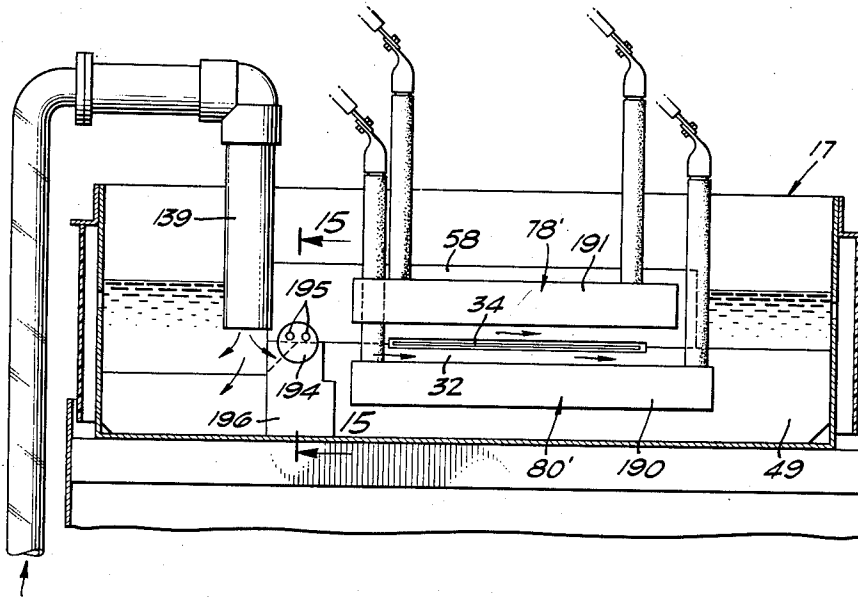
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**2,998,372**

# APPARATUS FOR ANODIZING ALUMINUM

Filed March 17, 1958

7 Sheets-Sheet 7



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2,998,372

## APPARATUS FOR ANODIZING ALUMINUM

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Filed Mar. 17, 1958, Ser. No. 721,991

11 Claims. (Cl. 204—206)

This invention generally relates to application of an electrolytic oxide coating on aluminum preferably in the form of foil, strip, tubing, bars and the like, and is particularly concerned with novel apparatus for anodizing such forms of aluminum to produce thereon an adherent ductile oxide coating.

This application is a continuation-in-part of my copending application Serial No. 678,321, filed August 15, 1957.

Apparatus and procedure are disclosed in my above copending application for forming oxide coatings particularly in a continuous manner on aluminum foil, strip and the like, to obtain smudge-proof, bloom-free and adherent oxide coatings especially adapted for subsequent dyeing of the aluminum surface, or for subsequent drawing of the aluminum article.

Such apparatus comprises a plurality of plate-type electrodes which are resistant to corrosion by the electrolyte bath, and preferably composed of carbon, said electrodes being arranged in one or more electrolytic tanks and disposed therein on opposite sides of the path of movement of the foil or strip of aluminum, to obtain uniform distribution of the aluminum oxide coating. However, in the fixed position of these electrodes, it is sometimes difficult to thread the machine with the aluminum foil or strip between the oppositely positioned electrodes prior to commencement of anodizing. Further, during operation, it is occasionally necessary to inspect the zone between the upper and lower electrodes, and through which the aluminum article passes, to determine if the device is operating properly, particularly in the event that any operating difficulty arises, or when it is desired to clean or repair the electrodes or other associated equipment.

It is accordingly one object of the invention to provide electrode structures of the aforementioned general type, but which are movable with respect to each other to readily permit initial threading of the machine with the aluminum foil or strip, and inspection of the zone between the adjacent, e.g., upper and lower electrodes. It is a further object to provide a movable electrode adjacent a fixed electrode, and associated structure operative for pivotal movement of the former electrode toward and away from the latter electrode without disengagement of any of the electrical connections to either of the electrodes, or without necessity for removal or disengagement of any mechanical connections or piping.

Also, in the apparatus of my above application, means are provided in conjunction with the oppositely disposed electrodes for circulation of electrolyte through the respective electrodes and for discharging the thus circulated electrolyte into the space between the electrodes and the aluminum foil or strip at a plurality of locations lengthwise of the foil or strip, the electrolyte flowing outwardly toward opposite side edges of the foil from a point intermediate said edges. Yet another object of the invention is provision of novel aluminum anodizing apparatus which includes in conjunction with the aforementioned pivotal construction for the electrodes, means for circulation of electrolyte through the electrodes to the anodizing zone.

The above and other objects and advantages will become apparent hereinafter.

The apparatus of the invention comprises oppositely

2

disposed spaced plate-type electrodes positioned in an electrolyte tank, providing a zone for free movement of an aluminum article such as foil or strip to be anodized, between said electrodes, at least one of said oppositely disposed electrodes being preferably hingedly mounted on the frame of the device for pivotal movement into operative relation with, and out of operative relation away from, the other electrode. The hinge for the movable electrode extends along a line parallel to the central plane of the electrodes, and parallel and adjacent to the opposite outer longitudinal edge of the opposite electrode plates. According to a specific preferred design of my device, the hinge is in the form of a pipe which has limited pivotal or angular movement, said pipe constituting a portion of the manifold for circulating electrolyte solution to the electrodes and into the space between opposite electrodes. Said pipe hinge is also provided with associated structure to permit circulation of electrolyte from a main pipe into said hinge pipe, and from said hinge pipe into distributing pipes for discharge through the electrodes and into the anodizing zone therebetween.

The invention will be more readily understood from the following description of a preferred embodiment of my apparatus, taken in connection with the accompanying drawings wherein:

FIG. 1 is an end view of the device shown in FIG. 2, taken on line 1—1 of FIG. 2 and showing the upper electrode in its upwardly pivoted position away from the lower electrode;

FIG. 2 is a plan view of the device;

FIG. 3 is a transverse section taken on line 3—3 of FIG. 2;

FIG. 4 is a transverse section taken on line 4—4 of FIG. 2;

FIG. 5 is a longitudinal vertical section taken on line 5—5 of FIG. 2;

FIG. 6 shows a detail plan view of the electrode employed in the invention device, taken on line 6—6 of FIG. 5;

FIG. 7 is a transverse vertical section taken on line 7—7 of FIG. 2;

FIG. 8 is a detail of the pipe hinge structure taken on line 8—8 of FIG. 7;

FIG. 9 is a sectional elevational view, of a portion of the upper and lower electrode structures taken on line 9—9 of FIG. 2, showing particularly the hinge for the upper electrode, and the relation between the upper and lower electrodes when the former is pivoted into inoperative position away from the lower electrode;

FIG. 10 is a vertical section taken on line 10—10 of FIG. 2, showing the structural relation between the main electrolyte circulating pipe and the hinge pipe for the upper electrode;

FIG. 11 is a section taken on line 11—11 of FIG. 10;

FIG. 12 is an assembly view showing an electrolyte circulating system employed in conjunction with my device;

FIG. 13 is a detail of the electrode rod structure; FIG. 14 is an illustration of a modification of the invention; and

FIG. 15 is a section taken on line 15—15 of FIG. 14.

Referring first to FIG. 12 of the drawings, the novel electrode structure of the invention, designated generally by the numeral 15, is mounted within an anodizing tank 17 which in turn is mounted in a sump tank 21 on cross bars 19 therein, said cross bars 19 being connected as by welding to the sides of tank 21. Electrolyte solution in sump tank 21 is circulated via a line 23 and a pump 25 through a heat exchanger 27 and thence via main feed line 29 back to the anodizing tank 17.

Referring now to FIGS. 1 to 7 of the drawings, there

is mounted in the anodizing tank 17 a series of identical lower electrodes 31, shown as three in number in FIGS. 2 and 5, and a series of identical upper electrodes 33, also shown as three in number in FIGS. 2 and 5.

As is seen in FIGS. 1 to 5 and 7, the lower series of electrodes 31 and the upper series of electrodes 33 are in the form of plates, said two series of electrodes when in operative position being disposed in horizontal parallel planes. The lower three electrodes are in longitudinal alignment and the upper three electrodes 33 also are in longitudinal alignment with each other, as best seen in FIG. 5, said lower and upper electrodes being disposed transversely of the tank 17. Electrode plates 31 and 33 are preferably formed of a conductive non-corrosive and non-metallic material inert to the acid electrolyte, preferably carbon. It is convenient to design lower electrode plates 31 somewhat larger transversely thereof than the upper electrode plates 33, so that the upper electrodes are offset along one edge thereof from the lower electrodes, as seen in FIGS. 1 and 2, although it will be understood that both the upper and lower electrodes may be of the same size. The terms "longitudinal" and "transverse" employed herein, unless otherwise indicated, are with respect to the aluminum foil or strip 34 being treated.

The lower electrodes 31 are fixed while the upper electrodes are movable away from the lower electrodes as described more fully below. In operative position for anodizing, the lower electrodes 31 are spaced from the upper electrodes 33 to form a zone 32 between said lower and upper electrodes through which the aluminum foil or strip 34 is arranged to be continuously conducted for production of an oxide coating thereon in the manner described more fully below.

The lower electrodes 31 are mounted on oppositely disposed longitudinally extending parallel blocks or rails 35 (see FIGS. 3 and 4), which are clamped in position against outer longitudinally extending supports 37, both the blocks 35 and supports 37 being positioned on the bottom 39 of the anodizing tank 17. The blocks 35 and supports 37 are maintained in clamped position by means of a series of transversely positioned spaced tie rods 41 (see also FIG. 5) having fixed to their opposite ends studs 42 of smaller diameter than tie rods 41. Nuts 43 are threadably engaged on the studs 42 for clamping the blocks 35 against the shoulders 44 at opposite ends of the tie rods 41 and against the outer supports 37. Mounted on the supports 37 is a front side bar 45 and a rear side bar 46. Side bars 45 and 46 are substantially coextensive in length with the supports 37 (see FIG. 2) and are connected to their opposite ends by means of bolts 47 to a pair of lower insulator spreader members 49 mounted transversely of the bars 45 and 46 along opposite sides of the anodizing tank 17. Viewing FIGS. 2, 5 and 7 there is disposed at approximately equal distances intermediate insulator spreaders 49, a pair of lower insulator spacers 51 which extend parallel to each other and to the insulator spreaders 49. The insulator spacers 51 are mounted at their opposite ends in grooves 50 and 52 formed in the front and side bars 45 and 46 respectively, and are maintained in position by means of bolts 53 connecting the insulator spacers 51 with the side bars 45 and 46.

The upper electrodes 33 are mounted on an upper front side bar 57 (see FIG. 4) and on an upper rear side bar 59. The side bar 57 is disposed above and offset slightly inwardly from the lower front side bar 45 and is disposed parallel thereto. The upper rear side bar 59 is positioned directly above the lower rear side bar 46 and extends parallel thereto. Side bars 57 and 59 are of the same length as side bars 45 and 46, and are connected to a pair of upper insulator spreader members 58 (see FIG. 2) by means of bolts 60. Mounted at spaced intervals on the upper front side bar 57 is a series of pins 61 which are press fitted into member 57 and ex-

tend inwardly thereof as seen in FIG. 3. Also mounted in the upper rear side bar 59 is a series of pins 63 which are press fitted into member 59, said pins also extending inwardly of the side bars 59. It will be noted that the pins 63 are offset in a longitudinal direction from the pins 61. Each of the upper electrodes 33 carries along one edge thereof a series of recesses 65 to receive pins 61 and each of said electrodes also carries along its opposite edge a series of recesses 67 to receive the pins 63. Hence it is seen that the upper electrodes 33 rest on the pins 61 and 63.

Positioned directly above the lower insulator spacers 51 (see FIGS. 2, 5 and 7) are a pair of upper insulator spacers 69 disposed at equal intervals between the upper insulator spreaders 58 at opposite sides of the tank. Insulator spacers 69 are received in grooves 71 of the upper front side bar 57 and in grooves 73 of the upper rear side bar 59, and are maintained in position on side bars 57 and 59 by means of bolts 75.

It will be noted that the lower insulator spacers 51 electrically insulate and separate the three lower electrodes 31, and the upper insulator spacers 69 electrically insulate and separate the three upper electrodes 33.

Viewing FIGS. 3, 4, 5 and 7, shallow recesses 70 are formed in each pair of lower and upper insulator spreaders 49 and 58 along adjacent inner contacting edges thereof, adjacent recesses in each pair of members 49 and 58 at opposite sides of the tank, forming slots 72. Also, the adjacent pairs of lower and upper insulator spacers 51 and 69 have recesses 74 formed along the upper edge of each of members 51 and along the lower contacting edge of each of members 69, forming slots 76. Hence, as seen most clearly in FIG. 5, there are two end slots 72 and a pair of intermediate slots 76, all of said slots being in the same horizontal plane and in alignment with each other to permit passage of the aluminum foil or strip 34 through the zone 32 between the lower and upper electrodes 31 and 33 in the anodizing tank 17.

Thus, it is seen that all three of the upper electrodes are positioned as a unit 78 within the insulator spreaders 58, front and rear side bars 57 and 59, and separated by the insulator spacers 69. This entire unit rests on the lower insulator spreaders 49 and the lower insulator spacers 51 and on front and rear side bars 45 and 46 of the lower electrode structural unit 80, when the upper movable electrode unit 78 is in operative position. When the unit 78 is pivoted away from the lower unit, as described more fully below, all three of the upper electrodes simultaneously move away from the lower unit 80 to the inoperative position shown dotted in FIG. 1.

Viewing FIGS. 3 to 6, particularly FIG. 6, it will be noted that each of the lower electrodes 31 has in the upper face 85 thereof a series of longitudinally extending central discharge ports 77 and two parallel longitudinal rows of discharge ports 79. The ports 77 and 79 communicate with a main central port 81 in each of the lower electrodes 31, said main central port 81 extending longitudinally almost the entire distance through the electrode, the electrode having a hole 82 at one side communicating with said port 81, said hole being normally closed by a plug 84. Hole 82 and plug 84 are provided for cleaning and inspection purposes. It will be noted that the central ports 77 are vertically disposed (see FIGS. 3 and 4) while the adjacent ports 79 are disposed at an acute angle, for proper distribution of electrolyte from the central port 81 through ports 77 and 79 and into the center of the anodizing zone 32.

In a similar manner, each of the upper electrodes 33 has in the lower face thereof a series of central ports 77' and two rows of adjacent ports 79', all of said ports communicating with a main central longitudinally extending port 81' similar to the central port 81 in the lower electrodes, one end of the upper central port 81' having a hole 82' closed by a plug 84'. As noted particularly in FIGS. 3 and 4, the discharge ends of the ports 77, 77',

the ports 79, 79' and the main central ports 81, 81' are in respective vertical alignment with each other, and the ports 79 and 79' are inclined outwardly, for efficient circulation of electrolyte fluid from the central portion of the upper and lower faces respectively of electrodes 31 and 33 into the center of the anodizing zone 32, and for even distribution of the electrolyte outwardly toward the sides of the electrodes in the anodizing zone between the electrodes and the aluminum foil 34. By the term "center" or "central" with respect to the location of the discharge of electrolyte from the adjacent faces of the electrodes into the anodizing zone therebetween is meant an intermediate location or zone between the outer edges of adjacent upper and lower electrodes which will provide uniform distribution of electrolyte temperature and electrolyte velocity through the anodizing zone. Since the apparatus described herein is substantially symmetrical, the zone noted above will be located substantially centrally.

Viewing FIGS. 2, 3 and 4 particularly, there are positioned in each of the lower electrodes a pair of front electrode rods 97, there being a total of six such rods in longitudinal alignment, as seen particularly in FIG. 2. It will be noted that the electrode rods 97 are mounted in the front offset portion 98' of the lower electrodes 31, said rods being received in recesses 98 formed along the front edge 100' of the upper front side bar 57 to permit placement of the upper electrodes in operative position above the lower electrodes without interfering contact between the electrode rods 97 and said upper side bar. There are also mounted in longitudinal alignment along the rear portion of the lower electrodes 31 a series of electrode rods 99, shown as six in number in FIG. 2, two of said rods 99 being provided for each lower electrode plate 31. It will be noted that the rear lower electrode rods 99 pass through transverse slots 100 formed in the upper electrode plates 33, said slots 100 each having a forward beveled edge 102 disposed at approximately a 45° angle for the purpose described hereinafter.

Mounted in longitudinal alignment in the front portion of upper electrodes 33 is a third series of upper longitudinally extending electrode rods 101, there being six in number, two for each electrode as seen in FIG. 2. Also mounted in the upper electrode plates 33 is a fourth series of six longitudinally positioned spaced rear electrode rods 103, two for each upper electrode plate. Rods 97, 99, 101 and 103 are preferably composed of a conductive material inert to the electrolyte solutions, such as carbon. Such rods are preferably coated or impregnated with an acid resisting material such as a resin, e.g., a vinyl resin, so that the rods will not act as wicks to draw solution up to the electrical terminals 113. It will be seen that the front lower electrode rods 97 are offset from each of the front upper electrode rods 101, and that the rear upper electrode rods 103 are similarly staggered or offset from each of the adjacent rear lower electrode rods 99. The reason for such staggering of the respective front and rear upper and lower electrode rods is to prevent interference and contact between rods 97 and 101 and between rods 99 and 103, and interference between the connecting cables when the upper electrode structure 78 including the upper electrode plates 33, is pivoted upwardly and away from the lower electrode structure 80 into the position shown in FIG. 9 and in phantom in FIG. 1. Each of the rods 97, 99, 101 and 103 is of substantially the same construction, each having a tapered lower end 105 (see FIGS. 3 and 4). The tapered ends 105 of the lower electrode rods 97 and 99 are press fitted into tapered holes 107 in the lower electrodes 31, and tapered ends 105 of the upper electrode rods 101 and 103 are press fitted into tapered holes 109 in the upper electrodes 33. The upper ends 109' of each of the electrode rods are also tapered as shown at 111' (see FIG. 13) to receive a terminal lug

113 having a matching tapered inner bore 115' which is press fitted over the upper taper 111' of the rods.

Disposed about substantially the entire length of each of the electrode rods 97, 99, 101 and 103 above the lower tapered portion 105 thereof is an insulating, e.g., a plastic sheath 111 (see FIGS. 1 to 4). This plastic insulating sheath functions to prevent undesirable current bypassing taking place between these carbon electrode rods and the electrolyte solution, and to force the current to pass from the electrode rods to the respective electrodes and then into the electrolyte solution in the zone 32 between the lower and upper electrodes without by-passing or shorting. Each of the terminals 113 (see FIG. 13) at the upper end of each of the electrode rods is adapted to be connected by suitable fasteners at 114 to the terminals 115 of electrical leads 117 connected to the source of current (not shown).

Referring now to FIGS. 1, 2, 5 and 7, there is disposed centrally in each of the upper electrode plates 33 a tapped hole 119 which communicates with the main central longitudinally extending port 81' in said electrodes. In each of these tapped holes 119 is threadably engaged an inlet nipple 121 to which is connected an elbow 122 mounted on an upper distribution or inlet pipe 123 the opposite end of which is connected to an elbow 124, there being three such pipes 123 parallel to each other (see FIG. 2). The lower end of elbow 124 carries a nipple 126 which slips over a downwardly extending pipe 128 which is fixed to a longitudinally extending manifold pipe 125. As seen in FIGS. 2 and 7, each of the three pipes 128 is connected to pipe 125 which is mounted for limited pivotal or angular motion in the manner described more fully below.

Referring now particularly to FIGS. 2, 8 and 9, it will be seen that the manifold pipe 125 is mounted on oppositely disposed bearing blocks 127 which are connected to the rear portion of adjacent insulator spreaders 49 by means of bolts 128. The opposite ends of manifold pipe 125 are closed by plugs 129 which are mounted on members 58 of the upper unit 78 by means of the bolts 131. Resting on the upper portion of manifold pipe 125 at opposite ends thereof for rotation therewith are upper journal blocks 133 which are connected to the rear portion of upper insulator spreaders 58 by means of bolts 134, so that the entire upper electrode unit 78 is resting directly on manifold pipe 125 through the journal blocks 133. Thus, it will be seen that when the entire upper electrode structure 78, including the oppositely disposed upper insulator spreaders 58, the upper side bars 57, the upper insulator spreaders 69, the three upper electrodes 33 and their associated piping systems, including the three inlet pipes 123, is pivoted upwardly from the front end with the journal blocks 133 on the semicircular journal 127' in bearing blocks 127, as indicated in FIG. 9, all of the aforementioned upper electrode structure 78 pivots with the manifold pipe 125 supported in the journals in bearing blocks 127. Hence the pipe 125 functions both as a hinge for the movable upper electrode structure and as a conduit for circulation of electrolyte to the electrodes 31 and 33, as described below.

It will be noted in FIG. 9 that the journal blocks 133 have a 45° shoulder 135 and the lower insulator spreaders 49 at their rear portions have a 45° shoulder 136. When the upper electrode structure 78 is pivoted counterclockwise about an approximately 45° angle to the position shown in FIG. 9, the shoulder 135 on the journal blocks 133 make contact with the upper horizontal edge 137 of the bearing blocks 127, and substantially simultaneously, the rear lower edge 138 of the upper insulator spreaders 58 make contact with the 45° shoulder 136 on the lower insulator spreaders 49. This structure forms a limit stop for upward pivotal movement of the upper electrode structure 78, and when this position is attained it will be noted, as shown in FIG. 9, that the rear electrode rods 99 of the lower electrodes 31 are still received within the slots 100

of the upper electrodes without contacting the 45° beveled or inclined side 102 of said slots 100.

Now referring particularly to FIGS. 1, 2, 10 and 11 there is provided a main electrolyte feed pipe 139 which is connected into the main circulating line 29 via the elbow 140, fitting 140' and flanges 140'', and is also connected via an elbow 141 to a distributing bushing or ring 143. Bushing 143 is provided with a circular aperture 145 for communication with elbow 141, and said bushing is fixedly mounted on a pair of oppositely disposed sealing rings 147 which are connected as by welding at 149 to the bushing 143. Thus it is seen that the manifold pipe 125 rotates with respect to the fixed bushing 143 and sealing rings 147 when the upper electrode structure 78 is pivoted as above described. The bushing 143 has a larger internal diameter than the external diameter of manifold pipe 125, and forms an annulus 153 between members 143 and 125 as best seen in FIG. 10. The manifold pipe 125 adjacent the annulus 153 is provided with a series of ports 155 for fluid communication between said annulus and the interior of the manifold 125. Hence it will be seen that electrolyte solution can be circulated through the feed pipe 139 into the annulus 153 via aperture 145, from said annulus into the manifold pipe 125 via the ports 155.

The bushing 143 has an aperture 156 in the lower portion thereof, which communicates with a depending flange 157 which slips over a pipe 159 in turn fixed on and communicating with a lower manifold pipe 161 which extends longitudinally from side to side of the anodizing tank along the bottom thereof directly beneath the pivoted manifold pipe 125. Branching off from the lower manifold 161 and in vertical alignment with pipes 123 is a series of three lower parallel distribution or inlet pipes 163 having elbows 165 attached to their inner ends (see FIGS. 5 and 7), said elbows being connected to nipples 167 each slipping into a hole 168 in the center of each of the lower electrodes 33, said holes 168 each communicating with the main central longitudinal port 81 in each of the lower electrodes 33.

Thus it will be seen that electrolyte solution circulated to the anodizing tank via pipe 29 and the feed pipe 139 is conducted via the annulus 153, aperture 156, the lower manifold pipe 161 and the lower distributing pipes 163 into the lower electrodes 31, and via the ports 81, 77 and 79 of the lower electrodes into the anodizing zone 32. Also electrolyte solution passes via annulus 153 and ports 155 into the manifold pipe 125, the upper distributing pipes 123 and the upper electrodes 33, and via the ports 81', 77' and 79' therein into the anodizing zone 32 between the upper and lower electrodes.

The opposite end walls 171 of the anodizing tank 17, as best seen in FIGS. 1 and 2, have attached to the upper ends thereof a flange 173 to the outwardly extending ends of which are attached depending plastic shields 175 which extend almost to the bottom of anodizing tank 17 and below the top of the sump tank 21. A plurality of aligned holes 177 is provided along each of the end walls 171 of the anodizing tank, said holes being at the desired maximum level of electrolyte solution to be maintained in the anodizing tank as seen in FIG. 1. Thus, electrolyte solution in the anodizing tank overflows through the overflow holes 177 into the vertical conduit 178 formed by the plastic shields 175 into the sump tank 21 directly below, from which the electrolyte passes to the heat exchanger 27 (see FIG. 12) wherein the electrolyte solution is cooled by means of water passed in heat exchange relation with the electrolyte, and the exiting electrolyte is then recirculated via line 29 to the feed pipe 139 for reuse in the anodizing tank 17. It will be noted that the level of the holes 177 is above the lower surface 87 of the upper electrodes 33 so that the anodizing zone 32 between the lower and upper electrodes is always full of solution, and the level of such holes 177 is also preferably below the upper surface of said electrodes 33, as seen in FIG. 1, to pre-

vent by-passing of solution across the top of the upper electrodes.

As seen in FIG. 5, the aluminum foil 34 to be anodized is fed through a slot 180 between upper and lower blocks 179 and 181 mounted on one of the side walls 172 of the anodizing tank, and through a slot 183 in said side wall. The foil is then conducted through the anodizing zone 32 between the three upper and three lower electrodes via slots 72 and 76, while electrolyte solution is circulated through said anodizing zone, as above described. The foil 34 then proceeds through an aperture 185 in the opposite side wall 172' of the anodizing tank and is conveyed externally of the tank via aperture 180' between another set of lower and upper blocks 179' and 181' mounted on the tank side wall 172'.

From the structure described about it will be seen that the upper hinged electrode structural unit 78 can be pivoted away from the lower electrodes for inspection of the foil 34 at any stage of the operation or for cleaning or repair purposes. During such pivotal movement, the entire upper electrode structure is supported upon the manifold or hinge pipe 125 which in turn rests upon the bearing blocks 127. If desired, not only can the entire upper electrode structure be pivoted away from the lower electrodes as seen in FIG. 9, but by simply disconnecting the flanges 140'' (see FIG. 1) the entire upper electrode structure 78 can be lifted free from the anodizing tank.

Instead of employing a series of three lower electrodes and a series of three upper electrodes, as described above and shown in the drawings, I may employ a single lower electrode plate and a single upper electrode plate or any number of such lower and upper electrode plates.

While I have described and shown the hinge for the upper electrode structure 78 in the form of a pipe which also functions to circulate electrolyte solution to the anodizing zone between the lower and upper electrode plates, such hinge can take any equivalent mechanical form. Thus, for example, instead of employing a pipe such as 125 as a hinge, I can employ instead any conventional hinge other than a pipe, or any pivot structure suitable for connection to the upper electrode plates for angular rotation thereof both away from and toward the lower electrode plates in a manner similar to that above described. Further, I can employ a separate manifold pipe which is not a part of the hinge, for distributing electrolyte solution to the upper and lower distributing pipes 123 and 163.

Also, the electrode hinge feature of the invention can be employed in conjunction with electrode plates of a design different from plates 31 and 33. Thus, for example, I can employ solid electrode plates not having ports therein and circulate electrolyte solution through anodizing zone 32 (viewing FIGS. 3 and 4) from one side of the zone (say the left) entirely through to the right side of said zone, instead of circulating the solution through the electrodes to the center of zone 32, and outwardly from the center to both sides of said zone, as above described. According to this modification I may then omit pipe members 119, 121, 122, 123, 124, 125 and 128, and also omit pipe members 159, 161, 163, 165 and 167, which convey the electrolyte to the electrode plates for passage therethrough.

Thus, for example, viewing FIGS. 14 and 15, there is shown in generally schematic form, the upper and lower electrode units 78' and 80', respectively, constructed and mounted as described above with respect to the lower and upper electrode units 78 and 80. In the instant modification, however, the lower and upper electrode plates 190 and 191, while being of substantially the same size and shape as electrode plates 31 and 33, are solid and do not contain circulating passages and ports therein. Also, in the instant embodiment, the lower end of the electrolyte feed pipe 139 discharges directly into the electrolyte bath at a position some-

what below the level of the top of the anodizing zone 32 adjacent said zone. The electrolyte solution then circulates through the anodizing zone 32 between the electrode plates 190 and 191 in contact with the foil 34, and passes out of the opposite end of the zone 32 and then out of the anodizing tank 17 for recirculation via line 29 in the manner previously described.

The upper electrode structure 78' of the instant embodiment is hinged by means of the rotatable members 194, which are mounted at opposite sides of the upper electrode unit 78', and which are connected by means of screws 195 to the rear portion of the upper insulator spreaders 58 of unit 78'. Rotatable members 194 are mounted for pivotal movement in journals 196' in bearing blocks 196 bolted to the lower insulator spreaders 49. Hence, the upper electrode unit 78' is mounted for pivotal movement on the frame with respect to the lower unit 80', by the rotatable members 194 in the journals 196' in blocks 196.

It will be further understood that instead of affording means for pivoting all three upper electrode plates simultaneously, I can modify my above described structure so as to pivot one or more of such upper electrode plates independently of the other upper electrode plates.

Further, while I have shown the electrode plates 31 and 33 as mounted horizontally in spaced vertical relation to provide an anodizing zone which extends horizontally for horizontal movement of a foil or strip of aluminum through the anodizing zone, I may mount the electrode plates vertically in the anodizing tank, to provide a vertically extending anodizing zone between the two sets of electrode plates 31 and 33. In this respect, e.g., either one set of electrode plates 33 can be mounted on a hinge for pivotal movement away from the other set of electrodes 31, as above described, or both sets of electrodes 31 and 33 can be mounted for angular movement away from or toward each other.

It will be understood that instead of anodizing aluminum foil or strip, or instead of anodizing an aluminum article which is passed or moved continuously through the anodizing zone, I can employ my apparatus for anodizing articles other than foil or strip, such as aluminum plates, and the aluminum article being anodized need not be moved continuously through the anodizing zone, but rather can be held stationary therein during electrolytic oxidation.

From the foregoing, it is seen that I have devised a novel anodizing apparatus providing means for mounting the electrodes for relative movement with respect to each other to thus facilitate inspection of the anodizing zone between the electrodes without requiring tedious disconnection of parts and reassembly thereof.

The apparatus hereof may be employed for electroplating operations as well as for anodizing.

The term "aluminum" employed herein is intended to denote pure aluminum or commercial aluminum containing small amounts of impurities, or aluminum alloys in which aluminum is the predominating element.

While I have described particular embodiments of my invention for the purpose of illustration, it should be understood that various modifications and adaptations thereof may be made within the spirit of the invention as set forth in the appended claims.

I claim:

1. Apparatus for anodizing an aluminum article, which comprises a frame, a first lower electrode plate, a second upper electrode plate, first means fixedly mounting said first plate in said frame, second means movably mounting said second plate in said frame in spaced substantially parallel relation to said first electrode plate, thereby providing between said plates a zone for passage of an aluminum article in a path parallel to and spaced from said plates, said second means including a hinge mounted adjacent an outer longitudinal edge of said second upper plate and connected thereto and to said frame, stop means

permitting limited angular movement to a maximum of about 45° of said upper plate on said hinge away from said lower electrode plate, first terminal rods connected to and extending upwardly from said lower electrode plate and second terminal rods connected to and extending upwardly from said upper electrode plate, said rods being adapted for connection to a source of electrical potential.

2. Apparatus for anodizing an aluminum article, which comprises a frame, a first lower electrode plate, a second upper electrode plate, first means fixedly mounting said first plate in said frame, second means movably mounting said second plate in said frame in spaced substantially parallel relation to said first electrode plate, thereby providing between said plates a zone for passage of an aluminum article in a path parallel to and spaced from said plates, said second means including a pipe hinge mounted adjacent an outer longitudinal edge of said second upper plate and connected thereto, bearings for said pipe hinge mounted at opposite ends of said frame, a feed conduit system for circulating electrolyte solution to the zone between said plates, said pipe hinge constituting a portion of said feed conduit system, first terminal rods connected to and extending upwardly from said lower plate, and second terminal rods connected to and extending upwardly from said upper plate, said rods being adapted for connection to a source of electrical potential.

3. Apparatus for anodizing an aluminum article, which comprises a frame, a first lower substantially flat electrode plate, a second upper substantially flat electrode plate, means fixedly mounting said first plate in said frame, means mounting said second plate in said frame in spaced substantially parallel relation to said first electrode plate, thereby providing between said plates a zone for passage of an aluminum article in a path parallel to and spaced from said plates, a feed conduit system for circulating electrolyte solution to the space between said plates and including a rotatable manifold pipe, said manifold pipe being mounted adjacent an outer longitudinal edge of said second upper plate and connected thereto, bearings for said manifold pipe on said frame, stop means associated with said upper plate and permitting limited angular movement of said upper plate on said manifold pipe away from said lower plate, first terminal rods connected to and extending upwardly from said lower plate, second terminal rods connected to and extending upwardly from said upper plate, said first and second rods being staggered and permitting angular movement of said upper plate with respect to said lower plate without interference between said first and second rods, said rods being adapted for connection to a source of electrical potential.

4. Apparatus for anodizing an aluminum article, which comprises a frame, a first lower carbon electrode plate, a second upper carbon electrode plate, first means fixedly mounting said first plate in said frame, second means movably mounting said second plate in said frame in spaced substantially parallel relation to said first electrode plate, thereby providing between said plates a zone for passage of aluminum foil, strip and the like in a path parallel to and spaced from said plates, said second means including a pipe hinge mounted adjacent an outer longitudinal edge of said second upper plate and connected thereto, bearings for said pipe hinge mounted on said frame, a feed conduit system for circulating electrolyte solution to the zone between said plates, said pipe hinge constituting a portion of said feed conduit system, stop means associated with said upper plate and permitting limited angular movement of said upper plate on said pipe hinge away from said lower plate, first carbon rods connected to and extending upwardly from said lower electrode plate, second carbon rods connected to and extending upwardly from said upper electrode plate, said first and second rods being staggered and permitting angular movement of said upper plate with respect to said lower plate without interference

between said first and second rods, said rods being adapted for connection to a source of electrical potentials.

5. Apparatus for anodizing an aluminum article, which comprises a frame, a first lower substantially flat electrode plate, a second upper substantially flat electrode plate, first means fixedly mounting said first plate in said frame, second means movably mounting said second plate in said frame in spaced substantially parallel relation to said first plate, thereby providing between said plates a zone for passage of aluminum foil, strip and the like in a path parallel to and spaced from said electrode plates, said second means including a pipe hinge mounted adjacent an outer longitudinal edge of said second upper plate and connected thereto, oppositely disposed bearings for said pipe hinge mounted on said frame, a feed conduit system for circulating electrolyte solution to the zone between said plates, said hinge constituting a portion of said feed conduit system, ports in said hinge pipe, a bushing mounted about said hinge pipe over said ports and forming an annulus between said bushing and said hinge pipe, a port in said bushing for introduction of electrolyte into said annulus and into said hinge pipe, cooperating abutments on said frame and connected to said upper plate for permitting limited angular movement of said upper plate and said pipe hinge on said bearings, first terminal rods connected to and extending upwardly from said lower plate, second terminal rods connected to and extending upwardly from said upper plate, said first and second rods being staggered and permitting angular movement of said upper plate with respect to said electrode plate without interference between said first and second rods, said rods being adapted for connection to a source of electrical potential.

6. Apparatus for anodizing an aluminum article, which comprises a frame, a first lower substantially flat carbon electrode plate, a second upper substantially flat carbon electrode plate, means fixedly mounting said first plate in said frame, means mounting said second plate in said frame in spaced substantially parallel relation to said first plate, thereby providing between said plates a zone for passage of aluminum foil, strip and the like in a path parallel to and spaced from said plates, a feed conduit system for circulating electrolyte solution to the space between said plates and including a rotatable manifold pipe, said manifold pipe being mounted adjacent and parallel to an outer longitudinal edge of said second upper plate and connected thereto, said manifold pipe forming a hinge for said plate, bearings for said manifold pipe on said frame, ports in said manifold pipe, a bushing fixedly mounted about said manifold pipe over said ports and forming an annulus between said bushing and said manifold pipe, a port in said bushing for introduction of electrolyte into said annulus and into said pipe, cooperating abutments on said frame and connected to said upper plate for permitting limited angular movement of said upper plate and said manifold pipe on said bearings, first carbon rods connected to and extending upwardly from said lower plate, second carbon rods connected to and extending upwardly from said upper plate, said first and second rods being staggered and permitting angular movement of said upper plate with respect to said lower plate without interference between said first and second rods, said rods being adapted for connection to a source of electrical potential.

7. Apparatus for anodizing an aluminum article, which comprises a frame, a first lower carbon electrode plate, a second upper carbon electrode plate, means fixedly mounting said first plate in said frame, means mounting said second plate in said frame in spaced substantially parallel relation to said first electrode plate, thereby providing between said plates a zone for passage of aluminum foil,

strip and the like in a path parallel to and spaced from said plates, a feed conduit system for circulating electrolyte solution to the space between said plates and including a rotatable manifold pipe, said manifold pipe being mounted adjacent and parallel to an outer longitudinal edge of said second upper plate and connected thereto, said manifold pipe forming a hinge for said plate, bearings for said manifold pipe on said frame, ports in said manifold pipe, a bushing fixedly mounted about said manifold pipe over said ports and forming an annulus between said bushing and said manifold pipe, a port in said bushing for introduction of electrolyte into said annulus and into said pipe, cooperating abutments on said frame and connected to said upper plate for permitting limited angular movement of said upper plate on said manifold pipe away from said lower plate, first carbon rods connected to and extending upwardly from said lower plate, second carbon rods connected to and extending upwardly from said upper plate, said upper plate having a plurality of transverse slots, at least some of said first carbon rods passing through said slots, said first and second rods being staggered, permitting angular movement of said upper plate with respect to said lower plate without interference between said first and second rods, said rods being adapted for connection to a source of electrical potential.

8. Apparatus as defined in claim 7, including a second port in said bushing, said feed conduit including a first distributing pipe between said manifold pipe and one of said electrode plates and a second distributing pipe between said second port in said bushing and the other electrode plate, a port in each of said electrode plates in communication with the respective distributing pipes and discharge ports in each of said electrode plates for discharging electrolyte solution into the space between said plates.

9. Apparatus as defined in claim 2, including a plurality of said first lower plates in longitudinal alignment with each other, a plurality of said second upper plates in longitudinal alignment with each other, insulating members separating said first plates from each other, insulating members separating said second plates from each other, all of said upper electrode plates being connected to said pipe hinge, and means mounting all of said upper plates on said pipe hinge for simultaneous angular movement away from and toward said lower plates.

10. Apparatus as defined in claim 7, including a plurality of said first lower plates in longitudinal alignment with each other, a plurality of said second upper plates in longitudinal alignment with each other, insulating members separating said first plates from each other, insulating members separating said second plates from each other, all of said upper electrode plates being connected to said manifold pipe, and means mounting all of said upper plates for simultaneous angular movement on said manifold pipe away from and toward said lower plates.

11. Apparatus as defined in claim 2, including first ports in said lower and upper electrode plates, means connected to said pipe hinge and to said electrode plates to provide fluid communication between said pipe hinge and said first ports, and discharge ports in said electrode plates in communication with said first ports, for conducting solution into the zone between said lower and upper plates.

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