FIG. 1

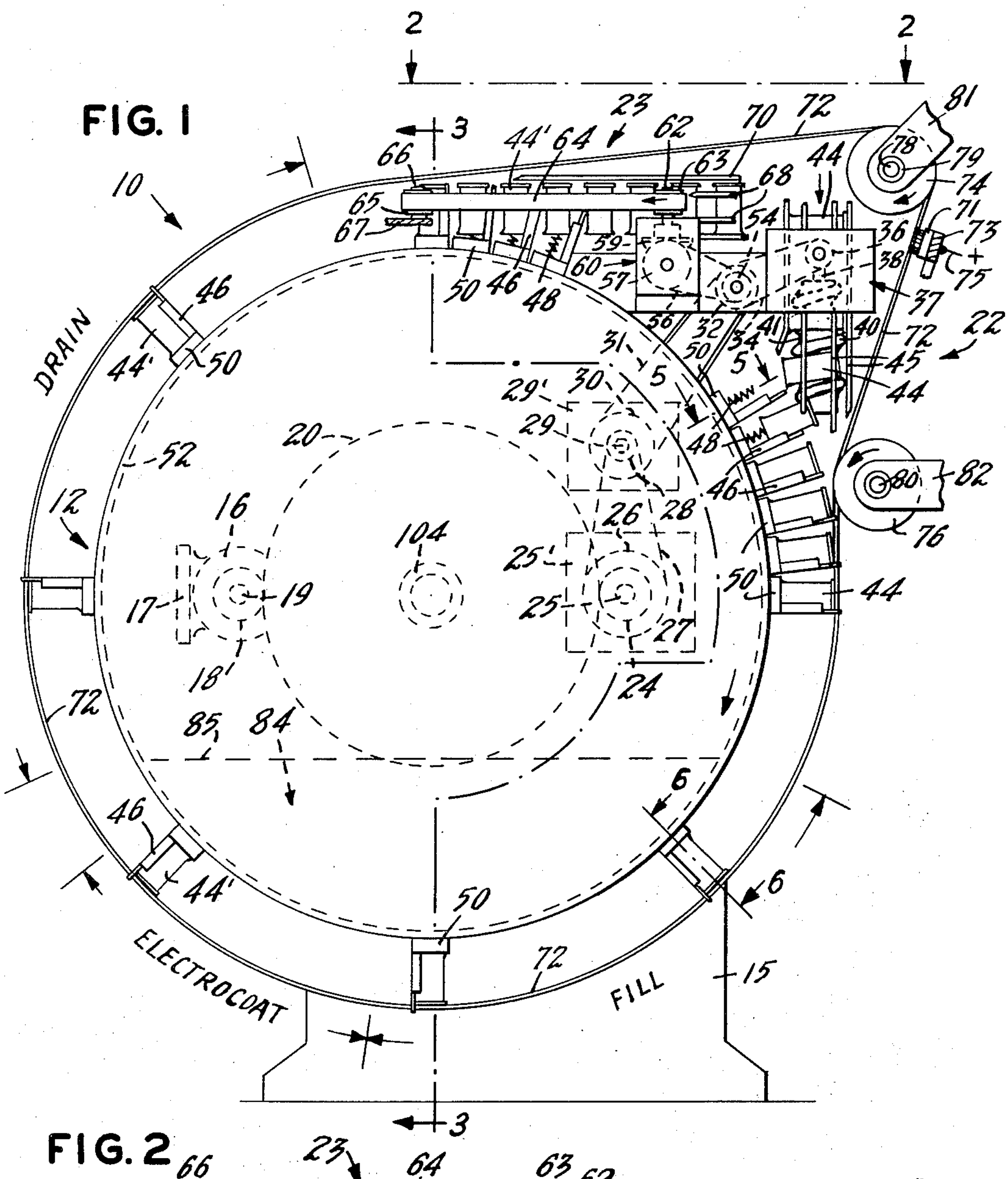


FIG. 2

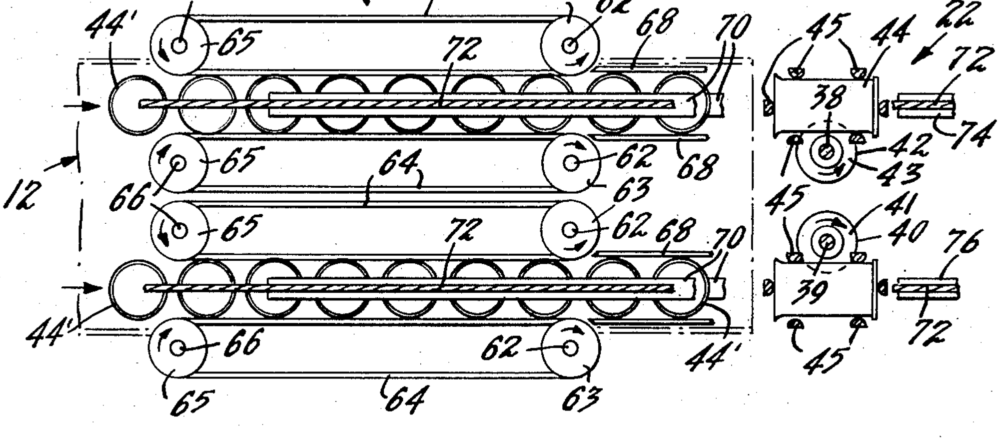
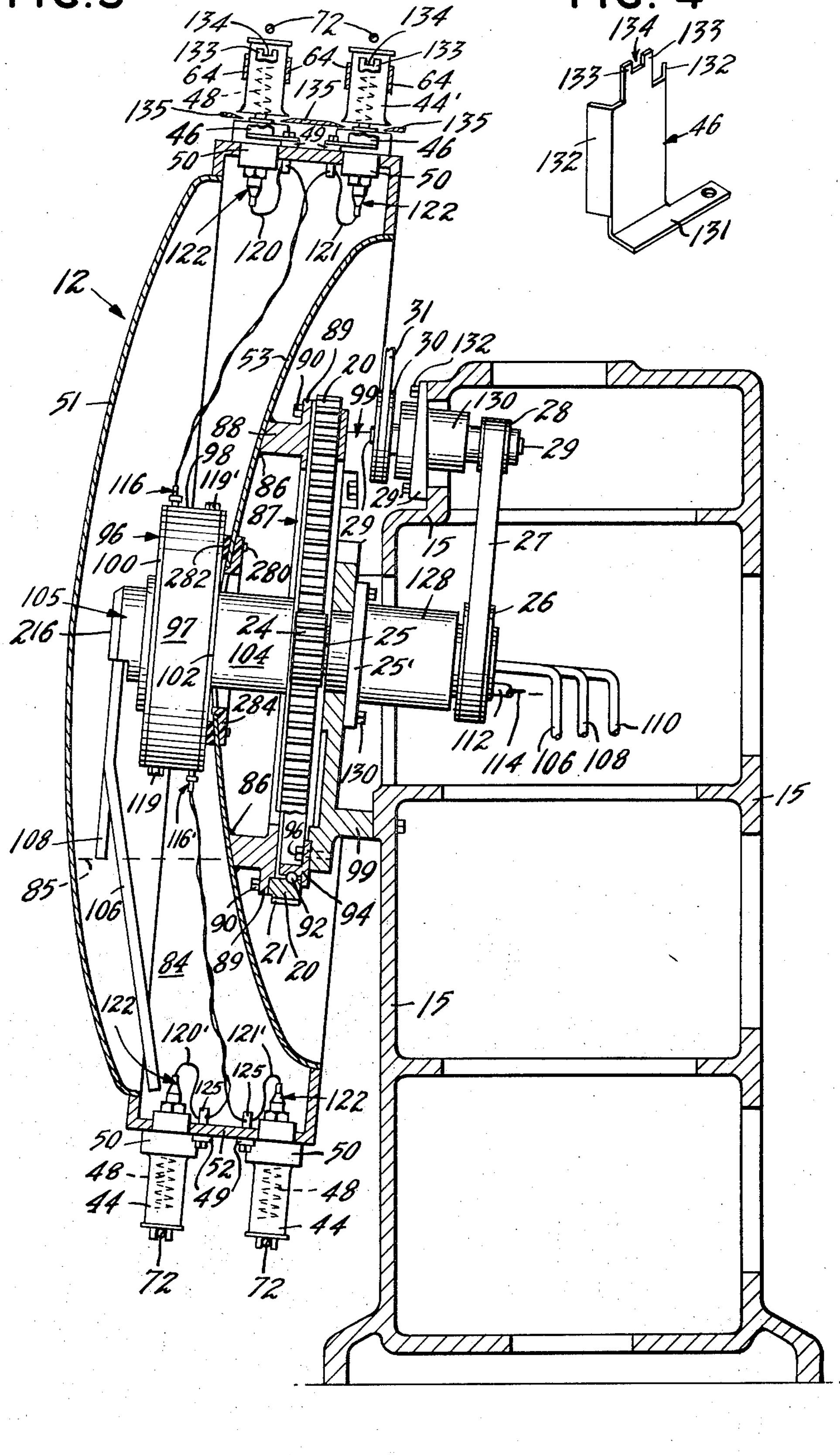


FIG. 3

FIG. 4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72
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133
133
64
64
64
48
44'
135
135
135
46
49
46
50
50
122
122
120
121
12
51
53
89
90
20
31
30
132
99
130
28
29
88
98
86
29'
116
119'
87
29
15
27
96
100
282
280
128
105
26
216
97
24
25
104
25'
102
284
110
112
114
106
108
130
86
119
116'
15
108
96
99
85
94
92
90
106
89
21
20
84
15
122
120'
121'
125
125
122
50
52
50
48
49
48
44
44
72
72
134
133
133
132
46
132
131

FIG. 5

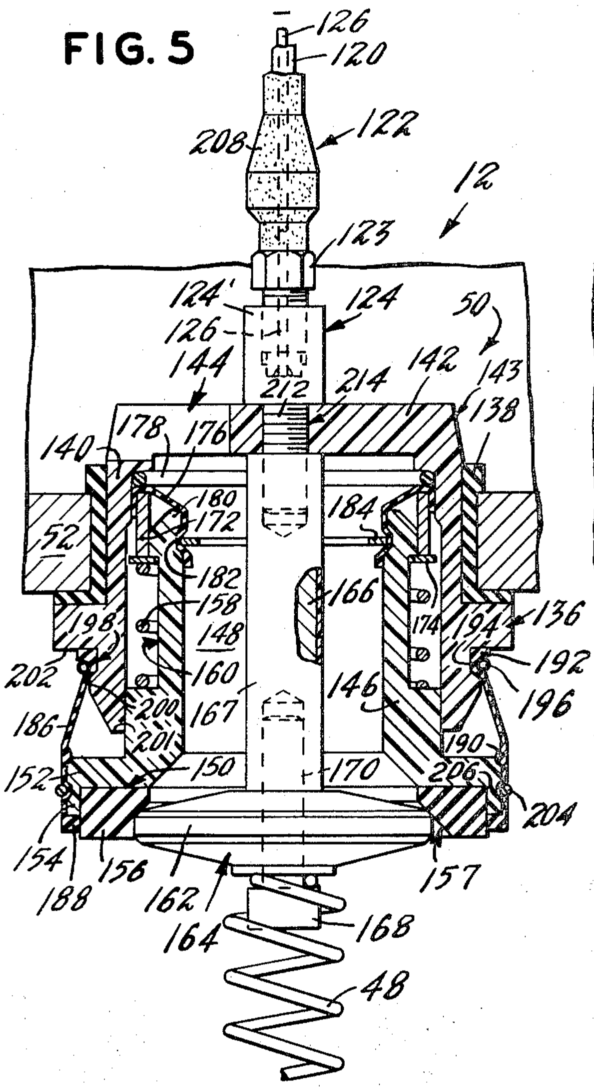


FIG. 6

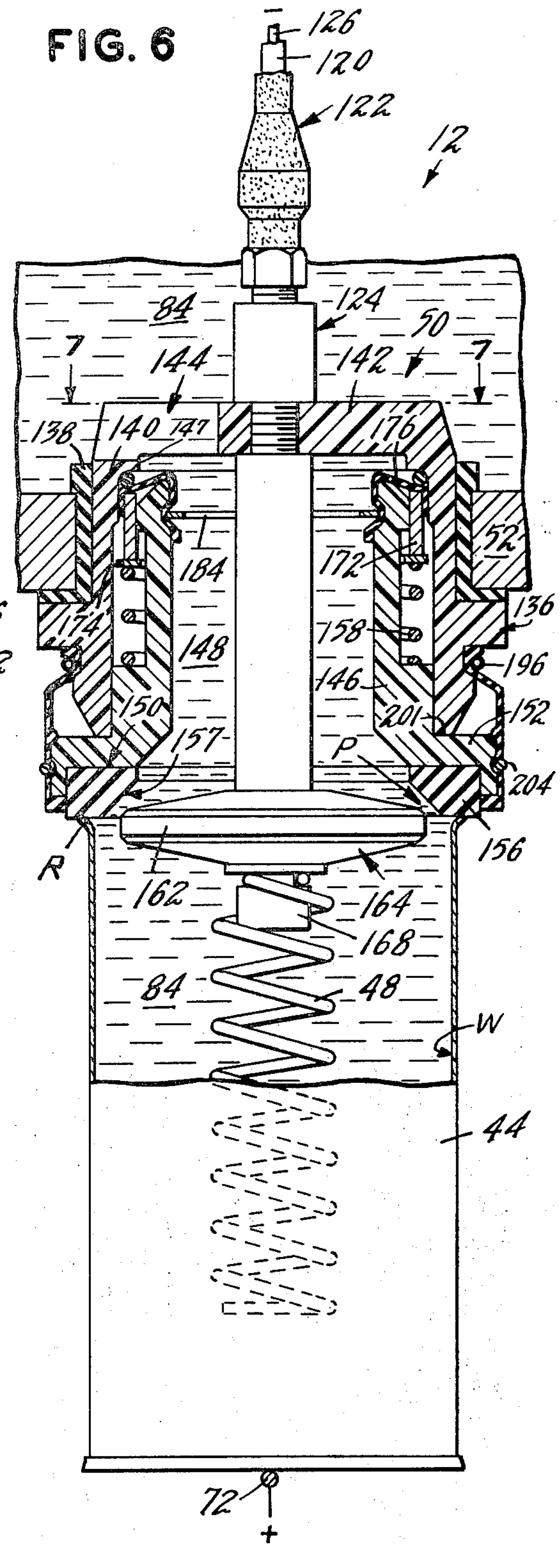


FIG. 7

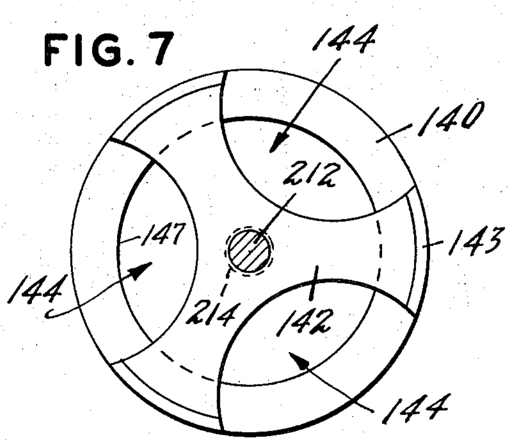
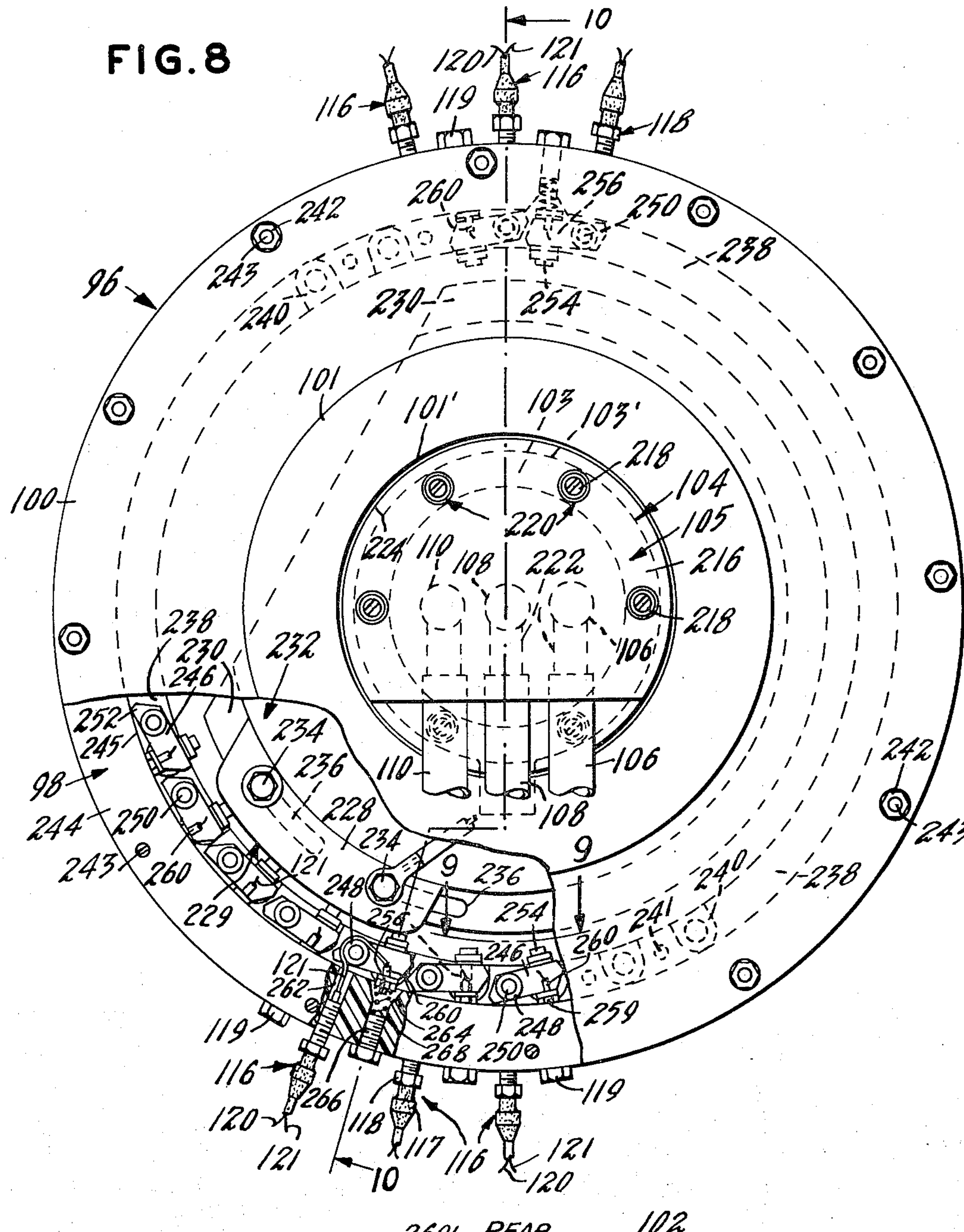


FIG. 8


10
120
121
116
119
118
260
256
250
242
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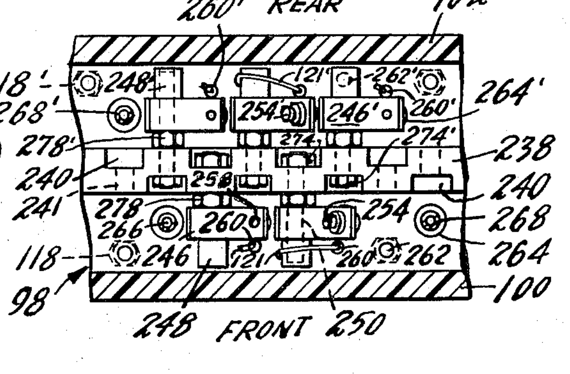
96
238
240
230
254
101
101'
103
103'
218
104
220
105
100
224
110
108
222
216
106
232
234
236
246
252
245
98
244
228
9
121
229
248
262
264
268
266
117
259
241

FIG. 9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REAR
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260'
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278'
274
274'
238
240
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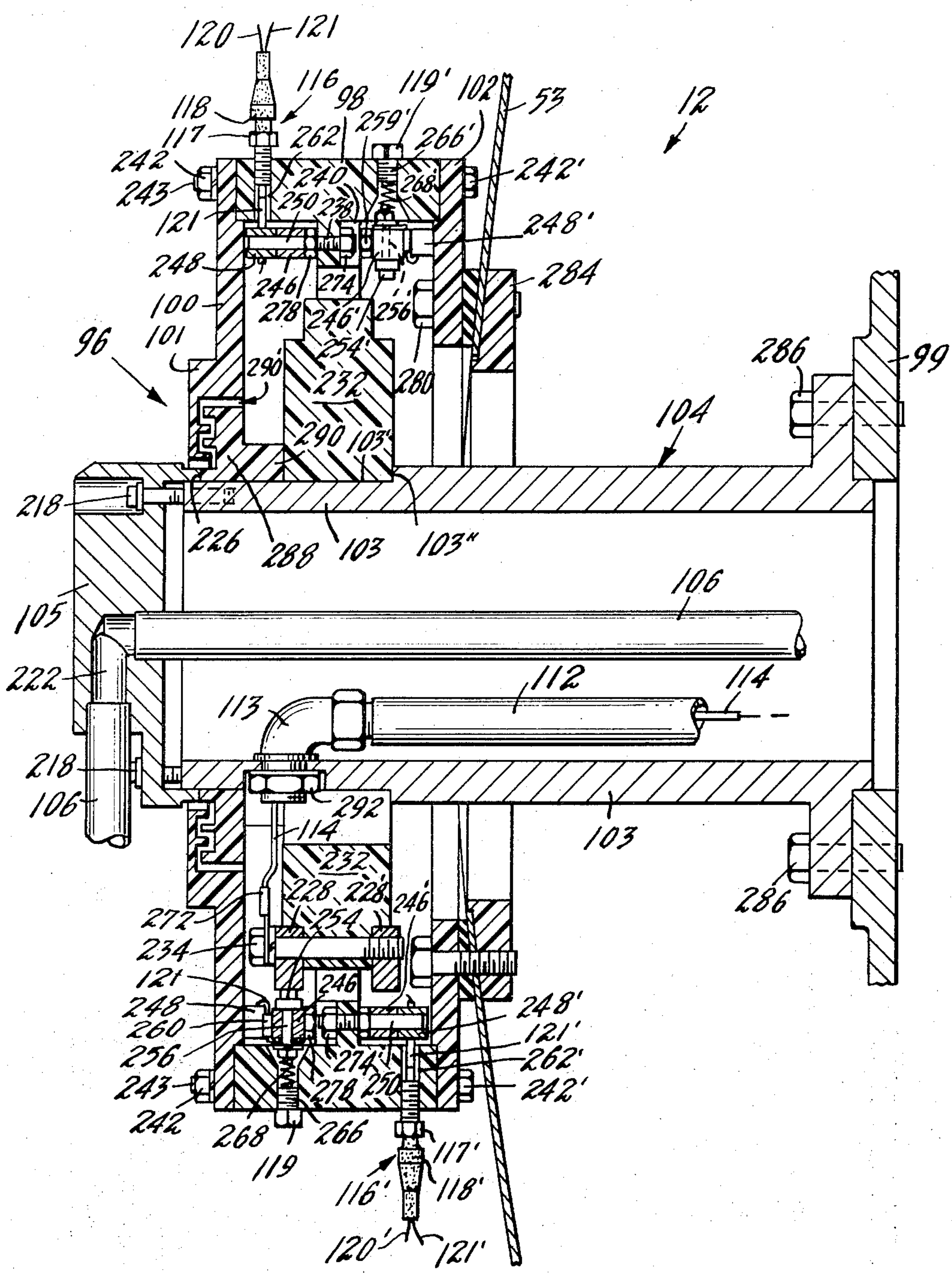
241
278
266
260
254
268
264
246
121
262
98
100
248
FRONT
250

FIG. 10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103'
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103"
106
105
222
112
114
113
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292
103
232
228
228'
246'
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121
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248'
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121'
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262'
243
278
250
242'
242
268
266
119
117'
116'
118'
120'
121'
286

United States Patent Office

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Patented Apr. 2, 1974

3,801,485
APPARATUS AND METHOD FOR ELECTRODEPOSITING A COATING ON INTERIOR SURFACES OF CONTAINER BODIES

Hans Kossmann, Barrington, Ill., assignor to American Can Company, Greenwich, Conn.

Filed Sept. 1, 1972, Ser. No. 285,643
Int. Cl. B01k 5/02; C23b 13/00
U.S. Cl. 204—181 41 Claims

ABSTRACT OF THE DISCLOSURE

An electrocoating system comprises an apparatus, method and valve for electrodepositing a coating on interior electrically-conductive surface areas of container bodies.

Container bodies having an open end are timedly fed onto circumferentially aligned rows of valves on the exterior of a rotating cylindrical drum containing an electrolytic fluid. Continuous anodic cables extend around the drum, exert axial pressure on the bottoms of the containers, render them anodic, sealingly engage their rims on the valves and thereby open the valves to gravity-feed the fluid into the bodies. With fluid therein, current passed through cathodic electrodes projecting from the valve exteriors into the bodies, electrodeposits a coating on the electrically-conductive surface areas of the container bodies. During continued drum rotation, fluid gravity-drains from the coated bodies back into the drum, and the empty, coated bodies are discharged from the system.

BACKGROUND OF THE INVENTION

This invention relates to the field of electrocoating metal substrates. More particularly, the invention relates to an electrocoating system including apparatus, method and valve for electrodepositing a coating on interior electrically-conductive surface areas of metal container bodies.

Basically, electrocoating is the electrodeposition of organic resinous coating materials on electrically-conductive surface areas, from polyelectrolytic electrocoating material mediums which can be anodic or cathodic aqueous or nonaqueous base bath solutions, suspensions or dispersions. The electrocoating mediums ultimately contain coating ions or polyelectrolytic particles, which, in the case of anodic mediums, carry a negative charge in the bath and when a voltage is applied and current is induced to flow through the medium, migrate to and discharge onto any positively charged surface of a metal substrate, i.e., the anode, which may be in contact with the medium. Conversely, the polyelectrolytic particles, in the case of cathodic mediums, carry a positive charge in the medium, and, upon application of a voltage, migrate to and discharge onto any negatively charged surface of a metal substrate, i.e. the cathode, which may be in contact with the medium.

A layer of particulate coating material is electrodeposited adjacent the electrically charged metal substrate as the direct current flows between it and an oppositely electrically charged electrode such as a wire or rod, immersed in the coating bath. The process is driven by an electrical potential which can be in the range of from 1 up to 500 volts, but more typically is from about 20 to 500 volts. The electrodeposition of the coating material takes place only at electrically-conductive surface areas of the metal object because only at such areas is there an electrical circuit and the electrical action which allows the flow of direct current needed to cause the polyelectrolytic particles to be electrodeposited adjacent the electrically-conductive surface.

The thickness of the layer of particulate material electrodeposited is automatically regulated by the characteristically low electrical conductivity of the particular mediums used. Once a certain layer thickness of coating material has attached to the electrically-conductive surface area of the metal substrate, the electrodeposited coating material, in having a low electrical conductivity characteristic, increasingly tends to insulate the surface area from the coating bath in which it is immersed, transforming it into a non-conductive surface, whereby direct current flow therein greatly diminishes and eventually ceases, with the resulting inhibition of further electrodeposition of coating material.

One particular field where it has been found desirable to coat metal substrates is in the manufacturing of metal containers or cans, where it is necessary that all the exposed, uncoated surface areas on the metal can be coated to protect the metal from corrosion.

At present, there is no conventional, commercial apparatus or method of quickly and efficiently electrocoating the interior surfaces of metal can bodies such as used in the packaging of beer or carbonated beverages. Presently, a typical method of perfecting coverage of the coating on the interior of such surfaces to protect them from environmental product attack, is to use a double coat system which involves initially applying a base coat by a roller onto the metal stock while it is in the flat, and, after fabricating the can from the coated stock, spraying a top coat on the interior of the fabricated can or component to seal any scratches, breaks or discontinuities or other electrically porous or conductive areas formed in the base coat during the fabrication operation. The top coat usually is an overall coat since the location of the discontinuities cannot precisely and reliably be ascertained.

While this two coat system has in general been satisfactory, it does have a number of disadvantages, especially in relation to the overall top spray coat. One is that it is relatively difficult to apply an overall top coat at high speeds because of problems usually associated with spraying machines. These include contamination of machine parts due to overspray, the need for frequent clean-ups and adjustments of spray heads, and the need to bake the finished ends to drive off solvents that have to be used to obtain the viscosity requisite for spraying top coat materials. The presence of solvents in the spray coat is problematical because they are dangerous to inhale and handle. They also pollute and require expensive exhaust and other pollution-preventing handling systems.

High speed commercial spray coating machines require deposition of repair coats in 2 seconds or less. At such speeds, spraying often does not obtain satisfactory seals of imperfections because the predetermined amount of material sprayed throughout the interior of the can body often does not provide enough material adjacent a particularly large discontinuity to adequately seal it.

Spraying an overall coat often does not provide uniform coatings since too little solvent results in too little coverage in some areas and lumps or accumulations in other areas, and too much solvent causes dripping, sags and runs.

Spraying is wasteful because coating material is applied to the entire interior surface area rather than limitedly as and where it is needed.

Lastly, spraying an overall top coat causes webbing and frilling about the pouring openings of easy-open can ends, due to the top coat completely covering the base coat and often adhering more strongly to the base coat than the base coat to the can ends, when the score-defined easy-open tear out portions are removed therefrom.

The electrocoating system of this invention solves all of the aforementioned disadvantages and problems and others as well. It is fast enough for commercial high speed operation. It has been used for example to repair coat in 2 seconds or less at rates of 600 cans per minute. There is virtually no contamination of machine parts due to overuse, and there is less need for clean-ups and adjustments.

The system is selective, self-limiting and non-wasteful. It deposits uniform coatings of sufficient quantity to attain satisfactory single and repair coats which do not web and frill.

The system is advantageous because aqueous electrocoating solutions can be employed therewith. These are not dangerous to handle and prevent pollution of the atmosphere by not requiring solvents. Aqueous materials do not require expensive solvent exhaust and handling systems. An added advantage is that the system of this invention can be used in place of four conventional body spray machines.

This system is especially advantageous because it can be used to apply a single full coat which satisfactorily coats the entire interior surface areas of the container bodies, or it can be used to repair or spot coat only imperfections in a previously applied base coat.

Numerous other advantages of the electrocoating system of this invention including apparatus, method and valve will be apparent as it is better understood from the description which follows, which, taken in conjunction with the drawings, discloses preferred embodiments thereof.

SUMMARY OF THE INVENTION

This invention is an electrocoating system including apparatus, method and a valve for electrodepositing a coating on interior electrically-conductive surface areas of container bodies having an open end. The apparatus comprises a rotatable reservoir or drum having a cylindrical wall, for containing an electrolytic fluid; means for rotating the drum; valve means mounted preferably radially in rowed, radially-aligned spaced pairs around the circumference of the cylindrical wall, for passing the fluid to and from the interior thereof, all portions of the valve means in contact with the fluid being non-conductive in relation thereto; an electrode, preferably a helical spring, connected to and projecting radially from the exterior of the valve means; the valve means including: means for carrying electric current therethrough to the electrode, a housing having fixed and moveable portions, the moveable portion having a mouth therein, a valve member fixedly connected to the fixed housing portion, and preferably having a metal core running therethrough, the core being included within the current carrying means, biasing means mounted between the fixed and moveable housing portions, and a resilient sealing ring located on the mouth of the moveable housing portion and moveably biased by the biasing means into sealing engagement with the valve member; means partly mounted on the drum for creating a potential difference between the electrode and the interior conductive surface areas of the container bodies, the aforementioned portion of the potential creating means, preferably being a commutator assembly means mounted interiorly of the drum and including intermediate circuitry connecting it to the current carrying means; and, means for feeding the container bodies onto the valve means so that the bodies are registered thereon, the electrode projects into the interior of the bodies and the rims of the bodies sealingly engage the sealing ring with pressure sufficient to break the sealing ring to create a passageway therebetween which allows the fluid to pass through the valve means and into the container bodies during a portion of the reservoir rotation, so that a potential created electrodeposits a coating on interior electrically-conductive surface areas of the container bodies.

The feeding means can include means, preferably cradles, mounted radially on the cylindrical wall adjacent each valve means for receiving the container bodies from a source and placing the bodies in register onto the sealing rings so that the electrode projects into the interior of the bodies. The feeding means can also include means for holding the can bodies in registered sealing engagement on the sealing ring and for providing pressure sufficient to create a passageway between the valve member and the sealing ring which allows the fluid to pass through the valve means and into the container bodies during a portion of the drum rotation so that the potential created during that portion of rotation electrodeposits a coating on interior electrically-conductive surface areas of the container bodies.

The apparatus can also include means connected to the interior of the drum for, preferably pressuredly, charging, leveling and draining the fluid to, in and from the drum, and it can include means for removing the container bodies from the valve members and from the drum. The removing means can include a knife for separating the rims of the container bodies from the sealing ring of the valve means.

The axis of the drum can be tilted and its non-cyindrical walls arcuate, so that liquid on the drum walls does not accumulate thereon but drains toward the bottom portion of the drum.

The method of the invention comprises rotating, preferably continuously, a reservoir or drum containing an electrolytic fluid and having valve means mounted in the exterior walls thereof, the valve means in turn having an electrode projecting therefrom; feeding, preferably simultaneously, the container bodies onto the valve means so that the bodies are registered on the valve means and the electrode projects into the interior of the container bodies; providing axial pressure against the container bodies, preferably against their exteriormost ends, sufficient to sealingly engage the rims of the can bodies against a portion of the valve means and to open the valve means; passing the fluid from the rotating drum through the open valve means and into the sealingly engaged bodies; creating a potential difference between the electrode and the interior surfaces of the bodies when they contain the fluid; and thereby electrodepositing a coating on the interior electrically-conductive surface areas of the bodies.

The pressure providing step can be maintained throughout a major portion of the drum rotation and the fluid passing step, preferably, is effected by gravity. The method can also include the steps of insulatnig the means for creating the potential and the means for carrying the electric current through the valve means to the electrode, and charging the fluid to the drum and removing the coated container bodies from the valve means and from the reservoir.

The fluid valve of this invention for electrodepositing systems wherein an electrolytic fluid and electric current insulatedly pass through the valve, comprises: a fixed exterior housing mountable on a wall of a reservoir containing the fluid, the exterior housing having a back wall with apertures therein communicating with the interior of the reservoir; a moveable interior housing, interior of and slidingly engaged with the exterior housing, the interior wall of the interior housing defining a central valve chamber and having a mouth opposite the back wall; a resilient sealing ring mounted in the mouth; a valve member fixedly connected at one of its ends to the back wall, extending axially into the chamber and having legs fixed to and extending transverse to its axis, the axial portion of the valve member having a conductive core connectable to circuitry; an electrode, preferably a helical spring, connected to and projecting, preferably radially, from the exterior of the valve member; means for sealing and preventing fluid from passing between the housing; and biasing means, preferably a helical spring extending around and being abuttingly biased against a support wall of the interior housing, for flexibly biasing the sealing ring and the interior housing into sealing engagement with the valve member legs to seal the fluid valve chamber, the biasing means being inwardly compressible towards the back wall by an axial force so that when the force is sufficient to compress the sealing ring and biasing means, a passageway is created between the valve member legs and the sealing ring which allows fluid to flow from the reservoir to the exterior of the valve chamber.

Preferably, all parts of the valve exposable to the fluid excluding the electrode are non-conductive in relation to the fluid. The biasing means can also include a rigid backing ring adjacent the back wall of the exterior housing for backing the spring, and a rigid lock washer mounted between the backing ring and the spring, for backing the spring and acting as a stop against outward movement of the interior housing. The fluid sealing and preventing means can include an annular, flexible, resilient interior sleeve partly within the chamber and sealingly fastened to the interior of the interior housing and the exterior of the exterior housing to prevent fluid from passing therebetween, and an annular, flexible, resilient exterior sleeve sealingly fastened to and for sealing the exteriors of the interior and exterior housings, exterior of the reservoir wall. The fluid sealing and prevention means can further include an annular, elastomeric O-ring between the back wall and an interior sleeve portion that is adjacent the backing ring.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front elevation showing the electrocoating apparatus of this invention.

FIG. 2 is a plan view taken substantially along line 2—2 of FIG. 1.

FIG. 3 is an enlarged vertical section taken substantially along line 3—3 of FIG. 1 showing a portion of the drum and the valves mounted thereon.

FIG. 4 is an enlarged perspective view of one of the cradles mounted on, but shown broken away from, the reservoir of FIG. 3.

FIG. 5 is an enlarged vertical section through a portion of the electrocoating reservoir and through a fluid valve mounted therein before a can body is placed on the valve.

FIG. 6 is an enlarged vertical section similar to that of FIG. 5, showing the fluid valve in an open position and liquid passing from the reservoir into a can body placed on the valve and shown partly broken away.

FIG. 7 is a plan view taken substantially along line 7—7 of FIG. 6 showing apertures in the valve housing wall.

FIG. 8 is a front view of the commutator assembly of FIG. 3 with parts broken away showing some of its mechanisms and electrical circuitry.

FIG. 9 is a top view taken substantially along line 9—9 of FIG. 8.

FIG. 10 is a vertical section taken substantially along line 10—10 of FIG. 8.

DETAILED DESCRIPTION OF THE INVENTION

In a preferred, exemplary embodiment of this invention, FIG. 1 shows an electrocoating or electrodepositing system generally designated **10** comprising a rotatable reservoir or drum **12** rotatably mounted on a main frame **15**. The reservoir (hereinafted drum) is driven by means for rotating the drum which include drive means such as motor **16**, whose flange **17** is mounted to a frame (not shown). Motor **16** drives pinion gear **18** mounted on shaft **19** which drives main ring gear **20** fixed to an interior wall (not shown) of drum **12**. Ring gear **20** in turn drives feeding means generally designated **22** for feeding container or can bodies **44** onto drum **12**, and discharge or take-off means generally designated **23** (hereafter discharge means) for discharging coated container bodies **44'** from drum **12**. "Coated" in this context means full or repair coated by an electrolytic fluid **84** in drum **12** according to this invention. Ring gear **20** drives both feeding means **22** and discharge means **23** by driving pinion gear **24** rotatably mounted on shaft **25**, mounted on flange **25'**, and fixed to pulley **26**. Pulley **26** drives belt **27** which in turn drives pulley **28** rotatably mounted on shaft **29**, mounted on flange **29'**, and fixed to pulley **30**. Pulley **30** drives belt **31** shown connected to pulley **32** which in turn drives belt **34** connected to pulley **36**. Box **37** represents mechanism (not shown) sufficient to transfer the rotary motion of pulley **36** into timed simultaneous rotation of feeding means **22** including shafts **38** (shown) and 39 (FIG. 2) respectively fixedly connected to worm feed screws **40** (shown) and **42** respectively having grooves **41** (shown) and **43** for timedly feeding can bodies **44** to means included within the feeding means such as cradles generally designated **46** for placing the container bodies in register on valve means **50** and on electrodes **48** connected to and projecting from valve means **50** mounted in the exterior, of preferably cylindrical, wall **52** of drum **12**.

Pulley **32**, driven by belt **31** and also fixed to pulley **54** on a shaft (not numbered), drives belt **56** which in turn drives pulley **57** fixed to a set of miter gears **58** (not shown) and **59** connected to other suitable mechanisms in box **60**. The miter gears are connected to other mechanisms (not shown) sufficient to rotate a series of vertical shaft **62** (FIG. 2) fixedly connected to drive pulleys **63**, on which are mounted continuous discharge or take-off belts **64**, also mounted on series of idler pulleys **65** on shafts **66** mounted to a broken away portion of frame **67**. Pairs of discharge belts **64** engage the sides of "coated" can bodies **44'**, lift them from cradles generally designated **46** and transfer them to removal chutes comprised of side discharge guard rails **68** and upper and lower discharge guide rails **70**. Coated can bodies **44'** can be further moved along the guide rails away from eelctrocoating system **10** by any suitable means such as a series of turrets, guide rails and moving belts (not shown) which, for example, could reverse their direction and move them to other stations for further processing.

As motor **16** drives ring gear **20** to continuously rotate drum **12** in a clockwise direction, and as it also simultaneously and timedly drives worm feed screws **40** and **42** to place uncoated can bodies **44** in register on valves **50**, the can bodies are held in register by holding means such as continuous cables **72** (one shown) driven by the rotation of drum **12**. Cable **72** passes over roller **74** mounted on shaft **78** and insulating sleeve **79**, and over roller **76** mounted on shaft **80**, each being respectively rotatably mounted on broken away arms **81** and **82**. Brush **71** on arm **73** (broken away) connected by wire **75** to a negative D.C. source (not shown), engages and thereby imparts an anodic, positive charge to cable **72**. Roller **76** brings cable **72** into engagement with cradles **46** and the bottom ends of uncoated container bodies **44**. This imparts the positive charge to bodies **44**, renders them anodic and pressuredly holds the bodies against valves **50** as drum **12** rotates for a major portion of its 360° of rotation. Cable **72** supplies sufficient axial pressure against bodies **44** that their rims of their open ends abutting above **50** sealingly engage sealing ring **156** (described later) of valve **50**, and the rim pressure opens the valves so that, as substantially hollow drum **12** rotates in a clockwise direction, electrolytic fluid **84** contained therein passes, preferably by gravity, through valve **50** and fills can **44** on the lower portion of drum **12** without leakage of electrolytic fluid **84** from the system. As further explained later, when can bodies **44** are filled with fluid **84**, a potential is created between electrode **48** and interior electrically-conductive surface areas of can bodies **44** so that a coating is electrodeposited on the surfaces. As drum **12** continues to rotate the upper portion of cable **72** separates from coated can bodies **44'** and allows them to be removed from valves **50** and cradles **46** for discharge from the system.

FIG. 2 is an enlarged top view taken along lines 2—2 of FIG. 1 and shows a portion of discharge means **23** of the apparatus of this invention. More particularly, FIG. 2 shows an upper portion of cylindrical drum wall **52** underlying a series of aligned shafts **62** and drive pulleys **63**, and shafts **66** and idler rollers **65**, the former of which are drivingly rotated in such directions that, as shown, the inner portions of upper and lower pairs of discharge belts **64** cooperate to engage the sides of coated can bodies **44'** and thereby particpiate in their removal from sealing rings **156** and electrodes **48** of valves means **50**, and from cradles **46**. Belts **64** also gradually move the cans along a horizontal plane. The rotation of drum **12** cooperates in the removal of electrodes **48** and cradles **46** from the can bodies. As the bodies are so carried along a horizontal plane, they are passed within the confines of pairs of side guide rails **68** (the uppermost one on each side shown) and upper and lower guide rails **70**, which can pass them to other suitable mechanisms such as turrets, belts and other guide rails (not shown) to further remove the coated bodies to other stations for further processing such as baking and filling.

The right-hand portion of FIG. 2 shows the uppermost of can bodies **44** in two respective stacks thereof within guide rails **45**, above their respective worm feed screws **40** (shown in FIG. 1) and **42** respectively having feed grooves **41** and **43** and being mounted on shafts **38** and **39** for synchronously, simultaneously and timedly feeding can bodies **44** onto cradles **46** and valves **50** of rotating drum **12**. Also shown are portions of cables **72** broken away on their respective, also broken away, rollers **74** and **76**.

FIG. 3 is an enlarged section taken substantially along line 3–3 of FIG. 1. More particularly, FIG. 3 shows drum **12** having front convex wall **51**, cylindrical wall **52** and rear concave wall **53**. Valves **50** are mounted on cylindrical wall **52** by insulating mounts, generally designated **49**, which also insulatedly mount cradles **46** (broken away) having at their upper ends, notches **134** between and defined by spaced tines **133**.

Fastened or attached to the rear of concave drum wall **53** as by weld **86** are arms **88** of a spider structure **87** whose flanges **89** have screws **90** passing therethrough and which fasten rear drum wall **53** to main ring gear **20** having peripheral teeth **21**. As motor driven pinion gear **18** (FIG. 1) drivingly rotates main ring gear **20** and drum **12**, the ring gear rotates on friction free ball bearings **92** in grooves within the inside of main gear **20** and within the exterior side of track **94** fixedly attached by screws **96** through its flange to bracket **99** in turn fixedly attached to main frame **15**.

Attached to the interior of rear drum wall **53** by means of bolts **280**, rubber spacers **282** and fastening rings **284**, is a portion of the means for creating a potential between electrodes **48** and interior electrically-conductive surface areas of can bodies **44** mounted on valve **50**. The aforementioned portion of the potential creating means can be a commutator assembly generally designated **96**, having a housing **97** comprised of a cylindrical wall **98** and front and rear walls **100** and **102**. Housing **97** is mounted on wall **53** around hollow support **104** whose axis, it is to be noted, is concentric with that of main ring gear **20** Running through hollow support **104** are means such as pipes **106** for draining, **108** for leveling, and **110** for filling drum **12** with an electrolytic fluid. The pipes extend through hollow support enclosure cap **105** downwardly into the lower portion of drum **12** to or into the upper level of fluid **84** represented by dashed line **85** (pipe **110** not being shown). The rear portions of pipes **106**, **108** and **110** can be connected to suitable means such as pumps for pressuredly or otherwise quickly effecting the draining, leveling and filling actions,

Also extending through hollow support **104** is conduit **112** for carrying wire **114** which can be connected exteriorly of drum **12** to a suitable portion of the potential creating means such as a voltage source (not shown). Conduit **112** carries wire **114** into commutator assembly **96** where it is attached to other portions of the aforementioned means for creating a potential.

As mentioned previously, commutator assembly **96** is affixed to drum **12** and rotates therewith. Connected to commutator assemby exterior cylindrical wall **98** and communicating with a portion of the means for creating a potential within commutator assembly **96** are offset fluid-proof terminals generally designated **116** on the upper, front portion, and **116'** on the lower rear portion of cylindrical wall **98**. Also connected to commutator assembly cylindrical wall **98** are bolts **119'** in the upper rear end, and **119** at the lower front end of wall **98**. Their function will be explained later. Connected to and running from terminals **116** and **116'** is intermediate circuitry comprising respective wires **120** and **121**, and **120'** and **121'** which are part of the potential creating means and which pass through the interior of drum **12**, through apertures in guide mounts **125** and are respectively connected to valves **50** by suitable electrical connecting means such as fluid-proof terminals **122** on the front and rear portions of drum **12**. Wires **120** and **121** and **120'** and **121'** communicate with and are connected to electrodes **48**, as shown later. Guide mounts **125** reduce the slack of the aforementioned wires and prevent them from flopping around in drum **12** as it rotates. Mounts **125** also acts as nuts for insulating mounts **49** on the exterior of cylindrical wall **52**.

FIG. 3 also shows pinion gear **24** fixed to shaft **25** whose central axis, it is to be noted, is offset towards the reader from the axis of hollow support **104**. Shaft **25** runs through bearing **128** attached through its flange by screws **130** to bracket **99**, and it runs through pulley **26** to which it is fixed and drivingly rotates. Pulley **26** drives belt **27** which drives pulley **28** fixedly mounted to shaft **29** running through support bearing **130**. Shaft **29** is fixedly connected to pulley **30** which drives belt **31** shown broken away but connected to other pulleys for driving the feeding and discharge means (FIG. 1). Support bearing **130** is fastened by means of screws **132** through its flange to frame **15**.

It is to be noted that the axis of hollow support **104** and shafts **25** and **29** are not horizontal but are slightly tipped so that drum **12** is angled slightly outwardly from its top to its bottom. Drum **12** is slightly angled in this manner so that no interior wall surface of the drum extends in a horizontal direction. This is to assure that electrolytic fluid on any interior wall surface of drum **12** can run in at least a somewhat downward direction toward the bottom of the drum for draining. This angularity helps to keep the interior surfaces of the drum clean by preventing fluid material or particles from accumulating on interior surfaces of the drum.

The lower portion of drum **12** shows the bottom closed ends of can bodies **44** pressuredly and sealingly engagedly mounted on valves **50**, filled with electrolytic fluid **84** (not shown) and held in such mounted position by holding means such as continuous cables **72** extending substantially around the circumference of cylindrical drum wall **52**. Cables **72** exert axial pressure against the bottom ends of the can bodies. Cables **72** can be prevented from falling off bodies **44** (or **44'**) and can be held in a substantially diametrical position relative thereto by being held in notches **134** between and defined by spaced tines **133** adjacent the ends of cradles **46**.

The upper portion of FIG. 3 shows cables **72** no longer pressuredly engaging the bottom ends of coated can bodies **44'**. It shows separating knives **135** having separated the rims of bodies **44'** from valves **50** so that respective pairs of discharge belts **64** engaging each side of respective bodies 44′ can carry the bodies from the drum in a substantially horizontal plane as drum 12 cooperatively continues to rotate and carry valves 50 and electrodes 48 in a circumferential arc downwardly out of the bodies 44′. Belts 64 carry the bodies to guide rails 68 and 70 (not shown).

FIG. 4 is an enlarged perspective view of one of cradles 46 shown broken away in FIG. 3. More particularly, FIG. 4 shows a cradle generally designated 46 having leg mount 131, arms 132 and spaced tines 133 defining notch 134 into which cable 72 fits during a major portion of the rotation of drum 12. Leg mounts 131 are fastened by bolts of insulating mounts 49 to drum cylindrical wall 52. Arms 132 help receive, register and keep registered bodies 44 on valve means 50, during rotation of drum 12. They also maintain bodies 44′ in position when cables 72 lose contact with the bottoms of bodies 44′ at approximately the 12 o'clock position (FIG. 1).

FIG. 5 is an enlarged section taken substantially along lines 5—5 of FIG. 1. More particularly, FIG. 5 shows valve means such as a fluid valve, generally designated 50, mounted in a wall of a reservoir such as cylindrical wall 52 of reservoir or drum 12, the valve means being shown in its closed position with no fluid in its chamber and no container body on its sealing rim 156.

Fluid valve means 50 is comprised of a fixed exterior housing, generally designated 136, fixedly mounted on cylindrical drum wall 52 by means of a substantially L-shaped sealing gasket 138, the exterior housing having a side wall 140 abutting gasket 138 and having a rigid back wall 142 proximate the interior of drum 12 and having apertures 144 therein (one shown) communicating with a portion of the interior of drum 12 which does not contain any of fluid 84. Fluid valve 50 is also comprised of a moveable interior housing 146 interior of and slidingly engaging exterior housing side wall 140 and defining a central chamber 148. Interior housing 146 has a mouth generally designated 150 and defined by flanges 152 and 154, in which is mounted and seated a resilient sealing ring 156 which is biased by biasing means such as helical spring 158 in cutout portion generally designated 160 in the exterior wall of interior housing 146. The biasing being sufficient to sealingly engage sealing ring 156 against leg 162 of fixed valve member generally designated 164 fixedly connected through current carrying means such as core 166 to back wall 142 adjacent apertures 144 in exterior housing 136. Connected to and extending or projecting from valve member 164 is an electrode such as helical spring 48 connected to head 168 of Phillips screw 170, also part of the current carrying means, threadedly engaged to core 166. Biasing means 158 includes rigid backing ring 172 located adjacent back wall 142, and one or more rigid lock washers 174 mounted between ring 172 and spring 158, for backing and biasing the spring and interior housing 146 outwardly toward and against leg 162 of valve member 164. Both ring 172 and lock washer 174 are located between interior housing 146 and exterior housing side wall 140.

Abuttingly engaged between the interiormost edge of backing ring 172 and an adjacent portion of exterior housing wall 140 is a fluid sealing and preventing means which includes a flexible and resilient annular interior sleeve 176 and an annular elastomeric O-ring 178 for sealing and preventing fluid from chamber 148 from passing between interior and exterior housings 146 and 136. Interior sleeve 176 extends between annular O-ring 178 and backing ring 172, around the interiormost edge 180 of interior housing 146 and is abuttingly engaged and compressedly fastened within an annular groove 182 in the interior wall of interior housing 146 defining chamber 148, by means of one or more rigid lock washers 184 (one shown) which peripherally forces adjacent portion of interior sleeve 176 into annular groove 182.

Also included as part of the fluid sealing and preventing means is a resilient flexible annular exterior sleeve

186, having flange 188 engagingly extending around interior housing flange 154 and abuttingly engaging sealing ring 156. Exterior sleeve 186 has an interior annular bead 190 abuttingly engaging the corner of interior housing flanges 152 and 154. Exterior sleeve 186 has at its interiormost end an integral, annular, exterior bead 192 defining an adjacent annular sleeve groove 194 within which an annular coiled garter spring 196 sealingly holds exterior sleeve 186 within annular exterior housing groove 198 formed by annular exterior housing bead 200 and flange wall 202. Exterior sleeve 186 is sealingly fastened to interior housing flange 154 by means such as annular steel wire 204 which sealingly holds a portion of the exterior sleeve within annular groove 206 in the exterior of interior housing flange 154.

The upper portion of FIG. 5 shows conductive metal wire portion 126 of an insulated wire such as designated 120 (or 120′, 121 or 121′) (FIG. 3), descending through terminal generally designated 122 and comprised of a connecting screw plug 123 having a non-conductive fluid-proof plastic or other suitable tube-shield 208 thereover. Plug 123 is threadedly engaged within the head of connecting screw jack 124 having a threaded shaft 212 threadedly engaged within bore 214 of exterior housing backwall 142 and within core 166 of valve member 164. Wire 120 runs through the center of plug 123 and extends down to and contacts a portion of jack head 124′. Plug 123 can be fastened to connector screw jack 124 or valve means 50 in any conventional manner that will provide a fluid-tight seal and will allow plug 123 to be screwed into jack 124 without unduly twisting the conductive metal wire portion 126.

FIG. 5 shows electrical circuitry that is part of the potential creating means of this invention. The circuitry includes conductive wire portion 126 of wire 120, terminal 122, solid metal core 166, Phillips screw 170, head 168, and helical spring electrode 48. Solid metal core 166 has a non-conductive moisture-proof polyolefin shield 167 thereround. Valve member legs 162 can be steel and also so covered with a similar material or it can be solid plastic.

It is to be noted that all portions of fluid valve means 50 which are or might be exposed to electrolytic fluid 84, excluding electrode 48, are made of, covered with or otherwise isolated from the current carrying means by, a suitable non-conductive material. For example, the housings can be manufactured of a commercially available rigid, moisture-proof, non-conductive material that will not gall with each other, such as an acetal resin sold under the trade designation "Delrin," a trademark owned by E. I. du Pont de Nemours & Co. Inc., for the interior housing, and a commercially available polycarbonate thermoplastic for the exterior housing. Annular sealing ring 156, can be made of an elastomer such as isoprene, and O-ring 178 and interior and exterior sleeves 176 and 186 of a suitable non-conductive flexible resilient non-permeable, fluid-sealing elastomer such as a neoprene. The only metal parts employed interior of exterior housing 136, i.e., spring 158, backing ring 172, and lock washers 174 and 184, are effectively non-conductively isolated from electrode 48 or from any fluid 84 in or flowing through chamber 148. The current carrying portions of fluid valve means 50, e.g., solid metal core 166 preferably is made of steel and is effectively non-conductively isolated from contact with electrolytic fluid 84 and will therefore not have a build-up of particles thereon which would require maintenance, clean-up and possible inefficient operation of the valve means.

FIG. 6 is an enlarged cross section taken substantially along line 6—6 of FIG. 1. More particularly, a fluid valve means 50 similar to that in FIG. 5 is shown in an open position. With sufficient axial pressure exerted by cable 72 against the bottom of container 44, its rim R is pressuredly sealingly engages sealing ring 156 and pushes interior housing **146** inwardly against the bias of spring **158**, such that interior housing flange wall **152** abuts exterior housing lip **201** and the interiormost edge of interior housing **146** flexes interior sleeve **176** inwardly towards aperture **144** of back wall **142**. As interior housing **146** is so moved inwardly and as sealing ring **156** about valve mouth **150** is also moved inwardly, its interior angular wall **157** is moved inwardly away from leg **162** of valve member **164** to break its sealing engagement therewith and thereby create a passageway P between sealing ring **156** and leg **162** which allows electrolytic fluid **84**, which had been in the bottom of drum **12** and within valve chamber **148**, to gravity-pass downwardly through passageway P and fill container body **44**.

As will be explained in detail in relation to FIG. 8, during a portion of the rotation of drum **12** when electrolytic fluid **84** is within container body **44**, a potential difference is created between spring electrode **48** and interior electrically-conductive surface areas of walls W of container body **44**. Due to the potential created, electric current flows through the circuit comprising the electrode, the fluid and the metal conductive body surface areas. Coating particles are thereby deposited on the surface areas to fully coat their entirety or to repair coat discontinuities in a base coat thereon.

FIG. 7 is a plan view taken substantially along line **7—7** of FIG. 6 and shows an upper portion of exterior housing back wall **142** having a bevelled edge **143**, and having apertures **144** in the wall defined by arcuate walls and in part by wall **147** of exterior housing **136**. FIG. 7 also shows a cross section through the threaded, shaft portion **212** of connector screw jack **124** threadedly fastened within bore **214** to back wall **142**.

FIG. 8 is a front elevation taken from the inside of drum **12** just interior of front wall **51** in FIG. 3. FIG. 8 shows front wall **216** of enclosure cap **105** having ports **222** and bolts **218** in holes **220** for securing enclosure cap **105** to wall **103** of hollow support **104**. Wall **103** has a stepped surface **103'** therein. Enclosure cap ports **222** join and house pipes **106, 108** and **110** entering from hollow support **104**, and their broken away portions descending therefrom towards the bottom of drum **12** (not shown).

FIG. 8 also shows front wall **100** of commutator assembly **96** having a protruding stepped portion **101** whose lowermost surface **101'** of its lowermost flange is just above cylindrical surface **224** of enclosure cap **105**.

The lower, broken away portion of commutator assembly **96** shows mounted within drum **12**, a portion of the potential creating means of this invention. It is to be noted that commutator assembly **96** of FIG. 3 should be considered as divided transversely in half, and that the largest broken away portion of FIG. 8 shows a portion of the front half of the commutator assembly (see FIG. 9). The dashed upper portion of FIG. 8 is also the front portion of the assembly interior of housing wall **100**.

The large broken away portion of FIG. 8 shows electrical cam bar **228** fastened to crib **230** of cam support **232** by means of bolts **234** whose threaded shafts pass through apertures **236** and are threadedly engaged to cam bar **228'** in the rear portion (not shown) of commutator assembly **96**.

It is also to be noted that cam support **232** on which is mounted cam bar **228**, is fixedly mounted upon fixed hollow support **104** which is in turn fixed to bracket **99**. Commutator assembly housing **97** (FIG. 3) including its exterior front wall **100**, protruding stepped portion **101** cylindrical wall **98** and cylindrical wall rib **238**, and all of the structure shown mounted on wall **98** and its rib **238** peripheral to or below cam bar **228**, rotate around the aforementioned fixed structures **232, 228** and **104**.

Cylindrical wall **98** has U-shaped cut-outs **240** in its rib **238** and is fastened to the periphery of housing wall **100** by means of nuts **242** being threadedly fastened to shafts **243**. Wall surface **244** of cylindrical wall **98** abutting the interior of wall **100** shows shaft **243** in section. Spacers **248** are mounted on shafts **250**. Pivot arms **246** are rotatably mounted on shafts **250** (front ends shown) which pass within bores **241** in rib **238** of cylindrical wall **98**. Pivot arms **246** have stop portions **252** which limit their rotation by abutting interior wall surface **245** of cylindrical wall **98**. Pivot arms **246** also have electrical contacts which can be carbon brushes or studs **254** mounted therein by their shafts **256** (FIG. 10) passing through arm bores **258** (FIG. 10) and being threadedly engaged by nuts **259** (FIG. 10). Secured to shafts **256** between nuts **259** and the bottom surfaces of pivot arms **246** are electrical connecting lugs **260** having wires **121** therein which extend over spacers **248**, down through holes **262** extending radially through cylindrical wall **98**, through terminals **116** and through the interior of drum **12** to terminals **122** of valves **50**. Each wire **121** is joined as by splicing to another wire **120** and each wire **120** and **121** extends fairly tautly within drum **12** to cylindrical wall **52** thereof, where they are electrically connected to valves **50**, as shown in FIG. 3.

FIG. 8 also shows a more deeply broken away portion of cylindrical wall **98** directly underlying contacts **254**. FIG. 8 there shows a substantially Y-shaped bore **264** in wall **98** having threadedly secured to its lower portion a threaded stud shaft **266** of a bolt **119**, the end of which provides a backing for biasing means, such as helical spring **268**, which abuttingly engages contact shaft **256** and nut **259** on the lower end of contact **254** and thereby normally biases contact **254** in its uppermost position. Contacts **254** remain in this position throughout most of the rotation of cylindrical wall **98**, commutator assembly **96**, and drum **12**, i.e. except for the period of rotation during which the contacts engage arcuately shaped surface **229** of cam bar **228**. As contacts **254** are rotated clockwise and are passed upwardly to the left around and against electrical cam bar **228**, they are moved downwardly on pivot arms **246** against the bias of springs **268**.

Although FIG. 8 only shows a few of the contacts, rocker-arms, spacers, terminals, etc., it is to be understood that such mechanisms are located all the way around the periphery of cylindrical wall **98** of commutator assembly **96**.

As mentioned previously, it is to be noted that commutator assembly **96** should be considered as having two halves and that the broken away portions of FIG. 8 show only the front portion of the front half of the commutator assembly. This can be more clearly seen in FIG. 9 which is an enlarged top view taken in section through lines **9—9** of FIG. 8. The lower portion of FIG. 9 is the front of commutator assembly **96**. If one considered front commutator assembly wall **100** removed from FIG. 9, the front of FIG. 9 would then show the largest cut away portion of FIG. 8.

Shown in FIG. 9 are pivot arms **246** having contacts **254** whose shafts **256** (not shown) are mounted in bores **258** therein and secured thereto by nuts **259** (not shown) which also secure electrical connecting lugs **260** to pivot arms **246**. Pivot arms **246** are mounted on shafts **250** passing through and mounted in cylindrical wall rib **238** by means of nuts **274** within U-shaped grooves **240**, being threadedly engaged to shafts **250**. Shafts **250** pass through bores **241** in rib **238** and have integral nut-shaped flanges **278** acting as spacers between rib **238** and pivot arms **246**. Shafts **250** also have mounted thereon spacers **248** which cooperate with flange spacers **278** to maintain pivot arms **246** in an aligned position so that the rotary path of commutator assembly's cylindrical wall **98** will bring contacts **254** into aligned contact with cam bar **228**. FIG. 9 shows wire **121**, crimped to and running from connecting lug **260**, passing over spacer **248** down through hole **262** (dotted circles under spacers **248**) in cylindrical wall **98** and down through terminal **116** (not shown) whose connecting screw jack **118** (not shown) is mounted in the bottom of cylindrical wall 98. Also shown in FIG. 9 are Y-shaped bores 264, under contacts 254 (here removed), the bores having springs 268 mounted therein and biased upwardly towards the reader by bolt stud shaft 266.

The rear portion of FIG. 9 is a duplication of the structure just described for the front portion of FIG. 9, except that the rear structures, it is to be noted, are given primed numerical designations and they are offset from the structures in the front.

FIG. 10 is a cross section taken substantially along line 10—10 through commutator assembly 96 of FIG. 8. More particularly, FIG. 10 shows, mounted within drum 12 on rear wall 53 by means of bolts 280, spacers 282 and ring 284, commutator assembly 96 having rear wall 102 secured to rear drum wall 53 and front wall 100, and, fixed therebetween, cylindrical wall 98. The upper portion of FIG. 10 shows rib 238 of cylindrical wall 98 having shaft 250 extending therethrough and being secured to rib 238 by means of nut 274 in U-shaped groove 240. Shaft 250 has integral flange spacer 278 between pivot arm 246 and rib 238. Wire 121 is shown passing from within commutator assembly 96 through bore 262, terminal connecting screw jack 118, and connecting screw plug 117, where it is joined by wire 120, both wires passing to valves on cylindrical drum wall 52 (not shown).

That portion of cylindrical wall 98 and commutator assembly 96 shown to the right of rib 238, which in FIGS. 8 and 9 has been called the rear of the commutator assembly, shows contact 254′ mounted on shaft 256′ and secured to rocker arm 246′ by nut 259′. Contact 254′ is biased in a downward direction by spring 268′ and by threaded stud shaft 266′ of bolt 119′.

The lower portion of FIG. 10 shows front cam bar 228 and rear cam bar 228′ secured to cam support ring 232 by means of bolt 234 passing within apertures 236 (not shown) and being threadedly engaged to cam bar 228′. FIG. 10 shows contact 254 mounted on rocker arm 246 and being biased against and contacting cam bar 228 to thereby close a circuit which allows electrodepositing current to flow from a voltage source (not shown) through wire 114 in conduit 112, connecting lug 272, bolt 234, cam bar 228, contact 254, shaft 256 connecting lug 260, wire 121, which passes over spacer 248 and passes down through offset front structure not shown, i.e. bore 262 and terminal 116 comprising connector screw jack 118 and connector screw plug 117 (such as shown in FIG. 8). At the interior of terminal 116, as in FIG. 8, wire 121 is joined by wire 120 and both wires run as part of intermediate circuitry to valves 50 on the lower portion of drum 12 (not shown). The aforementioned structure not shown in FIG. 10 but shown in FIG. 8, is the same as the structure through which wire 121′ passes at the lower rear of FIG. 10.

Commutator assembly 96 and all of its housing walls 100, 98 and 102 (affixed to rear drum wall) rotate with drum 12 around fixed hollow support 104 secured through its flanges to frame bracket 99 by bolts 286. Commutator assembly 96 rotates around cam support ring 232 fixedly mounted on hollow support 104 by enclosure cap 105 being bolted by bolts 218 to hollow support wall 103 and whose recessed flange surface 226 abuts spacer 288 whose hub 290 abuttingly and fixedly engages cam support ring 232 against wall stepped surface 103″.

FIG. 10 also shows that the lower interior surfaces of protruding stepped front wall 101 has flange rings (unnumbered) which cooperate with grooves and opposing flange rings in spacer 288 to form a labyrinth seal for preventing fluid within drum 12 from passing through channel 290′ and splashing into commutator assembly 96. FIG. 10 also shows drain pipe 106 (broken away) passing through hollow support 104 and through port 222 downwardly into drum 12. Conduit 112 passing through the interior of hollow support 104 has an elbow 113 and is secured to support 104 by nut 292 engaging flanges of support 104.

As shown in FIG. 9, contacts 254 and 254′ are staggered, each separately sending current through wires 121 and 121′ respectively staggered terminals 116 and 116′, and joining wires 120 and 120′, each of which wires 120 and 121 goes to one of an aligned pair of valves 50 and wires 121 and 121′ to the next aligned pair of valves 50 on cylindrical wall 52 of drum 12. This staggered arrangement of contacts 254 and 254′ means that as a front contact 254 engages cam bar 288, one will leave 288, during which time the number of rear contacts 254′ does not change. This keeps the current load fairly constant by not making more simultaneous contacts and therefore larger current demands.

The electrocoating system of this invention for electrodepositing a coating on interior electrically-conductive surface areas of container bodies, can be operated by a method which comprises starting the means for rotating the reservoir, i.e., the drive means which includes the motor 16, which in turn drives pinion gear 18 in a counterclockwise direction. This drives main ring gear 20 and reservoir or drum 12 attached thereto, in a clockwise direction. Main ring gear 20 in turn drives pinion gear 24 and the aforementioned series of belts and pulleys which in turn ultimately drive feeding means 22 for feeding can bodies 44 onto rotating drum 12, and also drive take-off or discharge means 23 for taking the coated can bodies 44′ off of drum 12 and discharging them from the system for further processing at other stations.

In the preferred embodiment shown in the drawings, a plurality of uncoated can bodies 44 from a source are individually passed through guide rails 45 defining two stacks, the lowermost can body 44 of each stack being taken within respective grooves 41 and 43 of respective worm feed screws 40 (FIG. 1) and 42 (FIG. 2), which, as they rotate, simultaneously, synchronously and timedly feed their respective can bodies onto each cradle 46 of a pair from a radially-aligned continuous series of such pairs mountedly aligned in two rows around the circumference of synchronously rotating drum 12. Uncoated can bodies 44 are passed from worm feed grooves 41 onto cradles 46 when the cradles are at an angle which allows the can bodies to slide down the cradles and over electrodes 48 protruding from each valve 50 mounted in the drum. Thus, worm feed screws 40 and 42 cooperate with cradles 46 to feed uncoated can bodies 44 in register onto valve means 50.

As drum 12 continues to rotate in a clockwise direction, the rims of each row of uncoated can bodies 44 restingly registered on valves 50 are diametrically, pressuredly engaged by continuous cables 72 driven by drum 12 to rotate in a clockwise direction over rollers 74 and 76. The tautness of cables 72 caused by the passage of cables 72 over the rollers maintains the diametrical pressured engagement with the bottoms of the can bodies throughout rotation of drum 12 until the coated can bodies 44′, are taken off drum 12. As shown in FIG. 3, cables 72 are aligned with and are positioned within cradle notches 134 of spaced tines 133 so that the cables remain aligned in diametrical position in relation to the can bodies throughout the rotation of the drum. Cables 72 provide sufficient axial pressure on the bottoms of the can bodies to sealingly engage their rims against sealing rings 156 in mouths 150 of valves 50, and to depress or move interior valve housings 146 inwardly against the bias of their springs 158 to create passageways P between valve member legs 162 and sealing rings 156. Cables 72 are taut enough to maintain this pressure and to maintain passageways P from approximately the three o'clock to approximately the twelve o'clock rotational position of drum 12 (FIG. 1).

When the uncoated bodies 44 are sealingly engaged against valves 50 and a passageway has been created leading from drum 12 to the interiors of the bodies, drum 12 continues to rotate. As can bodies 44 on open valves 50 are rotated downwardly, electrolytic fluid 84 within drum 12 gravity-passes through pasageways P into the interiors of bodies 44. Flud 84 gravity remains therein during drum rotation from about the four o'clock to about the eight o'clock rotation position during which time the electrodeposition process takes place when contacts 254 and 254' engage cam bars 288 and 288'. Fluid 84 in now coated bodies 44' gravity-passes therefrom through passageway P and drains back into drum 12. Fluid 84 continues to drain therefrom as the coated bodies 44' continue to be rotated from about the aforementioned eight o'clock position to about the eleven or twelve o'clock positin, where coated bdies 44' are remved from the drum. position, where coated bodies 44' are removed from the drum.

Before uncoated can bodies 44 on open valves 50 adjacent the three o'clock position are rotated downwardly to a position where fluid 84 begins to pass into the can bodies, a voltage is created in the potential creating means, e.g., in a power supply (not shown) sufficient to pass requisite current through wire 114 in conduit 112 of hollow support 104, the electrical circuitry of commutator 96, wires 120, 120' and 121, 121', and through valve members 164 of valves 50 to spring electrodes 48.

In the preferred embodiments shown in the drawings, electrode 48 is cathodic, and, current created therein and transferred to electrolytic fluid or coating medium 84 causes coating ions or polyelectrolytic particles therein and carrying a negative charge to migrate to and discharge onto interior electrically conductive, here positively, charged surface areas of the anodic metal can bodies. This electrodeposition or electrocoating process takes place during the time that contacts 254 and 254' engage cam bars 288 and 288', generally between about the six and nine o'clock rotational positions of drum 12, as shown in the broken away portion of FIG. 8. The length of time of electrodeposition can be varied by varying the length of the cam bars.

Coated can bodies 44' are held onto drum 12 by cables 72 until about the twelve o'clock position where the cables angle off the path of rotation of drum 12, and, as they leave the can bodies, the bodies are grasped between pairs of take-off or discharge belts 64 in a manner that allows the can bodies to be lifted from cradles 46 and from electrodes 48 without the electrodes contacting interior surfaces of the bodies or cradles 46 touching previous removed cans. Both front and rear-take off or discharge means 23 are driven by main ring gear 20 and by various belts and pulleys and they are simultaneously operated in timed, synchronous relationship with the rotation of drum 12 and with feeding means 22.

The reservoir or drum 12 of this invention can be of any suitable size or shaped and can be of any suitable material. Preferably, the reservoir is drum-like and has a cylindrical wall. When the drum is made of stainless steel or another conductive material, it is advantageous to coat the interior of the drum with a suitable material such as a conventional asphalt-epoxy coating (discussed later), that will prevent coating ions or electrolytic particles from depositing upon and accumulating upon the interior walls of the drum.

Fluid valve means 50 can be mounted in drum 12 in any suitable number, order, or arrangement, although it has been found advantageous to mount them in one or more and preferably a plurality of rows of radially aligned pairs. All parts of valve means 50 exposed to electrolytic fluid 84 are non-conductive in relation to fluid 84. They are isolated from electric current so that all exposed parts and movable parts are not subject to an accumulation or build-up of coating ions or electrolytic particles thereon. For example, conductive parts such as spring 158 and backing ring 172 are isolated from fluid 84 by interior housing 146, and stainless steel core 166 of valve 50 is insulated from fluid 84 by non-conductive thermoplastic insulative coatings such as 167 on valve member core 166.

Electrodes 48 preferably are helical springs for preventing can jam up on sealing rings 156 of valves 50. However, the electrodes can be of any suitable conductive material or design sufficient to deposit the requisite amount of coating ions or electrolytic particles on all interior electrically conductive surfaces areas of can body walls W. The electrode can be of any size or shape sufficient to allow the registered feeding of uncoated can bodies 44 thereover and the systematic continuous take-off of can bodies 44' therefrom without the electrodes touching or otherwise preventing the take-off and discharge from the electrocoating system.

Cradles 46 can be of any suitable shape and can be of any suitable conductive or non-conductive materials. However it is advantageous that the cradle be conductive when the means for holding the uncoated can bodies 44 on valves 50 has and imparts a positive charge such as cables 72 so that cradles 46 aid in passing this positive charge to the can bodies 44. When cradles 46 are conductive it is advantageous to mount them on non-conductive mounts to insulate a conductive, e.g., steel drum therefrom.

Feeding means generally designated 22 can include any suitable means for feeding can bodies 44 in timed, simultaneous synchronous registered fashion in relation to the rotation of drum 12 so that the bodies are deposited in cradles 46 and are mounted on electrodes 48 and registered on sealing rings 156 of valves 50. The feeding means includes cradles 46 or other suitable means for registering the can bodies on the sealing ring of valve means 50. Feeding means 22 also includes any suitable means such as continuous cables 72 for holding the bodies in registered sealing engagement on sealing rings 156 and for providing pressure sufficient to create passageways P between valve member legs 162 and sealing rings 156.

This invention is suitable for use with can bodies having either one or two open ends. However, when the bodies have two open ends, the holding means can include means for sealing the exteriormost open end of such bodies to retain the electrolytic fluid 84 therein during the electrocoating depositing process.

Take-off or discharge means 23 can include any suitable means such as knives 135 for separating the rims of the coated can bodies 44' from the valve means 50, and can include any suitable means for removing the coated can bodies 44' from radially protruding electrodes 48 and cradles 46 without electrodes 48 contacting the can bodies or either structure interfering with their removal. Discharge means 23 can also include any suitable means such as guide rails or conveyors for transferring the removed can bodies from the system to another loaction for further processing.

Container bodies suitable for having coating ions or electrolytic particles deposited upon their interior electrically-conductive surface areas, can be any can body made of conventional materials such as aluminium, tinplate, tin-free steel (TFS), or black plate. The container bodies coated according to this invention can be 2-piece bodies for making 3-piece cans, or 1-piece bodies for making 2-piece cans. The container bodies can have two open ends but preferably they only have one open end. The two-piece bodies for coating can have any conventional side seam construction, and the one-piece cans for coating can be drawn and ironed or impact-extruded.

As mentioned previously, can bodies 44, herebefore designated "uncoated" has been meant to include container bodies which do not have and are intended to receive a full single coat, or cans which have a base coat which requires a repair coat.

The means for creating a potential between electrodes 48 and can bodies 44 can include any conventional power source. It has been found advantageous to employ a standard, conventional, low ripple, constant voltage source such as that designated Model No. SCR-500, manufactured by Electronic Measurements Inc.

The amount of voltage employed to electrodeposit a single or repair coat from an organic polyelectrolytic medium can be any sufficient amount depending on the circumstances, preferably the least amount that will give a satisfactory single or repair coat in the time desired for the particular metal substrate and electrocoating medium employed. Typical voltages generally utilized in electrocoating processes are in the range of about 50–500 volts, more commonly from about 100–400 volts.

The polyelectrolytic electrocoating material mediums which can be employed in the electrocoating system of this invention can be any of the organic resin-containing materials utilizable as electrocoating concentrates or baths in metal electrocoating systems. The mediums can be aqueous or non-aqueous, i.e., solvent containing, but preferably they are aqueous. The mediums can be modified, extended, and stabilized with solubilizers or other materials.

Examples of aqueous mediums which can be employed are those disclosed in U.S. Pat. No. 3,230,162 issued to A. E. Gilchrist on Jan. 18, 1966. Disclosed therein are numerous concentrate compositions generally comprising about 50 to 95 percent by weight polycarboxylic acid resin, about 1 to 10 percent water soluble amino compound and the balance water. The polycarboxylic acid resins are film-forming at electrodeposition bath temperatures, and are curable to a tack-free film.

Other aqueous polyelectrolytic electrocoating material mediums which can be employed according to this invention are disclosed in U.S. Pat. No. 3,366,563 issued to Hart on Jan. 30, 1968. Generally, Hart discloses an aqueous electrocoating bath containing a solubilized vehicle resin which comprises the reaction product of a drying oil fatty acid ester or a semi-drying oil fatty acid ester with an alpha,beta-ethylenically unsaturated dicarboxylic acid or an anhydride of such an acid.

Examples of non-aqueous polyelectrolytic electrocoating material mediums which can also be employed are disclosed in U.S. Pat. No. 3,463,714 issued to W. D. Suomi and A. R. Ravve on Aug. 26, 1969. Disclosed therein are electrocoating baths prepared generally by dissolving a carboxyl-containing polymer and a basic nitrogen-containing compound in an organic solvent and adding a sufficient amount of a polar organic non-solvent having a solubility parameter greater than 12 and a hydrogen bond index greater than 7.5 to convert the solution into a suspension.

The polyelectrolytic electrocoating material mediums disclosed in the aforementioned patents are merely examples of some of the many aqueous and non-aqueous mediums which can be employed. For example, also utilizable are non-polycarboxylic acid resins such as rubber lattice suspended resins adsorbed by hydroxyl ions, and resins formulated for example from phenolics, polyvinyl ethers, cellulosic resins, polyimides and silicones.

That the electrocoating system of this invention can be employed to electrocoat interior, electrically-conductive surface areas of can bodies is shown in Table I wherein 2-piece drawn and 3-piece regular can bodies (respectively 1-piece and 2-piece during the coating operation), full and repair coated with aqueous electrocoating mediums or baths at rates as fast as 2 seconds, approximately 600 cans per minute, obtained satisfactory quick tests within the range of from 0 to 1.0 ma.

TABLE I

Examples	Type-can	Bath: Type	Bath: Solids, content, percent	Bath: Resistivity (ohm/cm.)	T. (° F.)	Voltage	Time[1] (seconds), approx.	Equiv. cans, min.	Quick test[2] (milli-amperes)
Full coating:									
1	2-piece drawn tinplate	A	10	1,980	85	400	4	300	0–0.25
2	do	A	10	1,980	85	500	2	600	0.5–1.0
Repair coating:									
3	3-piece TFS Miraseam[3]	B	2.5	Adjusted to 4,800	75–80	200	3.5	380	0.57
4	do	B	2.0	Adjusted to 5,500	80	100	2.0	600	0–0.4
5	do	B	2.1	Adjusted to 4,400	80	100	2.5	520	0–6.0

[1] The time in seconds is deposition time while contacts 254 engage cam bars 228 and 228'. However, times listed are approx. since some deposition takes place before and after the contacts engage the cam bars.

[2] A Quick Test (QT) determines the adequacy of film build-up and the effectiveness of full and repair coat seasls. A typical QT is to pour an aqueous 1% sodium chloride solution into an open-ended TFS can having its lap seam cemented with a polymeric material (Miraseam can), its closed end sealed with a steel end and its interior roller-coated with a layer of conventional lacquer. An electrode is placed in the solution and a 6 v. potential is induced in the circuit. Current flowing through the circuit, measured in ma., determines effectiveness of the repair coat. Perfect coverage is obtained when no current flows.

[3] Having thereon an epoxy-type, solvent-containing base coat designated H50,000, manufactured by M & T Chemicals Inc.

NOTE.—A and B=Anodic aqueous electrocoating baths prepared by diluting concentrates respectively designated CS576 (for A) and X1222 (for B) (manufactured by Pittsburgh Plate Glass Co). to the indicated percent solids solution, with ionized water. CS576 and X1222 are believed to be roughly 22 percent solids concentrate solutions of butyl acrylate-styrene-methacrylic acid-hydroxyethyl methacrylate and containing no more than 20 wt. percent of total polymer units derived from methacrylic acid and containing no more than 7 wt. percent of total polymer units derived from hydroxyethyl methacrylate.

The resistivity of the baths used for full coating the tinplate bodies was unadjusted, whereas that for the TFS bodies was adjusted by contacting the unadjusted bath with a weak electrolyte, CO_2 in the manner disclosed in U.S. patent application Ser. No. 209,305, filed on Dec. 14, 1971. The method disclosed in the aforementioned application can advantageously be employed in relation to the electrocoating system of this invention.

In the electrical coating circuitry of this invention, wire **114** (FIG. 10) is connected to the positive terminal of the power source (not shown), and is ultimately connected through the cam bars, contacts and valves to electrodes **48**, thereby rendering them cathodic. Wire **75** (FIG. 1) is connected to the positive terminal of the power source and is ultimately connected through the brushes and the cables to container bodies **44** and **44'**, thereby rendering them anodic. When, as shown in Table I, an anodic electrolytic fluid or bath such as X1222 fills the container bodies **44**, and the contacts engage the cam bars, negatively charged electrolytic coating particles in the bath migrate to, discharge onto and coat any positively charged interior conductive surfaces of the anodic container bodies.

It has been found highly desirable to isolate, and the embodiment of this invention essentially isolates, the interior surfaces of metal drum **12** from the aforementioned coating circuit.

This prevents electrolytic particles in fluid **84** from being electrodeposited on any such surfaces exposed to the fluid, and it prevents power loss from the power source through the exposures, to drum **12** which preferably is grounded.

Although electrolytic particles from electrocoating fluids would tend to increasingly insulate the exposed area as it coated the area, some recently developed fluids would not so readily coat the area and therefore would allow power loss.

The coating used to insulate the interior of drum **12** can be any coating or coatings suitable for insulating the drum. The type of coating will vary depending on the type of material used to make the drum. For the stainless steel drum of this invention, it has been found advantageous to condition the interior surface as by sand blasting, and to treat the surface with a 0.3 to 1 mil thick layer of a material such as an alcoholic solution, e.g., a "Polyclutch" Wash-Primer preparable by those skilled in the art according to MIL Specification MIL–C–15328, designated UC–40082, by PPG Industries, Inc. A conventional, commercially available material such as a two component system, polyamide-cured, heavy duty coal tar epoxy sold under the trade designation UC–40101 by PPG Industries, Inc. can be applied over the primed surface in thick layers of say about 6 mils each.

Of course, when drum **12** is not made of a conductive metal but is made of say a molded, cured glass filament epoxy material, the aforementioned coatings would not be employed.

I claim:

1. An apparatus for electrodepositing a coating on interior electrically-conductive surface areas of container bodies having an open end, which comprises:
- a rotatable reservoir for containing an electrolytic fluid;
- means for rotating the reservoir;
- valve means mounted on the reservoir for passing the fluid to and from the interior thereof, all portions of the valve means in contact with the fluid being nonconductive in relation thereto;
- an electrode connected to and projecting from the valve means, said valve means including:
  - means for carrying electric current through the valve means to the electrode,
  - a housing having fixed and moveable portions, the moveable portion having a mouth therein,
  - a valve member fixedly connected to the fixed housing portion,
  - biasing means mounted between the fixed and moveable housing portions, and
  - a resilient sealing ring mounted on the mouth of the moveable housing portion and moveably biased by the biasing means into sealing engagement with the valve member;
- means partly mounted on the reservoir for creating a potential difference between the electrode and interior conductive surface areas of the container bodies; and
- means for feeding the container bodies onto the valve means so that the bodies are registered thereon, the electrode projects into the interior of the bodies, and the rims of the bodies sealingly engage the sealing ring with pressure sufficient to break the sealing engagement between the valve member and the sealing ring to create a passageway therebetween which allows the fluid to pass through the valve means and into the container bodies during a portion of the reservoir rotation, so that a potential created electrodeposits a coating on interior electrically-conductive surface areas of the container bodies.

2. The apparatus of claim **1** wherein means are connected to the interior of the reservoir for charging, leveling and draining the fluid to, in and from the reservoir.

3. The apparatus of claim **2** wherein the means for charging, leveling and draining includes pressure means for pumping fluid into and from the reservoir.

4. The apparatus of claim **1** wherein there is also included discharge means for removing the container bodies from the valve means and from the reservoir.

5. The apparatus of claim **4** wherein the discharge means includes a knife for separating the rims of the container bodies from the sealing rings of the valve means.

6. The apparatus of claim **1** wherein the reservoir has a cylindrical wall and the valve means are mounted radially therein.

7. The apparatus of claim **6** wherein the valve means are mounted in rowed radially-aligned spaced pairs around the circumference of the cylindrical wall of the reservoir.

8. The apparatus of claim **6** wherein the reservoir is drum-like, its axis is tilted, and its non-cylindrical walls are arcuate so that liquid on the walls does not accumulate thereon but drains toward a bottom portion of the reservoir.

9. The apparatus of claim **6** wherein the electrode projects substantially radially from the exterior of the valve member.

10. The apparatus of claim **9** wherein a portion of the potential creating means is mounted interior of the reservoir, the means for carrying current through the valve means are within the valve member, and intermediate circuitry connects the potential creating means to the current carrying means.

11. The apparatus of claim **10** wherein the portion of the potential creating means interior of the reservoir is a commutator assembly means connected to the intermediate circuitry for providing direct current to the electrodes during the portion of reservoir rotation when the fluid is in the container bodies.

12. The apparatus of claim **6** wherein the feeding means includes means for registering the bodies on the sealing ring, and means for holding the bodies in registered sealing engagement thereon and for providing pressure sufficient to create the passageway between the valve member and the sealing ring.

13. The apparatus of claim **12** wherein the registering means includes cradles mounted radially on the cylindrical wall adjacent each valve means, for receiving the bodies from a source and placing them in the registered position.

14. The apparatus of claim **13** wherein the holding and pressure providing means is a continuous cable which extends around a major portion of the cylindrical reservoir wall and tightly engages the exteriormost ends of the container bodies.

15. The apparatus of claim **14** wherein the exteriormost portion of the cradles have a notch therein for aligning the cable and for maintaining the cable in engagement with the container bodies.

16. The apparatus of claim **15** wherein the current-carrying means is a metal core and the electrode is a helical spring connected to the core exterior of the valve means.

17. The apparatus of claim **13** wherein the source is a transferring means for timedly transferring the bodies to the cradles.

18. The apparatus of claim **17**, wherein the transferring means is a worm feed screw.

19. The apparatus of claim **13** wherein a portion of the potential creating means is mounted interior of the reservoir, the means for carrying current through the valve means are within the valve member and intermediate circuitry connects the potential creating means to the current carrying means.

20. The apparatus of claim **19** wherein the source is a transferring means for timedly transferring the bodies to the cradles.

21. An apparatus for electrodepositing a coating on interior electrically conductive surface areas of container bodies having an open end, which comprises:
- a rotatable drum having a cylindrical wall, for containing an electrolytic fluid;
- means for rotating the drum;
- value means mounted radially in the cylindrical wall for passing the fluid to and from the interior thereof, all portions of the value means in contact with the fluid being non-conductive in relation thereto;

an electrode connected to and projecting radially from the exterior of the valve means;

said valve means including:

means for carrying electric current through the valve means to the electrode,

a housing having fixed and moveable portions, the moveable portion having a mouth therein,

a valve member fixedly connected to the fixed housing portion,

biasing means mounted between the fixed and movable housing portions, and

a resilient sealing ring located on the mouth of the moveable housing portion and moveably biased by the biasing means into sealing engagement with the valve member;

means partly mounted on the drum for creating a potential difference between the electrode and interior conductive surface areas of the container bodies, a portion of the potential creating means being mounted interiorly of the drum, and including intermediate circuitry connecting it to the current-carrying means; and

means for feeding the container bodies in register onto the valve means, the feeding means including

cradles mounted radially on the cylindrical wall adjacent each valve means for receiving the bodies from a source and placing the bodies in register onto the sealing ring so that the electrode projects into the interior of the bodies, and

a continuous cable extending around a major portion of the cylindrical drum wall and tightly engaging the exteriormost ends of the container bodies so that rims of the bodies sealingly engage the sealing ring with pressure sufficient to break the sealing engagement between the valve member and the sealing ring to create a passageway therebetween which allows the fluid to pass through the valve means and into the container bodies during a portion of the drum rotation, so that a potential created during that portion of rotation electrodeposits a coating on electrically-conductive surface areas of the container bodies, and, during another portion of the rotation, allows the fluid to drain from the coated bodies back through the passageway and back into the drum.

22. The apparatus of claim **21** wherein the exteriormost portion of the cradles have a notch therein for aligning the cable and maintaining the cable in diametrical engagement with the container body.

23. The apparatus of claim **21** wherein there is also included means for removing the container bodies from the valve means and from the drum.

24. The apparatus of claim **23** wherein the removing means includes a knife for separating the rims of the container bodies from the sealing ring of the valve means.

25. The apparatus of claim **21** wherein the source is a worm feed screw.

26. The apparatus of claim **25** wherein a portion of the portion of the potential creating means interior of the drum is a commutator assembly means for providing direct current to the electrode during the portion of drum rotation when the fluid is in the container bodies.

27. The apparatus of claim **26** wherein the valve means are mounted in rowed, radially-aligned spaced pairs around the circumference of the cylindrical wall of the drum.

28. The apparatus of claim **26** wherein the axis of the drum is tilted and its non-cylindrical walls are arcuate so that liquid on the drum walls does not accumulate thereon but drains toward the bottom portion of the drum.

29. The apparatus of claim **28** wherein the current-carrying means includes a metal core running through the valve member and the electrode is a helical spring connected to the core exterior of the valve means.

30. The apparatus of claim **29** wherein means are connected to the interior of the drum for charging, leveling and draining the fluid to, in and from the drum.

31. The apparatus of claim **30** wherein the means for charging, leveling and draining the fluid includes pressure means for pumping the fluid into and from the drum.

32. The apparatus of claim **31** wherein there is also included means for removing the container bodies from the valve means and from the drum.

33. A method of electrodepositing a coating on interior electrically-conductive surface areas of container bodies which comprises:

rotating a reservior containing an electrolytic fluid and having valve means mounted in the exterior walls thereof, the valve means in turn having an electrode projecting therefrom,

feeding the bodies onto the valve means, so that the bodies are registered thereon and the electrode projects into the interior of the container bodies,

providing axial pressure against the container bodies sufficient to sealingly engage the rims of the bodies against a portion of the valve means and to open the valve means,

passing the fluid from the rotating reservoir through the open valve means into the sealingly engaged bodies,

creating a potential difference between the electrode and interior surface of the bodies when they contain the fluid, and thereby

electrodepositing a coating on interior electrically-conductive surface areas of the bodies.

34. The method of claim **33** wherein said rotating step is continuous and wherein said feeding step includes simultaneously feeding a plurality of bodies onto a plurality of valve means on the reservoir.

35. The method of claim **33** wherein the rotating step is continuous, the pressure providing step is maintained throughout a major portion of the reservoir rotation, and the fluid passing step is effected by gravity.

36. The method of claim **35** wherein there is also included the step of insulating the means for creating the potential and the means for carrying current through the valve means to the electrode, from the fluid.

37. The method of claim **33** wherein there is also included the steps of charging the fluid to the reservoir, and removing the coated container bodies from the valve means and from the reservoir.

38. A method of electrodepositing a coating on interior electrically-conductive surface areas of container bodies which comprises:

continuously rotating a drum containing electrolytic fluid and having valve means mounted in the exterior walls thereof, the valve means in turn having an electrode projecting therefrom,

simultaneously feeding a plurality of the container bodies onto a plurality of the valve means, so that the container bodies are registered on the valve means and the electrodes project into the interiors of the container bodies,

providing axial pressure against the exteriormost end of the container bodies, said pressure being maintained throughout a major portion of each reservoir rotation and being sufficient to sealingly engage the rims of the container bodies against a portion of the valve means and to open the valve means,

gravity-passing the fluid from the rotating drum through the opened valve means and into the sealingly engaged container bodies,

creating a potential difference between the electrode and the interior surfaces of the container bodies during a portion of the rotation when the bodies contain the fluid, and thereby electrodepositing a coating on the interior electrically-conductive surface areas of the bodies.

39. The method of claim **38** wherein there is also included the step of insulating the means for creating the potential and the means for carrying electric current through the valve means to the electrode, from the fluid.

40. The method of claim **39** wherein there is also included the step of removing the coated container bodies from the valve means and from the drum.

41. The method of claim **40** wherein there is also included the step of pumping the fluid to the reservoir.

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