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SURFACE TREATMENTS OF BATTERY
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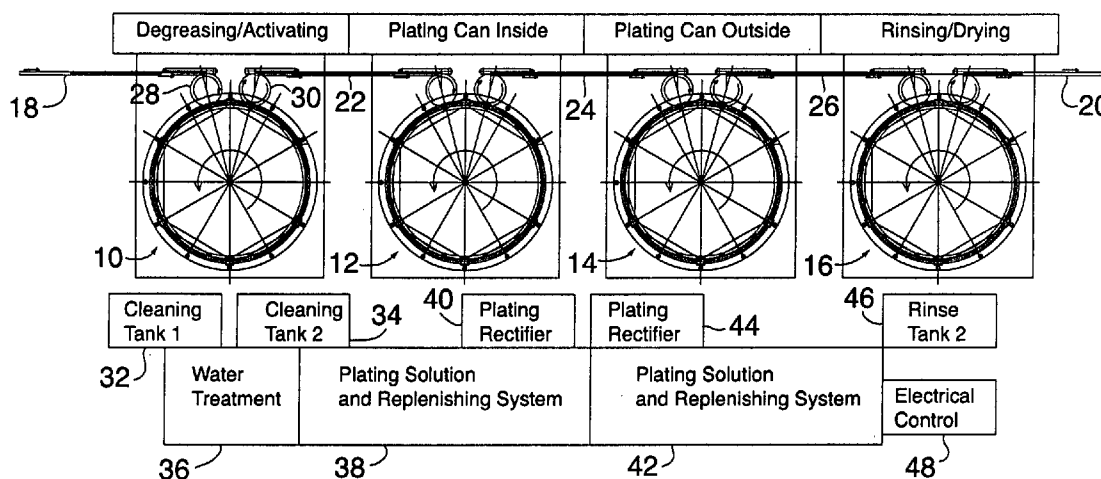
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(57)

ABSTRACT

Apparatus for surface treatment of battery cans, including cleaning and electroplating of the interior and exterior surfaces of battery cans as they are transported along a continuously moving production line. The battery cans are automatically loaded from a conveyor onto workpiece holders on a series of circular carriers. Surface processing enclosures operated by cam followers are arranged to enclose the battery cans so that a processing fluid may be automatically injected. The processing fluid may simply be a surface cleansing or drying agent or in the case of electroplating, the processing fluid is a liquid electrolyte so that a plating voltage can be applied to plate either the external or internal surfaces of the battery cans.



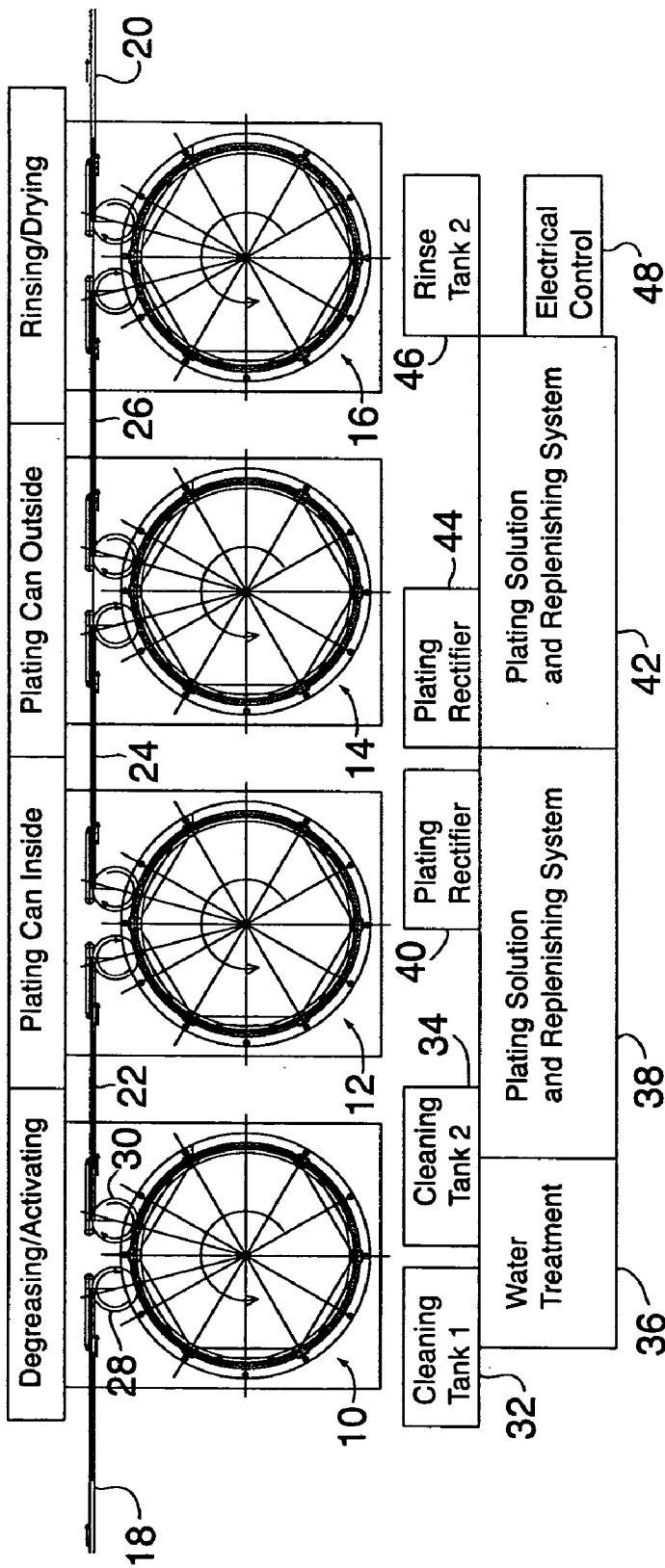


FIG. 1

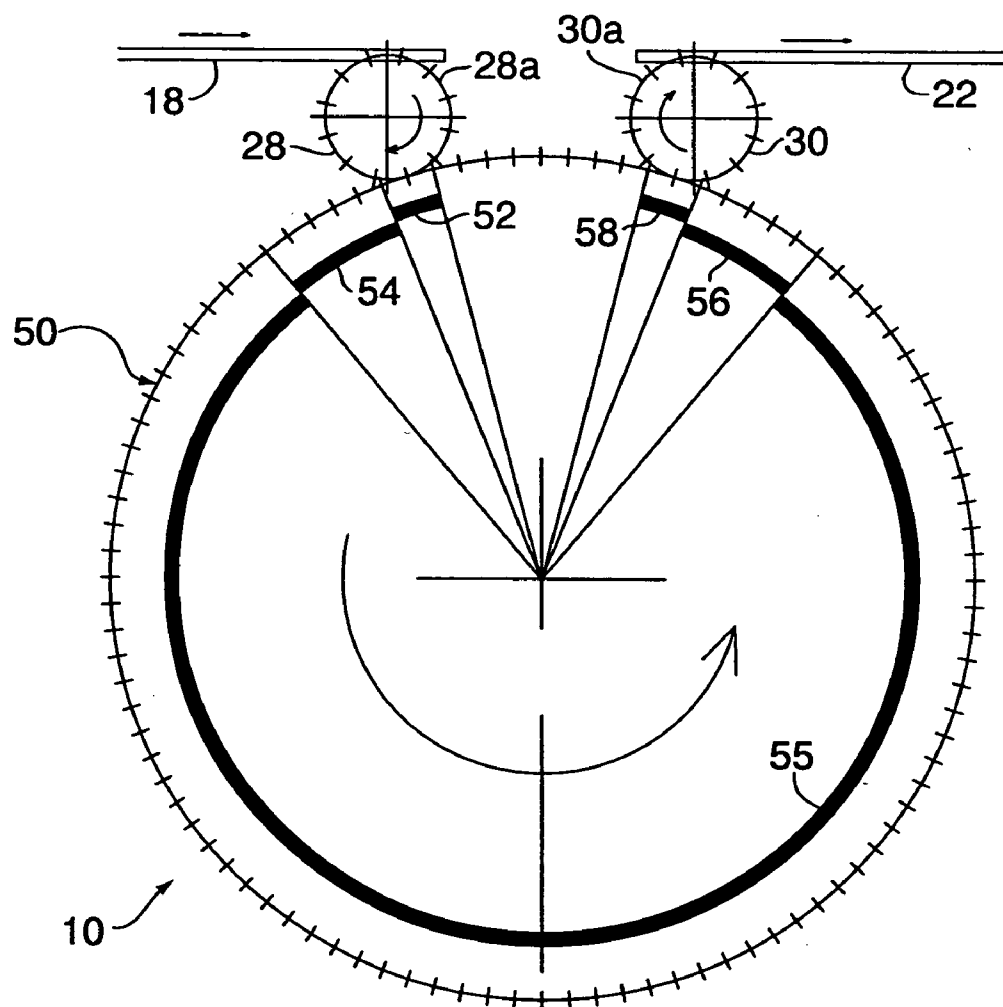


FIG. 2

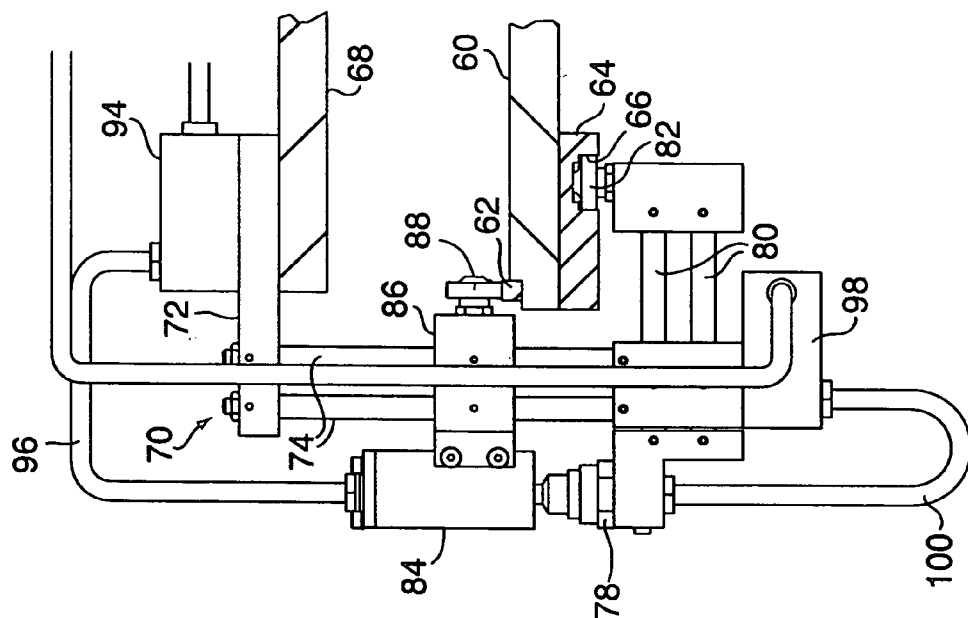


FIG. 4

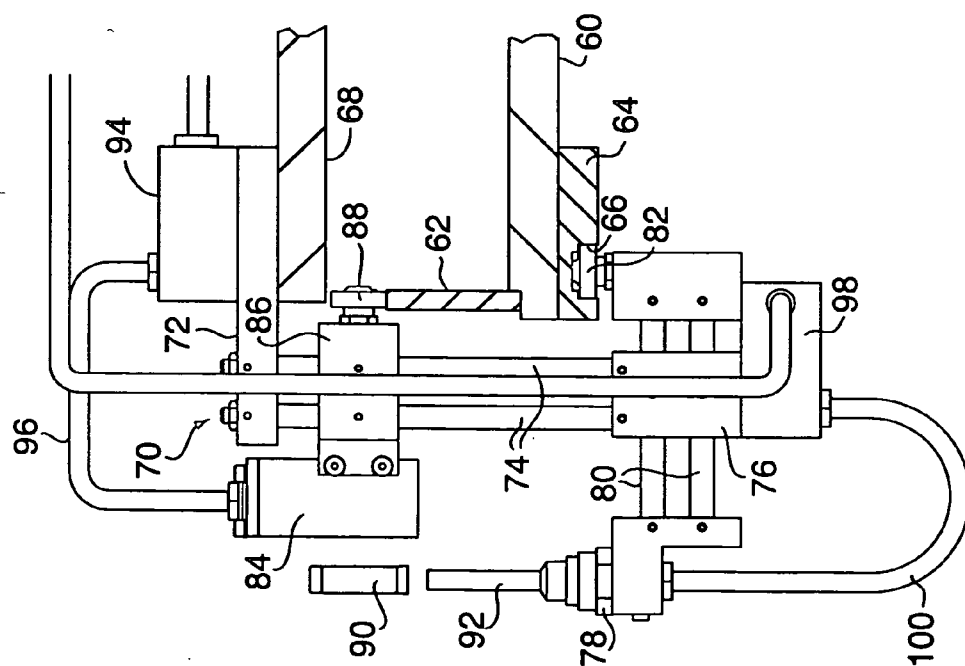


FIG. 3

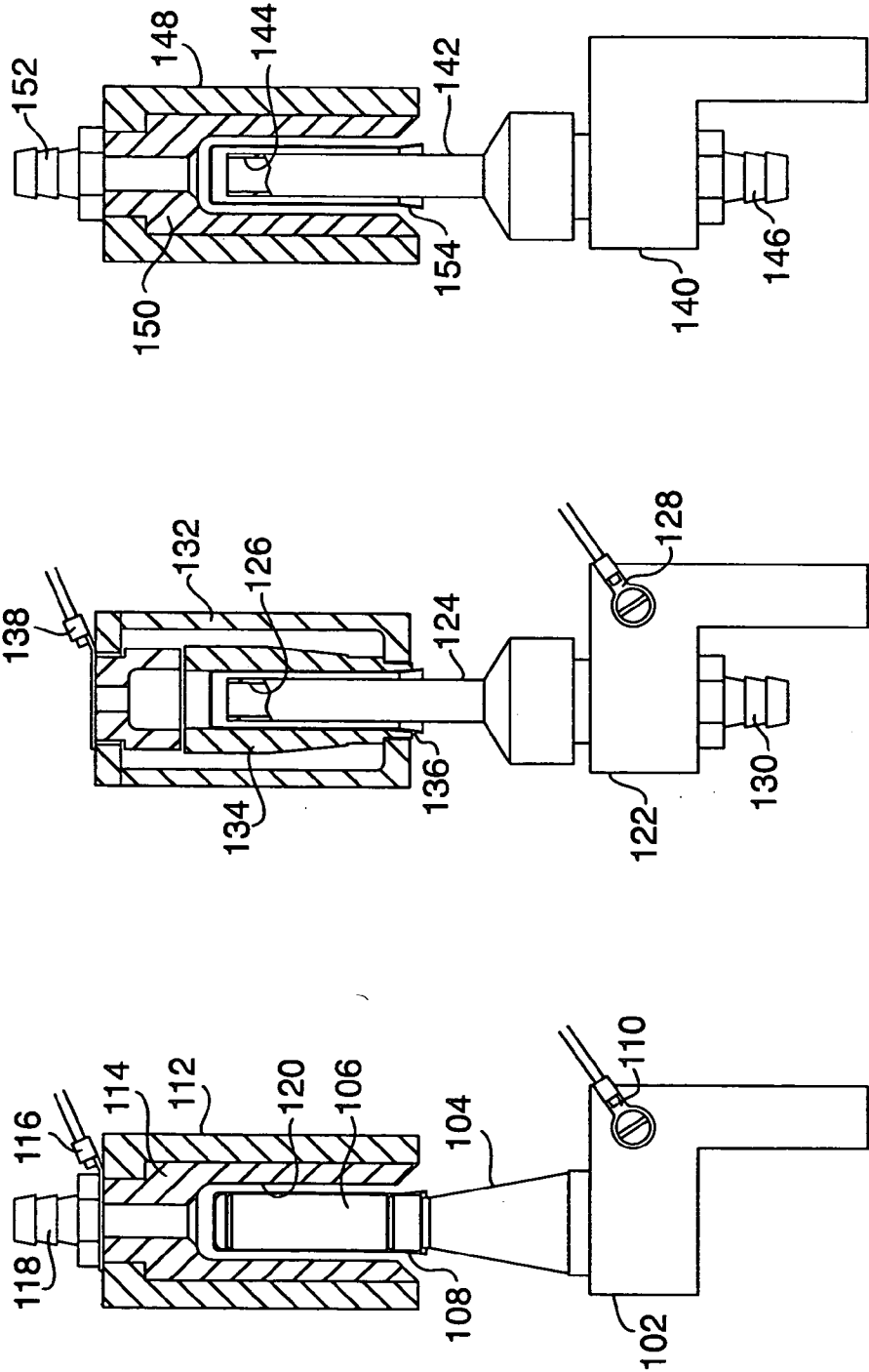


FIG. 7

FIG. 6

FIG. 5

PROCESS AND APPARATUS FOR MULTIPLE SURFACE TREATMENTS OF BATTERY CANS

BACKGROUND OF THE INVENTION

[0001] This invention relates generally to process and apparatus for surface treatment of work pieces as they move along a production line, and more particularly to surface treatments of battery cans, including cleaning and electroplating of the interior and exterior surfaces of battery cans as they are transported along a continuously moving production line.

[0002] Battery cans are produced today in huge quantities for use in the manufacture of electrolytic cells, such as AA, AAA, C and D cylindrical batteries and also prismatic batteries for special applications. The battery cans are usually manufactured by transfer presses, which draw the battery cans from an initial metal stamping into hollow longitudinal casings open on one end with a substantially uniform cross section along the length of the casing. Intermediate manufacturing steps after drawing the battery cans usually requires degreasing the interior and exterior surfaces, washing, cleaning and drying the cans. In some cases, it is desirable also to electroplate the interior and exterior surface of the battery can. In the past, electroplating of battery cans has been carried out in a batch process, requiring loading the cans on a fixture and plating the interior and exterior surfaces in a tank containing the electroplating solution. This is a cumbersome process requiring loading and unloading the fixture, whereas it is desirable for the battery cans to be continuously processed as they move along a production line so as to achieve high volume consistent treatment of the products.

[0003] Electroplating a moving work piece is particularly difficult. Yet it would be desirable to manufacture the battery cans from cold rolled steel, and then to degrease them, clean them, electroplate them with a metal such as nickel or other metal alloy or metal co-deposited with other conductive material such as graphite, and clean them by washing and drying as they move along a production line. It is known to speed up the plating process of a cylindrical surface in a batch process by utilizing an anode forming close clearances with the interior wall of the work piece. The prior art describes circulating a plating solution up into a tube connected as an anode and down around the outside of the tube to plate the interior wall of automotive cylinders. U.S. Pat. No. 5,642,600 issued Jul. 1, 1997 to Ikegaya et al. shows such a high speed plating method, wherein the flow rate and electric current density can be varied. U.S. Pat. No. 5,909,721 to Ikegaya issued Jun. 8, 1999 discloses a similar process wherein a plating solution flows between an automotive engine cylinder wall and the exterior of an electrode to plate the inner wall of the cylinder bore with nickel. The foregoing patents do not address the problem of loading and unloading the workpiece in a continuous plating process.

[0004] U.S. Pat. No. 4,303,481 describes a system for suspending work pieces in a common tank of electrolyte suitable for coating components in mass production on an industrial scale. Gripping jaws hold a workpiece to be electroplated inside a sealed tank. Electrolyte is introduced while a plating voltage is applied between the part and the tank. While the apparatus is suitable for plating the exterior of the article, it requires a semi-batch type loading of the

work piece and does not provide for high speed plating with close clearances between the work piece and the anode.

[0005] An inline process for manufacturing battery cans has been disclosed by the applicant's assignee in a pending application U.S. Ser. No. 10/705549 filed Nov. 10, 2003. In that pending application, battery cans are transported sequentially on a conveyor from one stage of the manufacturing process to the next. The manufacturing process includes washing and drying equipment for cleaning the battery cans after a graphite coating has been applied to the interior of the battery cans. All of the foregoing takes place in a continuously moving conveyORIZED production line. However, there is no provision for plating the interior and the exterior surfaces of the battery cans. It would be very desirable to enable electroplating a nickel or nickel cobalt alloy coating onto battery cans drawn from cold-rolled steel. Other surface treatment of the battery cans is necessary, such as degreasing to remove the drawing compound before electroplating and then rinsing and drying the plated cans. It would be desirable if this could be accomplished in an integrated fashion while the battery cans move continuously through the production process.

[0006] Accordingly, one object of the present invention is to provide an improved apparatus and process for sequential surface treatments of work pieces, including electroplating internal and external surfaces.

[0007] Another object of the invention is to provide an improved apparatus and process for moving battery cans through sequence of surface treatment operations in a continuous process rather than a batch process.

[0008] Another object of the invention is to provide an improved apparatus and process for electroplating the inside surface of a battery can.

[0009] Still another object of the invention is to provide an improved apparatus and process for electroplating the exterior surface of the battery can.

SUMMARY OF THE INVENTION

[0010] Briefly stated, the invention comprises apparatus for surface treatment of work pieces of the type having a hollow longitudinal casing open on one end with internal and external surfaces and a substantially uniform cross-section along the length of the casing, the apparatus comprising a stationary base defining a workpiece processing path between a loading station and an unloading station, a workpiece carrier arranged to traverse along the processing path, a plurality of guide members uniformly spaced along the workpiece carrier located so as to successively traverse the processing path, a plurality of workpiece holders disposed in the guide members and arranged to be movable in the guide members between a loading position and a processing position, a plurality of surface processing enclosures disposed on the carrier each having an open end and arranged to be movable with respect to a respective workpiece holder between an open position wherein a workpiece is openly disposed on a workpiece holder and a closed position wherein a workpiece is enclosed within a surface processing enclosure, and cam and follower means responsive to movement by the workpiece carrier with respect to the base, the cam and follower means being adapted to successively move a workpiece holder at the loading station

from the loading position into the processing position and then to move the surface processing enclosure into the closed position, whereby a workpiece placed in the workpiece holder at the loading station may be processed in the surface processing enclosure while it moves along the processing path to the unloading station.

[0011] In its preferred form, the carrier is circular and the work piece holders include an upwardly extending projection arranged to receive a work piece casing placed over the projection. The surface processing enclosures are arranged to enclose the casings so that a work piece processing fluid may be injected. The work piece processing fluid may simply be a surface cleansing agent or, in the case of electroplating, the processing fluid is a liquid electrolyte. A plating voltage can be applied to plate either the external or internal surfaces of the work pieces casing. In its preferred form, the apparatus is designed to treat battery cans, although similar shaped work pieces are also suitable for surface processing in the apparatus.

DRAWING

[0012] Other objects and advantages of the invention will be made more clear by reference to the following specification, taken in connection with the accompanying drawing, in which:

[0013] **FIG. 1** is a schematic plan view of four surface treatment units, each constructed to load and unload the battery cans in the same way, but specifically adapted to perform different surface treatment operations,

[0014] **FIG. 2** is an enlarged diagrammatic plan view, showing a timing diagram for a typical rotating work piece carrier,

[0015] **FIG. 3** is an elevational drawing, partly in cross section showing a work piece holder in a loading position and an associated surface processing enclosure in an open position,

[0016] **FIG. 4** is a view similar to **FIG. 3**, but showing the work piece holder in a processing position and the surface processing enclosure in the closed position,

[0017] **FIG. 5** is an elevational view of a work piece holder and a surface processing enclosure in cross section arranged for plating the external surface of the battery can,

[0018] **FIG. 6** is a different type of work piece holder with a surface processing enclosure shown in cross section and arranged to plate the internal surface of a battery can, and

[0019] **FIG. 7** is yet another type of work piece holder and a surface processing enclosure in cross section with fluid connections for degreasing, rinsing or drying.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0020] Referring now to **FIG. 1** of the drawing, a cleaning and plating system is shown. Surface treatment units are indicated at **10**, **12**, **14**, **16** arranged in a line and receiving work pieces, in this case battery cans, traveling along a conveyor at **18** and departing the system on a conveyor at **20**. Intermediate conveyors **22**, **24**, **26** move the battery cans from one unit to the next. A loading dial **28** and an unloading dial **30** serve as interfaces to transfer battery cans from

conveyor **18** to the surface treatment unit **10** which is rotating in a direction indicated by the arrow, and to remove treated battery cans and transfer them to the intermediate carrier **22** for transport to the next surface treatment unit **12**. Surface treatment unit **10** is adapted for degreasing and activating the battery cans through treatment with surface cleansing agents contained in tanks indicated at **32**, **34**. An example of such cleansing agents is AQUAEAS from Hubbard Hall. A water treatment system **36** is shown for the purpose of recycling water for the rinsing processes and to fulfill the environmental requirements before discharging water.

[0021] Surface treatment unit **12** is adapted to plate the inside surface of the battery can using a plating solution fluid supplied from a plating solution and replenishing system **38** and plating voltage supplied by a plating rectifier **40**. A suitable plating solution fluid for nickel-plating cold rolled steel battery cans consists of nickel sulfate, boric acid and deionised water.

[0022] Surface treatment unit **14** is arranged to plate the external surface of battery cans supplied from conveyor **24** and to transfer them to conveyor **26** through loading and unloading dials which are identical to dials **28**, **30**. A plating solution and replenishing system **42** supplies a plating solution fluid to unit **14**, while a plating rectifier **44** imposes a plating voltage.

[0023] Surface treatment unit **16** receives battery cans from intermediate conveyor **26** and performs a rinsing and drying operation. A rinse tank **46** supplies water for rinsing off plating solution fluid. Drying with air may also be performed in the surface treatment unit **16**.

[0024] The entire cleaning and plating system consisting of all four surface treatment units is controlled by a master control unit indicated at **48**. Controller **48** provides power to rotate the loading and unloading dials and the workpiece carriers of units **10**, **12**, **14**, **16** in synchronism, in accordance with a timing program.

[0025] Referring now to **FIG. 2** of the drawing, a single surface treatment unit timing diagram is schematically represented in order to illustrate the apparatus and process control. For purpose of illustration, the first surface treatment unit **10** will be described, but it is understood that the other three units **12**, **14**, **16** may be substantially identical with respect to the timing diagram. The only difference lies in the special adaptation of the work piece holders and surface processing enclosures. Loading dial **28** is arranged to receive battery cans in pockets or compartments corresponding to segments **28a** and to rotate in synchronism with a rotating workpiece carrier of unit **10**, depositing the battery cans with their open end facing downward over a projection on a battery can holder on the rotating carrier as it passes the loading dial **28**. Similarly, the unloading dial **30** is arranged to strip a battery can from a projection and carry it in a pocket or compartment corresponding to a segment **30a** to re-deposit it onto intermediate conveyor **22**. Mechanisms for loading and unloading the battery cans will be well understood by those skilled in the automation art. They preferably include magnetic holders for transferring the battery cans, such details not being material to the present invention.

[0026] The timing diagram for the circular path traversed by the work pieces is divided into circular segments **50** that

show the relative time allocated to each of the operations of the surface treatment units. Two such segments or units of time **52** are required to load the work piece onto the work piece holder. Five time units **54** are required to move the work piece holder from a loading position to a processing position and to enclose a work piece within a surface processing enclosure. The battery cans are then processed during a time of seventy-eight time units **55**. Five time units **56** are required to open the surface processing enclosure and move the work piece holder from a processing position to a loading position, and two time units **58** are required to strip the part from the work piece holder to a pocket corresponding to segment **30a** on the unloading dial **30**. The actual times for accomplishing these operations depend upon the rotational speed of the work piece carrier. The relative time for each operation are merely exemplary. However, in order to provide a universal cleaning and plating system at minimum cost, all four units and their timing diagrams are designed to be identical in the present case.

[0027] Referring now to **FIGS. 3 and 4** of the drawing, the apparatus is illustrated in its preferred form as comprising a stationary base **60** which, in its preferred form, is circular. **FIG. 3** shows the outside edge of the stationary base **60** at a loading position (see **52** in **FIG. 2**) and **FIG. 4** shows the outside edge of the circular stationary base at a processing position (see **55** in **FIG. 2**). A vertical motion cam **62** encircles the periphery of the base **60**. Cam **62** varies in height above base **60** as shown by a comparison of **FIG. 3** with **FIG. 4**. In a similar manner, a horizontal motion cam **64** with a slot **66** encircles the periphery of base **60**. The horizontal slot **66** varies in distance from the center of the circular base **60** as shown by a comparison of **FIG. 3** with **FIG. 4**.

[0028] A circular work piece carrier **68** is rotatably mounted on an axis and is slowly rotated by a motor to carry out operations according to the timing diagram discussed in connection with **FIG. 2**. Carrier **68** has circumferentially spaced guide members **70** uniformly spaced around its periphery, one of which is seen in **FIGS. 3 and 4**. Each such guide member **70** includes a radial extension **72**, a pair of vertical guide rods **74** and a guide block **76**. A work piece holder **78**, which may vary in its construction from one surface processing unit to the next, is attached to two horizontal guide rods **80** slidably disposed in guide block **76**. A cam follower **82** is connected to the other end of guide rods **80**. The follower **82** moves in horizontal motion cam slot **66** as the carrier **68** rotates. This moves the work piece holder **78** from a loading/unloading position shown in **FIG. 3** to a processing position shown in **FIG. 4**.

[0029] A surface processing enclosure **84** is supported by a guide block **86** slidably disposed on the vertical rods **74** of the guide members. A vertical cam follower **88** moves the guide block and surface processing enclosure **84** in a vertical direction between an open position seen in **FIG. 3** and a closed position seen in **FIG. 4** where it encloses the work piece. The work piece is illustrated in **FIG. 3** as a battery can **90** disposed with its open end above an upwardly extending projection **92** on the work piece holder.

[0030] Lastly, a fluid control valve **94** is shown mounted on guide member radial extension **72** with a hose **96** connecting its outlet to surface processing enclosure **84**. Similarly, a fluid control valve **98** is mounted to the guide

block **76** on the bottom of guide member **70**, and has an outlet connected by hose **100** to work piece holder **78**.

[0031] It remains to note that the cams **62** and **64** are designed so as to first move the work piece **78** horizontally to a processing position and then to move the enclosure **84** vertically to a closed position during the five time intervals **54** shown on the timing diagram of **FIG. 2**. For the balance of the cycle indicated by time intervals **55**, the work piece holder and surface processing enclosure remain closed in the processing position as shown in **FIG. 4**. Thereafter, the vertical cam **62** first raises enclosure **84** vertically and then cam **64** moves work piece holder **78** horizontally outwardly. This takes place during the five time intervals **56** shown on the timing diagram.

[0032] Referring now to **FIGS. 5, 6 and 7** of the drawing, exemplary surface treatment set ups are shown with slight variations in the work piece holders and the surface processing enclosures, depending upon the treatment taking place.

[0033] First referring to **FIG. 5** of the drawing, an arrangement is shown for plating the exterior of a battery can. This operation is shown taking place in surface treatment unit **14** in **FIG. 1**. A work piece holder **102** includes an upwardly extending projection **104** terminating in a conductive plug **106** designed to fit the inside of a battery can **108** (indicated in cross-section) and make good electrical contact therewith. A negative electrical connection is made at terminal **110** with a negative voltage imposed thereon so that the can **108** is connected as the cathode. A surface processing enclosure **112** holds a spray head **114**, both being conductive and supplied with an electrical connection **116** connected as the anode to plating rectifier **44**. (See **FIG. 1**). The spray head **114** is provided with a hose connection **118**. This may be connected to a hose and fluid control valve (not shown but similar to hose **96** and valve **94** in **FIGS. 3 and 4**). The spray head **114** has an internal surface **120** which forms close clearances with the external surface of battery can **108**. A plating solution is supplied through hose connection **118** to flow between the external surface of battery can **108** and the internal surface of spray head **114**. Because of the close clearance and the ability to control the flow of electrolyte and the plating voltage, high speed electroplating of the exterior of the battery can may be achieved. Thereafter, rinse water is supplied to the hose connection **118** to flow through the close clearances to clean the battery can. The electroplating portion of the operation and the rinsing portion of the operation are timed by computer controls as the carrier rotates so as to complete the operation by the time the work piece reaches the unloading station.

[0034] Referring to **FIG. 6** of the drawing, electroplating of the internal surface of the battery can is indicated. This operation is shown taking place in surface treatment unit **12** in **FIG. 1**. A work piece holder **122** includes an upwardly extending projection **124** terminating in a hollow tube **126** open at the upper end. An electrical terminal **128** is connected to rectifier **40** (**FIG. 1**) to connect tube **126** as the anode. A hose connection **130** is connected to a hose and valve similar to hose **100** and valve **98** shown in **FIGS. 3 and 4**.

[0035] A surface processing enclosure **132** includes an electrically conductive gripper **134** arranged to tightly enclose and make good electrical contact with a battery can

136. An electrical terminal **138** is connected as the cathode. The exterior of the anode tube **126** is so dimensioned as to form close clearances with the inside surface of the battery can **136**. A plating solution is introduced through the fluid connection **130**, flowing upward through tube **126** and down on its outside through the close clearances formed between the tube and the interior surface of the battery can. Application of a plating voltage performs rapid plating of the internal surface of the battery can. The rate of flow and plating voltage may be adjusted to perform high speed electroplating as the part moves on the carrier. Thereafter in the second portion of the processing cycle, the plating voltage is removed and rinse water is connected to hose connection **130** to flow up through tube **126** and down through the close clearance space to thoroughly wash the interior of the battery can.

[0036] Reference to **FIG. 7** shows a work piece holder and surface processing enclosure which may be used both before and after the electroplating operation in surface treatment units **10** and **16** (**FIG. 1**) to utilize various fluids for surface treatment. A work piece holder **140** includes an upwardly extending projection **142** terminating in a hollow tube **144** open at the upper end. A hose connection **146** may be connected to a fluid source and a control valve to supply detergent, rinse water, hot air or other fluid for cleansing or drying the part. A surface processing enclosure **148** includes a spray head **150** with a hose connection **152**. A battery can **154** is shown up-ended over the hollow tube **144**. Any desired combination of surface preparation, cleansing or drying fluids may be supplied through hose connections **146** and **152** either separately or simultaneously as the part is processed. In the preferred embodiment shown, degreasing and activating is done in unit **10** with this type of work piece holder and final rinsing and drying is carried out in unit **16** with the same type of work piece holder. Since the surface processing units are substantially identical except for the variations in work piece holders and surface processing enclosures, considerable savings can be effected in building these automated units. They may be designed to run in parallel or in tandem, the four units disposed in series being only exemplary of many types of surface treatment apparatus. Also, while the units are shown as circular, any desired shape of processing path, such as elliptical, race track, may be utilized with the carrier designed to traverse the processing path, as long as the carrier follows a closed path back to its starting point.

[0037] While the apparatus has been illustrated as processing cylindrical battery cans, any longitudinal shapes such as prismatic battery cans or other type of work pieces having a longitudinal shape of substantially uniform cross section can be processed in the apparatus according to the present invention.

[0038] While there has been disclosed what is considered the preferred embodiment of the invention, other modifications will occur to those skilled in the art, and it is desired to secure in the appended claims all such modifications as fall within the true spirit and scope of the invention.

1. Apparatus for surface treatment of workpieces of the type having a hollow longitudinal casing open on one end with internal and external surfaces and a substantially uniform cross-section along the length of the casing, said apparatus comprising:

- a stationary base defining a workpiece processing path between a loading station and an unloading station,
- a workpiece carrier arranged to traverse along said processing path,
- a plurality of guide members uniformly spaced along the workpiece carrier located so as to successively traverse said processing path,
- a plurality of workpiece holders disposed in said guide members and arranged to be movable in said guide members between a loading / unloading position and a processing position,
- a plurality of surface processing enclosures disposed on said carrier each having an open end and arranged to be movable with respect to a respective workpiece holder between an open position wherein a workpiece is openly disposed on a workpiece holder and a closed position wherein a workpiece is enclosed within a said surface processing enclosure, and

cam and follower means responsive to movement by the workpiece carrier with respect to said stationary base, said cam and follower means being adapted to successively move a workpiece holder at said loading station from said loading/unloading position into said processing position and then to move said surface processing enclosure into said closed position, whereby a workpiece placed in the workpiece holder at said loading station may be processed in said surface processing enclosure while it moves along the processing path to said unloading station.

2. Apparatus according to claim 1, wherein said workpiece processing path is circular about an axis, and wherein said carrier is rotatably mounted on said axis and having a circular periphery, and wherein said guide members are disposed on said periphery.

3. Apparatus according to claim 1, wherein said workpiece holders each include an upwardly extending projection arranged to receive a workpiece casing placed over said projection, and wherein said surface processing enclosures are arranged to enclose a workpiece casing placed over said projection and dimensioned to substantially conform to the external surface of said workpiece casing and form close clearances therewith.

4. Apparatus according to claim 3, wherein said surface processing enclosures include means to selectively inject a workpiece processing fluid into the clearance space between said surface processing enclosure and the external surface of said workpiece casing.

5. Apparatus according to claim 4, wherein said processing fluid is a liquid electrolyte, and further including means to impose a plating voltage between said casing and said surface processing enclosure of a polarity to plate the external surface of the workpiece casing.

6. Apparatus according to claim 4, wherein said processing fluid is a surface cleansing agent.

7. Apparatus according to claim 4, wherein said processing fluid is a surface drying agent.

8. Apparatus according to claim 1, wherein said workpiece holders each include an upwardly extending projection arranged to receive a workpiece casing placed over said projection and dimensioned to substantially conform to the internal surface of said workpiece casing and form close

clearances therewith and wherein said surface processing enclosures are arranged to enclose a workpiece casing placed over said projection.

9. Apparatus according to claim 8, wherein said projection is a hollow tube and further including means to inject a workpiece processing fluid through said hollow tube into the clearance space between said surface processing enclosure and the internal surface of said workpiece casing.

10. Apparatus according to claim 9, wherein said processing fluid is a liquid electrolyte, and further including

means to impose a plating voltage between said casing and said surface processing enclosure of a polarity to plate the internal surface of the workpiece casing.

11. Apparatus according to claim 9, wherein said processing fluid is a surface cleansing agent.

12. Apparatus according to claim 9, wherein said processing fluid is a surface drying agent.

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