

April 15, 1952

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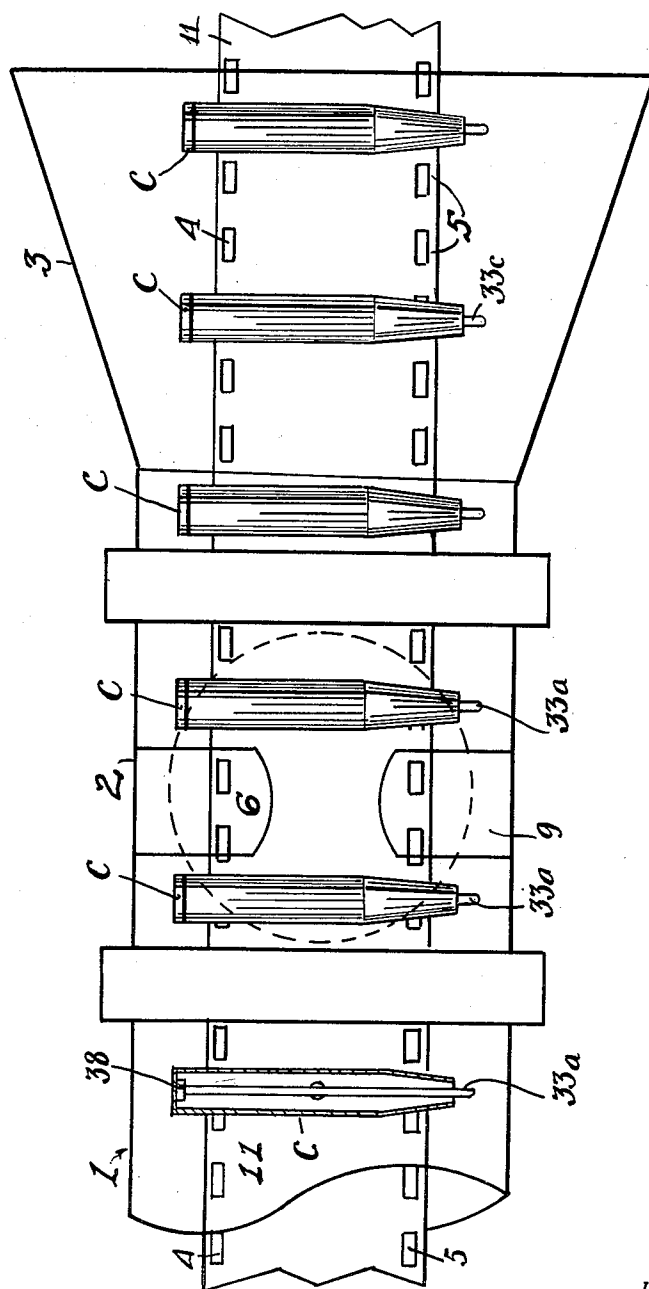
2,592,810

METHOD OF ELECTROLYTICALLY PROCESSING METALLIC ARTICLES

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4 Sheets-Sheet 1

Fig. 1.



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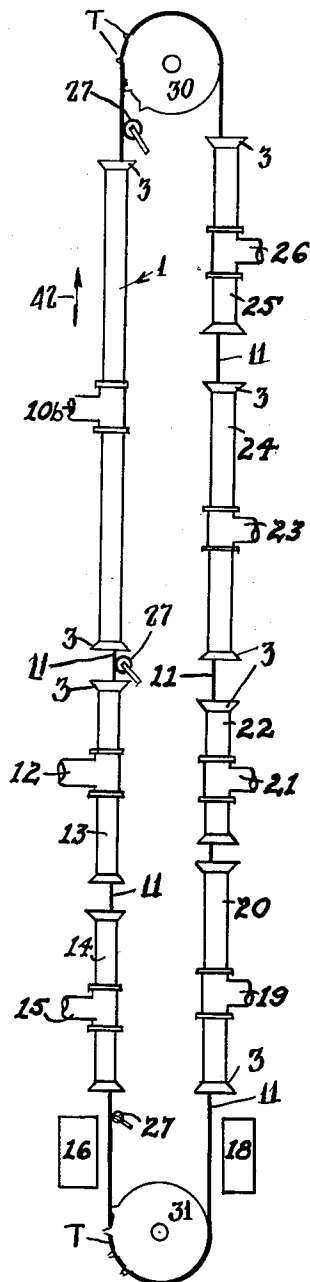


Fig. 4.

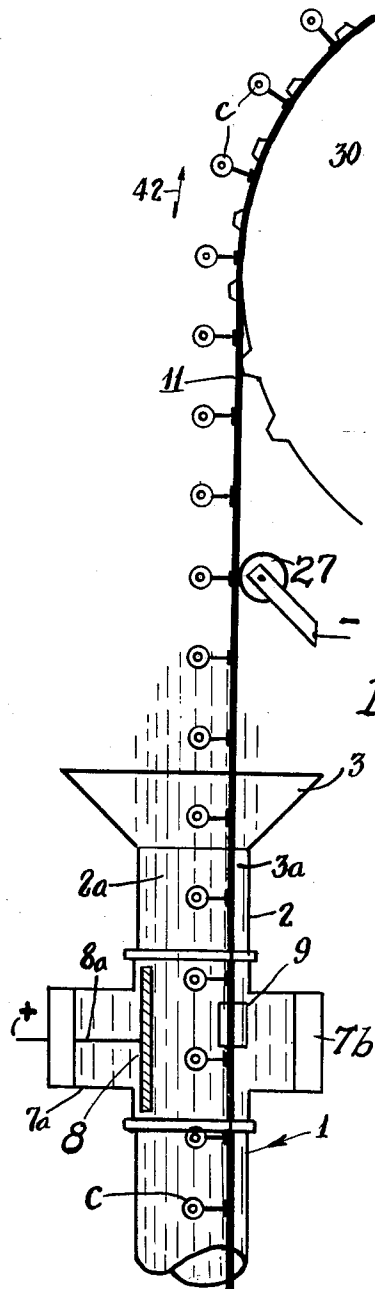


Fig. 3.

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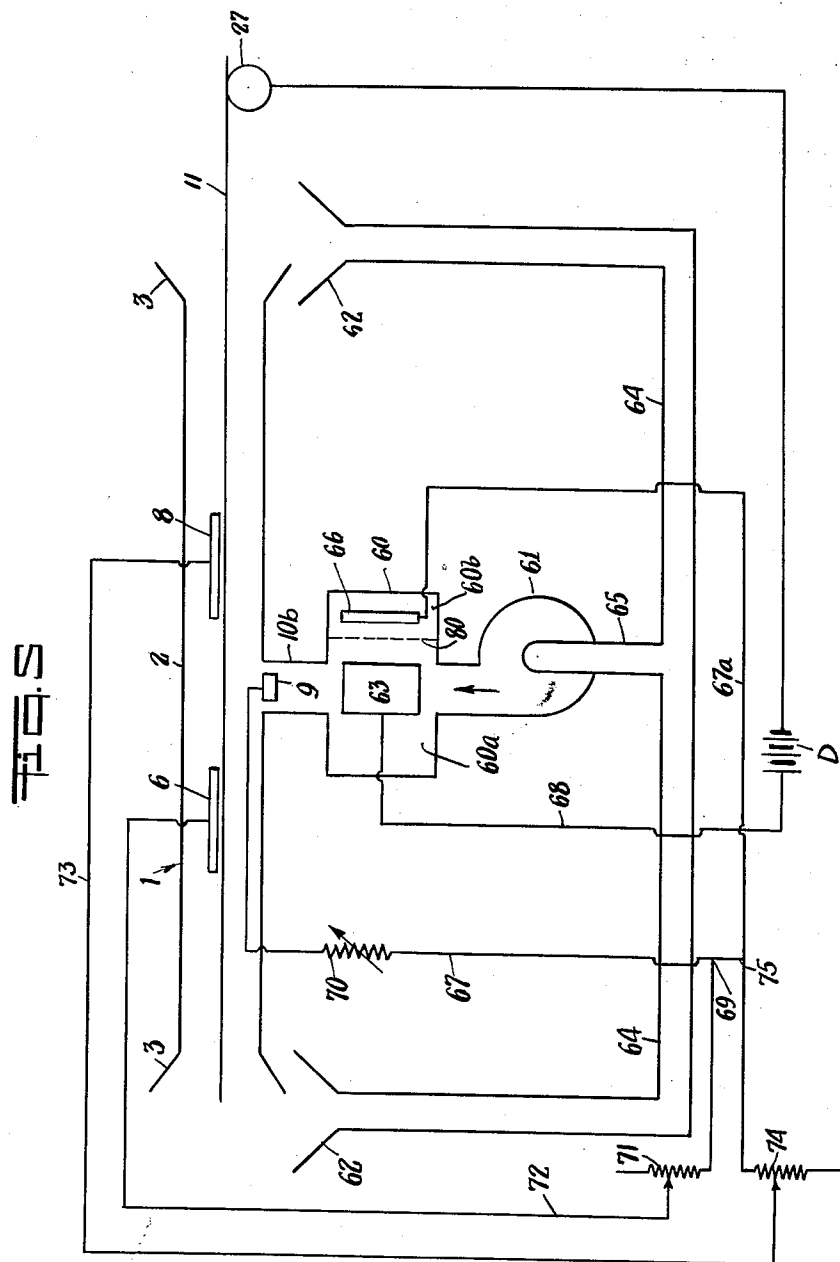
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METHOD OF ELECTROLYTICALLY PROCESSING METALLIC ARTICLES

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4 Sheets-Sheet 4



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METHOD OF ELECTROLYTICALLY PROCESSING METALLIC ARTICLES

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7 Claims. (Cl. 204—25)

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My invention pertains to a method of electrolytically processing or electroplating metallic articles such as cartridge cases and the like. The object of my invention is to speed up and simplify the finishing of such metallic articles.

The invention is described particularly in connection with the zinc plating and finishing of .30 and .50 caliber steel cartridge cases. The invention is not restricted to this purpose as it applies to all other electrolytic processes, such as the gold plating of costume jewelry, anodizing of aluminum parts, chromium plating of metal pieces and the electro-pickling and polishing of various metals and metal objects.

Such cartridge cases are now in many instances made of steel, and they are therefore plated with zinc in order to retard rusting and corrosion. Because of the enormous quantity of these cases that must be plated, mass production plating methods must be resorted to if any volume of production is to be obtained. Up to the present time, the available method for handling this plating has been plating barrels and automatic plating tanks.

The plating barrel has several disadvantages in zinc-plating .30 caliber cases and other objects, because the plating is generally not uniform. Some of the objects will receive deposits of zinc and other electro-deposited metal, much heavier than the specified thickness, whereas others will receive much less. Hence a close tolerance in thickness or weight of deposit cannot be maintained. Another disadvantage is that the plating efficiency (cathode efficiency) of most plating barrels is usually quite low and while a good sized load of work can be handled by them, the time consumed in plating a given thickness of weight of metal on the load, may be considerable. A third and perhaps less important disadvantage is that since these cases are closed at one end thereof, this creates large drag-out losses when such cup-shaped cases are treated in a barrel, and considerable time must be consumed in order to insure proper rinsing in order to avoid staining.

The automatic plating tanks in present use are large, cumbersome and complicated affairs, which have lever arms controlled by mechanism which automatically raise and lower the arms into and out of the plating solution, which is housed in a large rectangular open vat or tank. Each lever arm holds one or more racks of work. The racks are manually loaded by workers and then manually loaded onto the lever arms at the loading station by other workers. Similarly, but

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in reverse, the racks, after the plating has been completed, are manually removed from the lever arms and then manually unloaded by other workers. This involves a large amount of manual labor and time. The most important disadvantage of the automatic tank is that the current density which can be used, is greatly limited because of the type of solution agitation which is available in these rectangular open tanks. The plating period is considerably greater than if more energetic agitation of the plating solution were available. This disadvantage is very serious, when small objects are plated, such as .30 caliber and .50 caliber cartridge cases.

Numerous additional objects and advantages of my invention are stated in the annexed description and drawings, which illustrate several embodiments of my invention.

Fig. 1 is a diagrammatic side elevation which shows the outline of a part of an electro-plating tube, which is one of the elements of my invention, and it also shows a part of the conveyor belt and other elements in side elevation.

Fig. 2 is a transverse cross-section in a vertical plane, partially in elevation, of a different embodiment of the electroplating tube which is shown in Fig. 1, also showing the conveyor belt and certain auxiliary parts.

Fig. 3 is a diagrammatic detail top view of a modification which shows the outline of the electro-plating tube, and also shows certain other parts in top elevation.

Fig. 4 is a diagrammatic view of the complete apparatus which is used in the embodiment of Fig. 1.

Fig. 5 is a detail view, which shows how the electroplating solution is circulated through the electroplating tube.

The apparatus includes an endless, conductive conveyor belt 11, which is made of any metal or alloy which is a good conductor of electricity. As an example, the belt 11 can be made of stainless steel.

Said belt 11 is flexible and it is supported on respective pulleys or sprockets 30 and 31, one of which is actuated in order to operate said conveyor belt 11. Said belt 11 has respective parallel front and rear runs, which are located in respective vertical planes, so that the wide face of each said run is vertical. The front run of said belt is actuated in the direction of arrow 42.

Optionally, and as shown in Fig. 1, the belt 11 can have sprocket holes 4 and 5 adjacent its longitudinal edges, which engage the sprocket teeth T on pulleys 30 and 31. Belt 11 is driven con-

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tinuously at constant speed, in the direction of arrow 42.

As shown in Fig. 2, belt 11 is completely covered by flexible and compressible insulation 32, save for a bare zone 15, which is located midway between the top and bottom edges of said belt and save for the openings where the nuts 34 are located. Said insulation 32 may be vulcanized rubber, or any insulating material. It need not be soft and compressible. Bare zone 15 extends continuously horizontally around the respective face of belt 11.

Metal arms 33, which are equally longitudinally spaced from each other, are fixed conductively to the metal belt 11. For this purpose, metal nuts 34 are conductively fixed to the respective face of belt 11.

Each arm 33 has an externally threaded inner end, which is screwed into a respective nut 34. The assembly is completed by a lock-nut 35, which is made of insulating material or which is coated with insulating material. These lock-nuts 35 complete the insulation of the respective face of belt 11, so that said respective face is wholly insulated. The inner end of each arm 33 is thus insulated from the electroplating solution. The belt 11 is also wholly insulated from the electroplating solution, save at its bare median zone 15, which is transversely aligned with nuts 34.

Each metal arm 33 has a vertical leg 33a. Each arm 33 is covered by insulating material 36, which is spaced from the top of leg 33a. A metal nut 38 is conductively fixed to the bare threaded top portion 37 of each leg 33a.

Each cartridge casing C is supported by gravity on the top of a respective metal nut 38. Each case C can be fixed to a respective leg 33a, in any suitable manner. Each casing C is thus held conductively connected to the belt 11.

The front and rear runs of the belt 11, with the cartridge cases C supported on the legs 33a, are moved through a front series of tubes and a rear series of tubes. These tubes are of essentially the same construction.

Fig. 2 shows an electroplating tube 1, which has a vertical inlet tube 10a, through which the electroplating solution is forced downwardly from a suitable tank, into the electroplating tube 1. The impact of the inwardly flowing current of electroplating solution is thus received upon the closed tops of the cartridge cases C, so that said downward impact does not tend to dislodge the cases C from the nuts 38. Fig. 4 shows the use of horizontal inlets for the respective horizontal inlet tubes, as an alternative.

In each embodiment, the incoming current of electrolyte strikes the cartridge case C which is temporarily aligned with the respective inlet. The inlet may be aligned with two or more cartridge cases C.

The electroplating tube 1 is cylindrical, and it has flared ends 3.

In the embodiment of Fig. 2, internal anodes 6, 8, and 9 are located in the electroplating tube 1. These anodes are fixed in the positions shown in Fig. 2, by any conventional means. These anodes 6, 8, and 9 are connected to the positive terminal of a source of direct current D. These anodes 6, 8, and 9 are located close to the inlet port of tube 1, through which the electroplating solution enters. These anodes 6, 8, and 9 can be made of material which is inert to the electroplating solution, such as graphite, stainless steel, etc. These anodes are not dissolved in the electroplating process.

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The tube 1 is made of non-conductive material which is inert to the electroplating solution.

As an example, if a cartridge case is to be plated with zinc, the electroplating solution may be an aqueous solution of sodium zincate, $\text{Zn}(\text{ONa})_2$, or preferably NaHZnO_2 , and of the double cyanide, $\text{Zn}(\text{CN})_2 \cdot 2\text{NaCN}$.

As an example, such solution can be made by dissolving 8 ozs. of zinc cyanide, 3 ozs. of sodium cyanide, and 7 ozs. of sodium hydroxide, in a gallon of water. The invention is not limited to any specific plating solution.

The internal wall of the electroplating tube 1 is provided with vertical fins 10 and 7 which are shown in Fig. 2, and which are made of non-conductive and inert material. These vertical fins 10 and 7 are vertically separated from each other, in order to provide a horizontal space in which the horizontal legs of arms 33 can move through said tube 1, and the other tubes. Said fins 10 and 7 may be integral with the tube 1 and the other tubes.

The belt 11 may optionally be under sufficient tension so that its fully insulated face makes liquid-tight sliding contact with the fins 10 and 7, thus separating each tube into respective chambers 3a and 2a.

The entering stream of electroplating solution may be confined to the wide chamber 2a. This is not essential, because electroplating solution can enter chamber 3a directly through the vertical inlet tube 10a, or by leakage from chamber 2a, if the soft and compressible insulation 32 does not make liquid-tight contact with fins 10 and 7.

It is optional to prevent the electroplating solution from contacting with the bare zone 15.

If the inlet tube 10b is horizontal, as shown in Fig. 4, said inlet tube opens into wide chamber 2a. That is, the narrow chambers 3a of the tubes face each other in Fig. 4, and said chambers 3a are located between chambers 2a.

As shown in Fig. 4, turnable rolls 27 contact with bare zone 15. These rolls 27 are connected to the negative terminal of the source D of direct current.

Fig. 5 shows inlet tube 10b of Fig. 1, which corresponds to inlet tube 10a of Fig. 2, connected to an outlet port of a tank 60, which is closed save for said outlet port, and save for an inlet port which is connected to the outlet or delivery end of a pump 61. The flared ends 3 of tube 1 are located above collecting troughs 62, which are connected to the inlet or intake end of pump 61, by pipes 64 and 65. A soluble anode 63, which is made of zinc in this example, is located in tank 60. Said anode 63, like the anodes 6, 8, and 9, is connected to the positive terminal of current source D, which may be a battery or dynamo or of any other type. I can use rectified alternating current as the electroplating current.

The tank 60 is maintained filled with the electroplating solution. A permeable or porous diaphragm 66, made of unglazed porcelain or other well known material, separates tank 60 into two compartments 60a and 60b, each of which is maintained filled with said solution. An insoluble electrode 66, which is made of stainless steel or the like, is located in compartment 60b.

Soluble anode 63, which is made of zinc in this example, is connected to the positive terminal of source D, by wire 68.

Insoluble anode 9, which is optionally located in inlet tube 10b, is connected through adjustable resistance 70 to wire 67, which is connected

at 69, through an adjustable resistance 71, to wire 72, which is connected to insoluble anode 6. Insoluble anode 8 is connected by wire 73, through adjustable resistance 74, to point 75 of wire 67. Wire 67a connects point 75 to the insoluble electrode 66.

The direct current passes from the positive terminal of source D, to soluble or replenishing electrode 63, through the electroplating solution in compartment 60a, through diaphragm 80, through the electroplating solution in compartment 60b to insoluble electrode 66, through wire 67a, to wire 67. There is little or no resistance between points 69 and 75, so that these points constitute a common junction point for the branch circuits of the insoluble electrodes in tube 1.

From this junction point, the current passes through the respective adjustable resistors 70, 71, and 74, to the insoluble anodes 9, 6, and 8, through the electroplating solution which fills the cylindrical part 2 of the electroplating tube 1, to the casings C and belt 11, and through the contact roll or rolls 27, to the negative terminal of the source of direct current D.

The voltage of source D may be 2-10 volts. It is sufficient to decompose the respective electroplating solution, if an insoluble anode and an insoluble cathode are used, such as two electrodes made of graphite, etc.

There is sufficient potential difference between electrodes 63 and 66, so that the soluble or replenishing electrode 63 delivers zinc ions to the electroplating solution, in order to replenish said solution. The zinc salt which is formed by said replenishing action, does not pass through the diaphragm 80. The electroplating solution is thus maintained at the desired concentration, as it is forced through inlet tube 10 into the electroplating tube 1.

The insoluble anodes 6, 9, and 8 are as close as possible to the casings C, so that there is minimum resistance through the electroplating solution between said insoluble anodes and the casings C. Fig. 1 shows electrode 6 aligned with electrode 9. If the insulation 32 fits liquid-tight or substantially liquid-tight, against the fins 10 and 7, there is very high resistance through the electroplating solution, between the insoluble anodes and the bare zone 15 of the belt 11. Likewise, the resistance through the electroplating solution between the soluble anode 63 and said bare zone, is so great that the deposit of zinc on said bare zone 15 is negligible. Any such deposit can be easily removed by electrolytic stripping or by mechanical means, whenever required.

Even if the fins 10 and 7 are omitted, the same result can be secured, even if the electroplating solution contacts with bare zone 15.

This method of replenishing the electroplating solution cannot be used for electrodepositing all metals. It cannot be used, for example, in electrodepositing chromium. In such case, the electroplating solution is replenished by dissolving additional material therein, in tank 60. For example, in chromium plating, additional chromium trioxide, CrO_3 , is dissolved in the water in tank 60, in order to supply additional chromic acid. The electroplating solution can be replenished by dissolving additional salt or salts therein, in electrodepositing any metal. Hence it is optional to use a replenishing electrode, or to use the replenishing method disclosed herein.

If the first-mentioned replenishing method is used, the supply of current to the insoluble anodes

and to the replenishing anode is regulated, so that the replenishing electrode delivers zinc ions to the electroplating solution, at the rate at which such ions are removed by the electrodeposition. The connection between anode 63 and the positive terminal can also include an adjustable resistor, like the adjustable resistors 70, 71, and 74.

The electrode 9 may be omitted, or if used, it may be non-aligned with the inlet tube 10a or 10b. The major part of the electrodeposition may take place directly at the part at which the inlet tube 10b or 10a is connected to the electroplating tube. I can use any number of insoluble electrodes in the cylindrical part 2 of electroplating tube 1, and these insoluble electrodes can be located throughout said entire cylindrical part 2.

The stream of electroplating solution flows through the electroplating zone, at a sufficiently high velocity to produce turbulent flow in the electroplating zone, which is in the cylindrical part 2 of tube 1. This turbulent flow is defined by the Reynolds number.

As explained, for example, on pp. 188-195 of "Hydraulics" by Russell, published in 1942 by Henry Holt & Company, Inc., the critical velocity, above which laminar flow changes to turbulent flow, corresponds to a Reynolds number of 2000-3000. Turbulent flow is always secured when the Reynolds number exceeds 3000, save under unusual conditions.

The formula for the Reynolds number is,

$$\frac{vD}{u}$$

in which v is velocity of flow of the electroplating solution in feet per second; d is the density of the electroplating solution, in pounds per cubic feet, D is the internal diameter of the cylindrical part of the electroplating tube in feet; and u is the viscosity in pound-seconds per square foot of the electroplating solution.

As an example, if the height of the cartridge case is about 2 inches, the internal diameter of the cylindrical part 2 of the tube 1 is about 3 inches. In such case, the electroplating solution is forced with sufficient velocity into and through the tube 1, so that the velocity of the electroplating solution in the electroplating zone is 8-10 feet per second. I can use a velocity of flow of electroplating solution in the electroplating zone, which corresponds to a Reynolds number as high as 10,000,000 and more. The velocity of flow should preferably correspond to a Reynolds number of at least 100,000 in the electroplating zone, which is in the cylindrical part 2 of tube 1.

The electroplating solution flows horizontally in opposed directions through the tube 1, in substantially equal proportions, and in respective opposed directions.

I can use a plating current whose density is as high as 5,000 amperes per square foot, in comparison with the maximum density of 40-50 amperes per square foot, which is now generally used in plating steel with zinc. I can also thus greatly accelerate the electroplating while electrodepositing other metals, although the maximum current density will vary with each electrodeposited metal. The electroplating is uniform, and of as good quality as in using the much lower current density above mentioned.

The modification of Fig. 3 shows the tube 1 provided with an inlet extension 7a, through which an insoluble anode 8 can be inserted into tube 1. It also shows a rigid insulated wire or bar 8a, which is connected to anode 8 and which

extends through a plug of extension 7a. Said plug may optionally fill extension 7a. Tube 1 has an additional extension 7b which is also closed by a plug, which optionally fills extension 7b so that tube 1 will have a uniform inner cylindrical wall. These plugs are made of insulating and inert material.

Fig. 4 shows a loading station 16 at which the operator places the cartridge cases C on the metal nuts 38; an electrolytic cleaning tube 14 which has an inlet 15 for the electrocleaning solution; a rinsing tube 13, which has an inlet 12 for clean rinsing water; the electroplating tube 1 which has a horizontal inlet 10b; another rinsing tube 25 which has an inlet 26 for admitting clean rinsing water; a tube 24, which has an inlet 23 for admitting a standard chromate solution for protecting the zinc plating; a rinsing tube 22 which has an inlet 21 for admitting rinsing water; a drying tube 20 which has an inlet 19 for admitting hot air or the like; and an unloading station 18.

Each said tube has the same internal construction which is shown in Fig. 2. The inlets of said tubes may be vertical.

The flared ends 3 of the electroplating tube 1 are sufficiently flared, so that the velocity of flow of the electroplating solution out of the front and rear flared ends 3 of said tube 1, is about 10-20% or less of the velocity of flow in the electroplating zone in the cylindrical part 2 of tube 1. The entire cylindrical part 2 of tube 1, is always completely filled with the solution.

In each case where I treat the cartridge cases with a liquid or gas or mixture of gases, I prefer that the velocity of flow of the liquid or gas in the cylindrical part of each said tube 14, 13, 25, 24, 22, and 20 should greatly exceed the critical velocity of the respective liquid or gas. In each said tube 14, 13, 25, 24, 22, and 20, the incoming liquid or gas impacts upon the respective cartridge case or cases which are alined with the respective inlet tube, and said current of gas or liquid then flows longitudinally in equal proportions out of the front and rear ends of the respective tube.

The respective liquids are collected at the ends of the respective tubes, in the manner shown in Fig. 5. Each liquid has a reduced velocity of flow, as it passes out of the respective tube, as above stated.

In the electrocleaning operation, I can use conventional electrocleaning solutions.

If sprocket holes 4 and 5 are provided, which is optional, the belt is insulated at said holes, and at the edges of said holes.

The diameter of the inlet tube 10b or 10a is preferably selected so that the incoming stream of plating solution has a turbulent flow in said inlet tube, corresponding to a Reynolds number of at least 100,000, and preferably ten million and more.

In order to use high current density, it is necessary to minimize the thickness of the polarization film which is formed on the object C. The thickness of this film is approximately inversely proportional to the Reynolds number. By minimizing the thickness of said film, I can use a higher current density.

I prefer that the electroplating tube and the other tubes shown herein, should have horizontal axes.

The liquid or gas which laterally enters the respective tube, is projected against the longitudinal wall of the respective tube, thus creating

high turbulence in the main electroplating zone in which all or a major part of the electroplating is performed. This main electroplating zone is preferably wholly located in that part of the electroplating tube, in which the solution has the high turbulence which is caused by its change of direction.

The invention is not limited to the use of an electroplating tube which has a horizontal axis, or to an inlet tube which is perpendicular to the electroplating tube. It is not limited to the use of a tube through which the solution flows in equal and oppositely directed streams.

By making the end-portion 3 of sufficient length and taper, the velocity of the solution which passes out of the tube 1 is sufficiently reduced, so that said outgoing solution is collected by gravity in the collecting troughs 62, without spattering or loss.

Numerous changes and omissions and additions can therefore be made in or to the preferred disclosure herein without departing from the scope of the invention.

I claim:

1. A method of electroplating an object in a non-conductive tube which is open at each end thereof and which is closed intermediate said ends save at a lateral inlet of said tube which is located intermediate said open ends, which consists in moving said object unidirectionally into said tube through one of said ends and through said tube and out of said tube through the other of said ends, connecting said object during said movement to the negative terminal of a source of unidirectional current, forcing liquid electrolyte laterally into said tube at said lateral inlet to strike said object laterally at said inlet, said liquid electrolyte being thus forced laterally into said tube at said inlet at sufficient lateral velocity to strike the part of the closed wall of said tube which is alined laterally with said inlet and to abruptly change the direction of said laterally forced liquid electrolyte and to produce a zone of turbulence at said inlet and said part of said closed wall, said lateral velocity being sufficient to fill said tube and to produce respective streams of electrolyte which flow in respective opposed directions in turbulent flow away from said lateral inlet towards and out of said open ends, and passing unidirectional plating current from the positive terminal of said source through anode means and said electrolyte, said anode means being at least partially located in said zone of turbulence.

2. A method of electroplating an object in a non-conductive tube which is open at each end thereof and which is closed intermediate said ends save at a lateral inlet of said tube which is located intermediate said open ends, which consists in moving said object unidirectionally into said tube through one of said ends and through said tube and out of said tube through the other of said ends, connecting said object during said movement to the negative terminal of a source of unidirectional current, forcing liquid electrolyte laterally into said tube at said lateral inlet to strike said object laterally at said inlet, said liquid electrolyte being thus forced laterally into said tube at said inlet at sufficient lateral velocity to strike the part of the closed wall of said tube which is alined laterally with said inlet and to abruptly change the direction of said laterally forced liquid electrolyte and to produce a zone of turbulence at said inlet and said part of said closed wall, said lateral velocity being suf-

ficient to fill said tube and to produce respective streams of electrolyte which flow in respective opposed directions in turbulent flow away from said lateral inlet towards and out of said open ends, and passing unidirectional plating current from the positive terminal of said source through anode means and said electrolyte, said anode means being confined and located sufficiently close to said lateral inlet to perform the major part of said electroplating at said lateral inlet.

3. A method of electroplating an object in a non-conductive tube which is open at each end thereof and which is closed intermediate said ends save at a lateral inlet of said tube which is located intermediate said open ends, which consists in moving said object unidirectionally into said tube through one of said ends and through said tube and out of said tube through the other of said ends, connecting said object during said movement to the negative terminal of a source of unidirectional current, forcing liquid electrolyte laterally into said tube at said lateral inlet to strike said object laterally at said inlet, said liquid electrolyte being thus forced laterally into said tube at said inlet at sufficient lateral velocity to strike the part of the closed wall of said tube which is aligned laterally with said inlet and to abruptly change the direction of said laterally forced liquid electrolyte and to produce a zone of turbulence at said inlet and said part of said closed wall, said lateral velocity being sufficient to fill said tube and to produce respective streams of electrolyte which flow in respective opposed directions in turbulent flow away from said lateral inlet towards and out of said open ends, and passing unidirectional plating current from the positive terminal of said source through anode means and said electrolyte, said anode means being confined and located sufficiently close to said inlet to perform substantially all said electroplating at said inlet, said anode means being at least partially located in said zone of turbulence.

4. A method of electroplating an object in a non-conductive tube which is open at each end thereof and which is closed intermediate said ends save at a lateral inlet of said tube which is located intermediate said open ends, which consists in moving said object unidirectionally into said tube through one of said ends and through said tube and out of said tube through the other of said ends, connecting said object during said movement to the negative terminal of a source of unidirectional current, forcing liquid electrolyte laterally into said tube at said lateral inlet to strike said object laterally at said inlet, said liquid electrolyte being thus forced laterally into said tube at said inlet at sufficient lateral velocity to strike the part of the closed wall of said tube which is aligned laterally with said inlet and to abruptly change the direction of said laterally forced liquid electrolyte and to produce a zone of turbulence at said inlet and said part of said closed wall, said lateral velocity being sufficient to fill said tube and to produce respective streams of electrolyte which flow in respective opposed directions in turbulent flow away from said lateral inlet towards and out of said open ends, and passing unidirectional plating current from the positive terminal of said source through anode means and said electrolyte, the velocity of flow of said electrolyte in said tube corresponding to a minimum Reynolds number of 100,000, said anode means being at least partially located in said zone of turbulence.

5. A method of electroplating an object in a non-conductive tube which is open at each end thereof and which is closed intermediate said ends save at a lateral inlet of said tube which is located intermediate said open ends, which consists in moving said object unidirectionally into said tube through one of said ends and through said tube and out of said tube through the other of said ends, connecting said object during said movement to the negative terminal of a source of unidirectional current, forcing liquid electrolyte laterally into said tube at said lateral inlet to strike said object laterally at said inlet, said liquid electrolyte being thus forced laterally into said tube at said inlet at sufficient lateral velocity to strike the part of the closed wall of said tube which is aligned laterally with said inlet and to abruptly change the direction of said laterally forced liquid electrolyte and to produce a zone of turbulence at said inlet and said part of said closed wall, said lateral velocity being sufficient to fill said tube and to produce respective streams of electrolyte which flow in respective opposed directions in turbulent flow away from said lateral inlet towards and out of said open ends, and passing unidirectional plating current from the positive terminal of said source through anode means and said electrolyte, the velocity of flow of said electrolyte in said tube corresponding to a minimum Reynolds number of 10,000,000, said anode means being at least partially located in said zone of turbulence.

6. A method of electroplating an object in a non-conductive tube which is open at each end thereof and which is closed intermediate said ends save at a lateral inlet of said tube which is located intermediate said open ends, which consists in moving said object unidirectionally into said tube through one of said ends and through said tube and out of said tube through the other of said ends, connecting said object during said movement to the negative terminal of a source of unidirectional current, forcing liquid electrolyte laterally into said tube at said lateral inlet to strike said object laterally at said inlet, said liquid electrolyte being thus forced laterally into said tube at said inlet at sufficient lateral velocity to strike the part of the closed wall of said tube which is aligned laterally with said inlet and to abruptly change the direction of said laterally forced liquid electrolyte and to produce a zone of turbulence at said inlet and said part of said closed wall, said lateral velocity being sufficient to fill said tube and to produce respective streams of electrolyte which flow in respective opposed directions in turbulent flow away from said lateral inlet towards and out of said open ends, and passing unidirectional plating current from the positive terminal of said source through anode means and said electrolyte, said anode means being confined and located sufficiently close to said lateral inlet to perform the major part of said electroplating at said lateral inlet, the velocity of flow of said electrolyte in said tube corresponding to a minimum Reynolds number of 100,000.

7. A method of electroplating an object in a non-conductive tube which is open at each end thereof and which is closed intermediate said ends save at a lateral inlet of said tube which is located intermediate said open ends, which consists in moving said object unidirectionally into said tube through one of said ends and through said tube and out of said tube through the other of said ends, connecting said object during said

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movement to the negative terminal of a source of unidirectional current, forcing liquid electrolyte laterally into said tube at said lateral inlet to strike said object laterally at said inlet, said liquid electrolyte being thus forced laterally into said tube at said inlet at sufficient lateral velocity to strike the part of the closed wall of said tube which is alined laterally with said inlet and to abruptly change the direction of said laterally forced liquid electrolyte and to produce a zone of turbulence at said inlet and said part of said closed wall, said lateral velocity being sufficient to fill said tube and to produce respective streams of electrolyte which flow in respective opposed directions in turbulent flow away from said lateral inlet towards and out of said open ends, and passing unidirectional plating current from the positive terminal of said source through anode means and said electrolyte, said anode means being confined and located sufficiently close to said inlet to perform substantially all said electroplating at said inlet, the velocity of flow of said electrolyte in said tube corresponding to a minimum Reynolds number of 10,000,000, said anode means being at least partially located in said zone of turbulence.

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