June 19, 1973 AKIRA MIYATA ET AL 3,740,323

MOLTEN SALT ELECTROPLATING METHOD

Filed Oct. 26, 1970 4 Sheets-Sheet 1

FIG. 1

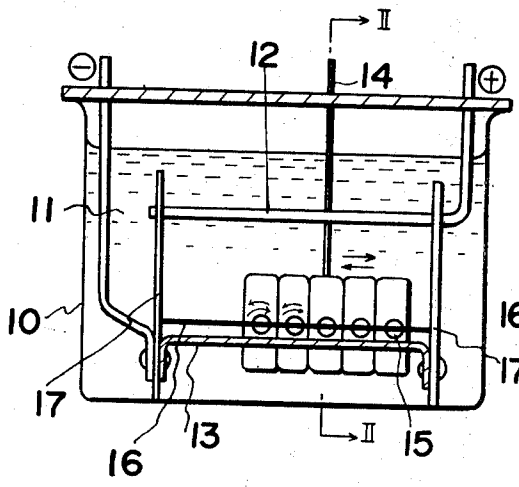


FIG. 2

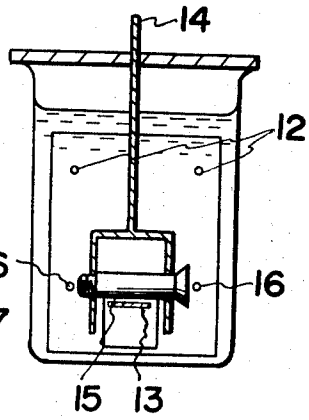


FIG. 3

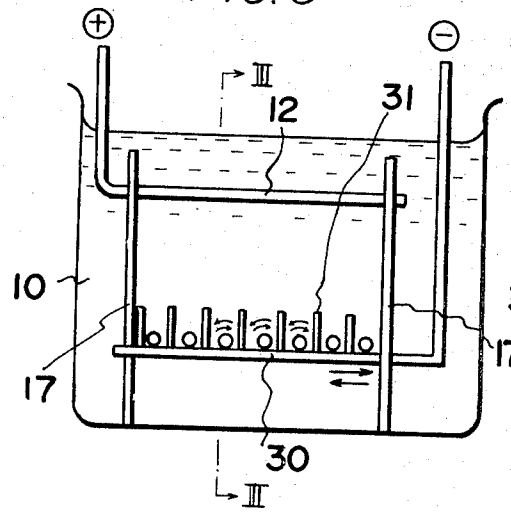
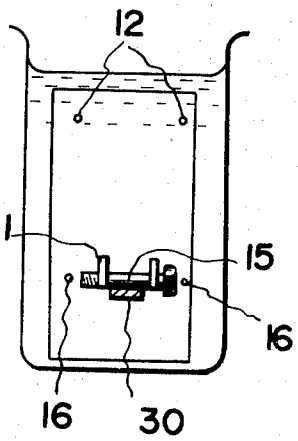


FIG. 4



MOLTEN SALT ELECTROPLATING METHOD

Filed Oct. 26, 1970 4 Sheets-Sheet 2

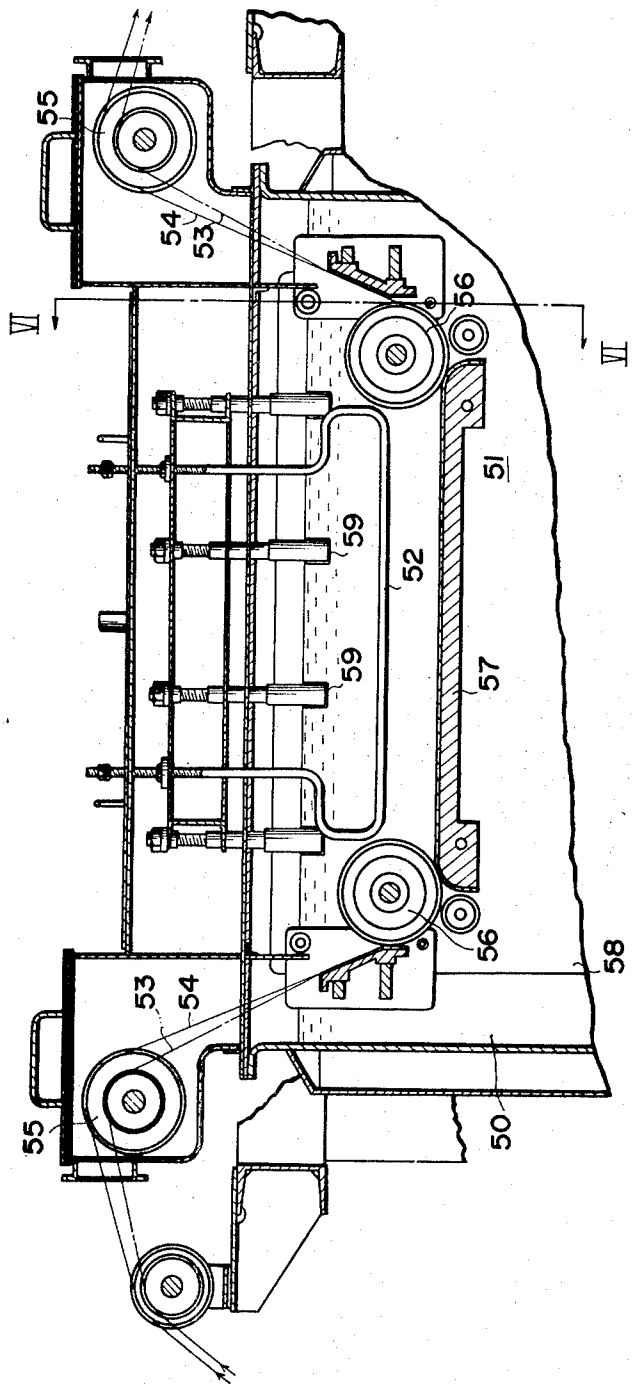


FIG. 5

FIG. 6

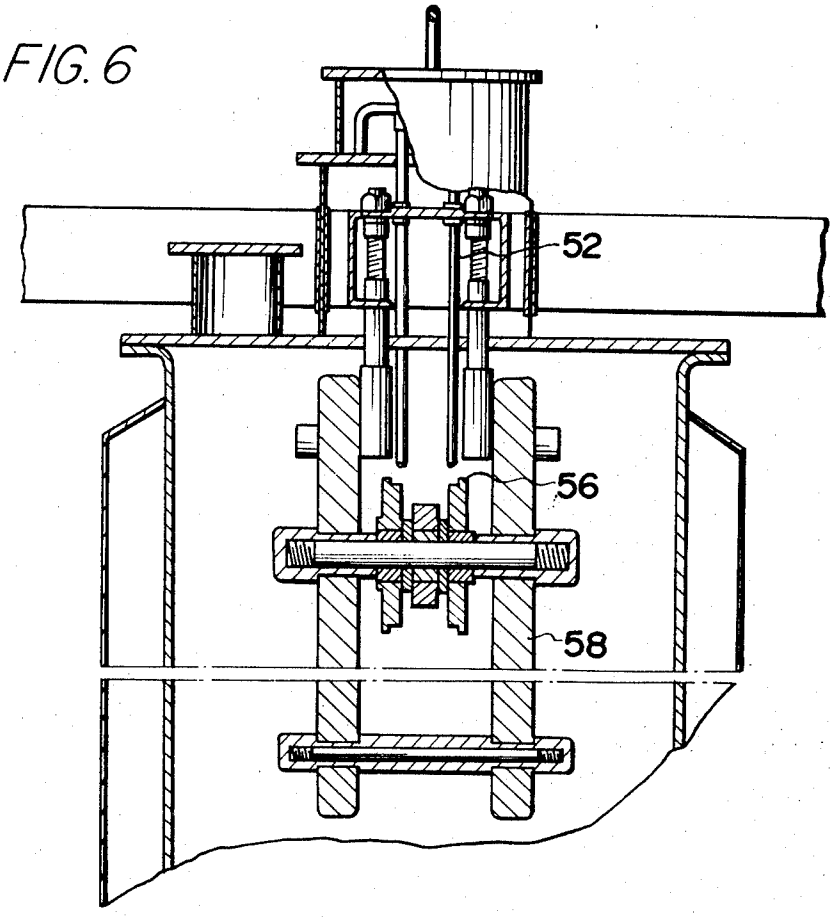


FIG. 7a

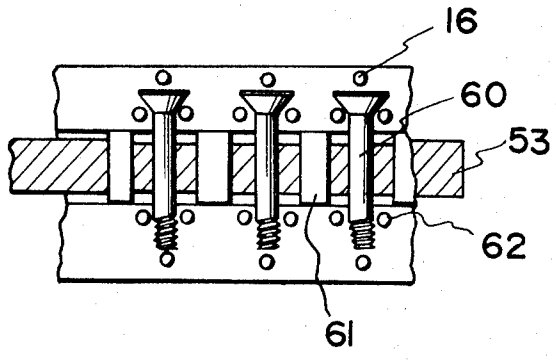


FIG. 7b

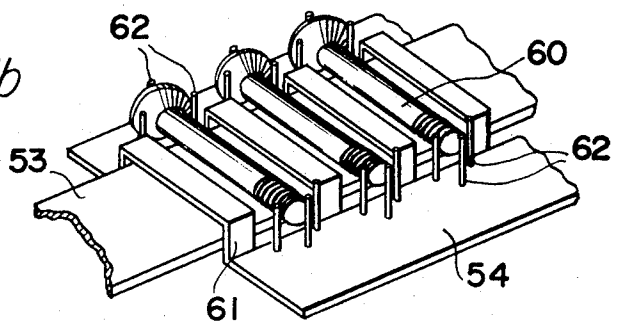


FIG. 8

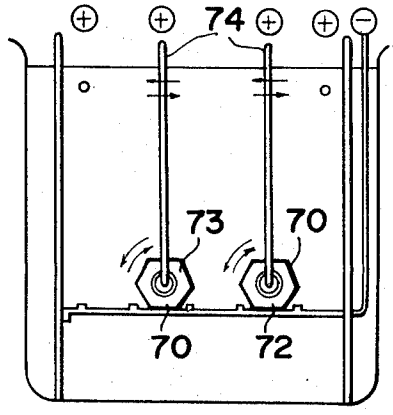
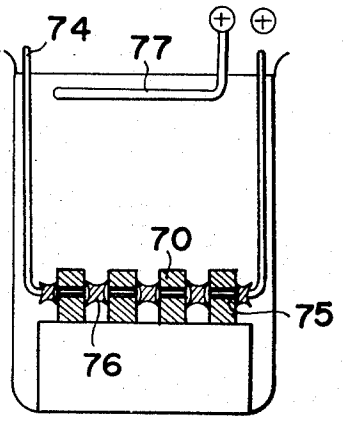


FIG. 9



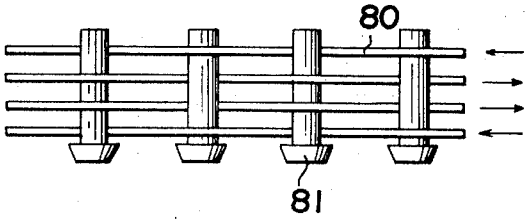


FIG. 10a

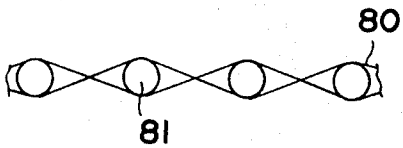


FIG. 10b

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3,740,323

MOLTEN SALT ELECTROPLATING METHOD

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Int. Cl. C23b 5/56; B01k 3/00
U.S. Cl. 204—25 1 Claim

ABSTRACT OF THE DISCLOSURE

Method and apparatus for electroplating a plurality of articles such as bolts, nuts, rivets, machine screws, and the like, in a molten salt bath wherein the articles are located in a spaced relationship on a cathode member in the bath. The articles are in line or face electrical contact with the cathode member and are caused to rotate on the cathode member. Preferably, relative movement is imparted between the cathode member and a holding means for the articles to cause the rotation of the articles relative to the cathode member.

FIELD OF INVENTION

This application has to do with a method for electroplating a plurality of articles and with apparatus therefor.

BACKGROUND OF INVENTION

Conventionally, a method called "Barrel Plating Method" has been very often used among the techniques of electroplating a number of bolts, nuts, rivets, machine screws and the like. However, there are several disadvantages present in this method. Only limited number of point-contacts can be obtained between the above-mentioned pieces and between the pieces and the cathode, so that the electric resistance becomes too high to assure uniform cathode current to the whole pieces to be coated in a barrel or basket and consequently to obtain a sufficient current for electroplating. As the cathode current flows through the point-contacts of high electrical resistance, the remote parts of pieces farther from the cathode become anodic, and the electrodeposited metals tend to be dissolved, discolored and non-uniform in such parts of the pieces. These phenomena take place on numberless contact points of pieces to be coated caused by the rotations of the barrel, so that many small defects can be scattered over the coating layers provided according to this method. These disadvantages can be especially pronounced in the molten salt electroplating treatment.

DETAILED DESCRIPTION OF INVENTION

The present invention relates to a method of electroplating, in a molten salt bath, a plurality of bolts, nuts, rivets, machine screws and the like made of metals such as iron, steel, titanium alloys, etc., and to an apparatus for carrying out the method, and is devised to provide good and beautiful smooth coatings on the surfaces of the pieces to be plated.

The present invention was conceived and developed under the above-mentioned background. Therefore, the object of the present invention is to prevent all the pieces to be coated from coming in point-contact with the cathode supplying an electroplating current, and to make the pieces in line or face contact directly with the cathode so as to be able to lower the excess current-density in the contacted parts of the piece and to easily supply an electroplating current to the pieces to be coated.

SUMMARY OF THE INVENTION

The present invention is devised to provide:

(a) A molten salt electroplating method for bolts, nuts and the like comprising aligning a plurality of pieces to be coated with equal spaces therebetween and in line or face contact with the cathode, and electroplating the pieces in rotation in a plating bath,

(b) A molten salt electroplating method for bolts, nuts and the like comprising supporting a plurality of pieces to be coated by auxiliary anodes, making the pieces in line or face-contact with the cathode and electroplating the pieces under rotation in an electroplating bath,

(c) A molten salt electroplating method for bolts, nuts and the like comprising aligning a plurality of pieces to be coated with equal spaces therebetween, weaving the pieces into a kind of plain fabric with a plurality of cathode wires and electroplating the pieces in rotation and movement in a plating bath, and

(d) Molten salt electroplating apparatus for carrying out the above methods, and specifically, an apparatus containing, in a plating bath, an anode rod hanging and freely moving up and down, a cathode belt, a fastener belt supporting and carrying a plurality of pieces to be coated on the said cathode belt so that the said pieces can be rotated freely and in contact with the said cathode belt, driving rollers and guide rollers for the said cathode and fastener belts, and a shoe placed between two sets of said guide rollers.

DRAWINGS

The present invention will be more clearly understood from the following description of some examples of embodiments according to the present invention and the accompanying drawings, in which:

FIGS. 1 and 2 show an electroplating apparatus according to the present invention containing a fixed cathode,

FIGS. 3 and 4 show an electroplating apparatus according to the present invention containing a movable cathode,

FIGS. 5 and 6 show an electroplating apparatus according to the present invention containing a belt cathode,

FIGS. 7(*a*) and 7(*b*) are an enlarged plan and an oblique perspective of the cathode and fastener belts as shown in FIGS. 5 and 6,

FIGS. 8 and 9 show an electroplating apparatus for nuts and the like according to the present invention, and

FIGS. 10(*a*) and 10(*b*) are plan and side elevations showing the contact of bolts with cathode wires which weave their way between bolts.

Especially in the case of electroplating bolts, it is advantageous to place the bolt shank in line-contact with the cathode. Besides, to obtain a uniform coating on the whole surface of bolt shank, it is desirable to rotate the bolt on the cathode, to rotate the bolt by moving the cathode, or to move both the bolt and the cathode so as to assure a face contact of the whole surface of the bolt shank with the cathode.

SPECIFIC EMBODIMENTS OF THE INVENTION

Example 1

1.2 kg. of molten salt comprising 60 mol percent of anhydrous aluminium chloride, 25 mol percent of sodium chloride and 15 mol percent of potassium chloride was put in a cylindrical glass receptacle and heated from the exterior so as to maintain the temperature of the salt at 160° C. In this bath was soaked an electrode holder which supports an aluminium plate as cathode plate, 1 mm. in thickness, 15 mm. in width and 80 mm. in length, and two aluminium wires as anodes, 3 mm. in diameter and 80 mm. in length, placed at a height of 80 mm. from the cathode plate.

5 flush head screws (of titanium alloy) to be coated for use in aircraft, 7 mm. in diameter of shank and 34 mm. in total length were cleaned, soaked in the plating bath with the shanks of the screws mounted on the cathode plate partitioned from one another by a glass holder and then electroplated on turning the screws on the cathode plate by moving the glass holder back and forth.

The treatment of aluminium electroplating was executed by supplying a DC current of 1 volt and 2 amperes between the cathode and the anode for 30 minutes, and moving the glass holder by 20 mm. right and left at a rate of two reciprocations per minute so as to assure slow rotation of the screws to be coated. As a result, uniform and smooth aluminium coatings of 10 microns in thickness were obtained on the whole surfaces of the screws.

This example can be carried out by using an apparatus as shown in FIGS. 1 and 2. FIG. 2 is a sectional elevation of the apparatus according to the present invention cut on the line II—II in the FIG. 1.

An electroplating tank **10** contains a plating bath **11**, in which an aluminium anode rod **12**, a cathode plate **13** and a glass holder **14** are submerged. The bolts **15** to be coated are aligned on the cathode plate **13**, spaced and separated by the glass holder **14** from each other, so that the bolt shanks can be in line-contact with the cathode plate. Two guiding rods of glass **16** are also used to prevent the bolts from spilling out of the holder **14**. If the glass holder **14** is moved right and left in the directions of the arrows shown in FIG. 1, by means of a moving means **17**, the bolt shanks can be easily made in face-contact with the cathode plate. The cathode plate **13** described in this example of embodiment and shown in FIG. 1 is fixed, but it can be movable, as in Example 2, which is explained below. The moving means **17** may be a motor driven mechanism or the like. Its construction should be apparent to those skilled in the art and is not shown herein for the sake of clarity.

Example 2

The treatment of molten salt aluminium electroplating was applied to hexagon headed bolts of high tension steel (9 mm. in diameter of shank and 54 mm. in total length). The composition of the molten salt and the temperature of electroplating in use were as same as in Example 1.

This time, the treatment of electroplating bolts were effected by placing the bolts in fixed positions on the cathode plate so that the bolt shanks can be in line-contact with the cathode plate and moving the cathode plate so as to assure rotation of the bolts. The anode was a pure aluminium rod and the cathode plate was an aluminium plate. The holder **17** can be made of Teflon, glass, porcelain or other heat and corrosion resisting electrically insulating materials.

20 hexagon headed bolts of steel and of the above-mentioned dimensions were put in this apparatus, and electroplated for 30 minutes at 1 volt and 5 amperes of current on moving the cathode plate by about 30 mm. right and left at a low velocity of 3 reciprocations per minute. As a result, uniform, smooth, white and beautiful aluminium coatings of about 8 microns in thickness were obtained on the whole surfaces of bolts.

This example can be carried out by an apparatus as shown in FIGS. 3 and 4, FIG. 4 is a sectional elevation of the apparatus cut in the line III—III in FIG. 3. In FIGS. 3 and 4, elements corresponding to those shown in FIGS. 1 and 2 are referred to with the same reference numerals.

In FIGS. 3 and 4, a plurality of bolts to be coated **15** are placed in alignment one by one between a plurality of bolt holders **31** fixed and equally spaced apart from the cathode plate **30**. The bolts are rotated by and according to the movement of the movable cathode plate **30** which is moved in the directions of the arrows in the figure.

Example 3

In the case of electroplating a number of bolts and the like continuously, the bolts to be coated are placed bridging over the two parallel belt holders running with the same speed, and these belts are passed through the plating bath. In the plating bath, the bolts with shank in line-contact with the cathode plate are electroplated on turning on the cathode plate (that is, in face-contact with it) according to the movement of the belt holders, and carried out of the bath one by one by the belt holders after treatment for the desired lapse of time.

An apparatus for thus electroplating bolts and the like continuously is shown in FIG. 5. FIG. 6 is a sectional elevation of the apparatus cut in the line VI—VI in FIG. 5. FIG. 7(*a*) is a partial plan of the belts and FIG. 7(*b*) is an oblique perspective of the parts of the belts. In these figures, an electroplating tank **50** contains an electroplating bath **51** and an anode rod **52** which can be adjusted to be placed at an appropriate position in the tank **50**. A cathode belt **53** to be in contact with the pieces to be coated and a fastener belt **54** moving on the cathode belt **53** are passed through the plating bath, driven and guided by two sets of driving rollers **55** and two sets of guide rollers **56**. A shoe **57** is placed between the two sets of guide rollers **56**. The driving rollers **55**, the guide rollers **56** and the shoe **57** are mounted on and between two porcelain plates **58** in the bath **51** as it is shown in FIG. 6. The porcelain plates **58** are supported by supporting structures **59**. The fastener belt **54** is put on the cathode belt **53** as it is shown in FIG. 7(*a*) and FIG. 7(*b*). The fastener belt **54** is in the overall sectional form of a channel with side extensions, i.e., and has a plurality of slits formed by members **61** wide enough for the bolts **60** to be able to turn freely and to be spaced from each other in the longitudinal direction. The bolts **60** inserted between the slits forming members **61** can be made, in contact with a surface of the cathode belt **53** engaged with the fastener belt **54** in the tank **50**, to turn mechanically as the fastener belt **54** moves on the shoe **57** in the plating bath **51**, and be made in face-contact with the cathode belt **53** so as to provide uniform coatings on the whole surfaces of bolts. In this case, of course, the cathode belt **53** is movable with a different velocity from the movement of the fastener belt **54** and is freely regulatable. Sets of bolt holders **62** are fixed erectly upon the surface of the fastener belt in correspondence with the width of slits so as to prevent the bolts **60** from slipping out of the slits formed by members **61**.

The belts are effectively made of strong materials which can be corrosion resistant to the bath and do not affect the electroplating process adversely. For example, in case of molten salt aluminium electroplating processes, materials such as thin aluminium plate, thin steel plate, Teflon, Teflon strengthened with glass cloth, etc. can be suitable for the belts. The bolt holder can be made of glass, Teflon or wires coated with Teflon. The bolt holders **62** can be fixed erectly on the surface of the fastener belt **54** by certain means suitable for the belts.

A molten salt composed of 60 mol percent of anhydrous aluminium chloride, 25 mol percent of sodium chloride and **15** mol percent of potassium chloride was put in the electroplating tank as shown in FIG. 5 and maintained at 160° C.

The belts as shown in FIG. 7(*a*) and FIG. 7(*b*) were made in composition of aluminium plates (0.5 mm. in thickness) and glass rods (3 mm. in diameter). Flush head steel screws **60** to be coated (7 mm. in diameter of shank and 34 mm. in total length) were inserted between the cathode belt and the fastener belt with 12 mm. of space between the screws, and electroplated at a belt speed of 45 mm. per minute, with a plating voltage of 3.5 v. and a current of 60 a. As a result, about 4 countersunk screws with smooth and uniform aluminium coatings of 9 microns in thickness were obtained continuously each minute.

Example 4

In the following description, the process of electroplating a plurality of nuts is detailed. This example can be carried out by an apparatus as shown in FIGS. 8 and 9. The nuts to be coated were hexagon nuts of steel, 8 mm. in diameter. It is desirable in the case of nuts to provide sufficient coatings both on the outside surface and on the tapped inside surface of each nut. In order to obtain such coatings, the nuts **70** may be rotatable between small protrusions **71** provided on the surface of the cathode plate **72**, and some auxiliary anodes **74** (for example, aluminium wires of 3 mm. in diameter) may be inserted into the tapped holes of nut **73** to cause rotations of the nuts and to be utilized for electroplating the threaded holes **73** themselves. Rotation of the nuts is caused by sidewise reciprocal motion of the auxiliary anodes **74** in the direction of the arrows in FIG. 8. These auxiliary anodes of aluminium wire, 3 mm. in diameter, may be covered with Teflon tubes **75** (6 mm. in outside diameter and 5 mm. in inside diameter) having a number of pores (2 mm. in diameter), to thereby prevent the anodes from being in contact directly with the nuts **70**, but not to prevent the anode current from passing through the anodes. The auxiliary anodes covered with Teflon tubes are passed through a plurality of nuts **70** and a plurality of glass spacers **76** alternately aligned. An anode **77** is used to electroplate the outside surfaces of nuts.

In using such an apparatus and the molten salts electroplating bath of the same composition as used in Example 1, 8 hexagon steel nuts (4 x 2 lines), 8 mm. in diameter, were under aluminium electroplating treatment. After 30 minutes of operation with 2.5–2.7 a. of current to electroplate the outside surfaces of the nuts and 0.8 a. of current to electroplate the inside threaded surfaces of the nuts, aluminium coatings of excellent appearance and about 9 microns in thickness could be obtained on the outside and inside surfaces of the nuts.

Example 5

An example of an embodiment according to the present invention using cathode wires (for example, aluminium flat wires) instead of the cathode plate so as to electroplate a plurality of bolts is detailed in the following description. Before putting the bolts in the plating bath, the bolts **81** are woven into a kind of plain fabric with a plurality of cathode wires **80**, as shown in FIGS. 10(*a*) and 10(*b*). The plain fabric of bolts and cathode wires is moved in an electroplating bath by means of rollers and the like. In this case, if a plurality of cathode wires are moved in the alternately opposed directions as shown by the arrows in FIG. 10(*a*), the bolts **81** can turn according to the movements of the cathode wires **80**, so as to provide uniform and smooth coatings on the whole surfaces of bolts.

In the examples described hereinbefore and in the accompanying drawings, all the bolts and the like are shown aligned on the cathode with heads in the same direction, but the present invention need not, of course, be limited to this arrangement.

As it has been above-described, the method and the apparatus according to the present invention permit, in the molten salt electroplating process, the surfaces of pieces to be coated to come in line or face-contact with the cathode so that the cathode current can be supplied sufficiently to the pieces to be coated and that the whole surface of the pieces to be coated can be provided with uniform and beautiful coatings. Therefore the method and the apparatus according to the present invention can be the most suitable for electroplating the pieces that require high precision (for example, screws and the like for aircraft), and is very advantageous in industry, because the present invention can assure an effective treatment of electroplating a number of bolts, nuts, rivets, machine screws and the like continuously. The present method is also suitable for electroplating a multitude of types of articles other than bolts, nuts, etc.

The present invention can, of course, be applied also to conventional electroplating treatments instead of to the conventional Barrel Plating Process.

What is claimed is:

1. In a molten salt electroplating apparatus including a cathode belt means and a separate fastener belt means having a plurality of projections immersed in an electroplating bath, a method of electroplating a plurality of articles comprising the steps of:

moving said cathode belt means through said electroplating bath at a predetermined rate of speed;

moving said fastener belt means through said electroplating bath in the same direction as that of said cathode belt means and at a rate of speed different from said predetermined rate of speed of movement of said cathode belt means;

applying direct current to both said cathode belt means and said fastener belt means;

mounting said articles on said cathode belt means and between projections of said fastener belt means, said projections extending above the upper surface of said cathode belt means and maintaining said articles in substantially equal spaced relationship on said cathode belt means with said articles in electrical contact with said cathode belt means; and

rotating said articles to be coated relative to said cathode belt means and relative to said fastener belt means by said moving of said cathode belt means and fastener belt means at said different rates of speed, to thereby uniformly plate said articles as they are fed through said electroplating bath.

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