Aug. 20, 1974 E. E. HANEY ET AL 3,830,716

ELECTROCOATING METHOD AND APPARATUS

Filed July 22, 1971 2 Sheets-Sheet 1

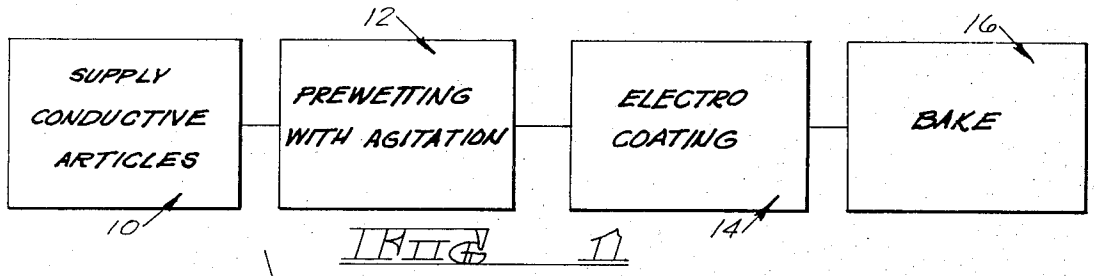

FIG. 1

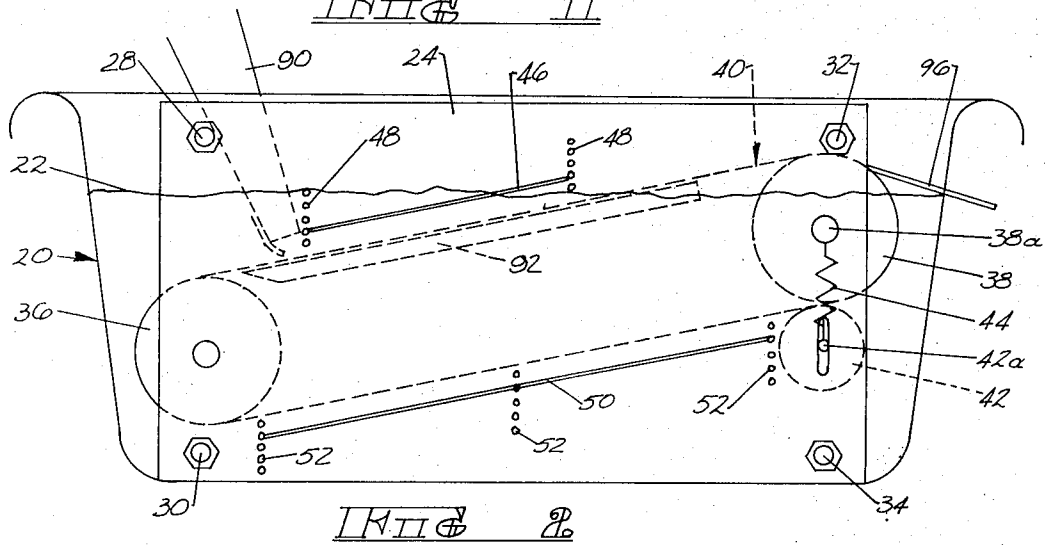

FIG. 2

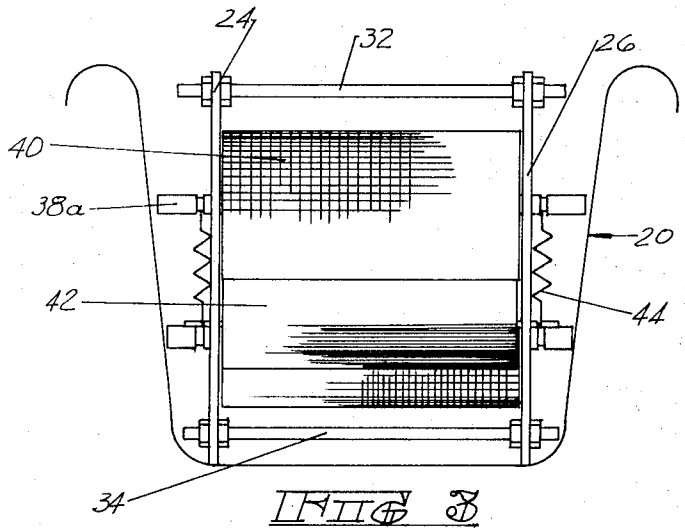

FIG. 3

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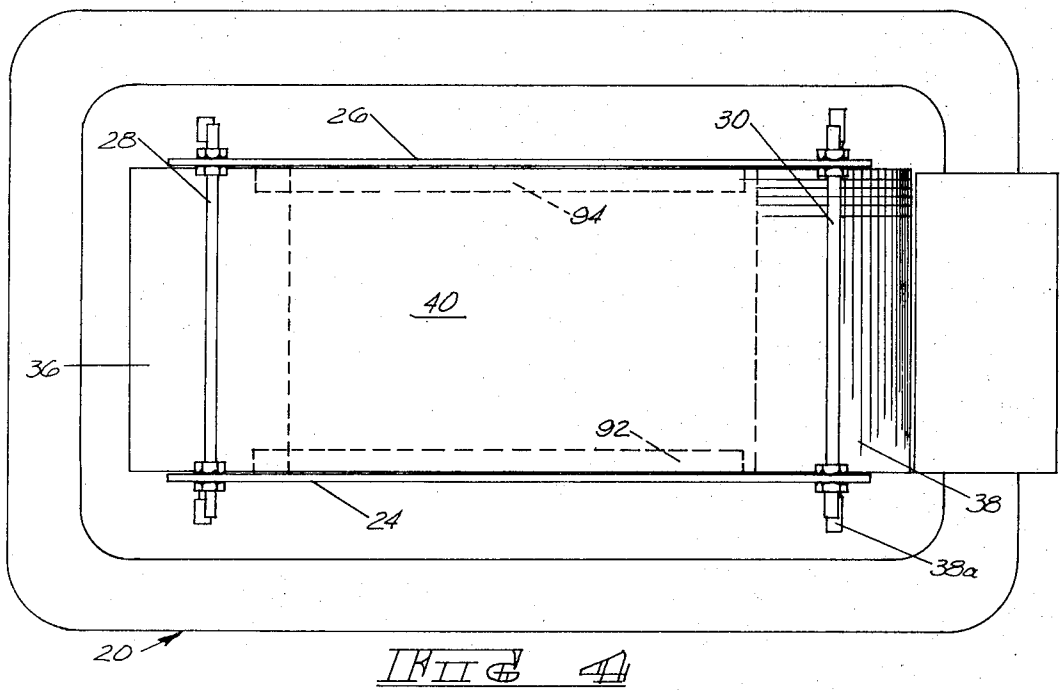

FIG 4

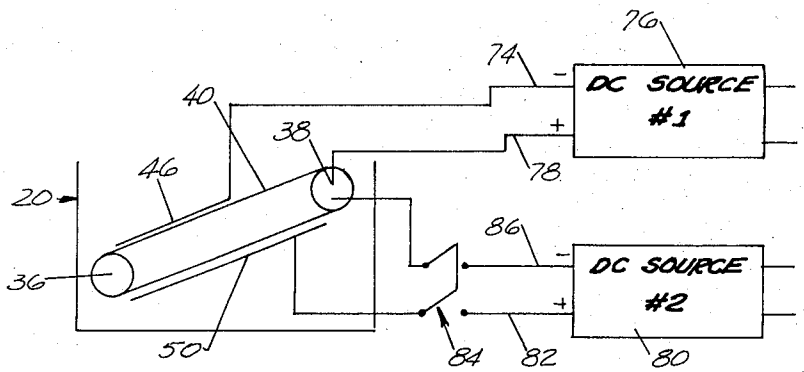

FIG 5

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3,830,716

ELECTROCOATING METHOD AND APPARATUS

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U.S. Cl. 204—181 20 Claims

ABSTRACT OF THE DISCLOSURE

A multiplicity of small articles to be electrocoated are delivered onto a conveyor for movement through the electrocoating bath. The conveyor must include a clean, preferably foraminous surface, and be effective to transmit an electric charge of one potentail to the articles carried thereby. An electrode at a second potential is disposed in the electrocoating bath adjacent the path of travel of the articles on the conveyor. The articles may be pre-wetted with a composition compatible with the electrocoating bath.

BACKGROUND OF THE INVENTION

This invention relates generally to a method and apparatus for continuously, simultaneously electrically depositing a coating film on a multiplicity of small, electrically conductive articles. Such systems, known per se, are variously referred to in the art as electrocoating, electrophoresis, or electropainting.

Electrocoating principles have evolved from the old and well known principles utilized in the electroplating art. As such, the article to be coated is placed in a specially formulated bath and given an electric charge at one potential. An electrode, also immersed in the bath, is given an electric charge at a different potential. Under the the influence of these charges, the resin and pigment components of the paint migrate toward the article and are deposited on the surface as a dense coating of uniformly distributed individual particles. Under the influence of a subsequent heat treatment, a tenacious film is formed.

At the present time, the electrocoating art is most highly developed in connection with the coating of relatively large components or long lengths of material. For example, automobile bodies or the like can be given an electric charge directly, and passed into a suitable bath. Similarly, it is easy to apply an electric potential directly to, for example, a coil of sheet steel.

However, in the case of coating small parts such as screws, nuts, bolts, and the like, it is readily recognized that direct application of an electric charge to each article is totally impractical. The art has developed a variety of arrangements which are effective to apply an electric charge to an article on a conveyor, through the conveyor. For example, reference is made to U.S. Pat. No. 3,616,-392, issued on October 26, 1971 in the name of Eugene E. Haney and entitled "Method For Coating Conductive Articles." According to the specific embodiment of that invention, two bucket conveyors are provided in a paint bath. The electric charge is applied to the conveyor, and from the conveyor to the articles carried in the individual buckets.

Reference is also made to U.S. Pat. 3,420,766 in the name of Michelson which teaches a vibratory conveyor for electroplating.

Empirical experience with the vibratory conveyor for electropainting has disclosed a number of rather severe disadvantages. In the first place, the conveying action is not positive. That is, the individual components will remain in the paint bath for varying lengths of time. In addition, apparatus of this type has been found to be less than fully satisfactory for commercial operation in that jam-ups and the like occur with some frequency.

The bucket type conveyor described in the Haney patent contemplates a rather complex mechanism, most of which is submerged in a paint bath for substantial periods of time. This arrangement leads to cleaning and maintenance problems.

The Haney patent referred to earlier also indicates, inter alia, that it is desirable to move the parts relative to one another during immersion in the paint bath. This of course requires some mechanism for agitating the parts relative to one another while in the paint bath. The Haney patent discloses the use of two conveyors in the bath, with means for transferring the parts from one conveyor to the other.

Neither of the apparatuses described in the two patents mentioned earlier have been successful in the production on a commercial basis of high quality coated articles. Under some circumstances, each will operate satisfactorily.

Keeping the foregoing comments in mind, it is a primary object of this invention to teach a method and apparatus for continuously, simultaneously electrocoating a multiplicity of small parts, which method and apparatus will successfully operate under commercial conditions for extended periods of time.

A further and more specific object of this invention is to provide a method and apparatus for electrocoating small articles which are relatively simple and which apparatus is inexpensive to construct and operate.

A further object of the invention is to provide an effective method and apparatus for electrocoating small articles which are largely trouble free.

These and other objects of the invention will become apparent to the skilled worker in the art as this specification proceeds.

SUMMARY OF THE INVENTION

From the method standpoint, this invention contemplates that the articles to be coated may be thoroughly and completely pre-wetted in a liquid composition which is compatible with the electrocoating composition subsequently used. Preferably, this pre-wetting step will include provision for agitation of the articles to be coated while in the pre-wetting composition. The pre-wetted articles are then delivered by a conveyor which is arranged to move them through the electrocoating field.

The conveyor apparatus contemplated includes a clean, foraminous surface which is effective to transmit an electric charge of a given potential to the articles carried thereby. The conveyor may be arranged in a sloping path so that the articles carried thereby will be moved out of the bath for further processing.

DESCRIPTION OF THE DRAWING

FIG. 1 is a block-type flow diagram generally indicating the steps contemplated in the successful practice of this invention.

FIG. 2 is a side elevational view of an electrocoating bath and conveyor structure.

FIG. 3 is an end elevational view of the apparatus shown in FIG. 2.

FIG. 4 is a top plan view of the apparatus shown in FIGS. 2 and 3.

FIG. 5 is a very schematic showing of the electrical circuitry necessary to continuously, electrically coat arti-

cles on a conveyor and electrically clean the conveyor surface.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring first to FIG. 1, the various steps necessary to the successful practice of this invention will be described generally.

As previously indicated, this invention is directed to the electrocoating of a multiplicity of small parts, such as, for example, screws, nuts, bolts and the like. For commercial purposes, it is desirable that the operation be continuous. Thus, a supply of articles to be coated is indicated at the box **10**. Preferably, the articles to be coated are continually moved from the supply **10** to the pre-wetting step **12**. This pre-wetting may be accomplished by any means which will continuously move the parts to be coated through a bath of the pre-wetting composition.

Preferably, the mechanism for conveying parts through the pre-wetting composition should include means for agitating the parts or for moving them relative to one another. By way of example, a vibratory conveyor such as taught in Michelson Pat. 3,420,766 may be used to carry out the pre-wetting step.

The pre-wetting composition must be compatible with the composition utilized in the electrocoating bath itself. Very clearly, identical composition can be used for pre-wetting and electrocoating. It is believed essential that the pre-wetting and electrocoating be carried out in compositions having substantially the same vehicle. In other words, when utilizing an aqueous organic electropainting solution, the pre-wetting can be carried out with another aqueous organic electropainting solution, or even with water.

Following the pre-wetting step **12**, the articles are delivered to the electrocoating bath **14**. As will be explained in more detail hereinafter, the bath indicated generally at **14** includes a conveyor onto which the articles are delivered. The conveyor must be characterized by a clean surface, and must be effective to transmit an electrical charge to the articles carried thereby. A second electrode will be disposed in the bath **14**, and as is well known in the art, a coating will be deposited upon the articles as they move with the conveyor through the bath **14**.

Finally, the coated articles are delivered from the bath **14** by any suitable mechanism to the final baking operation **16**. The application of heat to the electrically deposited coating transforms the coating into a uniform, tightly adherent film. The time, temperature, and other parameters for the final baking operation will depend upon the particular coating composition utilized. Successful practice of the instant invention clearly requires a final bake; but it is to be understood that the baking operation, per se, does not form a part of this invention.

Turning now to FIGS. 2, 3, and 4, one embodiment of the apparatus for conveying the articles to be coated through the electrocoating bath will be described. The container indicated generally at **20** is adapted to contain a supply of a suitable electrocoating composition. The normal level of the coating liquid in the container is indicated at **22**. It will of course be understood that in the case of a continuous, commercial operation, conventional means will be utilized for filling and replenishing the electrocoating composition, and a drain outlet may be provided. These components are not shown in the drawings.

The conveying apparatus includes the frame having the spaced apart, parallel side wall members **24** and **26**. These members are secured in the parallel, spaced relationship with the cross-rods **28**, **30**, **32**, and **34**. Thus, the entire conveyor structure which, as will be described hereinafter, is mounted on the frame, may be removed from the container **20** for maintenance, cleaning, and the like.

The conveyor comprises the rolls **36** and **38** which will be mounted for rotation between the side walls **24** and **26**, and the continuous belt **40** which of course passes around the rolls **36** and **38**. It will of course be understood that in a commercial embodiment of the invention, suitable bearing structures may be provided for the rolls **36** and **38**.

In the embodiment illustrated, the fully submerged roll **36** serves simply as a turn-around roll. It is to be constructed of a material which is electrically insulative.

The drive roll **38**, on the other hand, may be utilized to transmit or conduct an electric charge to the articles carried by the belt. In this event, the roll **38** must be constructed of an electrically conductive material.

It will be understood that a suitable driving mechanism will be provided. Such apparatus does not, per se, form a part of this invention and has not been shown in the drawing. By way of example, such drive mechanism may include an electric motor and gear reducing drive, which may be coupled with a flexible cable drive to the shaft **38***a* on which the roller **38** is mounted. It will be observed that the shaft **38***a* could easily be disposed above the level **22** of liquid composition in the bath, and hence the entire drive mechanism would not be exposed to the liquid environment.

The belt **40** may also be driven by the resilient roll **42** which will of course be suitably journaled for rotation in the side walls **24** and **26**. The roll **42** is normally urged against the belt **40** and roller **38** by means of the springs **44**. The drive mechanism would then be coupled to the shaft **42***a*. The belt indicated generally at **40** must serve two primary functions. First of all, it must of course carry the articles to be coated through a portion of the electrocoating bath. Secondly, as already indicated, the belt **40** must be effective to transmit an electric charge to the articles carried on it. It is, therefore, preferred that the belt **40** be of an electrically conductive material.

For some articles, a smooth belt **40** would be satisfactory; a dimpled belt would be better, and a foraminous belt is clearly best. As used in this specification, the phrase "foraminous belt" includes any belt having many closely spaced openings, such as a woven mesh screen or a perforated band.

It will be apparent that a variety of expedients can be used to conduct the electric charge to the belt **40**. For example, the current could be transmitted by brushes or a split ring to the shaft **38***a*, or by brushes or the like directly to the belt **40**.

The electrodeposition circuit also includes the electrode **46** which is disposed in the bath and closely adjacent the path of travel of articles carried by the belt **40**. The electrode **46** may comprise a flat sheet of material, or may be in the form of a grid. The electrode **46** may conveniently be supported by fingers or rods engaging the openings **48** in the side walls **24** and **26**. A plurality of such openings permit ready adjustability of the position of the grid.

At the present time, direct current, anodic coating techniques are most highly developed. That is, the article to be coated is given a positive charge and the electrode **46** will be given a negative charge. Under the influence of the applied currents, the resin and pigment components of the coating composition will migrate toward and be deposited upon the surface of the articles in a uniform coating.

Cathodic coating techniques are currently under development; and it will of course be understood that the apparatus herein described can readily be utilized by reversing the electrical connections.

Similarly, alternating current coating techniques can be utilized with the apparatus of this invention.

In any coating operation, it will be apparent that the belt **40** is under an applied electric potential substantially equal to that of the articles carried thereby. It would of course follow that the resin and pigment components of the paint would be expected to be deposited to some extent on the conveyor belt itself.

Prior workers in the art have generally deemed this factor unimportant. It has now been discovered that it is necessary, in order to achieve good results over extended periods of operation to maintain the conveyor belt **40** as clean as possible. This is important for two reasons. First of all, the accumulation of a coating on the belt tends to become loosely bonded in the nature after an extended period in the bath. The accumulation of a loosely bonded coating may prevent full electrical contact and result in non-uniform final coatings. More importantly, the film which is electrically deposited on the articles tends to stick to the loosely bonded coating on the belt. When the coated articles are removed, a portion of the coating on the article may be stripped off leaving a bare spot, or else the coated article will pull a globule of loosely bonded coating off the belt, again resulting in a non-uniform coating.

The cleaning may be accomplished in two rather different ways. On the one hand, there are certain materials, now known, which exhibit what might be called a rectification characteristic. That is, these materials are electrically conductive and will carry a charge to an article carried thereby. At the same time, these materials will not themselves become coated.

For example, in the case of anodic coating, anodized aluminum and zinc coated (galvanized) belts have been used with success. All of these materials will adequately conduct a charge to articles carried on the belt surface, and yet, after extended periods of operation, are found to be substantially free from coating material.

In the alternative, it is possible to continuously, electrically clean the belt. The phrase "reverse polarity cleaning", as used in this specification, refers to this operation. It is necessary to provide a second electrode, indicated in FIG. 2 at **50**. This electrode **50** may be adjustably supported in the openings **52** in the side walls **24** and **26**, and it will be observed that it is adjustably positioned adjacent the lower flight of the conveyor **40**.

A schematic electrical circuitry for reverse polarity cleaning is shown in FIG. 5. In this figure (and using for illustration an anodic coating process) the negative lead **74** of a first source of DC current **76** will be connected to the electrode **46**. The positive lead **78** will be connected in any suitable way to the roller **38** or belt **40**. A second source of direct current **80** will have its positive lead **82** connected across the switch **84** to the electrode **50**, and its negative lead **86** connected across the switch **84** to the roller **38** or belt **40**.

Thus, in the case of anodic electrocoating, the electrode **46** will be negatively charged while the electrode **50** will be positively charged. The roll **38** and belt **40** will be more positively charged than the electrode **46**. Hence, resin and pigment components of the electrocoating composition will migrate toward and be deposited on articles carried by the belt **40** as they pass beneath the electrode **46**.

At the same time, the roll **38** and belt **40** is less positively charged than the electrode **50**. Hence, coating material which has been deposited on the belt **40** as it passes beneath the electrode **46** will be transferred from the belt **40** as it passes on the lower flight of the conveyor, either going back into solution or being deposited on the electrode **50**.

The switch **84** of course must be closed to effect this reverse polarity cleaning. The system schematically shown in FIG. 5, further requires that there be no common ground between the current output of sources **76** and **80**. A common ground would short the system out.

Reverse polarity cleaning has a further, important effect. It is known that electro-depositable paint systems are satisfactory within certain solution characteristics. The pH level of the solution, for example, must be maintained within a fairly narrow range. As the resin and pigment components of the paint are depleted, the paint solution becomes more alkaline. Reverse polarity cleaning, to the extent that it attracts the material deposited on the belt **40** back into solution, tends to reduce the alkalinity, thus increasing the time during which proper pH level is maintained.

Empirical investigations have indicated that the most important variable with respect to the question of build up or accumulation of coating material on the belt, is the composition of the paint system. In connection with certain paint compositions or systems, the use of a foraminous belt **40** having rectifying characteristics may be sufficient to maintain the belt in a satisfactorily clean condition without reverse polarity cleaning.

By the same token, the apparatus of this invention can function equally well in the case of certain paint systems with a belt **40** not having rectifying characteristics by utilizing reverse polarity cleaning.

Still other paint systems may require both of these systems in order to obtain satisfactory results during extended periods of operation.

Returning now briefly to FIG. 2, it will be seen that a chute has been indicated schematically at **90** through which articles are delivered onto the conveyor belt **40**. As indicated earlier, one aspect of the method of this invention is the requirement that the articles to be coated be pre-wetted in a composition compatible with the electrocoating bath itself. Preferably, this pre-wetting step includes agitation or relative movement of the articles during pre-wetting. Any conventional conveying apparatus can be used to carry the articles from the pre-wetting step to deliver them to the chute **90** and hence to the belt **40**.

As best seen in FIG. **3**, the belt **40** should be a relatively fine mesh screen material. In the embodiment shown, narrow supports **92** and **94** (see FIG. 4) are provided for the edges of the top flight of the belt **40**. In the case of larger articles which are delivered via the chute **90**, it may be necessary to provide a support extending all the way across the belt at the point of impact to increase the working life of the belt **40**.

Finally, it will be observed that the roll **38** is elevated above the roll **36** and hence the belt **40** is inclined from the horizontal. Thus, the last portion of the upper flight of the belt **40** is completely above the normal level of the bath **22**. This permits easy transfer of articles carried by the belt **40** for further processing. In the embodiment shown, the slide chute **96** receives the articles from the belt **40** and transfers them to another conveying mechanism, not shown, for transfer to the final baking operation.

To complete the description of this invention, the following data is given from an actual coating operation utilizing this invention. The following data is to be considered illustrative only.

The articles to be coated were ¼ x 20 x 1 galvanized bolts. These articles were first cleaned by tumbling in a mill with alumina pellets. The parts were then rinsed, and a conversion coating was applied and prebaked.

Reference is made to said Haney Pat. No. 3,616,392 for a further description of the conversion coating and prebaking steps.

The articles were then pre-wetted in a solution compatible with the electrodepositable paint solution and then delivered to the conveyor structure shown in FIGS. 2 through 4.

One important aspect of this invention is the very short time required in the electrocoating bath in order to secure a complete coating. In the actual apparatus under consideration, the distance between the rolls **36** and **38** was approximately 61 cm. (24 inches), and the roll **38** was driven so as to move the belt at a speed of approximately 2 cm./sec. (4 feet/min.). This speed, and the level of the electrocoating bath were such that the articles were submerged in the bath for a period of approximately 30 seconds.

The electrocoating bath used was J D 1925, a low gloss black paint furnished by the Jones-Dabney Division of Celanese Coatings Co. The final bake was carried out at a temperature of about 316° C. (600° F.) for a time of two minutes.

The resulting articles were observed to have a very uniform, complete coating approximately .02 mm. (0.8 mils) thick.

It is believed that the foregoing constitutes a full and complete disclosure of this invention, and no limitations are intended except insofar as set forth in the claims which follow.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. Apparatus for continuously, simultaneously electrophoretically coating a multiplicity of small articles comprising:
- (a) a container for holding a bath containing an electrodepositable composition;
- (b) a conductive, non-vibratory continuous belt;
- (c) driving means mounting said belt adapted to be at least partially submerged in said bath;
- (d) means for prewetting said articles prior to delivering them onto said belt;
- (e) means for agitating said articles during said prewetting so as to remove occluded air bubbles from said articles;
- (f) means for delivering said prewetted articles onto said belt while said articles are still wet;
- (g) an electrode adapted to be mounted in said bath and overlying at least a portion of said belt;
- (h) electrical circuit means including
  - (i) means for applying a first potential to said articles carried on said belt and
  - (ii) means for applying a second potential to said electrode whereby to deposit uniformly a coating of said composition on said articles; and
- (i) means for transferring said coated articles from said belt for further processing.

2. The apparatus claimed in claim **1** wherein said belt is foraminous.

3. The apparatus claimed in claim **2** wherein said belt is aluminum.

4. The apparatus claimed in claim **2** wherein said belt is zinc coated.

5. The apparatus claimed in claim **1** wherein said belt comprises a material, which in said bath will conduct an electric charge of a first potential to said article carried thereon but will not receive itself a coating of said electrodepositable composition.

6. The apparatus claimed in claim **1** including means for continuously electrically cleaning said belt.

7. The apparatus claimed in claim **6** wherein said means for continuously electrically cleaning said belt includes a second electrode adapted to be mounted in said bath adjacent another portion of said belt, said electric circuit means including means for supplying a third potential to said second electrode.

8. The apparatus claimed in claim **1** wherein said belt is inclined with respect to the horizontal axis of the container whereby at least a portion thereof is adapted to extend above said axis.

9. Apparatus for continuously, simultaneously appying a coating from an electrodepositable composition to a plurality of small articles comprising:
- (a) means for pre-wetting said articles with a liquid composition compatible with said electrodepositable composition;
- (b) means for agitating said articles during prewetting;
- (c) non-vibratory conveyor means located in a container and adapted to be at least partially submerged in a bath of said electrodepositable composition and arranged to carry said articles through said bath;
- (d) an electrode adapted to be in said bath;
- (e) means for charging said electrode with a first potential; and
- (f) means for charging said articles carried by said conveyor means with a second potential whereby to deposit uniformly a coating of said electrodepositable composition on said articles.

10. The apparatus claimed in claim **9** wherein said conveyor means includes a continuous, foraminous belt.

11. The apparatus claimed in claim **10** including means for maintaining said belt substantially free from a coating of said electrodepositable composition.

12. The apparatus claimed in claim **11** wherein said means for maintaining said belt substantially free from a coating comprises a screen belt having rectifying characteristics.

13. The apparatus claimed in claim **11** wherein said means for maintaining said belt substantially free from a coating comprises means for continuously electrically cleaning said belt.

14. The method of continuously, simultaneously applying a coating from an electrodepositable composition to a plurality of small articles comprising the steps of:
- (a) pre-wetting said articles with a composition compatible with said electrodepositable composition;
- (b) agitating said articles while in contact with said prewetting composition;
- (c) delivering said articles onto a conveyor;
- (d) traversing said articles on said conveyor through a bath of said electrodepositable composition;
- (e) insuring that said articles do not move relative to said conveyor during said step of traversing said articles through said bath;
- (f) applying an electrical charge of a first potential to said conveyor whereby to charge said articles carried thereby;
- (g) applying an electric charge of a second potential to an electrode disposed in said bath adjacent said conveyor whereby to deposit uniformly a coating of said electrodepositable composition on said articles; and
- (h) preventing the accumulation of a loosely bonded coating of said electrodepositable composition on said conveyor.

15. The method claimed in claim **14** including the step of insuring that said pre-wetted articles are delivered onto said conveyor for entry into said bath while still wet.

16. The method claimed in claim **14** wherein said step of preventing the accumulation of a loosely bonded coating of said electrodepositable composition on said conveyor includes the step of using as said conveyor one which is comprised of a material having a rectification characteristic.

17. The method claimed in claim **16** wherein the said material selected for said conveyor is anodized aluminum.

18. The method claimed in claim **16** wherein the said material selected for said conveyor is a zinc coated belt.

19. The method claimed in claim **14** wherein said step of preventing the accumulation of a loosely bonded coating of said electrodepositable composition on said conveyor is accomplished by reverse polarity cleaning.

20. The method of continuously, simultaneously applying a coating from an electrodepositable composition to a plurality of small articles comprising the steps of:
- (a) pre-wetting said articles with a composition compatible with said electrodepositable composition;
- (b) agitating said articles relative to one another while in contact with said pre-wetting composition;
- (c) delivering said pre-wetted articles onto a conveyor while still wet;
- (d) traversing said articles on said conveyor through a bath of said electrodepositable composition;
- (e) applying an electrical charge of a first potential whereby to charge said articles carried thereby; and
- (f) applying an electrical charge of a second potential to an electrode disposed in said bath adjacent said

conveyor whereby to deposit uniformly a coating of said electrodepositable composition on said articles.

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U.S. Cl. X.R.

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