

## Field of the Invention

## Background to the Invention

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### Summary of the Invention

- With the above and other objects in mind, the present invention provides
- 10 apparatus for the electroplating of at least a part of an article, the electroplating to take place in a tank, the apparatus including a support structure having an upper frame, and a support frame depending from the upper frame; a support plate mounted for rotation relative to the support structure and for releasably retaining the article for rotation with the
- 15 support plate; and a drive means mounted on the support structure; the drive means being operatively connected to the support plate for the rotation of the support plate and the article during the electroplating of the at least a part of the article.
- 20 Preferably, the support frame has attached thereto at least one roller for supporting the article during the rotation of the article, and the support structure may have a lower frame, the at least one roller being attached to the lower frame.
- 25 The support structure may include a plurality of spaced-apart and substantially vertically arranged posts depending from the upper frame; each post having an upper portion terminating at a lower portion end thereof with an upper flange, and a lower portion terminating at an upper end thereof with a lower flange, the upper flange being releasably
- 30 connectable to the lower flange.

5 the upper frame may have a longitudinally extending central beam to which is attached a lifting plate; the lifting plate having an elongate slot therein with a scalloped upper edge to enable, in use, a lifting means to be located in a concave portion of the scalloped edge substantially above the centre of gravity of an assembly comprising the support structure, the  
10 article and the drive means.

There may be provided at least one electrical connector for electrical connection to enable the electroplating, the at least one electrical connector including a female connector releasably mounted at or adjacent an outer  
15 surface of a side wall of the tank; a male connector releasably mounted to the upper frame; the female connector being in the form of a block with a recess therein having an upper portion with a shape of an inverted, truncated cone, and a cylindrical portion depending therefrom; the male connector having a top portion substantially the same shape and size as  
20 the upper portion, and a lower portion substantially the same shape and size as the cylindrical portion.

Preferably, the cylindrical portion has a radius substantially the same as a minimum radius of the upper portion. More preferably, the upper portion  
25 and the cylindrical portion are coaxial, and the top portion and the lower portion may also be coaxial.

In another form the present invention provides an electrical connector having a male connector and a female connector, the female connector  
30 being in the form of a block with a recess therein having an upper portion

- 5 with a shape of an inverted, truncated cone, and a cylindrical portion depending therefrom; the male connector having a top portion substantially the same shape and size as the upper portion, and a lower portion substantially the same shape and size as the cylindrical portion.
- 10 Preferably, the cylindrical portion has a radius substantially the same as a minimum radius of the upper portion, and the upper portion and the cylindrical portion are coaxial. The top portion and the lower portion may also be coaxial.
- 15 The present invention also provides a method of electroplating at least a part of an article, the method including placing the article in a solution, providing an electrical connection to the article to make it a cathode during the electroplating process, placing an anode adjacent the at least a part of the article to be electroplated, passing a voltage across the anode  
20 and cathode and, during the electroplating process, rotating the article.

The article may be a piston having at least one piston-ring groove that forms the part to be electroplated, the piston being releasably attached to a support plate for rotation therewith such that the piston's longitudinal  
25 axis is substantially horizontal.

In a final form the present invention provides an anode for use in electroplating a piston-ring groove of a piston, the anode being in the form of a curved plate having an inner radial surface of a radius of curvature  
30 substantially the same as a radius of the piston-ring groove; the curved

5 plate having at least one insert there through extending beyond a front and a rear surface of the cured plate, the at least one insert being of material which is substantially electrically non-conductive.

The at least one insert may also extend beyond the inner radial surface  
10 and the radius of curvature of the radial surface may be substantially the same as the radius of curvature of the piston-ring groove at a top of the groove, or at a bottom of the groove.

There may be three of the inserts substantially equally spaced along the  
15 curved plate, and the curved plate is preferably of a thickness less than a width of the piston-ring groove.

A plurality of mounting arms may extend from the curved plate in a direction opposite to that of the radial surface, at least one of the mounting  
20 arms including an electrical connector. Preferably, the curved plate includes a plurality of plugs of antimony lead to increase current efficiency.

The anode may be used with and may form part of the electroplating  
25 apparatus and/or may be used with the electroplating method.

### **Description of the Drawings**

In order that the invention may be better understood and readily put into practical effect, there shall now be described by way of non-  
30 limitative example only a preferred embodiment of the present invention,

5 the description being with reference to the accompanying illustrative drawings in which:

Figure 1 is a side view of the apparatus of the preferred embodiment;

Figure 2 is a right-hand end view of the apparatus of Figure 1;

10 Figure 3 is a top plan view of the apparatus of Figures 1 and 2 with the support frame and upper frame removed;

Figure 4 is an exploded perspective view on a larger scale of the electrical contacts shown in Figures 1 to 3; and

15 Figure 5 is a side view on a larger scale of a preferred form of anode.

#### **Description of Preferred Embodiment**

To refer to Figures 1 to 3, there is shown electroplating apparatus having a tank 10 containing an appropriate electroplating solution (not shown). The tank 10 may be of any suitable shape such as, for example, 20 cylindrical or, as shown, a polygonal shape that, in this instance, is square. As such tank 10 has four mutually perpendicular side walls 12, as well as a base 14.

Mounted to the outer surface 13 of two opposed side walls 15 are 25 support plates 16. The plates 16 each support a female electrical contact 18 which cooperates with a male electrical contact 20 to enable the electrical current required for the electroplating process to pass there through.

As shown in Figure 4, the female connector 18 is in the form of a 30 block that may be of, or be lined with, copper or any other suitable

5 electrically conductive material. The female connector 18 has a funnel-shaped recess 24 which has an upper portion 26 which is the shape of an inverted, truncated cone; and a lower portion 28 which is the shape of a cylinder and of a diameter the same as the smallest diameter of upper portion 26.

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Male connector 20 has a similarly sized and shaped upper portion 30; and a similarly sized and shaped lower portion 32. The relative sizes are such that the top of lower portion 32 engages the upper lip of lower portion 28 before upper portion 30 engages upper portion 26. In this way  
15 male connector 22 is guided into connect engagement in female connector 20 and relative movement there between (other than a deliberate, axial upward movement) is prevented.

Each male connector 20 is mounted at the lower end of an  
20 insulating block 34, the block 34 being securely attached to an upper frame 36. Upper frame 36 is generally rectangular and has side members 33, end members 35, and a central beam 37.

Depending from upper frame 36 is a support frame 38 that has four  
25 corner posts 40 and a lower frame 50. Each of the corner posts 40 has an upper portion 42 that terminates at its lower end at an upper flange 44; and a lower portion 46 that terminate at its upper end with an upper flange 48. Flanges 44, 48 can be securely yet releasably secured together.

5 Mounted on lower frame 50 is a roller support 52, and which preferably has four spaced apart rollers 54. The roller support 52 and/or the rollers 54 may be moveable relative to lower frame 50 so as to be positionable to support the product being electroplated. As shown, the four rollers 54 are arranged as two pairs of adjacent rollers, one pair on  
10 each side of lower frame 50.

The rollers 54 assist in supporting in a rotational manner a piston 56 which has a side wall 58 in which are a number of concentric, axially-spaced piston-ring grooves 60. At its top 62, the piston 56 is attached to a  
15 support plate 64 that is driven for rotation relative to support frame 38 by a motor 68 and gearing system 66. The piston 56 is arranged with its longitudinal axis substantially horizontal. Motor 68 may be mounted to upper frame 36 and may drive support plate 64 by a gear drive system, belt drive, chain drive, rim drive system, or otherwise, as appropriate.  
20 Alternatively, motor 68 and gear system 66 may be submersible and thus be secured to support frame 38, as shown.

Securely attached to beams 37 is a multi-position lifting plate 70 adapted to be used to raise upper frame 36 and support frame 38 from,  
25 and lower them into, tank 10. The plate 70 has an elongate slot 72 therein with a scalloped upper edge 74. A lifting hook/shackle can be located in any of the concave portions 76 of edge 74 for the lifting/lowering. In this way the lifting/lowering will be vertical, with posts 40 generally vertical. The location of the concave portion 76 used will depend on the size and  
30 weight of piston 56 so that there will be compensation for the alteration in

5 the location of the center of gravity of the total assembly being lifted/lowered. The location of the concave portion 76 used should be that which is closest to being vertically aligned with the center of gravity of the assembly of upper frame 36, support frame 38 (including lower frame 50), motor 68, gearing system 66, and piston 56.

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The anode preferably used is shown in Figure 5 and comprises an arcuate plate 78 of a thickness less than the width of the grooves 60 and having a plurality, preferably three (as shown), mounting arms 80 extending therefrom. To one or more of the mounting arms 80 is mounted  
15 an electrical connector 82. The plate 78 is curved with a radial inner surface having a radius substantially the same as, or slightly greater than, the radius of curvature of the piston 56 side wall 58 at either adjacent the bottom of grooves 60 or the top of grooves 60. Arranged along the length of anode 78 are a number preferably three, inserts 84 of a material which is  
20 not electrically conductive. The inserts 84 extend outwardly beyond the front 90 and rear (not shown) surfaces of anode 78 and may extend beyond the radial surface 88, if desired. The inserts 84 act as spacers to prevent anode from contacting the piston 56 when in operation. The inserts 84 are preferably of a material such as, for example,  
25 polytetrafluoroethylene or PTFE.

Arranged around anode 78 are a plurality of plugs 86 of, for example, antimony lead to increase current efficiency during the electroplating process.

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5        If desired, the motor 68 may be fitted with a speed control so that  
the rotational speed of piston 56 can be accurately controlled. By using  
this apparatus, the piston 56 can be slowly rotated during the  
electroplating process. This minimizes hydrogen bubbles in the grooves  
60 as they rotate due to the effects of the rotating piston in the solution,  
10 and the bubbles rising to the surface. Furthermore, any contaminants (e.g.  
dirt) will be washed from the surface. It also increases the efficiency of the  
electroplating as the slow rotation results in a far more even plating. Tests  
have shown that with the prior art systems (static pistons) the efficiency of  
the electroplating using chromium is of the order of 10-20%. With the  
15 present invention efficiencies of over 20%, and up to 26%, have been  
recorded. The resulting surface would have a maximum hardness of  
about 65 to 68 using the prior art system; but with the present invention  
results of 70 to 85 have been achieved. The plating time may also be  
reduced by up to 30%.

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Furthermore, the shape of connectors 20, 22 provides a substantial  
contact area to maximize current flow and to minimize impedance to  
current flow. This assists in the electroplating process proceeding  
effectively and efficiently.

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Whilst there has been described in the foregoing description a  
preferred embodiment of the present invention, it will be understood by  
those skilled in the art that many variations or modifications in details of  
design, construction or operation may be made without departing from  
30 the present invention.

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The present invention extends to each of the features disclosed either singularly, or in all possible combinations and permutations.



## 5 Claims

1 Apparatus for the electroplating of at least a part of an article, the electroplating to take place in a tank, the apparatus including:

10 a support structure having an upper frame, and a support frame depending from the upper frame;

a support plate mounted for rotation relative to the support structure and for releasably retaining the article for rotation with the support plate; and

a drive means mounted on the support structure;

15 the drive means being operatively connected to the support plate for the rotation of the support plate and the article during the electroplating of the at least a part of the article.

2. Apparatus as claimed in claim 1, wherein the support frame has  
20 attached thereto at least one roller for supporting the article during the rotation of the article.

3. Apparatus as claimed in claim 2, wherein the support structure has a lower frame, the at least one roller being attached to the lower frame.

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4. Apparatus as claimed in any one of claims 1 to 3, wherein the support structure includes a plurality of spaced-apart and substantially vertically arranged posts depending from the upper frame; each post having an upper portion terminating at a lower portion end thereof with  
30 an upper flange, and a lower portion terminating at an upper end thereof



- 5 with a lower flange, the upper flange being releasably connectable to the lower flange.
5. Apparatus as claimed in any one of claims 1 to 4, wherein the upper frame has a longitudinally extending central beam to which is attached a lifting plate; the lifting plate having an elongate slot therein with a  
10 scalloped upper edge to enable, in use, a lifting means to be located in a concave portion of the scalloped edge substantially above the centre of gravity of an assembly comprising the support structure, the article and the drive means.
- 15 6. Apparatus as claimed any one of claims 1 to 5, wherein there is provided at least one electrical connector for electrical connection to enable the electroplating, the at least one electrical connector including:
- (a) a female connector releasably mounted at or adjacent an outer surface of a side wall of the tank;
  - 20 (b) a male connector releasably mounted to the upper frame;
  - (c) the female connector being in the form of a block with a recess therein having an upper portion with a shape of an inverted, truncated cone, and a cylindrical portion depending therefrom;
  - (d) the male connector having a top portion substantially the same  
25 shape and size as the upper portion, and a lower portion substantially the same shape and size as the cylindrical portion.
7. Apparatus as claimed in claim 6, wherein the cylindrical portion has a radius substantially the same as a minimum radius of the upper  
30 portion.



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8. Apparatus as claimed in claim 6 and claim 7, wherein the upper portion and the cylindrical portion are coaxial.

9. Apparatus as claimed in claim 7 wherein the top portion and the  
10 lower portion are coaxial.

10. An electrical connector having a male connector and a female connector, the female connector being in the form of a block with a recess therein having an upper portion with a shape of an inverted, truncated  
15 cone, and a cylindrical portion depending therefrom;

the male connector having a top portion substantially the same shape and size as the upper portion, and a lower portion substantially the same shape and size as the cylindrical portion.

20 11. An electrical connector as claimed in claim 10, wherein apparatus as claimed in claim 6, wherein the cylindrical portion has a radius substantially the same as a minimum radius of the upper portion.

12. Apparatus as claimed in claim 6 and claim 7, wherein the upper  
25 portion and the cylindrical portion are coaxial.

13. Apparatus as claimed in claim 7 wherein the top portion and the lower portion are coaxial.



5 14. A method of electroplating at least a part of an article, the method including placing the article in a solution, providing an electrical connection to the article to make it a cathode during the electroplating process, placing an anode adjacent the at least a part of the article to be electroplated, passing a voltage across the anode and cathode and, during  
10 the electroplating process, rotating the article.

15 15. A method as claimed in claim 14, wherein the article is a piston having at least one piston-ring groove that forms the part to the electroplated, the piston being releasably attached to a support plate for rotation therewith such that the piston's longitudinal axis is substantially horizontal.

20 16. An anode for use in electroplating a piston-ring groove of a piston, the anode being in the form of a curved plate having an inner radial surface of a radius of curvature substantially the same as a radius of the piston-ring groove; the curved plate having at least one insert there through extending beyond a front and a rear surface of the curved plate, the at least one insert being of material which is substantially electrically non-conductive.

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17. An anode as claimed in claim 16, wherein the at least one insert also extends beyond the inner radial surface.



- 5 18. An anode as claimed in claim 16 or claim 17, wherein the radius of curvature of the radial surface is substantially the same as the radius of curvature of the piston-ring groove at a top of the groove.
- 10 19. An anode as claimed in claim 16 or claim 17, wherein the radius of curvature of the radial surface is substantially the same as the radius of curvature of the piston-ring groove at a bottom of the groove.
- 15 20. For anode as claimed in any one of claims 16 to 19, wherein there are three of the inserts substantially equally spaced along the curved plate.
21. An anode as claimed in any one of claims 16 to 20, wherein the curved plate is of a thickness less than a width of the piston-ring groove.
- 20 22. An anode as claimed in any one of claims 16 to 21, wherein a plurality of mounting arms extend from the curved plate in a direction opposite to that of the radial surface, at least one of the mounting arms including an electrical connector.
- 25 23. An anode as claimed in any one of claims 16 to 22, wherein the curved plate includes a plurality of plugs of antimony lead to increase current efficiency.
24. An anode as claimed in any one of claims 16 to 23, when used with the apparatus of any one of claims 1 to 13.



5 25. Apparatus as claimed in any one of claims 1 to 13 including an anode as claimed in any one of claims 16 to 23.

26. A method as claimed in claim 14 or claim 15 using an anode as claimed in any one of claims 16 to 23.

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27. A method as claimed in any one of claims 14, 15 and 26 using the apparatus of any one of claims 1 to 13.