

March 14, 1950

R. A. SCHAEFER
METHOD OF PLATING

2,500,205

Filed April 12, 1945

3 Sheets-Sheet 1

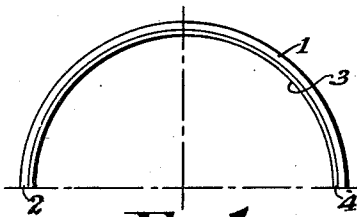


Fig. 1

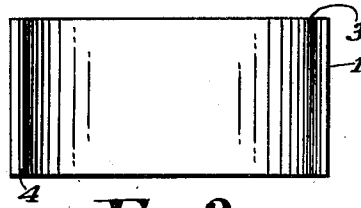


Fig. 2

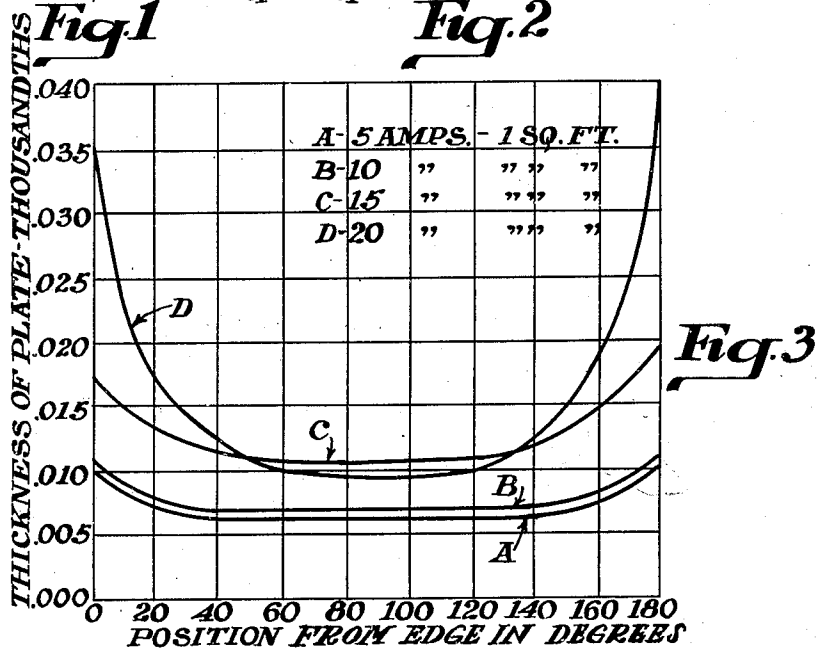
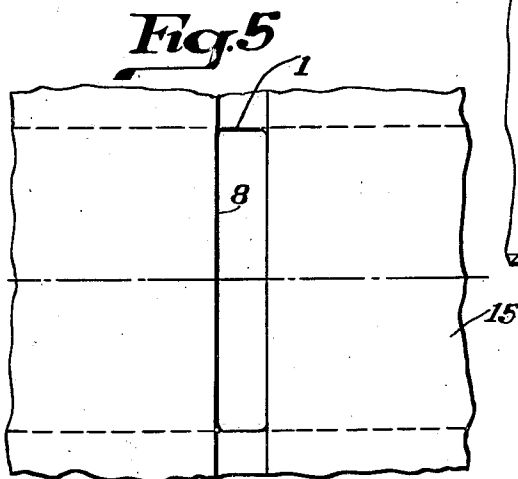


Fig. 5

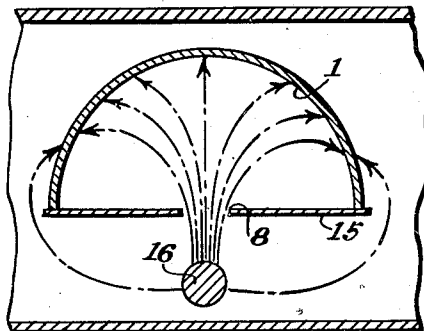


Fig. 4

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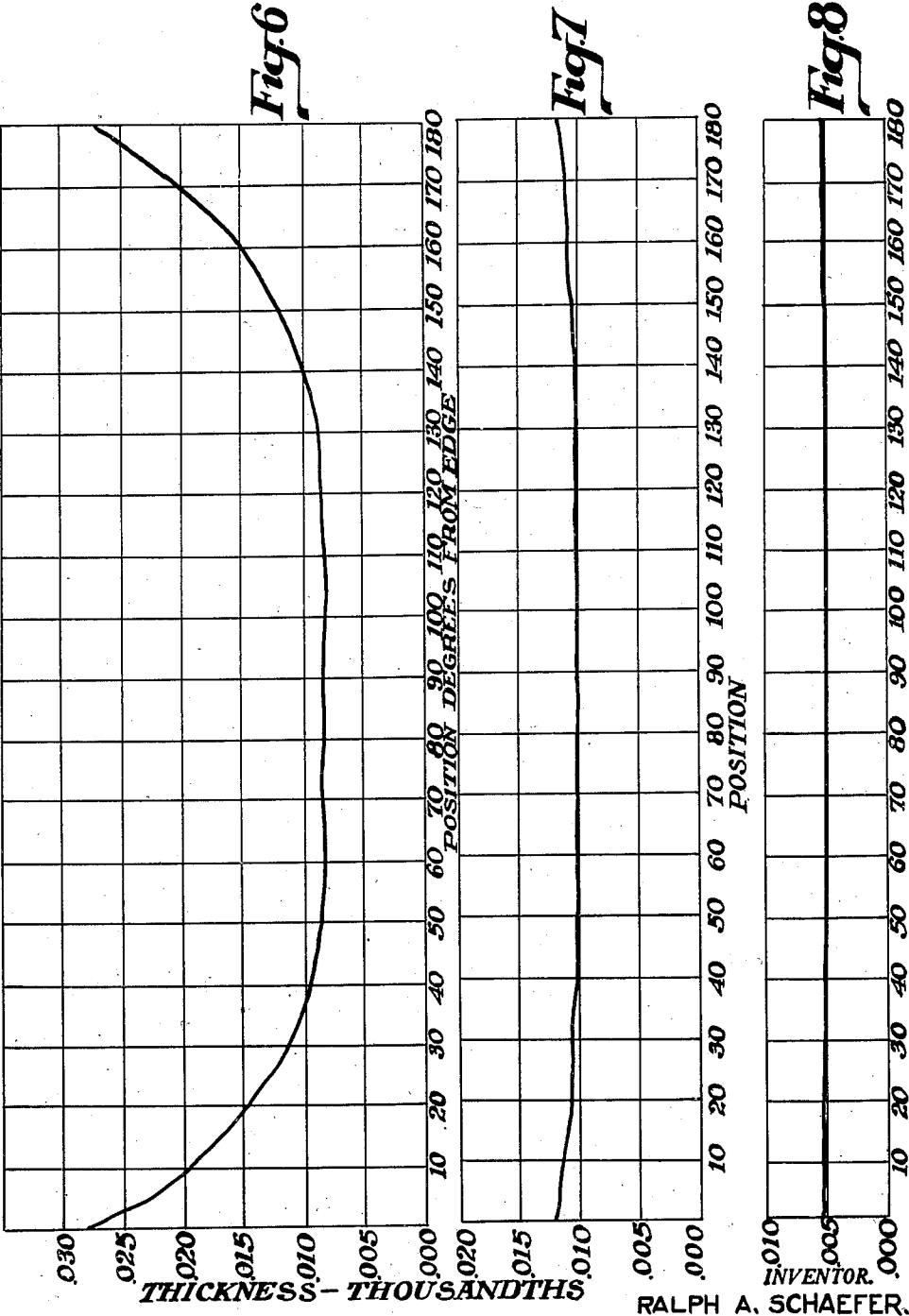
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3 Sheets-Sheet 3

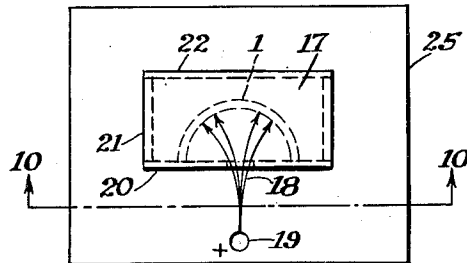


Fig. 9

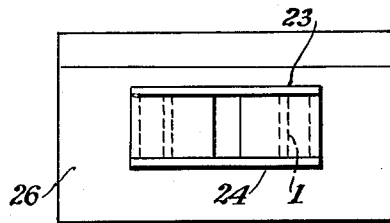


Fig. 10

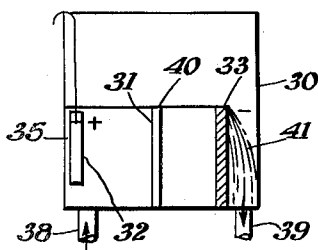


Fig. 12

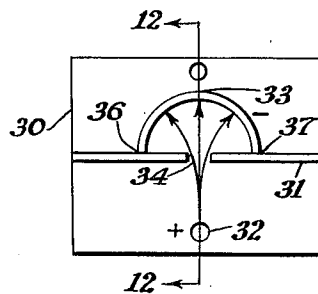


Fig. 11

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UNITED STATES PATENT OFFICE

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METHOD OF PLATING

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5 Claims. (Cl. 204—26)

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The present invention relating, as indicated to a method of plating is more particularly directed to the provision of a method of electro-depositing a layer of metal or metallic alloy onto the concave surface of semi-cylindrical articles and to maintaining a sufficiently uniform thickness of deposited metal so that for many articles and for many uses the variation in thickness, particularly in thin deposits, will make unnecessary or cheapen and simplify any subsequent metal removing operations, if required. The term "uniform," as used herein, is defined to mean a degree of uniformity in which the variations from the average is not more than 5% in thickness circumferentially and the variation in thickness at right angles thereto is substantially zero for approximately 90-95% of the extent of the deposit.

In electrodepositing layers of metal onto curved surfaces, it is very difficult to maintain a uniform thickness of the deposited metal. This is due to the difference in the distance between the anode and the surface of the article being plated, which is the cathode. This difference in distance results in a difference in current distribution over the surface of the article being plated. When electroplating irregular-shaped surfaces, it is a well-known fact that cathode positions nearest to the anode receive the most plate and that there is a resulting build-up on the surface nearest to the anode with the thickness of the plate decreasing progressively as the distance from the anode increases. With semi-cylindrical articles, plated on the concave face, the center of the article will have less plated metal adhering thereto than the lateral edges. The term "lateral edges," as used herein, denotes the straight parallel edges of the semi-cylindrical object, the inner or concave surface of which is to be plated. Prior attempts to control the thickness of the plated layer consisted in shaping the anodes to a contour similar to that of the cathode; constructing full cylinders with a centrally located anode; using the bi-polar method in which an insoluble anode of similar contour to the cathode is used in combination with soluble anodes, and also shielding and masking. None of these lend themselves to the economies of the present method.

To the accomplishment of the foregoing and related ends, said invention, then, consists of the means hereinafter fully described and pointed out in the claims; the annexed drawings and following description setting forth in detail certain structure embodying the invention, such disclosed means constituting, however, but one of

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various forms in which the principle of the invention may be used.

In said annexed drawings:

Fig. 1 is a plan view of a semi-cylindrical article which is electroplated on its concave face;

Fig. 2 is an elevational view of the article shown in Fig. 1;

Fig. 3 is a graph showing the variation in thickness of plated metal upon a semi-cylindrical article using various current densities;

Fig. 4 is a diagrammatic view illustrating the arrangement of a semi-cylindrical object, the inner surface of which is to be plated and which itself acts as a cathode with the barrier element which controls the direct electrical circuits between the anode and the portions of the surface;

Fig. 5 is a similar front elevational view of the assembly of Fig. 4;

Fig. 6 is a graph showing the variation in thickness of plated metal obtained upon a semi-cylindrical article;

Fig. 7 is another graph showing the variation in thickness of plated metal upon a semi-cylindrical article;

Fig. 8 is a graph showing the variation in thickness of plated metal upon a semi-cylindrical article;

Fig. 9 is a plan view of another means for plating a uniform layer of metal upon the concave surface of a semi-cylindrical article;

Fig. 10 is an elevational view taken along the plane 10—10 of Fig. 9;

Fig. 11 is a plan view of another means for plating a semi-cylindrical article, and

Fig. 12 is a sectional view of the arrangement shown in Fig. 11 on the plane 12—12.

The articles which it is desired to plate are composed of steel or may be composite structures consisting of a layer of steel and a layer of another metal or alloy such as copper-lead or silver. These articles are shaped to finished semi-cylindrical conformity prior to the plating operation. It is desired to hold the tolerances of the finished plated surfaces as close as possible and to obtain the same thickness of plate on each blank. The ordinary thickness which it is desired to hold is in the neighborhood of .001 inch to .005 inch.

When semi-cylindrical articles are plated in the conventional manner by simply hanging them in the electrolyte, the lateral edges plate to a considerably greater thickness than the center. In Fig. 1 is shown a semi-cylindrical article with a steel backing layer 1 and a plated layer of metal 3. In Fig. 2 is shown an elevational view of the same article. Fig. 3 is a graph which

shows the variation in thickness obtained at different current densities on semi-cylindrical articles plated in the conventional manner. The curves shown in Fig. 3 were obtained by plating articles similar to 1 in Fig. 1 by plating on chrome-plated steel blanks. These shells were hung in an electrolyte with the anode a convenient distance away with no attempt to shield any part of the article. The current was passed from the anode to the cathode, using 6 volts as a standard, and the articles were plated for the same period of time. They were withdrawn from the bath and the plated layer was stripped from the backing 1 in one piece, since there is little or no adhesion between a chrome surface and the plated layer. The thickness of this layer was then carefully measured and set out on the graph according to the number of degrees distant from the lateral edge, shown as 2 in Fig. 1, designated as 0, to 180 degrees, which is the lateral edge 4. It is quite apparent from the graph that the deposit of plated metal at the edges 2 and 4 of the shell 1 is excessive where a uniform thickness is desired. Curves A, B, C and D in Fig. 3 show the effect of different current densities on the uniformity of the plate thickness. The deposit increases in uniformity as the current density decreases, and if it were practical and commercial to reduce the current density sufficiently, it is conceivable that a nearly uniform deposit could be secured at a very low current density. Obviously, however, this would be an extremely slow and uncommercial procedure.

For all practical purposes, the limits of current density range from 5 amperes per square foot upward, and it is apparent from the graph of Fig. 3 that a uniform thickness of metal cannot be plated on a semi-cylindrical article at these rates by conventional methods and with equivalent economy.

In practicing the principle of the invention, the following means will serve as illustrations. One method of plating shells is shown as an assembly in Fig. 4, the slot opening 8 being adjustable in width and having a length not greater than the width of the shell 1. The article to be plated 1, which represents the cathode in the plating cell, is mounted against an insulating barrier plate 15 with the lateral edges of the article in substantially sealing contact with the face of this plate 15. The anode 16 may be placed in any convenient position in the electrolytic cell in front of the insulating barrier member 15. The primary plating circuit is from the anode 16 through the slot 8 to the concave surface of article 1. Under these conditions, a secondary plating circuit is from the anode 16 to the convex surface of the article 1. The thickness and uniformity of the plate on the convex surface will vary with the type of the electrolyte, current density and composition of the plating bath. In cases where a uniform convex surface is not required, this procedure is satisfactory. If, however, a uniformly plated or non-plated convex surface is required, it is conveniently accomplished by either protecting the convex surface with an insulating material while plating the concave surface or by introducing controlled resistance between the anode 16 and the convex surface of the article 1 to give a definite regulated thickness and uniformity to this deposit.

One method of preventing plating on the convex surface of the shell is by applying a material such as wax, or other masking compound, to the back and then performing the plating operation

by means of the set-up described with reference to Figs. 4 and 5. After plating, the masking material can be stripped off in the conventional manner. This method involves considerable time, however, and in order to eliminate the operation of masking and at the same time to provide a means for controlling the thickness of plated metal on the back, the set-up shown in Fig. 9 and 10 has been devised. The article 1, which is to be plated, is placed inside a box 17, which is made up of an insulating material such as hard rubber or the like, and is completely sealed electrically, except for the slot opening 18 in the face 20. This slot opening is adjustable in width and is no greater in length than the length of the lateral edges of the shell. The lateral edges of the shell 1 are held by means not shown securely against the face 20 of the box and the circumferential edges of the shell are sealed by the top and bottom members of the box 23 and 24. The box 17 with the shell 1 in place is suspended in the electrolyte 26 and made the negative side of an electrical circuit by means not shown. The anode 19 is suspended in the electrolyte 26 in the tank 25 and made the positive terminal of the electrical circuit. When the electrical current is introduced into the circuit, it passes from the anode 19 through the slot 18 to the cathodic shell 1, causing a uniform layer of metal to be deposited on the concave surface thereof. Since the box 17 is made of an insulating material and is tightly sealed electrically, no plating will occur on the back of the shell 1. If it is desired, however, to plate a controlled thickness of metal upon the back of the shell, it can be accomplished by controlling the fit of the back member of the box 22, in such a way as to allow a portion of the electrical current to enter through the back of box to deposit metal of the desired thickness. This fit between the back member 22 and the rest of the box 17 controls the resistance in the electrical circuit between the anode 19 and the back of the shell 1.

Another method whereby the plating on the back of the shell 1 is eliminated or becomes of minor importance is illustrated in Figs. 11 and 12. In this set-up the tank 30 is constructed with an insulating barrier member having a slot opening 34, and the shell 33 is placed against the barrier member in such a manner that the lateral edges 36 and 37 are firmly seated against the member 31, by means not shown. The shell 33 should be lined up with the center line of the slot opening 34 and the length of the slot should not be greater than the length of the lateral edges of the shell. The anode 32 is made the positive terminal of an electrical circuit and the shell 33 is made the negative terminal. The electrolyte 35 is introduced into the tank by means of a supply inlet 38 and rises in the tank, coming in contact with the concave surface of the shell until it reaches the top 40 of the barrier member 31, at which point it overflows into the other side of the tank 41 and is carried away through the opening 39. The side of the tank 41 is kept free of the electrolyte by controlling the outlet 39 and thus there is little or no contact with the back of the shell 33 by the electrolyte 35 because of the weir effect at the top of the barrier 40. The bottom of the article is of course sealed against leakage of electrolyte past the edge thereof.

Tests were run with different electroplating baths, namely silver and lead, using a shell having a diameter of approximately 4.5 inches.

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The opening of the slot in the barrier was changed to determine the effects on the uniformity of plate. Figs. 6, 7 and 8 show graphically how the thickness of the plated layer approached uniformity as the slot opening was narrowed. The slot opening used with the shells which is described by the graph in Fig. 6 was 4 inches; the slot opening on those described in Fig. 7 was 1.5 inches; and the slot opening on those described in Fig. 8 was 0.5 inch. The shells represented by Fig. 6 were run for four hours, those represented by Fig. 7 for three and a half hours and those represented by Fig. 8 for three and a half hours and all were plated with a current density of 20 amperes per sq. ft.

By using the present method, it is possible to produce electroplated coatings on the concave surfaces of semi-cylindrical articles to the order of .001 to .005 inch in thickness, for example, which are sufficiently uniform so that they may be termed "precision surfaces" and may be employed for many purposes, as for example in various machine assemblies without any further finishing operations. Actually, therefore, in the above thicknesses an electrodeposited surface can be produced which is of greater uniformity than that which is produced by electrodepositing or by casting a very considerable thicker layer and then machining it to the desired .001 to .005 inch thickness. Thus, for example, semi-cylindrical bearing shells may be coated with an electrodeposited layer of .001 inch (to a 5% tolerance) and with a surface which does not have to be further processed after being deposited.

For any particular application the tolerances allowed in regard to the thickness of plated layer will determine the size of opening to have in the barrier element. With very thin layers of plate, the variation will in most cases not be important but when the desired thickness ranges from .001 of an inch and above the variation may be very important. For example, if a semi-cylindrical article having an internal diameter of 2.9 inches be plated, the barrier element in front of the concave side of the article should have a slot of approximately five-eighths of an inch in width, the slot, of course, extending vertically of the barrier and in parallelism with the lateral edges of the article to be plated. This gives a ratio between the width of the slot and the diameter of the shell of approximately .215. As a second example, it has been found that a satisfactory width of slot for the plating of an article of a diameter of 4.5 inches, the slot should be one inch, which gives approximately the same ratio of .22, and throughout a considerable range of sizes it has been found that satisfactory uniformity, within the limits herein specified, can be secured with a ratio between the slot width and the diameter of the article of 25% or less.

It will be apparent from the foregoing description that the present method lends itself to important economies of manufacture since the thickness of a plated coating which is applied can be held to a precision thickness and all further operations which require metal removal can be eliminated. It is also possible, if it is desired, to apply say .010 of an inch of a given metal by electrodeposition and then machine this to a final thickness of .005 inch, although the savings in such an operation would not be as great as if the electrodeposited coating were employed in the condition as deposited and without further operations thereupon.

Other modes of applying the principle of my

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invention may be employed instead of the one explained, change being made as regards the process herein disclosed, provided the means stated by the following claims or the equivalent of such stated means be employed.

I, therefore, particularly point out and distinctly claim as my invention:

1. In a method of electroplating a uniform layer of metal of approximately .005 inch or less thick upon the concave surface of a semi-cylindrical article, the steps which consist of placing the parallel edges of the article against and with the concave side facing, an insulating barrier element having a slot opening parallel to and centrally located with respect to the lateral edges of the article and being otherwise impervious to the passage of current, the width of said slot being approximately 25% or less of the diameter of the article, immersing the article and barrier element in an electroplating bath, mounting an anode in the bath external to the article and passing a plating current from said anode to said article as a cathode through said slot.

2. In a method of electroplating a uniform layer of metal of approximately .005 inch or less thick upon the concave surface of a semi-cylindrical article, the steps which consist of placing the article against and with the concave side facing, a flat insulating barrier element having a slot opening parallel to and centrally located with respect to the lateral edges of the article and being otherwise impervious to the passage of current, the width of said slot being approximately 25% or less of the diameter of the article, immersing the article and barrier element in an electroplating bath, mounting an anode in the bath external to the article and passing a plating current from said anode to said article as a cathode through said slot.

3. In a method of electroplating a uniform layer of metal approximately .005 inch or less thick upon the concave surface of a semi-cylindrical article, the steps which consist in mounting an anode and a semi-cylindrical article as a cathode in an electroplating bath, there being interposed between them a flat insulating barrier plate disposed against the parallel edges of the article, said plate being provided with a longitudinal slot parallel with and equidistant from the parallel edges of said article and being otherwise impervious to the passage of current, with such slot having a width approximately 25% or less of the diameter of the semi-cylindrical article and having a length not greater than the length of the parallel edges of the article, and passing a plating current from said anode to the article through said slot.

4. In a method of electroplating a uniform layer of metal and controlling the thickness variation within $\pm 5\%$ upon the concave surface of a semi-cylindrical article, the steps which consist in placing the article with its lateral edges against a flat insulating barrier member in an electroplating bath, the barrier member having a longitudinal slot but being otherwise impervious to the passage of current, the width of said slot being less than 25% of the diameter of the article and positioned centrally with respect to the lateral edges of the article, mounting an anode in said bath in a position outside the barrier member and passing a plating current from said anode to said article as a cathode through said slot.

5. In a method of electroplating a uniform layer of metal approximately .005 inch or less thick and controlling the thickness variation within $\pm 5\%$ upon the concave surface of a semi-cylindrical article, the steps which consist in placing the article with its lateral edges against a flat insulating barrier member in an electroplating bath, the barrier member having a longitudinal slot but being otherwise impervious to the passage of current, the width of said slot being less than 25% of the diameter of the article and positioned centrally with respect to the lateral edges of the article, mounting an anode in said bath in a position outside the barrier member and passing a plating current from said anode to said article as a cathode through said slot.

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