Aug. 7, 1973 A. J. MACULA ET AL 3,751,343

BRUSH ELECTROPLATING METAL AT INCREASED RATES OF DEPOSITION

Filed June 14, 1971 2 Sheets-Sheet 1

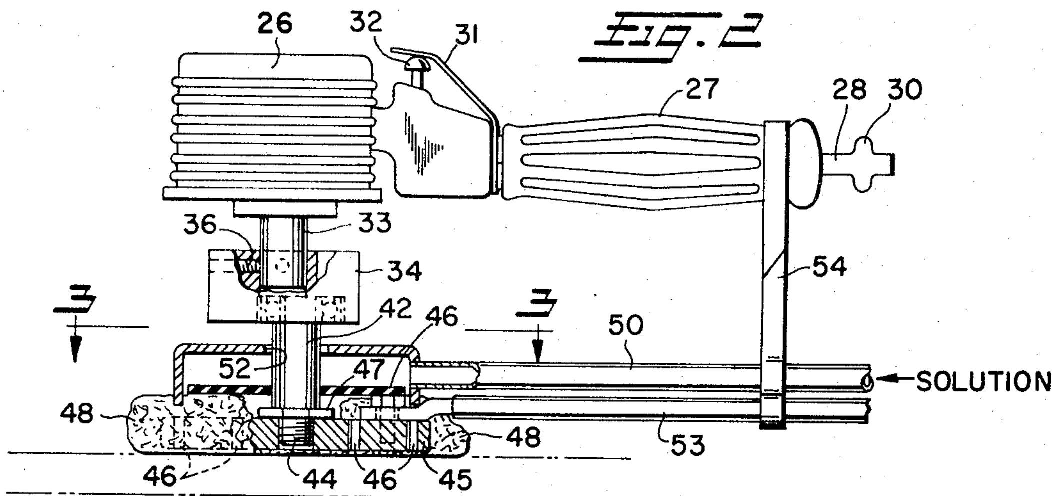

FIG. 2

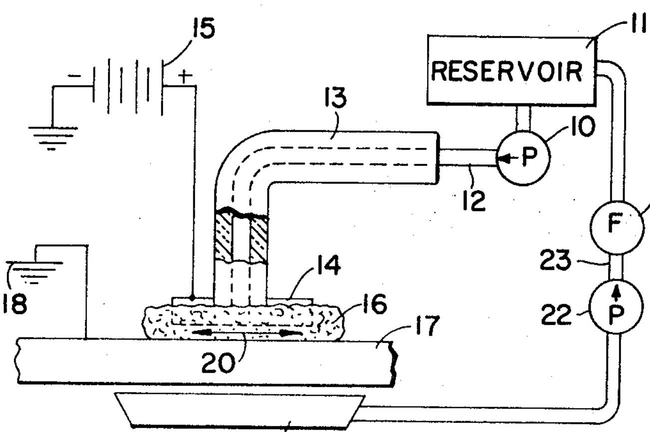

FIG. 1

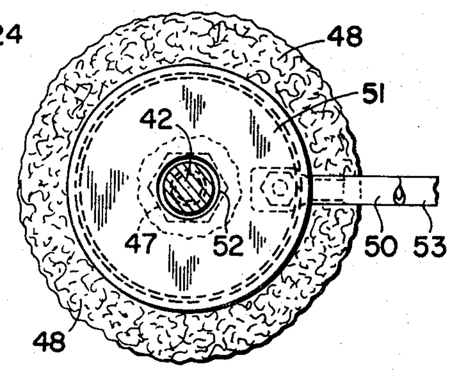

FIG. 3

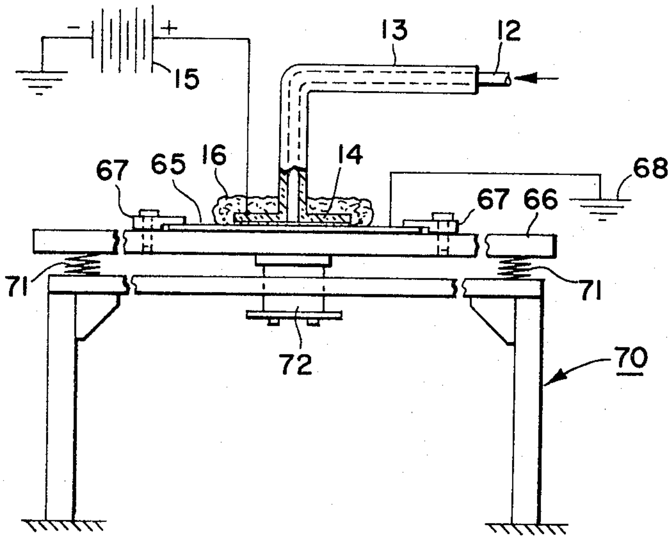

FIG. 7

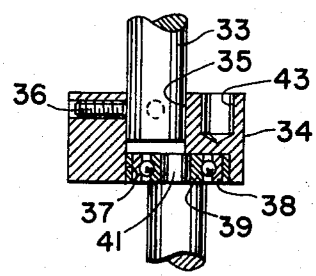

FIG. 4

INVENTORS.
ANDREW J. MACULA
JOHN T. MACULA
BENNO A. SCHWARTZ, JR
Bosworth, Sessions, Herstrom + Cain ATTORNEYS

Aug. 7, 1973 A. J. MACULA ET AL 3,751,343

BRUSH ELECTROPLATING METAL AT INCREASED RATES OF DEPOSITION

Filed June 14, 1971 2 Sheets-Sheet 2

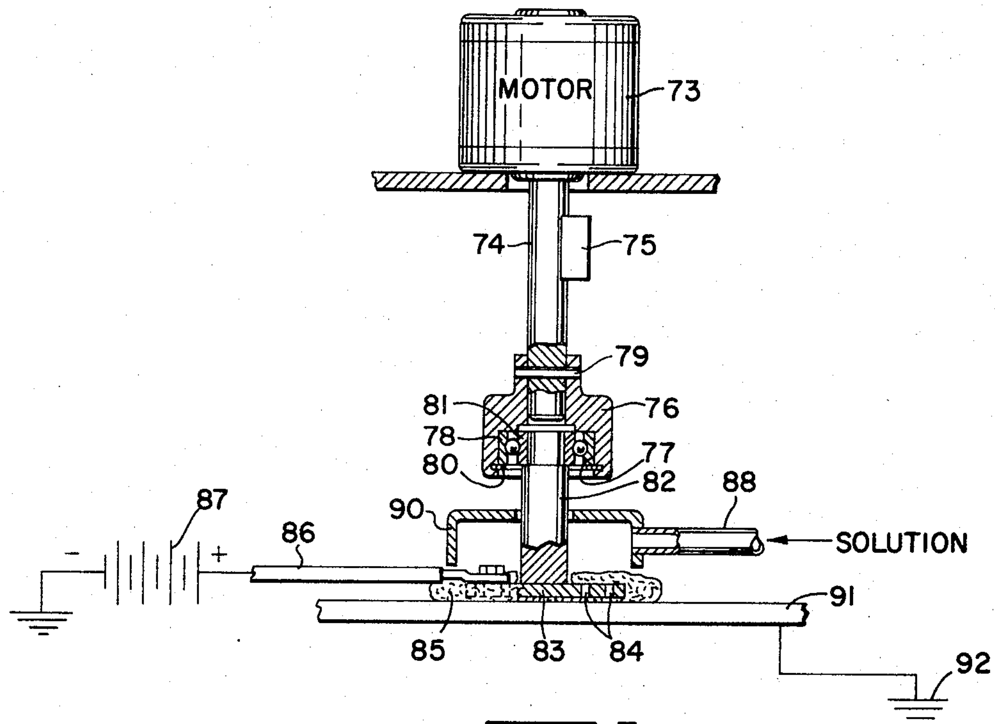

FIG. 8

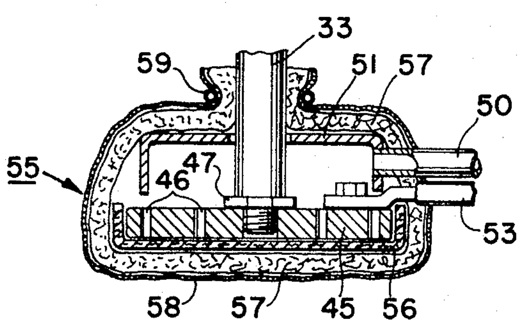

FIG. 5

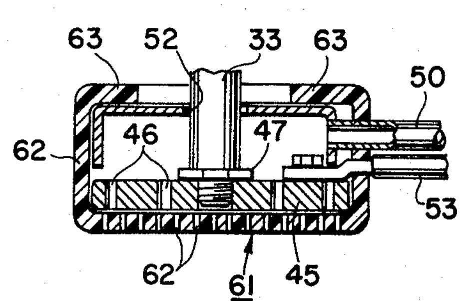

FIG. 6

INVENTORS.
ANDREW J. MACULA
JOHN T. MACULA
BENNO A. SCHWARTZ, JR.
Bosworth, Sessions,
Herrstrom & Cain
ATTORNEYS

United States Patent Office

3,751,343
Patented Aug. 7, 1973

3,751,343

BRUSH ELECTROPLATING METAL AT INCREASED RATES OF DEPOSITION

Andrew J. Macula, 6051 Fry Road, Brookpart, Ohio 44142; John T. Macula, 1013 Kenilworth 44113; and Benno A. Schwartz, Jr., 3278 W. 157th St. 44111, both of Cleveland, Ohio

Filed June 14, 1971, Ser. No. 152,802
Int. Cl. B01k *3/00;* C23b *5/48, 5/76*
U.S. Cl. 204—15 16 Claims

ABSTRACT OF THE DISCLOSURE

An improvement in the brush electroplating of metal in which appreciably increased rates of metal deposition are realized as compared to deposition rates previously obtained. In one form, the present brush apparatus includes a tool having an anode and a porous dielectric cover on the anode adapted to be wet by electrolyte and moved over a workpiece. During electroplating of metal, rapid relative movement takes place between the cover and the anode and preferably between the cover and both the anode and the cathode workpiece.

BACKGROUND OF THE INVENTION

Electroplating apparatus for the brush plating of metal is known in the art. Such apparatus is usually in the form of a hand tool which is rubbed or brushed against the surface to be plated as electrolytic action takes place. In the usual form the tool has a terminal which is made anodic with respect to a workpiece for plating and cathodic for electroetching or electrocleaning. The terminal is wrapped in a porous, dielectric fabric sock and rubbed over a surface while the sock is saturated with electrolyte. Brush plating techniques are described in U.S. Pats. 3,183,176; 3,313,715; and 3,393,134, all issued to B. A. Schwartz, Jr.

While brush plating has been successful in many applications, it is restricted to a relatively low rate of metal deposition. Such relatively low rates of electroplating are due to the inability of known brush apparatus to operate at high current densities. For instance, a standard copper plating solution plates well with the brush plating technique when the brush tool is in a circuit of about 4 volts and 10 amperes. However, as the voltage is raised to about 7.5 to 10 volts and the amperage to about 35 amperes, there is considerable burning, that is, a deposition of free amorphous copper rather than copper plating. Similar difficulties are encountered with other metals.

SUMMARY OF THE INVENTION

It is, therefore, a general object of the present invention to provide an improved brush electroplating apparatus and method. Another object is the provision of such apparatus and method by which increased rates of metal deposition are obtained. A further object is the provision of brush electroplating apparatus that may be used at higher current densities than previously possible.

Briefly, these and other objects of the invention are obtained by moving a porous dielectric cover on the terminal of the brush electroplating apparatus substantially constantly relatively to such terminal to provide a rubbing action. The motion of the dielectric covering relative to the terminal preferably takes place while the covering is in contact with both an anode of the brush applicator and a cathodic workpiece to provide a rubbing action on both the anode and workpiece. The speed at which the cover rubs the anode is large as compared to the speed at which the entire tool moves with respect to a workpiece. The relative movement of the cover is in a direction substan-

tially parallel to the surfaces of the anode and the workpiece and may take any path of travel such as a reversible, linear movement. However, a closed path such as a circular or elliptical loop is preferred to minimize or eliminate any opportunity for burning.

Vibration has been found to be well suited for producing the relative movement of the cover to a terminal. This may be accomplished by vibrating the terminal of the brush apparatus itself. Alternatively, vibrating the cathodic workpiece (or its support) while in contact with the porous cover on the brush apparatus terminal can be used. This also produces the relative slippage needed between the cover and the brush terminal. If desired, both the brush terminal and the cathodic workpiece can be vibrated.

While the invention is not to be limited by theory, it is postulated that the increased rate of deposition obtained by the present invention is possible, at least in part, because of replenishment of electrolyte at the anode surface to be plated at a much greater rate than is normally employed in brush plating. In the presence of electrolyte, the slippage of the cover with respect to the anode with a resultant scrubbing of the anode and the cathodic workpiece as well, when the covering contacts it as during a plating operation, removes the unwanted products of electrolysis and avoids passivation and polarization of the anode and cathode. The rubbing physically removes gases and unwanted impurities, precipitates, and spent electrolyte from the anode and as well from the surface to be plated.

In this manner, the rubbing at relatively high speed insures that electrolytic action emanates from and takes place on surfaces that are maintained in a clean condition and substantially free from gas. As a result, the voltage and amperage applied to the brush plating apparatus can be increased without undesirable effects.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring to the drawings:

FIG. 1 is a schematic drawing illustrating the relative positions of an anodic brush tool, a cathodic workpiece, and a porous dielectric covering in accordance with the present invention;

FIG. 2 is a side elevational view, partly in section, of a brush plating hand tool having vibratory means to insure lateral shifting of a covering relative to the tool;

FIG. 3 is a section of FIG. 2 on the line 3—3;

FIG. 4 is a vertical, center section of the rotatable head of the tool of FIG. 2;

FIG. 5 is a fragmentary, vertical center section of the anode of FIG. 2 having a preferred form of cover;

FIG. 6 is a fragmentary, vertical center section of the anode of FIG. 2 with a still different type of cover;

FIG. 7 is a semi-schematic drawing illustrating the application of a vibratory force on a cathodic workpiece instead of on the brush tool; and

FIG. 8 is a semi-schematic drawing showing a modified form of the application of a vibratory force on the anode of a brush tool.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring initially to schematic FIG. 1, a pump **10** transmits electrolyte from a reservoir **11** to a tube **12** extending through an insulated hand tool generally represented at **13**. The tool terminates in an anode **14** that is conventionally connected to a source of direct current **15**. A porous dielectric cover **16** is fixed to the anode plate **14** and, in use, is brushed across a cathodic workpiece **17** grounded as at **18**. The relative movement of the cover **16** with respect to the anode **14** and workpiece

17 is represented by the double headed arrow 20. This is preferably accomplished by rapidly moving the anode 14 or the workpiece 17 in a closed or linear path that may be of small dimensions as compared to the dimension of the tool and work. The electrolyte drains from the workpiece 17 into a sump 21 from which pump 22 returns it to the reservoir through a line 23 having a filter 24.

FIGS. 2, 3, and 4 illustrate a preferred form of brush tool and vibratory means for providing the necessary relative movement between a cover and tool anode. This tool is a modified form of a power driven hand tool described in U.S. Pat. 2,794,303 to Wickes. In this embodiment, a standard air driven motor 26 has a handle 27 equipped with a longitudinally extending tube 28 having a fitting 30 for attachment to a source of compressed air by which the motor 26 is operated. A finger operated lever 31 actuates a valve stem 32 that controls the operation of motor 26. The rotor of motor 26 (not shown) drives a shaft 33.

A cylindrical driving head 34 has a socket 35 to receive motor shaft 33 to which it is secured by set screws 36. A second socket 37 in head 34 has its axis offset radially from the axis of socket 35 as shown in FIG. 4. A ball bearing has an outer race 38 press-fitted in socket 37 and an inner race 39 which is press-fitted about a reduced upper end portion 41 of a spindle 42. With this arrangement, spindle 42 is free to rotate in the bearing of socket 37 and at the same time revolves with head 34 about the axis of shaft 33 to produce a vibratory effect on the spindle 42. One or more holes 43 may be drilled in head 34 (FIG. 4) to counterbalance the head and to compensate for the eccentric mounting of spindle 42. The use of counterbalancing holes 43 can reduce the amount of vibration of the brush apparatus which is transmitted to the spindle 42 should this be necessary or desirable.

Spindle 42 has a threaded stub 44 of reduced diameter which engages a central threaded opening in an anode plate 45 having peforations 46. A lock nut 47 tightly secures the spindle 42 and plate 45 together. A porous, compressible, dielectric cover 48 encompasses the plate 45 and is held in place by any suitable means, such as a pressure-sensitive tape. The cover 48 has a loose connection with respect to plate 45 to encourage slippage between the two parts. Similarly, the face of plate 45 is preferably smooth to minimize frictional drag of the plate on relative movement of the cover 48. The cover 48 extends across the face of plate 45 as shown in FIG. 2 and may comprise a fabric, woven or unwoven, such as cotton, flannel, felt, canvas, and the like. A preferred fabric comprises polyester fibers, such as Dacron polyester fibers, especially for chromium plating, since these materials have good resistance to attack by chromic acid. Cotton is attacked by chromic acid and can interfere with acceptable operation of an electrolyte.

A flexible tube 50 supplies electrolyte solution to a cap reservoir 51 which directs the electrolyte downwardly into the porous cover 48 through the perforations 46, and around the plate 45 onto a workpiece. The cap 51 is partially supported by the tube 50 and partially by the plate 45. The cap has an oversized opening 52 to pass spindle 42. Plate 45 and spindle 42 should not rotate with respect to each other to insure that vibration subjected on spindle 42 reaches plate 45 with as full a force as possible and to minimize lateral spraying of electrolyte. In the embodiment of FIG. 2, non-rotation of plate 45 is accomplished by the same means used to charge the plate, although these results can be separately accomplished if desired. An insulated electric cable 53 is bolted to a plate 45 and jointly supported with tube 50 by a tape 54 which is wrapped several loops around the tube 50, cable 53, and handle 27 of the brush tool. The tape 54 may be friction or masking tape and is preferred to more rigid means, such as a metal band, which tends to reduce the effect of the vibrations and movement of the cover 48 and plate 45.

In operation, motor 26 may drive shaft 33 at about 700 revolutions per minute to about 2,000 revolutions per minute, for example, depending on the size and/or contour of a workpiece. This produces a jiggling or shaking of plate 45 such that cover 48 cannot keep up with the frequency of the wobbling motion of the plate, thereby providing a slippage between the two, that is, a lateral movement of the cover 48 with respect to the plate 45. If a marking spot is placed on the plate 45 and a corresponding marking spot is placed on the cover 48, it has been noted that the two spots travel different paths of motion while the tool is in operation. Also, after use, the inside of the cover 48 (which faces plate 45) shows more scuffing and wear than the outside of the cover. For example, when shaft 33 rotated at about 2,000 revolutions per minute, by means of a marking spot anode 45 was observed to travel in a closed, elliptical path measuring one-fourth inch in major diameter and three-sixteenths inch in minor diameter. At the same time, while rotating at about 1,500 revolutions per minute, by means of a marking spot cover 48 was observed to travel in a closed, elliptical path measuring three-sixteenths inch in major diameter and one-eighth inch in minor diameter.

Electrolyte is pumped at a rate, for example, of one gallon every two to five minutes for a square anode measuring 2.5 inches on a side. An average flow of electrolyte for this anode is one gallon every three minutes. As electrolyte flows from tube 50 and cap 51, it passes through and around anode plate 45, through cover 48, onto a workpiece, and then by gravity to a suitable sump as in FIG. 1 from which it may be recirculated. An operator moves the entire tool relatively slowly over a surface to be plated, for example about 3 inches to 12 inches per second. The motion of cover 48 with respect to plate 45 can be in reversible linear directions and preferably at a sufficient rate that changes in linear directions are nearly as instantaneous as needed to prevent burning or inadequate metal deposition. Preferably, the path independently followed by the cover 48 is in a closed circular or elliptical loop and substantially parallel to the face of plate 45 and in the direction of brushing.

The use of restricting means on plate 45 which is less rigid than cable 53 results in different types of motion of the cover 48 relatively to plate 45. For example, a direct current potential can be impressed on other parts of the tool of FIG. 2 instead of on plate 45, such as on shaft 33 as by a brush. The cover 48 can then be less rigidly held against rotation as by a flexible tape connecting plate 45 to a stationary part of the tool such as handle 27. In operation, such less rigid restricting means has the effect of varying the amplitude of lateral vibration of the anode plate 45. Such less rigid restrictions also tend to convert the reciprocable linear motion of plate 45 into preferred rotary motion, such as circles having diameters as small as 0.25 inch.

FIGS. 5 and 6 illustrate the anode portion of the embodiment of FIG. 2 equipped with different types of covers. In each figure, clearance between the anode and the cover and between parts of a cover itself has been exaggerated for purposes of illustration. Parts similar to those of FIG. 2 have been indicated by like reference numbers.

FIG. 5 shows a preferred form of cover generally indicated at 55 comprising a three-layer or sandwich type of construction. A felt 56 contacts the face of anode 45 and extends upwardly along its sides. A fabric 57, woven or unwoven, contacts the felt 56 and extends upwardly alongside the cap reservoir 51 (leaving an opening for the tube 50 and cable 53) to a gathering point about the spindle 33. A gauze or snood 58 of open network encompasses both the fabric 57 and felt 56 and together with the fabric 57 is tied about the spindle 33 by a cord 59. The felt 56, fabric 57, and snood 58 may be composed of any of the materials disclosed for cover **48** of FIG. 2. The felt **56** is denser but thinner than fabric **57**. The snood **58** serves primarily to hold and tie the parts together.

In this preferred form of cover, the felt **56**, fabric **57**, and snood **58** preferably all have motion relatively to each other, the amount of relative motion of one part relative to a contiguous part decreasing in a direction away from plate **45**. The compressibility of the cover of FIG. 5 also enables it to serve as a shock-absorbing medium. This tends to concentrate the effect of vibration on the composite cover itself.

In FIG. 6, the cover comprises a pad generally shown at **61** of a synthetic resinous material having openings **62** to pass electrolyte. Any resinous material inert to electrolyte and electrolytic action may be used. Preferably the resinous material is sufficiently elastomeric that an upwardly extending cylindrical portion **62** may snap an inwardly directed rim **63** over the cap reservoid **51** and loosely hold the pad in place. Useful resins include nylon, polyvinyl resins such as polyvinyl chloride and polyvinyl acetate, polyethylene, polypropylene, polyacrylate esters, and the like. Polyurethanes may also be used because of their toughness and resistance to wear. A preferred resin is polytetrafluorethylene (Teflon) because of its low coefficient of friction.

The cathodic workpiece may be vibrated instead of the anode plate. FIG. 7 semi-schematically illustrates how this may be accomplished. The brushing tool of this embodiment is the same as that shown and described in connection with FIG. 1 and therefore the same reference numerals have been used to indicate like parts. A workpiece **65** is suitably fixed to a vibrating table **66** by holddown clamps **67** bolted to the table or by other suitable means such as a magnetic chuck. The workpiece **65** is grounded as at **68** or, if preferred, the table **66** which supports the workpiece can be grounded. In either case, a frame generally shown at **70** conventionally supports the table **66** by resilient means such as springs **71**. A conventional vibrator **72** of known construction is attached to the bottomside of table **66** and may be electrically or pneumatically energized. As electrolyte runs through tube **12** and covering **16** and across the anode **14** onto the workpiece **65**, the covering is jiggled with respect to the surface of the anode **14** preferably with respect to both the anode and workpiece **65**.

FIG. 8 illustrates still another modification of the present invention in which the anode is vibrated. A motor **73** rotates a shaft **74** having a fixed eccentric weight **75**. The motor **73** can be electrically operated but a pneumatically operated motor is preferred as a safety measure for operating personnel. A transverse pin **79** fixes a reduced neck portion of a tubular coupling **76** to shaft **74**, the coupling having a downwarlly exposed open socket **77**. A ball bearing that has outer race **78** press-fitted in socket **77** and also held in place by a retaining ring **80** mating with an internal groove in the socket. An inner race **81** is press-fitted about a reduced end portion of a spindle **82** suitably secured to an anode plate **83** having perforations **84**. Spindle **82** and plate **83** may be secured together in a manner similar to that for spindle **42** and plate **45** of FIG. 2. Anode **83** has a porous, dielectric cover **85** and is positively charged by a cable **86** bolted to the plate and connected to a source of direct current **87**. A tube **88** supplies electrolyte to a cap **90** which directs the electrolyte downwardly into the cover **85** and through and about plate **83** onto a workpiece **91** grounded as at **92**.

In operation, eccentric weight **75** causes the rotating shaft **74** to vibrate in an orbital manner, which vibration is transmitted to spindle **82**. The spindle is free to rotate relatively to the shaft **74** and is restrained from rotation by the connection to cable **86**. The rapid motion of shaft **74** causes the cover **85** to move with respect to anode **83** and results in a rapid rubbing of the anode **83** and, when in contact with workpiece **91**, of the workpiece as well.

Electrolyte solutions do not form a part of the invention. The present apparatus and method can be used to plate any metal for which there is an electroplating solution, such as copper, nickel, chromium, cobalt, silver, gold, zinc, tin, lead, iron, platinum, antimony, and the like. The anode may be either soluble or insoluble with respect to the electrolytic operation. Soluble anodes of nickel, copper, cadmium, silver, and gold may be used. Insoluble anodes include titanium or tantalum coated with either platinum or rhodium, and lead for chromium plating.

The following examples illustrate the invention and should not be construed as limiting the claims. Parts are by weight.

Example 1

A steel plate was prepared for electroplating by degreasing the damaged area, as by washing with a solution of sodium hydroxide, and then conventionally electrocleaning and electroactivating as described, for example, in Schwartz U.S. Pat. 3,393,134. A copper electrolyte consisting of:

	Oz./gal.
Copper sulfate	32
Sulfuric acid	8 to 10
Water, to make one gallon.	

was initially used with a standard brush tool, that is, one not moving a fabric cover relatively to an anode plate as herein described. At about 4 volts and 10 amperes, the operation of the standard brush tool proceeded smoothly. After five minutes, the electroplating was stopped and the copper plated area lightly polished with a sanding disc of 400 grit. The copper plate was quickly penetrated and bare metal was exposed, indicating an extremely thin copper plate had been deposited. This copper plate would have given poor resistance to rusting and corrosion.

With the same copper electrolyte solution and the same standard brush tool, an electroplating operation was attempted at increased voltages and amperage. As soon as the voltage was raised to about 7.5 to 10 volts and the amperage to about 35 amperes, there was considerable burning. A dark brown smear appeared on the steel plate which could be wiped away showing that copper had not even been plated.

With the same copper electrolyte solution, a brush tool of FIG. 2 was used. When a standard brush tool is used, an operator must supply the rubbing by moving the tool back and forth. But when a tool like that of FIG. 2 is used, the operator need merely guide it over a surface, the vibrations accounting for the desired motion. The voltage and amperage were increased on this tool, until they reached 20 volts and 50 amperes. The plating operation proceeded well with no burning. There was no indication that even greater voltages and amperage could not be used. The values indicated were not increased because 20 volts and 50 amperes were the limits of the rectifying apparatus used. This plating operation continued for five minutes. The plated area was then polished with a sanding disc of 150 grit, a rougher polishing operation than a disc for 400 grit. After 30 seconds, there was no penetration of the copper plate.

Example 2

A nickel electrolyte was used consisting of:

	Oz./gal.
Nickel sulfate	44
Nickel chloride	6
Boric acid	5
Water, to make one gallon.	

Score lines, scratches, and pits were deliberately made in the area of the steel plate of Example 1 that was to be plated. The tool of FIG. 2 was used, and the electrolyte was pumped to the tool at a rate of about one gallon every three minutes. The voltages and amperages applied to the tool were raised until the limit of the apparatus was reached, namely, 20 volts and 50 amperes. The plating operation lasted five minutes.

The score lines, scratches, and pits were filled in and could not be seen even after a finishing buffing operation. The metal layer deposited was so thick that even after removing some of it by buffing, the original scratches, score lines, and pits were still filled with metal deposit. For the same reason, an operator need not be nearly as careful in a buffing step for fear of taking off the entire nickel plate.

Example 3

A chromium electrolyte was used consisting of:

	Grams
Chromic acid	300
Sulfuric acid	1.25
Trichloroacetic acid	15
Trivalent chromium (as from chromium sulfate)	5
Sodium hydroxide	40
Water, to make one liter.	

When the present tool of FIG. 2 was used with different rectifying apparatus, excellent chromium plate was obtained on an area of a steel plate even though the voltage and amperage were raised to 18 volts and 90 amperes. Chromium was deposited at a rate of 0.015 inch per hour. When a standard hand brush tool was used with this solution at 12.5 volts and 35 amperes over the same area, chromium was plated at a rate of 0.002 inch per hour.

The relative motion of a cover to the anode plate and preferably to the cathodic workpiece as well enables production of uniform, high quality deposition at substantially increased rates as compared to those previously possible in brush plating.

Although the foregoing describes presently preferred embodiments of the invention, it is understood that the invention may be practiced in still other forms within the scope of the following claims.

What is claimed is:

1. A brush electroplating apparatus comprising a tool portion having a conductive electrode and a porous dielectric cover on said electrode and in contact therewith, said cover being adapted to be wet by electrolyte and brushed against a workpiece, means for supporting said cover for movement with respect to said electrode, and power means for substantially constantly moving said cover relative to said electrode to provide a rubbing action between said cover and said electrode.

2. Apparatus according to claim **1** wherein said electrode is an anode and wherein the relative movement between said cover and said anode is oscillatory.

3. The brush electroplating apparatus of claim **1** in which said cover is a fabric wrapped about said electrode.

4. The brush electroplating apparatus of claim **1** in which said cover is a fabric comprising polyester filaments.

5. The brush electroplating apparatus of claim **1** in which said cover comprises a felt member directly contacting said electrode, a fabric contacting said felt member, and a snood member encompassing said felt member and fabric attached about said electrode.

6. The brush electroplating apparatus of claim **1** in which said cover is a pad of a synthetic resinous material having openings to pass electrolyte.

7. The brush electroplating apparatus of claim **2** in which said power means comprises means for vibrating said anode.

8. The brush electroplating apparatus of claim **1** including means for supplying electrolyte to said cover.

9. Brush electroplating apparatus comprising a tool portion having an anode, a porous dielectric cover positioned in contact with said anode and movable with respect thereto and adapted to be wet by electrolyte and brush against a workpiece means for supporting a workpiece in cathodic relation to said anode, and power means for vibrating at least one of said anode and said support means to move said cover in an oscillatory path relative to said anode and thereby provide a rubbing action between said cover and said anode.

10. The brush electroplating apparatus of claim **9** including a workpiece carried by said support means in which said vibratory means vibrates at least one of said anode and said workpiece to move said cover with respect to both said anode and workpiece while in contact with both, and thereby provide a rubbing action against both said anode and workpiece.

11. Brush electroplating apparatus comprising a tool portion having an anode, a porous, dielectric flexible cover disposed in contact with said anode and movable with respect thereto and adapted to be brushed against a workpiece to be plated, conductor means for impressing an electric potential on said anode to make it anodic with respect to said workpiece, means for supplying electrolyte to said cover, and power means for oscillating said cover relative to said anode to provide a rubbing action thereagainst.

12. The brush electroplating apparatus of claim **10** in which said anode is perforate, and said means for supplying electrolyte comprises a cap means disposed about the anode and adapted to receive said electrolyte and pass it through the perforations of said anode and into the cover.

13. In a method of brush electroplating in which a tool having an anode provided with a porous, dielectric cover in contact therewith is brushed over a cathodic workpiece in the presence of electrolyte, the improvement comprising substantially constantly oscillating said cover relative to the anode to provide a rubbing action between said cover and said anode.

14. The method of claim **13** in which said cover is so moved while in contact with both said anode and said cathodic workpiece to provide a rubbing action on both of said anode and workpiece.

15. The method of claim **14** in which said movement of the cover is in a closed path.

16. The method of claim **13** in which said movement of the cover is in directions substantially parallel to the direction of brushing and to the contacting surfaces of the anode and cover.

References Cited

UNITED STATES PATENTS

3,346,477	10/1967	Wolfer	204—224
3,563,862	2/1971	Joly et al.	204—224 X
3,294,664	12/1966	Franklin	204—224
2,833,702	5/1958	Elfers	204—224 X
3,619,382	11/1971	Lupinski	204—224 X

FOREIGN PATENTS

493,108	9/1938	Great Britain	204—224
904,962	9/1962	Great Britain	204—224

GERALD L. KAPLAN, Primary Examiner

D. R. VALENTINE, Assistant Examiner

U.S. Cl. X.R.

204—222, 224 R