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Electroplating method and system

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SUMMARY:

The present invention relates to electroplating and, more particularly, to electroplating methods and systems for producing selective plating at predetermined or preselected regions of an article. This application is a continuation-in-part of parent application, Serial No. 608,779, filed August 3, 1945, now abandoned, for Electroplating.

An object of the present invention is to provide a new and improved method of and apparatus for electroplating that permits plating control over preselected regions of an article to be plated to the exclusion of adjacent regions, and affords a control over the thickness of plating in any predetermined regions of the article.

A further object is to provide a new and improved method of and apparatus for electroplating that is not subject to deleterious polarization effects near the surface of the article to be plated.

A further object is to provide a new and improved method of and apparatus for plating designs.

Other and further objects will be explained hereinafter and will be particularly pointed out in the appended

ENGLISH-CLAIMS:

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claims.

The invention will now be more fully described in connection with the accompanying drawings, Fig. 1 of which is a diagrammatic view of circuits and apparatus illustrating the invention in preferred form; Fig. 2 is a similar view of a modification adapted for automatically producing a plating pattern; Fig. 3 is a perspective view, partly cut away, of a particular type of plating that may be produced with the aid of the present invention; Fig. 4 is a fragmentary side elevation of a modified cathode-ray member; and Fig. 5 is a view similar to Fig.

ification.

Referring to Fig. 1, an anode electrode 5, as of carbon, is immersed in a plating bath, solution or other electrolytic medium 3 held in a tank container 1, shown in cross section. The anode electrode 5 is connected through a battery or other energy source 9 to the article 7 to be plated, which is maintained at cathode potential, as, for example, at ground potential.

An electron-gun envelope 11, as of glass, is shown supported in the bath 3 by a support 23, also constituted of a material such as glass that is unaffected by the plating bath or solution. The gun is shown in Fig. 1 as comprising conventional television cathode-ray or similar electron-tube gun elements including an electron-emissive electrode 13, maintained at cathode potential, as at ground potential, an electron-intensity-controlling electrode and an anode 17. A conventional electron-gun variable bias-voltage source 2 is connected between the cathode and the control electrode 15, providing variable electron-intensity control. A conventional electron-gun variable anode-supply source 4 is connected between the anode 17 and the cathode 1

3. The gun comprises also horizontal positioning means such as the electrostatic plates 19 and energized by a conventional variable horizontal positioning voltage source 6, and vertical positioning means such as a similar pair of vertical deflection plates 21 and 22 energized by a conventional variable ternal voltage sources may be water-proofed and otherwise provided with well-known coverings, such as rubber products, that prevent attack by the bath.

of the cathode-ray device 11, a conducting layer 37, as of aquadag, may be coated, preferably of the same day cathode-ray television tubes to serve as collecting by deflection coils, as is well known in the art. As will hereinafter be discussed, moreover, the thin conducting layer 37 may be formed of other materials than aquadag, such as thin aluminum, gold or other metal foil, as, for example, of thickness of the order of a few thousandths of an inch.

Electrons passing from the cathode 13 are accelerated past the control electrode in quantities dependant upon the bias voltage produced by the variable-intensity control 2, and then pass through the anode 17 in response to the accelerating anode-voltage source 4, continuing between the positioning or deflection members 19, 20, 21 and 22, finally to impinge upon or impact a predetermined region of the conducting layer 37 corresponding to a predetermined region of the electroplating solution) on the other side of the wall 2

5. The conducting layer 37 at this region becomes thus provided with an added negative charge since the electron stream produced within the envelope 11 is a stream of electric charges of negative sign. Because of the capacitive relationship of the conducting layer 37 and the article to be plated 7, moreover, as traced on one side from ground to the electrongun cathode 13 and through the tube to the layer 37, and on the other side from ground to the cathode 7, a corresponding charge influence is produced on a correspending predetermined region of the article 7 disposed opposite to the said predetermined region of the conducting layer 37 upon which the electron stream has impinged.

The battery 9 is preferably adjusted to a potential of of a mod- 4S value just under the electroplating potential of the electroplating solution so that current may be produced between the electrode and the article to be plated 7 of amperage insufficient to produce plating en the article. With the battery 9 so adjusted, the member 11 is then positioned with the wall disposed in a region close to the position at which the article 7 is suspended or otherwise supported, as illustrated. While the complete cathode-ray member is shown immersed in the bath or solution 3 this is not necessary. The member may obviously be shaped so that it can be disposed outside of the bath as, for example, above the surface of the bath,

and only the window and a small portion of the tube is inserted in the bath.

The batteries 2 and 4 are next adjusted within the normal limits of well-known television, electron microscope or other electron-gun grid or anode voltages until plating is visually observed on the article 7. When plating occurs, the charge produced at the predetermined region of the electroplating solution, corresponding to the predetermined region of the layer 37 on the wall upon which the electron stream has impinged, has effectively increased the said amperage to a value sufficient to produce plating on the oppositely disposed corresponding predetermined region of the article 7. The bias control 2 permits adjustment of the intensity of the electron stream and hence of the degree of plating. If insufficient plating is obtained, the member 11 may be moved closer to the article 7.

Since the intensity control 2 and the anode control 4 affect the intensity of the electron stream, these controls permit more or less plating at the region of the article corresponding to the region of the conducting layer 37 on the wall to which the stream is directed.

The control 6 permits horizontal positioning of the stream by applying horizontal electric-positioning fields of desired intensity between the deflection plates 19 and 20, and the control 8 similarly permits of vertical positioning of the electron stream such that the regions of the article 7 to be plated may be controlled and limited as desired.

It is to be understood, moreover, that the electron tube may embody further refinements including further focusing anodes and the like, as is well known in the cathoderay-tube art.

The production of charges at predetermined regions of the wall 25, furthermore, causes disturbances at the corrcsponding regions of the solution, which reduces the deleterious effects normally caused by polarization, that prevents the potential produced between the electrode and the article-to-be-plated 7 from continuously producing plating on the article.

The conducting layer 37 and wall of the gun 11 should preferably be placed as near to the article 7 as possible to prevent serious refraction and absorption effects in the bath.

The utility of the present invention is not, of course, dependant upon the existence or non-existence of theories whether accurate or inaccurate to account for the observed phenomenon. It is sufficient to describe and illustrate the invention as it has been found to work in practice.

theory of operation is, however, probably as follows:

The rendering negative of the conducting layer 37 mounted upon the window produced by the impingement of the electrons, capacitatively produces a negativecharge effect upon the oppositely disposed region of the article 7, thereby further lowering the potential of that region of the article 7 with respect to the anode 5 and selectively permitting plating at that region to the exclusion of the remainder of the cathode 7.

As an illustration, a conventional oscilloscope-type cathode-ray tube comprising a cathode 13, a control electrode 15, an anode 17, horizontal deflection plates 19, 20, vertical deflection plates 21, 22 and a wall carrying an aquadag layer 37 was immersed in a copper sulphate electroplating solution between an anode 5 and a flat piece of cleanly polished bronze 7. A storage battery 9 provided with a potentiometer was connected between the anode 5 and the cathode 7 so that the voltage therebetween could be varied from about zero to about six volts. The anode 5 and cathode 7 were placed opposite each other separated by about ten inches. The left-hand end or electron-gun part of the cathode-ray tube was actually supported mostly out of the bath but with the wall carrying the conducting layer 37 inserted in the solution adjacent and substantially parallel to the cathode 7, as in Fig. 1, but with the cathode 7 disposed at a slight incline to the vertical. This arrangement was necessary because of the small size of tank available for this particular test, but it is preferable to utilize a tank large enough to receive the complete member 11 under the solution, as illustrated in the drawinas. It was found that if the voltage-supply system 9 were adjusted to produce a voltage of about two-tenths of a volt, no discernible copper plating was produced on the article 7.

With the wall of the cathode-ray tube member spaced about one-eighth inch from the cathode 7 and with the application of anode voltage 4 of about volts and a grid 15-to-cathode 13 voltage of about volts, and with a positioning voltage 6 of about volts and a positioning voltage 8 of about the same value, an electron stream was produced in the tube impinging on the conducing coating 37 at a predetermined region. After about fifteen minutes of application of the said electron-gun voltages and the voltage from the source 9, a spot of copper plating was produced on the article 7 in the region oppositely disposed to the region of the conducting layer 37 and wall 25 upon which the electron stream had impinged. At no other region of the article 7 was any discernible plating produced. By varying the value of the bias voltage 2 to increase the electron flow, a heavier plating spot was produced, and by varying the value of the positioning voltages 6 and 8 within conventional positioning-voltage values, as, for example, from zero to about one-hundred fifty volts, the positioning of the spot v/as correspondingly moved to any desired predetermined location.

It was found, moreover, that the position of the layer 37 from the cathode 7 was not critical in that any close separations could be made to work merely by appropriately adjusting the various voltage controls within conventional limits. As another illustration, for a spacing from the wall to the article 7 of about one sixteenth of an inch and slightly smaller bias voltage 2 of about volts, satisfactory selective plating was produced upon the article 7. While, moreover, in the above apparatus, a copper-sulphate plating solution was employed, any other plating bath or medium may be similarly employed, such as for the electroplating of silver, chromium and nickel, to mention but a few, since the effects produced by the present invention are purely a matter of potentials and charges, with the type of metal or other element being electroplated being immaterial.

If desired, moreover, a control type of plating may be obtained by adjusting the horizontal and vertical posi-

The M tioning controls 6 and 8 and the intensity controls 2 and 4 to produce, for example, the waffle-like structure 29 of Fig. 3 upon a cathode article 27. All that is neeessary is to move the electron stream from spot to spot along the conducting layer 37 allowing it to remain in each region long enough to produce the corresponding structure 29. Such a plating has application in the production of chromium-plated roller bearings where surfaces void of chrome are desired to permit lubrication, and also in the production of televison mosaics, since the plated material 29 may be of one of the metals, such as silver, from which photo-sensitive surfaces are prepared.

Various plating designs, moreover, may be produced by an automatic design-plating mechanism as illustrated in Fig.

2. The system of Fig. 2 is very similar to that previously described in connection with Fig. 1 except that the horizontal and vertical positioning voltages 6 and 8 are replaced by sweep generators. The horizontal deflection plates 19 and are energized by a sweep condenser 12. a charging resistor 14, a battery 16 and a gas-discharge tube 10 that constitute a conventional relaxation sweep oscillator. A horizontal scan or deflection voltage is thus produced between the plates 19 and to cause the electron stream emitted from the cathode 13 to be deflected in a horizontal row or line along the layer 37. The vertical deflection plates 21 and 22 are shown fed by similar vertical sweep voltages from a sweep condenser 32, a charging resistor 34, a battery 36 and a discharge tube 30. The successive horizontal sweeps are, therefore, successively lowered by the vertical sweep-circuit scan to Permlt a tw dimensional scan of the layer 37. The timeconstant-controlling elements 12, 14, 16 and 32, 34, 36 of the horizontal and vertical scan circuits are shown variable to permit any desired frequencies of scan. It is to De understood, of course, that other types of deflecting cr scannm generators may also be employed as is known in the television art.

The Ia5er 37 is& gt; therefore, automatically scanned along successive rows and columns by the electron stream automatically to produce corresponding rows and columns of plating upon the article 7. The sweep circuits, moreover, may be modified as is well known, to produce circular, spiral or other geometrical scan configurations according to conventional television techniques.

With the before-described experimental apparatus, for example, utilizing only a horizontal sweep generator comprising a gas-tube relaxation oscillator of sixty-cycle sweep connected between the horizontal deflection plates 19

and for producing about a thirty-volt saw-tooth voltage, and with substantially the same voltage settings and anode, cathode and electron-gun spacings before described, a horizontal line of plating has been automatically produced upon a cathode 7 to the exclusion of plating elsewhere.

If desired, furthermore, the automatic or scanning plating may be utilized to obtain a pattern such as that illustrated in Fig. 3. It is merely necessary during the scanning, periodically to cut on and off the electron stream thereby to produce the separated plated regions 29. This may be effected by connecting a modulation generator 38, such as a pulse generator of the well-known multivibrator type, between the control electrode 15 and cathode 13 of the cathode-ray member, periodically to cut the electron beam on and off during the scanning at any desired repetition rate. The modulation of the generator 38 may, of course, be of any other desired type to produce any desired design. If, for example, it is of the equally wellknown saw-toothed type and of frequency equal to or greater than the horizontal scan frequency of the generator 10121416, then a plating line, the degree of plating of which increases with horizontal positioning along the article 7, would be produced. Many other designs will, of course, immediately suggest themselves.

In all cases, where electron-gun voltage terminals or other components, associated voltage leads and the like are exposed in the plating solution or bath, they may be water-proofed and protected from the bath by rubber and other gaskets or coverings, as before stated.

While the conducting layer 37 has heretofore been described as placed upon the front wall of the tube, it may be disposed along a wall at an angle thereto, just so long as the electron stream can impinge thereon and the wall carrying the layer may be placed in juxtaposition to the article to be plated. The layer 37, moreover, need not cover the complete wall 25. In Fig. 4, for example, the glass wall of the cathode-ray tube is shown provided with a pattern of successive aquadag or other coated regions 37, each insulated from the other by the wall 25.

Only when the electron stream impinges on the conducting regions 37, therefore, may the above described effects be produced. A pattern similar to that previously discussed in connection with Fig. 3 may be effected with the aid of such a cathode-ray member 25.

If, indeed, it is desired to utilize a strong, thin conducting window as, for example, of the Lenard type, instead of and in substitution for the combination of the wall and its conducting layer 37, such an arrangement may be provided as shown in Fig. 5. Fig. 5 is identical with Fig. 1 except that it embodies a Lenard-type window in place of the combination of the wall and conducting layer 37. The material of the window will be 58 selected so that interaction with the plating bath or solution will be obviated. For the before described copper plating, as an illustration, a gold-foil window may be utilized.

Further modifications will occur to persons skilled in go the art and all such are considered to fall within the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A method of electroplating an article disposed with fl5 574,316 Germany----------Apr. 12,1933 496,113 Great Britain_____Mar. 23,1938 an electrode in an electroplating solution that comprises producing a potential of magnitude less than the electroplating potential between the electrode and the article, producing an electron stream in a cathode-ray envelope provided with a wall comprising a conducting layer, disposing the wall close to the article, impinging the electron stream on selected regions of the wall, and adjusting the intensity of the impinged electron stream to control the plating of the article at the said regions.

2. A method of electroplating an article disposed with an electrode in a metal electroplating solution that comprises producing a potential of magnitude less than the electroplating potential of the metal solution between the electrode and the article, producing an electron stream in a cathode-ray envelope provided with a widow, disposing the window close to the article, impinging the electron stream on selected regions of the window, and adjusting the intensity of the impinged electron stream to control the plating of the article at the said regions only.

3. An electroplating system having, in combination, a container for the electroplating electrolytic medium, an electroplating electrode disposed in the electrolytic medium, means for producing between the electrode and an article to be plated a potential insufficient continuously to produce plating on the article, a cathode-ray tube provided with a window and means for producing and controlling an electron beam to impinge the same upon the window, and means for supporting the article to be plated in the electrolytic medium adjacent the window in order to control the plating upon the article in accordance with the impingement of the electron beam upon the window.

4. A method of electroplating an article disposed with an electrode in an electroplating medium that comprises producing between the electrode and the article a potential insufficient continuously to produce plating on the article, producing an electron stream in a cathode-ray envelope provided with a window, disposing the window near to the article, impinging the electron stream upon selected regions of the window, and adjusting the intensity Of the impinged electron stream to control the plating of the article near the said regions only.

5. A method of electroplating an article disposed with an electrode in an electroplating medium that comprises producing between the electrode and the article a potential insufficient continuously to produce plating on the article, producing a stream of negative electric charges in an evacuated envelope provided with a window, disposing the window near to the article, impinging the stream Of negative electric charges upon selected regions of the window, and adjusting the intensity of the impinged negative electric charges to control the plating of the article near the said regions only.

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