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ELECTROPLATING METHOD AND APPARATUS

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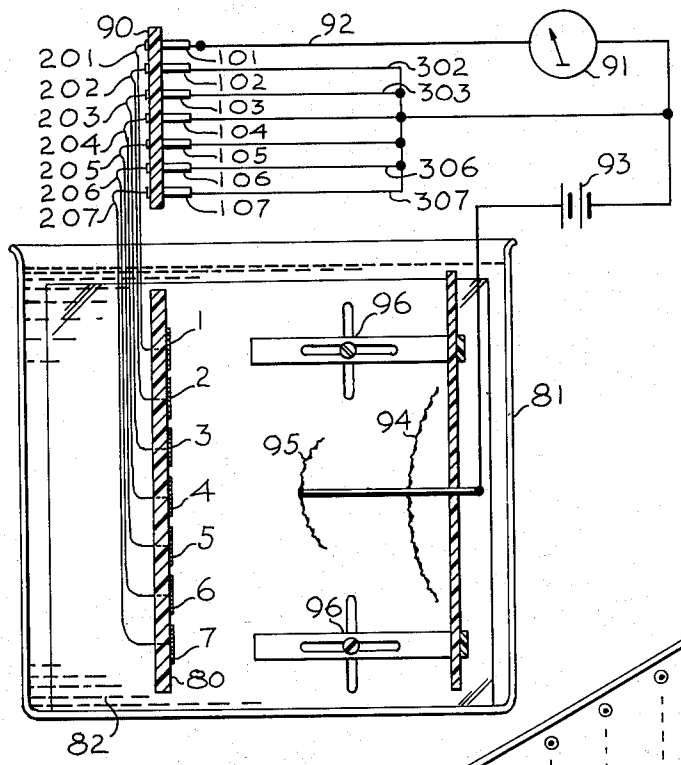

Fig. 1

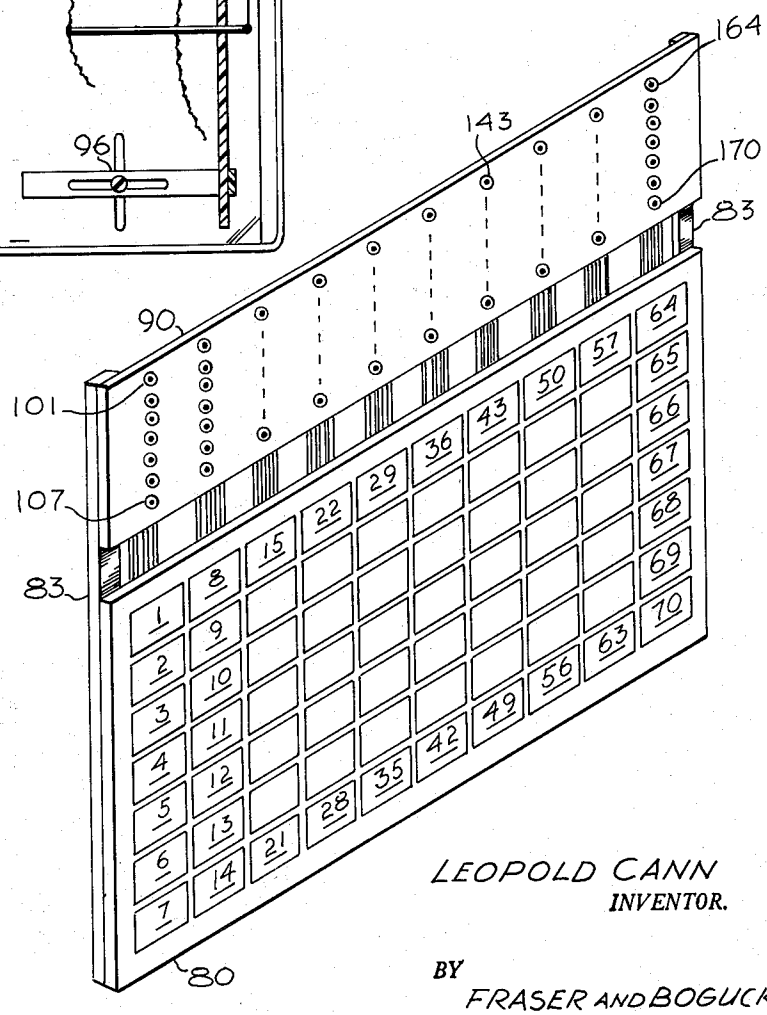

Fig. 2

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ELECTROPLATING METHOD AND APPARATUS

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This invention relates to electroplating methods and apparatus and more particularly to an improved method and apparatus for electroplating large areas uniformly.

In electroplating processes the thickness of the material deposited is a function of the current density in the area being plated. Where the plated object is small or where the dimensions thereof are not critical, variations in current density are usually of minor significance. However, in some situations, it may be important to provide an extremely uniform deposit on an object being electroplated. One such situation is the case of a magnetic screen memory structure which may be formed by plating a thin layer of remanently magnetic material over an ordinary copper screen. In such a structure it is extremely important that the remanently magnetic material be uniformly deposited over the screen in order that the individual memory elements which comprise the magnetic material surrounding individual meshes of the screen may have uniform operating characteristics.

The problems of obtaining a uniform electrodeposit are well known to those skilled in the art. It is also known to compensate for variations in plating current density by specially shaping the anode and by employing what are known as "thieves." These "thieves" are auxiliary anodes which may be selectively positioned in order to provide preferred current paths, thus compensating for existing non-uniformities. To set up such compensating arrangements properly, however, it is essential that the actual current distribution of the particular arrangement be ascertained. Heretofore, where it was important, an approximation of the current distribution has been afforded by calculations related to the dimensions and configurations of the electrodes. However, calculation of the theoretical current distribution over an electrode of extended area is complicated and rarely relates adequately to the practical attainment of the desired uniformity. Furthermore, it is even less satisfactory when the article to be plated bears some unusual configuration, such as a sphere or a surface having various irregular convolutions or the like.

It is an object of the invention to improve the uniformity of an electrodeposited layer over an extended area.

It is also an object of the invention to improve the uniformity of plating over an electrode of irregular shape.

It is another object of the invention to provide for increased uniformity of current density over the area of an object being electroplated.

It is a further object of the invention to simplify the procedure followed for establishing uniformity of material deposited in an electroplating process.

More particularly, it is an object of the invention to provide a quantitative measurement of current distribution for a particular configuration of electroplating electrodes.

Briefly, in accordance with the invention, special techniques are presented for improving the uniformity of the plating in an electroplating process. These special techniques permit an actual determination of the current variation throughout the extent of the object to be plated. This determination of the current variation is more accurate and may be performed in much less time than the calculation of a theoretical current distribution over the extent of the electrode, previously relied upon.

The invention may be practiced with particular advantage in connection with the plating of articles such as the above mentioned magnetic screen memory structure. Accordingly, the method and structure of the invention will be described as related to the plating of a screen for such a device. It should be understood, however, that the principles of the invention are applicable more generally to other objects of various configurations involved in the electroplating process and the invention is not to be limited to the particular use described herein.

In one arrangement of the invention, a sectionalized test screen of similar area and type to a screen which is to be plated for the magnetic memory is prepared upon a plastic support. Each individual screen section which is a part of the over-all test screen is fastened to the plastic support by means of nylon thread and is electrically connected by means of individual leads to a power source. An ammeter is inserted in series with the individual leads from each screen section to measure the current carried thereby without distorting the current distribution over the remaining screen surface area. The resulting current measurements may be plotted to provide a graphical representation of the existing current distribution. It will be clear to those skilled in the art that the current distribution may be ascertained in this manner with as great a degree of precision as desired, simply by dividing the over-all screen area into individual sections of suitably small dimensions.

Once the current distribution is determined in this manner, the screens comprising the opposite electrode, which is commonly the anode, are then distorted to shapes which result in a more uniform current distribution. In this manner, the arrangement of the invention thus provides more uniform plating upon the main screen which is placed in the position occupied by the sectionalized screen during the determination of the current distribution. In addition to shaping the anode as described, auxiliary anode screen sections may be added in order to effect the desired uniform current distribution. A particular configuration of the anodic screen may then be tested as above to determine its current distribution. By repeating the above steps a number of times, a particular configuration of the anodic screen can be achieved which results in an especially uniform current distribution over the cathodic screen area. Thus it is possible to attain an extremely uniform deposit of material upon a cathode of extended area or irregular shape by the process in accordance with the invention which accurately and quickly determines the plating current distribution for a particular configuration of electrodes.

A better understanding of the invention may be gained from a consideration of the following detailed description taken in conjunction with the drawing in which:

FIGURE 1 illustrates one particular arrangement for practicing the invention;

FIG. 2 is a perspective view of a particular portion of the arrangement shown in FIG. 1.

An arrangement for practicing an electroplating process in accordance with the invention is shown in FIG. 1 which includes a container 81 filled to a suitable level with an electrolyte 82. A suitable insulating frame 80 is provided to which a number of conducting elements or sections 1–70 are attached. This portion of the apparatus is better illustrated in the perspective view of FIG. 2 which shows elements 1–70 mounted on the frame 80.

Each individual element 1–70 corresponds to a particular portion of an electrode that is to be plated in place of the elements 1–70 and the composite structure serves as a test electrode. In accordance with the invention the structure is prepared so that these elements in the aggregate assume the shape and dimensions of the electrode to be plated. While in the depicted arrangement the elements 1–70 are shown in a planar array of columns and

rows, thus corresponding to a flat electrode such as a screen structure which is to be plated, it will be understood that they may be arranged as desired to assume the shape and dimensions of any electrode configuration that is to be plated.

Additional frame members 83 affix the insulated frame 80 to a terminal frame 90 having arrayed thereon a plurality of terminals 101–170 in correspondence with the sections 1–70. Leads 201–270 are individually connected between corresponding ones of the terminals 101–170 and the corresponding sections 1–70, each lead providing a portion of a circuit path for carrying current from the respective sections 1–70. The plating circuit is completed through a source 93 of potential connected to plating anodes 94 and 95 and, through individual leads, to each of the terminals 101–170, of which only certain leads 302–307 are shown in FIG. 1. In accordance with the invention an ammeter 91 is connected to the potential source 93 and has a lead 92 for insertion in selected ones of the terminals 101–170. The framework supporting the anodes 94 and 95 is adjustably positioned within the plating bath of FIG. 1 by the slotted bars 96.

In accordance with the invention, an array of elements such as the elements 1–70, each corresponding to a particular section of a structure to be plated, is attached to the insulating frame member 80. Each element is insulated from the others and connected by one of the associated leads 201–270 to a corresponding terminal 101–170. As the plating current flows from the anodes 94 and 95, each of the sections 1–70 carries a portion of this current which is proportional to the plated material deposited at that section. A lead 92 of the ammeter 91 may be inserted in each of the terminals 101–170 in succession in order to measure the current at each of sections 1–70. The readings of the ammeter 91 may be plotted, thus providing a graph of the current distribution over the area encompassed by the sections 1–70 and giving an indication of the actual distribution of the plated material. It will be understood of course, that a plurality of current measuring instruments such as the ammeter 91 may be disposed in additional terminals 101–170 if desired in order to provide a plurality of current measurements simultaneously.

In accordance with the current distribution thus provided, the anode elements 94 and 95 may be varied in position or configuration or additional anodes may be added in order to achieve the desired uniform current distribution over the extent of the area occupied by the sectional elements 1–70. Thereafter, when a suitably uniform current distribution over all of the elements 1–70 is attained, the insulated frame 80 with its elements 1–70 may be removed and the electrode to be plated may be substituted therefor with assurance that the desired uniform layer of plated material will be deposited thereon.

The invention has been described in terms of an electroplating process for depositing a material layer on a cathodic element. The invention is equally applicable, of course, to processes such as anodizing where a corresponding treatment of an anodic element is afforded. In such cases a sectionalized anode may be first processed with measurements of current taken as before to determine the current distribution over the anode. Thus the invention may be practiced generally where it is required to provide a uniform distribution of current either to or from a particular electrode.

Although one specific arrangement of the invention has been described above, it will be appreciated that the invention is not limited to this arrangement. Accordingly, any and all modifications, variations or arrangements falling within the scope of the annexed claims should be considered to be a part of the invention.

What is claimed is:

1. A method of providing a uniform deposit of material over an area being electroplated comprising the steps of positioning in place of the article to be plated a plurality of individual sections which in the aggregate have a similar configuration and extent to the article to be plated, connecting each of the individual sections in a separate circuit to an electroplating current source, measuring on an individual basis the current at each of the sections, determining the current distribution over the extent of the sectionalized electrode, modifying the configuration and position of the oppositely disposed electrode to provide a uniform current distribution over the extent of the sectionalized electrode, and replacing the sectionalized electrode with the article which is to be plated.

2. A method of providing a uniform current density over the extent of a cathode in an electroplating bath comprising the steps of subdividing the cathode into a number of sections of substantially equal size, insulating the sections from each other within the electroplating bath, electrically connecting each individual section to the electroplating current source, connecting an ammeter in circuit with each of the individual sections, measuring the current from each of the individual sections, and modifying the configuration of an electroplating anode in accordance with the measured current distribution in order to improve the uniformity of the current distribution.

3. A method of providing a uniform current distribution over an area to be plated in an electroplating process comprising the steps of substituting for the article to be plated a plurality of small sections which in the aggregate conform to the composition and configuration of the article to be plated, arranging the individual sections in electrical isolation from each other, connecting individual leads to each of the sections, connecting a current measuring device in series with the individual leads between the sections and the electroplating current source, plotting the current distribution over the extent of the over-all cathode area from the individual measurements of current at the respective sections, modifying the anode in configuration in accordance with the plotted current distribution to compensate for deviations from uniformity thereof, measuring and plotting the distribution of current density over the cathode area after the modification of the anode, and repeatedly modifying the anode in the same manner in accordance with the last plotted current distribution and measuring and plotting a succeeding current distribution until the current density over the cathode area is uniform.

4. An electroplating apparatus comprising a removable test electrode including a planar surface having a plurality of conducting elements electrically insulated from each other, an anode, a power source, means connecting said anode to said power source, means for selectively connecting the conducting elements to said power source, means for measuring the current in each of said conducting elements, and means for adjusting the position of said anode with respect to said test electrode.

5. An electroplating apparatus comprising a container for an electrolyte, a removable test electrode including a member having disposed thereon a plurality of conducting elements arranged in columns and rows and electrically insulated from each other for immersion in the electrolyte, an anode for immersion in the electrolyte, a power source, means connecting said anode to said power source, means for individually connecting certain of the conducting elements of said removable test electrode to said power source to establish an electrical circuit for each element so that the connected elements in the aggregate assume the shape and dimensions of an article to be plated, means for measuring the current in each of said electrical circuits, and means for adjusting the position of said anode with respect to said test electrode, whereby a desired current distribution can be obtained and said test electrode can be removed and replaced by the article to be plated.

6. An electroplating apparatus comprising a container for an electrolyte, a removable test electrode including a planar array of conducting elements electrically insu-

lated from each other for immersion in the electrolyte, an anode for immersion in the electrolyte, a power source, means connecting said anode to said power source, means for individually connecting certain of the conducting elements of said removable test electrode to said power source to establish an electrical circuit for each element so that the connected elements in the aggregate assume the shape and dimensions of an article to be plated, means for measuring the current in each of said electrical circuits, and means for adjusting the position of said anode with respect to said test electrode, whereby a desired current distribution can be obtained and said test electrode can be removed and replaced by the article to be plated.

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