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METHOD OF ELECTROPLATING COPPER

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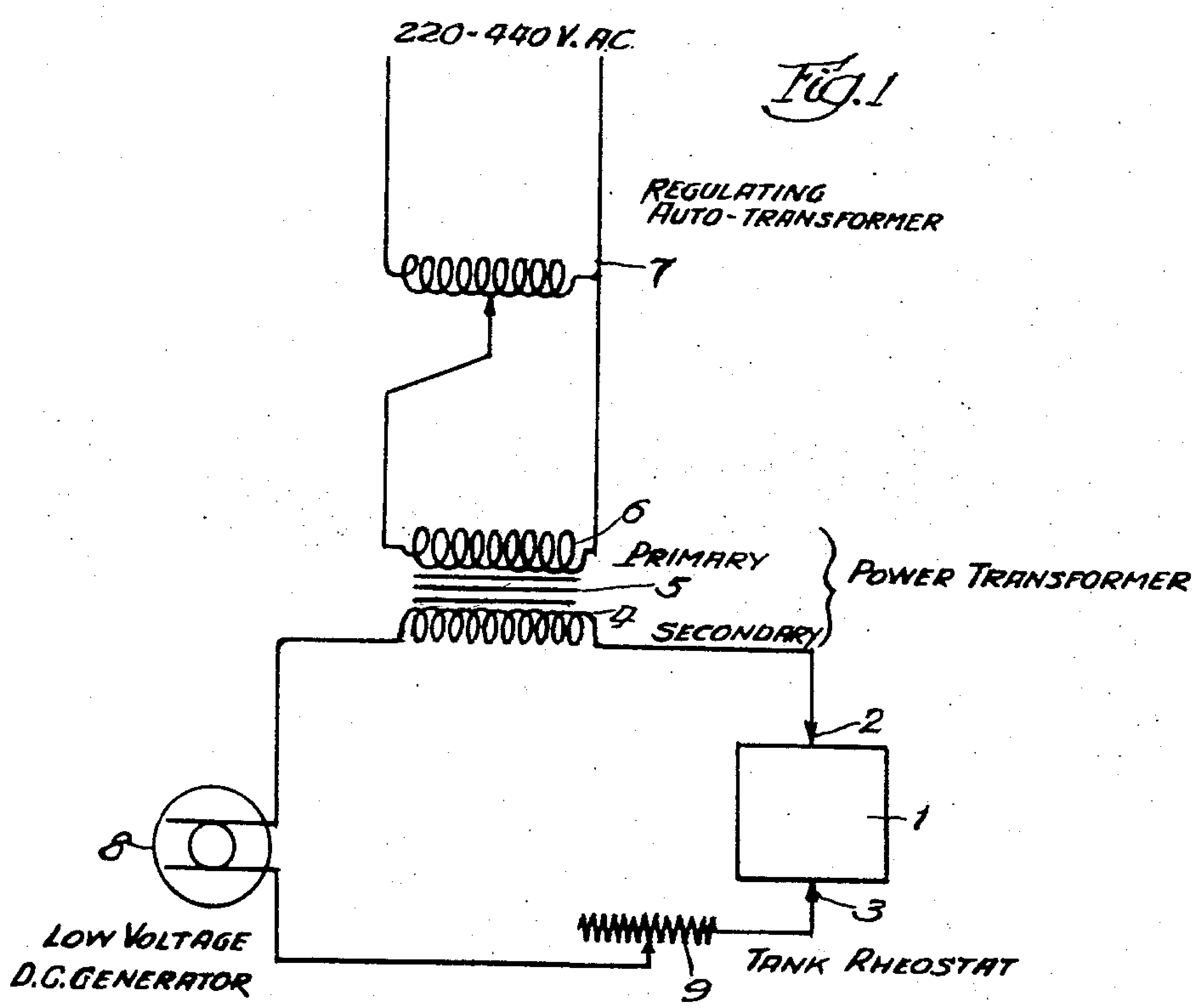

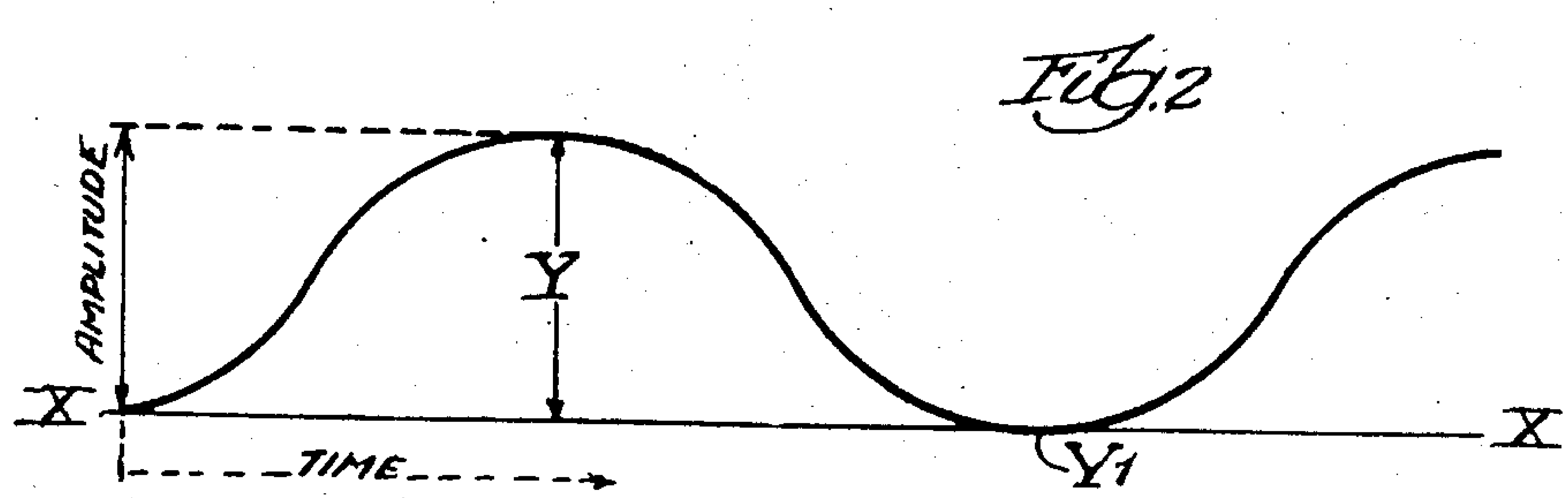

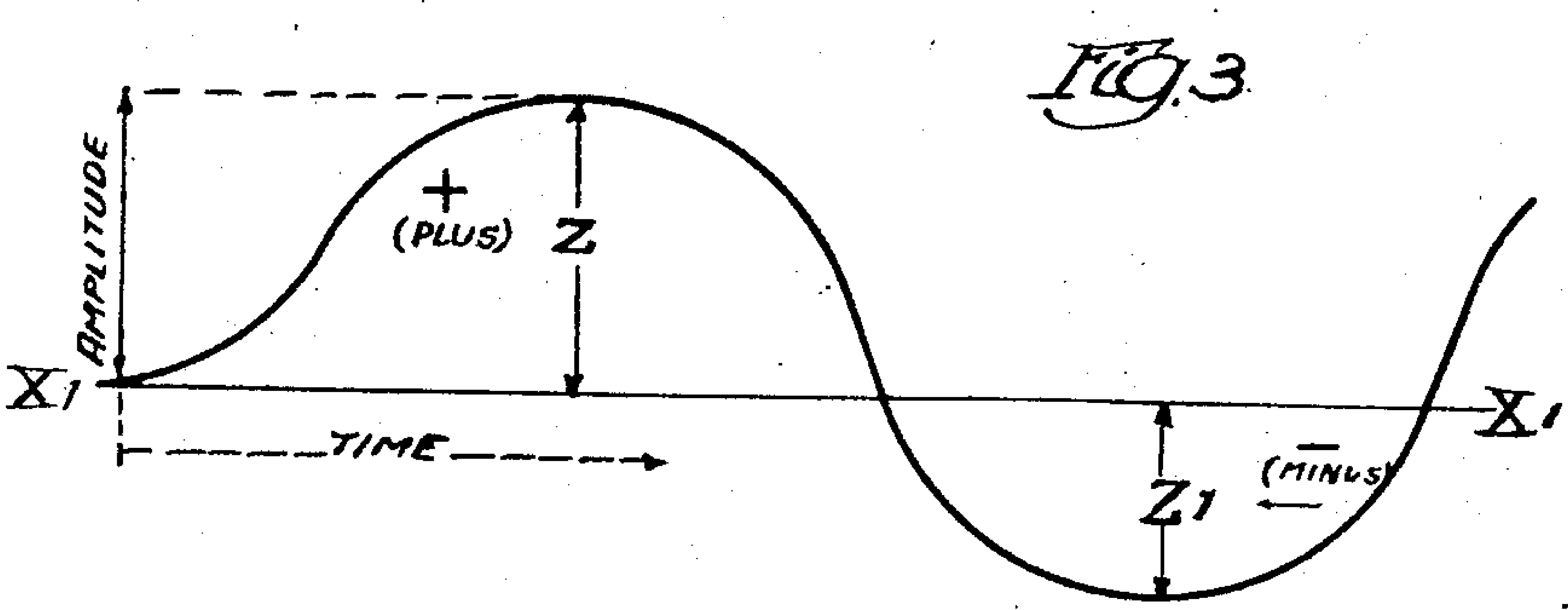

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METHOD OF ELECTROPLATING COPPER

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2 Claims. (Cl. 204—52)

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This invention relates to a new and improved method of electroplating, and more particularly to a method of electrodepositing metals from a plating bath in a new and improved manner adapted to produce substantially uniform distribution on articles or objects of configurations such that the ordinary type of electroplating causes uneven distribution of the electrodeposited metal.

It is well known that flat objects, when electroplated in the usual way in an electroplating bath, tend to build up a higher concentration of metal near the edges than in the middle. This is true to some extent in objects of other configurations and various devices have been proposed in order to overcome this difficulty.

One of the objects of the present invention is to provide a new and improved method for overcoming the difficulty mentioned above and for electrodepositing metals from plating baths in a uniform manner.

Another object of the invention is to provide a new and improved method for electrodepositing metals on flat sheets or other flat objects in a manner such that substantial uniformity of distribution is obtained.

A still further object is the provision of a new and improved method for controlling the distribution of a metal from a plating bath.

Other features and advantages of the invention will appear hereinafter by reference to the following description thereof, in conjunction with the accompanying drawings in which

Fig. 1 illustrates diagrammatically one form of apparatus suitable for the practice of the invention;

Fig. 2 illustrates graphically one of the limits of the wave form of the plating current; and

Fig. 3 illustrates another limit of the wave form of the plating current in accordance with the preferred practice of the invention.

Generally stated, the invention involves a new and improved method of controlling the distribution of copper deposited on an electrically conducting surface from a plating bath by superimposing alternating current on direct current within certain predetermined limits. The invention is especially applicable to electroplating operations in which the work or article is so shaped that the electrodeposited metal builds up in some areas more than others. The plating current for the purpose of this invention may be described as an asymmetric alternating current in which the negative peak value of the wave form varies from zero (as illustrated in Fig. 2)

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to $-\frac{2}{3}$ of the positive peak value (as illustrated in Fig. 3).

Referring to Fig. 1, the apparatus illustrated comprises a suitable receptacle 1 containing the plating bath, provided with one or more electrodes, generally indicated at 2, and a work piece or conducting surface to be plated, generally indicated at 3. As will be understood, the electrode 2 forms the anode and the work piece 3 the cathode.

The anode 2 is connected by suitable conductors to the secondary 4 of a power transformer having a core 5 and a primary 6. The primary 6 is connected to a regulating auto-transformer, generally illustrated at 7, which in turn is connected to a suitable source of electrical energy, such as a 220 or 440 volt alternating current. Direct current is supplied by means of a low voltage current generator, generally shown at 8, one side of which passes to the work piece 3 through a rheostat 9, and the other side of which is connected to the secondary 4 in the manner shown.

In Figs. 2 and 3 the wave form of the current is graphically illustrated in a conventional manner, the horizontal axis (X—X) representing time and the vertical axis amplitude. The peak values are calculated from the equation

$$E = 1.414\sqrt{E^2 \text{ A. C. (R. M. S.)} + E^2 \text{ D. C.}}$$

where E is voltage. For the wave form to be asymmetric, the negative peak value must drop below the X-axis. Thus, the wave form of Fig. 2 becomes asymmetric when the negative peak (Y_1) falls below the X-axis and is a different value from the positive peak value (Y in Fig. 2, Z in Fig. 3). Fig. 3 represents the maximum negative value (Z_1) which may be employed for the purpose of this invention. Any wave form similar to Fig. 2 in which the negative peak value is positive or above the X-axis may be described as pulsating direct current.

In a broader sense, the apparatus described and the hook-up of the component parts is believed to represent a new and improved system for the electrodeposition of metals by the superimposition of an alternating current on a direct current, irrespective of whether the ratios of alternating current to direct current are within the limits preferred for uniform distribution. Thus, this type of apparatus may be employed in plating articles of any configuration with other ratios of alternating current to direct current where the distribution of the electrodeposited metal is not an important factor. This type of apparatus is suitable, therefore, for electroplating operations by the superimposition of alternating current on direct current in such a manner as to form a pulsating direct current.

The method of controlling distribution of the electrodeposited metal as described herein is especially suited for the formation of very thin, substantially uniform films or coatings of a metal on an electrically conductive surface. For example, it has been found that this invention is especially adapted for forming coatings of copper on steel or cast iron objects in which the thickness of the coating is within the range of .000005 inch to .00005 inch. Steel or cast iron objects, when plated with copper in accordance with the invention to the thickness described, are especially suitable for the addition of coatings of vitreous enamels, as described and claimed in my copending application Serial No. 555,953, filed September 27, 1944 now Patent No. 2,615,836. The thickness and uniformity of the plate is an important factor because it has been found that if the electrodeposited plate is insufficient, the desired bonding action will not occur. The same is true if the thickness of the coating is too great. Thus, this invention makes possible new and improved results in the art of enameling, as well as new and improved results in controlling the distribution of metals by electrodeposition.

The invention will be further illustrated but is not limited by the following example:

Example I

A typical copper plating bath which may be employed has the following composition:

	Ounces per gallon
$Cu\ SO_4.5H_2O$	24
H_2SO_4	6
Glue (optional)	⅛

It will be understood that the invention is susceptible to some variation and modification in the manner of its practical application.

The ratios of alternating to direct current which are preferably employed in accordance with the invention in order to obtain the desired wave form, are about 2–4 volts (root mean square) A. C.: 2.5 volts D. C., preferably at current densities from 2 to 15 amperes per square foot. Alternating currents of different frequencies may be used, but it is preferable to employ either a 25 cycle or a 60 cycle current. The plating time will vary depending upon the amount of metal which it is desired to deposit. Thus, for thicknesses of the type previously mentioned for vitreous enamel work, a plating time from 8 seconds to 1½ minutes is sufficient. It will be understood that higher current densities may be used, and that the alternating and direct current voltages may be larger or smaller, provided that the ratio produces a predetermined wave form of the type previously described. Thus, if the direct current is 0.5 volt, the alternating current would be correspondingly reduced in accordance with the foregoing ratio. If the direct current is 10 volts, the alternating current is increased in the foregoing ratio.

The plating current will be governed by the surface area of the article being plated, the size of the bath, power facilities and other factors which will be recognized by those skilled in the art.

The expression "copper plating bath" is intended to include plating baths of the type described in Example I where other metals or salts thereof are present in minor proportion as well as those in which such metals or salts are absent.

The invention provides a new and improved method for controlling the deposition of copper on electrically conducting surfaces. It is especially useful in applying even, uniform coatings to articles having a configuration in which, by ordinary direct current plating methods, the deposited metal tends to build up in some areas more than others. Thus, it is especially important for electroplating flat surfaces when a thin plate of substantially uniform thickness is desired.

This application is a continuation-in-part of my copending application Serial No. 555,954, filed September 27, 1944, now U. S. Patent No. 2,515,192.

The invention is hereby claimed as follows:

1. In a method of controlling the electrodeposition of copper from an acid copper sulfate plating bath onto an electrically conducting object of a type in which the copper would normally be deposited in greater concentrations in some areas than in others by a direct plating current; the step which comprises electrodepositing the copper by subjecting said object in an acid plating bath to a plating current having an asymmetric alternating wave form comprising an alternating current superimposed on a direct current in the ratio of 2–4 volts R. M. S. to 2.5 volts D. C., regardless of the specific current values, at current densities from about 2 to about 15 amperes per square foot.

2. In a method of controlling the electrodeposition of copper from an acid copper sulfate plating bath onto a workpiece of the type in which the copper is normally deposited in greater concentrations in some areas of the work than in others by direct current plating; the step which comprises electrodepositing copper on said workpiece from an acid bath by a superimposed alternating-direct plating current comprising an alternating current to direct current ratio from about 2 to about 4 volts R. M. S. alternating current having a frequency within the limits from about 25 cycles to about 60 cycles to about 2.5 volts D. C., regardless of the specific current values, at current densities from about 2 to about 15 amperes per square foot for a period of time within the range from 8 seconds to about 1½ minutes.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,918,605	Jones	July 18, 1933
2,063,760	Schulein	Dec. 8, 1936
2,443,599	Chester	June 22, 1948
2,515,192	Chester	July 18, 1950

OTHER REFERENCES

Transactions of the Faraday Society, vol. 24 (1928), pp. 348–58.

Transactions of the Faraday Society, vol. 18 (1922), pp. 102–111.

American Electroplaters Society Monthly Review, February 1944, page 168.

Transactions of American Electrochemical Society, vol. 41 (1922), pp. 151–180.