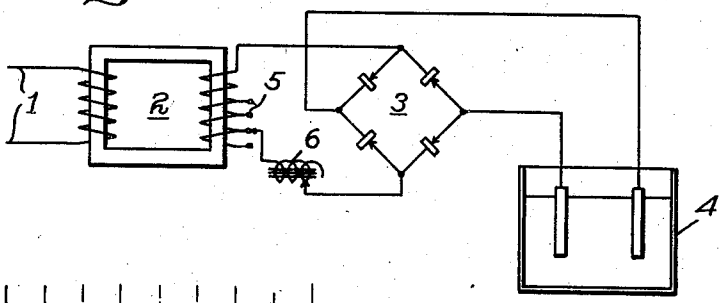
Dec. 16, 1930. R. J. PIERSOL 1,785,389

PROCESS FOR CONTROLLING ELECTROPLATING

Filed Jan. 14, 1929

Fig. 1.



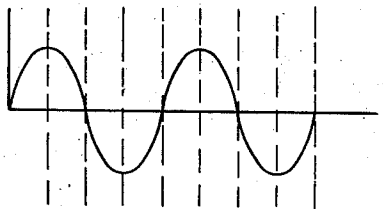


Fig. 2.

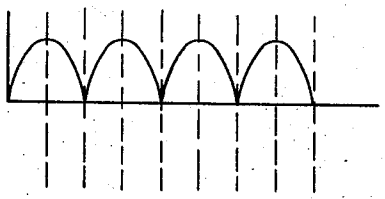


Fig. 3.

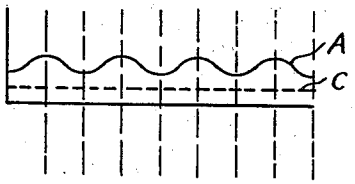


Fig. 4.

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UNITED STATES PATENT OFFICE

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PROCESS FOR CONTROLLING ELECTROPLATING

Application filed January 14, 1929. Serial No. 332,396.

This invention relates to electro-plating and particularly to a process for maintaining a plating solution in continuously operative condition, and for maintaining the plating action constant.

In electro-plating, the chemical action, or ionization, which accompanies the transfer of current through the plating solution, causes the evolution of hydrogen by decomposing the water content of the solution. The hydrogen collects at the surface of the cathode, or article being plated, and oxygen at the anode. The greater part of the hydrogen escapes from the solution, but some hydrogen remains and constitutes a thin film on the cathode surface, establishing a condition known as polarization. The film of hydrogen acts as an insulating layer.

The decomposition voltage of water is less than the plating voltage of a solution.

In the electro-plating of chromium, the high current density used causes extreme liberation of hydrogen which builds up the film of insulation on the cathode and decreases the current for a given voltage. After an accumulation of the gas builds up to relative thickness, it suddenly is carried off by gassing.

The periodic change in the voltage and the current between the anode and the cathode has been observed as a characteristic of a chromium plating solution. The duration of such change varies with plating conditions. For example, the voltage may start at 6 volts with a current of 100 amperes for 20 seconds, and then drop suddenly to a voltage of 4.5 volts with a current of 60 amperes. After a similar period of about 20 seconds, more or less, the voltage jumps up to the previous value with a corresponding increase in current.

One explanation of this action is that chromium has an active and a passive state, with different solution voltages, the difference between them being about 1.8 volts. Above a certain current density, the evolution of free active hydrogen is very intense, throwing the chromium into the active state.

The other explanation of this action is that it is due to the hydrogen polarization of the cathode with the periodic release of the hydrogen from the cathode surface.

Irrespective of the cause of the fluctuations, it is desirable to eliminate such fluctuations in order to establish constant current and plating conditions.

An object of my invention, therefore, is to provide a process for counter-acting the effects of polarization in a plating solution, whereby the solution may be maintained continuously operative and the plating action even and steady.

Another object of my invention is to provide a process for electro-depositing chromium, which shall establish an even steady plating action and obviate the fluctuations heretofore observed in the voltage and current conditions in chromium-plating solutions.

I have found that a modification of the normal direct plating current of constant value into an undulating direct current, so modifies the plating action as to cause it to be steady and even, and entirely free of the periodic changing of conditions heretofore referred to.

The normal plating voltage range for chromium as now generally employed is from 6 to 12 volts. With a current modified into an undulating current, I have been regularly and successfully plating with voltages as low as 2.8 volts.

The modified plating voltage is an undulating or periodically varying direct voltage whose value varies about 1 volt above and below a mean or average voltage. The periodic recurring variation of about two volts between the maximum and minimum values of the modified plating voltage considerably changes the evolution of hydrogen at the cathode. The result appear to be a resonant or whipping action which induces regular and steady escape of the hydrogen from the cathode surface. The hydrogen is thus discharged from the cathode surface before a substantial film may collect.

In order to obtain a current of the character described, I rectify both waves of an

alternating current and introduce sufficient reactance as may be necessary, to effect the proper variation of the resultant current from an average or mean value.

The maner in which I obtain such current may be understood upon reference to the accompanying drawings in which Fig. 1 illustrates diagrammatically a plating system in which alternating current energy is changed to direct current energy for the plating circuit by rectification; and Fig. 2 shows a graph of the undulating nature of the plating current.

As is illustrated in Fig. 1 of the accompanying drawings, the plating system comprises a source 1 or supply circuit of alternating current, of normal commercial voltage, which energizes a transformer 2 to supply a low alternating voltage approximating plating voltage, which is then rectified by rectifying means 3 and supplied to plating solution 4.

The transformer may be provided with tap connections 5 or other suitable means for varying the derived voltage available for the plating action. Such connections may be provided on the primary or the secondary winding, or both, in such number as to provide the gradation that may be desired.

In order to control the extent of undulation or variation of the derived current, a variable reactor 6 is provided for the plating circuit.

The steps whereby the varying plating current is derived are illustrated in Figures 2, 3 and 4. In Figure 2 is illustrated the sine wave of the alternating current derived from the secondary winding of the transformer. When rectified by the rectifying means, the current would be substantially as illustrated in Figure 3 and so supplied to the plating solution.

The rectifying means may be of the mercury arc or thermionic types, in which current is transmitted practically in one direction only, or it may be of the electrolytic or metal oxide types in which a small negative current is transmitted. If rectifying means of the first-mentioned types are employed the rectified waves will be substantially as shown in Figure 3. If rectifying means of the second-mentioned types are employed, the form of the rectified waves will be modified somewhat by the small negative components, which will dimnish the resultant amplitude of the positive waves. The curve in Figure 3 may therefore be considered as representing the general form of resultant rectified waves of an alternating current.

By means of the inductance of the reactor 6, the rectified waves of Figure 3 are smoothed out to establish a plating current as illustrated by curve A in Figure 4.

The amount of inductance shoud be sufficient to prevent the minimum value of the fluctuations of the derived plating current from diminishing to a value less than the contact voltage of the plating solution. For example, as illustrated in Figure 4, the line C represents the contact voltage of the solution. Below this value of impressed voltage, on a chromium solution, for example, the back voltage tends to establish an electric cell action and throw the deposited chromium back into solution. Since the rate of dissolution of chromium, for example, greatly exceeds the rate of deposition, the variation in the plating voltage must not be sufficient to reduce the plating voltage below the contact voltage of the solution.

The magnitude of the variations or fluctuations in the plating circuit may be varied by adjusting the reactor 6. Where a special transformer is designed and provided for a particular system, a suitable amount of inductive reactance may be provided in the transformer itself.

By means of the variation in the plating current, the rate of evolution of hydrogen is varied frequently and suddenly, and the gradual accumulation of hydrogen at the cathode surface is obviated. The troublesome sudden variations in plating conditions caused by such accumulations are likewise obviated.

Moreover, the necessity for higher plating voltages is also obviated, since the resistance of the hydrogen does not have to be overcome.

My invention is not limited to the specific details illustrated since the same action may be obtained without departing from the spirit and scope of the invention as set forth in the appended claims.

I claim as my invention:

1. A plating system including a plating solution having two electrodes therein, and means for supplying a plating current thereto comprising a source of alternating current, a transformer having its primary winding connected to said source, and rectifying means connected between the secondary winding of the transformer and the electrodes in the plating solution, and means for controlling the amplitude and the phase condition of the current supplied to the rectifying means.

2. A system as in claim 1, in which the rectifying means are of the metal-metal-oxide type.

3. A system as in claim 1, in which means are provided to modify the form of the rectified waves to establish a resultant undulating current, whose minimum value does not diminish below the contact voltage of the solution.

4. A system for electro-plating including a solution having two electrodes, a source of alternating current, rectifying means for converting the alternating current to direct cur-

rent, means for variably modifying the current to be rectified in order to vary the range of the undulating portion of the rectified current, means for controlling the amplitude of the rectified current, and means for supplying the rectified current to the electrodes in the solution.

5. A plating system including a plating solution having two electrodes therein, a source of alternating current, a transformer having its primary winding connected to the alternating source, rectifying means connected between the secondary winding and the electrodes in the solution, and variable means including inductive means for controlling the amplitude and phase relation of the current supplied to the rectifying means to control the amplitude of the rectified current and the nature of the undulating portion of the rectified current.

In testimony whereof, I have hereunto subscribed my name this 20th day of December, 1928.

ROBERT J. PIERSOL.