

[54] **LAYER THICKNESS INDICATING
DEVICE FOR ELECTROLYTICALLY
DEPOSITED MATERIALS**

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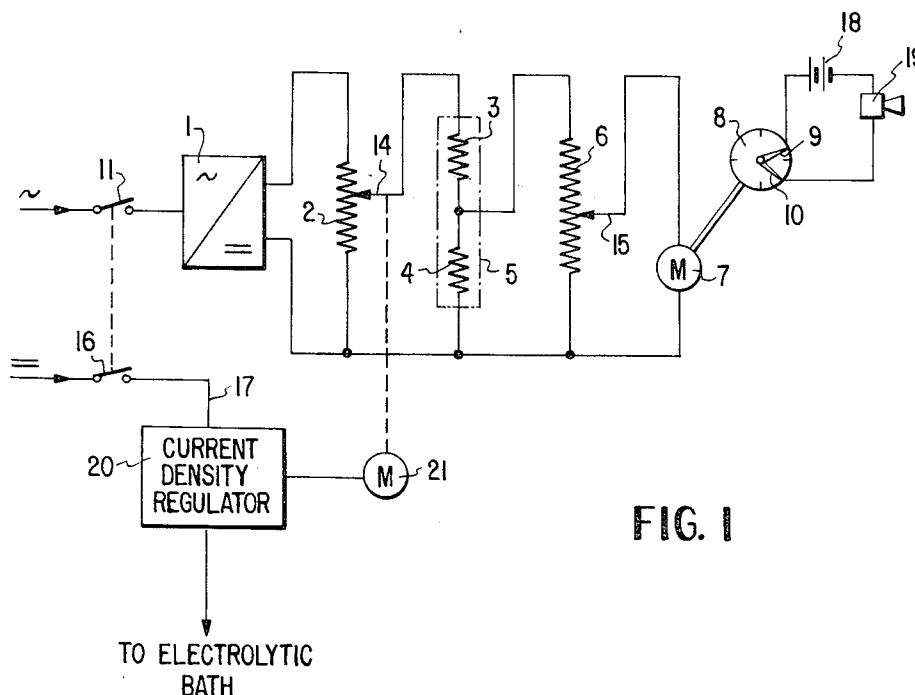
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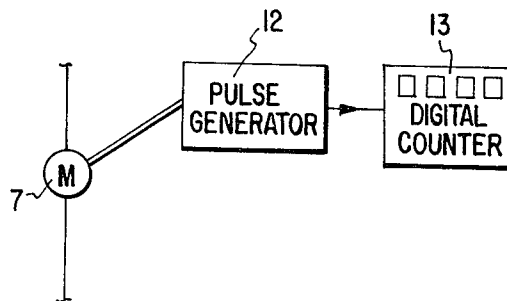
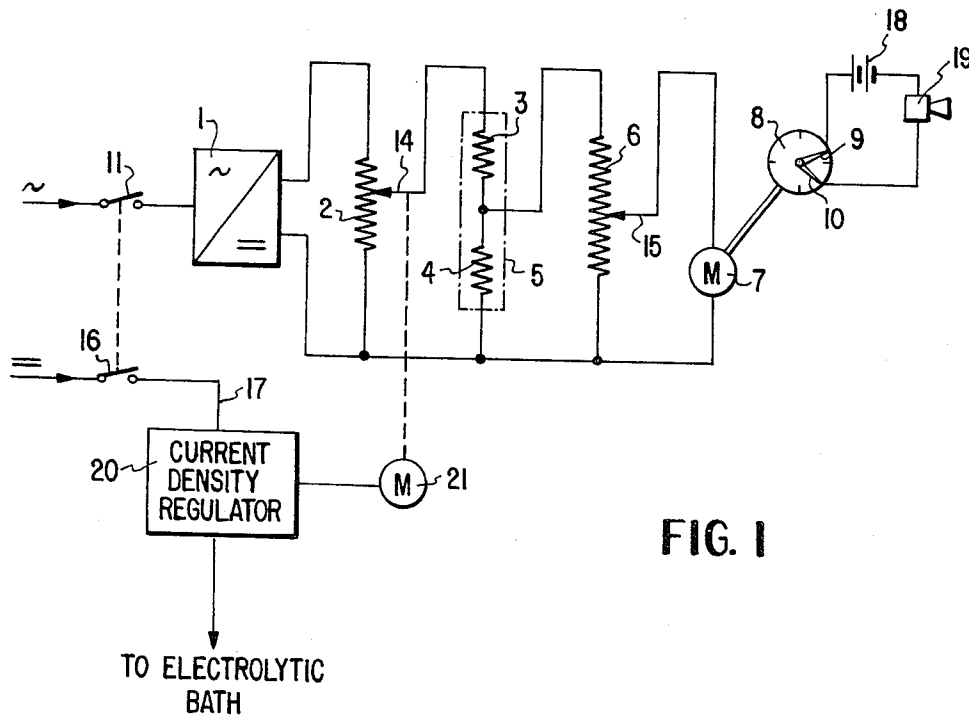
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ABSTRACT

A device for indicating the thickness of a layer of material deposited in an electrolytic bath. In the device, the output signal from a constant voltage source is fed to a voltage proportioning circuit wherein the input voltage is proportioned according to the current density and efficiency of the electrolytic bath and for the deposition equivalent and the specific weight of the particular material to be deposited in the electrolytic bath. The thus proportioned voltage signal is then integrated with respect to time and an indication of the integrated value provided as a continuous measure of the thickness of the layer of material being deposited in the electrolytic bath.

10 Claims, 2 Drawing Figures





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LAYER THICKNESS INDICATING DEVICE FOR ELECTROLYTICALLY DEPOSITED MATERIALS

BACKGROUND OF THE INVENTION

The present invention relates to a device for indicating the thickness of the layer of material deposited on a substrate material in an electrolytic bath. More particularly, this invention relates to a device which continuously and automatically indicates the thickness of the layer of the material being deposited in the electrolytic bath.

In the formation of coatings by means of electrolytic baths, it has thus far been the custom to leave the substrate material being processed in the electrolytic baths for a predetermined period of time so that depending on the operating conditions, and in particular the speed of the deposition of the respective bath, a desired average layer thickness of the deposited material on the substrate material being processed results. In order to determine the period of time for which the substrate material being processed must be immersed in the electrolytic bath, it is necessary to make relatively expensive computations taking into consideration the surface of the substrate material being processed, the current efficiency of the electrolyte, and the deposition equivalent of the material being employed for the deposition. These computations are relatively complex and can only be carried out by trained personnel. Moreover, in spite of the efforts involved, the thickness of the layer of deposited material can only be predicted within a rather wide margin which is undoubtedly unsatisfactory.

SUMMARY OF THE INVENTION

It is accordingly the object of the present invention to provide a relatively simple device with which the thickness of the layer of material deposited on a substrate material being processed in an electrolytic bath can be continuously determined even before the electrolysis is completed and without requiring any type of calculations.

The above object is achieved according to the present invention by means of a device including a constant voltage source which is switched on at the instant the electrolytic deposition is initiated, a voltage proportioning circuit connected to the output of the constant voltage source, an integrating device for integrating the output voltage from the voltage proportioning circuit over time, and an indicator for providing a continuous indication of the integral. The voltage proportioning circuit includes a first and a second potentiometer and a voltage divider connected in series in an arbitrary sequence. The sliding contact of one of the potentiometers is set to a value corresponding to the current density of the electrolytic bath, the sliding contact of the other potentiometer is set to a value corresponding to the current efficiency of the electrolytic bath, while the divider ratio of the voltage divider corresponds to the deposition equivalent and specific weight of the material to be deposited. The integrated output of the device is thus a continuous indication of the thickness of the layer of material being deposited and hence the device according to the invention has the advantage that even an unskilled person can easily determine the thickness of the deposited layer of material at any time during the electrolytic process, and with great accuracy, by merely reading the indicator.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic circuit diagram of a thickness indicating device according to the invention.

FIG. 2 is a schematic diagram illustrating a modified form of the indicating device of the embodiment of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the figures, there is shown a constant voltage source 1 which may, for example, be a regulated d.c. power supply. As indicated, operating power for the constant voltage source 1 is supplied by conventional source of a.c.

power via a switch 11. Connected across the output terminal of the constant voltage source 1 is a voltage proportioning circuit consisting of the series connection of a potentiometer 2, a voltage divider consisting of resistors 3 and 4, and a further potentiometer 6. It is to be understood, that the sequence of the connection of the potentiometers 2 and 6 and the voltage divider 5 is completely arbitrary and accordingly may be other than that specifically shown in the figure.

Connected to the output of the potentiometer 6 is an integrating device which, as illustrated, and in a manner well known in the art may comprise a measuring motor 7. Coupled to the output of the motor 7, for example, by means of a step down gear mechanism (not shown), is an indicator 8 having a rotatable indicating pointer 9. It will of course be understood that other types of integrating and indicating devices or combinations thereof may be utilized. For example, in place of the purely mechanical indicator 8, as shown in FIG. 2, the output of the integrating motor 7 may be coupled to a pulse generator 12 whose output pulses are fed to a digital counter 13 which then serves as the indicator. Additionally, in place of the motor 7 a purely electronic device which integrates the voltage at the output of the potentiometer 6 over time may be utilized.

In order for the circuit according to the invention to provide a continuous indication of the thickness of the layer of material being deposited in the electrolytic bath, the various parameters affecting the deposition must be taken into consideration. Accordingly, the sliding contact 14 of the potentiometer 2 is set so that the output voltage therefrom has a value which corresponds to the current density required for the particular electrolyte and the substrate material being processed in the bath; the resistors 3 and 4 are proportioned relative to one another so that the divider ratio of the voltage divider 5 takes into consideration the specific weight and the deposition equivalent of the particular material to be deposited in the electrolytic bath; and the sliding contact 15 of the potentiometer 6 is set to a value which corresponds to the current efficiency of the particular electrolyte being utilized. Since the relationship between the resistors 3 and 4 is specific to the particular material being deposited, and hence these resistors must be changed for each different type of material being deposited, they are preferably connected into the circuit in a manner whereby they can be easily removed, for example, by means of plug-in connections. By means of the various settings of the various elements 2, 5 and 6, the measuring motor 7 is thus supplied with a voltage which is adopted to the current density, the deposition equivalent and specific weight of the material being deposited and the current efficiency for the particular electrolytic bath being utilized.

To provide a proper indication of the thickness of the layer of material being deposited in the electrolytic bath, the integration of the output signal from the potentiometer 6 must be initiated at the time that the electrolysis process is initiated. This may be done in a relatively simple manner, for example, by connecting the switch 11 to a switch 15 in the current input line 17 for the electrolytic bath so that power is supplied to the electrolytic bath and to the constant voltage source 1 at the same instant of time. Closure of the switch 11 thus causes a voltage signal to be applied to the motor 7 which actuates the indicator 8 whose scale extends, for example, from 0 to 50 μm , causing the pointer 9, which is set at 0 at the initiation of the electrolysis process, to rotate and thus continuously indicate the thickness of the deposit layer of material. Preferably the indicator 8 is also provided with a manually adjustable marker, for example, an additional pointer 10, which can be set to the desired layer thickness of the deposited material prior to the initiation of the electrolysis process. By merely observing the relationship between the moving pointer 9 and the stationary pointer 10, the operator of the electrolytic process can determine at any time whether the desired layer thickness has been attained or even exceeded.

According to a further feature of the invention, in order to prevent the thickness of the layer of deposited material from

exceeding the desired layer thickness, the indicator may be provided with a signal generator which emits a signal whenever the nominal or desired value of the thickness of the layer of deposited material preset into the indicator has been reached, thus telling the operator of the process to open the switches 11 and 16 and thus terminate the electrolytic process. As illustrated in FIG. 1, such a signal generator may comprise a battery 18 and a bell 19 connected in series with electrical contacts formed on the pointers 9 and 10, whereby closure of the contacts on the pointers 9 and 10 will complete the circuit and cause the bell to emit an audible signal. Alternatively, the indicator may be provided with a signal generator whose output signal, in a manner well known in the art, automatically causes the electrolytic process to be terminated and/or the material being processed to be removed from the electrolytic bath.

It should be noted, that when the electrolysis current is disconnected, and hence the current to the layer thickness measuring device is also disconnected, the pointer 9 of the indicator 8 will remain in the position attained at the time of disconnection, so that the layer thickness of the material deposited on the substrate material being processed can be easily determined even after the substrate material has been removed from the bath. Upon the subsequent initiation of a further electrolytic deposition process, the pointer 9 must be returned to the zero position, either automatically or manually, in order to begin the indication of the thickness of the new layer of material being deposited.

According to a further feature of the invention, in the event that a current density regulator as indicated by the reference numeral 20 is utilized for the electrolytic bath, automatic setting of the potentiometer 2, which proportions the output voltage from a source 1 in accordance with the current density of the electrolytic bath, can be achieved by positioning the sliding contact 14 by a motor 21 driven by an output signal from the current density regulator 20 in a conventional manner. With this arrangement, any changes in the current density of the electrolytic bath are automatically transferred to the layer thickness measuring device according to the invention.

The following table represents several examples for the various settings of the various elements 2, 3, 4 and 6, wherein I is the respective ion of a particular material to be converted; P_2 is the preset current density; R_3 is the resistance of resistor 3; R_4 is the resistance of resistor 4; P_6 is the current efficiency for the particular electrolytic bath; and L is the thickness of the layer of the material being deposited.

I	P_2 [A/dm ²]	R_3 [Ω]	R_4 [Ω]	P_6 [%]	L [μ m]
Cu ¹⁺	1	76.4	12,089	95	25.25
Cu ¹⁺	2	76.4	12,089	84	44.60
Cu ¹⁺	3	76.4	12,089	72	57.50
Cu ²⁺	2	538.3	857.8	100	26.56
Cu ²⁺	5	538.3	857.8	100	66.39
Ni ²⁺	1	572.1	749.2	98	12.05
Ni ²⁺	4	572.1	749.2	96	47.20

This table represents only a few values and is, of course, not exhaustive. It shows the substantial differences of copper in a cyanidic bath (Cu¹⁺) and in an acid bath (Cu²⁺) and of nickel in an acid bath (Ni²⁺). Whereas the current efficiency in the acid copper bath is almost 100 percent, it lies between 50 and 95 percent in the cyanidic copper bath and between 90 and 98 percent in the acid nickel bath depending on the operating conditions.

It will be understood that the above description of the present invention is susceptible to various modifications, changes and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

What is claimed is:

1. A device for continuously indicating the thickness of a layer of material deposited in an electrolytic bath comprising: a constant voltage source;

a voltage proportioning circuit, including first and second potentiometers and a voltage divider connected in series in an arbitrary sequence, said voltage proportioning circuit being connected to the output of said constant voltage source, and having the sliding contact of said first potentiometer set proportional to the current density of the electrolytic bath, the sliding contact of said second potentiometer set proportional to the current efficiency of the electrolytic bath, and the voltage divider ratio being related to the deposition equivalent and the specific weight of the particular material to be deposited in the electrolytic bath;

integrating means connected to the output of said voltage proportioning circuit; and
indicating means connected to the output of said integrating means.

2. The device as defined in claim 1 including means for causing indication by said indicating means to be initiated at the instant the deposition of the material in the electrolytic bath is initiated.

3. The device as defined in claim 1 wherein said integrating means is a measuring motor.

4. The device as defined in claim 3 wherein said indicating means has a pointer for continuously indicating the instantaneous thickness of the layer of material deposited and a movable marker which is set at the desired thickness of the layer of deposited material.

5. The device as defined in claim 1 wherein said indicating means includes a pulse generator coupled to the output of said integrating means for producing pulses proportional to the output signal from said integrating means, and a digital counter connected to the output of said generator for providing an indication of the number of pulses produced by said pulse generator.

6. A device as defined in claim 1 wherein said indicating means includes means for providing a signal whenever a desired layer thickness of deposited material has been reached.

7. A device as defined in claim 1 wherein said first potentiometer is a motor driven potentiometer whose sliding contact is automatically positioned in accordance with an output signal from a means for regulating the current density of the electrolytic bath.

8. A device as defined in claim 1 wherein said first potentiometer, said second potentiometer and said voltage divider are connected in cascade one to the next in a selected sequence.

9. A device as defined in claim 8 wherein said first potentiometer has a first end, a second end and its sliding contact defines an intermediate point between its ends; said second potentiometer has a first end, a second end and its sliding contact defines an intermediate point between its ends; said voltage divider has a first end, a second end and an intermediate point between its ends; said first ends are connected together and to a point of reference voltage; one of said second ends is connected to said constant voltage source; a second one of said second ends is connected to a first one of said intermediate points; a third one of said second ends is connected to a second one of said intermediate points; and a third one of said intermediate points is connected to one terminal of said integrating means, the other terminal of said integrating means being connected to said point of reference voltage.

10. A device as defined in claim 8 wherein said first potentiometer has a first end and a second end; said second potentiometer has a first end and a second end; said voltage divider has a first end, a second end and an intermediate point between its ends; said first ends are connected together and to a point of reference voltage; said second end of said potentiometer is connected to said constant voltage source; said second end of said voltage divider is connected to said sliding

contact of said first potentiometer; said second end of said second potentiometer is connected to said intermediate point; and said sliding contact of said second potentiometer is connected to one terminal of said integrating means, the other terminal of said integrating means being connected to said point of reference voltage.

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