

July 30, 1946.

C. P. CROCO

2,404,948

CONTROL OF ELECTROLYTIC PROCESSES

Filed Dec. 8, 1942

Fig. 1.

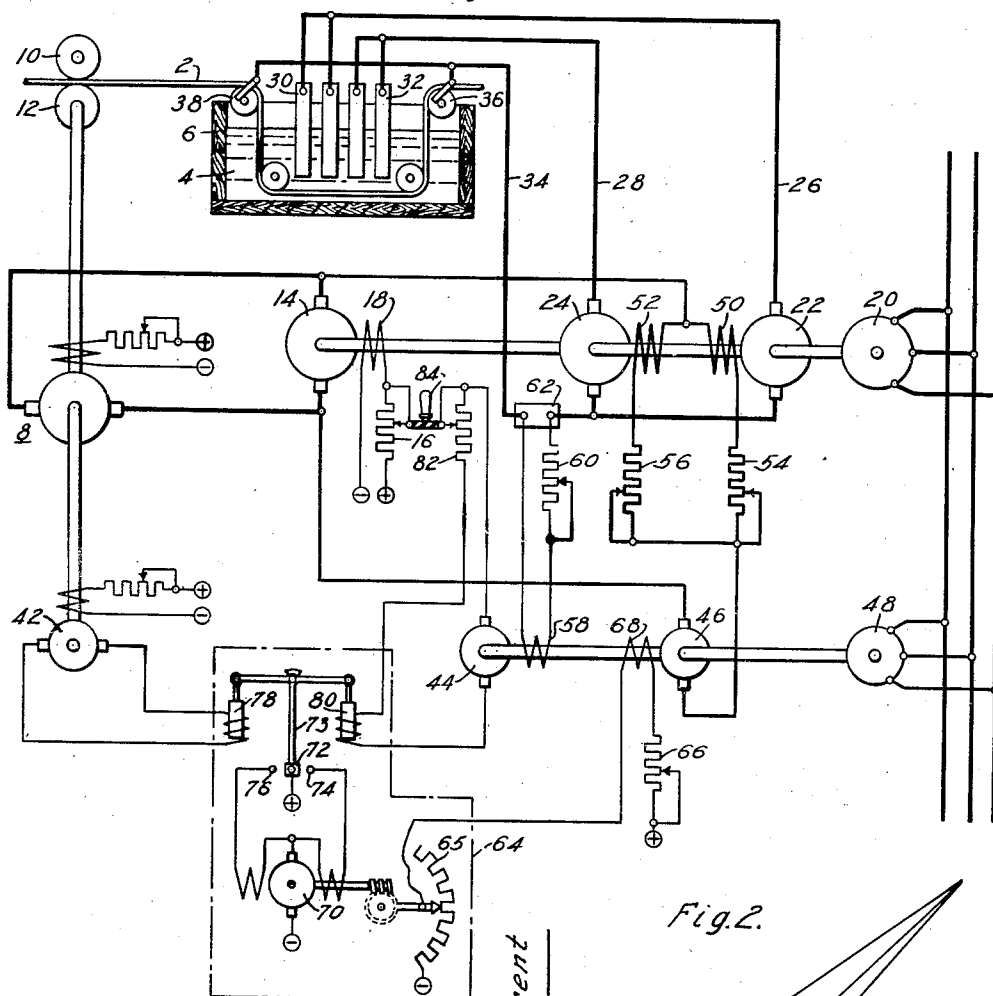
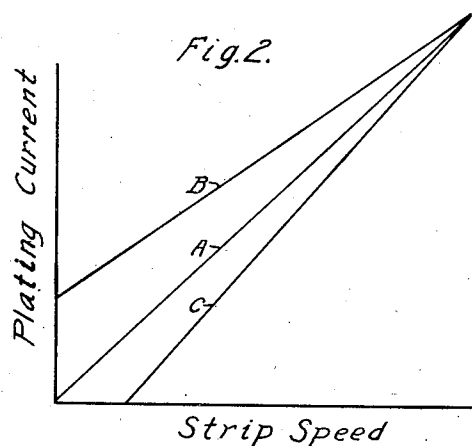


Fig. 2.



WITNESSES:

H. F. Lusser
Joe Weber

INVENTOR

Charles P. Croco
BY *M. Crawford*
ATTORNEY

UNITED STATES PATENT OFFICE

2,404,948

CONTROL OF ELECTROLYTIC PROCESSES

Charles P. Croco, Mount Lebanon, Pa., assignor
to Westinghouse Electric Corporation, East
Pittsburgh, Pa., a corporation of Pennsylvania

Application December 8, 1942, Serial No. 468,227

11 Claims. (Cl. 204—205)

1

The present invention relates, generally, to the control of electrolytic processes and, more particularly, to the control of the electrolytic treatment of continuously moving lengths of material.

In the manufacture of metal coated or plated materials, such as tin-plate, it has been the practice to apply the coating material to the material to be coated by dipping it into the molten coating material. It has been found that this process is wasteful of the coating material for the reason that it is very difficult to control the thickness of the coating and, as a consequence, much more of the coating material is used than is necessary to properly coat the material for the purpose for which it is to be used.

It has been found that such metal coatings may be applied very uniformly by electrolytic means, and long sheets of material have been thus coated by passing them through an electrolytic bath. The amount of material deposited electrolytically is a function of the length of time the material to be coated is exposed to the plating current and the density of the plating current. It will be apparent then that a uniform deposit of coating material will be made upon a strip of material as it moves through an electrolytic plating bath at a constant speed while the current density is kept constant.

In order to expedite the production of plated material by this electrolytic process, it has been found that the process can be made continuous by securing the ends of successive lengths of material together as they are fed to the plating apparatus to thereby avoid stopping the length of material and the plating apparatus for the purpose of threading each new length of material through the plating apparatus. In the operation of such a plating system, it is necessary that the speed of travel of the length of material through the plating apparatus be decreased materially when the next succeeding length of material is to be attached thereto to form the continuous length of material. It will be apparent that this decrease of the speed of the length of material through the plating bath will cause the length of material to be acted upon by the plating current for a greater period of time than when it is traveling at normal speed, and it will be necessary to decrease the density of the plating current to prevent the deposition of an excess quantity of coating material. In certain processes, it may be desirable to maintain a fixed ratio between the speed of the length of material and the plating current density, while in other processes it may

2

be desirable to vary this ratio as the speed of the length of material changes.

An object of the present invention is to provide a control system for a continuous electrolytic process which shall function to coordinate the speed and current density in the process.

Another object of the invention is to provide a control system for an electrolytic process for continuously treating a continuously moving length of material which shall function to so coordinate the current density and the speed of travel of the length of material as to produce uniform treatment of the length of material regardless of changes in the speed of travel of the length of material.

Another object of the invention is to provide a control system for an electrolytic process for continuously treating a continuously moving length of material which shall function to provide any desired ratio between the speed of the length of material and the current density in the process and which shall function to vary the ratio of speed to current density in response to changes of the speed of the length of material.

These and other objects and advantages will be apparent from the following detailed description taken in connection with the accompanying drawing, in which:

Figure 1 is a diagrammatic representation of an electrolytic system embodying the principal features of the invention; and

Fig. 2 is a graphical illustration of the functioning of the system of Fig. 1.

In practicing the invention, a strip of material 2 is drawn through an electrolyte 4 in a tank 6 by means of a motor 8 which drives roll members 10 and 12, engaging the strip 2. The armature of the motor 8 is connected to be energized by a generator 14 whose output potential may be varied by a rheostat 16 which varies the energization of its field winding 18. The generator 14 may be driven by any suitable means such as a substantially constant speed alternating current motor 20.

A plurality of plating generators, such as generators 22 and 24, may be driven by the motor 20 and connected by means of conductors 26 and 28 to separate sets of plating electrodes 30 and 32. The other terminals of the generators 26 and 28 are connected by means of a common conductor 34 to contact rolls 36 and 38 which engage the strip 2 as it passes through the electrolyte.

A pilot generator 42 is connected to be driven by the motor 8 and its speed and output potential are, therefore, proportional to the speed of travel of the strip 2 through the electrolyte 4. Gener-

ators 44 and 46 may be driven continuously by any suitable means such as a substantially constant speed alternating current motor 43. The generator 46 is connected in series circuit relation with the generator 14 as shown to energize the field windings 50 and 52 of the plating generators 22 and 24, respectively, through variable resistors 54 and 56, respectively.

The generator 44 has a field winding 53 which is energized through a variable resistor 60 by the potential drop across a shunt device 62 in the common conductor 34 of the plating current circuit. The excitation of the generator 44 thus varies in accordance with the plating current, and its output potential is, therefore, a measure of the plating current density.

A regulator 64 functions to control a variable resistor 65 which is connected in series circuit with a variable resistor 66 and the field winding 68 of the generator 46 so that the output potential of the generator 46 is varied in accordance with the setting of the variable resistor 65 by the regulator 64.

The regulator 64 comprises a reversible motor 70 which is connected in driving relation with the variable resistor 65 and which may be made to rotate in a reverse or forward direction by means of a movable contact element 72 in cooperation with fixed contact elements 74 and 76. The movable contact element 72 is mounted upon a pivoted arm 73 which is disposed to be operated in opposite directions by solenoids 78 and 80.

The solenoid 78 is connected, as shown, to be energized by the pilot generator 42 and thus acts upon the pivoted arm 73 with a force proportional to the speed of the strip 2 through the electrolyte 4. The solenoid 80 is connected to be energized by the output potential of the generator 44 in circuit with a variable resistor 82 and, therefore, acts upon the pivoted arm 73 with a force which is proportional to the density of the plating current. The variable resistor 82 is disposed to be actuated simultaneously with the variable resistor 16 by an operating member 84.

In the operation of the system, since the speed of the strip 2 depends upon the speed of the motor 3 which, in turn, varies with the potential of the generator 14, and since the excitation and output potential of the plating generators 22 and 24 are varied by variations of the potential of the generator 14, it follows that the speed of the strip and the plating current, as controlled by the generator 14, will vary proportionately.

The variable resistor 60 may function as a calibrating resistor to selectively fix the desired ratio of proportionality between the strip speed and the plating current. The variable resistor 82 also functions as a calibrating resistor to vary the sensitivity of the circuit of the solenoid 80. If there is any variation in the proportionality between the speed of the strip 2 and the plating current, as fixed by the resistors 60 and 82, the resulting unbalance of the forces acting on the pivoted arm 73 will cause the contact element 72 to engage one of the fixed contact elements 74 and 76 which, in turn, will cause the motor 70 to operate the variable resistor 65 in such direction as to cause the generator 46 to increase or decrease the excitation of the generators 22 and 24 to thereby compensate for the variation in the proportionality between the speed of the strip and the plating current.

When it is desired to reduce the speed of the strip 2 to such a speed as will permit attachment of the leading end of a succeeding strip to

the following end of the strip to thereby provide a continuous process and continuous movement of the strip, the speed of the strip may be reduced by actuating the operating member 84 to thereby reduce the potential of the generator 14 and, in turn, the speed of the motor 3. The effective resistance of the variable resistor 82 will be increased as the effective resistance of the variable resistor 16 is increased and this will decrease the force of the solenoid 80 per unit of plating current, thus causing the regulator 64 to increase the excitation of the generator 46. This will increase the excitation of the generators 22 and 24 to thereby increase the plating current. Thus the ratio between current and speed will be increased as the speed is decreased.

The curve A of Fig. 2 illustrates the variation of plating current with strip speed for one setting of the variable resistor 60 and one rate of variation of the effective resistance of the resistor 82. The resistor 82 may be designed for a different rate of variation to vary the plating current with strip speed in a manner illustrated by the curve B of Fig. 2. The variable resistor 82 may also be so designed that its effective resistance will vary in such a manner as to produce a speed-current characteristic similar to that illustrated by the curve C of Fig. 2.

In order to obtain the best plating results, it may be desirable that the plating current provided by one of the generators 22 and 24 be greater than the other. The variable resistors 54 and 56 are provided to so proportion the excitations of the plating generators 22 and 24 as to produce any desired proportionality between the plating currents provided by these generators.

It is to be understood that the regulator 64 is merely illustrative of one type of regulator that may be employed to perform the regulator function described herein, and that any regulator that will function in response to potentials proportional to the speed of the strip and the plating current may be employed.

It is to be understood that only two plating generators have been shown and described herein merely for the purpose of illustration and that as many plating generators as desired may be employed and controlled in accordance with the principles described herein.

It is also to be understood that the description of the electrolytic process as an electroplating process is merely illustrative of the principles of operation of the control system, and that the control system may be employed if desired in any electrolytic process in which it is desired that a current density in the process vary in any desired manner in response to variations in the speed of the length of material which is being electrolytically treated in the process.

Thus it will be seen that I have provided a control system for an electrolytic plating process for plating a continuously moving length of material which shall function to coordinate the speed of travel of the length of material and the plating current density, which shall function to provide any desired ratio between the speed of the length of material and the current density in the process, and which shall function to vary the ratio of speed to current density, as desired, in response to changes of the speed of the length of material.

In compliance with the requirements of the patent statutes, I have shown and described herein a preferred embodiment of my invention. It is to be understood, however, that the invention is not limited to the precise construction shown and

5

described, but is capable of modification by one skilled in the art, the embodiment shown herein being merely illustrative of the principles of the invention.

I claim as my invention:

1. In a control system for an electrolytic process, an electric motor for causing a length of material to travel through the electrolytic process, a variable voltage generator for supplying power to the motor, means for varying the current in the electrolytic process in accordance with the voltage applied to the electric motor by said generator, and means for varying the current flow in the process in response to variations in the ratio between the speed of travel of the length of material through the process and the density of the current in the process.

2. In a control system for an electrolytic process, an electric motor for causing a length of material to travel through the electrolytic process, a source of variable voltage power for energizing the motor, means for varying the current in the electrolytic process in accordance with the voltage applied to the electric motor, control means for varying the current flow in the process in response to variations in the ratio between the speed of travel of the length of material through the process and the density of the current in the process, and means for simultaneously varying the voltage applied to the electric motor and the ratio to which the control means is responsive.

3. In a control system for an electrolytic process, an electric motor for causing a length of material to travel through the process, a generator for energizing the motor, means for varying the current density in the process in accordance with variations of the output potential of the generator, control means responsive to the ratio between the speed of travel of the length of material through the process and the density of current flow in the process for varying the current flow in the process, and means for simultaneously varying the output potential of the generator and the ratio to which the control means is responsive.

4. In a control system for an electrolytic process, an electric motor for causing a length of material to travel through the process, first generator means for energizing the motor, second generator means for supplying current to the electrolytic process, third generator means, circuit means for connecting said first and third generator means to excite said second generator means, and control means for automatically varying the potential of said third generator means in accordance with variations of the ratio between the speed of travel of the length of material and the current flow in the process.

5. In a control system for an electrolytic process, an electric motor for causing a length of material to travel through the process, first generator means for energizing the motor, second generator means for supplying current to the electrolytic process, third generator means, circuit means for connecting said first and third generator means to excite said second generator means, control means for automatically varying the potential of said third generator means in accordance with variations of the ratio between the speed of travel of the length of material and the current flow in the process, and means for simultaneously varying the potential of the first generator means and the ratio to which the control means is responsive.

6. In a control system for an electrolytic process,

6

an electric motor for causing a length of material to travel through the process, generator means for energizing the motor, means for supplying current to the electrolytic process, control means for said current supplying means connected for energization to the generator means to provide a predetermined ratio between the speed of travel of the length of material and the current flow in the process, means for varying the voltage of said generator means to vary the speed of the strip, and means including regulator means jointly responsive to the speed of the material and the current in the process for additionally controlling the energization of the said control means to maintain said predetermined ratio of speed and current flow.

7. In a control system for an electrolytic process, an electric motor for causing a length of material to travel through the process, generator means for energizing the motor, means for supplying current to the electrolytic process, control means for said current supplying means connected for energization to the generator means to provide a predetermined ratio between the speed of travel of the length of material and the current flow in the process, means for varying the voltage of said generator means to vary the speed of the strip, additional generator means connected to control the energization of said control means for varying the output of the current supplying means, and regulator means jointly responsive to the speed of travel of the material and the current flow in the process for controlling the excitation of the additional generator means to maintain said predetermined ratio of speed and current.

8. In a control system for an electrolytic process, an electric motor for causing a length of material to travel through the process, generator means for energizing the motor, means for supplying current to the electrolytic process, control means for said current supplying means connected for energization to the generator means to provide a predetermined ratio between the speed of travel of the length of material and the current flow in the process, means for varying the voltage of said generator means to vary the speed of the strip, additional generator means connected to control the energization of said control means for varying the output of the current supplying means, pilot generator means operable to develop an output voltage proportional to the speed of the material, additional pilot generator means operable to develop an output voltage proportional to the output of the current supplying means, and regulator means jointly responsive to the voltages of said pilot generators for controlling the excitation of said additional generator means for additionally controlling the energization of the control means to maintain said predetermined ratio of speed and current.

9. In a control system for an electrolytic process, an electric motor for causing a length of material to travel through the process, generator means for energizing the motor, means for supplying current to the electrolytic process, control means for said current supplying means connected for energization to the generator means to provide a predetermined ratio between the speed of travel of the length of material and the current flow in the process, means for varying the voltage of said generator means to vary the speed of the strip, additional generator means connected to control the energization of and control means for varying the output of the current sup-

7

plying means, pilot generator means operable to develop an output voltage proportional to the current flow in the process, regulator means jointly responsive to the speed of the material and the output voltage of the pilot generator means for controlling said additional generator means for additionally controlling the energization of the control means to maintain said predetermined ratio of speed and current, and means operable to simultaneously vary the output voltage of the first generator means and the effectiveness of the output voltage of the pilot generator means upon the regulator means to change the ratio of speed and current.

10. In a control system for an electrolytic process; an electric motor for causing a length of material to travel through the process, first generator means for energizing the motor, second generator means for supplying current to the process, said second generator means having an excitation circuit connected to be energized in accordance with the voltage of the first generator means, third generator means connected in said excitation circuit, a first pilot generator operable to develop a potential proportional to the speed of the material, second pilot generator means operable to develop a potential proportional to the current supplied to the process, regulator means jointly responsive to the potentials of said first and second pilot generators for controlling the excitation of the third generator means, control means operable to vary the excitation of the first generator means, and means actuated in accordance with said control means for varying the ef-

8

fectiveness of the second pilot generator potential on said regulator means, thereby to provide for varying the ratio between speed and current as the speed of travel is varied.

5 11. In a control system for an electrolytic process; an electric motor for causing a length of material to travel through the process, first generator means for energizing the motor, second generator means for supplying current to the process, said second generator means having an excitation circuit connected to be energized in accordance with the voltage of the first generator means, third generator means connected in said excitation circuit, a first pilot generator operable to develop a potential proportional to the speed of the material, second pilot generator means operable to develop a potential proportional to the current supplied to the process, regulator means operable to control the excitation of the third generator means, said regulator means having one operating circuit energized in accordance with the potential of the first pilot generator and a second operating circuit energized in accordance with the potential of the second pilot generator, first variable resistance means operable to vary the excitation of the first generator means, and second variable resistance means actuated in conjunction with said first variable resistance means for varying the effectiveness of the potential of the second pilot generator on said second operating circuit of the regulator means, thereby to provide for varying the ratio between speed and current as the speed of travel is varied.

CHARLES P. CROCO.