Dec. 22, 1942. B. BERGHAUS ET AL 2,305,758

COATING OF ARTICLES BY CATHODE DISINTEGRATION

Filed April 22, 1938 3 Sheets-Sheet 1

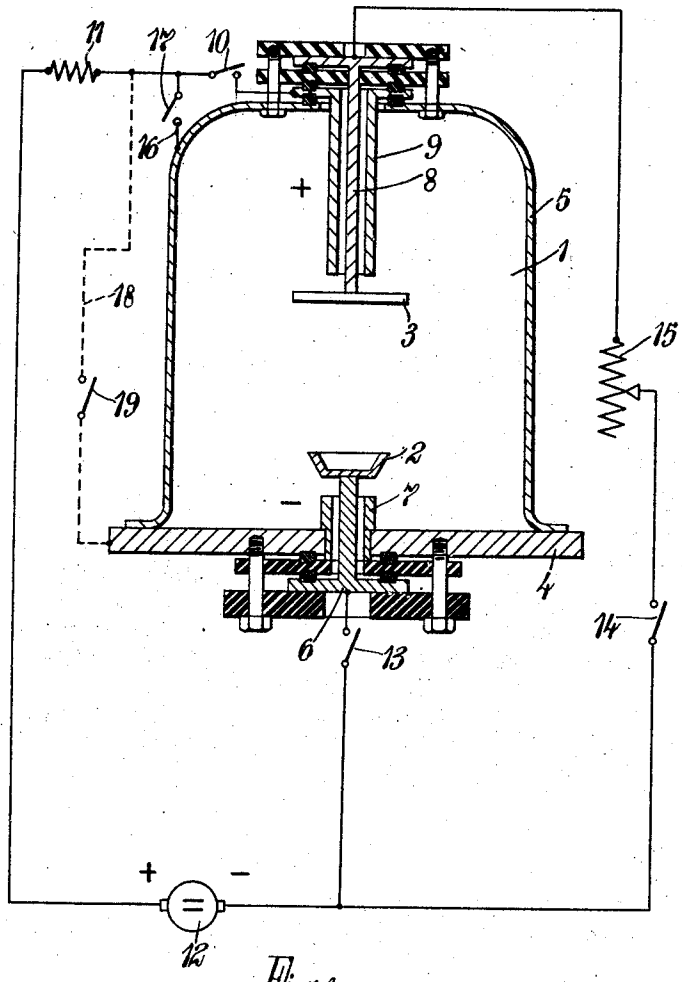


Fig. 1.

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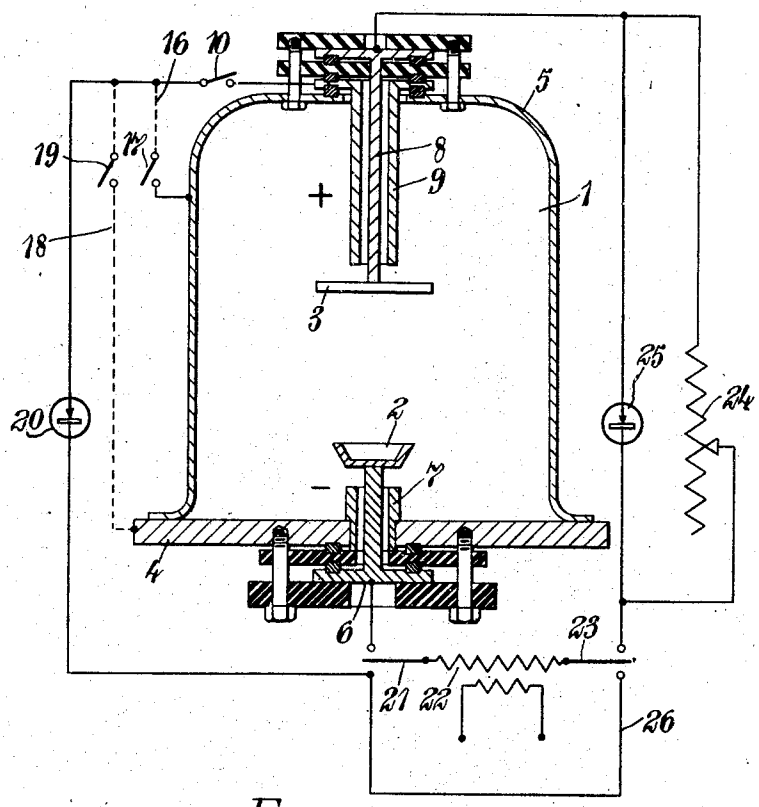


Fig. 2.

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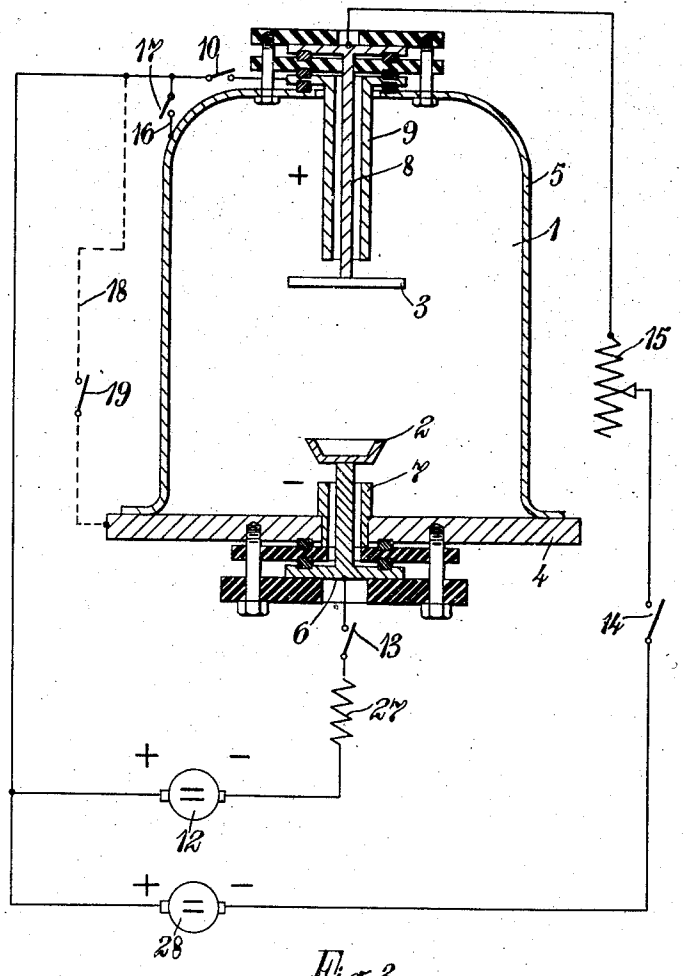


Fig. 3.

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UNITED STATES PATENT OFFICE

2,305,758

COATING OF ARTICLES BY CATHODE DISINTEGRATION

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Application April 22, 1938, Serial No. 203,672
In Germany May 25, 1937

4 Claims. (Cl. 204—192)

This invention relates to a method of coating metallic articles by cathode disintegration and it consists mainly in that the article is continuously or intermittently connected up as a cathode before or during the disintegration. The invention makes it possible to provide metallic articles with layers of any desired thickness, with perfect texture and great adhesion. It is an advantage to disintegrate the cathode only intermittently. The article may carry cathode potential in the disintegration intervals. An alternating current voltage of any desired frequency may be applied as disintegration voltage between the article and the cathode. In order to be able to vary the intensity of the current applied to the article with the cathode potential, regulating means are inserted in the electric lead. When the disintegrating voltage is a direct current voltage or a rectified alternating voltage an adjustable resistance may, for instance, be inserted in the electric lead to the article to which the cathode potential is applied.

When the disintegrating voltage is an alternating current voltage, a rectifying valve is, for instance, inserted in the lead and connected in parallel with an adjustable resistance. The object of the rectifying valve is to allow the positive alternation to pass through without being weakened, in order to maintain the full current for the disintegration of the cathode material. The negative alternation on the other hand is stopped, and the current is adjusted to the desired intensity by means of the variable resistance connected in parallel. Of course, use may be made of other methods of connection.

By suitably adjusting the current density, a metal article to which the cathode potential is applied continuously or intermittently may reach any desired temperature up to incandescence. The current density on the surface of the article is preferably chosen smaller than the current density on the surface of the cathode material to be disintegrated.

The cathode material to be disintegrated is preferably disintegrated in an incandescent state or from a crucible in a liquid state, the heating and melting being effected by the actual electric gas discharge. The pressure of the filling gas may vary between 5 and 0.001 millimeters of mercury, and the disintegration voltage is between 400 and 10,000 volts. In order to protect the insulation of the electric leads, which are constructed as a support for the cathode material to be disintegrated and the article to be coated, against detrimental heat and coating, the leads are provided with a metal covering. The metal covering is provided at such a distance, that between it and the leads no glow discharge can be produced.

The distance between the cathode to be disintegrated and the article to be coated may vary. However, it is especially advantageous to choose the shortest possible distance; the same is given by the unhindered formation of the glow fringe around the article and around the cathode material to be disintegrated.

By the method according to the present invention coatings can be provided on metallic articles of any form. The layers show throughout a uniform crystalline formation which holds together and they excel by their reliable adherence. For instance, layers of one-tenth of a millimetre thickness produced on metal sheets do not flake or crumble, even with a bending stress reaching the fracture point of the metal sheet, and they can be subsequently treated and polished.

The current to the article acting as cathode while being heated up is adjusted according to the sensitiveness of the article to heat. The current densities can be adjusted to values at which the articles are heated up to incandescent temperatures. The degree of the heating depends on the material of the article and the coating material. The upper temperature limit is determined by the fusing point of the materials which are used.

In the case of intermittent disintegration and heating up of the article by its being connected up as a cathode between the periods of disintegration the extent of the disintegration and the duration of the heating-up periods depend on the temperature it is desired to impart to the article.

Although it was to be assumed that the major part of the coated material will be removed again from the article brought to cathode potential during the disintegration, it was surprising to obtain in a short period of time a dense reliable coating, which was even more uniform on the surface of the article than is the case with the known cathode disintegration methods, in which the article is neutral or connected as an anode.

The current densities are so chosen that the current density of the article is smaller than on the cathode material to be disintegrated. For instance, a ratio of current densities of 1:30 has been found favourable in the case of coating of silver on copper at a pressure of 0.5 millimeter of mercury. In this case, in 30 minutes 3.68 grams of silver are coated and a layer of a thickness of 0.294 millimeter is obtained. The voltage between the disintegration electrode and the

anode was in that case 2,000 volts, and between the article and the anode 1,000 volts.

A separate adjustable source of voltage may be used, each for the disintegration of the cathode and the "cathodic" connection of the article to be coated; either a source of direct current voltage or of alternating current voltage may be used.

By using the two sources of current the advantage is obtained that, with different voltage on the cathode material to be disintegrated and on the article to be coated, the circuits can be regulated independently of one another. This connection offers special advantages in the case of large total currents on the articles to be coated, as compared with the current of the cathode to be disintegrated, since electric losses, as they occur when use is made of only one source of voltage owing to the voltage differences between the article and the cathode, are avoided.

Apparatus for carrying out the invention is illustrated in the accompanying drawings wherein:

Fig. 1 is a section through an arrangement for coating articles by cathode disintegration in which a source of continuous current serves as the disintegration voltage,

Fig. 2 is a section through another arrangement for coating articles by cathode disintegration in which a source of alternating current serves as the source of the disintegration voltage, and

Fig. 3 is a section through a cathode disintegration arrangement in which separate sources of current are used for the disintegration of the cathode material and for the "cathode" connection of the article to be coated respectively.

Referring to Figure 1, 1 is the cathode disintegration chamber which can be evacuated, 2 is the cathode to be disintegrated and 3 the article to be coated, which is for instance of metal. The cathode disintegration chamber comprises a base 4 and a removable upper housing part 5. The cathode holder 6 is arranged in an insulated manner in the base 4 and is surrounded by a screen 7 which is spaced from the holder. A filling gas, such as argon, hydrogen, nitrogen, helium, or the like, may also be supplied through the base 4, which may be provided with a short connecting pipe leading to the vacuum pump. The metal holder 8 for the article is mounted in an insulated manner in the upper part 5 and is surrounded by a screen 9 which is spaced from the metal holder 8, in which space a glow discharge cannot take place, the screen being connected through a switch 10 and a protecting resistance 11 to the positive pole of a source 12 of continuous current, or a source for rectified alternating current. The negative pole of the source of continuous current may be connected through a switch 13 to the cathode holder 6 and through a switch 14 and an adjustable resistance 15 to the article holder in any desired sequence. The screen 9 of the article holder may be connected through a conductor 16 and a switch 17 to the wall of the chamber, or through a conductor 18 and switch 19 over the base 4 to the screen 7 of the cathode holder, if necessary.

The operation of the apparatus described is as follows:

The article 3 is connected to the source of current 12 through the switch 14 and adjustable resistance 15, by means of which the current can be so adjusted that the current flowing through the article 3 will attain any desired temperature, even the temperature of incandescence, before the actual coating is started. During this period, the positive pole of the source of current 12 is connected to the screen 9 through the switch 10, or to the part 5 through the switch 17 and connection 16, or to the base 4 through the connection 18 and switch 19, which screen, part 5 and base then constitute the anode. In this way the article is first of all freed of any gas, before the actual coating is effected. At the same time the voltage of the source 12 may be so chosen that a cathode disintegration also takes place on the article 3, whereby the surface of the article is made rough and is cleaned, so that, during the subsequent metal coating period of the article when the switch 13 is closed, the cathode 2 is disintegrated and the metal serving for the coating of the article 3 is deposited thereon. Normally the switch 14 is open during the coating period, but it may also be left closed, more particularly when the article 3 to be coated is to be additionally heated during the coating. A few minutes will suffice for the preliminary cathodic treatment of the article.

Referring to Figure 2, 1 is the cathode disintegration chamber, 2 the cathode to be disintegrated and 3 the metallic article to be coated. The coated disintegration chamber consists of a base 4 and an upper part 5. The cathode holder 6 is mounted in an insulated manner in the base 4 and is surrounded by a screen 7. The metallic article holder 8 is mounted in an insulated manner in the upper part 5 and is surrounded by a screen 9, which may be connected through a switch 10 and a rectifying valve 20 for the negative alternation over a change-over switch 21 to the one pole of a high voltage alternating current transformer 22. The transformer may be connected with its other pole over a change-over switch 23 and an adjustable resistance 24 which is shunted by a rectifying valve 25 for the negative alternation to the article holder and, therefore, to the article. By means of the circuit containing the resistance connected in shunt with the rectifier 25, a small alternating current can pass through in both directions. In that case the rectifier 25 allows only the anodic alternation to pass through. Alternatively, the transformer may be connected with one pole through the switch 23 to a conductor 26, which leads through a rectifying valve for the negative alternation to the screen of the article holder, and by means of the change-over switch 21 the other pole of the transformer may be connected to the cathode holder 6 and thus to the cathode to be disintegrated. The screen 9 of the article holder may be connected through the conductor 16 and switch 17 to the wall of the chamber, or through the conductor 18 and switch 19 over the base 4 to the screen 7 of the cathode holder, if required. The individual switches may be actuated in any desired sequence.

The operation of the apparatus shown in Figure 2 is similar to that described with reference to Figure 1 if it is borne in mind that the two rectifiers 20 and 25 do not allow one of the alternations (positive or negative) to pass through in one of the two directions of the alternating current supplied by the transformer 22, and that the shunt circuit containing the adjustable resistance 24 allows a small adjustable alternating current to pass through in both directions. When one pole of the transformer is connected to the rectifier 20 through the switch 21 and its other pole is connected to the resistance 24 through the switch 23, we get the preliminary cathodic

treatment of the article. With the switch 23 connected to the conductor 26 and switch 21 connected to the cathode holder 6 and thus to the cathode 2, we get the required circuits for the actual coating process with the article disconnected from the source of current.

In Fig. 3 the apparatus for carrying out the invention differs from that shown in Fig. 1 merely in this, that a source 12 of voltage is provided for the disintegration of the cathode 2, which is connected through a resistance 27 and a switch 13 to the cathode 2, and through a second source of voltage 28 to the article 3 over the switch 14 and the resistance 15.

What we claim is:

1. A method of coating metal articles by cathode disintegration within a metal housing having a cathode to be disintegrated therein insulated with respect to the housing and the article to be coated arranged within and insulated with respect to the housing which comprises, impressing a voltage across the article and the housing with the article connected as a cathode to create a glow discharge within the housing heating the article, and impressing a voltage across the cathode to be disintegrated and the housing to disintegrate particles therefrom onto the article so as to coat the same.

2. A method of coating a metallic article which comprises, supporting the article in an insulated manner within a sealed housing having a cathode therein, adjusting the pressure within the housing to support a glow discharge and cathode disintegration therein, impressing a voltage across the housing and the article with the article being negative with respect to the housing to create a glow discharge within the housing heating the article, and impressing a voltage across the cathode and the housing with the cathode being negative with respect to the article for disintegrating particles from the cathode onto the heated article.

3. A method of coating a metallic article which comprises, supporting the article within a sealed housing having a cathode therein, adjusting the pressure within the housing to support a glow discharge and cathode disintegration therein, impressing a voltage across the housing and the article with the article being negative with respect to the housing to create a negative glow discharge around the article heating the article, and disintegrating particles from said cathode onto the heated article with the cathode being negative with respect to said article.

4. A method of coating a metallic article which comprises, supporting the article within a sealed housing having an anode and a cathode therein, adjusting the pressure within the housing to support a glow discharge and cathode disintegration therein, impressing a voltage across the anode and the article with the article being negative with respect to the anode to create a glow discharge around the article heating the article, and impressing a voltage across the anode and the cathode with the cathode being negative with respect to the article for disintegrating particles from the cathode onto the heated article.

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