Feb. 21, 1939. W. BURKHARDT ET AL 2,148,046

METHOD OF METAL COATING BY CATHODE DISINTEGRATION

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Fig. 2

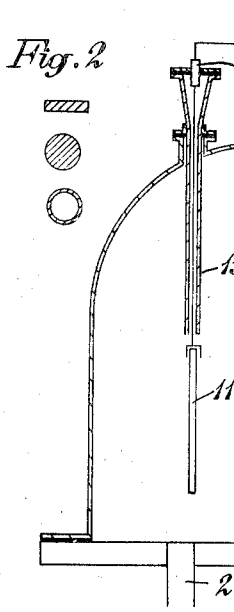
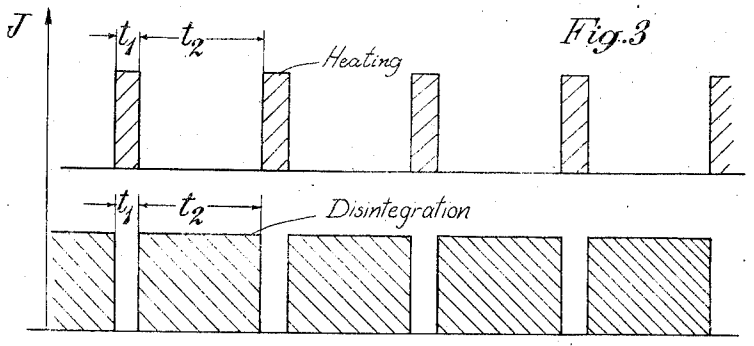


Fig. 1

Fig. 3



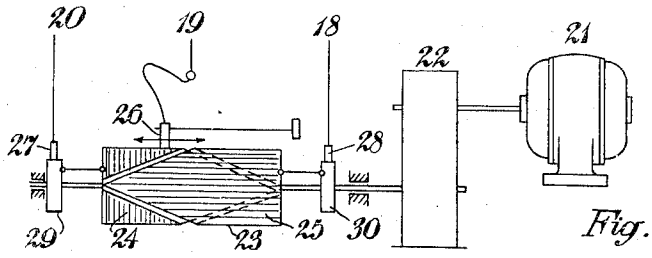


Fig. 4

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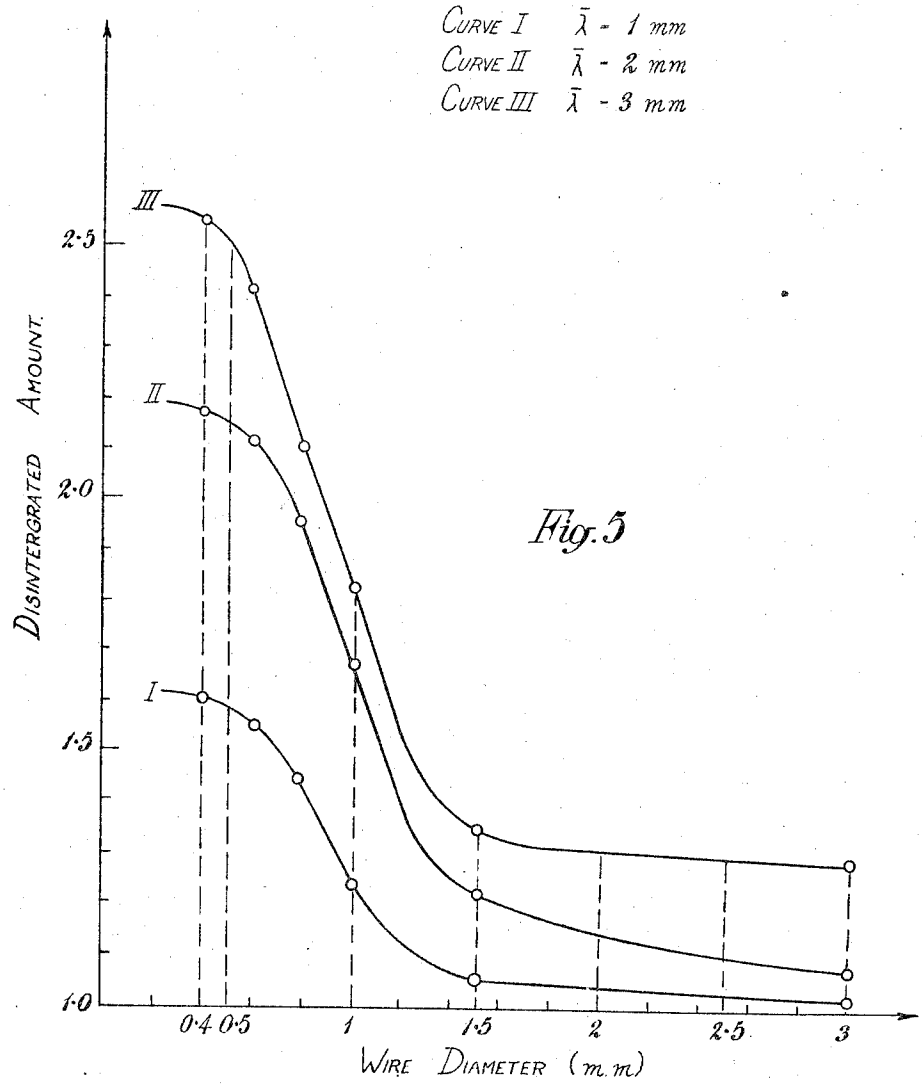


Fig. 5

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METHOD OF METAL COATING BY CATHODE DISINTEGRATION

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2 Claims. (Cl. 91—70.1)

In the metallisation by cathode disintegration it has been found that the shape of the cathodes has an influence on the amount that is disintegrated. Use has hitherto been made of tubular cathodes, plate cathodes, wire and band cathodes and it has been found in connection therewith, that the smaller the dimensions of the cathode the greater is the amount disintegrated per unit of time. Wire cathodes have proved to be especially suitable. In this respect Güntherschulze says as follows in the Zeitschrift für Tech. Physik, of the year 1927, page 169 to 178:

"If the diameter of a wire cathode is reduced more and more, so that it is comparable to the free path of the gas molecules, then the amount disintegrated from it increases with the reduction in the wire diameter of the cathode, since a far smaller number of metal atoms find their way back to the cathode; moreover, with decreasing wire diameter, the temperature of the cathode increases up to incandescence, finally, reaching even fusing temperature." It is stated on page 171, left-hand column, chapter 3, paragraph 1, that the cathode is heated by the heat of the current. Moreover, the use of wire or band cathodes, the thickness of which is of the order of the free path, has been made known by a patent. In this known method, use may be made of a large number of thin cathodes of wire or band shape. Although it is mentioned in the patent specification that a substantial acceleration in the disintegration is obtained by resistance or high frequency heating, it is proposed, as a simplification of the heating, to reduce the cross-section to such an extent that the glow current can take over the heating up. The glow current may be defined as the electric current which flows in the cathode disintegration chamber during the disintegration between the anode and the cathode and which heats the cathode. In the glow discharge used for the cathode disintegration the current flowing through the cathode disintegration chamber comprises two components, viz., (1) the stream of electrons flowing from the cathode to the anode and, (2) the stream of ions flowing towards the cathode. The latter stream is referred to herein as the "glow current". The effect obtained by this measure does not differ in any way from that found by Güntherschulze. It was determined by experiments that, in the case of resistance heating of wire or band-shaped cathodes, an increase in the disintegrated amount as compared with a wire or band-shaped cathode of the same dimensions which was not preheated, was never noticed. On the contrary, it was found that by an additional heating the disintegrated amount became smaller, as compared with the case when no preheating was used. The experiments were carried out as follows:

A copper wire of 0.3 mm. diameter was heated by the glow current to a temperature of about 900°. As compared with larger wire diameters a maximum of disintegrated amount was obtained, a further reduction in the diameter, the load being the same, resulting in the fusing of the cathodes. Also, each time the free path was varied, a maximum was ascertained with the same wire diameter of 0.3 mm. as compared with others of larger diameters, as will be seen from the curves in Fig. 5 of the accompanying drawings. It was now tried, by resistance heating, to heat a wire cathode of about 1.5 mm. diameter, with which a well determined amount was disintegrated, to the temperature which the wire cathode of 0.3 mm. attained owing to the glow current load. The resistance heating was effected by means of continuous current, and it did not result, as it was to be assumed, in the same disintegrated amount, which was produced from the thin wire cathode of 0.3 mm. diameter, but, on the contrary, in a smaller amount than was ascertained before the heating. On the other hand, if the heating current of the cathode is interrupted, and the mean temperature is so adjusted that it corresponds to that which is imparted by the glow current to a wire of 0.3 mm. diameter, then the disintegrated amount increases, reaching even values which are obtained with the disintegration of a wire cathode of 0.3 mm. Also thicker wire cathodes, which were additionally intermittently preheated also with other free paths, produced in each case a substantially greater disintegrated amount in the same time, than was produced by the same wire cathodes without the use of intermittent heating up.

The essence of the method according to the present invention consists in that the heating up of the cathodes is effected by an intermittent supply of energy, the cross-section of the cathodes being greater than that for which heating exclusively by a glow current produces a maximum of disintegrated amount. It is immaterial what profile the cathode has. Thus, for instance, use may be made of circular, square, rectangular, triangular, solid and hollow and other profiles. The heating up impulses may be of different duration as compared with the periods of rest of the heating. Thus, the same mean temperature may be produced with a large energy and small impulses with larger intervals of rest, as, for in-

stance, vice versa, with a smaller energy and long impulses with short periods of rest of the heating. It is an advantage to keep the heating impulses small as compared with the periods of rest of the heating, since the disintegration takes place unhindered during the said periods of rest. By continuously heating the cathode with, for instance, continuous current, a magnetic field is produced around the wire, which deflects the incoming ions effected by the disintegration of the metal more and more in the longitudinal direction of the wire cathodes, so that, when they come to an impact, they are no longer capable of parting completely with their energy. This explains the decrease in the disintegrated amount in the case of a resistance heated cathode. However, the supply of the heating current being intermittent, the discharge can now come into action in the periods of rest of the heating, since no magnetic field which may have a detrimental effect is now present. The cathode temperature to be adjusted by the heating current in a predetermined sequence in time is chosen as high as the cathode material will practically permit it. Very special advantages are attained by the method according to the invention in the case of materials having a high melting point, such as for instance, chromium, tungsten, molybdenum, titanium, tantalum, zirconium, etc., since the costs of manufacture of such thin wires, as would be necessary for obtaining a maximum disintegrated amount per unit of time with the heating by the glow current, are very high, as compared with wires of larger diameter. But also in the case of other materials, such as for instance, silver and gold, it is very expensive to work with thin wire or band cathodes, since, after a short period of disintegration, the diameter of the wires is so reduced, that they burn through, owing to the higher specific current load. The utilisation of the cathode material is thus very poor. Moreover, the operation is often interrupted by the frequent change of cathodes, whereby expenses are entailed by the renewed evacuation of the apparatus in addition to the loss of time which cannot be made up again.

One arrangement of the means for carrying the invention into effect is illustrated in the accompanying drawings diagrammatically and by way of example.

Figure 1 is a diagram of a plant for cathode disintegration, part of the apparatus being shown in section;

Figure 2 is a section along the line II—II of Figure 1 through the cathode to be disintegrated;

Figure 3 is a diagram of the heating current having the duration t_1, and of the disintegrating current having the duration t_2;

Figure 4 is a device for the automatic control of the switching to be used instead of the two hand switches shown in Figure 1;

Figure 5 is an explanatory diagram.

Referring to Figure 1, **1** is the cathode disintegrating chamber, which is connected through the pipe **2** to a vacuum pump, which is not shown, being evacuated to a pressure between about 5 mm. and 0.001 mm. of mercury. A filling gas, such as hydrogen, argon, nitrogen, or the like, may be supplied through the connecting pipe **3**. The cathode **4** to be disintegrated may be heated to the desired temperature of incandescence by means of a source of current **5** over an adjustable resistance **6** by closing the switch **7**. The material to be disintegrated may, for instance, be a metal or an alloy. The switch **7** is closed for a period of time t_1 and is then opened, whereupon the switch **8** is closed. The source of disintegrating voltage **9** of, for instance, 2000 volts, now supplies the disintegrating voltage over a resistance **10** for the article **11** to be coated and which is connected up as the anode. **12**, **13** and **14** are the insulations for the current leads, and **15**, **16** and **17** are metallic screens, which are arranged at a short distance of, for instance, 1 to 3 mm. round the current leads. **18**, **19**, **20** are the connecting leads for the automatic switching device, according to Figure 4.

Figure 2 shows cathode profiles which may be rectangular, circular or annular.

It will be seen from Figure 3, which is a diagram showing the path of the heating current J, which is connected up during the period of time t_1 and of the disintegrating current connected up for the period of time t_2, how the heating and the disintegration of the cathode alternate with one another. The heating period and the disintegration period may be chosen according to the material to be disintegrated.

Referring to Figure 4, illustrating the automatic control device substituted for the hand switches **7** and **8** shown in Figure 1, **21** is the driving motor, which drives the controller **23** through the intermediary of a gear **22** with the desired gear ratio, the said controller being provided with metallic coatings **24** and **25** insulated from one another and co-operating with an adjustable sliding contact **26** connected to the lead **19**. **18** and **20** are the other two leads (see Figure 1) and **27** and **28** are sliding contacts which slide on the slip rings **29** and **30**, the latter being connected to the coatings **24** and **25** of the controller respectively.

Figure 5 shows the disintegrating amount as a function of the diameter of the wire in millimetres for different lengths of free paths, curve I showing it in a free path length of $\lambda=1$ mm.; curve II for a free path length of $\lambda=2$ mm.; and curve III for a free path length of $\lambda=3$ mm.

What we claim is:

1. A method of coating articles connected up as an anode with a metal obtained from a cathode by the disintegration of the latter, consisting in heating up by an intermittent supply of electric energy in the form of an electric current a cathode, the cross-section of which is greater than that which gives a maximum disintegrated amount exclusively with heating by means of a "glow current", and allowing the metal particles disintegrated from the said cathode to be deposited as a coating on the article connected up as an anode.

2. A method of coating articles connected up as an anode with a metal obtained from a cathode by the disintegration of the latter, consisting in heating up by an intermittent supply of electric energy in the form of an electric current a cathode, the cross-section of which is greater than that which gives a maximum disintegrated amount exclusively with heating by means of "glow current", the said intermittent supply of electric energy comprising heating up impulses the duration of which is different from the duration of the periods of rest of the heating, and allowing the metal particles disintegrated from the said cathode to be deposited as a coating on the article connected up as an anode.

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