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METALIZATION BY CATHODE DISINTEGRATION

Filed Feb. 18, 1937

Fig. 1



Fig. 2

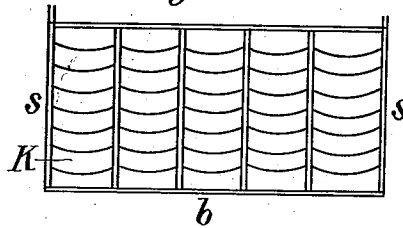


Fig. 3

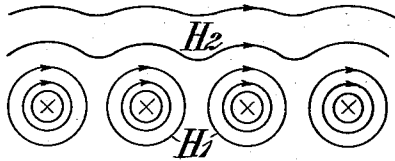


Fig. 5

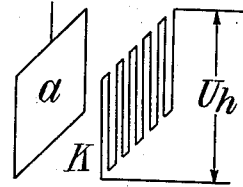


Fig. 4



Fig. 6

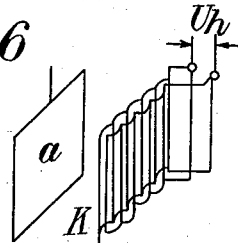


Fig. 8

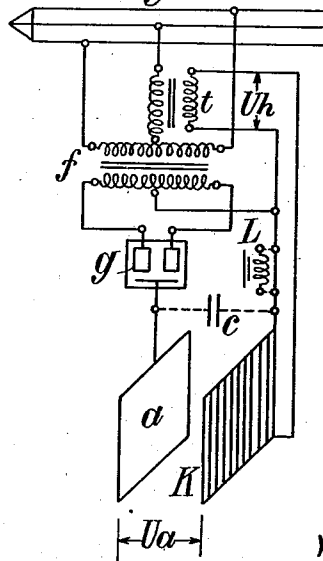
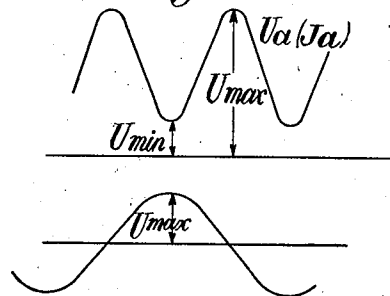


Fig. 7



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METALLIZATION BY CATHODE
DISINTEGRATION

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The metalization by cathode disintegration has the disadvantage that a portion of the particles leaving the cathode returns thereto, whereby the efficiency is reduced. The cathodes have hitherto been used in the form of a band, metal sheet, plates, tubes or wires. When the cathode is in the form of a wire, the diameter of which is comparable with the length of the free path of the gas molecules, a much smaller number of vaporized metal atoms find their way back to the cathode as compared with a large flat cathode, the number thereof being the smaller the smaller the diameter of the wire, (see A. Güntherschulze in the Zeitschrift für "Technische Physik" 1927, pages 169 to 178, and more particularly right-hand column on page 174). Thus, according to Güntherschulze, the partial pressure of the gas in front of the cathode, and therewith, also, the amount reaching the anode, must increase with the decrease of the diameter of the wire. In this known method heated cathodes are also known, since in the cathode disintegration the wires are heated by themselves and reach incandescent temperatures. According to page 171, left column, chapter 3, paragraph 1, it is known that the cathodes become hot by the heating of the electric current. This arrangement of thin cathode wires of the order of the length of the free path, which according to Güntherschulze is known, forms the basis of a subsequent Austrian patent specification No. 136,250 of 1932, which relates to a method of metalizing by cathode disintegration, the essential feature of which is, that use is made of heated electrodes, the thickness of which is of the order of the length of the free path of the metal atoms. In this known method use may be made of a large number of thin wire or hand-like electrodes. On the other hand, more recent experiments have shown that the most favourable wire thickness is not dependent upon the length of the free path, as it is assumed in the Austrian patent specification. Further, according to the latter, it should be possible, in the metalization by cathode disintegration, to accelerate the disintegration when the cathodes are heated.

However, the disintegration experiments made in this direction with resistance-heated cathode wires, more particularly of metals which disintegrate with difficulty, revealed an important disadvantage in connection with the usual method: the temperature of the cathode wires, in order to obtain a substantial acceleration of the disintegration, more particularly in the case of materials which are disintegrated with difficulty,

such as tantalum, chromium, tungsten and their compounds and carbides, for metallurgical purposes, must reach a very high degree, which requires large heating currents, which, in their turn, produce very disturbing magnetic fields around the wires. Owing to these magnetic fields, which increase in a hyperbola-like manner with respect to the cathode surface, the paths of the electrons and ions (the latter disintegrate the cathode when they impinge upon it) are also increasingly deflected in the longitudinal direction of the cathode wires. These movement components of the charge carriers, which run in a direction at right-angles to the direction of disintegration, prevent an increase in the intensity of disintegration taking place.

The above mentioned disadvantages are removed almost completely by the present invention, which relates to a method of metalization by cathode disintegration, by means of heated cathodes, and which consists in that, for the heating of the cathode, in order to reduce the deflection of the charge carriers produced by the magnetic fields of the cathode heating currents, use is made of an alternating current. For the disintegration of the cathode use is preferably made of a pulsating direct current voltage. Preferably, the heating of the cathode is effected by means of an alternating current voltage, and the disintegration of the cathodes by means of a pulsating direct current voltage, the maximum values of which occur when the heating voltage reaches its minimum values. The cathodes to be disintegrated may, preferably, consist of metals fusing at a high temperature, such as, for instance, tantalum, chromium, tungsten and the like and their compounds. The wave of the pulsating direct current voltage may preferably be so chosen that its minimum values do not fall below the extinguishing voltage, which corresponds each time to the path of the discharge.

Further, the deflection of the discharge carriers is reduced by using wires for the cathodes, the current in the successive wires being each time reversed with respect to one another. The cathode wires may be provided with a core of a metal fusing at a higher temperature as compared with the metal to be disintegrated. This has the advantage that the fusing point of the metal to be disintegrated can be approached to a greater extent, without being afraid that the wire will break. The cathode wires may be connected in series or in two parallel rows, which are displaced relatively to one another and connected in parallel in opposite directions. Further, the

cathode wires, which are placed horizontally, may be supported by insulating bars.

Further, according to the invention, instead of the uninterrupted heating of the cathode for the purpose of reducing the deflection of the charge carriers produced by the magnetic fields of the cathode heating currents, by means of an alternating current, use may preferably be made of a periodic heating. Thus, use is made, not only of an alternating current but of a periodic heating. For the periodic heating use may advantageously be made of a pulsating direct current. The individual impulses or maximum values of the heating current lie preferably between those of the disintegration voltage with respect to time. The pulsating direct current for the heating may, with advantage, consist of an intermittent direct current. The intermittent direct current represents a limit case of the pulsating direct current, in so far as the voltage drops down to nil, so that a current interruption takes place between the individual impulses. The duration of the interruption in which the disintegration takes place, without being hindered by detrimental magnetic fields, depends upon the nature of the cathode material and its heat capacity. The heating impulses and the intervals of rest may be different with respect to time. Preferably, the duration of the heating is chosen small with respect to that of the disintegration. For the disintegration voltage use may preferably be made of an intermittent direct current voltage. The heating and the disintegration of the cathode may advantageously take place alternately.

For the heating of the cathode wires use may thus be made of pulsating or intermittent direct current, for instance, in the form of a half-wave of an alternating current voltage, in such manner that these half-waves lie between the maximum values of the disintegration voltage as regards time. If the same is, for instance, a direct current voltage obtained by a double rectification of an alternating current voltage of 50 periods and pulsating with 100 periods, the cathode heating is preferably effected only by one half-wave of an alternating current voltage of 100 periods obtained by half rectification, or also by a pulsating direct current voltage, the superposed alternating current voltage of 100 periods of which is displaced in phase through 90° with respect to the disintegration voltage.

The disintegration voltage may also consist of a half-wave of an alternating current voltage of, for instance, 50 periods, which is preferably superposed on a direct current voltage, the value of which is not below the extinguishing voltage. The heating of the cathodes then takes place only by means of a half-wave of an alternating current voltage, also of 50 periods. In both examples the alternating current voltage half-waves, serving for the heating of the cathodes, lie between the half-waves or maxima of the intermittent or pulsating disintegration voltage.

If it is desired to obtain a still sharper time separation between the heating and the disintegration voltage, than it is possible to obtain by sinusoidal intermittent or pulsating voltages, use may be made of intermittent voltages of rectangular or trapezoidal form as can be obtained, for instance, by means of valve tubes with a saturation characteristic. By using pulsating, preferably intermittent heating currents, and disintegration voltages of the cathodes, the advantage is attained that, owing to the unin-

terrupted heating currents, no deflection of the charge carriers occur during the disintegration.

One arrangement for carrying the method into effect comprises a source of alternating current for heating, which is connected to the cathode wires, a source for pulsating direct current for the disintegration connected to the anode and the cathodes, and means such as capacities or self-inductances in order to adjust the phase difference of the alternating current and pulsating direct current in such a manner that the maximum of the disintegration voltage coincides with the minimum of the heating voltage.

The invention permits of wires of larger diameter being advantageously used as compared with wires which are brought to the temperature required for the maximum disintegration by the glow current only.

The accompanying drawing illustrates, by way of example, various modes of carrying the invention into effect.

Figure 1 is a section through a cathode wire provided with a core;

Figure 2 is a vertical section through the support of horizontally suspended cathode wires;

Figure 3 is a horizontal section through four cathode wires which are traversed by a current in the same direction;

Figure 4 shows a horizontal section through four other cathode wires, in which the current flows in opposite directions in alternate wires;

Figure 5 is a diagrammatic illustration of the cathode wires connected in series;

Figure 6 shows the parallel connection of the cathode wires;

Figure 7 is a diagram showing the course of the pulsating direct current voltage for the cathode disintegration, and of the alternating current voltage for the heating of the cathodes;

Figure 8 is a diagram of connections of an arrangement for the heating of the cathodes by means of an alternating current voltage, and for the disintegration of the cathodes by means of pulsating direct current voltage.

Referring to Figure 1, which is a section through a cathode wire provided with a core, K is the cathode material to be disintegrated and d is the core. Since the wires may reach the flow limit, owing to the use of the high temperatures, they are preferably provided with a thin core of a metal fusing at a higher temperature than the metal to be disintegrated. The metal core of higher fusing point may, according to the nature of the metal to be disintegrated, consist, for instance of tantalum, chromium, tungsten or the like.

Referring to Figure 2, which illustrates the support of the horizontally suspended cathode wires, s are the bus bars, between which the cathode wires K are suspended, preferably horizontally. The cathode wires are supported by a number of insulating bars, for instance of porcelain, which may form a rigid frame b . With such a suspension arrangement use may be made of wires without a wire core having a higher fusing point.

Figure 3 shows a cross-section through four cathode wires which are traversed by a current in the same direction, the fields H_1 of which are combined to a total field H_2 , which, according to the direction of the charges, imparts a greater deflection to their paths as compared with the arrangement shown in Figure 4, which illustrates a cross-section through four cathode wires, in which the current flows in opposite directions

in alternate wires. In view of the fact that the direction of the heating current in successive cathode wires is alternately reversed, the total magnetic field H_2 around the cathode wires, considered as a whole, disappears, so that the fields H_1 can be formed.

Figure 5 shows an arrangement of cathode wires K connected to the voltage U_h arranged opposite the anode a . In this arrangement the heating current flows in the opposite direction through adjacent wires.

Referring to Figure 6, K are the cathode wires connected in parallel and arranged opposite the anode a , the said cathode wires being connected to the heating voltage U_h . In this arrangement two rows of cathode wires connected in parallel are formed, which lie in the same plane, and each of which is connected to two bus bars. The two rows are connected in parallel in opposite directions, so that the current is reversed in adjacent wires. In the arrangement according to Figures 5 and 6, a magnetic field according to Figure 4 is produced. The arrangements of the cathode wires according to Figures 5 and 6 may also be used in conjunction with the horizontal arrangement according to Figure 2.

Figure 7 is a diagram showing the course of the pulsating direct current voltage U_a for the cathode disintegration and of the alternating current voltage U_h for the heating of the cathodes. It will be seen from this diagram that, when the heating voltage U_h reaches its maximum, the disintegration voltage U_a reaches its minimum and vice versa, when the heating voltage U_h passes through the zero point the disintegration voltage U_a reaches its maximum.

The disturbing effect of the magnetic fields produced by the heating current of the cathode wires is reduced to a minimum by that a pulsating direct current is used for the anode current effective in the path of discharge and an alternating current for the cathode heating, in such a manner that the maxima of the heating current I_h occurs when the discharge current I_a reaches its minima, whilst at the time of the maximum of the discharge current the heating current passes through zero.

Figure 8 shows a diagram of connections of an arrangement for the disintegration of the cathodes by means of a pulsating direct current voltage, and for the heating of the cathodes by means of an alternating current voltage. The arrangement consists of a source for the pulsating direct current voltage U_a and of a source of alternating current voltage U_h for the heating. The disintegration current is obtained in a known manner, for instance, by a double rectification of a single phase alternating current, as is indicated diagrammatically by the rectifying device g . The natural wave of the first harmonic of the alternating current voltage of 67% superposed on the direct current component may be reduced, as desired, by a filter, consisting of

a choke L and a condenser C . The minimum of the disintegration voltage U_a may advantageously be so chosen, that it does not lie below the extinguishing voltage which prevails at the time in the discharge path.

The heating alternating current voltage U_h which is displaced in phase through 90° with respect to the alternating current voltage supplying the pulsating anode direct current voltage U_a , may, for instance, be derived over a transformer t , from a phase of a three-phase transformer f , which is star connected, whilst the other two phase voltages supply the anode disintegration voltage U_a over a transformer by geometric subtraction.

Since the two consuming parts, viz., the disintegration and the heating, constitute almost pure ohmic loads, the phase displacement of 90° between the disintegration current I_a and the heating current I_h is attained with sufficient accuracy.

The arrangement illustrated in Figure 8 is given only by way of example. It is to be understood that the pulsating direct current for the disintegration, and the alternating current for the heating, may be obtained in any other known manner, and be relatively adjusted as desired.

What we claim is:

1. A method of metalizing by the disintegration of heated cathodes, consisting in effecting the heating and the disintegration of the cathode alternately by two separate currents alternately and repeatedly applied thereto, whereby the deflection of the charge-carriers produced by the magnetic fields of the current heating the cathode is reduced.

2. A method as claimed in claim 1, consisting in effecting the heating of the cathodes by means of an alternating current.

3. A method as claimed in claim 1, consisting in effecting the heating periodically by means of a pulsating direct current.

4. A method as claimed in claim 1, consisting in effecting the heating periodically by means of an intermittent direct current.

5. A method as claimed in claim 1, consisting in effecting the disintegration of the cathodes by means of a pulsating direct current voltage.

6. A method as claimed in claim 1, consisting in effecting the heating of the cathodes by means of an alternating current, and the disintegration of the cathodes by means of a pulsating direct current voltage, the maxima of which occur at the points where the alternating current used for the heating of the cathodes changes its direction.

7. A method of metalizing by the disintegration of heated cathodes as claimed in claim 1 consisting in effecting the disintegration of the cathodes by means of a pulsating direct current voltage.

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