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ELECTROLYTIC SEPARATION OF METALS.
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Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.
To all whom it may concern:

Be it known that I, CARL LANGER, a subject of the King of Great Britain, and residing at Bucklebury Place, Woolhampton, in the county of Berkshire, England, have invented certain new and useful improvements in Electrolytic Separation of Metals, of which the following is a specification.

This invention relates to the electrolytic separation of metals.

In all processes hitherto employed for the separation of metals by means of an electric current, only one of the metals could be deposited during the electrolysis on the cathode. The other metal or metals had to be recovered from the electrolyte by chemical means or by a subsequent electrolysis with insoluble anodes.

It is one object of this invention to enable two or more metals to be recovered simultaneously from a composite anode by means of electrolysis. Another object of the invention is to enable one metal to be deposited from an electrolyte containing two or more metals, by the use of a pervious cathode at such a potential that the required metal will be deposited selectively while the electrolyte containing the other metal or metals is caused to flow through the pervious cathode.

The following description will explain how the results according to the invention are obtained. If an anode, containing, for example, two metals, such as copper and nickel, immersed in an electrolyte consisting of a solution of a salt of the more electronegative metal—in this instance, say nickel sulphate—is exposed to the action of an electric current of a potential sufficiently high to decompose the nickel salt, both copper and nickel will be dissolved at the anode, but for a short time only nickel will be deposited at the cathode. Later on copper will also be deposited owing to the gradual diffusion of the dissolved copper to the cathode.

In order to prevent this diffusion of the copper to the cathode, I remove the same from the electrolyte before it can reach the cathode on which nickel is depositing by means of a second cathode placed at a suitable distance from the anode. This second cathode must be pervious to the electrolyte so as to allow the ions a free passage from the anode to the nickel cathode; it may, for instance, be made of a porous or perforated conducting material or of a grating or strips of such material.

The electric current flowing from the anode through this second cathode must have a potential high enough to decompose the copper salt, but not high enough to decompose the nickel salt. The two electric currents used are preferably obtained from two independent generators and are so regulated that their density is proportionate to the copper and nickel contents of the anode used. If, for instance, the anode contains 50% copper and 50% nickel, the current densities should be equal, but if the anode contains 25% copper and 75% nickel, the current flowing through the nickel cathode should be three times that flowing through the copper cathode.

The distances apart of the cathodes and the anode will depend upon the metals to be deposited and the potential differences at which the deposition takes place. For example, in the case of depositing copper and nickel, if the potential difference between the nickel cathode and the anode is 2 volts, while the potential difference between the pervious cathode and the anode is to be 0.5 volts, the pervious cathode will be placed at a distance from the anode less than one quarter of the distance between the anode and the nickel cathode.

As the electrolysis proceeded, the electrolyte would become weaker near the nickel cathode and more concentrated near the anode. In order to equalize the conditions I maintain a slow circulation of the electrolyte from the anode through the copper cathode to the nickel cathode by continuously returning a certain amount of the electrolyte from the vicinity of the nickel cathode to the anode by means of a pump or air lift.

Having briefly stated the principle on which my invention is based, I will now describe how I may apply this principle in practice.

The process is applicable for the separation of a number of metals, but as the separation of copper and nickel is a well-known problem, I will describe the application of my process more particularly for this purpose. The starting point in this case is bessemerized nickel-copper matte containing about 80% of nickel and copper in varying proportions, about 19% sulphur and about 0.3% iron. This matte is crushed, ground and submitted to a thorough calcination to eliminate the sulphur and to convert the
metals into oxides. The oxides thus obtained are mixed with the requisite amount of carbon, melted down in a reverberatory furnace and cast into anodes.

The electrolytic cell to be employed may vary in construction according to the composition of the matte to be treated, the purity of the nickel aimed at and other conditions that may arise.

Some suitable constructions are shown in the accompanying drawings wherein Figures 1 and 4 illustrate in sectional plan view two forms of cells; Figures 2 and 3 are detail sectional views drawn to a larger scale illustrating forms of cathodes; and Figure 5 shows a sectional-elevation of the cell of Figure 4.

If the matte treated contains only a small amount of copper and the iron contents of the produced nickel may be as high as 1% to 2%, I may use the cell shown in Figure 1. T is a tank made of any suitable non-conducting material, such as slate, timber, concrete with a coating of asphaltum, and so forth. This tank is divided into two compartments by the cathode C. The anode A is suspended in one compartment, and the nickel cathode C, in the other. The cathode C slides into grooves cut in the two sides and bottom of the tank and must be a good fit so that no solution can pass round it. The cathode C itself can be made in various ways, but it is essential that the openings or gaps in the same should not be too large and that they should be as uniformly distributed as possible. Figure 2 and Figure 3 show two constructions which answer well. In Figure 2, F is a hard lead frame made to fit well into the grooves of the tank. A perforated lead sheet S is burned on to this frame at the left-hand side in Figure 2, then an asbestos sheet B is laid on top of the perforated lead sheet, and the space inside the frame is filled up with fine lead turnings K; finally, a second perforated lead sheet S is burned on to the other side of the frame in order to keep the turnings in position.

In the construction shown in Figure 3, the hard lead frame F is filled up with sheet lead strips P alternating with asbestos tape or cord B.

The copper deposited on this cathode must be removed from time to time so as to keep the passages for the electrolyte free. For this purpose, the cathode frame F is made removable as described, and when removed it can be replaced by a similar frame so that the electrolyte deposition can be continued, while the plate with copper deposited upon it is being freed from the deposit ready for re-use. I remove the deposited copper by electrolysis in a separate tank containing copper sulphate as electrolyte and copper sheets as cathodes. As lead is not acted upon in this operation, I give this metal preference in the construction of these porous cathodes.

I prefer to surround the anode A by a canvas bag in order to prevent the contamination of the deposited copper by insoluble impurities from the anode. Such a bag is indicated by the dotted lines E in Figure 1.

As cathodes for the deposition of the nickel, I may use iron or other metal sheets rubbed down with graphite in order to prevent the nickel from adhering too firmly.

The tank is filled with a solution of nickel sulphate containing about 400 grms. of the salt per litre, to which a small amount of sulphuric acid is added in order to prevent the formation of basic salts.

The anode A is connected to the positive poles of two generators G, and G, of which G, gives a current at a higher voltage than G, the voltage of G, being high enough to decompose the nickel salt, while that of G, is only high enough to decompose the copper salt. Generator G, may for instance give a potential difference of 0.5 volts, while G, gives from 1.5 to 2 volts. The cathode C, is connected to the negative pole of generator G, and the cathode C, to the negative pole of generator G,.

A few minutes after the flow of the current has been started through the anode to the cathode C, the electrolyte in the anode compartment will show the presence of copper at the bottom of the tank. In order to prevent the accumulation of more concentrated electrolyte at the bottom, I maintain a strong circulation of the electrolyte round the anode by means of a pump or by means of an air current. In Figures 1, 4 and 5, P is a perforated lead pipe placed at the bottom of the tank through which an air current is forced; the escaping air causes the electrolyte to circulate round the anode as shown by the arrows in Figure 5.

In order to replace the weakened electrolyte from near the cathode C, I continuously withdraw a small amount of the electrolyte by means of a pump or air lift L, Figure 1, which delivers the electrolyte into the anode compartment, thus causing a slow circulation of the more concentrated electrolyte through the porous cathode C, towards cathode C,. The speed of this flow is so regulated that time is allowed for all the copper to be removed from the electrolyte during its passage through the porous cathode C,. If the matte to be treated contains a considerable amount of copper and the recovered nickel has to be practically free from iron, I may carry out the process in a cell constructed as shown in Figure 4 and Figure 5.

In this case I partition the tank T into three compartments by means of the cathode C, constructed and secured in position as in the previous case, and a diaphragm D. This
diaphragm is made of a material which offers only a small resistance to the passage of the electric current, but it is practically watertight. A suitable material for this purpose is strong parchment paper or silicated asbestos or millboard.

As the amount of copper to be deposited is much larger in this case I interpose between the pervious cathode C₁ and the anode A a third cathode C₂ which is also connected to the negative pole of generator G₂, and on which, owing to the lesser resistance of the electrolyte, the bulk of the copper will be deposited. This cathode C₂ should have large openings for the circulation of the electrolyte and is conveniently made of vertical metal strips held in a frame so as to stand edgewise to the anode as shown in the illustration, or of metal sheets with large perforations or slots.

The electrolyte in the anode chamber is maintained in active circulation as in the previous case in order to prevent the accumulation of concentrated solutions at the bottom of the cell. The flow of the electrolyte through the cell in this case takes place as follows:—The electrolyte enters the cell in a continuous slow stream at the point marked 30 of the compartment containing the nickel cathode C₁; after passing this compartment it flows through the pipe M into the anode compartment, then through the cathodes C₂ and C₃, and leaves the cell through the outlet O in front of the diaphragm D.

The discharged electrolyte is freed from iron in any suitable or known way and re-introduced into the cell at I.

Various other combinations of cathodes and diaphragms are possible, but the two examples given above will serve to indicate the methods which I may adopt in practice in order to attain the objects of the invention. If more than two metals are to be separated by electrolysis, separate pervious cathodes at different potential differences, and different distances from the anode, will be used for the first and second metals to be deposited. If for any purpose only one of two or more metals is to be deposited, while the electrolyte is to pass away with the other metal or metals therein, the cathode C₃ may be omitted, or may be disconnected from the electric circuit, while the one metal required will be deposited on the pervious cathode as the electrolyte passes therethrough in the manner already described.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:

1. In a pervious cathode adapted for use in the deposition of metals by electrolysis, said cathode consisting of a metal plate with openings through the same, metal in the form of loose pieces packed in the apertures of said plate in such manner as to leave interstices for the percolation of an electrolyte therethrough, and means for retaining the said loose pieces of metal in the openings of said plate, said means being such as to be pervious to an electrolyte.

2. Apparatus for depositing metals by electrolysis, comprising a cell, an anode therein, a pervious cathode, and a second cathode disposed in said cell beyond said pervious cathode in relation to the said anode, means for supplying electric current at two different potentials between said anode and the respective cathodes, and means for maintaining a flow of the electrolyte from said anode through said pervious cathode and towards said second cathode.

3. Apparatus for depositing metals by electrolysis comprising a cell, an anode adjacent one end of said cell, a pervious cathode in the middle zone of said cell and occupying the whole cross section of said cell in the part thereof which is intended to be occupied by the electrolyte, a second cathode adjacent the end of said cell opposite to that in which said anode is situated, means for maintaining the flow of an electrolyte through said pervious cathode, and sources of electric current at two different potentials in connection between said anode and the respective cathodes adapted to maintain a greater potential difference between the anode and said second cathode as compared with the potential difference between the anode and said pervious cathode.

4. Apparatus for depositing metals by electrolysis comprising a cell, an anode adjacent one end of said cell, a pervious cathode in the middle zone of said cell and occupying the whole cross section of said cell in the part thereof which is intended to be occupied by the electrolyte, a second cathode adjacent the end of said cell opposite to that in which said anode is situated, a third cathode consisting of spaced metallic pieces constituting a frame with interstices therethrough, said third cathode being disposed in said cell between the anode and said pervious cathode, means for maintaining the flow of an electrolyte through said third cathode and said pervious cathode, and sources of electric current at two different potentials in connection between said anode and the respective cathodes adapted to maintain a greater potential difference between the anode and said second cathode as compared with the potential difference between the anode and said third cathode and pervious cathode while said third cathode and said pervious cathode are connected to the same poles of one of said sources of current.

5. The process of separating metals by electrolysis consisting in electrolyzing in a cell an anode containing said metals, and depositing said metals by the use of a pervious cathode and a second cathode situated be-
yond said pervious cathode on the side thereof distant from said anode, by the flow of electric currents between said anode and cathodes maintaining said pervious cathode at a less potential difference than that of the second cathode in relation to the potential of said anode, while also maintaining a slow circulation of said electrolyte through the cell from said anode through the pervious cathode to said second cathode.

6. The process of separating metals by electrolysis, consisting in electrolyzing in a cell an anode containing the metals to be separated and depositing said metals by the use on the one hand of a cathode composed of spaced metallic pieces and of a pervious cathode, both of which cathodes are maintained at a potential which is sufficient to effect deposition of one of the metals of the anode but not sufficient to effect deposition of another metal, and on the other hand of a cathode disposed beyond said pervious cathode and maintained at a potential sufficient to effect deposition of another of the metals of the anode, while the electrolyte is maintained in a condition of slow circulation from said anode through said cathode composed of spaced metallic pieces, through said pervious cathode, and towards the cathode which is maintained at a potential sufficient to deposit the second metal contained in the anode.

7. The process of separating metals by electrolysis, consisting in electrolyzing in a cell an anode containing the metals to be separated, maintaining a slow circulation of the electrolyte away from the anode towards the cathodes, effecting the deposition of one of the metals of the anode upon a cathode which is pervious and which is maintained at a potential only sufficient to deposit a metal which is not highly electro-positive, and effecting the deposition of a second metal upon a cathode maintained at a potential sufficient to deposit a metal which is so much more electro-positive that it will not be deposited on said pervious cathode.

CARL LANGER.