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(54) **Title:** EQUIPMENT AND METHOD FOR ELECTROLYTIC RECOVERY OF METAL

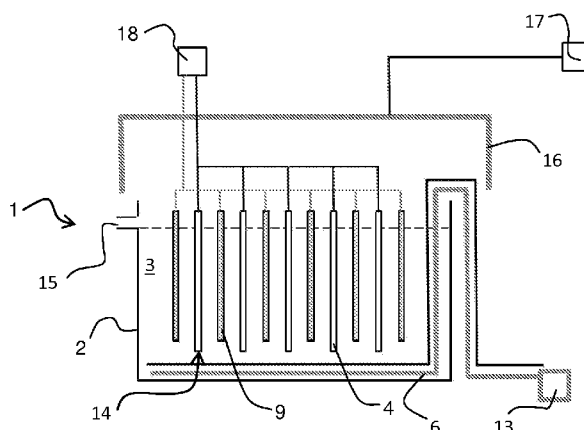


Fig. 1

(57) **Abstract:** The invention concerns a system of gas ducts (6) for transporting gas, for example, into electrolytic equipment, in connection with which there are means (13) for taking at least gas into the system of gas ducts, whereby there is a suitable number of gas supply holes (7) in the system of gas ducts in a wall (19) limiting the system of gas ducts, whereby the material, such as gas, flowing in the system of gas ducts (6) is prevented at least in part from passing through the wall (19) of the system of gas ducts (6). The invention also concerns equipment and a method for electrolytic recovery of metal, such as copper.



EQUIPMENT AND METHOD FOR ELECTROLYTIC RECOVERY OF METAL

FIELD OF THE INVENTION

The invention concerns a gas duct system as well as equipment and a method for electrolytic recovery of metal, such as copper, as defined in the independent claims.

BACKGROUND OF THE INVENTION

Electrolytic recovery, for example, is used as a hydro-metallurgic method when production of pure metal, such as copper, is the objective. In the recovery electrolysis, copper is reduced directly from the electrolytic solution, which is a copper sulphate solution. In the process, copper is precipitated on to the surface of cathodes made of, for example, acid-proof steel, whereupon the copper is removed mechanically from the plate surface. The anodes are insoluble metal plates in the process. The precipitation rate of the metal, such as copper, depends on the current density, but this can not be increased indefinitely without lowering the quality of the precipitate. In practice, the highest possible current density is determined by the so-called critical maximum current density, that is, the highest current density, when the precipitate is still of a sufficiently high quality, which is proportional, for example, to the content of metal to be precipitated and inversely proportional to the thickness of the so-called diffusion layer.

It is known in the art to boost electrolytic recovery by bubbling, that is, by blowing gas into the electrolyte basin. The mass transport on to the cathode surface improves, because bubbling reduces the thickness of the diffusion layer. It is hereby possible to use a higher current density without lowering the surface quality of the precipitate.

A method and equipment for bubbling in electrolytic recovery are known from the US 2007/0251828 publication. According to this method, the process produced air bubbles with a diameter of 0.5 – 3 millimetres, and a pipe system of a porous material is used for supplying bubbling gas into the basin.

It is also known that the use of very small air bubbles is more advantageous for the recovery process as it promotes the production of a thinner diffusion layer on the cathode surface, which will for its part allow the use of a higher current density without resulting in a poorer precipitate quality.

PURPOSE OF THE INVENTION

The purpose of the invention is to present a new and more efficient way of electrolytic production of metal, such as copper. A particular purpose of the invention is to bring about a new kind of equipment and method for electrolytic recovery of metal, such as copper, in a manner wherein the production of gas bubbles on the electrolyte and further on the cathode surfaces is controlled by equipment according to the invention. In accordance with the invention, the formation of bubbles in the basin preferably takes place in such a way that the joining together of bubbles and the formation of large bubbles are prevented.

SUMMARY OF THE INVENTION

The characteristic features of the invention emerge from the appended claims.

With the solution according to the invention it is possible to use a higher current density without lowering the quality of the metal precipitate. The production capacity of plants can thus be increased. The gas bubbles promoting process conditions in the basin can be kept small enough, which promotes an optimum mixing event on the cathode surface. With the aid of the invention an even wall of bubbles of a small size can be achieved using a lower pressure and with an even lower energy consumption than before.

LIST OF FIGURES

The equipment according to the invention is described in greater detail by referring to the drawing, in which

Figure 1 is an overall view of the invention;

Figure 2 shows equipment in accordance with an embodiment of the invention;

Figure 3a shows an embodiment of the invention;

Figure 3b shows an embodiment of the invention;

Figure 4 shows an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The invention is illustrated in Figure 1, which shows an electrolytic recovery process, and in Figure 2 showing a related piece of electrolysis equipment 1 according to an embodiment of the invention. In a basin 2, in which there is an electrolyte 3 containing metal, such as copper to be reduced, a suitable number of cathodes 4 are suspended, so that the direction of suspension is the lengthwise direction of the basin. There are, of course, anodes 9, between the cathodes in the basin. According to an embodiment of the invention, a suitable number of gas supply holes 7 are arranged in a system of gas ducts 6, such as a piping, in a wall 19 limiting the system of gas ducts for transporting gas into the equipment 1 for electrolytic recovery of metal, that is, into electrolysis equipment. In connection with the equipment there are means 13 for taking at least gas into the system of gas ducts, whereby the material flowing in the system of gas ducts 6, such as gas 8, is prevented at least in part from passing through the wall 19 of the system of gas ducts 6. The invention concerns a method for electrolytic recovery of metal, such as copper, whereby anodes 9 and cathodes 4 are placed in turns in the basin 2 into an electrolytic solution 3 containing metal ions, whereby gas bubbles 8 are spread out into the electrolytic solution, whereby gas bubbles are spread out on to the surfaces of cathodes 4 from the system of gas ducts, in which the passage of gas through wall 19 of the system of gas ducts is prevented in part.

According to an embodiment of the invention, the bubbling device 13 belonging to the equipment 1 contains a piping 6, which has gas supply holes 7 for supplying gas into the electrolytic solution 3. In addition, the bubbling device 13 contains means for producing gas bubbles and for controlling the volume of air supplied for their production, such as a pump. Electrolyte is removed from the basin, for example, as an overflow 15 or by pumping it into a separate container. Above the basin 2 there is a hood 16, from which the acid fog formed in the process is recovered by a treating device 17. In addition, a current source 18 is connected to the basin to produce a current for the process.

In the system of gas ducts 6 of the equipment 1 there is a sufficient number of gas supply holes 7, from which gas bubbles are spread out under the effect of a pressure into the electrolyte 3 and further on to the surfaces of cathodes 4, where they will affect the thickness of the diffusion layer. In accordance with the example, the system of gas ducts consists of a piping 6 and of a porous material, whereby the diameter of the supply holes 7 therein is less than 3 millimetres. According to the example shown in Figure 2, the piping of the bubbling device is placed in the basin 2 at least partly in a perpendicular position in relation to the suspension direction B of the cathodes 4. The piping 6 of the gas supply device consists, for example, of pipes, which are placed in a perpendicular position in relation to the suspension direction of the cathodes and which are connected to each other in such a way that gas is allowed to pass between the pipes. In accordance with an embodiment of the invention, it is also possible to make the system of gas ducts 6 from one piece by bending. The gas supply holes 7 of the piping are located in such a way in the piping 6 that the bubbles are allowed to discharge directly upwards in basin 2 without colliding with each other as the gas 8 is discharging from the supply hole 7. In passing through the holes formed in the piping wall, the gas will form bubbles, which will end up on the cathode surfaces. According to the invention, the access of gas through the piping wall is prevented in part. The gas is guided to be carried through wall 19 of piping 6 in the part located on the side of cathode 4. The gas penetrates the wall at the wall on the side of the cathodes of the piping, from which the bubbles are free to ascend directly on to the cathode surfaces. According to the invention, the diameter of the piping is preferably within a range of 4 – 40 millimetres.

In accordance with the invention, the piping for supplying gas can be implemented in different ways. According to the embodiment shown in Figure 3a, the piping is of a porous gas-permeable material, whereby the gas supply holes preferably have a diameter of less than 3 millimetres. According to an embodiment of the invention, a separate part 11 impermeable to gas is placed when required as a replacement into the wall 19 of piping 6 to prevent gas from passing through the wall. That part of the piping, which is on the side of the basin bottom, can hereby be coated at least in part with a gas-impermeable material 11, which can be exchanged easily, such as paint, lacquer or glue. The piping can advantageously be implemented in such a way that the walls of the piping are impermeable to gas in a place, such as the part on the side of the basin bottom, where passage of gas will cause a harmful effect to the process. Figure 3b shows an example of a way of embodying the invention, in

accordance with which there are gas supply holes in the pipe wall on that side only, where the gas penetrates the pipe. That part of the piping, which is gas-permeable, is coated with a material promoting the disintegration of gas bubbles. According to the example, the gas supply holes 7 of piping 6 are also coated with a material 10 promoting the splitting up of gas bubbles to become even smaller, such as with an industrial fabric. According to an embodiment of the invention, the piping 6 functioning as the system of gas ducts is formed of a sufficient number of interconnected pipes, in which there are gas supply holes 7 at least in that place of the pipe, which is located under the cathode 4. According to an advantageous embodiment of the invention, no more than a 70 % part of the surface area of the wall of the system of gas ducts is gas-permeable.

The embodiment presented in Figure 4 shows a situation where the piping 6 functioning as the system of gas ducts of the bubbling device is placed in the basin in a parallel position in relation to the direction of suspension B of cathodes. The guiding of bubbles 8 on to the surfaces of cathodes is thus promoted with the aid of guiding elements 12. The bubbling device 13 is placed in the basin in such a way that the distance A of the top edge 19 of piping 6 from the bottom edge 14 of the cathode is no more than 100 centimetres, such as preferably 5 – 70 cm, so that the bubbles are guided from piping 6 in an optimum manner to both sides of the cathode. The guiding elements can be located in the spaces between the cathodes, such as, according to the example, in the anodes located in the spaces between the cathodes. The guiding element 12 is an element guiding the flow and guiding the gas bubbles in the desired direction.

In the following, the invention is illustrated with the aid of examples.

Example 1

About 10 m of seepage hose was placed in a framework forming nine rows, each row one metre long. The hose was treated with suitable glue, so that the air to be blown through the pipe was not allowed to penetrate from the pipe walls other than directly upwards. The framework was placed in a transparent cell, which was filled with water. When blowing air into the seepage hose piping at a rate of $120 \text{ ml m}^{-1} \text{ min}^{-1}$ from the hoses, an even bubble wall resulted with the bubble size varying within a range of 0.1 – 3 mm.

Example 2

An industrial fabric was wrapped tightly around a metal pipe having holes pointing directly upwards. The pipe was placed on the bottom of an electrolysis cell having a height of 1.2 m (width 25 cm, volume 62 L) under a steel plate functioning as a cathode, so that when blowing air into the piping, bubbles were distributed from the bottom edge of the cathode and they ascended uniformly to both sides of the cathode. The cell was filled with an electrolyte containing 40 g/l of copper and 175 g/l of sulphuric acid. 46.5 L/h of electrolyte was supplied into the cell and the temperature of the electrolyte was 45°C during the test. Copper was precipitated on to the cathode surface for 24 h using a current density of 450 Am^{-2} , at the same time blowing air through the piping. The surface of the copper precipitate formed was examined with a SEM microscope (scanning electron microscope) and with an optical microscope. In addition, a cross-sectional micro-section was examined with an optical microscope. The precipitate had a smooth surface, it was dense, the crystalline growth was uniform and the grain boundaries were difficult to detect in the SEM image. The test was repeated without bubbling, whereby the copper precipitate was rough, porous and the grain size was quite large.

Example 3

With the equipment of Example 2, a bubbling piping was placed in a transverse position against the cathodes. Guiding components were attached to the anodes to guide the bubbles uniformly on to the cathode surface. The test according to Example 2 was repeated using a current density of 450 Am^{-2} and the copper precipitate was examined. The precipitate had a smooth surface, it was dense and the crystalline growth was uniform, as in the case of Example 2, where the copper precipitate was produced with the aid of bubbling.

It is obvious to a person skilled in the art that as the technology develops the basic idea of the invention can be implemented in many different ways. Thus, the invention and its embodiments are not limited to the examples described above, but they may vary within the scope defined by the claims.

CLAIMS

1. A system of gas ducts (6) for transporting gas, for example, into electrolysis equipment, in connection with which there are means (13) for taking at least gas to the system of gas ducts, whereby there is a suitable number of gas supply holes (7) in the system of gas ducts in a wall (19) limiting the system of gas ducts, **characterized** in that the material, such as gas (8), flowing in the system of gas ducts (6) is prevented at least in part from flowing through the wall (19) of the system of gas ducts (6), when the gas bubbles are allowed to discharge directly upwards from the gas supply holes (7).
2. A system of gas ducts as defined in claim 1, **characterized** in that the system of gas ducts (6) is made of a porous material, whereby the diameter of the supply holes (7) located therein is less than 3 millimetres.
3. A system of gas ducts as defined in claim 1 or 2, **characterized** in that the system of gas ducts (6) is coated at least in part with a material (11), which is impermeable to gas.
4. A system of gas ducts as defined in claim 3, **characterized** in that paint, lacquer, glue or some other corresponding material is used as the material impermeable to gas.
5. A system of gas ducts as defined in claim 1, **characterized** in that the system of gas ducts (6) is formed of a sufficient number of interconnected pipes.
6. A system of gas ducts as defined in claim 1, **characterized** in that the system of gas ducts (6) is formed by bending a solid piece.
7. A system of gas ducts as defined in any preceding claim, **characterized** in that the size of the diameter of the system of gas ducts (6) is preferably in a range of 4 – 40 millimetres.

8. A system of gas ducts as defined in any preceding claim, **characterized** in that the part of the system of gas ducts (6), which is gas-permeable, is coated with a material promoting disintegration of gas bubbles.
9. A system of gas ducts as defined in claim 1, **characterized** in that no more than 70 % of the wall surface area of the system of gas ducts is gas-permeable.
10. Equipment (1) for electrolytic recovery of metal, such as copper, and containing
 - anodes (9) and cathodes (4) placed in turns into a basin (2)
 - an electrolyte solution (3) containing metal ions**characterized** in that the equipment comprises a system of gas ducts (6) as defined in any one of claims 1 – 9, so that its gas-permeable parts are arranged in such a way that bubbles are guided on to the cathode surfaces, when there are gas supply holes (7) in the system of gas ducts (6) at least in a place below the cathode.
11. Equipment as defined in claim 10, **characterized** in that the distance (A) of the top edge (19) of the system of gas ducts (6) from the bottom edge (14) of the cathode is no more than 100 centimetres.
12. Equipment as defined in claim 10, **characterized** in that the system of gas ducts (6) is placed in the basin (2) at least partly in a perpendicular position in relation to the suspension direction (B) of the cathodes (4).
13. Equipment as defined in claim 10, **characterized** in that the system of gas ducts (6) is placed in the basin (2) in a parallel position in relation to the suspension direction (B) of the cathodes.
14. Equipment as defined in claim 10, **characterized** in that in the places between cathodes there are separate guiding elements (12) for guiding the material supplied to the basin on to the surfaces of the cathodes (4).
15. Method for electrolytic recovery of metal, such as copper, whereby anodes (9) and cathodes (4) are placed in turns into a basin (2) into an electrolyte solution (3)

containing metal ions, whereby gas bubbles (8) are spread out into the electrolyte solution, **characterized** in that gas bubbles are spread out on to the surfaces of the cathodes (4) from a system of gas ducts (6), in which the passage of gas through a wall (19) of the system of gas ducts is prevented in part the gas is guided to travel along through gas supply holes (7) in the wall (19) of the system of gas ducts (6) from the part located on the side of the cathode (4).

16. Method as defined in claim 15, **characterized** in that into the wall (19) of the system of gas ducts (6) a separate part impermeable to gas is placed as a replacement when required to prevent gas from passing through the wall.
17. Method as defined in claim 15, **characterized** in that the passage of material supplied from the system of gas ducts (6) is guided in the basin with the aid of separate guiding elements (12).

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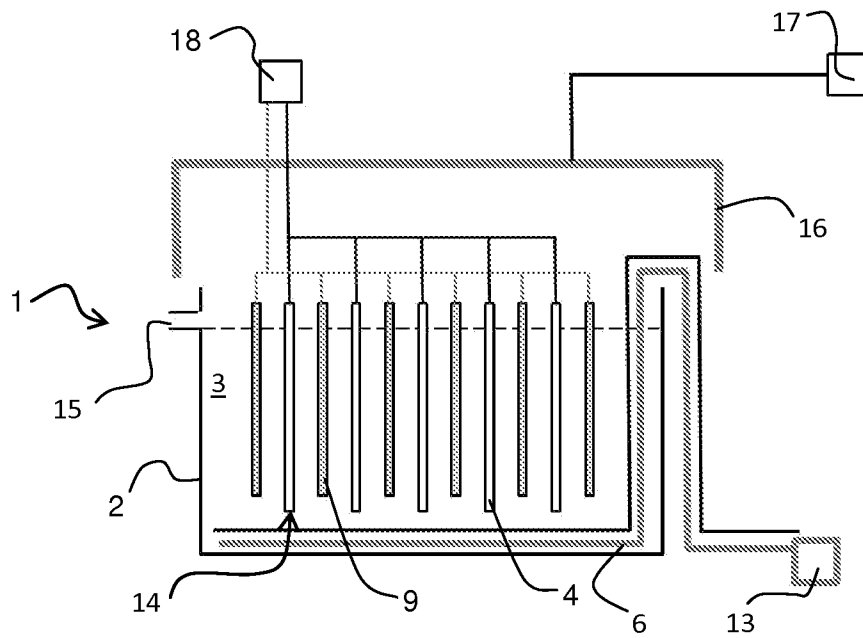


Fig. 1

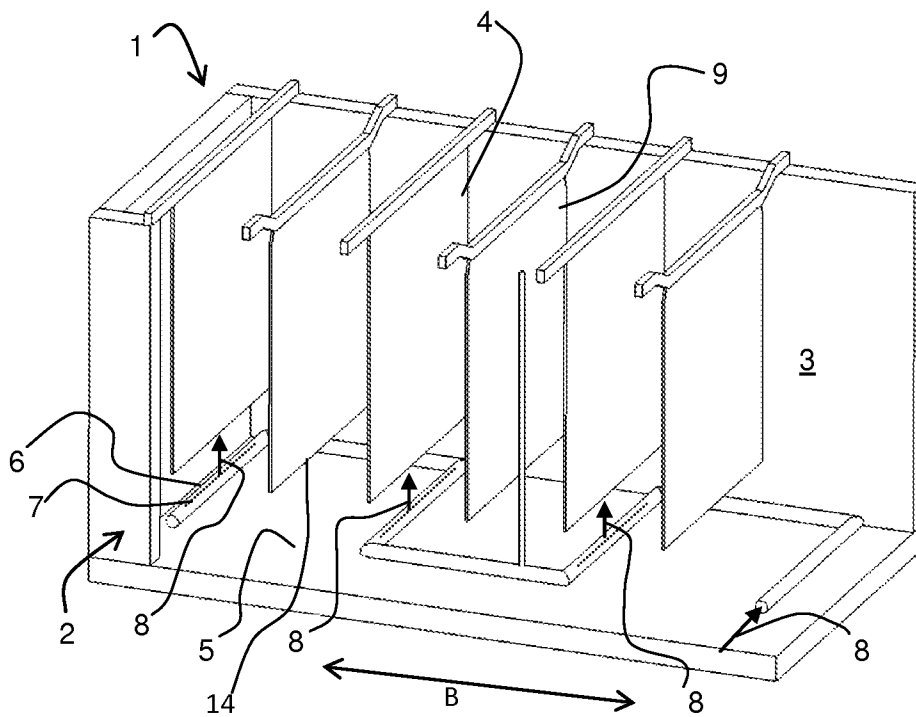


Fig. 2

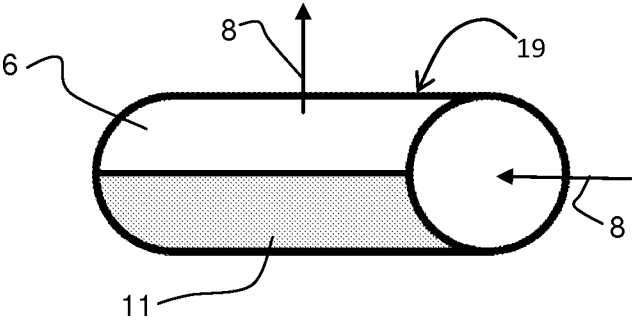


Fig. 3a

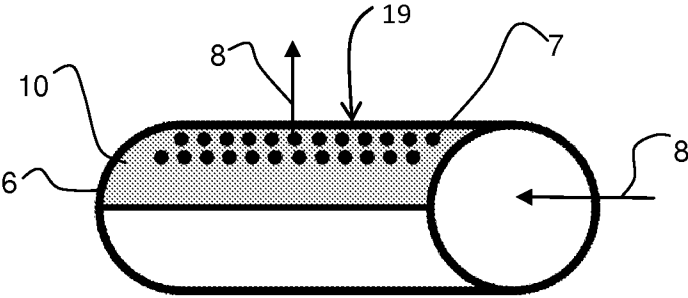


Fig. 3b

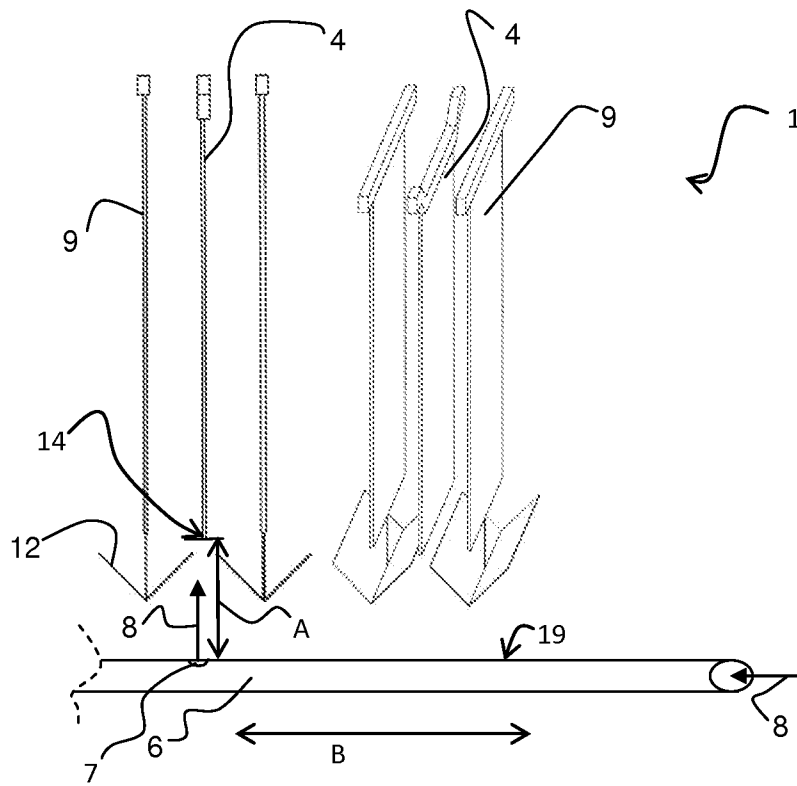


Fig. 4