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(54) Title: SAFE ANODE FOR ELECTROCHEMICAL CELLS

(57) Abstract: Safe anode for electrochemical cells, of the type of vertical anodes constituted of a hanging structure based on a first horizontal bar, second vertical distribution bars defined by a copper or aluminum core with a titanium exterior layer, and coated or uncoated titanium anode plates attached to the second distribution bars, on both sides, such that the safe anode incorporates an adapter element that comprises, at least, one current limiter assembly, arranged between, at least, one of the second vertical distribution bars, and, at least, one coated or uncoated titanium anode plate, connecting the vertical distribution bar to the coated or uncoated titanium anode plate.

SAFE ANODE FOR ELECTROCHEMICAL CELLS

DESCRIPTION

OBJECT OF THE INVENTION

The following invention, as expressed in the heading of this specification, relates to a safe anode for electrochemical cells, of the type of vertical anodes used in electrochemical cells, and specifically in the electrowinning of metals, with the anodes consisting of a hanging structure, based on a horizontal current supply conductor bar and vertical distribution bars connected to the current supply bar, the distribution bars of which are defined by a copper or aluminum core, and a titanium outer layer or skin.

Based on this conventional embodiment, a first objective of the invention is that the electrical connection between the vertical distribution bars and the coated or uncoated titanium anode plate or plates is provided by means of respective adapter elements, which comprise a current limiter assembly, in order to prevent short-circuits that could destroy or damage the coated or uncoated titanium anode plates.

A second objective of the invention is to reduce the dispersion of the emission of oxygen bubbles with sulfuric acid, channeling them through the central part of the anode, for which reason the anode plates are arranged at an angle with respect to the vertical plane defined by the vertical distribution bars, generating a chimney effect that carries them and facilitates collection by a collector, avoiding harmful "acid mist" and its serious environmental effects.

This results in a significant economic advantage, because, on one hand, it avoids the destruction or damage to the coated or uncoated titanium anode plates, and on the other, if a short-circuit occurs, the affected plate is not destroyed and the other plates continue to function.

FIELD OF APPLICATION

The present specification describes a safe anode for electrochemical cells and is applicable to cells for the electrowinning of metals, such as copper.

BACKGROUND OF THE INVENTION

First, it may be stated that the containers, tanks, or electrochemical cells are filled with an electrolytic solution made up of, among other components, the

metal to be deposited, and in which a plurality of anode/cathode pairs are submerged, in alternating positions, which, when supplied with electrical current, deposits the metal on the cathodes.

This means that when vertical anodes are used in said cells for the electrowinning of metals, said vertical anodes are constituted of a hanging structure, based on a horizontal current supply conductor bar and vertical distribution bars connected to the current supply bar, the distribution bars of which are defined by a copper or aluminum core, and a titanium outer layer or skin.

The coated or uncoated titanium anode plates are therefore electrically connected to the distribution bars, with the anodic electrolysis operation taking place on the surface of anode plates.

Conventional anodes present multiple combinations in terms of the number of vertical bars per horizontal current supply bar.

As indicated, the conventional vertical bars used in processes for electrowinning of metals are bimetallic bars with a copper or aluminum core and a titanium outer layer or skin. Copper or aluminum present the low electrical resistivity that is necessary for the effective transmission of large currents and the titanium protects the copper or aluminum against the chemical attack of the electrolyte, while at the same time allowing the connection of the coated or uncoated titanium anode plates to these vertical bars.

In this way, the anodes, and specifically the anode surfaces used in the processes for electrowinning of metals, in order to obtain optimum output and maximum capacity, operate close to the cathodes and have a large surface area in relation to the short anode-cathode distance, for example, a surface of 100x100 centimeters with a separation of 5 cm. This inevitably introduces the risk of electrical contact between the anode and cathode, or in other words, a short-circuit, in the case of any deformation or alteration of the flatness at any point on the cathode surface.

Cathodic surfaces are unstable by nature because their thickness changes quickly during the production process itself, and also because an increase in the thickness of the cathode at a single point on its surface reduces the anode-cathode distance, which reduces the electrical resistance, and applying Ohm's Law, increases ionic current at the point in question.

Increasing the current or ionic deposition increases the thickness of the

metal deposited on said points, such that these events clearly present a positive feedback system, that, as we know, are intrinsically unstable processes, which in these cases end up creating anode-cathode contact, or a short-circuit.

Moreover, any alignment error or existing mechanical deformation will also cause direct anode-cathode contact, or a short-circuit.

Once direct electrical contact has been established between the anode and cathode, the potential electrochemical barriers between the electrolyte and the anode disappear, and the relatively high resistance of the electrolyte will also be eliminated. In these circumstances, the electrical current spikes to unacceptable values, damaging or destroying the coated or uncoated titanium anode plate, at the same time causing significant production losses.

Also, in the work process of the anodes in a cell for the electrowinning of metals, and specifically copper, oxygen bubbles with sulfuric acid are generated, a phenomenon known as "acid mist". This "acid mist" creates a serious environmental contamination problem and can directly affect the health of plant operators, requiring the use of masks in cell rooms and the deterioration of the environment in the area in which the plant is located.

For example, in case of copper electrowinning, the electrolyte is mainly made up of a solution of sulfuric acid and copper sulfate. In its normal electrolysis process, the anode generates oxygen bubbles that are contaminated, holding sulfuric acid; a large part of these bubbles leave the electrolyte and form part of the surrounding atmosphere creating what is known as acid mist.

Moreover, a current limiter is a device that reacts to and cancels any current above a particular value, this value is characteristic of the specific device or model.

A very familiar example is the fuses in our homes; when there is a short-circuit or direct contact of the wires in the network, the fuse is blown and disconnects, leaving us in the dark. We must then reset or replace the fuse to provide lighting again. We use this example to explain the concept of resetting and to go into more detail in regard to the possibility of having the lights come back on automatically, after a period of time, if the physical short-circuit is no longer present, and with no external intervention. In this case, the fuse is an automatic reset fuse.

There are two ways to protect against short-circuits; one is canceling or

forcing the current to zero, and the other is modulating the current to admissible lower values. Both cases are considered to be current limiters, but we will call the former digital on-off limiters, and the latter analog limiters.

We can also cite patent document WO 2015/079072, which describes an anode structure for the electrowinning of metals, which comprises a horizontal support bar and vertical bars, coated with plastic or epoxy, to which anode plates, called sub-meshes with an area of 25 to 225 cm2, are attached to which electricity is supplied by means of the respective wiring and/or printed circuits, which are protected by a series of insulating structures, and that are installed inside the bars coated with plastic or epoxy.

DESCRIPTION OF THE INVENTION

The present invention relates to an anode for electrochemical cells as defined in claim 1, of the type of vertical anodes that comprise a hanging structure having/comprising:

- a horizontal current supply conductor bar and;
- one or more vertical distribution bars connected to the current supply bar, the distribution bars comprising:
    - a core of a conductive element selected from the group consisting of copper, aluminum, lead and alloy thereof, and
    - an outer layer or skin of a material selected from the group consisting of titanium or alloys thereof, valve metals or alloys thereof, and lead or alloys thereof, and;
- at least one coated or uncoated titanium anode plate associated with the vertical distribution bars,

characterized in that the anode (1) incorporates an adapter element (6) arranged between at least one of the vertical distribution bars (3) and at least one of the coated or uncoated titanium anode plates (4), the adapter element (6) comprising at least one current limiter assembly (7) having a current limiter (10), said current limiter assembly (7) being associated with the at least one vertical distribution bar (3) and the at least one coated or uncoated titanium anode plate (4) in such a way that connects the vertical distribution bar (3) to the coated or uncoated titanium anode plate (4).

With the expression “vertical distribution bars” it is meant any and all prismatic element capable of withstanding a (vertical) hanging position and

suitable for being associated or attached to an adapter element. Said one or more "vertical distribution bars" may have a section of circular, ovoidal or polygonal shape, they may exhibit different aspect ratios and, in the limit, be a panel, such as for example a lead panel. Besides, with the expression "anode plate" it is meant an element of any shape and size suitable for being used as an anode and which presents at least one surface capable of evolving oxygen or chlorine; more specifically the anodic plate may be a flat, curved or partially curved, corrugated, solid, porous, foraminous, cut, etched or perforated material.

This summary describes a safe anode for electrochemical cells, of the type of vertical anodes constituted of a hanging structure based on:

- a horizontal current supply conductor bar and;
- vertical distribution bars connected to the current supply bar, the distribution bars of which are made up of:
    - a copper or aluminum core, and;
    - a titanium outer layer or skin, and;
- at least one coated titanium anode plate associated with the vertical distribution bars,

such that the safe anode incorporates an adapter element that comprises a current limiter assembly, arranged between at least one of the vertical distribution bars and at least one coated titanium anode plate, the adapter element of which connecting the corresponding vertical distribution bar to the coated titanium anode plate attached to it.

In a further embodiment, the hanging structure of the anode specifically consists of:

- a horizontal current supply conductor bar; and
- vertical distribution bars connected to the current supply bar, the distribution bars consisting of:
    - a copper or aluminum core, and
    - a titanium outer layer or skin; and
- at least one coated titanium anode plate associated with the vertical distribution bars.

In one practical embodiment of the invention, the adapter element of the safe anode is defined by a current limiter assembly that is attached directly to a vertical distribution bar and to a coated or uncoated titanium anode plate,

connecting the vertical distribution bar to the anode plate.

This means that the adapter element is defined by the current limiter assembly itself.

In a first variant of practical embodiment of the invention, the adapter element of the safe anode is defined by a titanium strip that holds a current limiter assembly, with the titanium strip attached to a vertical distribution bar and the corresponding coated or uncoated titanium anode plate, the anode plate of which has a surface area of 250 to 1670 cm2, attached to the current limiter assembly.

In a second variant of practical embodiment of the invention, the safe anode adapter element is defined by a titanium strip that holds two current limiter assemblies, one at each of its two ends, with the titanium strip attached to a vertical distribution bar and the pair of current limiter assemblies is attached to the corresponding coated or uncoated titanium anode plate.

Likewise, the safe anode adapter element, which comprises at least one current limiter assembly, is attached to the corresponding vertical distribution bar, defining a slight angle with respect to a vertical plane, with the coated or uncoated titanium anode plate that is attached to it having the same angle. As “slight angle” it should be understood a minor angle with respect to the vertical line, that is to say, an angle of a minor magnitude. Preferably, as shown in the figures, the slight angle is equal or less than 3.25 degrees with respect to the vertical plane of the bar (3). In a more preferred embodiment, the slight angle is of 3 degrees with respect to the vertical plane of the bar (3).

The anode adapter elements that comprise at least one current limiter assembly may have different magnitudes in the slight angle at which they are mounted, with the anode plates associated with them also angled depending on the different angles with respect to a vertical plane.

Moreover, the anode adapter elements that comprise at least one current limiter assembly, and that have different magnitudes in the slight angle at which they are mounted, are attached, along the length of the corresponding second vertical distribution bar, with a magnitude that increases from the bottom to the top, causing a chimney effect on the upward flow of oxygen bubbles and acid.

The titanium strip, which forms part of the adapter element, may have a tubular configuration, incorporating a current limiter in its central internal portion, associated with at least one sheet bent at right angles that extends to the

outside and to which the corresponding anode plate is attached.

Likewise, the titanium strip, which forms part of the adapter element, may have a block of epoxy resin or a similar material interposed on it, in which a current limiter is embedded.

Since the survival of the anode is normally affected by the aforementioned short-circuits and not due to other causes, an anode can be said to be safe when it is able to withstand short-circuits without suffering significant damage and remaining operational.

Therefore, the current limiter assembly, which forms part of the adapter element, and into which the current limiter is integrated, is defined by a box. With the term box it is meant a housing, a case, a partial or total enclosure that houses or includes, completely or in part, a titanium strip. The box can be made of any material, provided it is suitable for its intended purpose as well as for being immersed in the acid environment of an electrolytic bath for the electrowinning of metals. In a preferred case, the box is made of a conductive material suitable for the commented purpose, and more preferably it is made of titanium or its alloys. The box can comprise or not an insulating material, in such a way that in a particular embodiment the titanium strip is insulated by an insulating material of the box that contains it, the insulating medium of which incorporates one, two or more current limiters, connected by a terminal to the intermediate titanium strip and to the box by another terminal.

Likewise, the current limiter assembly, which forms part of the adapter element, and into which the current limiter is integrated, is defined by a pair of bimetallic titanium/copper pieces, with the copper surfaces facing each other, with a current limiter interposed between them, constituted of a polymer layer and respective sheets of copper on both surfaces, a transversal central and perimeter depression corresponding to the width of the copper of both opposing bimetallic pieces being embodied, said depression being filled with epoxy resin or a similar insulator.

It is another object of the invention an electrochemical cell for electrowinning of metals that comprises at least one anode as previously defined. In a preferred case, the cell is for electrowinning of a non-ferrous metal, including but not limited to copper or nickel.

To complete the description provided below, and for the purpose of helping to make the characteristics of the invention more readily

understandable, the present specification is accompanied by a set of figures which by way of illustration and not limitation represent the most characteristic details of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a side view of a conventional anode, in which the horizontal current supply bar, the vertical distribution bars, and the two coated or uncoated titanium anode plates associated with the vertical distribution bars are visible.

Figures 2 and 3 show respective front elevation and plan views of the conventional attachment by welding of the coated or uncoated titanium anode plate to a vertical bar.

Figures 4 and 5 show respective front elevation and plan views of the attachment of a coated or uncoated titanium anode plate to a vertical distribution bar through an adapter element that comprises a current limiter assembly.

Figures 6 and 7 show respective front elevation and plan views of the attachment of a coated or uncoated titanium anode plate to a vertical distribution bar through an adapter element that comprises, as specified in a first practical embodiment, a titanium strip and a current limiter assembly.

Figure 8 shows a front view of an adapter element attached to a vertical distribution bar constituted of a titanium strip and with the respective current limiter assemblies at its ends.

Figure 9 shows a plan view of an embodiment in which the adapter element comprises, according to second practical embodiment, a titanium strip and two current limiter assemblies.

Figures 10 and 11 show respective cross-sectional views of the connection of a current limiter assembly, according to two practical embodiment variations, to the end of a titanium strip.

Figures 12 and 13 show a front view of the attachment of an adapter element constituted of a titanium strip and two current limiter assemblies, to a vertical bar, and a plan view with the respective anode plates attached to the current limiter assemblies.

Figure 14 shows a plan view of a first variant of a practical embodiment of the titanium strip, which forms part of the adapter element, with a tubular

configuration and incorporating at least one current limiter inside thereof, associated with an extending sheet bent at right angles to which the corresponding anode plate is attached.

Figure 15 shows a plan view of a second variant of a practical embodiment of the titanium strip, which forms part of the adapter element, in which the current limiter itself is embedded in a block of epoxy resin or a similar material, with the aforementioned titanium strip divided by the limiter, said titanium strip attached to a vertical bar at one end and to the corresponding anode plate at the other.

Figures 16, 17, ad 18 show respective front, elevation, and plan views of a practical embodiment in which the anode plates are mounted at a slight angle with respect to the vertical plane.

Figures 19 and 20 show a front and plan view of a practical embodiment in which a series of coated or uncoated titanium anode plates are attached to a second vertical distribution bar, showing how the anode plates have a slight angle, the angle of which increases from the lower portion to the upper portion, or in other words, from bottom to the top, generating a chimney effect.

Figure 21 shows a side elevation of the embodiment of the previous figure in which the path that the bubbles follow as a result of the chimney effect created by the angled arrangement of the anode plates is shown.

Figures 22 and 23 show a front view of the attachment of an adapter element comprising a current limiter assembly having a current limiter and an internal border that is a titanium strip having a U shape and attached to a vertical bar, said titanium strip being housed in an external border that is a box fashioned as an U-shaped container, and a plan view with the respective anode plates attached to the current limiter assembly.

DESCRIPTION OF A PREFERRED EMBODIMENT

As shown in the aforementioned figures and in accordance with the specified numbering, it can be seen how starting with a conventional configuration in which the anode 1 is constituted of a hanging structure based on a current supply conductor bar 2 and a series of vertical distribution bars 3, to which at least one coated or uncoated titanium anode plate 4 is attached (hereinafter we will refer to these simply as anode plates), with figure 1 of the drawings showing how, in said practical embodiment, the anode has two anode

plates 4. In said conventional embodiment, the anode plates 4 are attached to the vertical distribution bars 3 by spot welds 5, as shown in figure 2 of the drawings.

Starting with the conventional configuration described above, a first object of the invention is based on the incorporation of an adapter element 6, which comprises at least one current limiter assembly 7, as shown in figure 4, through which the electrical current supply or connection is established to the anode plates 4 from the corresponding vertical distribution bar 3.

In accordance with figures 4 and 5, in one practical embodiment the adapter element 6 comprises a current limiter assembly 7, which is attached directly to a vertical distribution bar 3 and to an anode plate 4, such that the electrical current reaches the anode plate through the current limiter 7 from the vertical distribution bar 3. In this embodiment, the current limiter assembly 7 itself acts as the adapter element 6.

In addition, according to figures 6 and 7 of the drawings, in a first variant of a practical embodiment, the adapter element 6 is defined by a titanium strip 8 which is attached at one of its ends to a vertical distribution bar 3 and at the other end it incorporates a current limiter assembly 7, while, according to figure 8 of the drawings, in a second variant of a practical embodiment, the adapter element 6 is made up of a titanium strip 8, attached to a vertical distribution bar 3, and which has both current limiter assemblies 7 at each end, to which the respective anode plate 4 is attached, the electrical current reaching the anode plates 4, from the vertical distribution bar 3, though the titanium strip 8 and the corresponding current limiter 7.

The current limiter assembly, preferably auto-resetting, will be embodied using any mechanism available in the industry, that is to say, a bimetallic breaker, digital fuses with automatic reset, analog fuses with automatic reset, transistors with cutoff or regulation, etc.

By way of example, and in accordance with figures 8, 9, and 10 of the drawings, we can state that a first type of current limiter assembly 7 to be used as a component of the adapter element 6 can be defined by a pair of titanium/copper bimetallic pieces 9, with the copper surfaces facing each other, with a current limiter 10 interposed between them, constituted of a layer of polymer and respective sheets of copper on both sides, with a transversal central and perimeter depression corresponding to the width of the copper of

both bimetallic pieces 9 facing each other, said depression being filled with epoxy resin 11 or a similar insulator.

In this way, figure 8 of the drawings shows how, in regard to the current limiter assembly 7, the two shaded parts would correspond to the copper of the bimetallic piece 9 and the outline around them would correspond to the transversal central and perimeter depression that, in the connection of the two bimetallic pieces 9 with the current limiter 10 itself interposed between them, it would be filled with epoxy resin 11 or another insulating material.

A second type of current limiter assembly 7, according to figures 11, 12, and 13 of the drawings, may be constituted of a titanium box 12 in which one end of the titanium strip 8 is housed with an insulating material 13 interposed, and the insulating material 13 of which incorporates two current limiters 10 into it, such that, preferably, it incorporates two titanium boxes 12, as shown in figure 13 of the drawings, one at each end of the titanium strip 8, which is connected by a terminal to the titanium strip 8, and by its other terminal to the titanium box 12, in other words, the flow of electricity would be vertical distribution bar 3 - titanium strip 8 - current limiter 10 - titanium box 12 - anode plate 4.

We note that we omit the explanation for the extension to 3, 4, etc. limiters per adapter element because we consider it obvious based on the cases presented with 1 and 2 limiters per adapter.

The insulating material 13 may be a layer of epoxy resin or plastic material, or any other equivalent material.

Logically, the structure described in regard to the adapter element, can likewise have other embodiments equivalent to those described, and thus, in figure 14 of the drawings, it can be seen how the titanium strip 8, which forms part of the adapter element 6, may have a tubular configuration and house the current limiter 10 in the inside thereof, perfectly insulated, associated to a first sheet 14 bent at right angles to which the corresponding anode plate 4 is attached. Likewise, a double configuration is also possible, such that two sheet 14 bent at right angles extend from the inside of the tubular strip 8, one at each end, to which the corresponding anode plates 4 are attached.

Likewise, according to the embodiment of figure 15, the current limiter itself, which forms part of the adapter element 6, may be embedded in a block 15 of epoxy resin interposed on the titanium strip 8, it being divided in two parts,

and the titanium strip 8 of which is bent at right angles in order to be able to attach it to the respective anode plate 4. As in the previous case, the adapter element may have a double configuration to attach it to two anode plates 4.

The number of vertical distribution bars 3 and anode plates 4 per anode 1 does not affect the object of the invention, but an adequate number of these would make it possible to adjust the performance and cost of the installation, such that a practical number of elements is: 3 vertical bars, 30 adapter elements per anode where each one feeds 2 anode plates, therefore a total of 60 anode plates per anode. In addition, the anode plates have an area of 250 to 1670 cm^2.

In addition, in a conventional anode, the number of anode plates 4 is one or two, such that in the case of two plates, there is one per surface, as shown in figure 1 of the drawings. Although the object of the invention can be applied to this conventional model, its effectiveness increases if a larger number of anode plates 4 are installed per anode, and also, the cost and installation difficulties would prevent excessively high values, thus establishing a compromise between the two.

We consider that an area of anode material defines an anode plate that is different from another provided that the electrical resistance between both areas is sufficiently high so that when a cathodic contact is established with one of them, the other can continue its process of electrolysis, at least to the order of 30% of activity.

Each adapter element 6 will comprise at least one current limiter assembly 7, which in case of a short-circuit will cut off the current or will at least limit that current to acceptable values, acceptable values being considered to be values that are not dangerous to the integrity of the anode and that do not represent a large loss of current. We recommend a value similar to the normal operating or nominal current, but we could work with higher values without significantly affecting performance up to a short-circuit current that does not exceed five times the value of the nominal operating current.

In addition, a second objective of the invention is to try to control the emissions of "acid mist" produced by anodic electrolysis. To do this, in the cells for the electrowinning of metals, such as copper, for anodes that feed two anodic plates 4, as shown in figure 1, spaced between 10 to 30 mm apart, by means of arranging the anode plates 4 at a slight angle, as shown in figures 17,

20, and 21, it is possible to control and channel the bubbles produced, obtaining the path followed, according to the arrows "A", as a result of the angle of the anode plates, which can be obtained in a very wide variety of ways.

Moreover, varying the magnitude of the angle of the anode plates, and arranging them with an increasing angle from the bottom up an arrangement is created, in an inverted herringbone pattern, that generates a chimney effect that makes it possible to avoid dispersion and allows controlled emission of the acid bubbles as they are confined and rise as if in a chimney between the two sides of the anode plates of an anode.

The angle of the anode plates, as we mentioned, can be achieved in different ways, and as such, in the first place, the adapter element 6 that comprises a current limiter assembly 7, figure 5 of the drawings, can be attached to the vertical distribution bar 3 directly with the desired angle, or the titanium strip 8 itself may be attached to the corresponding vertical distribution bar 3 according to the desired angle or the titanium strip 8 itself, as shown in figures 17 and 18, may be twisted and its ends may be angled, and when the corresponding current limiter assembly is attached, the anode plate attached to it will has the desired angle.

This phenomenon that concentrates the upward flow of bubbles inside the anode provides the following advantages:

- ✓ reduction of the resistance of the electrolyte to the passage of the current between the anode and cathode, because the upward bubbles between the anode and cathode are insulators, so they increase the effective resistance of the electrolyte;
- ✓ more uniform copper deposition on the cathode plate; it is well known that there is higher current density, and therefore a higher incidence of short-circuits in the lower part of the anode, or in other words, a slightly greater thickness of copper on the lower part. If the bubbles that concentrate at the upper part are prevented between the anode and the cathode, the copper plate that is obtained will be flatter with a smaller difference in thickness between the upper and lower parts of the copper plate;
- ✓ reduce the probability that these bubbles will reach the cathode and cause oxidation, which has a negative effect on the efficiency of the process of cathodic deposition of the metal and its quality, and;

- ✓ when a large percentage of acid bubbles rise through the narrow inner area of the two anodic surfaces, the installation of a collector at the exit of the chimney will allow very effective collection of the "acid mist" and, as a result, significantly reduce environmental contamination.

In addition, in one practical embodiment shown in figures 22 and 23 of the drawings, the current limiter assembly (7) comprises at least an external border that is a box (12) containing an insulating material (13) and at least one internal border that is a titanium strip (8), said at least one internal border being partially or completely housed within said at least one external border, said at least one external border and at least one internal border having a U-shaped profile, in such a way that the at least one internal border is attached and partially enfolds a portion of at least one of said one or more vertical distribution bars (3) and said at least one external border being associated or attached to at least one anode plate (4).

This embodiment has the advantage of simplifying the production of the adapter elements and reduce the production costs. In fact, said embodiment may provide an improvement in terms of manufacturing, integration and electrical efficiency of the adapter element according to the invention. Regarding the manufacturing, the U-shaped profile of the titanium strip (8) and the box (12) allows to efficiently manage and/or reduce the amount of titanium required to build the adapter element. The container is constructed from two U profiles by placing one inside the other; these profiles are manufactured in long strips automatically and with high efficiency using folding machines without the need for welding and difficult cuts. Besides, welding the leads of current limiters it is done with much comfort and efficiency, lending itself to being robotized process; this means high manufacturing capacity at very competitive costs. Finally, with regard to the electrical efficiency, it should be taken into account that by wrapping or surrounding the current distribution bar with the adapter itself, the current path is perpendicular to the face of the adapter, which means maximum section and minimum length of the circuit.

The embodiment hereinbefore described can be used in a configuration that allows a chimney effect, if so desired. In such case it is the anode plate to be mounted with a tilt or bend with respect of the vertical position to direct the flow of the gas bubbles from the electrochemical reaction taking place at the anode. For example the anode plates are bent to be shaped like the integral

symbol "∫", or any other shapes that the skilled person would easily recognize as suitable for the purpose. Alternatively, between the anode plates and the adapter element, it is possible to insert a conductive wedge or shaper that allow welding the anode plate with a an angle with respect to the vertical direction.

Finally, the present invention further relates to the following embodiments A-K:

A) A safe anode for electrochemical cells, of the type of vertical anodes constituted of a hanging structure based on:

- a horizontal current supply conductor bar and;
- vertical distribution bars connected to the current supply bar, the distribution bars of which are defined by:
  - a copper or aluminum core, and;
  - a titanium outer layer or skin, and;
- at least one titanium anode plate coated and associated with the vertical distribution bars,

characterized in that the safe anode (1) incorporates a safe anode adapter element (6), arranged between at least one of the vertical distribution bars (3) and at least one coated titanium anode plate (4), the adapter element (6) of which comprises at least one current limiter assembly (7) into which the current limiter (10) is integrated, which, associated with a vertical distribution bar (3) and a coated titanium anode plate (4), connects the vertical distribution bar (3) to the coated titanium anode plate (4).

B) The safe anode for electrochemical cells, according to the embodiment of item A, characterized in that the adapter element (6) of the safe anode is defined by a current limiter assembly (7), into which the current limiter (10) is integrated, being attached to a vertical distribution bar (3) and a coated titanium anode plate (4).

C) The safe anode for electrochemical cells, according to the embodiment of item A, characterized in that the adapter element (6) of the safe anode is defined by a titanium strip (8), holding at least one current limiter assembly (7), the titanium strip (8) being attached to a vertical distribution bar (3) and the corresponding coated titanium anode plate (4) being attached to the current limiter assembly (7).

D) The safe anode for electrochemical cells, according to the embodiment of item A and C, characterized in that the adapter element (6) of

the safe anode is defined by a titanium strip (8), holding two current limiter assemblies (7), one at each end, the titanium strip (8) being attached to a vertical distribution bar (3) and the corresponding coated titanium anode plate (4) being attached to the pair of current limiter assemblies (7).

E) The safe anode for electrochemical cells, according to the embodiment of item A, characterized in that the adapter element (6) of the safe anode, which comprises at least one current limiter assembly (7), is attached to the corresponding vertical distribution bar (3), defining a slight angle with respect to a vertical plane, with the coated titanium anode plate (4) that is attached to it having the same angle.

F) The safe anode for electrochemical cells, according to the embodiment of item E, characterized in that the adapter elements (6) of the anode that comprise at least one current limiter assembly (7), may have different magnitudes in the slight mounting angle thereof, the anode plate (4) being associated with them also being angled depending on different angles with respect to a vertical plane.

G. The safe anode for electrochemical cells, according to the embodiment of item F, characterized in that the adapter elements (6) of the anode that comprise at least one current limiter assembly (7), and that have different magnitudes in the slight mounting angle thereof, are attached, along the length of the corresponding second vertical distribution bar (3), with a magnitude that increases from the bottom to the top, causing a chimney effect.

H) The safe anode for electrochemical cells, according to the embodiment of item C, characterized in that the titanium strip (8), which forms part of the adapter element (6), has a tubular configuration, incorporating a current limiter (10) in its central internal portion, associated with at least one sheet (14) bent at right angles that extends to the outside and to which the corresponding anode plate (4) is attached.

I) The safe anode for electrochemical cells, according to the embodiment of item C, characterized in that the titanium strip (8), which forms part of the adapter element (6), has a block (15) of epoxy resin or a similar material interposed on it, in which a current limiter (10) is embedded.

J) The safe anode for electrochemical cells, according to the embodiment of item A, characterized in that the current limiter assembly (7), which forms part of the adapter element (6), and into which the current limiter

(10) is integrated, is defined by a box (12) that houses a titanium strip (8), insulated by an insulating material (13) of the box (12) that contains it, the insulating material (13) of which incorporates two current limiters (10), connected by a terminal to the intermediate titanium strip (8) and to the box (12) by the other terminal.

K) The safe anode for electrochemical cells, according to the embodiment of item A, characterized in that the current limiter assembly (7), which forms part of the adapter element (6), and into which the current limiter (10) is integrated, is defined by a pair of bimetallic titanium/copper pieces (9), with the copper surfaces facing each other, with a current limiter (10) interposed between them, constituted of a polymer layer and respective layers of copper on both sides, with a transversal central and perimeter depression corresponding to the width of the copper of both opposing bimetallic pieces (9), said depression being filled with epoxy resin (11) or a similar insulator.

CLAIMS

1. **An anode for electrochemical cells**, of the type of vertical anodes provided with a hanging structure having:
   - a horizontal current supply conductor bar and;
   - one or more vertical distribution bars connected to the current supply bar, the distribution bars comprising:
     - a core of a conductive element selected from the group consisting of copper, aluminum, lead and alloy thereof, and
     - an outer layer or skin of a material selected from the group consisting of titanium or alloys thereof, valve metals or alloys thereof, and lead or alloys thereof, and;
   - at least one coated or uncoated titanium anode plate associated with the vertical distribution bars,

characterized in that the anode (1) incorporates an adapter element (6) arranged between at least one of the vertical distribution bars (3) and at least one of the coated or uncoated titanium anode plates (4), the adapter element (6) comprising at least one current limiter assembly (7) having a current limiter (10), said current limiter assembly (7) being associated with the at least one vertical distribution bar (3) and the at least one coated or uncoated titanium anode plate (4) in such a way that connects the vertical distribution bar (3) to the coated or uncoated titanium anode plate (4).

2. **The anode for electrochemical cells** according to claim 1, **wherein** the adapter element (6) is attached to the vertical distribution bar (3) and to the titanium-coated anode plate (4).

3. **The anode for electrochemical cells** according to claim 1, **wherein** the adapter element (6) of the anode comprises a titanium strip (8) that holds the at least one current limiter assembly (7), in such a way that the titanium strip (8) is attached to the vertical distribution bar (3) and the current limiter assembly (7) is attached to the corresponding coated or uncoated titanium anode plate (4).

4. **The anode for electrochemical cells** according to claim 1, **wherein** the

adapter element (6) of the anode comprises a titanium strip (8) having two ends that hold two current limiter assemblies (7), one at each end, in such a way that the titanium strip (8) is attached to the vertical distribution bar (3) and the pair of current limiter assemblies (7) is attached to the corresponding coated or uncoated titanium anode plate (4).

5. **The anode for electrochemical cells** according to claim 1, **wherein** the adapter element (6) of the anode is attached to the vertical distribution bar (3) defining a slight angle with respect to the vertical plane of the bar (3), in such a way that the coated or uncoated titanium anode plate (4) attached to the current limiter assembly (7) also has the same angle.

6. **The anode for electrochemical cells,** according to claim 5, **wherein** the anode comprises more than one adapter element (6), each adapter element (6) being attached to the vertical distribution bar (3) defining a slight angle with respect to the vertical plane of the bar (3) which has a different magnitude from the other angles, in such a way that the anode plates (4) associated with the current limiter assemblies (7) also have the same angles.

7. **The anode for electrochemical cells** according to claim 5 or 6, wherein the angle is equal or less than 3.25 degrees with respect to the vertical plane of the bar (3).

8. **The anode for electrochemical cells,** according to claim 6 or 7, **wherein** the magnitude of the angles defined by the adapter elements (6) with respect to the vertical plane of the bar (3) increases from the bottom to the top along the length of the vertical distribution bar (3).

9. **The anode for electrochemical cells** according to claim 3, **wherein** the titanium strip (8) has a tubular configuration, incorporating the current limiter (10) in its central internal portion associated with at least one sheet (14) bent at right angles that extends to the outside of the corresponding anode plate (4) to which the sheet (14) is attached.

10. **The anode for electrochemical cells** according to claim 3, **wherein** the

current limiter (10) of the adapter element (6) is embedded in a block (15) of epoxy resin or a similar material interposed on the titanium strip (8).

11. **The anode for electrochemical cells** according to claim 1, **wherein** the current limiter assembly (7) comprises a box (12) having an insulating material (13) that houses the titanium strip (8), the insulating material (13) incorporating two current limiters (10) connected to the titanium strip (8) by a terminal and to the box (12) by another terminal.

12. **The anode for electrochemical cells** according to claim 1, **wherein** the current limiter assembly (7) comprises a pair of bimetallic titanium/copper pieces (9), with the copper surfaces facing each other, with a current limiter (10) interposed between them, constituted of a polymer layer and respective layers of copper on both sides, with a transversal central and perimeter depression corresponding to the width of the copper of both opposing bimetallic pieces (9), said depression being filled with epoxy resin (11) or a similar insulator.

13. **The anode for electrochemical cells** according to claim 11, **wherein** the current limiter assembly (7) comprises at least an external border that is a box (12) containing an insulating material (13) and at least one internal border that is a titanium strip (8), said at least one internal border being partially or completely housed within said at least one external border, said at least one external border and at least one internal border having a U-shaped profile, in such a way that the at least one internal border is attached and partially enfolds a portion of at least one of said one or more vertical distribution bars (3) and said at least one external border being associated or attached to at least one anode plate (4).

14. **An electrochemical cell for electrowinning of metals** characterized in that it comprises at least one anode as defined in any one of the previous claims.

15. The electrochemical cell of the previous claim, wherein the metal is a non-ferrous metal.

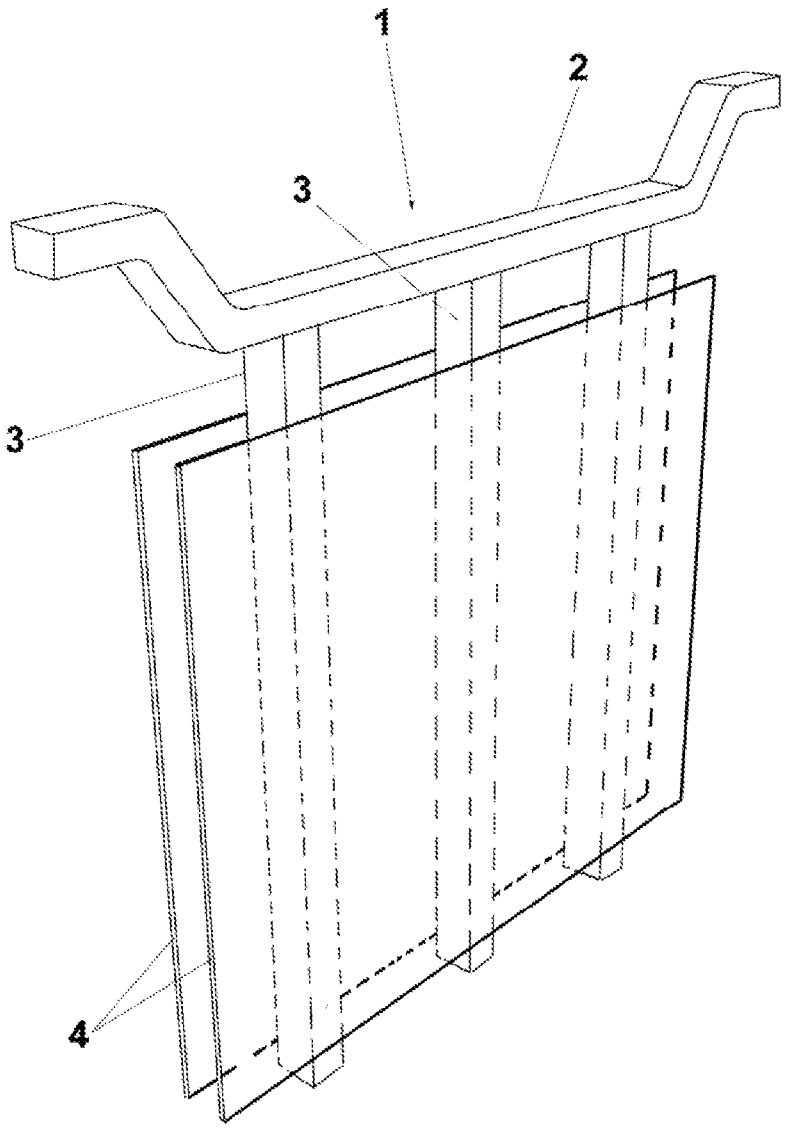

FIG.1

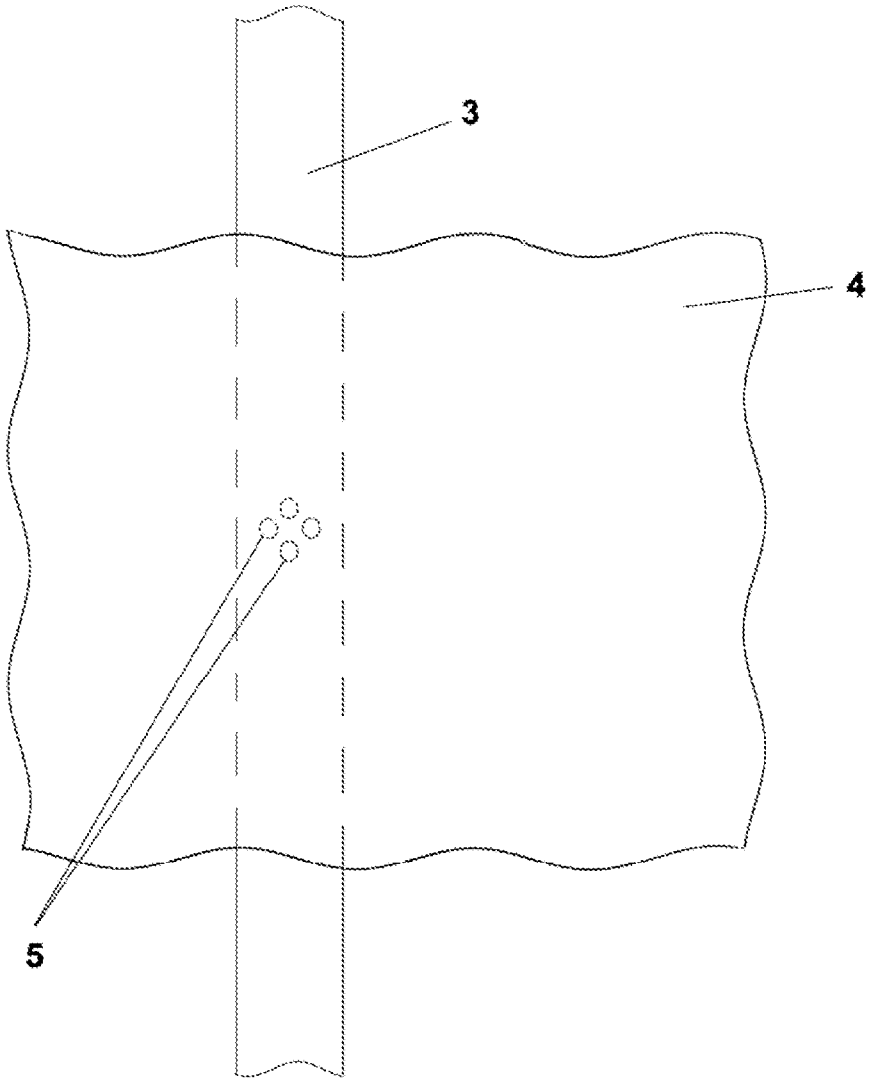

FIG.2

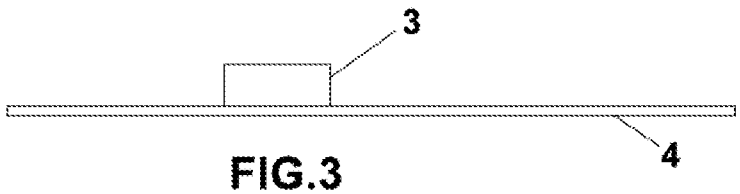

FIG.3

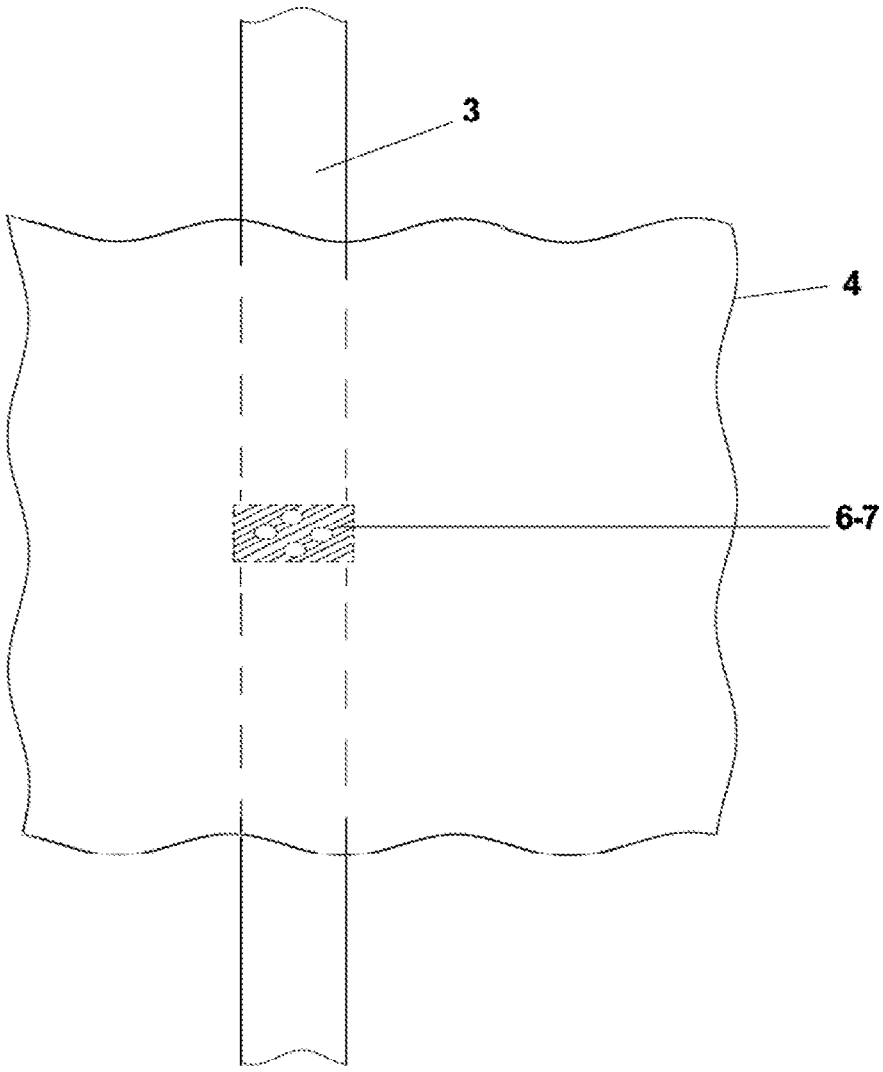

FIG.4

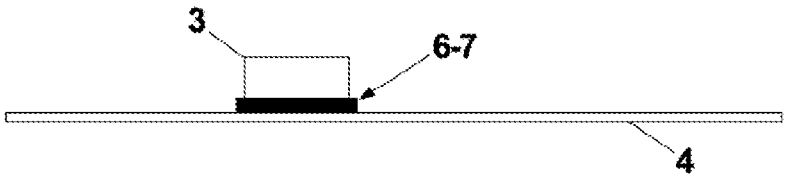

FIG.5

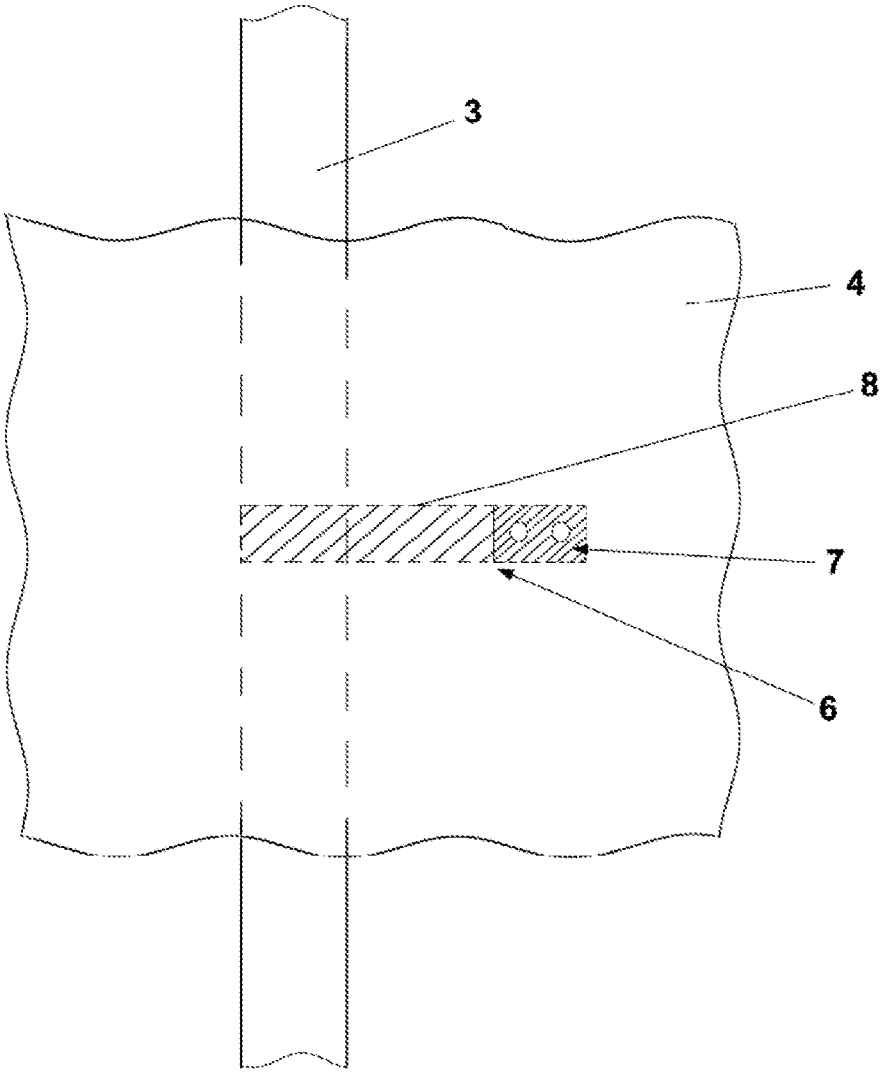

FIG.6

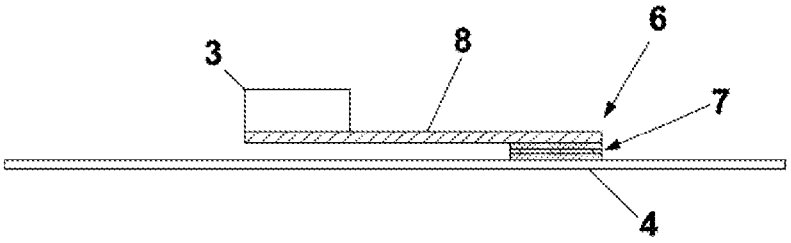

FIG.7

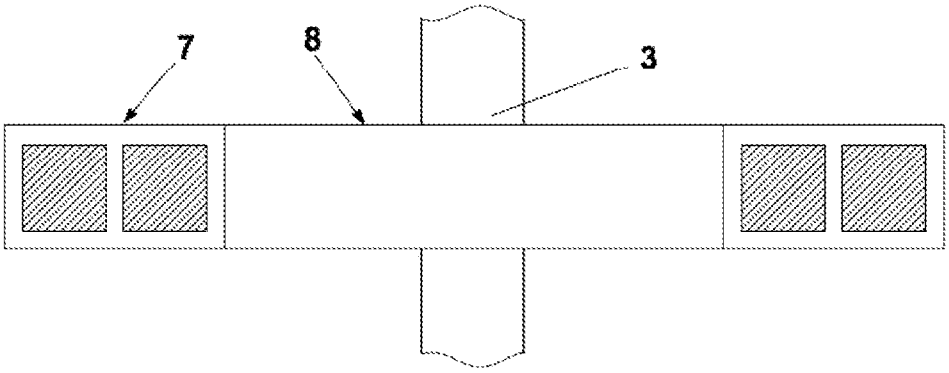

FIG.8

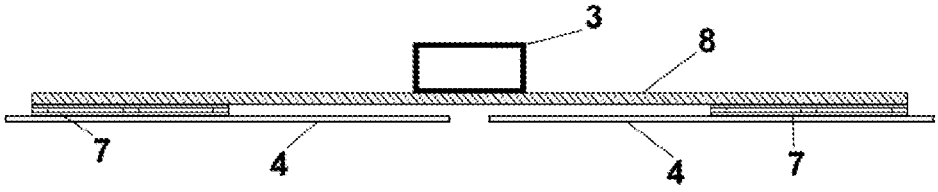

FIG.9

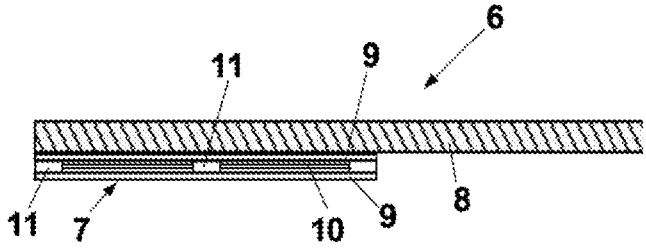

FIG.10

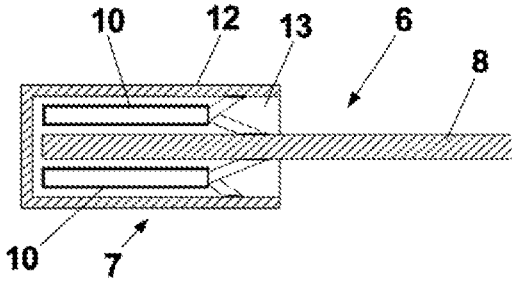

FIG.11

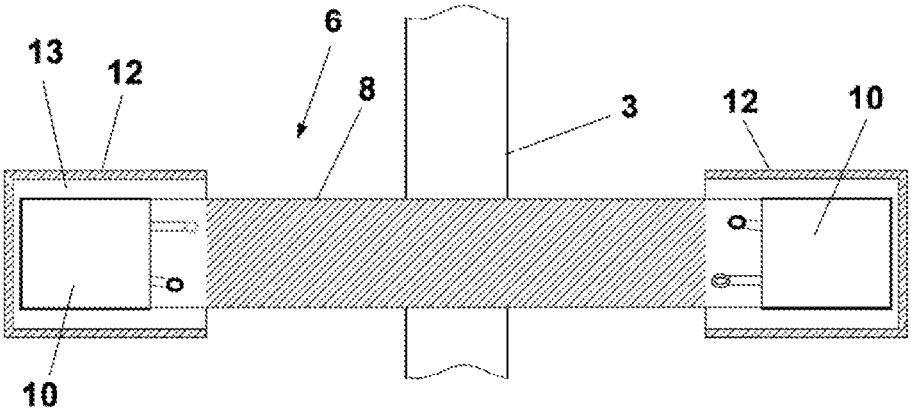

FIG.12

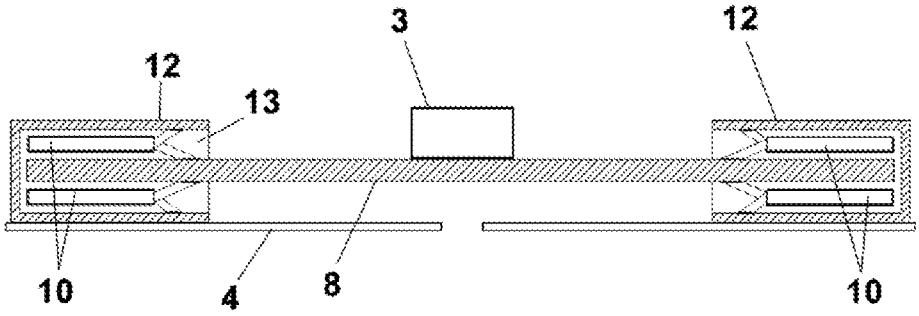

FIG.13

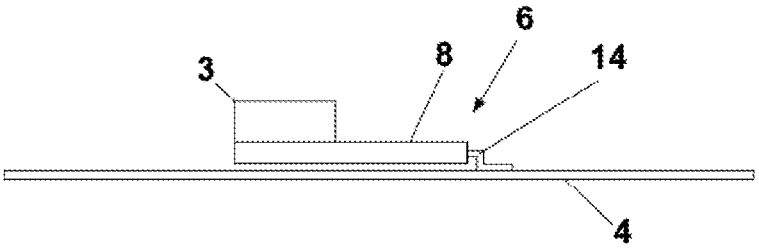

FIG.14

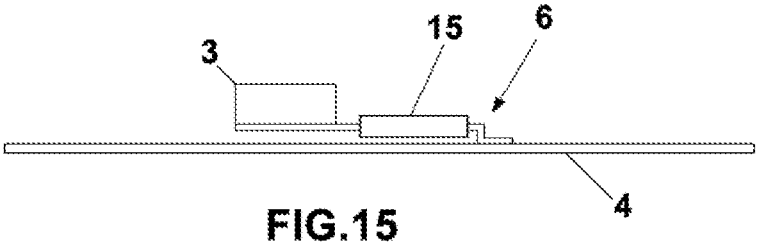

FIG.15

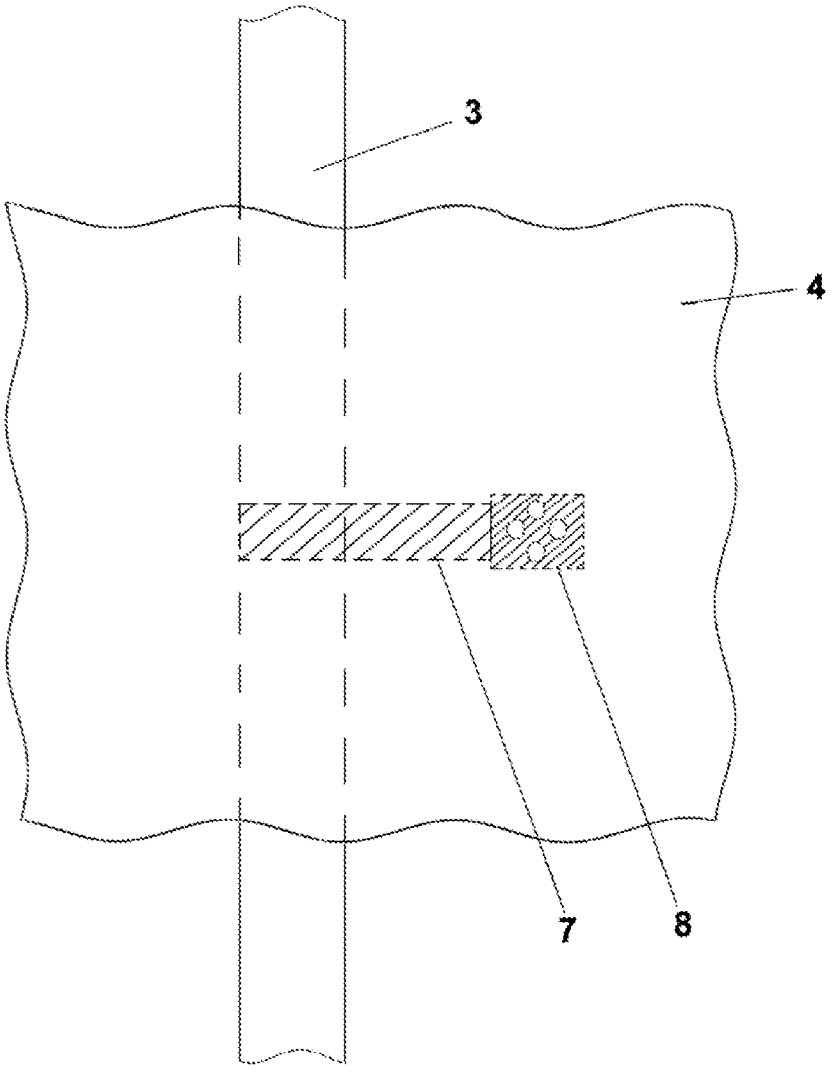

FIG.16

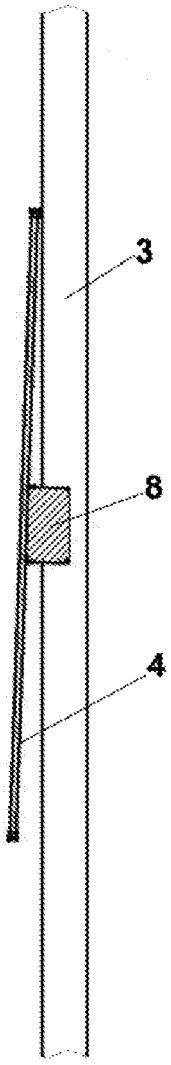

FIG.17

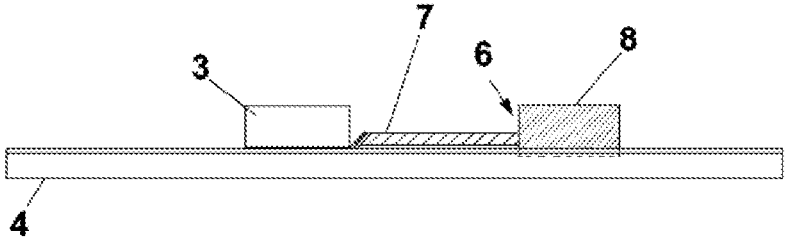

FIG.18

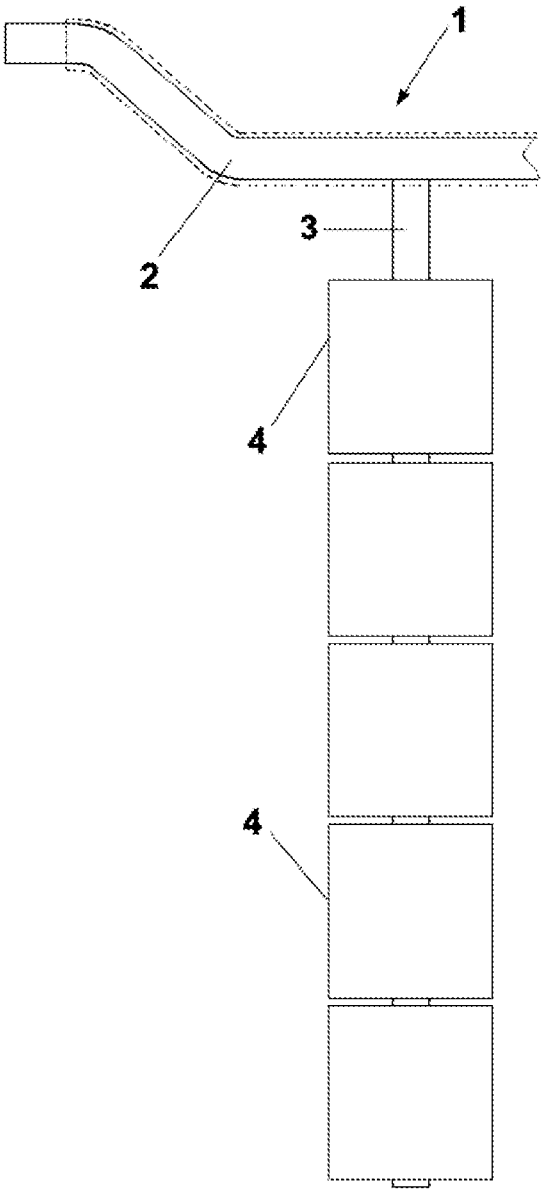

FIG.19

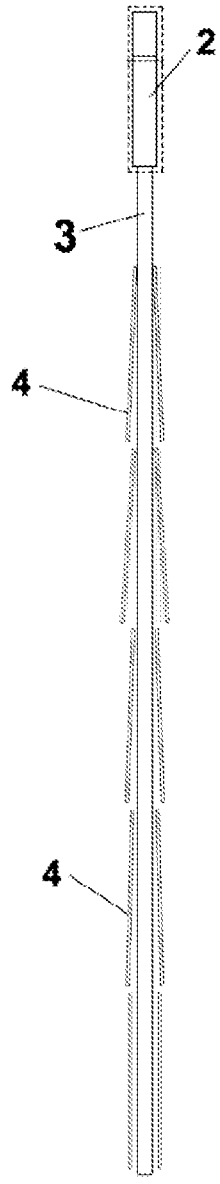

FIG.20

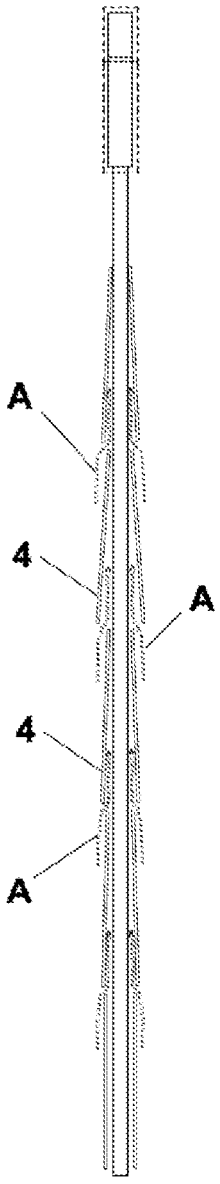

FIG.21

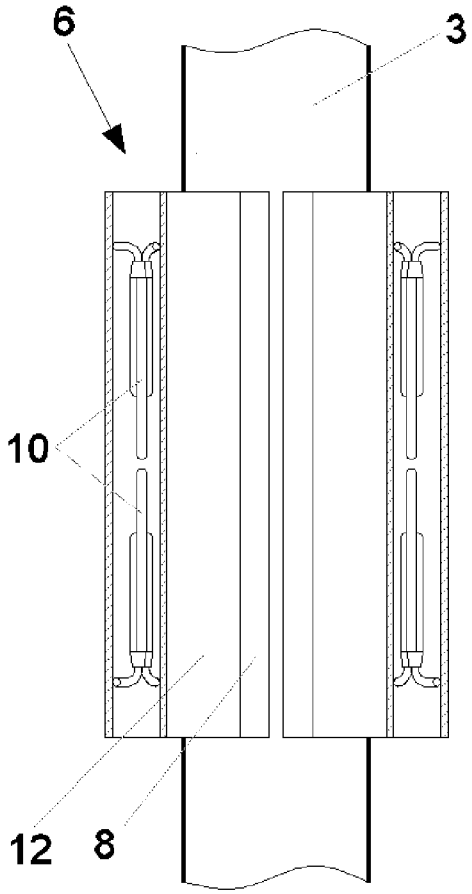

FIG. 22

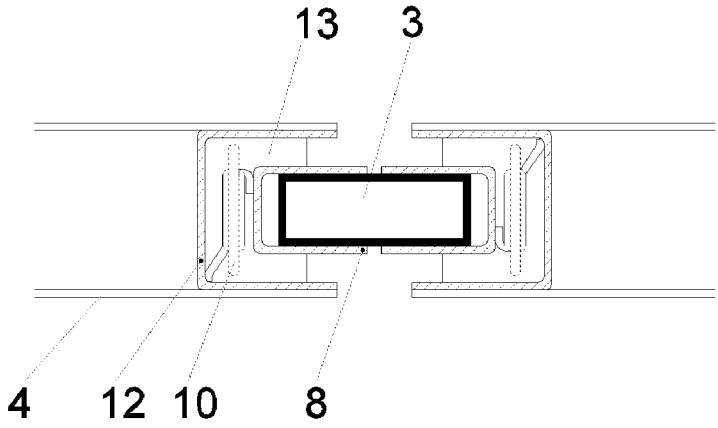

FIG. 23

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2017/052403

A. CLASSIFICATION OF SUBJECT MATTER
INV. C25C7/02 C25C7/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C25C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 679 240 A (ANASTASIJEVIC NIKOLA [DE] ET AL) 21 October 1997 (1997-10-21) claim 1; figures 1-6	1-15
Y	US 2016/010233 A1 (GRANT DUNCAN [GB] ET AL) 14 January 2016 (2016-01-14) paragraphs [0027], [0028], [0084], [0085]; claim 1	1-15
Y	WO 2015/079072 A2 (INDUSTRIE DE NORA SPA [IT]) 4 June 2015 (2015-06-04) page 10, lines 4-17; claim 1; figure 2	1-15
A	US 4 512 866 A (LANGLEY ROBERT C [US]) 23 April 1985 (1985-04-23) column 8, line 52 - column 9, line 36; figure 1	3,4,9

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 July 2017	18/07/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Hammerstein, G

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2017/052403

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2010/051452 A1 (SONG GUANGLING [US] ET AL) 4 March 2010 (2010-03-04) paragraph [0013]; claim 1	1-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2017/052403

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(30)优先权数据
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(85)PCT国际申请进入国家阶段日
2018.09.05

(86)PCT国际申请的申请数据
PCT/IB2017/052403 2017.04.26

(87)PCT国际申请的公布数据
WO2017/187357 EN 2017.11.02

(71)申请人 德诺拉工业有限公司
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(74)专利代理机构 中国国际贸易促进委员会专利商标事务所 11038
代理人 曾祥生

(51)Int.Cl.
C25C 7/02(2006.01)
C25C 7/00(2006.01)

权利要求书2页 说明书9页 附图12页

(54)发明名称

用于电化学电池的安全阳极

(57)摘要

本发明涉及用于电化学电池的安全阳极，为由悬挂结构构成的竖直阳极类型，该悬挂结构基于第一水平杆、由铜或铝芯部和钛外层限定的第二竖直分配杆、以及涂覆或未涂覆的钛阳极板，该钛阳极板在两侧附接到第二分配杆，使得安全阳极包括适配器元件，该适配器元件包括至少一个电流限制器组件，其布置在至少一个第二竖直分配杆和至少一个涂覆或未涂覆的钛阳极板之间，将竖直分配杆连接到涂覆或未涂覆的钛阳极板。

CN 108713074 A

1.一种用于电化学电池的阳极,为设置有悬挂结构的竖直阳极类型,具有:

-水平电流供应导体杆,和;

-一个或多个竖直分配杆,所述一个或多个竖直分配杆附接到电流供应杆,分配杆包括:

o芯部,该芯部由选自铜、铝、铅及其合金的导电元件制成,和

o外层或表皮,该外层或表皮由选自钛或其合金、阀金属或其合金以及铅或其合金的材料制成,以及;

-至少一个涂覆或未涂覆的钛阳极板,该钛阳极板与竖直分配杆相关联,

其特征在于,阳极(1)包括布置在至少一个竖直分配杆(3)和至少一个涂覆或未涂覆的钛阳极板(4)之间的适配器元件(6),适配器元件(6)包括具有电流限制器(10)的至少一个电流限制器组件(7),所述电流限制器组件(7)与所述至少一个竖直分配杆(3)和所述至少一个涂覆或未涂覆的钛阳极板(4)相关联,使得竖直分配杆(3)连接到涂覆或未涂覆的钛阳极板(4)。

2.根据权利要求1所述的用于电化学电池的阳极,其中适配器元件(6)附接到竖直分配杆(3)和涂覆钛的阳极板(4)。

3.根据权利要求1所述的用于电化学电池的阳极,其中阳极的适配器元件(6)包括钛条带(8),该钛条带保持所述至少一个电流限制器组件(7),使得钛条带(8)附接到竖直分配杆(3)并且电流限制器组件(7)附接到对应的涂覆或未涂覆的钛阳极板(4)。

4.根据权利要求1所述的用于电化学电池的阳极,其中阳极的适配器元件(6)包括钛条带(8),该钛条带具有两个端部,所述两个端部保持两个电流限制器组件(7),每个端部处保持一个电流限制器组件,使得钛条带(8)附接到竖直分配杆(3)并且一对电流限制器组件(7)附接到对应的涂覆或未涂覆的钛阳极板(4)。

5.根据权利要求1所述的用于电化学电池的阳极,其中阳极的适配器元件(6)附接到竖直分配杆(3),以相对于竖直分配杆(3)的竖直平面限定微小角度,使得附接到电流限制器组件(7)的涂覆或未涂覆的钛阳极板(4)也具有相同的角度。

6.根据权利要求5所述的用于电化学电池的阳极,其中阳极包括多于一个的适配器元件(6),每个适配器元件(6)附接到竖直分配杆(3),以相对于竖直分配杆(3)的竖直平面限定与其它角度大小不同的微小角度,使得与电流限制器组件(7)相关联的阳极板(4)也具有相同的角度。

7.根据权利要求5或6所述的用于电化学电池的阳极,其中所述角度相对于竖直分配杆(3)的竖直平面等于或小于3.25度。

8.根据权利要求6或7所述的用于电化学电池的阳极,其中由适配器元件(6)相对于竖直分配杆(3)的竖直平面限定的角度的大小沿着竖直分配杆(3)的长度从底部到顶部增加。

9.根据权利要求3所述的用于电化学电池的阳极,其中钛条带(8)具有管状构造,在管状构造的中心内部部分中结合有电流限制器(10),该电流限制器与以直角弯曲的至少一个片材(14)相关联,所述片材延伸至与片材(14)附接的对应的阳极板(4)的外侧。

10.根据权利要求3所述的用于电化学电池的阳极,其中适配器元件(6)的电流限制器(10)嵌入环氧树脂或类似材料的块(15)中,该块插置在钛条带(8)上。

11.根据权利要求1所述的用于电化学电池的阳极,其中电流限制器组件(7)包括盒子

(12),该盒子具有容纳钛条带(8)的绝缘材料(13),该绝缘材料(13)包括两个电流限制器(10),这两个电流限制器通过一个端子连接到钛条带(8)并通过另一个端子连接到盒子(12)。

12.根据权利要求1所述的用于电化学电池的阳极,其中电流限制器组件(7)包括一对双金属钛/铜件(9),其中铜表面彼此面对,在铜表面之间插置有电流限制器(10),该电流限制器由聚合物层和两侧上的相应的铜层构成,对应于两个相对的双金属片(9)的铜的宽度具有横向中心和周边凹陷,所述凹陷填充有环氧树脂(11)或类似的绝缘体。

13.根据权利要求11所述的用于电化学电池的阳极,其中电流限制器组件(7)包括至少一个外部边界和至少一个内部边界,所述外部边界是包含绝缘材料(13)的盒子(12),所述内部边界是钛条带(8),所述至少一个内部边界部分地或完全地容纳在所述至少一个外部边界内,所述至少一个外部边界和至少一个内部边界具有U形轮廓,使得所述至少一个内部边界附接并且部分地包围所述一个或多个竖直分配杆(3)中的至少一个的一部分,并且所述至少一个外部边界与至少一个阳极板(4)相关联或附接。

14.一种用于金属电解提取的电化学电池,其特征在于,其包括至少一个如前述权利要求中任一项所述的阳极。

15.根据前一个权利要求所述的电化学电池,其中金属是非铁金属。

用于电化学电池的安全阳极

[0001] 发明目的

[0002] 如本说明书的标题所述,以下的发明涉及用于电化学电池的安全阳极,为用于电化学电池特别是用于金属电解提取的竖直阳极类型,阳极由悬挂结构组成,基于水平供电导体杆和连接到电流供应杆的竖直分配杆,分配杆由铜或铝芯部以及钛外层或表皮限定。

[0003] 基于该常规实施例,本发明的第一个目的是竖直分配杆和涂覆或未涂覆的钛阳极板之间的电连接通过相应的适配器元件提供,该适配器元件包括电流限制器组件,以防止可能破坏或损坏涂覆或未涂覆的钛阳极板的短路。

[0004] 本发明的第二个目的是减少氧气泡与硫酸排放的分散,将它们引导通过阳极的中心部分,因此阳极板相对于由竖直分配杆限定的竖直平面成一角度布置,以产生烟囱效应,从而携带它们且便于收集器收集,避免有害的"酸雾"及其严重的环境影响。

[0005] 这导致显著的经济优势,因为一方面,它避免了涂覆或未涂覆的钛阳极板的破坏或损坏,另一方面,如果发生短路,受影响的板不会被破坏而其它板继续运作。

技术领域

[0006] 本说明书描述了用于电化学电池的安全阳极,并且适用于电解金属(例如铜)的电池。

背景技术

[0007] 首先,可以说明,容器、罐或电化学电池填充有电解质溶液,除了其它成分之外,该电解质溶液由待沉积的金属等组成,并且在交替位置中,多个阳极/阴极对浸没在该溶液中,当供应有电流时将金属沉积在阴极上。

[0008] 这意味着当在所述电池中使用竖直阳极用于金属电解提取时,所述竖直阳极由悬挂结构构成,基于水平电流供应导体杆和连接到电流供应杆的竖直分配杆,分配杆由铜或铝芯部以及钛外层或表皮限定。

[0009] 因此,涂覆或未涂覆的钛阳极板电连接到分配杆,阳极电解操作发生在阳极板的表面上。

[0010] 常规阳极在每个水平电流供应杆的竖直杆的数量方面呈现多种组合。

[0011] 如所指出的,在金属电解提取方法中使用的常规竖直杆是具有铜或铝芯部以及钛外层或表皮的双金属杆。铜或铝具有低电阻率,这是有效传输大电流所必需的,钛保护铜或铝免受电解质的化学侵蚀,同时允许将涂覆或未涂覆的钛阳极板连接到这些竖直杆。

[0012] 以这种方式,为了获得最佳输出和最大容量,阳极且特别是金属电解提取过程中使用的阳极表面在阴极附近操作并且相对于短阳极-阴极距离具有大表面积,例如,100x100厘米的表面,间隔5cm。在阴极表面上的任何点处的平坦度的任何变形或改变的情况下,这不可避免地引入阳极和阴极之间的电接触的风险,或者换句话说,短路。

[0013] 阴极表面本质上是不稳定的,因为它们的厚度在生产过程本身期间快速变化,并且还因为阴极在其表面上的单个点处的厚度增加减小了阳极-阴极距离,这降低了电阻,并

且适用于欧姆定律，在所述的相关点处增加离子电流。

[0014] 增加电流或离子沉积增加了沉积在所述点上的金属的厚度，使得这些事件清楚地呈现正反馈系统，如我们所知，这是本质上不稳定的过程，在这些情况下最终产生阳极-阴极接触或短路。

[0015] 此外，任何对准误差或现有的机械变形也将导致阳极-阴极直接接触或短路。

[0016] 一旦在阳极和阴极之间建立了直接电接触，电解质和阳极之间的潜在电化学屏障消失，并且电解质的相对高的电阻也将被消除。在这些情况下，电流达到不可接受的值，损坏或破坏涂覆或未涂覆的钛阳极板，同时造成显著的生产损失。

[0017] 此外，在用于金属电解，特别是铜电解的电池中的阳极的工作过程中，产生具有硫酸的氧气泡，这种现象被称为“酸雾”。这种“酸雾”造成了严重的环境污染问题，并且可能直接影响工厂操作人员的健康，需要在工作室中使用口罩，并且导致工厂所在区域的环境恶化。

[0018] 例如，在铜电解提取的情况下，电解质主要由硫酸和硫酸铜的溶液组成。在其正常的电解过程中，阳极产生持有硫酸的被污染的氧气泡；这些气泡的大部分离开电解质并形成周围大气的一部分，形成所谓的酸雾。

[0019] 此外，电流限制器是对特定值以上的任何电流作出反应并取消的装置，该值是特定装置或型号的特征。

[0020] 一个非常熟悉的例子是我们家中的保险丝；当网络中的电线短路或直接接触时，保险丝熔断并断开，使我们处于黑暗中。然后我们必须重置或更换保险丝以再次提供照明。我们使用这个例子来解释复位的概念，并详细介绍在一段时间之后，如果物理短路不再存在，并且在没有外部干预的情况下灯自动重新启动的可能性。在这种情况下，保险丝是自动复位保险丝。

[0021] 有两种方法可以防止短路；一个是取消或强制电流为零，另一个是将电流调制到允许的较低值。两种情况都被认为是电流限制器，但我们将前者称为数字开关限制器，后者称为模拟限制器。

[0022] 我们还可以引用专利文献WO2015/079072，其描述了用于金属电解提取的阳极结构，其包括水平支撑杆和涂有塑料或环氧树脂的竖直杆，称为具有面积为25至225cm^2的子网格的阳极板通过相应的布线和/或印刷电路附接到电源，所述布线和/或印刷电路由一系列绝缘结构保护，并且安装在涂有塑料或环氧树脂的杆内。

发明内容

[0023] 本发明涉及如权利要求1所述的用于电化学电池的阳极，该阳极为竖直阳极的类型，包括悬挂结构，所述悬挂结构具有/包括：

[0024] -水平电流供应导体杆；

[0025] -一个或多个竖直分配杆，所述一个或多个竖直分配杆附接到电流供应杆，分配杆包括：

[0026] ○芯部，该芯部由选自铜、铝、铅及其合金的导电元件制成，和

[0027] ○外层或表皮，该外层或表皮由选自钛或其合金、阀金属或其合金以及铅或其合金的材料制成，以及；

[0028] -至少一个涂覆或未涂覆的钛阳极板，该钛阳极板与竖直分配杆相关联，

[0029] 其特征在于，阳极(1)包括布置在至少一个竖直分配杆(3)和至少一个涂覆或未涂覆的钛阳极板(4)之间的适配器元件(6)，适配器元件(6)包括具有电流限制器(10)的至少一个电流限制器组件(7)，所述电流限制器组件(7)与所述至少一个竖直分配杆(3)和所述至少一个涂覆或未涂覆的钛阳极板(4)相关联，使得竖直分配杆(3)连接到涂覆或未涂覆的钛阳极板(4)。

[0030] 表达“竖直分配杆”是指任何和所有棱柱形元件，其能够承受(竖直)悬挂位置并且适于与适配器元件相关联或附接。所述一个或多个“竖直分配杆”可以具有圆形、卵形或多边形的截面，它们可以具有不同的纵横比，并且在极限情况下，可以是面板，例如引线面板。此外，表达“阳极板”是指任何形状和尺寸的元件，其适合用作阳极并且具有至少一个能够产生氧气或氯气的表面；更具体地，阳极板可以是平的、弯曲的或部分弯曲的、波纹状的、实心的、多孔的、有小孔的、切割的、蚀刻的或穿孔的材料。

[0031] 该发明内容描述了一种用于电化学电池的安全阳极，为由悬挂结构构成的竖直阳极类型，其基于：

[0032] -水平电流供应导体杆；

[0033] -竖直分配杆，其连接到电流供应杆，分配杆由以下部分组成：

[0034] ○铜芯部或铝芯部，和；

[0035] ○钛外层或表皮，以及；

[0036] -与竖直分配杆相关联的至少一个涂覆的钛阳极板，

[0037] 使得安全阳极包括适配器元件，该适配器元件包括电流限制器组件，该电流限制器组件布置在至少一个竖直分配杆和至少一个涂覆的钛阳极板之间，该适配器元件将相应的竖直分配杆连接到与其附接的涂覆的钛阳极板。

[0038] 在另一个实施例中，阳极的悬挂结构具体包括：

[0039] -水平供电导体杆；和

[0040] -竖直分配杆，其连接到电流供应杆，分配杆包括：

[0041] ○铜芯部或铝芯部，和

[0042] ○钛外层或表皮；以及

[0043] -与竖直分配杆相关联的至少一个涂覆的钛阳极板。

[0044] 在本发明的一个实际实施例中，安全阳极的适配器元件由电流限制器组件限定，该电流限制器组件直接附接到竖直分配杆和涂覆或未涂覆的钛阳极板，以将竖直分配杆连接到阳极板。

[0045] 这意味着适配器元件由电流限制器组件本身限定。

[0046] 在本发明实际实施例的第一变型形式中，安全阳极的适配器元件由钛条带限定，钛条带保持电流限制器组件，钛条带附接到竖直分配杆和相应的涂覆或未涂覆的钛阳极板，阳极板的表面积为250至1670cm^2，附接到电流限制器组件。

[0047] 在本发明的实际实施例的第二变型形式中，安全阳极适配器元件由钛条带限定，该钛条带保持两个电流限制器组件，其两端各有一个，钛条带附接到竖直分配杆并且该对电流限制器组件附接到相应的涂覆或未涂覆的钛阳极板。

[0048] 同样，包括至少一个电流限制器组件的安全阳极适配器元件附接到相应的竖直分

配杆，以相对于竖直平面限定微小角度，使得与其附接的涂覆或未涂覆的钛阳极板具有相同的角度。作为“微小角度”，应该理解为相对于竖直线的小角度，也就是说，大小较小的角度。优选地，如图所示，相对于杆(3)的竖直平面，微小角度等于或小于3.25度。在更优选的实施例中，相对于杆(3)的竖直平面，微小角度为3度。

[0049] 包括至少一个电流限制器组件的阳极适配器元件可以在它们安装的微小角度上具有不同的大小，其中与它们相关联的阳极板也根据相对于竖直平面倾斜成不同角度。

[0050] 此外，包括至少一个电流限制器组件并且在它们安装的微小角度上具有不同大小的阳极适配器元件沿着相应的第二竖直分配杆的长度附接，其大小从底部到顶部增加，对氧气泡和酸的向上流动造成烟囱效应。

[0051] 形成适配器元件的一部分的钛条带可以具有管状构造，在其中心内部部分中包含电流限制器，该电流限制器与至少一个以直角弯曲的片材相关联，所述片材延伸到外部并且相应的阳极板附接到所述片材。

[0052] 同样地，形成适配器元件的一部分的钛条带可以在其上插置有环氧树脂或类似材料的块，在该块中嵌入有电流限制器。

[0053] 由于阳极的存活通常受到上述短路的影响而不是由于其它原因，因此当阳极能够承受短路而不会遭受严重损坏并且保持工作时，可以说阳极是安全的。

[0054] 因此，形成适配器元件的一部分并且电流限制器集成在其中的电流限制器组件由盒子限定。术语盒子是指壳体、外壳、部分或完全的封闭件，其完全地或部分地容纳或包括钛条带。盒子可以由任何材料制成，只要它适合于其预期目的并且适合于浸入电解浴的酸性环境中以用于金属电解提取。在优选的情况下，盒子由适于所述目的的导电材料制成，更优选地，其由钛或其合金制成。盒子可以包括或不包括绝缘材料，使得在特定实施例中，钛条带由包含其的盒子的绝缘材料绝缘，绝缘介质包含一个、两个或更多个电流限制器，电流限制器通过一个端子连接到中间钛条带并通过另一个端子连接到盒子。

[0055] 同样，形成适配器元件的一部分并且电流限制器集成在其中的电流限制器组件由一对双金属钛/铜件限定，其中铜表面彼此面对，在铜表面之间插置有电流限制器，该电流限制器由聚合物层和两个表面上的相应的铜片材构成，对应于嵌入的两个相对的双金属片的铜的宽度具有横向中心和周边凹陷，所述凹陷填充有环氧树脂或类似的绝缘体。

[0056] 本发明的另一个目的是一种用于金属电解提取的电化学电池，其包括至少一个如前所述的阳极。在优选的情况下，电池用于非铁金属的电解提取，包括但不限于铜或镍。

[0057] 为了完成下面提供的描述，并且为了帮助使本发明的特征更容易理解，本说明书附有一组附图，这些附图通过说明而非限制的方式表示本发明的最具特征的细节。

附图说明

[0058] 图1示出了常规阳极的侧视图，其中水平电流供应杆、竖直分配杆以及与竖直分配杆相关联的两个涂覆或未涂覆的钛阳极板是可见的。

[0059] 图2和3分别示出了通过将涂覆或未涂覆的钛阳极板焊接到竖直杆上的常规附接的正视图和平面图。

[0060] 图4和5分别示出了通过包括电流限制器组件的适配器元件将涂覆或未涂覆的钛阳极板附接到竖直分配杆的正视图和平面图。

[0061] 图6和7分别示出了通过适配器元件将涂覆或未涂覆的钛阳极板附接到竖直分配杆的正视图和平面图，该适配器元件包括如第一实施例中所规定的钛条带和电流限制器组件。

[0062] 图8示出了附接到竖直分配杆的适配器元件的前视图，该适配器元件由钛条带构成，并且在其端部处具有相应的电流限制器组件。

[0063] 图9示出了一个实施例的平面图，其中根据第二实际实施例，适配器元件包括钛条带和两个电流限制器组件。

[0064] 图10和11分别示出了根据两个实际实施例变型形式的电流限制器组件与钛条带的端部连接的横截面图。

[0065] 图12和13示出了由钛条带和两个电流限制器组件构成的适配器元件与竖直杆附接的前视图以及相应的阳极板附接到电流限制器组件的平面图。

[0066] 图14示出了钛条带的实际实施例的第一变型形式的平面图，其形成适配器元件的一部分，具有管状构造并且在其内部结合有至少一个电流限制器，与以直角弯曲的延伸片材相关联，相应的阳极板附接到该延伸片材。

[0067] 图15示出了钛条带的实际实施例的第二变型形式的平面图，其形成适配器元件的一部分，其中电流限制器本身嵌入环氧树脂或类似材料的块中，上述钛条带被限制器分开，所述钛条带在一端处附接到竖直杆，在另一端处附接到相应的阳极板。

[0068] 图16、17和18分别示出了实际实施例的前视图、正视图和平面图，其中阳极板相对于竖直平面以微小角度安装。

[0069] 图19和20示出了实际实施例的前视图和平面图，其中一系列涂覆或未涂覆的钛阳极板附接到第二竖直分配杆，示出了阳极板如何具有微小角度，该角度从下部部分到上部部分增大，或者换句话说，从底部到顶部增大，以产生烟囱效应。

[0070] 图21示出了前一图的实施例的侧视图，其中示出了由于阳极板的倾斜布置产生的烟囱效应而导致气泡跟随的路径。

[0071] 图22和23示出了适配器元件的附接的前视图和相应的阳极板附接到电流限制器组件的平面图，该适配器元件包括具有电流限制器和内部边界的电流限制器组件，该内部边界是具有U形形状并附接到竖直杆的钛条带，所述钛条带被容纳在外部边界中，该外部边界是盒子，该盒子形成U形容器。

具体实施方式

[0072] 如上述图中所示并且根据指定的编号，可以看出如何从常规构造开始，其中阳极1由基于电流供应导体杆2和一系列竖直分配杆3的悬挂结构构成，至少一个涂覆或未涂覆的钛阳极板4附接到该悬挂结构(下文中我们将这些简称为阳极板)，附图中的图1示出了在所述实际实施例中阳极如何具有两个阳极板4。在所述常规实施例中，阳极板4通过点焊5附接到竖直分配杆3，如附图的图2所示。

[0073] 从上述常规构造开始，本发明的第一个目的是基于适配器元件6的结合，该适配器元件包括至少一个电流限制器组件7，如图4所示，电流供应或连接通过该电流限制器组件从相应的竖直分配杆3建立到阳极板4。

[0074] 根据图4和5，在一个实际实施例中，适配器元件6包括电流限制器组件7，该电流限

制器组件直接附接到竖直分配杆3和阳极板4，使得电流通过电流限制器7从竖直分配杆3到达阳极板。在该实施例中，电流限制器组件7本身用作适配器元件6。

[0075] 此外，根据附图的图6和7，在实际实施例的第一变型形式中，适配器元件6由钛条带8限定，钛条带在其一端处附接到竖直分配杆3并且在另一端处包括电流限制器组件7，而根据附图的图8，在实际实施例的第二变型形式中，适配器元件6由附接到竖直分配杆3的钛条带8构成，该钛条带在每个端部处均具有电流限制器组件7，相应的阳极板4附接到电流限制器组件7，电流从竖直分配杆3通过钛条带8和对应的电流限制器7到达阳极板4。

[0076] 优选自动复位的电流限制器组件将实施为使用工业中可用的任何机构，也就是说，双金属断路器、具有自动复位的数字熔断器、具有自动复位的模拟熔断器、具有截止或调节的晶体管等。

[0077] 作为示例并且根据附图的图8、9和10，我们可以陈述用作适配器元件6的部件的第一类型的电流限制器组件7可以由一对钛/铜双金属件9，其中铜表面彼此面对，在铜表面之间插置有电流限制器10，该电流限制器由聚合物层和两侧上的对应的铜片材构成，对应于彼此面对的两个双金属件9的铜的宽度具有横向中心和周边凹陷，所述凹陷填充有环氧树脂11或类似的绝缘体。

[0078] 以这种方式，附图的图8示出了关于电流限制器组件7，两个阴影部分将如何对应于双金属件9的铜并且围绕它们的轮廓将如何对应于横向中心和周边凹陷，在两个双金属件9与插置在它们之间的电流限制器10本身的连接中，其将填充有环氧树脂11或其它绝缘材料。

[0079] 根据附图的图11、12和13的第二种类型的电流限制器组件7可以由钛盒子12构成，钛条带8的插置有绝缘材料13的一端容纳在该钛盒子中，绝缘材料13中包括两个电流限制器10，使得优选地包括两个钛盒子12，如附图的图13所示，钛条带8的每一端处有一个钛盒子，其通过一个端子连接到钛条带8，并且通过其另一个端子连接到钛盒子12，换句话说，电流将是竖直分配杆3——钛条带8——电流限制器10——钛盒12——阳极板4。

[0080] 我们注意到，我们省略了对每个适配器元件的3个、4个等限制器的扩展的解释，因为我们认为很明显是基于每个适配器提供1个和2个限制器的情况。

[0081] 绝缘材料13可以是环氧树脂或塑料材料层，或者任何其它等效材料。

[0082] 逻辑上，关于适配器元件描述的结构同样可以具有与所描述的那些等同的其它实施例，因此，在附图的图14中，可以看到形成适配器元件6的一部分的钛条带8如何可以具有管状构造并且在其内部容纳电流限制器10，完全绝缘，与相应的阳极板4所附接的以直角弯曲的第一片材14相关联。同样，双重构造也是可能的，使得两个以直角弯曲的片材14从管状条带8的内部延伸，每个端部处一个片材，与对应的阳极板4附接。

[0083] 同样，根据图15的实施例，形成适配器元件6的一部分的电流限制器本身可以嵌入插置在钛条带8上的环氧树脂块15中，其被分成两部分，并且钛条带8以直角弯曲，以便能够将其附接到相应的阳极板4上。如在先前的情况中那样，适配器元件可以具有双重构造以将其附接到两个阳极板4。

[0084] 每个阳极1的竖直分配杆3和阳极板4的数量不影响本发明的目的，但是足够数量的这些部件将使得可以调节装置的性能和成本，使得实际数量的元件是：每个阳极有3个竖直杆、30个适配器元件，每个适配器元件供给2个阳极板，因此每个阳极总共有60个阳极板。

此外，阳极板的面积为250至1670cm^2。

[0085] 另外，在常规的阳极中，阳极板4的数量是一个或两个，使得在两个板的情况下，每个表面有一个板，如图1中所示。尽管本发明的目的可以应用于这种常规模型，但是如果每个阳极安装更多数量的阳极板4，则其效率会提高，并且成本和安装困难也会阻止过高的值，从而在两者之间进行折中。

[0086] 我们认为阳极材料区域限定了与另一个不同的阳极板，条件是两个区域之间的电阻足够高，以便当与其中一个建立阴极接触时，另一个可以继续其电解过程，至少达到活动量的30％。

[0087] 每个适配器元件6将包括至少一个电流限制器组件7，其在短路的情况下将切断电流或至少将该电流限制到可接受的值，可接受的值被认为是对于阳极的完整性不危险并且不表示大的电流损失的值。我们建议使用与正常操作电流或额定电流相似的值，但我们可以使用更高的值，而不会显著影响性能，直至不超过额定操作电流值的五倍的短路电流。

[0088] 此外，本发明的第二个目的是试图控制由阳极电解产生的“酸雾”的排放。为此，在用于电解金属(例如铜)的电池中，对于供给通过以微小角度布置阳极板4(如图17、20和21所示)而间隔10至30mm的两个阳极板4的阳极，如图1所示，可以控制和引导产生的气泡，从而由于可以通过各种各样的方式获得的阳极板的角度而获得遵循箭头“A”的路径。

[0089] 此外，改变阳极板的角度大小，并从底部向上以增大的角度布置它们，以倒置的人字形图案形成的布置产生烟囱效应，使得可以避免分散并允许控制酸气泡的排放，原因在于气泡受到限制并且就像在阳极的阳极板两侧之间的烟囱中一样上升。

[0090] 如我们所提到的，阳极板的角度可以以不同的方式实现，并且因此，首先，包括电流限制器组件7的适配器元件6(附图的图5)可以直接以期望的角度附接到竖直分配杆3，或者钛条带8本身可以根据期望的角度附接到对应的竖直分配杆3，或者如图17和18所示，钛条带8本身可以是扭曲的并且其端部可以成角度，并且当附接对应的电流限制器组件时，附接到其上的阳极板将具有期望的角度。

[0091] 这种将气泡的向上流动集中在阳极内的现象具有以下优点：

[0092] √因为阳极和阴极之间的向上气泡是绝缘体，所以它们增加了电解质的有效电阻，从而降低了电解质对阳极和阴极之间电流通过的阻力；

[0093] √阴极板上的铜沉积更均匀；众所周知，存在较高的电流密度，因此在阳极的下部具有较高的短路发生率，或者换句话说，在下部的铜的厚度略大。如果在阳极和阴极之间防止了集中在上部的气泡，则获得的铜板将更平坦，铜板的上部和下部之间的厚度差异更小；

[0094] √降低这些气泡到达阴极并引起氧化的可能性，氧化会对金属阴极沉积过程的效率及其质量产生负面影响，以及；

[0095] √当大部分酸性气泡通过两个阳极表面的狭窄内部区域上升时，在烟囱出口处安装收集器可以非常有效地收集“酸雾”，从而大大减少环境污染。

[0096] 此外，在图22和23所示的一个实际实施例中，电流限制器组件(7)包括至少一个外部边界和至少一个内部边界，所述外部边界是包含绝缘材料(13)的盒子(12)，所述内部边界是钛条带(8)，所述至少一个内部边界部分地或完全地容纳在所述至少一个外部边界内，所述至少一个外部边界和至少一个内部边界具有U形轮廓，使得所述至少一个内部边界附接并且部分地包围所述一个或多个竖直分配杆(3)中的至少一个的一部分，并且所述至少

一个外部边界与至少一个阳极板(4)相关联或附接。

[0097] 该实施例具有简化适配器元件的生产并降低生产成本的优点。实际上,所述实施例可以在根据本发明的适配器元件的制造、集成和电效率方面提供改进。关于制造,钛条带(8)和盒子(12)的U形轮廓允许有效地管理和/或减少构建适配器元件所需的钛量。容器由两个U型材构成,一个放在另一个内;这些型材采用长条带自动生产,使用折叠机而具有高效率,无需焊接和困难的切割。此外,焊接电流限制器的引线,使其具有更高的舒适性和效率,使其成为机器人化过程;这意味着高生产能力,而且成本极具竞争力。最后,关于电效率,应该考虑到通过用适配器本身缠绕或围绕电流分配杆,电流路径垂直于适配器的表面,这意味着电路的最大截面和最小长度。

[0098] 如果需要,上文描述的实施例可以用于允许烟囱效应的构造中。在这种情况下,阳极板安装成相对于竖直位置倾斜或弯曲,以引导气泡从阳极发生的电化学反应流动。例如,阳极板被弯曲成类似于积分符号“∫”的形状,或者技术人员容易认为适合于该目的的任何其它形状。作为另外一种选择,在阳极板和适配器元件之间,可以插入导电楔或成形器,其允许阳极板相对于竖直方向以一定角度焊接。

[0099] 最后,本发明还涉及以下实施例A-K:

[0100] A)用于电化学电池的安全阳极,为由悬挂结构构成的竖直阳极类型,其基于:

[0101] -水平电流供应导体杆,和;

[0102] -竖直分配杆,其连接到电流供应杆,该分配杆由以下限定:

[0103] ○铜芯部或铝芯部,和;

[0104] ○钛外层或表皮,以及;

[0105] -至少一个钛阳极板,其被涂覆并与竖直分配杆相关联,

[0106] 其特征在于,安全阳极(1)包括安全阳极适配器元件(6),其布置在至少一个竖直分配杆(3)和至少一个涂覆的钛阳极板(4)之间,适配器元件(6)包括至少一个电流限制器组件(7),电流限制器(10)集成在该电流限制器组件中,与竖直分配杆(3)和涂覆的钛阳极板(4)相关联的电流限制器组件将竖直分配杆(3)连接到涂覆的钛阳极板(4)。

[0107] B)根据项A的实施例的用于电化学电池的安全阳极,其特征在于,安全阳极的适配器元件(6)由电流限制器组件(7)限定,电流限制器(10)集成在该电流限制器组件中,该电流限制器组件附接到竖直分配杆(3)和涂覆的钛阳极板(4)。

[0108] C)根据项A的实施例的用于电化学电池的安全阳极,其特征在于,安全阳极的适配器元件(6)由钛条带(8)限定,该钛条带保持至少一个电流限制器组件(7),钛条带(8)附接到竖直分配杆(3)并且对应的涂覆的钛阳极板(4)附接到电流限制器组件(7)。

[0109] D)根据项A和C的实施例的用于电化学电池的安全阳极,其特征在于,安全阳极的适配器元件(6)由钛条带(8)限定,该钛条带保持两个电流限制器组件(7),在每个端部处保持一个电流限制器组件,钛条带(8)附接到竖直分配杆(3)并且对应的涂覆的钛阳极板(4)附接到一对电流限制器组件(7)。

[0110] E)根据项A的实施例的用于电化学电池的安全阳极,其特征在于,包括至少一个电流限制器组件(7)的安全阳极的适配器元件(6)附接到对应的竖直分配杆(3),以相对于竖直平面限定微小角度,使得与其附接的涂覆的钛阳极板(4)具有相同的角度。

[0111] F)根据项E的实施例的用于电化学电池的安全阳极,其特征在于,包括至少一个电

流限制器组件(7)的阳极的适配器元件(6)在其微小安装角度下可具有不同的大小,与它们相关联的阳极板(4)也相对于竖直平面倾斜成不同角度。

[0112] G)根据项F的实施例的用于电化学电池的安全阳极,其特征在于,包括至少一个电流限制器组件(7)并且在其微小安装角度下具有不同大小的阳极的适配器元件(6)沿着对应的第二竖直分配杆(3)的长度附接,其大小从底部到顶部增加,从而引起烟囱效应。

[0113] H)根据项C的实施例的用于电化学电池的安全阳极,其特征在于,形成适配器元件(6)的一部分的钛条带(8)具有管状构造,在该管状构造的中心内部部分中结合有电流限制器(10),该电流限制器与以直角弯曲的至少一个片材(14)相关联,所述片材延伸至外侧并且对应的阳极板(4)附接到所述片材。

[0114] I)根据项C的实施例的用于电化学电池的安全阳极,其特征在于,形成适配器元件(6)的一部分的钛条带(8)上插置有由环氧树脂或类似材料制成的块(15),电流限制器(10)嵌入到该块中。

[0115] J)根据项A的实施例的用于电化学电池的安全阳极,其特征在于,形成适配器元件(6)的一部分并且集成有电流限制器(10)的电流限制器组件(7)由容纳钛条带(8)的盒子(12)限定,该钛条带由包含该钛条带的盒子(12)的绝缘材料(13)绝缘,该绝缘材料(13)包括两个电流限制器(10),这两个电流限制器通过一个端子连接到中间钛条带(8)并通过另一个端子连接到盒子(12)。

[0116] K)根据项A的实施例的用于电化学电池的安全阳极,其特征在于,形成适配器元件(6)的一部分并且集成有电流限制器(10)的电流限制器组件(7)由一对双金属钛/铜片(9)限定,其中铜表面彼此面对,在铜表面之间插置有电流限制器(10),该电流限制器由聚合物层和两侧上的相应的铜层构成,对应于两个相对的双金属片(9)的铜的宽度具有横向中心和周边凹陷,所述凹陷填充有环氧树脂(11)或类似的绝缘体。

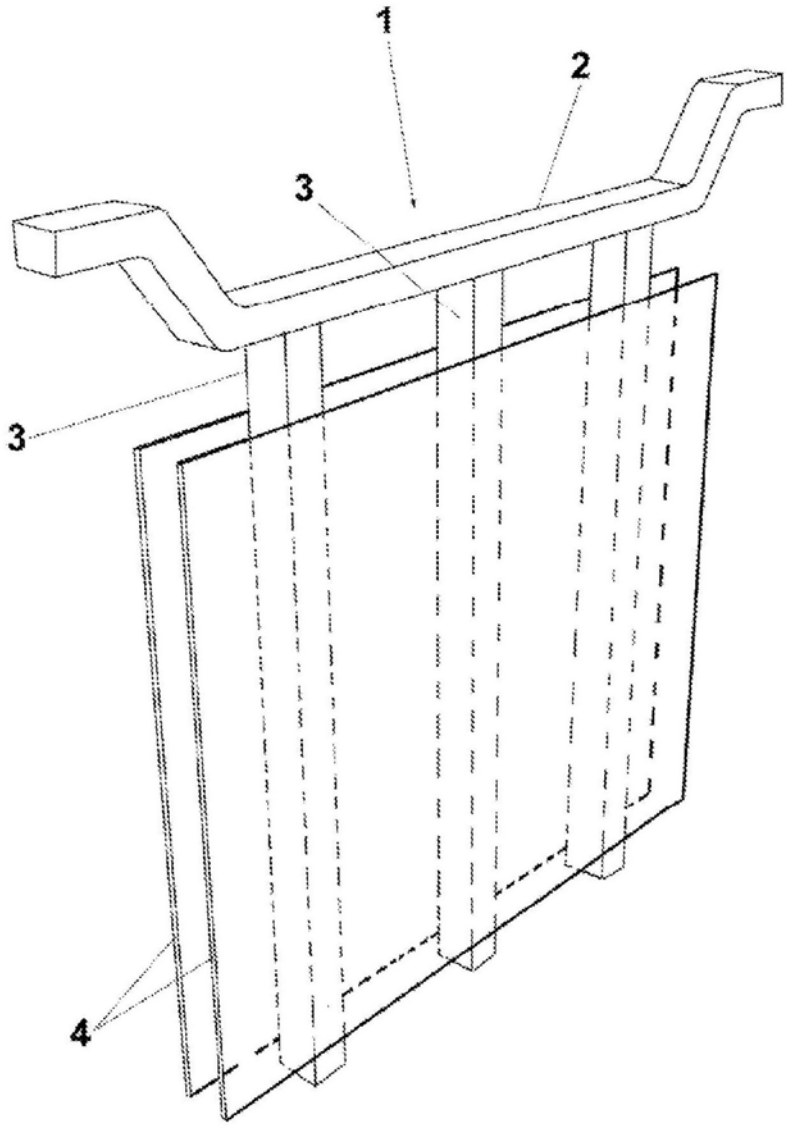

图1

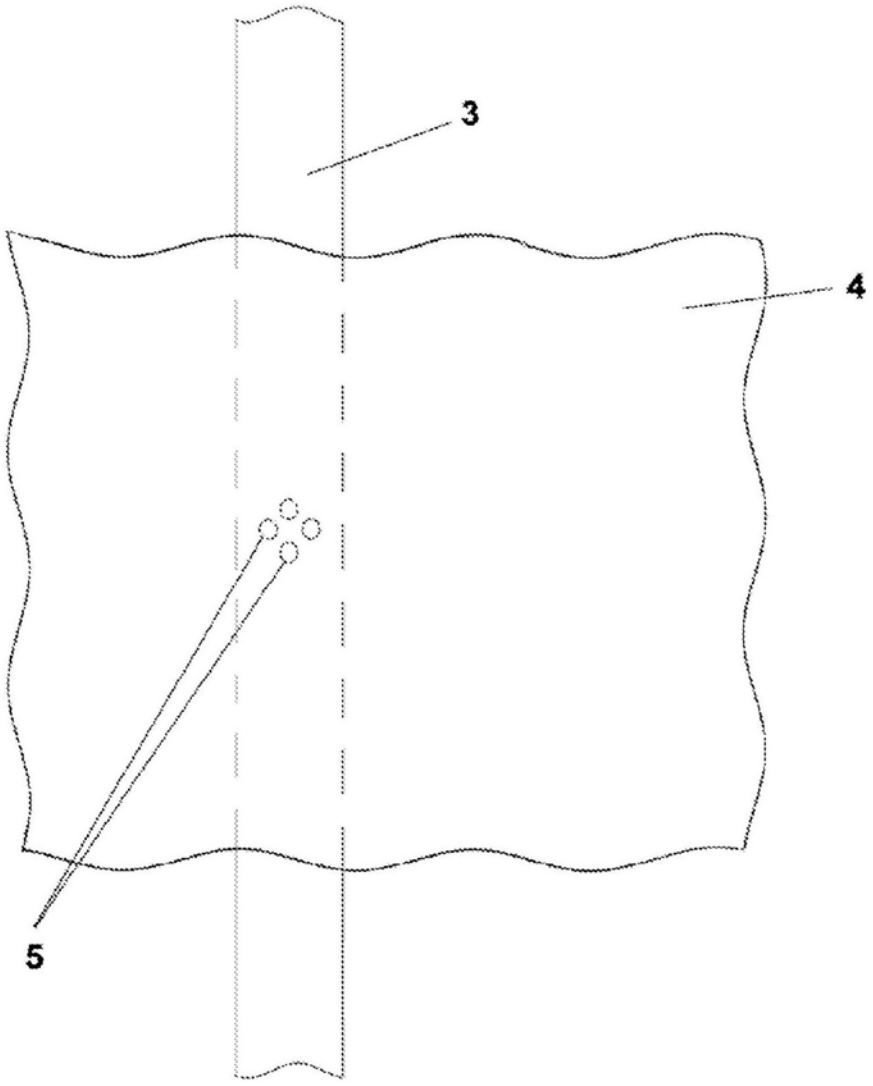

图2

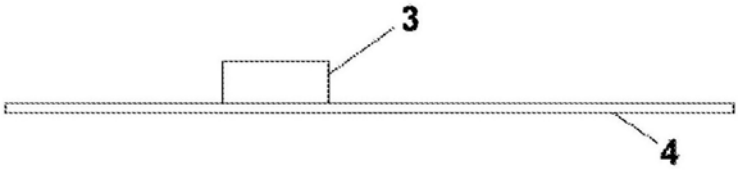

图3

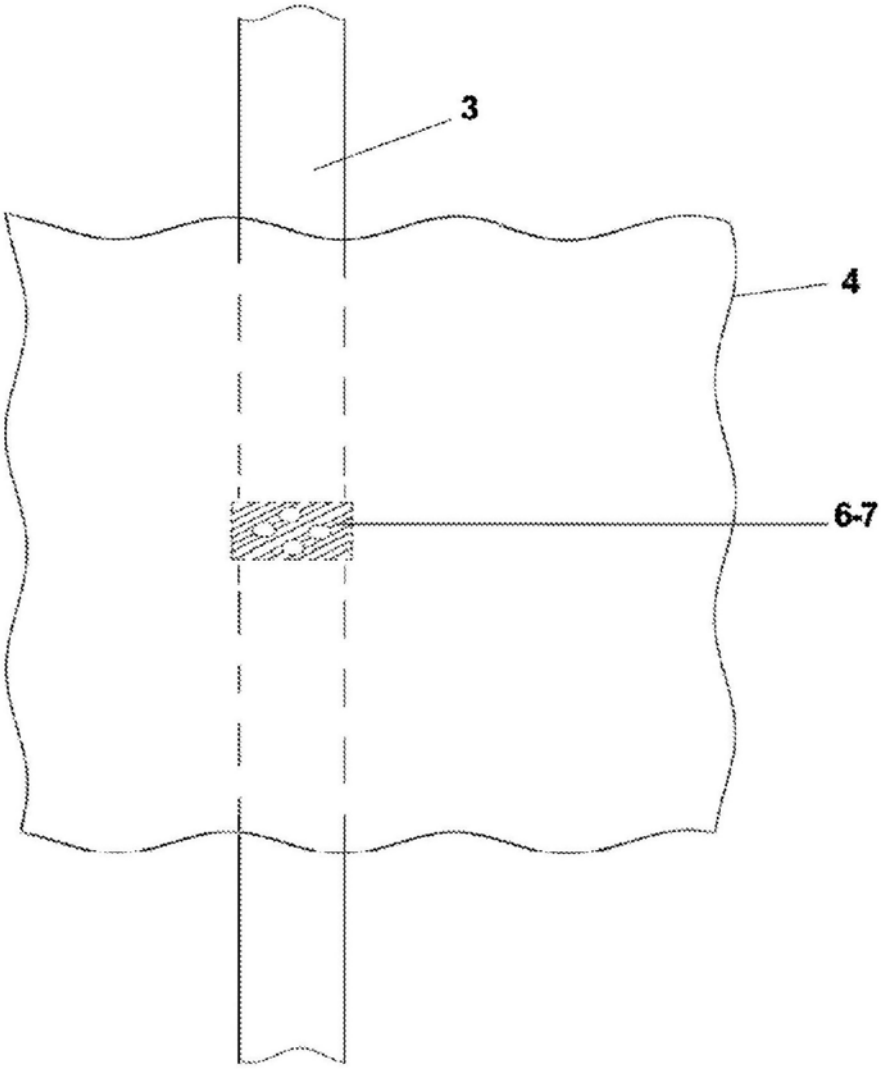

图4

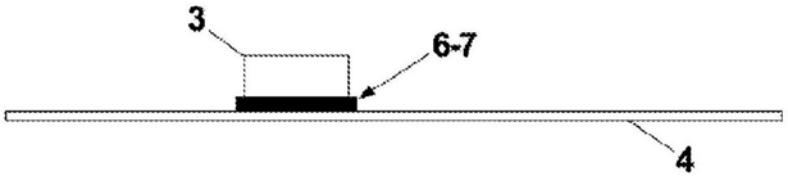

图5

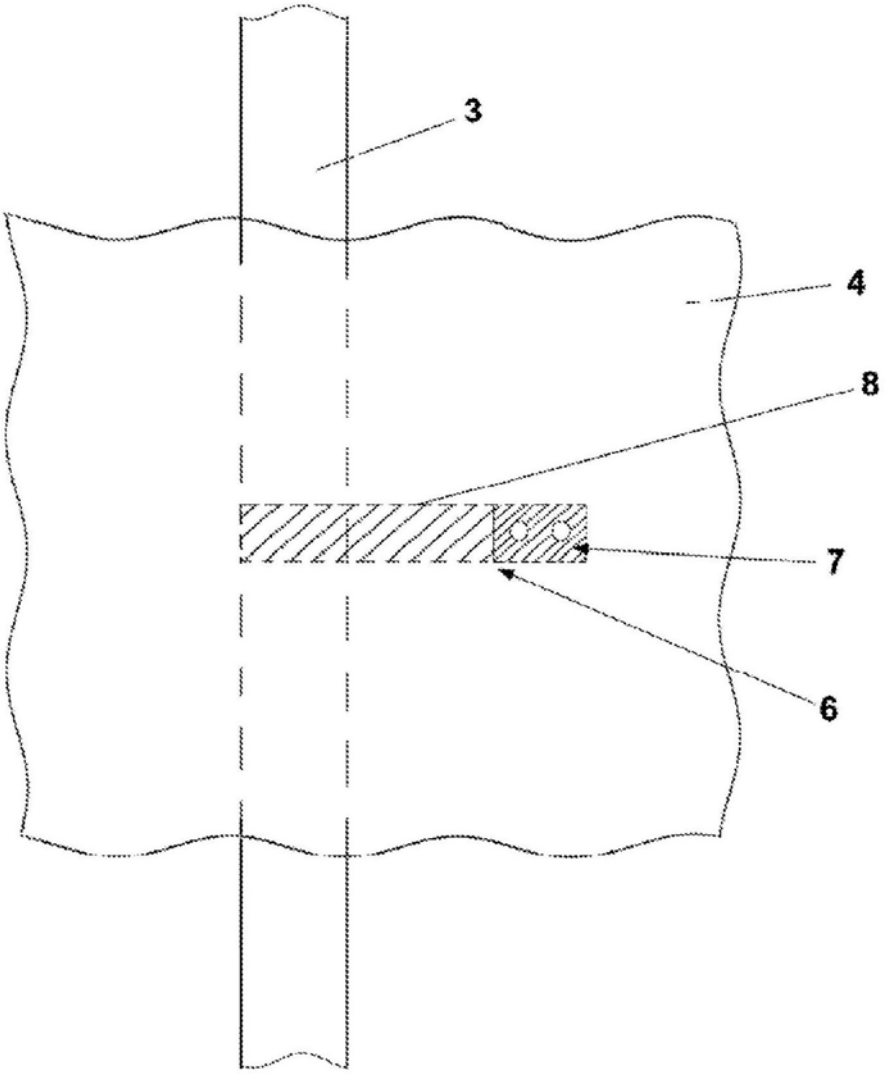

图6

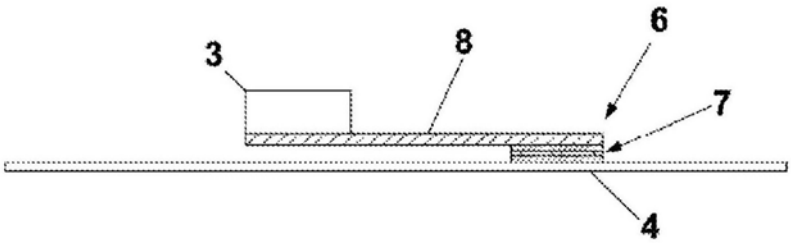

图7

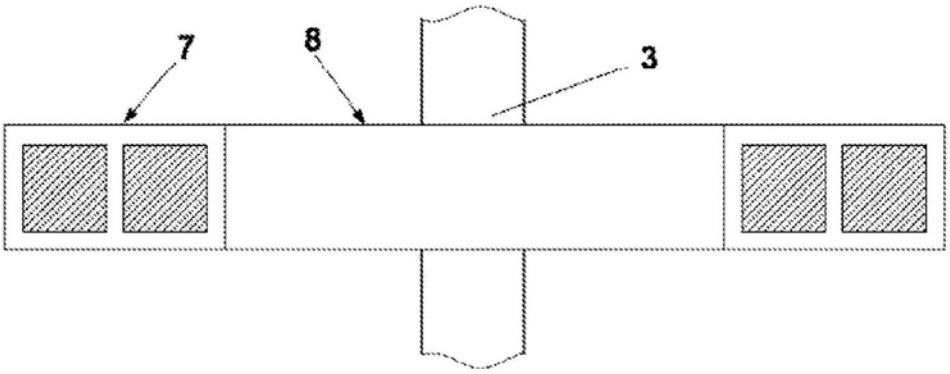

图8

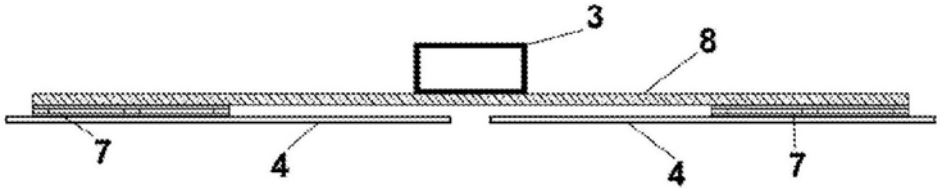

图9

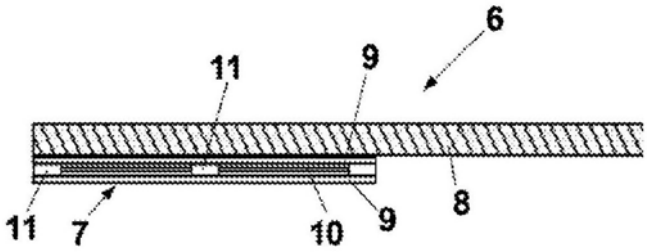

图10

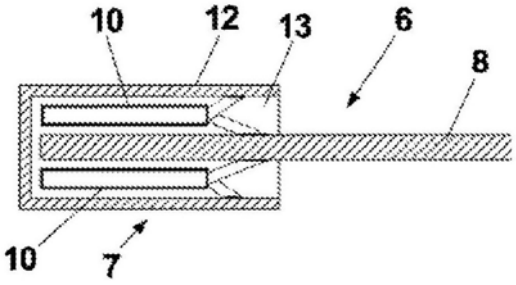

图11

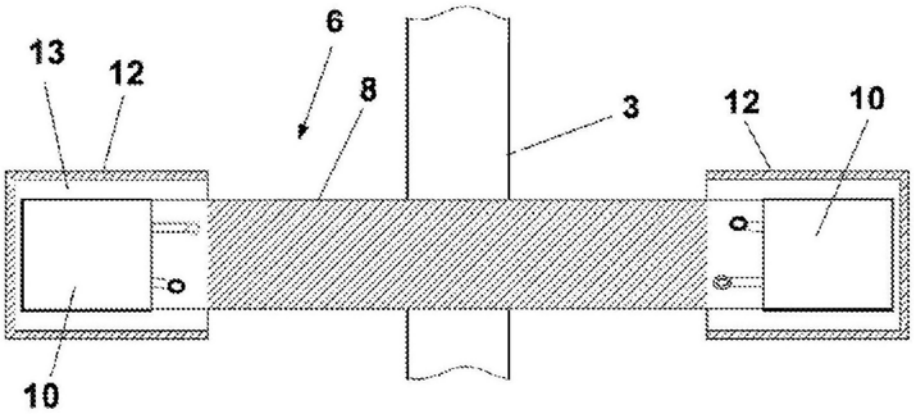

图12

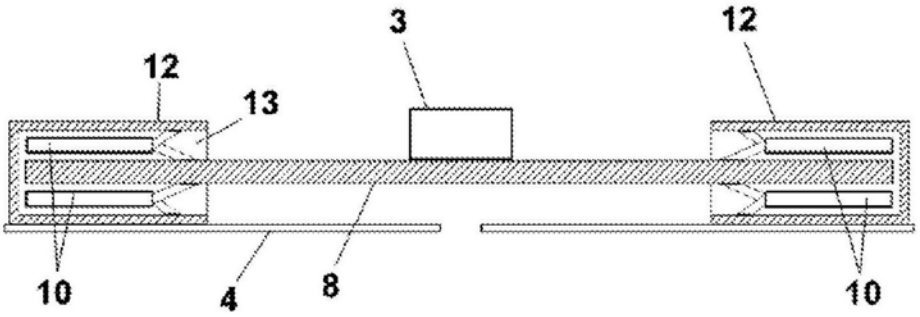

图13

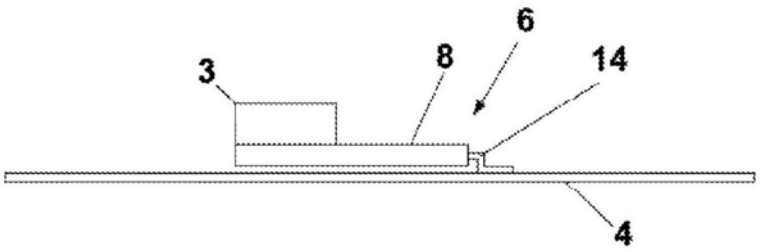

图14

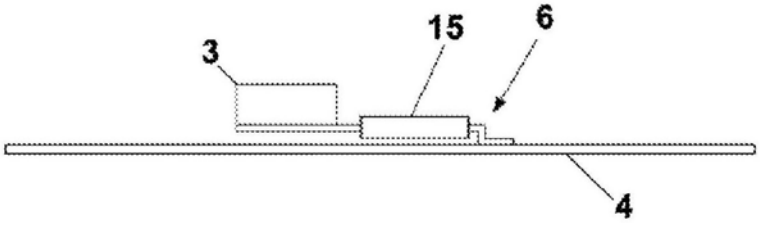

图15

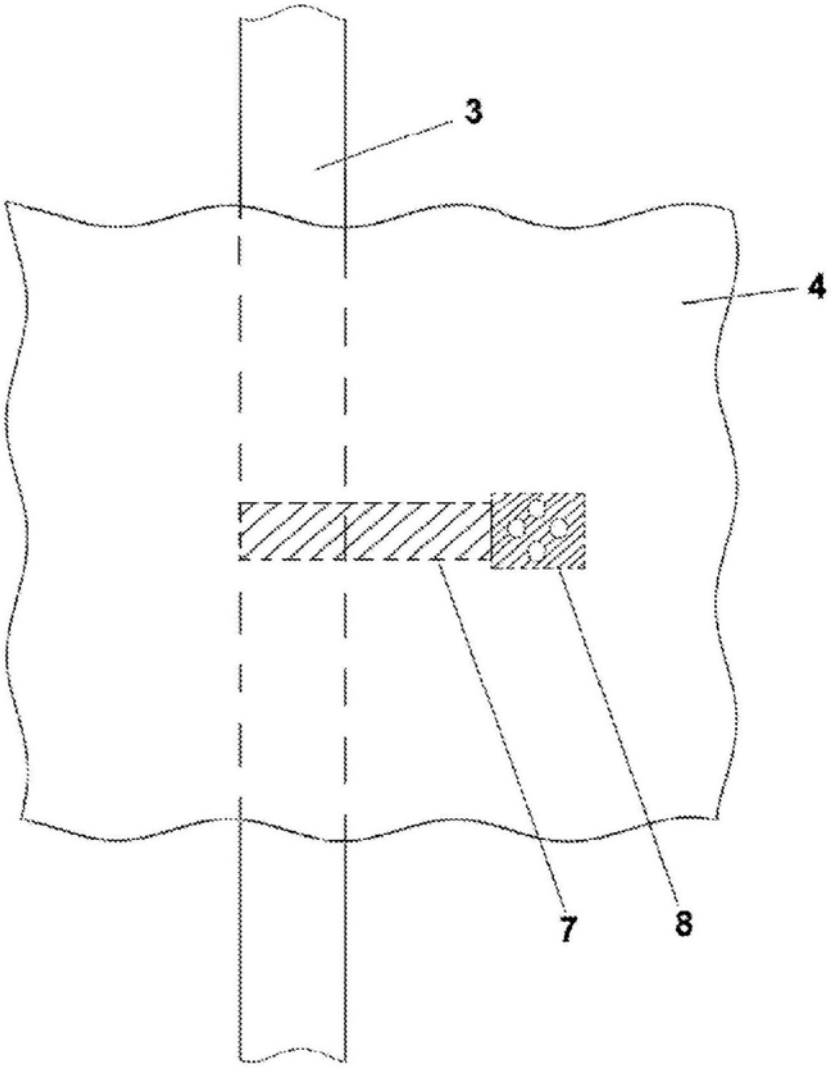

图16

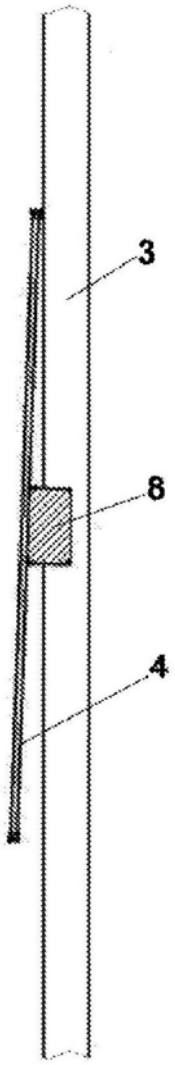

图17

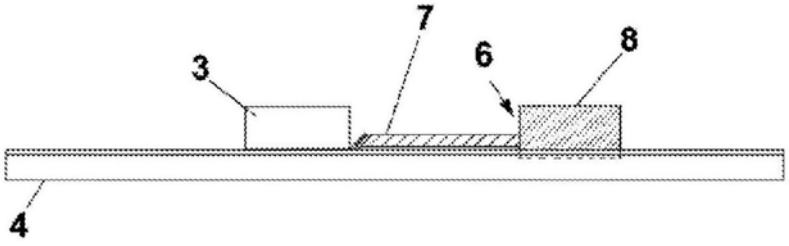

图18

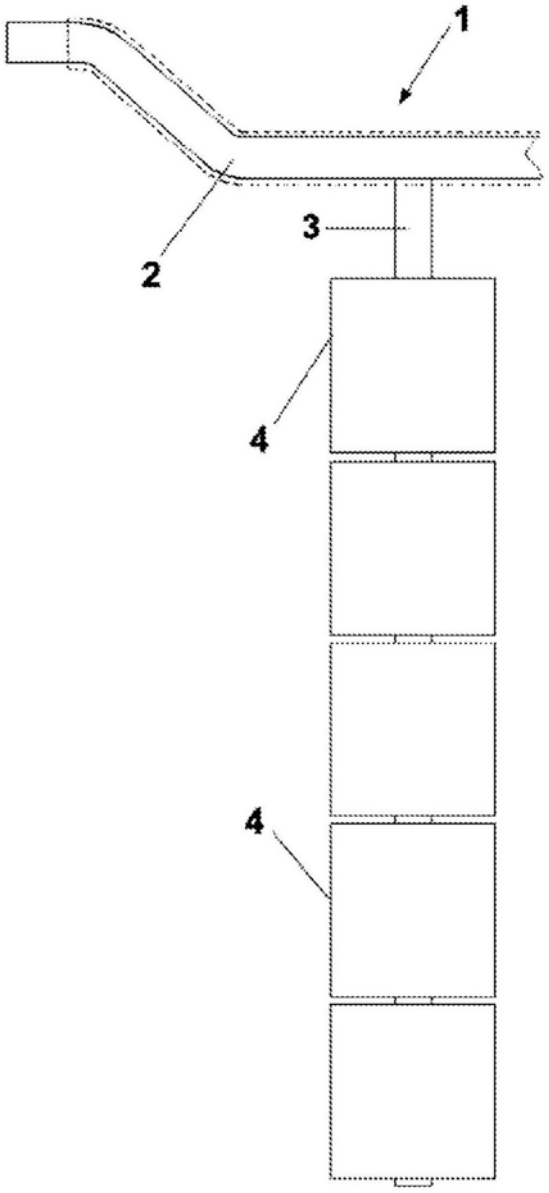

图19

图20

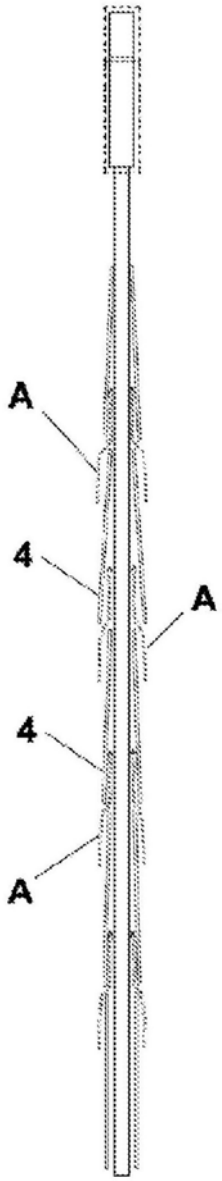

图21

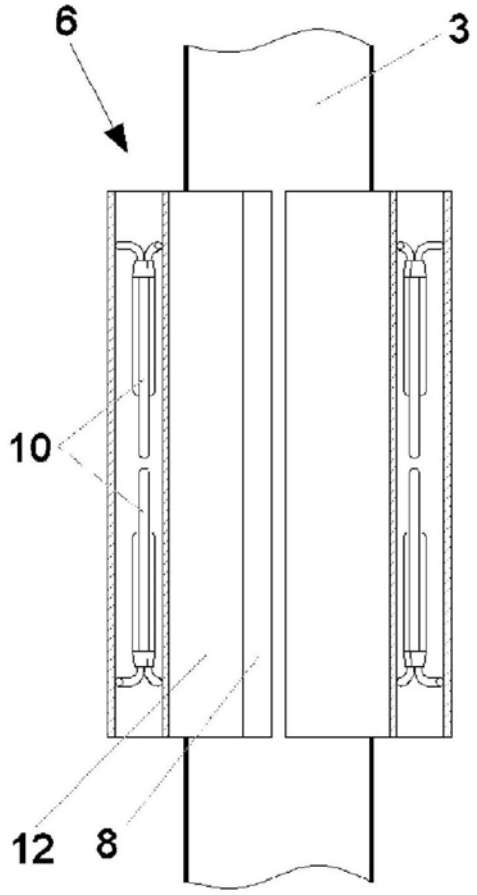

图22

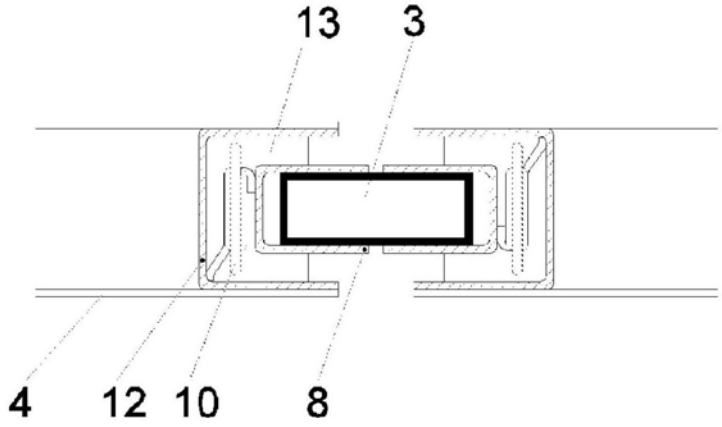

图23