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(54) Title: AN ARRANGEMENT FOR MONITORING A CURRENT DISTRIBUTION IN AN ELECTROLYTIC CELL

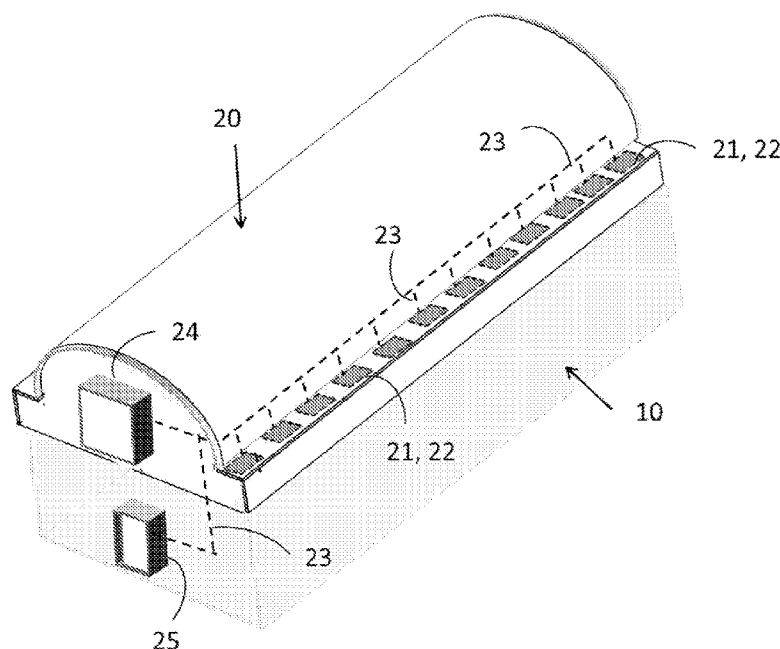


Fig. 2B

(57) Abstract: A removable elongated hood (20) is arranged above the elongated electrolytic cell (10) to cover the electrolytic cell (10) and to capture evolving harmful emissions from the electrolytic cell (10). An arrangement for monitoring a current distribution in the electrolytic cell (10) comprises a plurality of current sensors (21) arranged in the acid mist capture hood (20) at locations that, when the acid mist capture hood (20) is placed in its position above the cell (10), are aligned with locations of cathode electrodes (C).

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AN ARRANGEMENT FOR MONITORING A CURRENT DISTRIBUTION IN AN ELECTROLYTIC CELL

FIELD OF THE INVENTION

The present invention relates to monitoring an operation of an electrolytic process, and particularly to monitoring a current distribution in an electrowinning cell.

BACKGROUND OF THE INVENTION

Electrowinning may be defined as a hydrometallurgical process in which a valuable metal, typically copper, nickel, cobalt or zinc, dissolved in the acidic electrolyte is selectively recovered from the solution by the passage of current through an electrowinning cell. A direct current supply is connected to the anode and cathode. As current passes through the cell, metal is deposited on the cathode. When sufficient metal has been deposited on the cathode, the cathode is removed from the cell, and the deposited metal is recovered from the cathode. This is also referred to as cathode harvesting. Typically the rich electrolyte is pumped through a series of cells or tanks in an electrowinning tankhouse.

In electrowinning tankhouses short circuits can develop between anodes and cathodes because of different disturbances in the process. It is very important to detect and remove short circuits because due to short circuits energy is wasted, production is lost and bags are destroyed in tankhouses where diaphragms are used. All this means increasing expenses and decreasing earnings. Early detection and removal is especially important in tankhouses where mixed metal oxide anodes (MMO) are used because shorts can damage anodes.

Identifying short circuits between the anodes and cathodes was commonly accomplished by measuring a current flowing through a cathode. The current measurement is not a problem in principle. US7445696 discloses identifying short circuits manually using a hand-held Hall effect meter to detect abnormal magnetic fields flowing through the cathode. Such a procedure generally required physically walking over the anodes and cathodes in each cell while closely observing the hand-held meter to detect a large deflection in a meter needle. Oftentimes, the meter was affixed to a distal end of a long stick or pole, whereby it can then be held close to the cathode hanger bar. Regardless, the task was both ergonomically difficult and accident-prone.

Moreover, walking on the cells frequently misaligned the anode and cathodes, could lead to possible contamination, and often lead to further problems as well.

Continuous measurement of the current distribution is more complicated and difficult, because one has to measure current from each cathode in the cell. The current monitoring equipment should be placed somewhere, one has to have a current sensor close to each cathode, get power to each sensor and send the acquired data to somewhere. One obvious position to place the equipment is in the cathode hanger bar. US4394619 discloses a current measurement utilizing a Hall-effect sensor mounted on a cathode hanger bar. However, this approach is very cumbersome, because one should lift and harvest the electrodes. In addition, power source for the measurements is also problematic due to environment, electrode handling and very hot cathode surface temperature during short circuit condition. If one utilizes an external bar on the electrodes for carrying the sensors, it would be rather large and needs to be removed during harvests, being very unpractical. US7445696 discloses autonomous (unmanned) monitoring equipment wherein an external sensor bar is provided and incorporates one Hall effect sensor for each cathode of each electrolytic cell thereby enabling simultaneous measurement of all of the cathodes. Thus, a cathode with a short circuit can be identified. The sensor bar may also be carried by a rail car, an overhead crane, robotic, etc., so as to enable moving the sensor bar from one cell to another for measurement or for harvest.

The cell which has a short circuit or short circuits can be indicated by measuring a drop in a cell voltage. Such approach is disclosed in WO2005/090644, WO2005/052700 and US2011/0054802. This approach has in practice been applied in the CellSenseTM control system and the CellSensorTM device of Outotec Oyj. The CellSensorTM device is a device for measuring the process parameters in an electrolytic process carried out in an electrolytic cell, and for wirelessly transmitting the measured process parameters to the CellSenseTM control system for further analysis. However, the cell voltage measurement cannot detect the exact electrode pair where the short circuit is located in the cell. Also current distribution in the cell must be even and monitoring it would be important in order to detect disturbances, e.g. failure in the anode function, bad contacts or misaligned electrodes. Uneven current distribution leads to too high a current density for some cathodes and

too low for others.

Thus, there still is a need for a continuous current distribution monitoring which is easy and economical to construct, install and maintain while being robust and enabling harvesting of the cathodes.

5 DISCLOSURE OF THE INVENTION

An aspect of the invention is an arrangement recited in the independent claim. The preferred embodiments of the invention are disclosed in the dependent claims.

According to an aspect of the invention an arrangement for
10 monitoring a current distribution in an electrowinning cell comprises a plurality of current sensors arranged in a removable elongated hood arranged above an elongated electrowinning cell to capture an acid mist from the electrowinning cell. The current sensors are arranged in the acid mist capture hood at locations that, when the acid mist capture hood is placed in its position
15 above the cell position, are aligned with locations of cathode electrodes.

The current sensors are attached to an external hood that has also another function, namely to capture an acid mist from the electrowinning cell. Covering the cell with an acid mist collection hood enables to capture evolving harmful emissions from the cell, such as sulphuric acid mist, with a result that
20 no gas masks are required in the cell aisle and health and safety requirements are fulfilled. Need for other safety arrangements and ventilation is reduced. The acid mist capture hood is placed above the electrowinning cell during the electrowinning process and removed for the maintenance and harvesting. Having the current sensors provided in appropriate locations in the acid mist
25 capture hood, the current sensors are always located on the cell close to the cathodes and still automatically removed during cathode harvests. Further, the acid mist collection hood will not be a superfluous component for carrying sensor electrodes but has another independent function which justifies its existence. When integrated, the both functions are implemented more
30 economically.

In an embodiment, the arrangement comprises means for indicating cathode electrodes which cause an uneven direct current distribution in the electrowinning cell based on the measurements of the current sensors. In an embodiment, said indicating means comprise a plurality of alarm indicators,
35 such as LEDs, provided in said acid mist capture hood at locations of said plurality of cathode electrodes to locally indicate cathode electrode or

electrodes causing an uneven direct current distribution in the electrolytic cell.

In an embodiment, the indicating means comprise an indicator panel arranged in the acid mist capture hood or the electrowinning cell to commonly indicate and identify any cathode electrode or electrodes causing an uneven
5 direct current situation in the electrolytic cell. The indicator panel may be a display, for example.

In an embodiment, the current sensors may be energized with electric power taken from electrically conductive busbars which are arranged to supply electric current to the anode and cathode electrodes in the electro-
10 winning cell.

In an embodiment, said energizing means comprise
a common power supply unit arranged to take the electric power from
said electrically conducting busbars, and
a power supply bus in said acid mist capture hood for intercom-
15 necting said plurality of current sensors to said common power supply.

In an embodiment, said energizing means comprise a power supply wiring in said acid mist capture hood for interconnecting said plurality of current sensors to said electrically conducting busbars.

In an embodiment, the arrangement comprises a common
20 processing unit for processing the measurements of said plurality of current sensors, said common processing unit further comprising a wireless communication unit for communicating over a wireless communication network.

In an embodiment, at least one of said common processing unit, said common power supply, and said common indicator panel is part of a
25 measurement unit arranged to measure at least one further process parameter of the cell, preferably at least a cell voltage.

In an embodiment, the arrangement comprises comprising a signal bus in said acid mist capture hood for interconnecting said plurality of current sensors to a further device, such as a common wireless communication unit, a
30 common processing unit and/or a common indicator panel.

In an embodiment, each of said plurality of current sensors comprises a wireless communication unit for communicating with a further device, such as a common processing unit and/or a common indicator panel.

In an embodiment, each of said plurality of current sensors
35 comprises a magnetic sensor arranged to sense a magnetic field induced by the direct current flowing in the respective neighbouring cathode electrode.

In an embodiment, each of said plurality of current sensors comprises a Hall-effect sensor.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following the invention will be described in greater detail by means of exemplary embodiments with reference to the attached drawings, in which

Figure 1A is a top view of an exemplary electrowinning cell;

Figure 1B is a perspective top view of an exemplary electrowinning cell;

Figure 1C is a cross-sectional view of an exemplary electrowinning cell;

Figure 2A is a cross-sectional view of an electrowinning cell having a current monitoring arrangement according to an exemplary embodiment of the invention;

Figure 2B is a perspective top view of an exemplary electrowinning cell having a current monitoring arrangement according to an exemplary embodiment of the invention;

Figure 3 is a block diagram of an exemplary current sensor;

Figure 4 is a block diagram of an exemplary common processing and common power supply unit; and

Figure 5 is a block diagram of an exemplary common indicator panel and a common power supply unit.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Referring now to Figures 1A, 1B and 1C, an exemplary electrolytic tank or cell 10 is shown. The body 13 of the electrolytic cell 10 forms tank which is open at the top and contains an aqueous electrolyte 14. The material of the body 13 of the cell 10 may be any material that tolerates the electrolyte 14. Example of a suitable material is polymer concrete. Anode plates A (i.e., "anodes") and cathode sheets C (i.e., "cathodes") are alternately arranged to hang close to one another and immersed in the electrolyte 14. The anodes A and cathodes C cell are in ear-contact with positive and negative current busbars or rails 12 that run lengthwise of the elongated electrolytic cell 10. The busbar 12 may provide contact the support lugs 15 and 16 with both sides of each anode and cathode, such as the Double Contact Bus Bar System available from Outotec. When the anodes A are connected to the positive (+)

current busbar 12 and the cathodes C are connected to the negative (-) current busbar 12, the busbars 12 carry electrical current to the electrolytic cell 10 to assist in metal ion migration from the anodes A to the cathodes C. More specifically, during the electrowinning a rich electrolyte is pumped through the electrolytic cell and a direct current passes from the anode A through the electrolyte to the negatively charged cathode C, i.e. a starter sheet or blank, causing the metal (e.g. copper) ions in the electrolyte solution to plate (attach) onto the starter sheet or blank. The thin sheets of the metal to be recovered may be called starter sheets, and sheets of another metal, such as stainless steel sheets, may be called blanks. The anode sheets A may be made of lead, for example. After having been for a relatively long time in the electrolytic cell, such as several days, sufficient amount of metal has been deposited on the cathode sheets C and the cathodes are harvested. The number of cathodes per cell may vary depending on the application from less than ten up to 100. In Figure 1C anode A, which is shown in the foreground, is placed lower down than cathode C which is in the background. As is generally the case, the anodes and cathodes are placed in the cell alternately. The cathodes C and the anodes A are supported by support lugs 15 and 16, respectively, to the busbar 12 placed on side walls of the body 13 electrolytic cell 10. In the example shown, the side wall may also provide a partition wall between two adjacent electrolytic cells or tanks 10. Typically, there is a plurality of the electrolytic cells or tanks in an electrowinning tankhouse. Only the support lugs of the anodes and cathodes of the neighboring cells are visible in Figure 1C. The busbar 12 may provide contact the support lugs 15 and 16 with both sides of each anode and cathode.

Referring now to Figures 2A and 2B, an exemplary electrolytic cell having a current monitoring arrangement according to an exemplary embodiment of the invention is shown. The structure of the electrolytic cell 10 and the cathodes C and the anodes A may be similar to that described with reference to Figures 1A, 1B and 1C. Same reference symbols refer to same structures and functions in all figures. However, it should be appreciated that the present invention is not limited to any specific type of electrolytic cell but may applied to any electrolytic cell type suitable for electrowinning.

In the example of Figures 2A and 2B, a removable elongated hood 20 is arranged above the elongated electrolytic cell 10 to cover the electrolytic cell 10 and to capture evolving harmful emissions from the electrolytic cell 10.

The acid mist capture hood 20 is placed above the electrolytic cell 10 for the electrowinning process and is removed for the maintenance and harvesting. It should be appreciated that an overall acid mist capture system may contain various other components in addition to the hood 20, such as gas removal
5 ducts, off-gas scrubber with drop separator, off-gas fan, stack and water recycling system. These may be integrated into the cell 10, the hood 20 or they may be separate components. However, from the invention point of view only the presence of the acid mist capture hood 20 is expected.

According to an aspect of the invention an arrangement for
10 monitoring a current distribution in the electrolytic cell 10 comprises a plurality of current sensors 21 arranged in the acid mist capture hood 20 at locations that, when the acid mist capture hood 20 is placed in its position above the cell 10, are aligned with locations of cathode electrodes C. The current sensors 21 may preferably be provided at a longitudinal side of the hood 20 inside the
15 hood 20 where the current sensors 21 are inherently close to the cathodes C, or more particularly the support lugs 15 thereof, but the current sensors may alternatively be provided closer to the longitudinal axis of the hood 20. There may be current sensors 21 on both sides of the hood 20, particularly if the busbar 12 may provide contact for the support lugs 15 with both sides of each
20 cathode C. There may be more than one current sensor 21 for each cathode C.

In an embodiment, the current sensors 21 may be energized with electric power taken locally from the busbars 12. The current sensors 21 may have associated contact elements to make an electrical contact with the
25 busbar 12 when the hood 20 is placed to cover the electrolytic cell 10.

In an embodiment, the current sensors 21 may be energized from a common power supply unit 24 or 25 over a power supply bus 23 provided in the acid mist capture hood 20 for interconnecting the current sensors 21 to the common power supply. The common power supply unit 24 or 25 may be
30 arranged to take the electric power from the busbars 12. The common power supply unit 24 or 25 may be provided in the hood 10 or in the cell 10, preferably at one end thereof as illustrated in Figure 2B. The power supply bus 23 may implemented with any suitable cabling or like. If the common power supply unit 25 is in the cell, a connector may be provided between the hood 20
35 and the cell 10 to automatically provide an electrical connection when the hood 20 is placed to cover the electrolytic cell 10, and to disconnect the electrical

connection during the harvests. Alternatively, the power supply bus or cable 23 may be manually plugged on and off.

In an embodiment, a plurality of alarm indicators 22, such as LEDs, may be provided in said acid mist capture hood 20 at locations of the cathodes C to locally indicate cathode electrode or electrodes causing an uneven direct current distribution in the electrolytic cell C. The alarm indicators 22 are arranged in a manner that they can be seen from outside of the hood 20. Each alarm indicator 22 are electrically connected to and driven by the current sensor 21 of the respective cathode C. The alarm indicators 22 may be integrated with the current sensors 21.

In an embodiment, an indicator panel 24 or 25, such as display unit, may be arranged in the acid mist capture hood 20 or the electrolytic cell 10 to commonly indicate and identify any cathode electrode or electrodes C causing an uneven direct current situation in the electrolytic cell 10. The indicator panel 24 or 25 may preferably be located at one end thereof as illustrated in Figure 2B. The indicator panel may display the number or other identity of the cathode C, for example. The current sensors may be connected to the indicator panel 24 or 25 by means of a signal bus provided in the acid mist capture hood 20. The signal bus may be implemented by means of a dedicated line or cable for each current sensor 21. Preferably, the signal bus may be implemented by means of a common bus or a cable to which all current sensors 21 are connected. More preferably, the signal bus may be implemented by means of the same bus or cabling as the power supply bus, e.g. both the electric power and the information may be transferred of the same bus 23. The information transfer may be digital information transfer. In an embodiment, the information between the current sensors 21 and the indicator panel 24 or 25 may be transferred over a wireless connection. This may particularly be the case, if there is no common power supply unit for the current sensors 21.

In an embodiment, the arrangement comprises both the common indicator panel 24 or 25 and the plurality of alarm indicators 22.

In an embodiment, the current sensors 21 may manage the measurement and sampling locally. There may further be a common processing unit 24 or 25 that may be arranged to read or receive or collect the measurement data from the sensors and to perform further processing of the measurement data, such a current distribution calculations. Thus, the current sensors 21 can be maintained as simple as possible. The information transfer

and the current sensors 21 to the common processing unit 24 or 25 may be implemented in a similar manner as described above for the common indicator panel. The common processing unit 24 or 25 may make decision on which cathode electrode or electrodes are causing an uneven direct current distribution in the electrolytic cell C and indicate them to the user, e.g. by means of the common indicator panel. The common processing unit 24 or 25 may transmit the processed measurement data further to a central unit, such as a server. The central unit may collect data from a plurality of common processing units 24 or 25 located in different electrolytic cells 10 in the tank house. The transmission of the processed measurement data may preferably be performed over a wireless network. The common processing unit may also operate only as a common wireless unit.

The common processing unit 24 or 25 may also control the common indicator panel.

In an embodiment of the invention, the common processing unit, the common indicator panel, and the common power supply may be implemented in a same unit 24 or 25.

In an embodiment of the invention, the common processing unit and the common indicator panel may be implemented in a same unit, and the common power supply may be implemented in a separate unit.

In an embodiment of the invention, the common processing unit and the common power supply may be implemented in a same unit 25, and the common indicator panel may be implemented in a separate unit 24.

In an embodiment of the invention, the common processing unit and the common power supply may be implemented by means a measurement unit existing in a electrolytic cell 10 for measuring other process parameters of the electrolytic cell 10, such as a temperature and/or a cell voltage. Such measurement unit may already have a sufficient processing capacity and a wireless transmission capability as well as a power supply which can be shared with the arrangement for monitoring a current distribution in the electrolytic cell. Thus, additional equipment and cost required for the current distribution monitoring can be further reduced. Examples of a suitable device are disclosed in WO2005/090644, WO2005/052700 and US2011/0054802. Example of such a measurement unit is a CellSensor™ system device available from Outotec. CellSensor™ system is a data collection system, based on robust wireless communication and powered by the cell bus bar

voltage. Cell voltage, electrolyte temperature and other diagnostic data are collected a plurality of CellSensor devices through the wireless and redundant CellSensor™ network to the CellSense™ Server computer. The central unit described above may be implemented by means of the the CellSense™
5 Server computer. Thus, also the collection of current distribution measurement data from the tankhouse can be implemented without new equipment.

In preferred exemplary embodiments, the current sensors 21 are implemented based on a Hall-effect sensor. A block diagram of an exemplary current sensor 21 is illustrated in Figure 3. A Hall-effect sensor device 211,
10 such as a Hall-effect microchip is mounted inside the hood 20. The Hall effect sensor 21 is a transducer that varies its output voltage in response to a magnetic field. In its simplest form, the sensor operates as an analog transducer, directly returning a voltage. For example, in this case, when the location in relation to the adjacent cathode C is fixed, the output voltage of the
15 Hall-effect sensor 211 may vary according to a magnetic field caused by the current flowing through the cathode C. The output voltage of the Hall-effect sensor 211 is monitored by a sensor control 212. The sensor control 212 may be an analog circuit or a logic or a digital circuit. For example, the sensor control 212 may be an analog or digital comparator which compares the
20 measured voltage with a predetermined limit or predetermined upper and lower limits. If the measured voltage reaches the limit, the sensor control 212 may activate a LED-driver circuit 214 to activate the alarm indicator led 22 or to change the colour of the alarm indicator led 22. Alternatively or in addition to, the sensor control 212 may send an alarm notification to a common indicator
25 panel and/or a common processing unit 24 or 25 through the bus interface 210 and a communication /power supply bus 23. As a further example, the sensor control 212 may store and/or forward the measurement data to a common processing unit 24 or 25 through the bus interface 210 and a communication /power supply bus 23. The type of the bus interface 210 depends on the type
30 of the bus 23 and on the type transmission standard used. The current sensor 21 may obtain its electric power through a power interface either from the common power supply bus 23 or directly from the busbar 12 via the contact 24.

A block diagram of an exemplary common processing and power supply unit 25 is illustrated in Figure 4. A controller 252 performs all data
35 processing and controls the operation of the unit 24. The controller 252 may communicate with the plurality of current sensors 21 through the bus interface

250 and a communication/power supply bus 23. The type of the bus interface 250 depends on the type of the bus 23 and on the type transmission standard used. The unit 25 obtain its electric power through a power supply 250 from the busbar 12 of the electrolytic cell 10. The power supply 253 may also be
5 arranged to supply electric power to the plurality of current sensors 21 over the common power supply bus 23. The controller 252 may also be arranged to measure e.g. a cell voltage or other process parameters through a cell voltage interface 254. The controller 252 may control the measurements through the interface 250 and 254, and it may process the obtained measurement results
10 and/or transmit the raw measurement data or the processed measurement data to a central unit over a wireless network interface 251, such as a WLAN adapter. The controller 252 may also control a common display panel 24 to indicate and identify any cathode electrode or electrodes C causing an uneven direct current situation in the electrolytic cell 10. The display 4 may display the
15 number or other identity of the cathode C, for example. The display 24 may be integrated in to the unit 25, or it may be separate unit as illustrated in Figure 2B. In the former case the controller 252 may control the display 24 via an internal bus, while in the latter case the controller 252 may control the display 24 via the communication bus 24.

20 A block diagram of an exemplary common display unit 24 is illustrated in Figure 5. A controller 242 controls the operation of the display 244. The controller 242 may communicate with the plurality of current sensors 21 and/or the processing unit 25 through the bus interface 240 and a communication/power supply bus 23. The type of the bus interface 240
25 depends on the type of the bus 23 and on the type transmission standard used. The unit 25 may obtain its electric power through a power supply 240 from the busbar 12 of the electrolytic cell 10. The power supply 243 may also be arranged to supply electric power to the plurality of current sensors 21 over the common power supply bus 23. Alternatively the power supply 243 may
30 receive the electric power over the common power supply bus 23 from a common power supply, such as from the power supply 253 in Figure 4.

Embodiments of the present invention may provide one or more of the following advantages: enables continuous, automatic current measurement for each electrode; makes process control very easy: shorts and bad contacts
35 are indicated directly in the place; process/equipment failures can be removed immediately; decreases labor costs; no labor is needed to walk from cell to cell.

It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

Claims

1. An arrangement for monitoring a current distribution in an electrowinning cell, comprising
 - 5 a removable elongated hood arranged above an elongated electrowinning cell to capture an acid mist from the electrowinning cell,
 - a plurality of current sensors arranged in the acid mist capture hood at locations that, when the acid mist capture hood is in a use position, are aligned with locations of cathode electrodes among a plurality of transverse
 - 10 anode electrodes and transverse cathode electrodes alternating in the longitudinal direction of said elongated electrowinning cell, each said plurality of current sensors being arranged to measure a direct current flowing in the respective aligned cathode electrode, and
 - means for indicating cathode electrodes which cause an uneven
 - 15 direct current distribution in the electrowinning cell based on the measurements of the current sensors.
2. The arrangement as claimed in claim 1, wherein said indicating means comprise a plurality of alarm indicators provided in said acid mist capture hood at locations of said plurality of cathode electrodes to locally
- 20 indicate cathode electrode or electrodes causing an uneven direct current distribution in the electrolytic cell.
3. The arrangement as claimed in claim 1 or 2, wherein said indicating means comprise an indicator panel arranged in the acid mist capture hood or the electrowinning cell to commonly indicate and identify any cathode
- 25 electrode or electrodes causing an uneven direct current situation in the electrolytic cell.
4. The arrangement as claimed in any one of claims 1-3, comprising means for energizing said plurality of current sensors with electric power from electrically conductive busbars which are arranged to supply
- 30 electric current to said plurality of anode and cathode electrodes in said electrowinning cell,
5. The arrangement as claimed in claim 3, wherein said energizing means comprise
 - a common power supply unit arranged to take the electric power from
 - 35 said electrically conducting busbars, and
 - a power supply bus in said acid mist capture hood for inter-

connecting said plurality of current sensors to said common power supply.

6. The arrangement as claimed in claim 3, wherein said energizing means comprise a power supply wiring in said acid mist capture hood for interconnecting said plurality of current sensors to said electrically conducting
5 busbars.

7. The arrangement as claimed in any one of claims 1 - 6, comprising a common processing unit for processing the measurements of said plurality of current sensors, said common processing unit further comprising a wireless communication unit for communicating over a wireless
10 communication network.

8. The arrangement as claimed in any one of claims 1 - 7, wherein at least one of said common processing unit, said common power supply, and said common indicator panel is part of a measurement unit arranged to measure at least one further process parameter of the cell, preferably at least
15 a cell voltage.

9. The arrangement as claimed in any one of claims 1 - 8, comprising a signal bus in said acid mist capture hood for interconnecting said plurality of current sensors to a further device, such as a common wireless communication unit, a common processing unit and/or a common indicator
20 panel.

10. The arrangement as claimed in any one of claims 1 - 8, wherein each of said plurality of current sensors comprise a wireless communication unit for communicating with a further device, such as a common processing unit and/or a common indicator panel.

25 11. The arrangement as claimed in any one of claims 1 - 10, wherein each of said plurality of current sensors comprises a magnetic sensor arranged to sense a magnetic field induced by the direct current flowing in the respective neighbouring cathode electrode.

12. The arrangement as claimed in any one of claims 1 - 11,
30 wherein each of said plurality of current sensors comprises a Hall-effect sensor.

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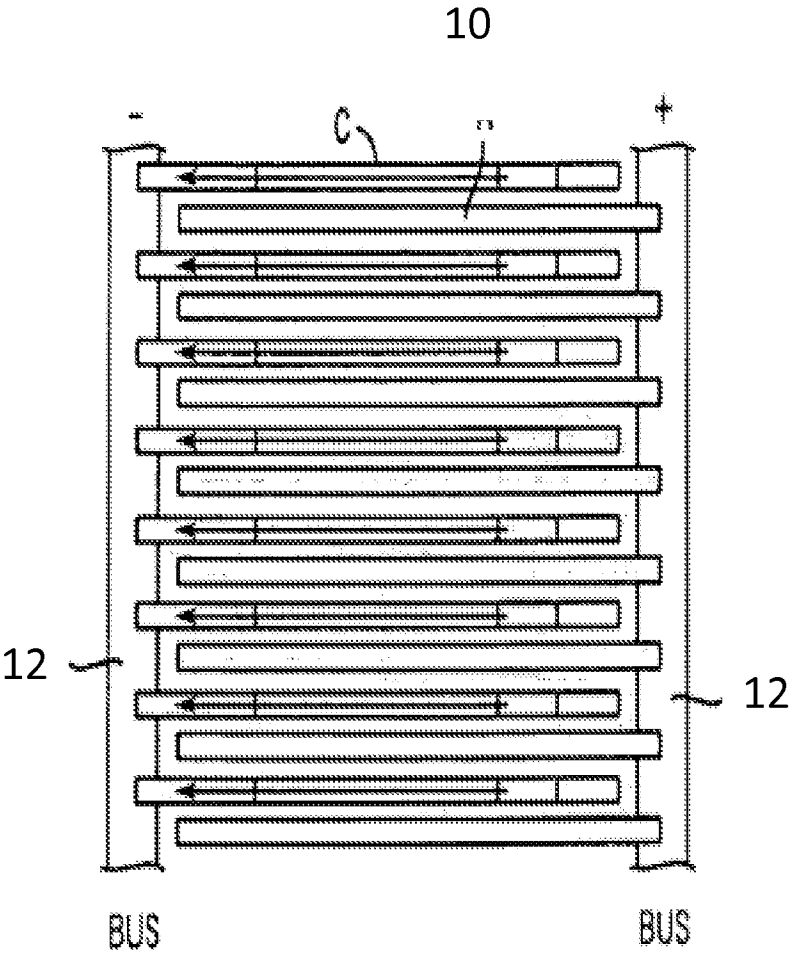


Fig. 1A

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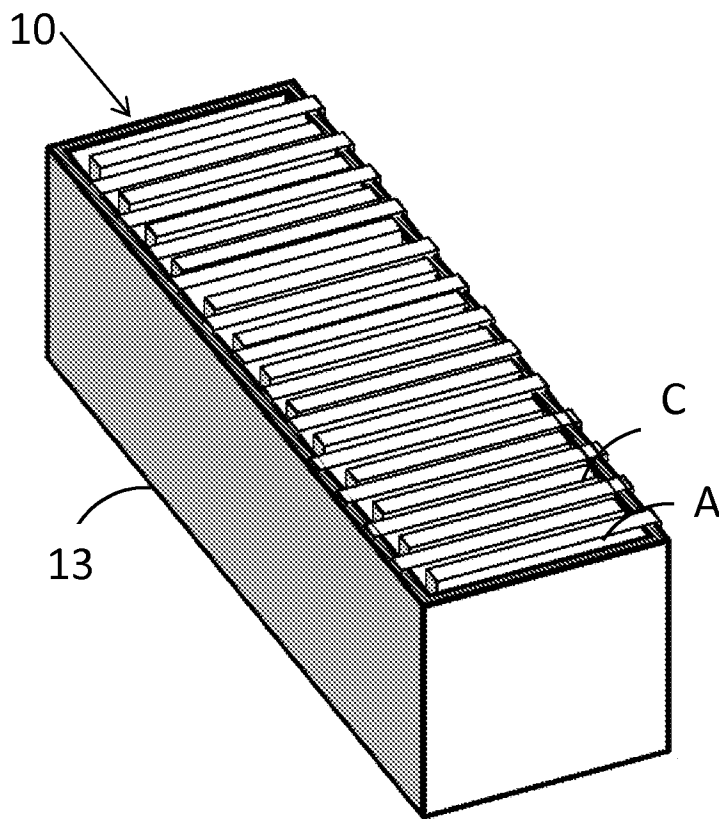


Fig. 1B

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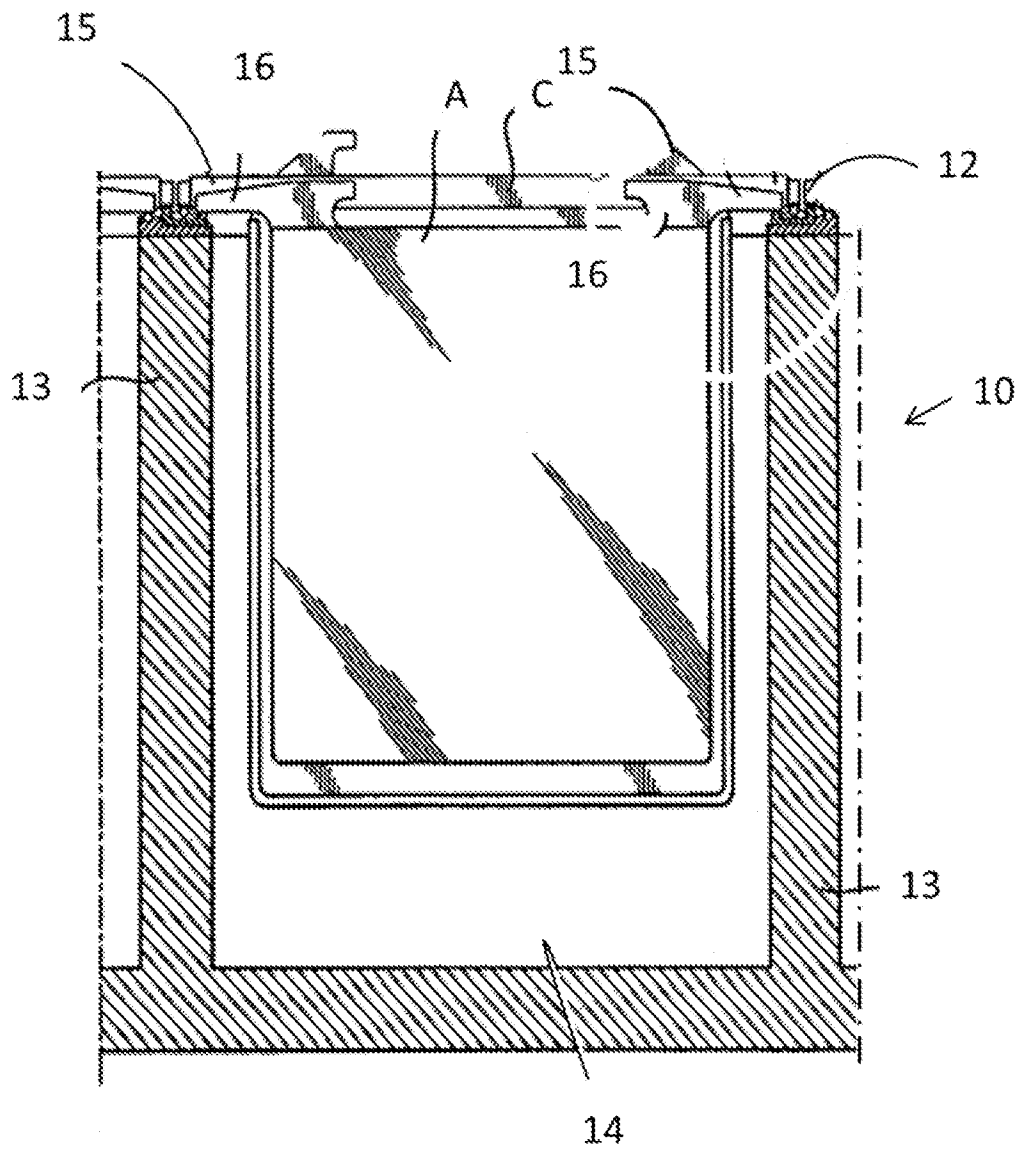


Fig. 1C

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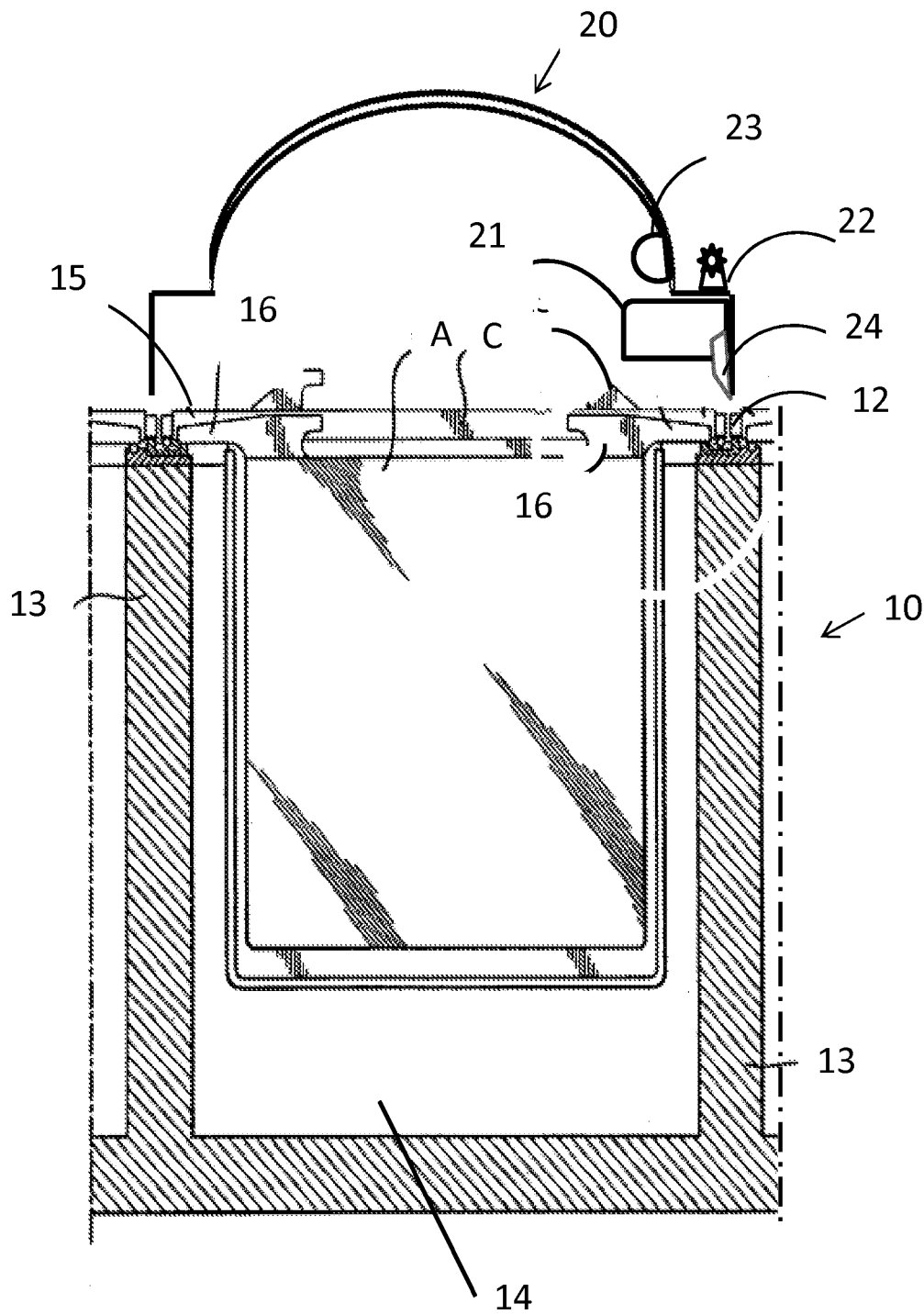


Fig. 2A

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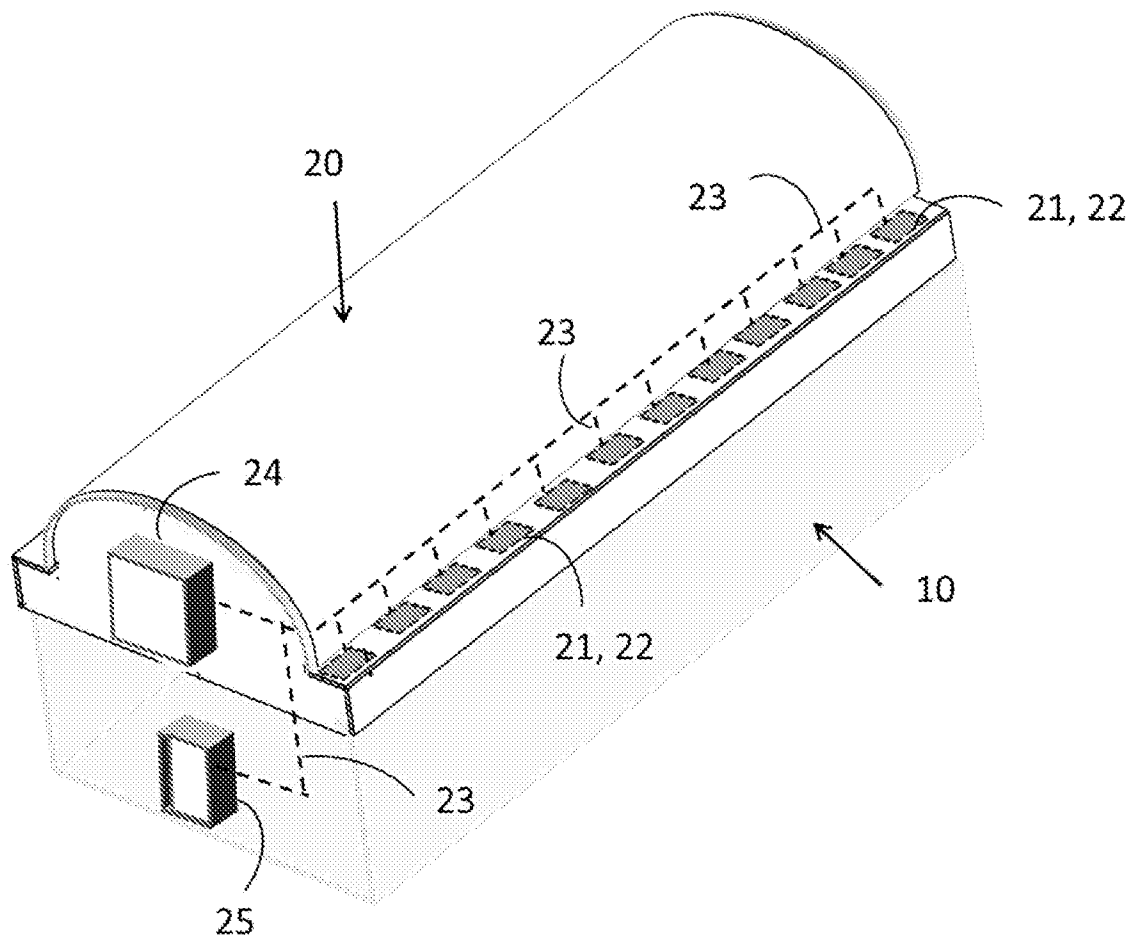


Fig. 2B

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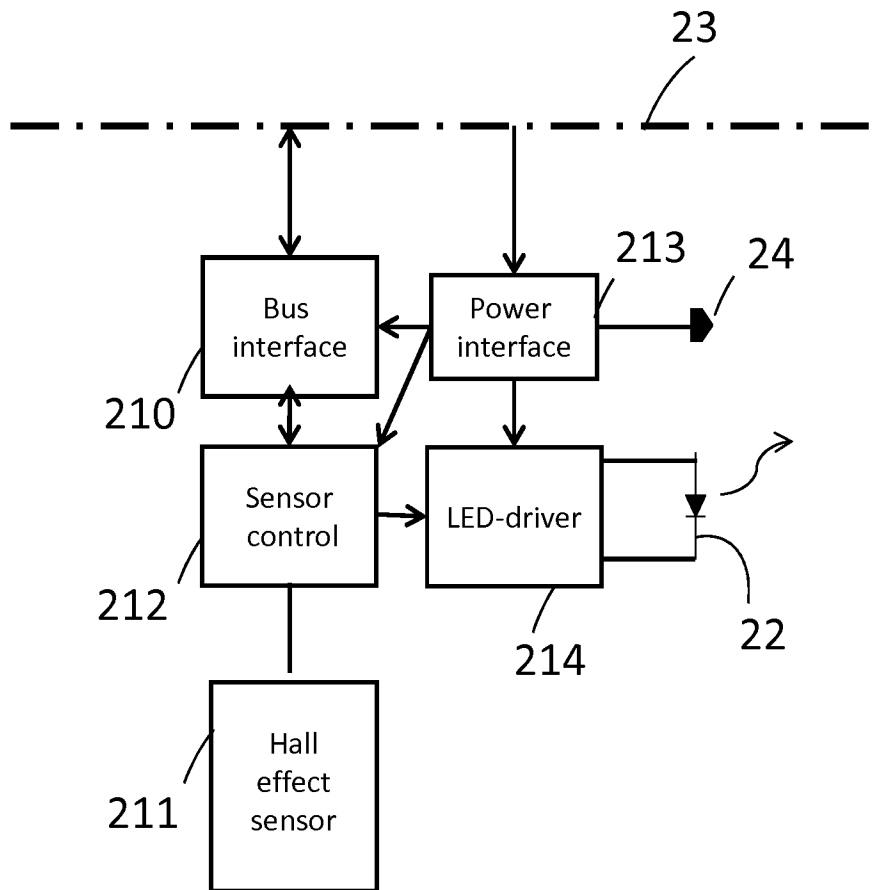


Fig. 3

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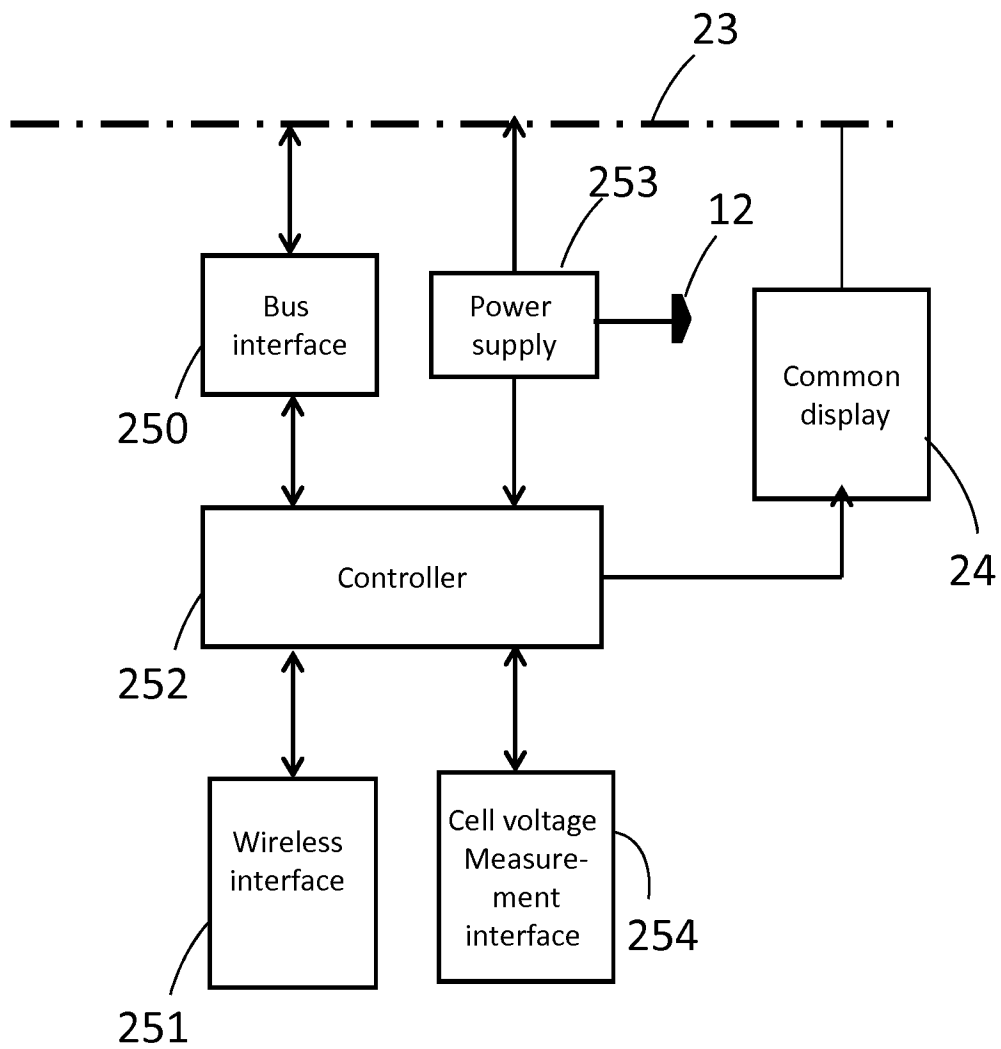


Fig. 4

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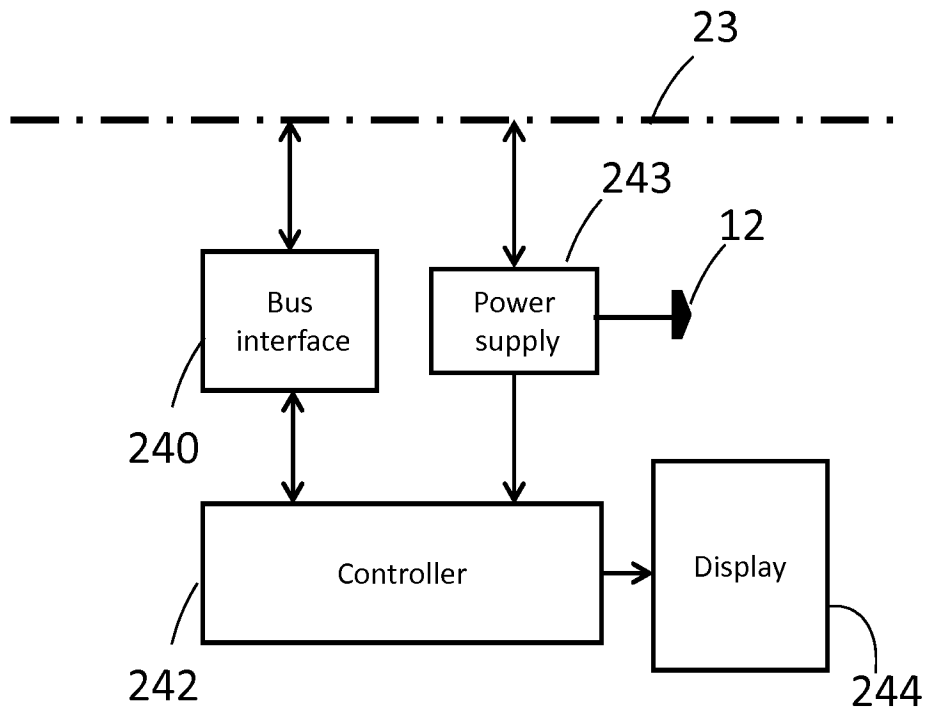


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2013/051075

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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)

IPC: C25C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
FI, SE, NO, DK

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI, XPIEE, XPI3E, BIOSIS, COMPDX, INSPEC, XPAIP, XPESP, XPESP2, XPIOP, NPL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2009016190 A2 (ANCOR TERMIN S A [CL]) 05 February 2009 (05.02.2009) abstract; page 14, lines 29-37; page 16, lines 31-36; page 20, lines 16-30; page 22, lines 11-19; page 26, lines 4-12; figures 3, 7	1-12
A	US 7445696 B2 (YOU EUGENE YANJUN [US] et al.) 04 November 2008 (04.11.2008) abstract; the whole document	1-12
A	US 2006213766 A1 (YOU EUGENE Y [US]) 28 September 2006 (28.09.2006) the whole document	1-12



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

06 March 2014 (06.03.2014)

Date of mailing of the international search report

11 March 2014 (11.03.2014)

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2013/051075

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	Aqueveque P., et al., Short-Circuit Detection for Electrolytic Processes Employing Optibar Intercell Bars, IEEE Transactions on Industry Applications, Vol. 45, No. 4, Pages 1225-1231, 01.07.2009 the whole document	1-12

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INTERNATIONAL SEARCH REPORT

International application No.
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CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

C25C 7/06 (2006.01)