(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 643 813 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
29.04.2020 Bulletin 2020/18

(21) Application number: **18895625.4**

(22) Date of filing: **21.12.2018**

(51) Int Cl.:
C25C 3/16 *(2006.01)* ***C25C 7/02*** *(2006.01)*

(86) International application number:
PCT/RU2018/050166

(87) International publication number:
WO 2019/132737 (04.07.2019 Gazette 2019/27)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **29.12.2017 RU 2017147133**

(71) Applicant: **Obshchestvo s Ogranichennoy Otvetstvennost'yu "Obedinennaya Kompaniya Rusal Inzhenerno-Tekhnologicheskiy Tsentr"**
Krasnoyarsk 660111 (RU)

(72) Inventors:
- **MANN, Viktor Khrist'yanovich**
  Krasnoyarsk 660111 (RU)
- **PINGIN, Vitalij Valer'evich**
  Krasnoyarsk 660111 (RU)
- **PLATONOV, Vitalij Vladimirovich**
  Krasnoyarsk 660111 (RU)
- **ZAVADYAK, Andrej Vasil'evich**
  Krasnoyarsk 660111 (RU)

(74) Representative: **Tobiasz-Dumania, Katarzyna**
Baker & McKenzie
Krzyzowski i Wspolnicy sp. k.
Rondo ONZ 1
00-124 Warszawa (PL)

(54) MODULAR BUSBAR FOR SERIES OF ALUMINIUM ELECTROLYZERS

(57) A busbar consists of an anode part which is capable of connecting anodes in a series of electrolyzers by means of anode buses, a cathode part which consists of cathode rods with flexible packets and is capable of being connected to an anode part of a following electrolyzer in a series by means of a bus-type module comprising assembled cathode buses on the input side and on the output side of a cathode shell, connecting buses arranged under the bottom of an electrolyzer, at least one anode riser arranged on the input side and at least one anode riser arranged on the output side of an electrolyzer. The busbar is capable of supplying currents for two identical series of electrolyzers consisting of a single row of electrolyzers formed independently of one another in terms of power supply and having an opposite current direction, and comprises a correction bus.

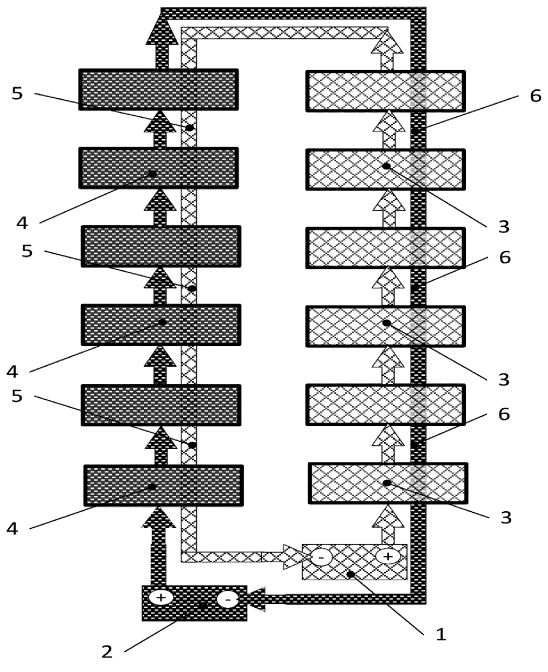


FIG. 1

EP 3 643 813 A1

Description

[0001] The invention relates to aluminum smelting by the method of electrolysis of melted cryolite salts in electrolysis cells (pots) arranged side-by-side in the cell (pot) room.

[0002] A busbar system is a current-conductive element of an electrolysis cell structure and consists of two parts, anodic and cathodic. Electrolysis cells arranged in rows one after another are coupled with each other by current conductors made of aluminum or copper busbars of different cross-section and connected in an electrical circuit in series: cathode busbars of one cell are connected to anode busbars of another cell. A group of electrolysis cells combined into one electrical circuit is called a potline (or cell line). The anode part of the busbar system comprises flexible straps in a stack (or flexible strap stacks), anode risers and anode buses. The current is transferred from the anode buses to aluminum anode rods, and then to prebaked carbon (anode) blocks. The cathode part of the busbar system comprises flexible straps in stacks (or flexible strap stacks) that drain current from collector bars in the bottom of the cell to main (collecting) cathode buses, and then to cathode buses.

[0003] There are many known busbar system designs for electrolysis cells. A busbar system is developed for a specific electrolysis cell design using computer-based mathematical models (or simulations) and depends on cell type, cell amperage, cell position in the pot (or cell) room and in the potline, the availability of adjacent (or neighboring) pot rooms, local climate, the remoteness of raw materials suppliers, product consumers, and the cost of electricity, raw materials and finished products.

[0004] When developing a busbar system, it is a common practice to be guided by the following conditions:

- Compliance of design solutions with safety rules (SR) and an electrical safety code (ESC);
- Optimal current density in a busbar system and current-carrying parts of an electrolysis cell;
- Balanced Lorentz forces on the melt, i.e. optimal electric and magnetic fields in the melt;
- Possibility to quickly and safely disconnect (cut out) and connect (cut in) one cell or a group of cells from/to an electrical circuit without having operational perturbations in adjacent (or neighboring) cells and without breaking or curtailing the potline amperage;
- Buses in Russia are currently manufactured mainly from A7E grade aluminum having a temperature coefficient of electrical resistance of 0.004. This means that when the bus temperature changes by 10°C, its resistance changes by 4%, which should also be taken into account. In practice, this can be taken into account only roughly, since the temperature of any bus depends not only on the density of current flowing through it (the Joule-Lenz law), but also primarily on its thermal balance that is determined by busbar shape, weight and material, molecular heat dissipation or heating from another thermal source, heat dissipation or generation through radiation, convective heat exchange or the influence of sources of cold;
- When designing cathode and anode busbar systems, it is desirable to have a more uniform current distribution in collector bars and anodes in order to minimize planar currents in the metal that adversely affect the magnetohydrodynamic (MHD) stability of electrolysis cells, which results in the degradation of their technical and economic performance indicators (TEPI);
- When designing, the flexible strap stacks of the anode busbar system should be calculated in such a way that they do not experience mechanical damage during anode beam (or rack) movement up and down to the limit switches and limit stops within a pre-set range; and
- A potline with a busbar system should be reliably insulated from 'earth' and from the cathode shell to reduce current leakage. Current leakages not only determine direct current losses, which cannot be used in the process of electrolysis, but also cause the hard-to-remove MHD instability of the melt in electrolysis cells, in those places that are close to current leakages.

[0005] There is a known busbar system for electrolysis cells that are arranged side-by-side in the potroom, which contains main (collecting) busbars with cathode flexibles installed along the upstream and downstream longitudinal sides of the cell, and anode risers installed on the upstream side, through which equal currents flow. The anode busbar system is connected with the previous cell by means of risers, where the outermost risers are connected to the outermost main (collecting) cathode busbars of the upstream side of the cell by busbar stacks located along the end faces of the cell and to the main (collecting) cathode busbars of the downstream side of the cell, while the middle risers are connected to the middle main (collecting) busbars of the upstream side of the cell by busbar stacks arranged symmetrically under the cathode blocks being closest to the cell ends and to the main (collecting) cathode busbars of the downstream side of the cell, wherein the busbar extending under the bottom and located closer to an adjacent (or neighboring) row of electrolysis cells carries 15% of the upstream side current, while the other one carries 10% of the upstream side current, and there is an intermediate busbar under the cell bottom that extends halfway between the potline axis and the cell end, on the side opposite to the adjacent (or neighboring) row of electrolysis cells, wherein 5% of the upstream side current flows through this busbar (patent FR2552782, PECHINEY ALUMINIUM, IPC C25C 3/08, 1985).

[0006] A disadvantage of the above busbar system is the impossibility of using it for electrolysis cells operating

at an amperage of greater than 380 kA, since asymmetrical busbar systems, from a design point of view, have limitations in compensating for the magnetic field that is picked up from an adjacent row of electrolysis cells.

[0007] There is a known current supply/drainage apparatus to/from aluminium reduction cells with double-row, side-by-side arrangement in a row, which comprises an anode busbar system connected to anodes by anode rods, a cathode busbar system composed of collector bars with flexible strap stacks projecting on both sides of the cathode shell of the cell with a bottom, main (collecting) cathode busbars on the upstream and downstream sides of the cathode shell of the cell, connecting busbars, a shunt element, a connection between the cathode and anode busbar systems, and magnetic field correction (compensation) loop busbars that are located in parallel to the transversal axis of the electrolysis cell near the cathode shell ends. The connection between the cathode busbar system and the anode busbar system of the following cell in a row is made in the form of bus modules composed of two semi-risers, wherein one of the semi-risers is rigidly connected to the downstream main (colleting) cathode busbar that, in turn, is connected to four flexible strap stacks, and another semi-riser is connected by busbars located under the cathode shell bottom and coupled with the upstream (collecting) cathode busbar stacks, each of them being connected to two flexible strap stacks, wherein the connecting busbars are located under the cathode shell bottom in parallel to the transversal axis of the electrolysis cell and each other, while the current supplied to the correction (compensation) loop is supplied in the direction coincident with the current direction in the potline, and the current in the magnetic field correction (compensation) loops is preferably 20-70% of the potline amperage (patent FR 2583069, PECHINEY ALUMINIUM, 1986-12-12).

[0008] A disadvantage of this busbar system is that it uses independent magnetic field correction (compensation) busbars from two conductors extending along both ends of electrolysis cells in a circuit, in the potline amperage direction. The correction (compensation) current is 20-70% of the potline amperage. For example, when the potline amperage is 500 kA, the correction (compensation) current can reach 350 kA. A current equal to 500 + 350 = 890 kA that flows along the potline generates a magnetic field corresponding to 890 kA rather than to 500 kA in the potroom, which primarily has an adverse effect on potroom personnel. The additional weight of the busbar system due to correction (compensation) busbars will come to about 10 metric tonnes per each cell of the potline. In any case, the use of a correction (compensation) circuit (loop) leads to an increase in the busbar system weight, growth in power consumption due to a voltage drop in the correction (compensation) circuit (loop), and an increase in expenditures on the floor space for the installation of the correction (compensation) circuit (loop). For example, when the correction (compensation) current is 450 kA, correction (compensation) busbars will be composed of 16 buses with a cross-section of 650×70 mm (the width of one stack is about 2 meters, and the width of two stacks is about 4 meters).

[0009] "New Busbar Network Concepts Taking Advantage of Copper Collector Bars to Reduce Busbar Weight and Increase Cell Power Efficiency" by Marc Dupuis, Proceedings of 34th International ICSOBA Conference, Quebec, Canada, 3-6 October, 2016, p. 883, ISSN 2518-332X, Vol. 41, No. 45 provides a new concept of the magnetic field from an adjacent row of cells in a potline, including simultaneous optimization (magnetic field depression with respect to the Bz component in the cell ends).

[0010] The first method of the new concept provides for the use of anode risers on the upstream side of the cell only. In the simplest form of the concept, 100% of the potline amperage returns back to the current supply station via additional correction (compensation) busbars located under the bottom of the cells in a potline.

[0011] According to the second version of this new concept, the upstream busbars of the cell carry half of the potline amperage under the bottom of the cell to the upstream risers of the following cell. The downstream busbars of the cell carry the second half of the potline amperage to the risers of the following cell under the bottom, to the risers located on the downstream side of the cell. As in the first concept, the total potline current of opposite direction flows in the adjacent (neighbored) additional compensation busbars under the bottoms.

[0012] A considerable disadvantage of both options of the said concept is that they are only of theoretical interest and cannot be implemented in practice. This is due to the fact that the potential difference between the poles of power supply stations of modern potlines is 1,000 V and higher. Since the potline's cathode busbar system and correction (compensation) busbar stacks (that return current to the power source) are located in immediate proximity, an electric arc (plasma) will inevitably emerge between them, which is unacceptable according to the Safety Rules (SR) and the Electrical Safety Code (ESC).

[0013] There are currently no industrially applicable, inexpensive and reliable methods for insulating between high-current conductors that have a potential difference of 1,000 V and higher between each other, considering a large conductor area, a short distance between conductors and high amperage.

[0014] Similarly, there is another known patent application WO 2016/128824, C25C3/16 published on August 18, 2016. The application claims consist mainly of a set of technical solutions, namely:

- Claim 1 states that a side-by-side busbar system has anode risers both on the upstream side and on the downstream side of an electrolysis cell.
- Claim 19 states that an electrolysis cell busbar system is an electrical modular structure.

[0015] In the meantime, claim 1 states that the busbar

system has at least one first compensation loop located under electrolysis cells and capable of passing through itself the first compensation current (amperage) under electrolysis cells in the direction opposite to the total electrolysis amperage direction.

- Claim 1 also states that the busbar system can have at least one second electrical compensation loop located at least on one side of electrolysis cells and capable of passing the second compensation current in the electrolysis amperage direction.

[0016] The availability of two correction (compensation) lines and a potline itself implies heavy expenditures for three independent power supply stations, taking into account that an emergency margin is required for each of them, and expenditures for additional busbars of the 2 correction (compensation) loops, power losses in both correction (compensation) loops and their power supply stations, which is a disadvantage of the known application.

[0017] Fig. 6 in the said application shows electrolysis cells, whose collector bars pass through the bottom perpendicular to the metal pad. Protection against metal leakage between the collector bars and the lining is likely to be cost-consuming, since the collector bars, the lining, and the cathode shell are substantially different in terms of their physical, electrical and thermal properties. During an electrolysis cell campaign (6-7 years), the probability of molten aluminum leakages, vertical collector bar dissolution and metal run-out is very high, since the said elements of the electrolysis cell constantly move relative to each other, and their geometry and physical properties change, which is another disadvantage of the application.

[0018] The known cell busbar system according to patent RU 2288976, taken as prior art, has a double-row side-by-side arrangement in a line, contains an anode busbar system part connected to anodes by anode rods and a cathode busbar system part composed of collector bars with flexible strap stacks projecting on both sides of the cathode shell of the cell. The connection between the collector bars and the anode busbar system of the following cell in a row is made in the form of bus modules composed of main (collecting) cathode busbars, connecting busbars and anode risers. At least one riser in each module is located on the upstream side of the cell and at least one riser in each module is located on the downstream side of the cell.

[0019] In the meantime, the upstream anode risers are powered from the collector bars both on the upstream side and on the downstream side of the previous electrolysis cell, and the downstream anode risers are powered from the collector bars on the downstream side of the previous electrolysis cell. About 1/2-3/4 of the module current flows through the upstream anode risers, while about 1/2-1/4 of the module current flows through the downstream anode risers, the connecting busbars are located under the cell bottom, and some connecting busbars of the outermost modules can at least pass around the cell ends and be preferably located at the molten metal level.

[0020] The disadvantages of the said prior-art busbar system are:

- A limitation in developing electrolysis cells for an amperage of more than 600 kA due to the necessity of feeding a larger amount of current via busbar stacks passing around the cell ends, due to the need to lengthen the cell cavity, which will complicate the busbar system design, increase its weight and require an increase in the spacing between cells, thus having an adverse effect upon its competitiveness; and
- Relative complexity of the busbar system design.

[0021] The objective and technical result of the invention is the formation of an optimal magnetic field in the melt of electrolysis cells arranged side-by-side in a potroom so as to develop and deploy potlines for amperage of 600 kA to 2,000 kA, preferably for 800 kA.

[0022] This result is achieved due to fundamental differences between the proposed application for an invention of a busbar system and the busbar system of the prior art, which are as follows:

1. The busbar system shall obligatorily be part of a facility comprising two single-row lines of electrolysis cells, such lines being independent in terms of electrical current supply.
2. The cathode correction (compensation) busbars of each line are located in close proximity to the cathode busbar system of the adjacent cell row.
3. The current in the lines is directed in opposite directions to each other.
4. The anode risers on the upstream and downstream sides of an electrolysis cell are located symmetrically with respect to the YZ plane of the cell.

[0023] In the meantime, it is impossible to have an optimal magnetic field without using the technical solutions specified in the limiting (restrictive) part of the prior art, these technical solutions comprise:

5. The availability of anode risers on both the upstream and downstream sides of the cell.
6. The possibility of selecting an optimal current distribution in the anode risers on the upstream and downstream sides, in those ranges that are specified in the limiting (restrictive) part of the application claims.
7. The possibility of passing part of the current around the cell ends when designing an optimal field in the melt.

[0024] Hereinafter, a description of the drawings is provided.

Fig. 1 shows a schematic diagram for the facility composed of two lines of electrolysis cells 3, 5, 1 and 4, 6, 2 in plan view, where the correction (compensation) busbars of adjacent potlines 5 and 6 extend under each row of potlines 3 and 4 in the immediate vicinity of the cathode busbar system of the line. The potlines are independent with respect to power supply and each of them is connected to separate power sources 1 and 2.

Fig. 2 shows an example of a 4-module busbar system according to the application for an invention that is designed for an amperage of 800 kA, with anode risers 16 and 17 arranged on both sides of the cell and correction (compensation) busbars 5 and 6 located in the immediate vicinity of the cathode busbar system of electrolysis cell rows 3 and 4 belonging to the adjacent potline, respectively.

Fig. 3 shows a connection diagram for electrolysis cell rows 3 and 4 in cross-section view according to the application, including upstream risers 16 and downstream risers 17, and correction (compensation) busbars to compensate for the magnetic field from adjacent potlines 5 and 6, respectively.

Fig. 4 shows the magnetic field, in mT, for magnetic induction vector component Bz in the middle of the metal pad of a pilot electrolysis cell, according to the prior-art patent, at an amperage of 550 kA.

Fig. 5 shows the magnetic field, in mT, for magnetic induction vector component Bz in the middle of the metal pad of an electrolysis cell, according to the application for an invention, at an amperage of 800 kA.

Fig. 6 shows the magnetic field, in mT, for magnetic induction vector component By of an electrolysis cell similar to the application for an invention, with upstream anode risers 16 only and correction (compensation) busbars 5 and 6 to compensate for the magnetic field from the adjacent potline, respectively.

Fig. 7 shows the magnetic field, in mT, for magnetic induction vector component By of an electrolysis cell according to the application for an invention, with anode risers 16 and 17 located on both sides of the cell symmetrically with respect to the YZ plane and correction (compensation) busbars 5 and 6 to compensate for the magnetic field from adjacent cell rows 3 and 4, respectively.

[0025] The busbar system consists of two single-row lines 3, 5, 1 and 4, 6, 2 of serially connected electrolysis cells, the lines being independent with respect to power supply. The current in the potlines flows in opposite directions. Potline 3, 5, 1 is powered from independent current source 1, while potline 4, 6, 2 is powered from independent current supply source 2. Potline 3, 5, 1 returns current to power source 1 with the help of correction (compensation) busbars 5 extending in close proximity to the cathode busbar systems of adjacent electrolysis cell row 4. Similarly, potline 4, 6, 2 returns current to power source 2 by means of correction (compensation) busbars 6 located in close proximity to the cathode busbar systems of the potline composed of electrolysis cell row 3.

[0026] As an example, Fig. 2 shows a four-module busbar system designed for an amperage of 800 kA. Depending on the number of modules to be selected, it can be developed for electrolysis cells operating at any acceptable (from technical and economic points of view) amperage (1,000-1,500 kA and higher; for example, 2,000 kA). Developing potlines composed of single-module busbar systems is not ruled out.

[0027] The busbar system shown in Fig. 2 and Fig. 3 comprises an anode busbar system 7 with anodes 8 and anode rods 9, a cathode busbar system composed of collector bars 10 and flexible strap stacks 11, and bus modules A, B, C and D. Each module includes upstream main (collecting) cathode busbars 12 and downstream main (collecting) cathode busbars 13 of the cathode shell 14, connecting busbars 15, and upstream anode risers 16 and downstream anode risers 17 located symmetrically with respect to the YZ symmetry plane. The connecting busbars 15 are located in close proximity to the cathode busbar system of potlines 3 and 4. The upstream anode risers 16 are connected to the upstream cathode busbars 13 of the previous electrolysis cell. The downstream anode risers 17 are connected to the upstream cathode busbars 12 of the previous electrolysis cell. The correction (compensation) busbars 5 and 6 to compensate for the magnetic field from the adjacent potline are located in close proximity to the cathode busbar system.

[0028] As shown in Fig. 1, Fig. 2 and Fig. 3, the current from the collector bars 10 is transferred by means of the flexible strap stacks 11 to the main (collecting) cathode busbars 12 and 13, then, it is transferred to the anode busbar system 7 via the connecting busbars 15 and through the anode risers 16 and 17, and then it is transferred to the rods 9 and the anodes 8 of the following cell in a potline. The current in the correction (compensation) busbars 5 and 6 to compensate for the magnetic field from the adjacent cell rows 3 and 4 is oriented in the opposite direction to the potline amperage.

[0029] It should be noted that the technical solution of the application for an invention is based on the understanding that low-amperage electrolysis cells do not require over-complication of the busbar system in view of low magnetic field intensity, a small density of horizontal currents, and a limited volume of molten metal. Good results during electrolysis can be achieved even in the case of one-side current drainage from the cathode and one-side current supply to the anode busbar system. Such electrolysis cells can be arranged end-to-end in two

or four rows within the potroom, which has no substantial effect on the mutual influence of the magnetic fields.

[0030] High-amperage electrolysis cells (up to 2,000 kA) are disclosed herein, which are assembled from parallel lines of low-amperage electrolysis cells (modules), whose current is unidirectional. In the meantime, adjacent (neighboring) cells (modules) of each potline are combined into one combined cell, as shown in Fig. 2.

[0031] MHD instability issues in each low-amperage electrolysis cell (module) are minimal, so there will be no substantial issues related to MHD stability in a high-amperage electrolysis cell composed of low-amperage electrolysis cells (modules).

[0032] It is efficient to arrange the combined cell transversely to the cell room axis. This allows a considerable reduction in the magnetic field intensity contribution from the cathode busbar system.

[0033] The main prerequisites for the optimal character of the magnetic field in the metal for side-by-side electrolysis cells operating at an amperage of up to 500 kA are as follows:

- Vertical (Bz) and transverse (Bx) magnetic fields in the metal should not exceed 1.5 mT;
- Direction of the vertical component (Bz) of the magnetic field should be alternating in sign with respect to each quarter of the cell (propeller-like character);
- Longitudinal component (By) of the magnetic field should be antisymmetric with respect to the YZ symmetry plane.

[0034] These criteria are insufficient to ensure high technical and economic performance indicators for electrolysis cells designed for an amperage of more than 500 kA.

[0035] When the vertical component (Bz) of the magnetic field, which acts upon a molten metal layer, has the same sign of direction (plus or minus) over a vast area of the electrolysis cell, especially along its longitudinal sides, coherent and increasing surface oscillations may occur in the melt due to the accumulation of the longitudinal moment along the cell. They cause a low MHD stability of electrolysis cells and, as a result, their poor technical and economic performance indicators. Therefore, an increase in MHD stability, as a result of magnetic field optimization in the molten metal, is achieved through frequent changes in sign for the Bz magnetic field component along the longitudinal sides of the electrolysis cell, and, as this takes place, a change in sign should be antisymmetric with respect to the YZ symmetry plane of the cell.

[0036] In this application for an invention, this problem is solved as follows. The structure of the anode and the cathode of electrolysis cells includes great-in-size ferromagnetic masses that possess substantial metal protection properties against the magnetic field of the cathode busbar system.

[0037] Unlike the magnetic field generated by the cathode busbar system, the magnetic field generated by the anode risers, through which the total potline current passes, mainly generates the vertical (Bz) magnetic field in the metal, considering that there are no ferromagnetic shields between the metal and the risers, which reduce the effect of the magnetic field from the risers upon the metal. The (Bz) field directed downward (minus) is generated in the metal on the right side along the current flow in the riser, and the field directed upward (plus) is generated on the left side from the riser. A sinusoid-like field for the (Bz) component with an amplitude of no more than 3.0-3.5 mT can be generated by selecting an appropriate distance and amperage in the risers on one longitudinal side. If similar anode risers are located on the opposite side, symmetrically with respect to the YZ plane, this will result in the generation of the vertical magnetic field as shown in Fig. 4, which is antisymmetric with respect to the YZ and XZ planes.

[0038] However, as the cell amperage increases due to the installation of additional modules and the cell becomes longer, the value of the magnetic induction vertical component will grow, especially in the outermost cell modules A and D, see Fig. 2.

[0039] Also, with an increase in the amperage, for compensating the magnetic field picked up from the adjacent row, it will be required to increase the distance between the electrolysis cell rows to transfer current to the stacks passing around the cell ends from a greater number of collector bars in order to compensate for the growing Bz component of the magnetic field. This will have a negative effect on the busbar system weight and costs per unit of the potroom area.

[0040] These two problems are solved herein by the installation of correction (compensation) busbars under the cathode busbar systems of the cell row of the adjacent line, as shown in Figs. 1, 2, 3, within 80-100% of the total number of busbars. The correction (compensation) current flows in the direction opposite to the current flowing in the cathode busbar system of the cell row of the adjacent line.

[0041] Since the potential difference between the poles of power supply stations of modern potlines can reach 1,000 V and higher, the correction (compensation) busbars should be connected to their own, separate current source to preclude the potential difference between the cathode busbar system and the correction (compensation) busbars in order to avoid arcing, especially in the electrolysis cells that are located near the power source.

[0042] To solve this problem, this application provides for using the second potline to be independent in terms of electrical current supply. In other words, the facility that comprises the busbar system specified in the application consists of two single-row potlines. The current in one potline is directed clockwise (in plan view), and the current in another potline is directed counter-clockwise, as shown in Fig. 1, wherein the electrolysis cell rows belonging to two potlines 3 and 4 are depicted.

[0043] The second rows in each potline are replaced

by the correction (compensation) busbars 5 and 6 located in close proximity, mostly, under the bottoms of the adjacent cell rows of potlines 3 and 4. Since the currents in the cathode busbar system and the correction (compensation) busbars are equal and flow in opposite directions, then, as a rule of thumb, the current from the busbars of the cathode busbar system and the correction (compensation) busbars compensates for the magnetic field around itself. The correction (compensation) busbars, first, compensate for the vertical magnetic field in the melt of electrolysis cells to bring it to optimal values and, second, subtract the magnetic field around each of two rows 3 and 4 of the potlines, thus preventing the influence of the magnetic field on the adjacent row of electrolysis cells.

[0044] This allows installing rows of electrolysis cells in close proximity to each other, for example, in the same pot room. However, the correction busbars not only optimize the vertical field component (Bz) in the metal, but also have an effect on the longitudinal component (By) generated mainly by volume currents and currents of collector bars, namely, they subtract it on the upstream longitudinal side of the cell and increase this component, by being added to it, on the downstream side, because they coincide in direction. Fig. 6 shows the By field component in the metal of the cell with the risers installed only on the upstream side, provided the correction busbars are available. As can be seen, the magnetic field has a 100% positive direction with respect to this component. Being equal to (-2-0 mT) on the upstream side, it reaches (+36-+38 mT) on the opposite longitudinal side. Upon interaction with the vertical current, Lorentz forces occur in the melt, they are being directed from the upstream longitudinal side to the downstream longitudinal side (in plan view), which causes metal heaving or, more correctly, metal shifting from the upstream longitudinal side to the downstream side. As this takes place, the upstream longitudinal side becomes "hot" and the downstream side becomes "cold". This leads to asymmetry in the thermal balance and the ledge profile, as well as in the electric field in the metal, and more specifically, to the occurrence of planar currents that, as is known, reduce the MHD stability of electrolysis cells and their technical and economic performance indicators.

[0045] In this application for an invention, this problem is solved by the availability of anode risers located on the opposite, downstream side 7 of the cell, as shown in Fig. 2 and Fig. 3. In this case, the total current in the risers on the upstream side reduces by approximately 2 times, and thus, facilitates an increase in the magnetic field Bx component on the upstream side, since the magnetic field generated by the anode risers with respect to the By component adds to a similar field generated by the correction (compensation) busbars. To the contrary, the magnetic field from the anode risers on the downstream side subtracts the field from the correction (compensation) busbars. By selecting the amperage for the anode risers on the upstream and downstream sides of the cell, within the limits set in the application claims, it is possible to have a magnetic field to be antisymmetric with respect to the YZ plane along the longitudinal sides, and thus, symmetric metal heaving as shown in Fig. 7.

[0046] "Light metals-2017", editor Ante P. Ratvik, p. 26, ISSN 2367-1181 ISSN 2367-1696 (electronic) The Minerals, Metals & Materials Series, ISBN 978-3-319-51540-3 ISBN 978-3-319-51541-0 (eBook), contains the key operating parameters of a test group of 550-kA electrolysis cells, whose busbar system is assembled in accordance with the prior art in this application for an invention (RU 2288976). Tests have been underway for more than 2 years.

[0047] In case of the magnetic field shown in Fig. 4 and measured with respect to the Bz component, which is similar to the magnetic field according to the application for an invention (Fig. 5), the test group operates with the following operating characteristics:

- Amperage - 550 kA;
- Current efficiency - 94.5%;
- Voltage - 3.8 V; and
- Specific energy consumption - 12,000 MWh/kg.

[0048] Since the start of testing these electrolysis cells, it has not yet been possible to achieve MHD instability. Their noise is 5-6 mV under normal operating conditions and does not exceed 20 mV during operational disturbances.

[0049] The practical measurements and calculations point to the same qualitative and quantitative character of the magnetic field with respect to the Bz and Bx field components both in the melt of the prior-art cell and in the melt of the cell for 800 kA according to the application for an invention, as shown in Fig. 4, Fig. 5 and Fig. 7.

[0050] Said coincidences predict, with high confidence, that the operating parameters of a cell with the busbar system according to the application (up to 2,000 kA) will be no worse than those of the prior-art cell.

Claims

1. A busbar system for aluminum electrolysis (reduction) cells arranged side-by-side in series, consisting of an anode part designed to connect anodes in a cell line by means of anode rods, a cathode part composed of collector bars with flexible strap stacks and designed to connect to the anode part of the next cell in a line by means of a bus module comprising main (collecting) cathode busbars on the upstream and downstream sides of the cathode shell of the cell, connecting busbars located under the cell bottom, some of which in the outermost bus modules are designed to pass around the cell ends and be located at the molten metal level, at least one anode riser on the upstream side and at least one anode riser on the downstream side of the cell, which are

located symmetrically with respect to the YZ symmetry plane of the electrolysis (reduction) cell and designed to be powered by the collector bars on the upstream and downstream sides of the previous cell in a line and to pass 1/2-3/4 of the bus module current through the anode risers on the upstream side and 1/2-1/4 of the bus module current through the anode risers on the downstream side, ***characterized in that*** it is designed to supply current to two similar aluminum cell lines composed of one row of electrolysis (reduction) cells, such lines being independent from each other in terms of power supply and having opposite current directions, in the meantime, it comprises correction (compensation) busbars located in close proximity to the cathode part of the electrolysis (reduction) cell row of the adjacent cell line, including ensuring compensation for the magnetic field.

2. The busbar system according to claim 1, ***characterized in that*** the correction (compensation) busbars are parallel to the busbars of the cathode busbar system.

3. The busbar system according to claim 1, ***characterized in that*** the correction (compensation) busbar stacks are designed to be partially arranged under the bottom and along the ends of electrolysis (reduction) cells.

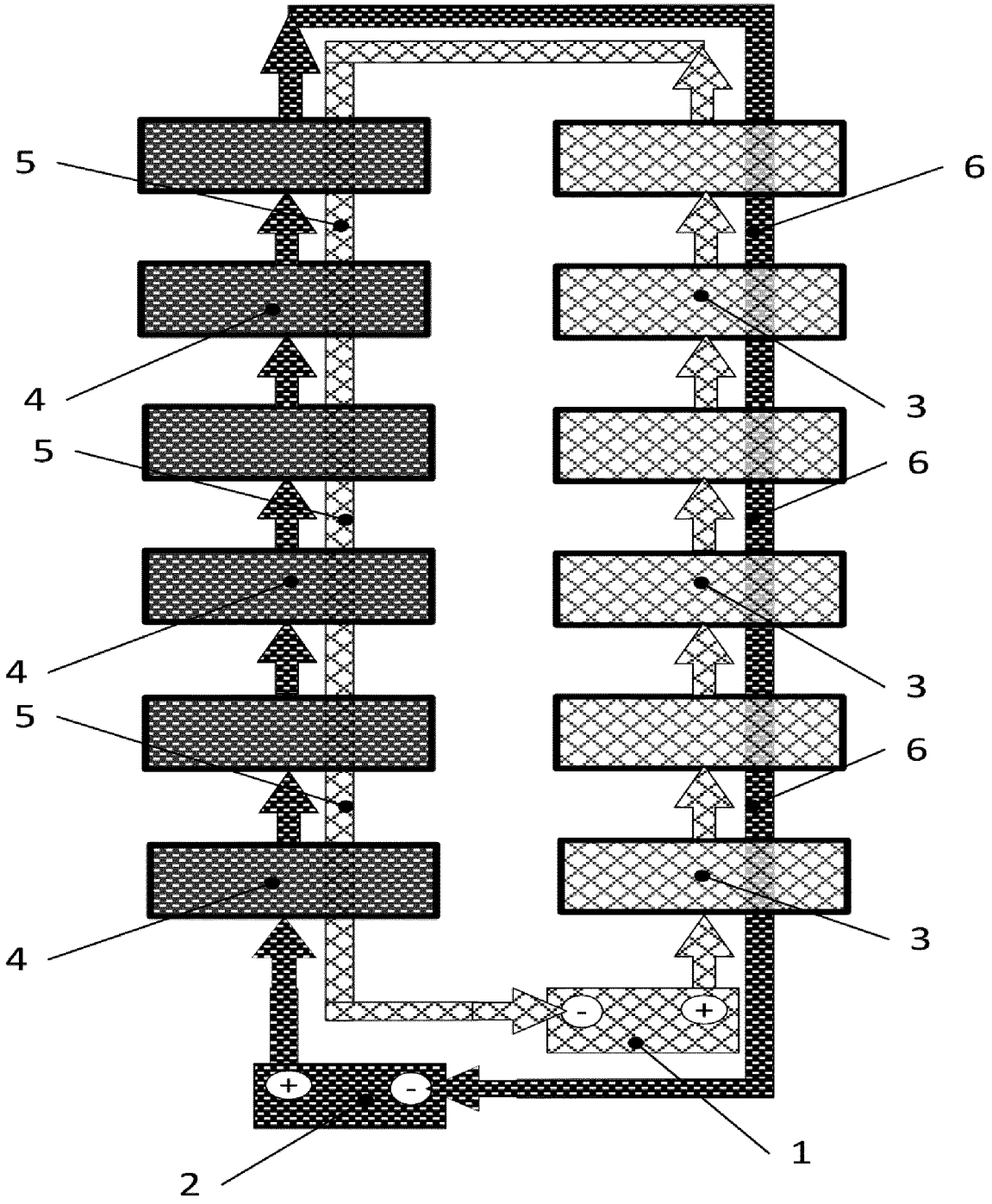


FIG. 1

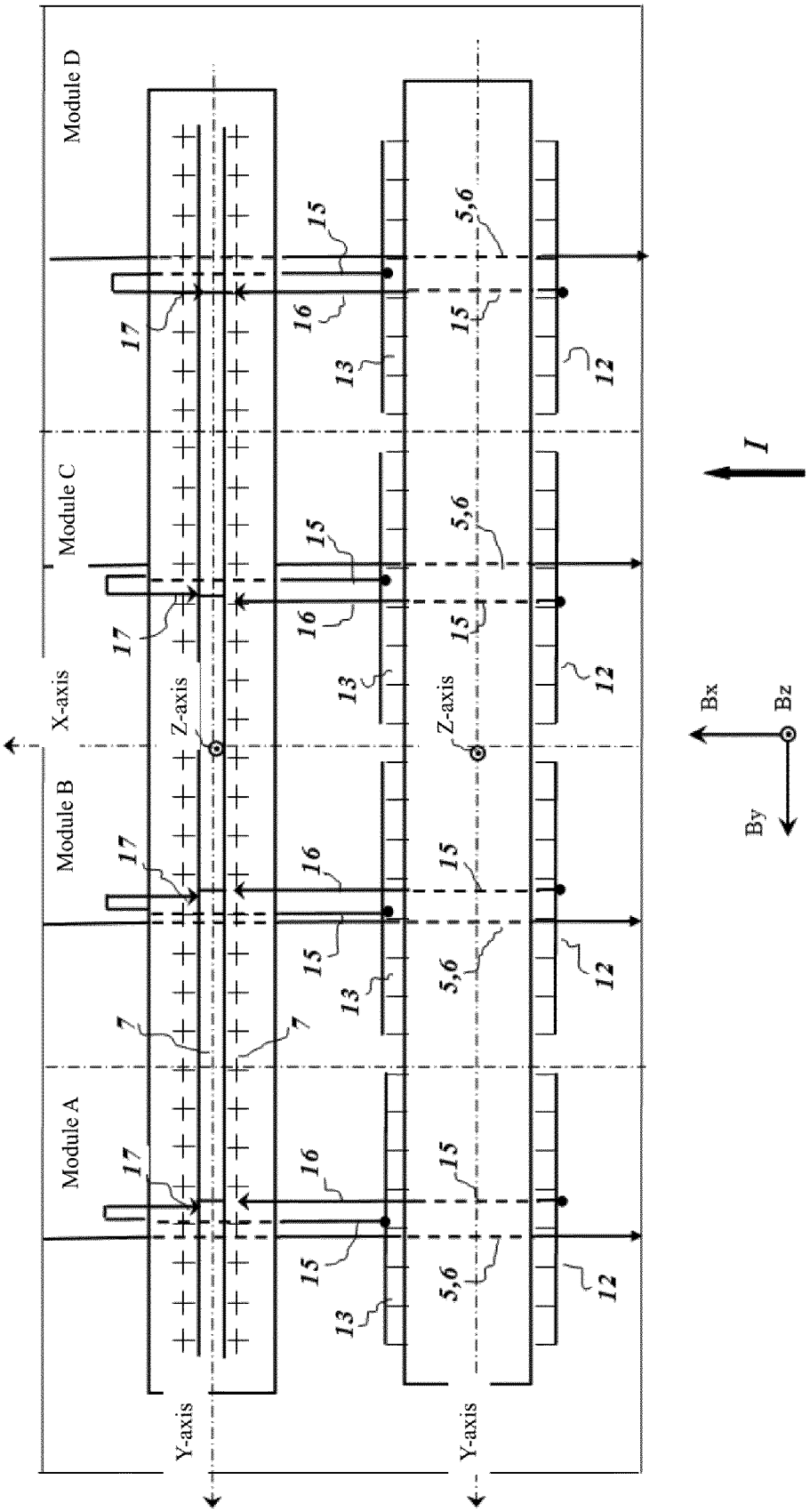

Module D
Module C
Module B
Module A
X-axis
Z-axis
Y-axis
Bx
By
Bz
I
17
16
15
13
12
7
5,6

FIG. 2

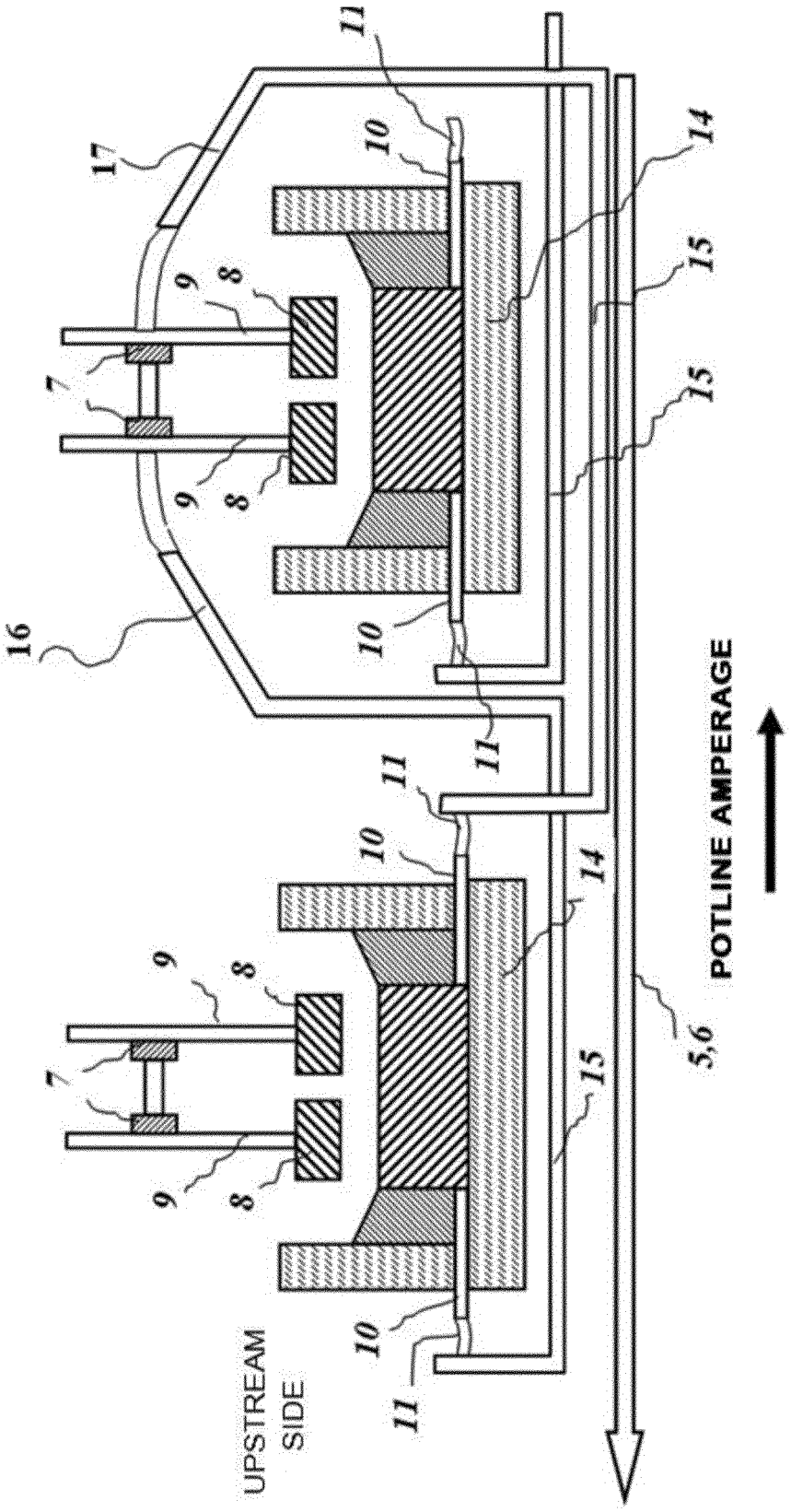

11
17
10
14
9
8
15
7
15
9
8
16
10
11
11
10
14
9
8
7
15
9
8
10
11
UPSTREAM SIDE
POTLINE AMPERAGE
5,6

FIG. 3

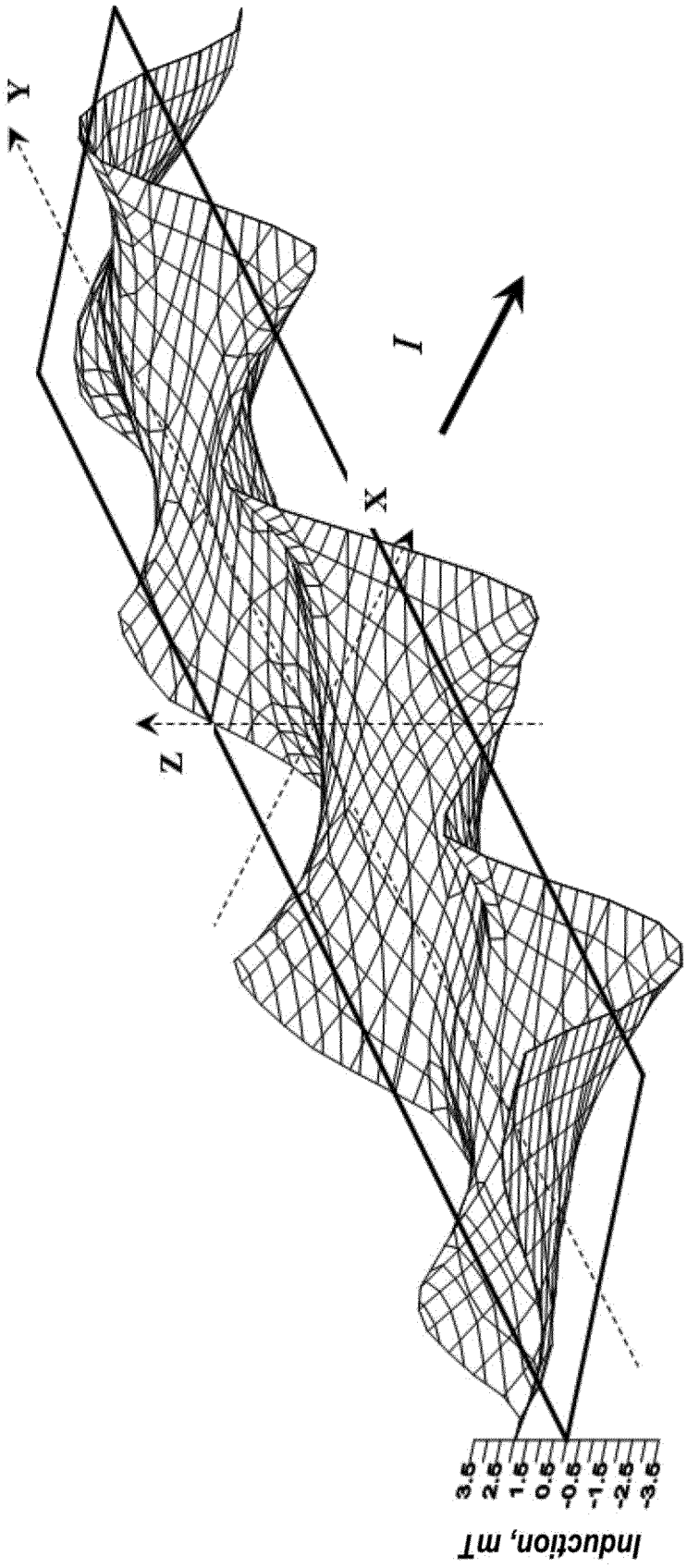


FIG. 4

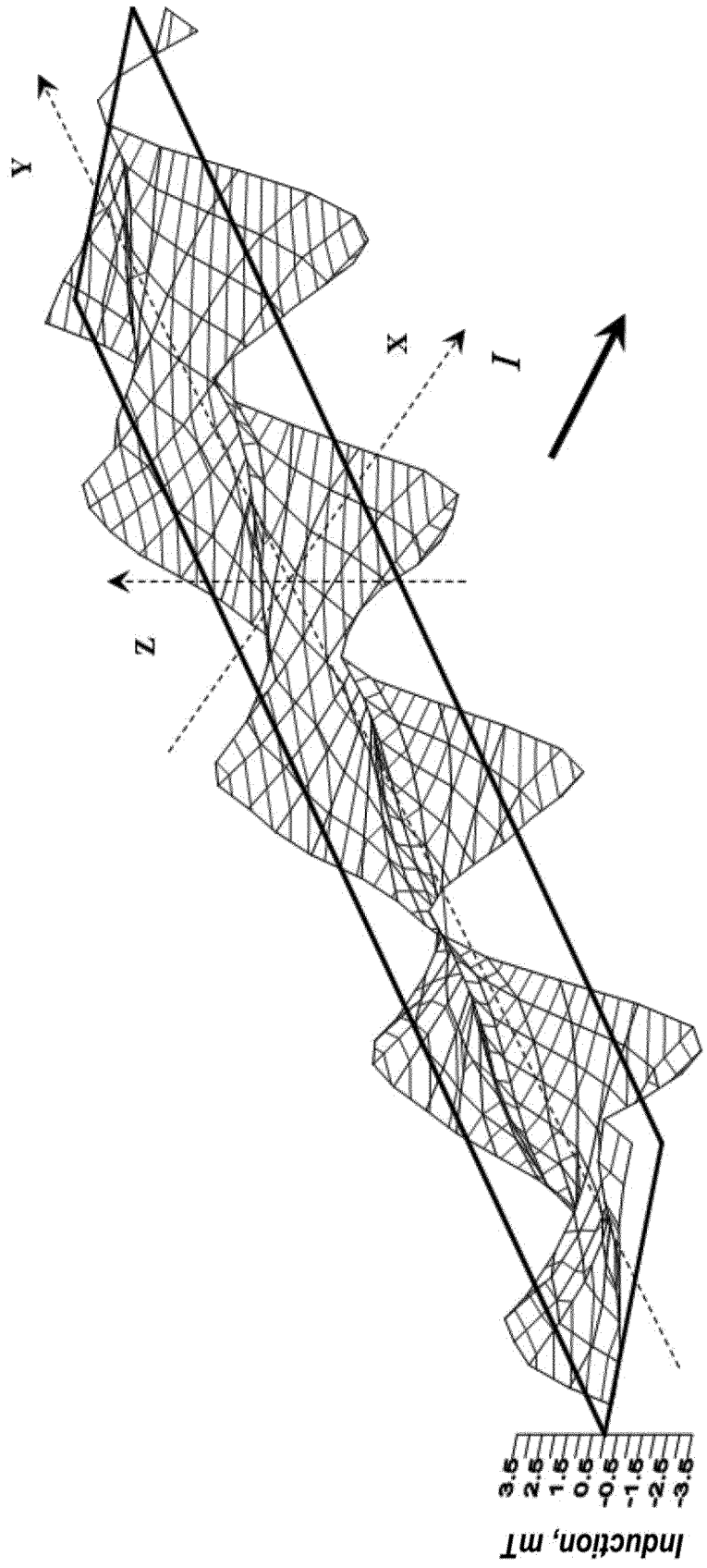


FIG. 5

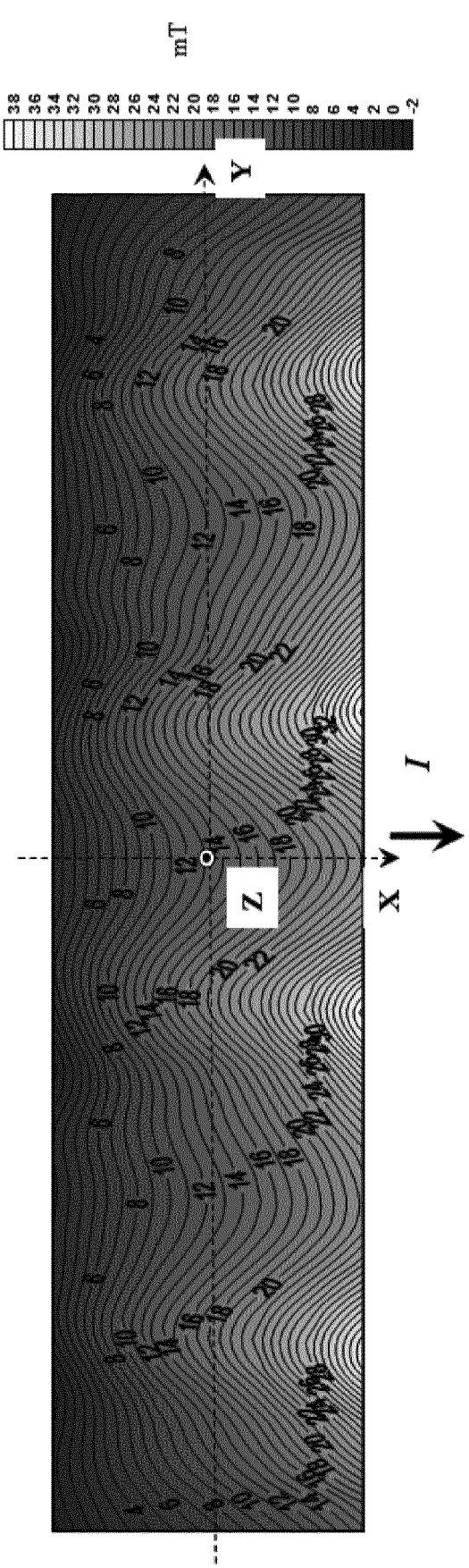

mT
38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0 -2
Y
Z
X
I

FIG. 6

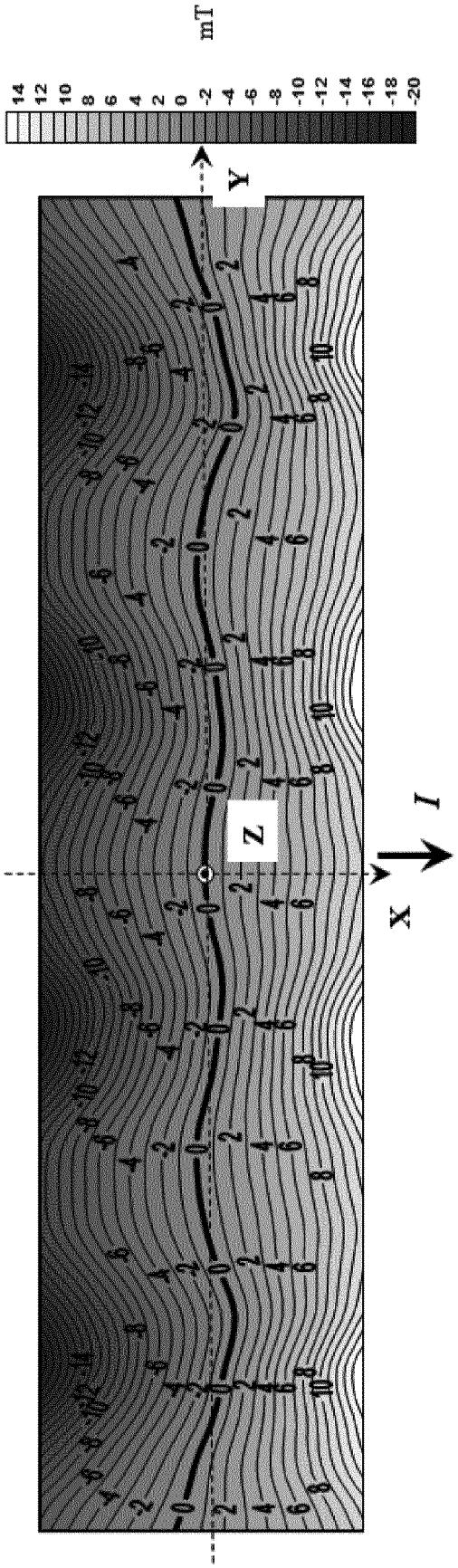

mT
14 12 10 8 6 4 2 0 -2 -4 -6 -8 -10 -12 -14 -16 -18 -20
Y
Z
X
I

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/RU 2018/050166

A. CLASSIFICATION OF SUBJECT MATTER
C25C 3/16 *(2006.01)*
C25C 7/02 *(2006.01)*
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)
C25 3/00, 3/06, 3/10, 3/16, 7/00-7/02; H05K 9/00

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)
ESP@CENET, PAJ, Patsearch, RUPTO

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	RU 2288976 C1 (PLATONOV VITALY VLADIMIROVICH et al.), 10.12.2006	1-3
A	RU 2316619 C1 (PINGIN VITALY VALEREVICH et al.), 10.02.2008	1-3
A	CN 101423960 A (ALUMINUM CORP OF CHINA LTD), 06.05.2009	1-3

☐ Further documents are listed in the continuation of Box C. ☐ 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
12 March 2019 (12.03.2019)	21 March 2019 (21.03.2019)
Name and mailing address of the ISA/ RU Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- FR 2552782 **[0005]**
- FR 2583069 **[0007]**
- WO 2016128824 A **[0014]**
- RU 2288976 **[0018] [0046]**

Non-patent literature cited in the description

- **MARC DUPUIS.** New Busbar Network Concepts Taking Advantage of Copper Collector Bars to Reduce Busbar Weight and Increase Cell Power Efficiency. *Proceedings of 34th International ICSOBA Conference,* 03 October 2016, vol. 41 (45), ISSN 2518-332X, 883 **[0009]**
- Light metals-2017. The Minerals, Metals & Materials Series. 26 **[0046]**