A device for compensating a magnetic field in a linearly arranged series of electrolysis cells consists of a combination of main and supplemental electrical compensating conductors. Main inner and outer compensating conductors are spaced from the respective sides of the cells in a series. An inner supplemental compensating conductor is disposed at the bottom of the cells and along the main inner compensating conductor. First and second outer supplemental compensating conductors are disposed at the bottom of the cells. The first supplemental conductor is positioned at the cathode bars at the outer side of the cell. The second outer supplemental conductor is positioned between the first outer supplemental conductor and small axis of the cell.
ABSTRACT OF THE DISCLOSURE

A device for compensating a magnetic field in a linearly arranged series of electrolysis cells consists of a combination of main and supplemental electrical compensating conductors. Main inner and outer compensating conductors are spaced from the respective sides of the cells in a series. An inner supplemental compensating conductor is disposed at the bottom of the cells and along the main inner compensating conductor. First and second outer supplemental compensating conductors are disposed at the bottom of the cells. The first supplemental conductor is positioned at the cathode bars at the outer side of the cell. The second outer supplemental conductor is positioned between the first outer supplemental conductor and small axis of the cell.
TITLE OF THE INVENTION

[001] A Device For Compensation Of Magnetic Field Induced By A Neighboring Row Of High-Power Reduction Cells Connected In Series

FIELD OF THE INVENTION

[002] The invention relates to the production of aluminum by electrolysis in high-power electrolysis cells, and more specifically it relates to devices for compensation of magnetic fields induced by adjacent cells.

BACKGROUND OF THE INVENTION

[003] Aluminum is often carried out by electrolysis of a solution of alumina in cryolite, in cells electrically connected in series brought to a current passing through the cell.

[004] Each electrolysis cell consists of a rectangular cathode forming a crucible. The bottom of the cells is formed by blocks of carbon disposed on the steel cathode rods which are adapted to transmit the current from the cathode toward the anodes of the following cell. The anode system, also made of carbon, is fixed beneath an anode bus bar super-structure and is connected to the cathode rods of the preceding cell.

[005] The electrolysis bath in the form of solution of alumina in cryolite is disposed between the anode system and the cathode. The produced aluminum is deposited on the cathode. To provide a thermal fly-wheel effect a layer of liquid aluminum about 20 cm thick is permanently kept at the bottom of the cathode crucible. In view of the rectangular configuration of the crucible, the anode rods supporting the anodes are generally parallel to its large edges of the crucible, while the cathode rods are parallel to the small edges thereof, known as cell heads.

[006] The cells are arranged in lines in a longitudinal direction or in a transverse direction depending upon whether the large sides or the small sides are parallel to the axis
of the line. The cells are electrically connected in series with the ends of the series being connected to the positive and negative outputs of an electrical rectification and regulation sub-station. Each series of cells comprises a certain number of lines branched in series, the number of lines preferably being even so as to avoid needless lengths of conductors.

[007] The flow of electric current through the various conductors such as electrolyte, liquid metal, anodes, cathodes and connecting conductors creates substantial magnetic fields. These fields induce in the electrolysis bath and in the molten metal contained in the crucible forces which are harmful to the proper operation of the cell. The cells and the respective connecting conductors are arranged, so that the magnetic fields created by the different parts thereof are adapted to compensate each other. A cell having the vertical plane parallel to the line of cells and passing through the center of the crucible as its plane of symmetry is thus obtained. However, the cells are also subjected to the harmful interfering magnetic fields emanating from the adjacent line or lines.

[008] U.S. Patent 3,616,317 discloses the device provided for compensation effect of magnetic field from neighboring reduction cells arranged the end-to-end relationship including the direct current conductor on the outer side of the potline, the current in it runs, at this, in the direction opposite to the potline current direction. The current load in the conductor constitutes about 25% of the potline current.

[009] This prior art device is adapted for use exclusively in low-amperage potlines where cells are arranged in the end-to-end relationship.

[010] The magnetic field from the conductor expands hyperbolically. The distance from the neighboring row of cells arranged end-to-end to the longitudinal axis of molten aluminum layer in the cell is between 10 and 18 m, whereas the distance from the compensation conduction to the axis of the molten aluminum layer is between 2.5 and 3.5 m. The amperage in the compensation conductor is almost four times less than the potline
amperage. In this manner, the vertical magnetic fields from the neighboring row of electrolytic cells and similar fields from the compensation conductor busbar are directed opposite each other. The field in the aluminum melt from the compensation conductor busbar and the magnetic field from the neighboring row electrolytic cells changes hyperbolically and from the compensation busbar more intensively than the field from the neighboring row of the cells. As a result, compensation of magnetic field from the neighboring row of cells is provided at a small area of the melt having the length of only between 3.5 and 4.5 meters. However, when the cells are arranged side-by-side and when it is necessary to compensate the magnetic field in the aluminum melt over an area between 10 and 18 m and, the above-discussed prior art device does not provide the required compensation. This is because compensation of the magnetic field in one-half of the cell and insufficient compensation of the magnetic field in the opposite half of the cell does not provide the required quality compensation.

[011] U.S. Patent 4,072,597 teaches the prior art method of compensation of the effect of magnetic field from neighboring rows of the electrolytic cells arranged side-by-side, wherein the current to anode of the downstream cell is supplied from the cathode of the neighboring upstream cell. In this arrangement, the current from cathode is taken from input and output cathode bars. The upstream cathode bars on the side closer to the neighboring row of cells and downstream cathode bars on the side opposite to the neighboring row of cells form an electric loop generating an additional magnetic field, which is essentially equal to that of the neighboring magnetic fields and acting in the opposite direction. This is due to the higher amperage in the conductor on the side close to the neighboring row and connected with the cathode bars of the upstream cell.

[012] U.S. Patent 4,159,034 discloses a device provided for compensation of the magnetic field from the neighboring rows of cells connected in series. Each cell comprises a metal cathode device. Neighboring parallel rows of cells oriented across the longitudinal axis of the row of the cells with the cathode device carrying a liquid
aluminum layer on the cathode lining. This prior art device incorporates two compensating electric conductors disposed substantially at the level of liquid aluminum layer and provided on both sides of each row of cells. The source of direct current is connected to the compensation conductors. In this arrangement, one compensation conductor is positioned separately on the inner side of the series of the cells, potline (inner conductor) and the other compensation conductor which is separately provided on the outer side of the cells (outer conductor). Direct current in the inner compensation conductor runs in the same direction as the current in the potline. On the other hand, the direct current in the outer conductor runs in the opposite direction relative to the current direction in the potline. The inner and outer compensation conductors are connected in series. The amperage in the compensation conductor is defined by the following equation:

\[ B = \frac{2i}{d} \]

where:

- \( B \) is magnetic field in \( 10^{-4} \) Tesla;
- \( i \) is amperage in kiloamperes;
- \( d \) is the distance in meters.

The compensation conductor is selected in such a manner that the average total magnetic field along the longer axis of the cell is to be equal to zero.

[013] Main drawbacks of the above-discussed prior art compensation devices are that they cannot efficiently compensate the magnetic field induced by neighboring rows of high-power cells or from conductors with amperage up to 320-400 kA and more.

[014] In order to use the device of U.S. Patent 4,159,034 a line of the cells with intensity or amperage 350-400 kA and it is necessary to substantially increase the distance between the rows of the cells (potlines) more than by 150 m to maintain acceptable magnetic field value around the melt. This will considerably increase the cost of land use under the
potrooms, cost of long busbars between the potlines. Furthermore, electric power consumption will be substantially increased because of warming voltage in the long busbars. The above-discussed factors substantially decrease the income from investments into high-amperage potlines.

[015] Hereinafter, the terms "upstream" and "downstream" used in the application are related to the general direction of the electrical current flowing through the predetermined row of cells (the direction of the electric current in the series). The term "adjacent line" means the line nearest the line under consideration and the term "field of the adjacent line" means the resultant of the fields of all the lines apart from the line under consideration.

[016] Bx, By and Bz, the components of the magnetic field along the axes Ox, Oy and Oz in a direct right-angled trihedron, whose center O is the center of the cathode plane of the cell, Ox is the longitudinal axis in the direction of the cell, Oy is the transversal axis and Oz is the vertical axis directed upwards, internal side of a cell is situated toward the adjacent line and external side opposes the adjacent line.

**SUMMARY OF THE INVENTION**

[017] The present invention provides an arrangement for compensating a magnetic field from neighboring lines of electrolysis cells connected in series and adapted for the intensity or amperage of at least 350-400 kA. It relates to the compensating arrangement adapted for use with electrolysis cells which are situated in one potroom under the same roof in the side-by-side relationship in at least two lines.

[018] The object of the invention is to increase current efficiency and to reduce fixed expenses. It is a further object of the invention to create optimum magnetic field in the
melt of the electrolytic cells arranged in the potlines in the side-by-side relationship and installed in one electrolysis potroom, consisting of at least two lines of the cells.

[019] In the arrangement of the invention the magnetic field from the neighboring lines of cells is compensated by the current bearing independent conductors and not by the asymmetric design of cell busbar as proposed by the prior art.

[020] One aspect of the invention provides an arrangement for compensating a magnetic field induced in a linearly arranged series of electrolysis cells by an adjacent generally parallel line of cells. Each electrolysis cell contains a metal shell extending in one direction between top and bottom portions thereof and between inner and outer sides in other direction. A cathode device containing a plurality of cathode bars is provided with the cells.

[021] A main inner electrical compensating conductor is provided spaced laterally from the inner side of said cells in the series. The device also includes a main outer electrical compensating electrical conductor spaced laterally from the outer side of the cells in the series.

At least one inner supplemental electrical compensating conductor is disposed at the bottom portion of the cells in the potline in the vicinity of the cathode bars situated at the inner side of the respective cells and along the main inner compensating conductor.

At least first and second outer supplemental electrical compensating conductors are disposed at the bottom portion of the cells along the main outer compensating conductor. The first outer supplemental conductor is positioned in the vicinity of the cathode bars situated at the outer side of the respective cells. The second outer supplemental conductor is positioned between the first outer supplemental conductor and small axis of the respective cell.
[022] As to another aspect of the invention, the main inner and outer electrical compensation conductors are disposed substantially at a level of the layer of liquid aluminum in the respective cell.

[023] As to still another aspect of the invention, the device of the invention further comprises a source of direct current associated with said compensation conductors. The direction of the direct current in the inner electrical compensation conductor coincides with the direction of the current in the line of cells. The direction of current in the outer electrical compensation conductor is opposite to the current in the line cells, with the inner and outer electrical compensation conductors being connected in series.

[024] The supplemental compensation conductors can be oriented substantially parallel to the main electrical compensation conductors.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[025] FIG. 1 is a schematic cross-section view of an electrolysis cell arranged transversely to the axis of the series, the Ox axis extends substantially perpendicular to the plane of the figure;

[026] FIG. 2 is a schematic partial top view of a series of electrolysis cells arranged in two parallel lines; and

[027] FIG. 3 is a diagram illustrating interaction of the magnetic fields from neighboring lines of cells resulted from utilization of the compensation arrangement of the invention.

**DETAILED DESCRIPTION OF THE INVENTION**

[028] Referring now to the drawings in general and Figs. 1 and 2, a compensating arrangement of the invention is specifically illustrated. Each electrolysis cell 10 comprises a metal shell 15 provided with a cathode in the form of blocks of carbon 16 and an anode structure 14. Metal cathode rods 18 submerged in the blocks of carbon 16
collect the current leaving the cell. Busbars conduct the current through side riser to the conductors of the subsequent cell forming a beam for suspension of the anodes. The electrolytic bath 22 and the layer of liquid aluminum 20 are contained within the cell. In this conventional arrangement, the cathode outputs of each cell thus supply the subsequent downstream cell via the upstream head.

[029] It is illustrated in Fig. 1, the electrolysis cell 10 extends longitudinally between an internal side 28 and an external side 30. In the vertical direction the cell 10 extends between top 24 and bottom 26 portions. As further illustrated in Fig. 2 the cells in the series are oriented transverse to an axis of the series with a short or longitudinal axis of each cell being oriented along or substantial parallel to the axis of the cells in the respective line. As further illustrated in Fig. 1 in each cell 10 the vertical axis OZ and the short or longitudinal axis OX passes through a center O of the cathode plane.

[030] Referring now to FIG. 2 illustrating a part of a series of electrolysis cells arranged in two parallel lines 42 and 44 within the same potroom 46. The main internal compensating conductors 32 are provided for compensation the field of the adjacent line. On the external side of the series the main external electrical compensating conductors 34 are provided. Such main compensation conductors may be joined by means of the connector 35. The dotted line represents the direction of passage of the electrolysis current. In each line the main internal compensating conductors 32 are arranged along the internal sides 28 of the cells and the main external compensating conductor 34 is arranged along the external sides 30 of the cells. Both main compensating conductors can be supplied with direct current, either separately or by positioning in series by means of the connector 35 from an auxiliary rectifier. The total power dissipated in these compensating conductors is relatively low relative to the energy consumed in the electrolysis process. As shown in FIG. 1 both main compensation conductors 32 and 34 are situated approximately at the level of the liquid aluminum metal 20 in the electrolysis cells.
[031] Reference numeral 25, illustrates the direction of current in the designated line of electrolysis cells, line 42 for example, whereas the numeral 27 shows the direction of current in the neighboring line 44 of cells. Supplemental compensation conductors 36, 38 and 40 adapted for passage of the direct current are provided under the bottom portion 26 of the cells in each line of cells in the series the supplemental conductors are positioned along or substantially parallel to the respective main internal and external compensation conductors 32 and 34. At least one internal supplemental electrical compensation conductor 36 is disposed under the bottom portion 26 of the respective cells in the series in the vicinity of the outer cathode rods 18 on the side of the internal main compensation conductor 32. The direction of current in the internal supplemental compensation conductors 36 and the main internal compensation conductors 32 is substantially identical.

[032] At least a pair of external electrical supplemental compensation conductors 38 and 40 is disposed under the bottom 26 of the cell in the series along the main external compensation conductor 34. The first external supplemental conductor 38 is provided at the outer cathode rods 18 of the side of the external main electrical compensation conductor 34. The second external supplemental compensation conductor 40 is disposed between the first external supplemental compensation conductor 38 and a plane passing through the short axis X of the respective electrolysis cells. The direction of current in the main and supplemental external conductors 34, 38 and 40 is substantially identical.

[033] The internal compensation conductors 32, 36 can be connected to the external compensation conductors 34, 38 and 40 by means of the busbar 35. In one embodiment of the invention both groups of compensation conductors are connected to one source of direct current. In the alternate embodiment, each compensation conductor is connected to an individual source of direct current. In the line of the electrolysis cells 42 the potline current is directed in the bottom to top direction with respect to the observer. On the other hand, in the neighboring row of cells 44 the current is directed in the opposite
direction. The entire series consisting of two lines 42 and 44 of electrolysis cells and the compensation device of the invention are accommodated in the same potroom 46 under the same roof.

[034] In one embodiment of the invention the first 38 and second 40 external supplemental compensation conductors are provided between the external sides 30 of the respective shells 15 and at a plane passing through the center O of the cathode 16 and the short or longitudinal axis OX. In the vertical plane the first and second external supplemental compensation conductors 38 and 40 are spaced from the bottom portion 26 of the respective cells. The internal supplemental compensation conductors 36 are disposed between the internal sides 28 of the respective shells 15 and the plane passing through the center O of the cathode 16 and the longitudinal axis of the cell OX. The supplemental internal compensation conductor 36 and the external compensation conductors 38 and 40 are separated from each other by a substantial gap and are positioned on opposite sides of the vertical plane passing through the longitudinal axis OX.

[035] The compensation arrangement of the invention operates in the following manner. Each line 42, 44 of electrolysis cells in the series is adapted for the intensity or amperage of about 400 kA. Each line of the cells creates in the melt of the cells of the adjacent line a vertical or upwardly oriented magnetic field component. The distance between the longitudinal axes of the lines 42 and 44 is about 30 m. In the chart of Fig. 3 the curve K illustrates the effect of the magnetic field of the adjacent line having intensity which varies from the inner side to outer side of the cell in an almost hyperbolic manner from 48.9·10⁻⁴ Tesla to 23.2·10⁻⁴ Tesla.

[036] The main internal 32 and external 34 electrical compensation conductors create in the melt a vertically oriented, hyperbolically expanding magnetic field having orientation which is opposite with respect to the magnetic field of the adjacent line of cells. The
length of the electrolysis cell adapted for the intensity or amperage of at least 400 kA is between 10-18 m. Thus, the magnetic field from the main compensation conductors 32 and 34 does not provide optimal compensation to the magnetic field generated in the melt of the neighboring line of cells. However, in the device of the invention the supplemental compensation conductors 36, 38 and 40 interacting with the internal and external main compensation conductors 32 and 24 are capable of providing optimal compensation to the magnetic field produced by the adjacent line of cells.

[037] In the above-discussed embodiment the respective current intensity in the compensation conductors is as follows: the main compensation conductor 32 - 50 kA; the main compensation conductor 34 – 35 kA; the supplemental compensation conductor 36 – 40 kA; the supplemental compensation conductor 38 – 40 kA; and the supplemental compensation conductor 40 – 15 kA. The compensation conductors of the compensation device of the invention are arranged and their respective amperage is selected by computer programs employing the principals of Biot-Savart-Laplace taking into consideration ferromagnetic structures.

[038] In the chart of Fig. 3 curve L reflects the total magnetic field from the main internal 32 and external 34 compensation conductors as well as the supplemental compensation conductors 36, 38 and 40. Curve K represents the magnetic field from the neighboring line of cells. Curve M represents the total or resulting magnetic field from the neighboring line of cells and the magnetic field from the compensation conductors, it represents the algebraic sum of the magnetic fields, i.e. M=K+L.

[039] The above-discussed examples illustrate that utilization of the compensation device of the invention provides optimum compensation of the magnetic field generated by the neighboring row of cells. In this respect, it is clearly illustrated in the chart of FIG. 3 that the value of the effective magnetic field from the adjacent lines of the electrolysis cells
represented by the curve $M$ is minimal and close to zero, with deviation of not more than $3 \times 10^{-4}$ Tesla.

[040] The device of the invention provides compensation of the magnetic field induced by the neighboring row of in-series connected cells and generates an optimum magnetic field in the operational zone of potline of high-power cells with the intensity of at least 350-400 kA arranged side-by-side. In this manner the optimal performance of the electrolysis cells is provided at the reduced level of expenses.
What is claimed is:

1. A device for compensating a magnetic field induced in a linearly arranged series of electrolysis cells by an adjacent generally parallel line of cells, each said electrolysis cell containing a metal shell extending in a vertical direction between top and bottom portions thereof and between internal and external sides in other direction, a cathode device containing at least a plurality of cathode bars, said cells being oriented transverse to an axis of the series, each said shell containing a layer of liquid aluminum, said compensating device comprising:

   a main internal electrical compensating conductor spaced laterally from the internal sides of said cells in the series, a main external electrical compensating electrical conductor spaced laterally from the external sides of said cells in the series;

   at least one internal supplemental electrical compensating conductor disposed under the bottom portion of the cells in the line and in the vicinity of the cathode bars situated at the internal sides of said cells along said main internal compensating conductor;

   at least first and second external supplemental electrical compensating conductors disposed at the bottom portion of the cells in the series along said main external compensating conductor, said first external supplemental conductor positioned in the vicinity of the cathode bars situated at the external sides of said cells, said second external supplemental conductor positioned between said first external supplemental conductor and a short longitudinal axis of said cell.

2. A device according to claim 1, wherein said main internal and external electrical compensation conductors are disposed substantially at a level of the layer of liquid aluminum in the respective cell.
3. A device according to claim 1, wherein said cathode bars form a part of a cathode device, said cathode bars are connected by means of a cathode busbar with anode risers of a respective anode device of a downstream electrolysis cell in the series of electrolysis cells.

4. A device according to claim 1, further comprising a source of direct current associated with said compensation conductors, the direction of the direct current in the main internal electrical compensation conductor coincides with the direction of the current in the line of cells, whereas the direction of current in the main external electrical compensation conductor being opposite to the current direction in the line cells.

5. A device according to claim 1, wherein said supplemental compensation conductors being oriented substantially parallel to the main electrical compensation conductors.

6. A device according to claim 1, wherein each said electrolysis cell further comprises a center of the cathode plane of the cell with at least a longitudinal axis and a vertical axis passing through said center, said first and second external supplemental compensation conductors are positioned between said external side of the shell and a plane passing through said short longitudinal axis.

7. A device according to claim 6, wherein said first and second external supplemental compensation conductors are spaced from said bottom portion of the cell.

8. A device according to claim 7, wherein the direction of current in said first and second external supplemental compensation conductors is opposite to the direction of the current in the series.
9. A device according to claim 6, wherein said at least one internal compensation conductor is positioned between said internal side of the shell and said plane passing through the longitudinal axis.

10. A device according to claim 9, wherein the direction of current in said at least one inner supplemental conductor coincides with the direction of the current in the series.

11. A device according to claim 6, wherein said supplemental internal and external compensation conductors are separated from each other by a substantial gap and are positioned on opposite sides of said plane passing through said longitudinal axis.
FIG. 3