ELECTROLYTIC FURNACES FOR THE PRODUCTION OF ALUMINUM

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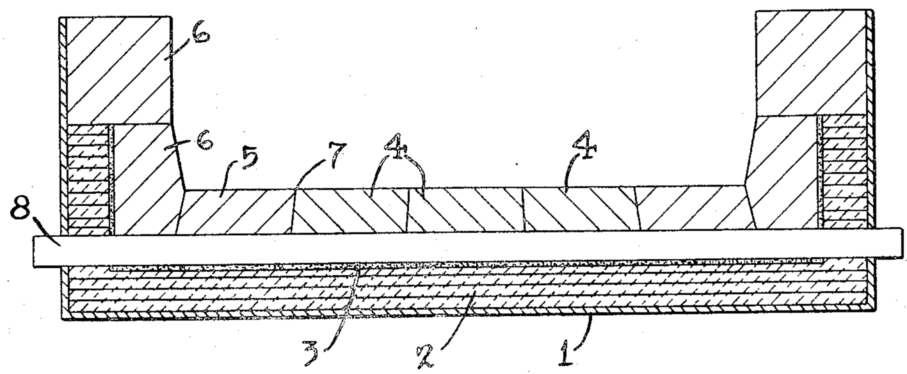
Fig 1



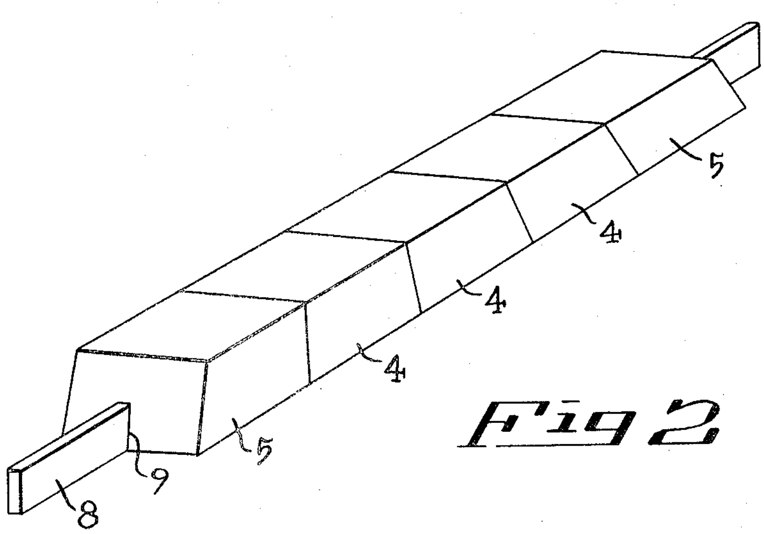


Fig 2

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ELECTROLYTIC FURNACES FOR THE PRODUCTION OF ALUMINIUM

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ABSTRACT OF THE DISCLOSURE

A set of blocks of carbon and/or graphite intended for assembly to form the cathode of a cell for the production of aluminium by fusion electrolysis, these blocks possessing four lateral surfaces, at least a pair of which opposed to each other being inclined at different angles to the vertical in order to obtain a mutual wedging of the blocks against upwards acting forces, particularly within a row of blocks arranged along a conductor bar. An electrolytic cell with a cathode made of such blocks.

This invention relates to cells intended for use in the fusion electrolysis process for production of aluminium.

The selection of cathodes for use in the fusion electrolysis process for production of aluminium depends upon the resistance of the cathode material to electrolyte and metal melt as well as upon their electrical properties. The cathodes generally used consist of a number of rows of parallelepipedic blocks comprising carbon or graphite, which are assembled together in an electrolysis tank to form a substantially flat base, the joints between the blocks being tamped or filled with cementing compositions. The carbon, carbon bonded graphite (semi-graphite) or graphite blocks from which the cathode is generally formed and, in particular, the jointing composition together present an available pore volume of the order of 20 to 30% of the cathode volume, into which electrolyte and melt penetrate during operation of a cell comprising the cathode. Constituents of the electrolyte and molten aluminium react at the operating temperature with carbon or graphite, so that aluminium carbide and intermediate compounds, in particular, are formed. The reaction products have a larger volume than the reactants, so that tensile stresses are set up in the cathode, and these are only partially taken up by the tank housing the cathode. The mechanical stresses eventually lead to buckling and bulging of the cathode, especially in the region of its surface. For this reason a substantially spacing apart between anode and cathode is required so as to avoid short-circuits. The increase in spacing causes an increase in the voltage drop and a less satisfactory current efficiency and also relatively large quantities of metal have to be retained within the furnace if electrolysis is to be maintained. The increasing buckling of the cathode can lead to individual blocks being lifted out of place, with formation of cracks, particularly in the jointing composition. This eventually makes it necessary for the electrolysis cell to be switched off for repairing or remaking the cathode.

Attempts have been made to reduce the buckling or distortion of the cathode by constructing it from materials which are substantially resistant to molten aluminium and electrolyte, instead of from carbon or graphite. For example, German Offenlegungsschrift 1,533,439 has described a cathode built up from several layers, the layer facing the bath containing materials resistant to aluminium and electrolyte, for example borides, nitrides and carbides of aluminium. The exapnsion during electrolysis

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of such cathodes is less than 3%. However, such cathodes are very costly to construct.

According to one aspect of the present invention, there is provided a set of blocks of carbon and/or carbon-bonded graphite and/or graphite intended for assembly to form a cathode for use in a cell for the fusion electrolysis of an alumina-containing electrolyte to produce aluminium, the blocks being shaped so as to abut closely one against the next over a common interface and each block having parallel end surfaces of different size so that, when assembled together, the smaller end surfaces together form one face of the cathode and the larger end surfaces together form an opposite face of the cathode, the blocks being grooved or slotted so that, when they are assembled to form a cathode, a conductor bar can pass through the grooves or slots in an assembled row of the blocks.

According to a second aspect of the invention, there is provided for use in the production of aluminium by fusion electrolysis of an alumina-containing electrolyte, a tank in the bottom of which is arranged a cathode as a lining therefor, the cathode being constituted by a set of blocks of carbon and/or carbon-bonded graphite and/or graphite according to the invention which has been assembled so that the blocks abut closely over a common interface with the smaller end surfaces together the top surface of the cathode and the larger end surfaces together forming the bottom surface of the cathode, the slots or grooves in the blocks being aligned with a conductor bar arranged therein.

Assuming that the aforesaid faces of the cathode are flat, at least some of the lateral surfaces of the blocks, that is the faces other than the aforesaid parallel faces will generally be of different slope. Although there is no limit to the number of lateral faces, for simplicity of construction of the cathode, there will generally only be four, that is to say, the blocks will be of trapezoidal cross-section in at least one direction therethrough which is perpendicular to said parallel surfaces and parallel to an edge of a said opposed surface. This allows assembly of the blocks in line with the shorter edges of the trapezoidal faces being uppermost in the assembled cathode.

If the blocks are of trapezoidal cross-section in two such directions, this will ensure improved cathode behaviour when blocks are assembled in a two dimensional layout. However, for reasons which will be apparent from the description of the preferred manner of assembly of the cathode, the blocks will generally only be of trapezoidal cross-section in one direction; two opposed lateral sides will be vertical.

Owing to the manner of assembly of the component blocks of the cathode with the larger of their parallel faces together forming the cathode base, the mechanical stresses caused by thermal expansion and chemical reactions are distributed over the base of the cathode and are largely taken up by the blocks. The loosening of the individual blocks of the cathode, with formation of cracks in the jointing composition, is substantially, if not completely, avoided. The manner of assembly of the blocks allows narrow joints to be obtained. The width of the joints is preferably less than 1 mm. This means that the power transmission between the blocks is improved and that, by reducing the amount of the jointing material which reacts particularly readily with electrolyte and molten metal, the overall expansion of the cathode is reduced.

Accordinng to a preferred embodiment of the invention, a layer capable of being compressed is arranged between the blocks from which the cathode is formed and the base or the lateral walls of the tank. The compressible layer preferably consists of a porous material. The compressible layer allows a certain degree of free expansion of the carbon block layer to occur. This "floating" arrangement further contributes to the suppression of mechanical stresses in the monolithic carbon block bed. The effect of the compressible layer is enhanced if the base of the tank bottom is connected by expansion joints to the tank walls, the joints advantageously being provided with gas-impervious seals. The compressible layers employed can be formed, for example, of porous refractory bricks which disintegrate under compressive stresses, of fillings of loose refractory material or thermoplastic plastics-bound carbon-containing compositions.

Although all the cathode blocks can be formed of the same carbonaceous material, the cathode is preferably formed from a combination of types of blocks, blocks of graphite and/or carbon-bonded graphite being located in the centre of the cathode area and blocks of carbon being located at the cathode margins. By using cathode blocks having different thermal conductivities, which are generally from 3 to 15 kcal./m.h. ° C. for carbon blocks, from 20 to 40 kcal./m.h. ° C. for carbon-bonded graphite blocks and from 60 to 160 kcal./m.h. ° C. for graphite blocks, the temperature distribution in the cathode is evened out. This contributes further to the suppression of mechanical sresses between the blocks.

By constructing the cathode in the aforesaid manner according to the invention, it is possible to substantially reduce, or eliminate bulging of the bed of blocks from which it is formed which would impair the operation of the furnace and cause the voltage drop to increase. Bulging of the cathode bed can be largely prevented even after operating for a relatively long time. The cathodic current distribution is more likely to be constant than with known arrangements, so that a better current efficiency is obained. Whereas the life of cells for production of aluminium by electrolysis with conventional cathodes is generally, on average, about 1200 days, cells using cathodes according to the invention are expected to have a life of at least 2500 days.

For a better understanding of the invention and to show how the same can be carried into effect, reference will now be made, by way of example only, to the accompanying drawing, in which:

FIG. 1 is a cross-section through the pot of a cell for use in the production of aluminium by fusion electrolysis with thank and cathode, and

FIG. 2 is a perspective view of part of the cathode for the cell.

Referring to FIG. 1 of the drawing, there is shown a steel tank **1** lined with fire-clay bricks **2**. On the surface of the bricks **2** remote from the tank **1** is provided a compressible layer **3** consisting of coke and graphite powder and a thermoplastic binder, on which layer is formed an arrangement of blocks of carbonaceous material. Thus, away from the margins of the tank **1** are arranged carbon-bonded graphite blocks **4** while carbon blocks **5** are arranged in the marginal regions of the cell tank. Each block has opposed surfaces of rectilinear dimensions, the top surfaces being smaller than the bottom surfaces and the angles between the vertical and the contact surfaces between two adjacent blocks becoming larger with increasing distance from the centre of the cell tank for any one row of blocks **4** and **5**.

The blocks **4** and **5** comprise slots for accommodating a conductor bar **8**. The rows of blocks within the tank are supported against the lateral boundary of the tank by marginal blocks **6**, which also consist of carbon and also contain slots in line with the slots in the blocks **4** and **5**. The distance between two blocks is about 0.8 mm. and the joints **7** therebetween are filled with a carbon-containing cementing composition. Because of the mutual wedging of the blocks which results from their being trapezoidal in section and the favourable anchoring of the rows of blocks with the marginal blocks, the bulging of the cathode formed from the blocks and a lifting of individual blocks in the event of a joint defect is substantially, if not completely, prevented.

Referring next to FIG. 2, the shape and arrangement of the blocks **4** and **5** straddled on the conductor bar **8** can be seen more clearly. Since a small gap **9** exists between the bar **8** and the blocks **4** and **5** and the marginal blocks **6**, this gap is filled with a cast metal or is tamped with a carbon-containing composition. The blocks **4** and **5** shown in FIG. 2 have the preferred shape according to the invention, that is, they have two lateral surfaces inclined relatively to the vertical at different angles, through which surfaces the conductor bar extends, and two vertical, lateral boundary surfaces extending parallel to the conductor bar. The assembly of a row of the blocks is particularly facilitated by this arrangement. Although, in principle, only a single row of blocks may be required, cells for use on a commercial scale will generally be at least 5 to 6 metres long and about 4 metres wide. Since the blocks are generally about 50 to 80 cms. long in their various directions, this will mean that a number of rows of the blocks will generally be used. In this case, all the lateral boundary surfaces of the blocks can be inclined relatively to the vertical, each two successive lateral faces in either direction being inclined at different angles relatively to the vertical. This will allow a cathode to be produced which is particularly stable against buckling. However, a cathode comprising such an arrangement of blocks will be difficult to construct in practice, particularly in view of the resulting large number of different block shapes necessary, this being in contrast to the simple symmetrical arrangement shown in FIG. 2, where only a small number of different block shapes is needed.

For this purpose, the blocks for assembly to form a row are inverted and assembled with their grooves in line. A conductor bar is placed in the continuous groove, and, molten iron is poured into the remaining small gap. When the iron has solidified, the blocks of the row are connected together through the conductor rod and can be placed in the bottom of the cell tank. A number of such assembled rows of blocks will be laid in side-by-side relationship in the tank. A sufficient reduction in the tendency of the cathode to buckle is provided by the construction of the individual rows of blocks with the conductor rods connected thereto by cast iron, even in the case of blocks having the shape shown in FIG. 2.

The cathode material will generally extend some way up the side walls of the tank. The side walls will also generally be formed of carbon blocks and will preferably be vertical continuations of the rows of blocks in the bottom of the tank. For this reason, the lowermost block of each vertical row will generally be keyed to the adjacent marginal block of the adjacent horizontal row of blocks. For similar reasons to those set out in connection with the horizontal rows of blocks, the vertical rows of blocks will abut each other over parallel surfaces at right angles to the end walls of the tank.

What we claim is:

1. In a cell for the fusion electrolysis of aluminum, the combination comprising

- a tank for the alumina containing electrolytes,
- a set of electrically conductive blocks arranged in a substantially horizontal plane in said tank forming the cathode of said cell,
- the blocks having inclined lateral surfaces shaped so that each lateral surface will abut closely against a lateral surface of the adjacent block, each block having parallel end surfaces of different size so that, when assembled together, the smaller end surfaces together form the upper face of the cathode and the larger end surfaces together form an underside of the cathode.

2. A cell according to claim **1**, each block having a groove aligned with the grooves of the adjacent blocks receiving a conductor bar.

3. A cell according to claim **1**, in which each block possesses four lateral surfaces, at least a pair of which lateral surfaces which are opposed to each other being inclined at different angles to the vertical, said blocks being assembled into a plurality of parallel rows.

4. A cell as claimed in claim 1, in which at least one block remote from marginal blocks of the cathode is formed of graphite and/or carbon-bonded graphite and marginal blocks of the cathode are formed of carbon.

5. A cell as claimed in claim 1, in which the spacing between any two abutting surfaces of the blocks is not more than 1 mm..

6. A cell as claimed in claim 1, in which at least one layer of compressible material is disposed between the tank and the blocks.

7. A cell as claimed in claim 6, wherein the compressible material is porous.

8. A cell as claimed in claim 7, wherein the compressible material consists of refractory bricks which disintegrate under compressive stress.

9. A cell according to claim 7 wherein the compressible material comprises loose refractory material.

10. A cell according to claim 7 wherein the compressible material comprises a thermoplastic plastics-bound carbon containing composition.

11. A cell as claimed in claim 4, wherein any carbon block present in the cathode has a thermal conductivity of from 3 to 15 kcal./m.h.° C.

12. A cell as claimed in claim 4, wherein any carbon-bonded graphite block present in the cathode has a thermal conductivity of from 20 to 40 kcal./m.h.° C.

13. A cell as claimed in claim 4, wherein any graphite block present in the cathode has a thermal conductivity of from 60 to 160 kcal./m.h.° C.

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