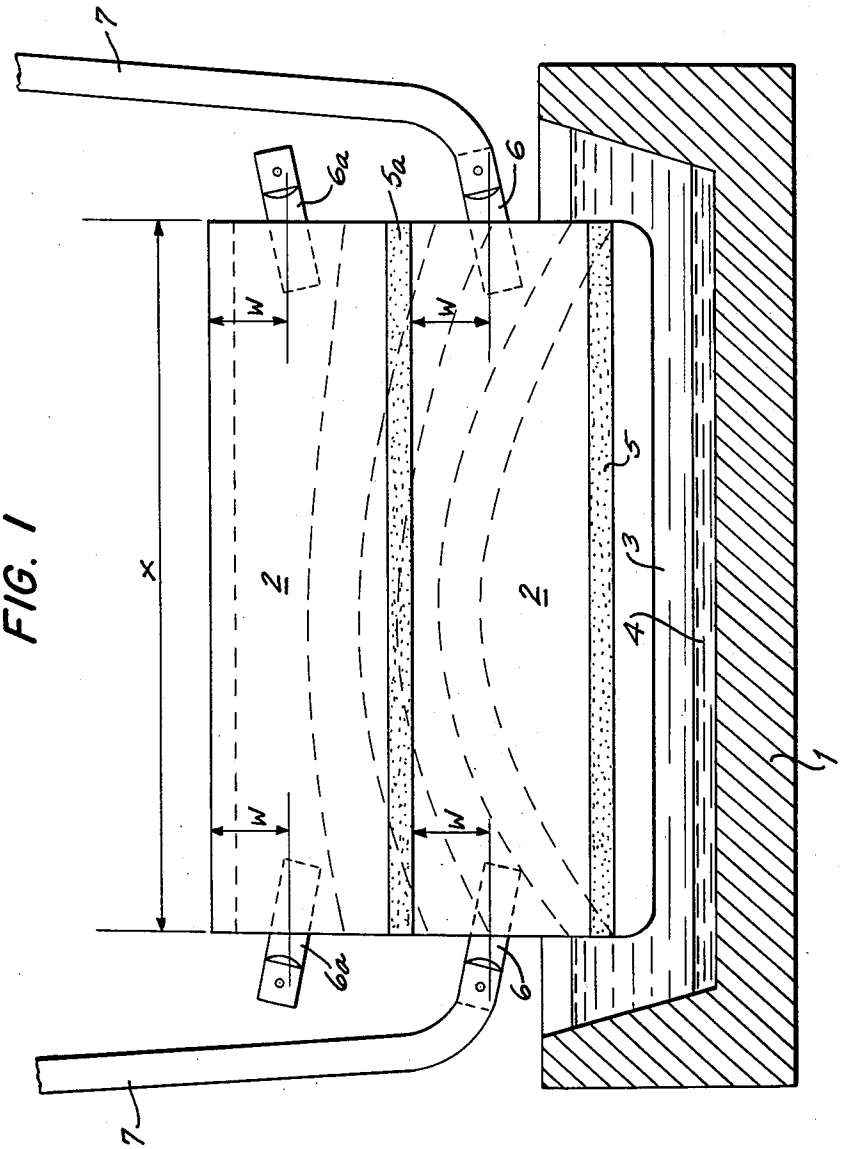
Nov. 21, 1961 W. HELLING ET AL 3,009,870

ELECTROLYTIC CELL

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FIG. 1



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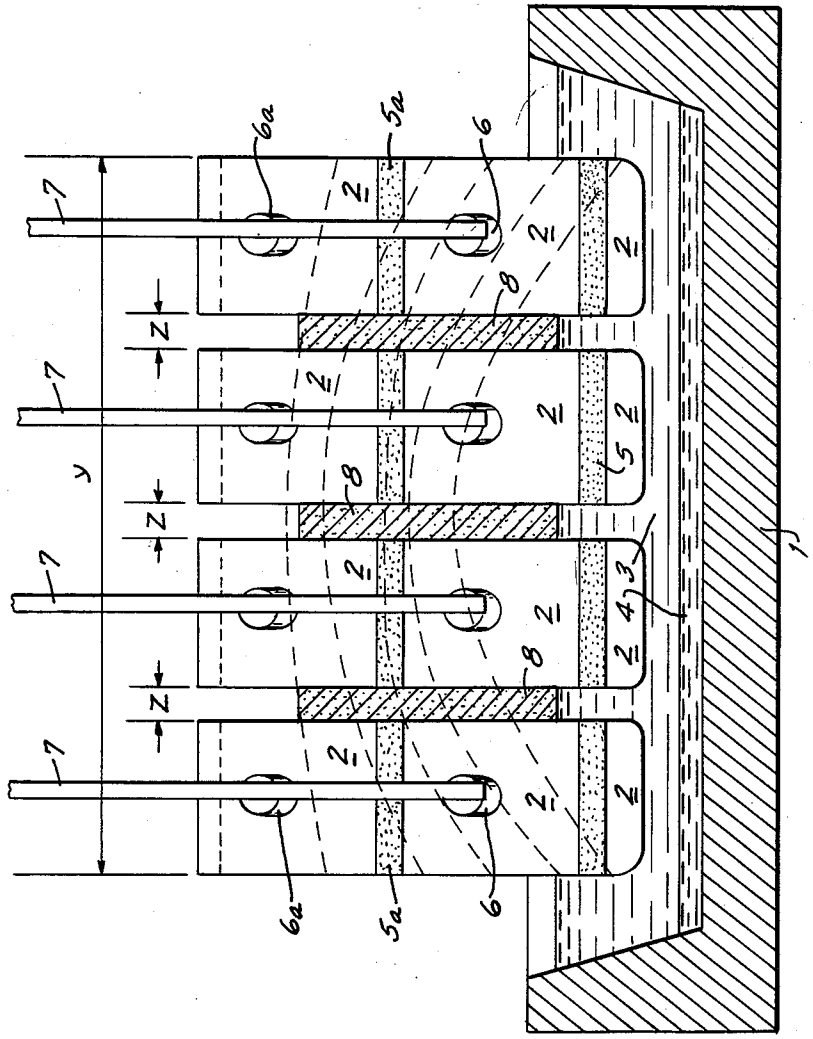
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ELECTROLYTIC CELL

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FIG. 2



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3,009,870

ELECTROLYTIC CELL

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Claims priority, application Germany May 25, 1954
1 Claim. (Cl. 204—243)

The present invention relates to an electrolytic cell for the production of aluminum from an alumina-containing molten electrolyte material, and more particularly, it relates to an electrolytic cell including a plurality of continuous carbon block anodes.

The present application is a continuation-in-part of our copending application Serial No. 509,012, filed on May 17, 1955, and now abandoned, and entitled "Continuous Melt-Electrolytic Recovery of Aluminum."

It has been found advantageous for the large scale production of aluminum by electrolysis of an alumina-containing molten electrolyte to replace the previously used discontinuous carbon anodes with continuous carbon anodes and particularly with prebaked continuous carbon anodes. Such prebaked continuous carbon anodes consist essentially of superposed prebaked carbon blocks which are adhered to each other by a layer of carbonaceous cement. The layer of carbonaceous cement is to be such as to harden and firmly adhere the superposed carbon blocks of the anode to each other upon being heated to a suitable elevated temperature.

The layer of carbonaceous cement has to be thus hardened while current conducting nipples are still inserted into the lower of the two prebaked carbon blocks. These nipples serve not only for conducting current to the anode but also for holding and suspending the entire carbon block anode structure in the electrolytic cell. The entire carbon anode is slowly lowered into the molten electrolyte and the nipples have to be removed from a carbon block before being lowered to the upper level of the molten electrolyte. At the time of removal of the nipples from the lower carbon block, nipples previously inserted into the superposed carbon block will serve to carry the entire anode structure and to conduct current thereto. It follows that at the time when the nipples are removed from the lower carbon block, the carbonaceous cement must have been sufficeintly hardened so that the lower carbon block will adhere to and be carried by the superposed carbon block.

However, it has been found that an arrangement such as the above is extremely difficult to make and to operate since on the one hand the nipples have to be removed from the carbon block before reaching the surface of the molten electrolyte and also before being heated to a temperature which would damage the nipple, while on the other hand the carbonaceous cement layer located above the nipple between the carbon block carrying the nipple and the superposed carbon block, has to be heated to a sufficiently high temperature to assure that the lower carbon block, upon removal of the nipples therefrom, will be safely carried by the superposed carbon block.

It is therefore an object of the present invention to overcome the difficulties incurred in the use of a series of continuous carbon block anodes in the operation of aluminum producing cells.

It is another object of the present invention to provide in an electrolytic cell a plurality of continuous prebaked carbon block anodes in such a manner that the electrolytic cell can be easily and economically operated in a continuous manner and without exposing the means for suspending the anodes and conducting current thereto to unduly high temperatures.

Other objects and advantages of the present invention

will become apparent from a further reading of the description and of the appended claim.

With the above and other objects in view, the present invention mainly comprises in an electrolytic cell for the production of aluminum from an alumina-containing molten electrolytic material, in combination, a plurality of continuous carbon block anodes, each of the anodes comprising at least two superposed prebaked carbon blocks and a layer of a carbonaceous cement adapted to coke and harden at a temperature of at least about 500° C. located between and adhering to adjacent faces of the superposed prebaked carbon blocks, each of the anodes having a length of at least about 1000 mm., the anodes being arranged parallel to each other with elongated side faces of adjacent anodes facing each other, the anodes being spaced from each other at a distance not exceeding about 100 mm., and the distance of the outer elongated side faces of the two outer anodes of the plurality of anodes from each other being at least 1000 mm., whereby upon immersion of the lower portions of the anodes in the molten electrolyte and operation of the electrolytic cell, a crust of electrolyte material will be formed between adjacent anodes adjacent to the surface of the molten electrolyte thereby defining a channel between the upper level of the crust and adjacent side faces of adjacent anodes, a tightly stamped packing consisting essentially of pulverulent electrolyte constituents arranged between adjacent carbon block anodes, the packing being adapted to rest with its bottom face on the crust and to substantially fill the channel up to a predetermined height, the predetermined height being so chosen that the upper level of the packing will be located adjacent to portions of the side faces of adjacent anodes which during operation of the electrolytic cell will have a temperature not exceeding about 400° C., and current conducting suspension means operatively connected with the carbon block anodes, the suspension means including elongated nipples extending, respectively, through opposite short vertical frontal faces of at least one prebaked carbon block of each of the anodes, into the interior of the one prebaked carbon block, the distance from the point where the axis of the nipple cross-sects the frontal face of the one prebaked carbon block to the upper face of the one prebaked carbon block not exceeding 250 mm., whereby upon operation of the electrolytic cell and concurrent lowering of the anodes into the molten electrolyte, the carbonaceous cement between the one prebaked carbon block and a prebaked carbon block superposed thereon will be heated to at least 500° C. and thereby coked and hardened, thus firmly adhering the one and the superposed carbon block to each other before the nipples extending into the one prebaked carbon block have been lowered to the upper level of the molten electrolyte.

In this connection, it should be noted that the carbonaceous cements which are customarily used in accordance with the present invention either in the form of a heavy paste or in the form of strips or plates which are solid at room temperature and will soften at somewhat elevated temperature, generally are plastic at a somewhat elevated temperature, which temperature is reached when the layer of carbonaceous cement is still rather far distant from the upper level of the molten electrolyte (the molten electrolyte generally having a temperature of about 950° C.). During lowering of the carbon block anode corresponding to the degree to which the lower portion of the lowest carbon block of the anode is consumed, the temperature of the carbonaceous cement layer rises, and generally when the temperature of the layer of carbonaceous cement has reached about 500° C., the same hardens so as to firmly adhere the superposed carbon blocks to each other and so as to, at the same time, permit the passage of current from the superposed carbon block

through the layer of cement to the lower carbon block which is partially immersed in the molten electrolyte.

While the present invention is not to be limited to any specific composition of the layer of carbonaceous cement, the carbonaceous cement or binder material should preferably have a composition which corresponds substantially to the composition of an unbaked electrode mass such as is used for instance in the so-called Soederberg anodes. The composition of such a carbonaceous cement is given below by way of examples only, the present invention, however, not being limited to any specific composition of the carbonaceous cement between superposed prebaked carbon blocks.

Table I

Compositions of Carbonaceous Cement, percent by weight	Example Number			
	1	2	3	4
Petroleum coke 0–0.2 mm	26	------	5	28
Petroleum coke 0.2–1 mm	22	------	------	20
Petroleum coke 1–3 mm	15	------	------	13
Pitch coke 0–0.2 mm	------	26	7	------
Pitch coke 0.2–1 mm	------	20	20	------
Pitch coke 1–3 mm	------	14	13	------
Soot	3	5	2	3
Graphite	2	2	20	------
Machine oil	2	------	1	1.6
Naphthalene	2	0.8	2.8	------
Ammonium persulfate	------	0.2	------	0.2
Sulfur	2.0	------	0.2	1.2
Pitch (softening point 75° C.)	23	25	23	26
Tar oil	3	7	6	7

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claim. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

FIG. 1 is a schematic elevational view in cross-section of an electrolytic cell according to the present invention; and

FIG. 2 is a schematic elevational view in cross-section of the same electrolytic cell taken in a direction normal to the direction of the cross-section shown in FIG. 1.

Referring now to the drawing, the electrolytic cell is shown to comprise a trough-shaped cathode **1** and a series of superposed carbon block anodes, each anode comprising a plurality of carbon blocks **2**. The anodes are immersed with their lower portions in molten electrolyte **3** having a temperature of about 950° C. A layer **4** of molten aluminum formed by operation of the cell is shown at the bottom of cathode trough **1**. The molten electrolyte consists customarily of an alumina-containing molten cryolite.

Electric current is carried to the anodes through current supply rods or nipples **6** and **6***a*. Nipples **6** are connected with rails **7** which conduct the electric current and also serve for the purpose of controlling the position of the anodes relative to the upper level of molten aluminum **4** so that the desired position is accurately maintained by lowering the anodes corresponding to the rate at which the portion of the anodes submerged in the molten electrolyte are consumed.

As shown in the drawing, nipples **6***a* are not connected with the current conducting rails **7** and consequently not yet operative. Nipples **6***a* will be connected to rails **7** at the time when nipples **6**, due to the continuous downward movement of the anodes, have so closely approached the surface of molten electrolyte **3** that the danger of damaging the nipples has arisen. At that time nipples **6***a* will be connected with the current conducting and anode carrying rails **7** and nipples **6** will be disconnected and removed. Nipples **6** and rails **7** form current conducting suspension means.

In order to be able to operate the electrolytic cell in a continuous manner, it is necessary that at the time nipples **6** are disconnected, the layer **5***a* of carbonaceous cement is already sufficiently hardened so that the lower prebaked carbon block **2** suspended therefrom will not drop off and can be supplied with current through rails **7**, nipples **6***a*, upper prebaked carbon block **2** and carbonaceous cement layer **5***a*, since the entire anode will now be only suspended at upper prebaked carbon block **2** by nipples **6***a* and rails **7**. Similarly, at the stage illustrated in the drawings, carbonaceous cement layer **5** has already long been hardened so as to be capable of holding the partially consumed carbon block suspended from layer **5**.

It has been found, according to the present invention, that specific dimensional relationships are required in order to achieve that layer **5***a* will be sufficiently heated so as to be hardened at the time when nipples **6** are disconnected and nipples **6***a* together with rails **7** become the sole suspension means of the anode. It has been observed that, particularly in the case of large anodes, the isothermal planes form an inner upward arch which increases corresponding to an increase in the horizontal dimensions of the anodes.

In the drawings, the isothermal planes are indicated by dotted lines. It is apparent that particularly in the case of large anodes, large parts of the carbonaceous cement are heated to higher temperatures at an earlier stage and are consequently hardened earlier or quicker than would be the case with anodes in which the isothermal planes due to the smaller horizontal dimensions of the anodes have a substantially horizontal shape.

It has now been found that the desired early hardening of the carbonaceous layers during operation of continuous prebaked carbon anodes can be achieved by fulfilling a number of requirements. It is necessary, according to the present invention, to arrange the individual anodes in series parallel and spaced from each other with their long vertical side faces adjacent to each other. The distance between adjacent anodes is to be not more than about 100 mm. preferably about 50 mm., and for practical reasons not less than about 30 mm., the present invention, however, not being limited to any specific minimum distance between adjacent anodes.

The space between adjacent anodes is partially filled with a packing **8** consisting of tightly stamped pulverulent electrolyte materials, for instance, cryolite, or alumina or a mixture of the same. This packing prevents thermal losses due to heat radiation and also achieves that from the point of view of heat and temperature distribution, the entire series of anodes will react substantially like one single block. The packing is upwardly spaced from the lower edge portions of the adjacent anodes and it extends upwardly filling the entire space between adjacent anodes up to a height where during operation of the cell the anode temperature will not rise above about 400° C. In any event, the packing will extend upwardly for a sufficient distance to be in contact with portions of the side faces of two superposed carbon blocks **2** and with the side faces of the interposed carbonaceous layer **5***a*. In addition to preventing heat losses, the packing serves also to prevent oxidation of the elongated anode side faces by preventing access of oxygen thereto. Due to the fact that the molten electrolyte forms at its upper level a hardened crust, it is a simple method of positioning the packing to stamp the same into the space between adjacent anodes while temporarily closing the channel formed by the hardened crust of the electrolyte and the adjacent side faces of adjacent anodes with pieces of sheet metal extending along the planes formed by the opposite short vertical faces of the anodes, respectively.

In order to achieve the desired temperature distribution within the anode according to the present invention, the horizontal length of the individual anodes, i.e. the horizontal lengths of the elongated side faces must be at least 1000 mm. This distance is indicated in FIG. 1 or the drawing by the line *x*. Furthermore, the total length

of the series of the entire anodes including the spaces between the same must also be at least 1000 mm., as indicated by line *y* in FIG. 2 of the drawing. Furthermore, the nipples **6** and **6***a* are to be arranged not further distanced than about 250 mm. from the top face of the carbon block **2** in which they are inserted. This distance is to be measured from the point where the nipple axis cross-sects the front face of the carbon block and is indicated in FIG. 1 by line *w*. The distance between adjacent anodes which is not to exceed 100 mm. is indicated in FIG. 2 as *z*.

Thus, according to the present invention, a packing consisting of pulverulent electrolyte constituents is stamped into the channel formed between the individual anodes. The packing extends from the upper crust of the electrolyte to a height at which the temperature at the packing covered anode surface is below 400° C. The individual anodes are formed by cementing superposed prebaked carbon blocks having metal bolts as nipples fastened to their vertical short frontal faces. The nipples of carbon block **2** nearing the electrolyte are connected with nearly vertical rails **7** which carry the anode and supply electric current thereto. Corresponding to the consumption of the anode at its lower end which is immersed into the molten electrolyte, the anodes are lowered by lowering rail **7** so as to retain the desired distance between anode and cathode. Correspondingly, additional prebaked carbon blocks are superposed at the upper end of the anode and adjacent carbon blocks are adhered to each other by carbonaceous cement layers **5** and **5***a*. When anode carrying nipples **6** have been lowered towards the surface of the electrolyte so that there exists danger of destruction or serious damage to the nipples due to the heat emanating from the electrolyte, rails **7** are fastened to the next higher set of nipples **6***a* and nipples **6** are removed from the prebaked carbon block. The dimensions which are critical or preferred for assuring tight adherence of superposed prebaked carbon blocks due to timely hardening of the carbonaceous cement, are summarized in the following Table II. Hardening of the carbonaceous cement layer **5***a* safely takes place when the same is heated to temperatures above 500° C. due to the heat distribution throughout the anode series.

Table II

Horizontal lengths of carbon blocks: at least 1000 mm., preferably between 1000 and 2500 mm.

Horizontal width of carbon blocks: preferably between 200 and 1000 mm.

Distance between adjacent anodes: not exceeding 100 mm., preferably 50 mm.

Horizontal distance between outer elongated side faces of outermost anodes of entire anode series: at least 1000 mm., preferably between 1000 and 10,000 mm.

Distance from point where nipple axis cross-sects vertical frontal face of carbon block to upper face of carbon block: not exceeding 250 mm., preferably between 200 and 250 mm.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of electrolytic cells differing from the types described above.

While the invention has been illustrated and described as embodied in an electrolytic cell for the production of aluminum from alumina-containing molten electrolyte material, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claim.

What is claimed as new and desired to be secured by Letters Patent is:

In an electrolytic cell for the production of aluminum from an alumina-containing molten electrolyte material having a temperature of about 950° C., in combination, a plurality of continuous carbon block anodes, each of said anodes comprising at least two superposed prebaked carbon blocks having substantially flat lower and upper faces, respectively, and a layer of a carbonaceous cement adapted to coke and harden at an elevated temperature below said temperature of said molten electrolyte located between and adhering to adjacent faces of said superposed prebaked carbon blocks, each of said anodes having a horizontal length of at least about 1000 mm., said anodes being arranged parallel to each other with elongated side faces of adjacent anodes facing each other, said anodes being spaced from each other at a distance not exceeding a fraction of said horizontal length of each of said anodes, and the horizontal distance of the outer elongated side faces of the two outer anodes of said plurality of anodes from each other being at least 1000 mm., whereby upon immersion of the lower portions of said anodes in said molten electrolyte and operation of said electrolytic cell, a crust of electrolyte material will be formed between adjacent anodes adjacent to the surface of said molten electrolyte thereby defining a channel between the upper level of said crust and adjacent side faces of adjacent anodes; and current conducting suspension means operatively connected with said carbon block anodes, said suspension means including elongated nipples extending, respectively, through opposite short vertical frontal faces of at least one prebaked carbon block of each of said anodes, into the interior of said one prebaked carbon block whereby upon operation of said electrolytic cell and concurrent lowering of said anodes into said molten electrolyte, said carbonaceous cement between said one prebaked carbon block and a prebaked carbon block superposed thereon will be heated to said elevated temperature and thereby coked and hardened, thus firmly adhering said one and said superposed carbon block to each other before said nipples extending into said one prebaked carbon block have been lowered to the upper level of said molten electrolyte.

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