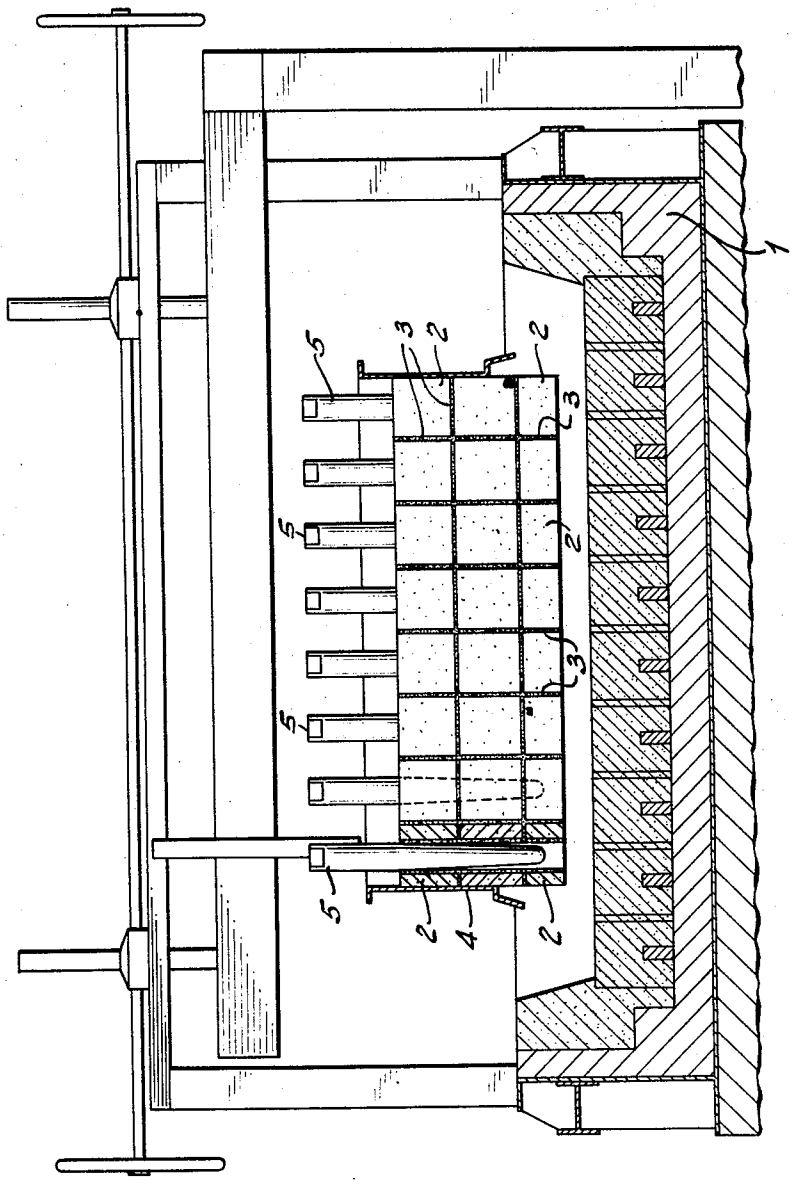
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METHOD OF MAKING SELF-BAKING CONTINUOUS ELECTRODES

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Fig. 1



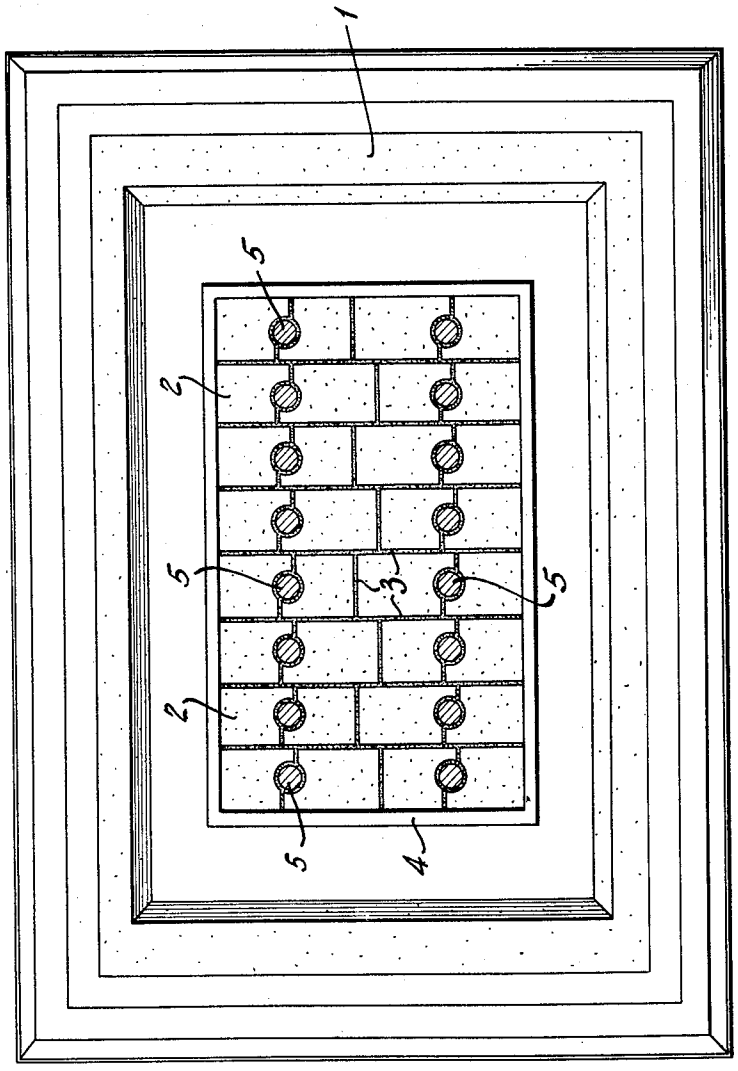
INVENTORS
HANS SCHMITT
KURT TOMA
BY
Morrison, Kennedy & Campbell
ATTORNEYS

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Fig. 2.



INVENTORS
HANS SCHMITT
KURT TOMA
BY
Harrison, Kennedy & Campbell
ATTORNEYS

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METHOD OF MAKING SELF-BAKING CONTINUOUS ELECTRODES

Hans Schmitt and Kurt Toma, Rheinfelden, Baden, Germany, assignors, by mesne assignments, to Elektrokemisk A/S, Oslo, Norway, a corporation of Norway

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5 Claims. (Cl. 204—67)

In electrolytic cells for the production of aluminum in a fused salt bath two types of anodes are used: The self-baking anodes of the so-called Söderberg type which are produced continuously according to their consumption in the cell or the so-called pre-baked anodes, made from pressed carbonaceous material and baked in a separate furnace, which have to be replaced after consumption by new pre-baked anodes, so that the anodes are handled discontinuously.

The cells provided with pre-baked anodes have the advantage of a lower anodic voltage drop compared with the cells with self-baking anodes. The difference is mainly caused by the lower specific resistance of the pressed and pre-baked anodes. The specific resistance of pre-baked anodes has a value of 50 to 70.10^{-4} ohm.cm.^{2}.cm.$^{-1}$ at a temperature of 20° C. whereas the baked Söderberg paste has a specific resistance of 80 to 110.10^{-4} ohm.cm.^{2}.cm.$^{-1}$. Furthermore the voltage drop between the contact studs and the carbon anode is generally lower in the pre-baked anodes than in the Söderberg anodes, as the contact studs are fixed into the pre-baked anodes outside the cell, where this operation can be done carefully, whereas with Söderberg anodes the contact studs must be driven into the carbonaceous mass on the pot during the operation in such a way that they may be loosened and pulled out when they have reached their deepest position. Moreover the smallest distance between the lower end of the contact stud and the lower face of the pre-baked anode just before replacing the latter is generally smaller than the corresponding distance between the contact stud and the lower face of the Söderberg anode before pulling out the stud. That means that the average path of current from the stud to the lower face is generally shorter in pre-baked anodes than in Söderberg anodes.

All in all it is possible to operate cells with pre-baked anodes with an anodic voltage drop which is by 0.15 to 0.3 volt lower than in cells with self-baking anodes. This voltage gain enables to make savings of 0.5 to 1 kwh. per kilogram aluminum.

But nevertheless the Söderberg anodes are generally preferred especially in electrolytic cells of high current intensity as in this case it is not necessary to prepare a plurality of anodes outside the cell, the dimensions of which anodes are limited through the pressing and baking process, and as it is possible to equip the cell with one large or at most two anodes. It is known that the use of Söderberg anodes presents great advantages as to the construction of the anodic part of the cell and the operation of the same. A further advantage of the use of only one or two large anodes in each cell consists in the fact that the current is distributed more uniformly over the whole cross-section of the anode and that therefore the distance of the anode from the cathode layer is rather the same over the whole cross-section of the anode because of a more uniform consumption of the same. With a plurality of pre-baked anodes in one cell it is practically impossible to distribute the current uniformly and to keep all anodes at the same distance from the cathode layer.

This advantage of the Söderberg anodes compared with the pre-baked anodes is especially noticeable in cells which are operated with a current intensity of more than 60,000 amperes. It is known that in cells of such a high current intensity electromagnetic forces are generated which may cause a vaulting of the molten metal leading to troubles in the normal operation. In a cell with a plurality of anodes the surface of the molten metal fluctuates more and in a greater extent than in a cell with one or two large anodes, probably because of the different distance of the electrodes from the cathode layer and of the different current charging rates of the anodes. Also during the replacement of consumed anodes always troubles arise in the distribution of the current; these troubles favour the vaulting of the moten metal. Also in cells with Söderberg anodes the electromagnetic forces cause a vaulting of the molten metal but the vaulting is not as great as in the cells with pre-baked anodes as the current is more uniformly distributed and the operation continuous.

That is why in cells with pre-baked anodes the average distance of the anodes from the cathode must be greater than in Söderberg cells of the same current intensity. This greater distance results in a higher bath voltage without increase of current yield, as the increased vaulting of the molten metal causes a re-oxidation of the metal deposited on the cathode and therefore a decrease of the current yield.

With respect to the vaulting of the molten metal, cells of a current intensity of 60,000 amperes and more with pre-baked anodes must therefore be operated with a higher bath voltage than Söderberg cells with one anode.

The advantage of the lower anodic voltage drop in the cells with a plurality of pre-baked anodes is thereby practically nullified and when operating with very high current intensities of for example 80,000 or 90,000 amperes the advantages of the Söderberg cell predominate more and more. Cells with pre-baked anodes and of such a high current intensity must be operated generally with a higher voltage than Söderberg cells of the same current intensity.

To make the best of the advantages of a cell with one or only a small number of continuous Söderberg anodes without renouncing to the low electric resistance of pressed and pre-baked anodes, one has already tried to use anodes composed of two or more pressed and pre-baked carbon blocks arranged side by side and to operate them continuously by setting up new blocks according to the consumption of the anodes and to join them with the lower blocks by means of a carbonaceous paste. After consumption of the lower blocks the contact studs must be displaced from the lower to the upper blocks. This may only be done when the joining carbonaceous paste between the blocks has been baked and has thereby reached such a high conductivity that no inadmissible voltage drop in the joint arises. It is the disadvantage of these continuous anodes from pre-baked blocks that no adhesive has yet been found allowing an infallible joining of the pre-baked blocks and that there is always the danger of an unsufficient joining of the blocks or of an unsufficient baking or coking of the adhesive which consists generally of coke or carbon powder and pitch. This may lead to remainders (scraps) of the lower block falling down into the bath or to a high voltage drop in the joint.

The present invention relates to a method of making a continuous anode to be used in electrolytic cells for the production of aluminum and avoiding the mentioned disadvantages of the known pre-baked or self-baking continuous anodes. According to this method a continuous

anode is made by joining and sticking together unbaked pressed, rammed or extruded blocks of carbonaceous material. The anode is made a continuous one by setting up on the anode in the cell new unbaked blocks according to the consumption of the lower blocks and joining the unbaked blocks to the lower blocks by means of a carbonaceous adhesive, for example Söderberg paste. An adhesive having a lower viscosity than the carbonaceous material of the blocks, so that it begins to flow at a lower temperature, is preferred. Such a material can be better brought into the joints between the blocks as a material of a higher viscosity and fills also more thoroughly the holes on the surface of the blocks. The adhesive may be applied in liquid or sappy state by pouring into the joints or by spreading over the surface. A carbonaceous material of a higher viscosity than Söderberg paste may also be used as adhesive, for example a material of the same composition as the material of the blocks or a similar material but with a lower pitch content; but such an adhesive must be applied by stamping instead of pouring.

The composition of the carbonaceous material (consisting for instance of pulverized coke and coal-tar pitch) of the blocks which have to be used for making the anodes according to the invention corresponds to the composition of the normal and usual anodes before baking, that is to say that the content of pitch as a binder amounts to about 16 to 20 percent.

Examples for the composition of the anodes

(1) An anode material consisting of about 70 percent pitch coke and 30 percent purest coal coke with an addition of pitch as a binder.

(*a*) Composition of the mixture:

Coke type	Grain size according to the Tyler sieve, mm.	Content in percent of the whole mixture
Pitch coke	1.68 to 3.36	8
Do	0.21 to 1.68	30
Do	0 to 0.21	19
Purest coal coke	1.68 to 3.36	3
Do	0.21 to 1.68	8
Do	0 to 0.21	14
Hard pitch		18
		100

(*b*) Specification of the hard pitch:

Softening point according to Krämer-Sarnow	°C	86
Coking residue	percent	60
Insoluble in anthracene oil	do	14
Insoluble in benzene	do	44

(2) An anode material consisting of 55 percent pitch coke, 30 percent coal coke obtained at high temperature and 15 percent pulverized anode scrap with an addition of solid pitch as a binder.

(*a*) Composition of the mixture:

Coke type	Grain size according to the Tyler sieve, mm.	Content in percent of the whole mixture
Pitch coke	1.68 to 3.36	7
Do	0.21 to 1.68	24
Do	0 to 0.21	14
High temperature coal coke	1.68 to 3.36	5
Do	0.21 to 1.68	9
Do	0 to 0.21	10
Anode scrap	0 to 3.36	12
Hard pitch		19
		100

(*b*) Specification of the hard pitch as in Example 1.

Examples for the composition of the carbonaceous adhesive (Söderberg paste)

(1) A Söderberg paste consisting of 70 percent pitch coke, 30 percent purest coal coke and an addition of middle hard pitch as a binder.

(*a*) Composition of the mixture:

Coke type	Grain size according to the Tyler sieve, mm.	Content in percent of the whole mixture
Pitch coke	1.68 to 3.36	7
Do	0.21 to 1.68	24
Do	0 to 0.21	18
Purest coal coke	1.68 to 3.36	2
Do	0.21 to 1.68	6
Do	0 to 0.21	13
Middle hard pitch		30
		100

(*b*) Specification of the middle hard pitch:

Softening point according to Krämer-Sarnow	°C	76
Coking residue	percent	60
Insoluble in anthracene oil	do	4
Insoluble in benzene	do	30

(2) A Söderberg paste consisting of pitch coke and hard pitch as a binder.

(*a*) Composition of the mixture:

Coke type	Grain size according to the Tyler sieve, mm.	Content in percent of the whole mixture
Pitch coke	1.68 to 3.36	17
Do	0.21 to 1.68	24
Do	0 to 0.21	31
Hard pitch		28
		100

(*b*) Specification of the hard pitch:

Softening point according to Krämer-Sarnow	°C	84
Coking residue	percent	55
Insoluble in anthracene oil	do	6
Insoluble in benzene	do	31

The accompanying drawing shows as an example an electrolytic cell for the production of aluminum provided with an anode according to the invention. Fig. 1 shows a side view of the cell partly in section. Fig. 2 shows the cell in a top view, the upper parts of the cell with the current supply being not shown.

The numeral **1** designates the pot of the cell provided with a carbon lining. This pot is of known type. The anode made according to the invention is composed of the blocks **2** of carbonaceous material. The joints **3** are filled with Söderberg paste. The whole packet of carbonaceous blocks is surrounded and held by the iron frame **4**, the suspension of which being for the sake of simplicity not shown. The anode slides downwards within this frame **4** according to its consumption. Before setting on new blocks the upper surface of the lower blocks is covered with the Söderberg paste as adhesive for the joining of the blocks. The horizontal distance between the blocks put side by side is preferably 5 to 20 mm.; the joints are also filled with Söderberg paste.

In the example the blocks **2** forming the anode are staggered in the horizontal plane. But it is also possible to arrange them vertically staggered.

In the lower part of the anode the joined blocks are baked by the effect of the heat generated in the cell and the Söderberg paste is coked. In the upper part of the anode the blocks are still unbaked and the Söderberg paste not yet coked.

The current supply to the anode is ensured by means of contact studs which are preferably of round section, made

of steel and arranged vertically; one of them is shown in Fig. 1, designated with the numeral 5. Half cylindrical grooves on abutting faces of two blocks arranged side by side form the hole for driving in the contact stud; this hole extends through all blocks set upon each other. The diameter of this hole is preferably 20 to 50 mm. larger than the diameter of the contact stud. The grooves are formed during pressing or ramming the blocks. The holes may also be arranged in the interior of the blocks and formed for example by means of a mandrel during the extrusion of the blocks. After driving in the contact stud, the hole is filled up with Söderberg paste.

The contact studs are pulled upwards from time to time according to the consumption of the anode, their lower extremity remaining always in the baked part of the anode.

One may also use as contact studs slit tubes or tubes composed of two tube-halves, these tubes being provided with a metal insert spreading the two parts of the tube against the hole wall. Before pulling the tube-studs upwards the inserts are drawn out, so that the tube-studs may easily be loosened.

Of course the contact studs may also have another cross-section than a circular one, for example a square one.

A cell with an anode according to the invention may be put in operation in the same way as a cell with a Söderberg anode:

Conducting elements are inserted between the bottom of the cell forming the cathode and the lower extremity of the contact studs on the unbaked anode which rests on the said bottom. These elements connect electrically the contact studs with the cathode, as the unbaked carbonaceous material is non-conducting. This material is baked through the current heat generated in the conducting elements, so starting the coking process of the anode. The conducting elements may be made of iron, graphite or a baked carbonaceous material.

It is also possible to start with an anode the lower blocks of which have been pre-baked in their lower part outside the cell.

Tests with a cell equipped with an anode according to the invention have shown that pressed blocks from unbaked carbonaceous material with Söderberg paste as a sticking agent are thoroughly joined together during the progressive coking, so that a sufficient mechanical and electrical joint is ensured. The voltage drop in the joint is hardly higher than in the baked mass of the block and there are no remainders and fragments falling down into the bath as it happens often in cells with the known continuous pre-baked anodes.

In anodes according to the invention the blocks do not run during the coking process under the influence of the heat in the cell as in Söderberg anodes. Because of their lower pitch content, the blocks soften without losing practically their shape.

Cells provided with anodes according to the invention have the advantage of a lower anodic voltage drop compared with the Söderberg cells, as they allow to utilize the higher conductivity of pressed blocks, and like cells with pre-baked anodes they have the advantage of working with a lower bath voltage. It is therefore possible to operate cells provided with anodes according to the invention with an overall voltage which is by 0.15–0.3 volt lower than in Söderberg cells, so that the consumption of energy is decreased by about 0.5–1 kwh. per kg. of aluminum.

What we claim is:

1. The method of operating cells for the electrolytic production of aluminum in fused fluorides containing bath using self-baking continuous consumable anodes from carbonaceous material with metallic studs for the supply of current, which method comprises repeatedly covering the top of the carbonaceous self-baking anode with a layer of carbonaceous paste of substantially the same composition as the carbonaceous material of the anode and laying unbaked preformed blocks of carbonaceous material and of predetermined size and shape thereon without interrupting the operation of the cell, the bottom of the anode being already baked and having substantially the electrolysis temperature and the top of the anode being unbaked, and bonding the unbaked preformed blocks side by side by means of carbonaceous paste of substantially the same composition as the carbonaceous material of the anode, the unbaked preformed blocks being added to the top of the anode at a rate to compensate for the progressive consumption of the bottom of the anode.

2. The method according to claim 1, wherein the carbonaceous paste used for repeatedly covering the top of the carbonaceous self-baking anode has a lower viscosity than the carbonaceous material of the unbaked preformed blocks being added to the top of the anode.

3. The method according to claim 1, wherein the unbaked blocks are made from a carbonaceous material consisting essentially of pulverized coke and pitch.

4. The method according to claim 1, wherein the carbonaceous adhesive consists essentially of pulverized coke and pitch.

5. The method according to claim 1, wherein the assembled blocks are surrounded by a metal frame and slide downward as a unit along said frame as the anode is consumed.

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