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ELECTROLYTIC APPARATUS AND PROCESS FOR PRODUCING ALUMINUM

Filed Jan. 5, 1956

2 Sheets-Sheet 1

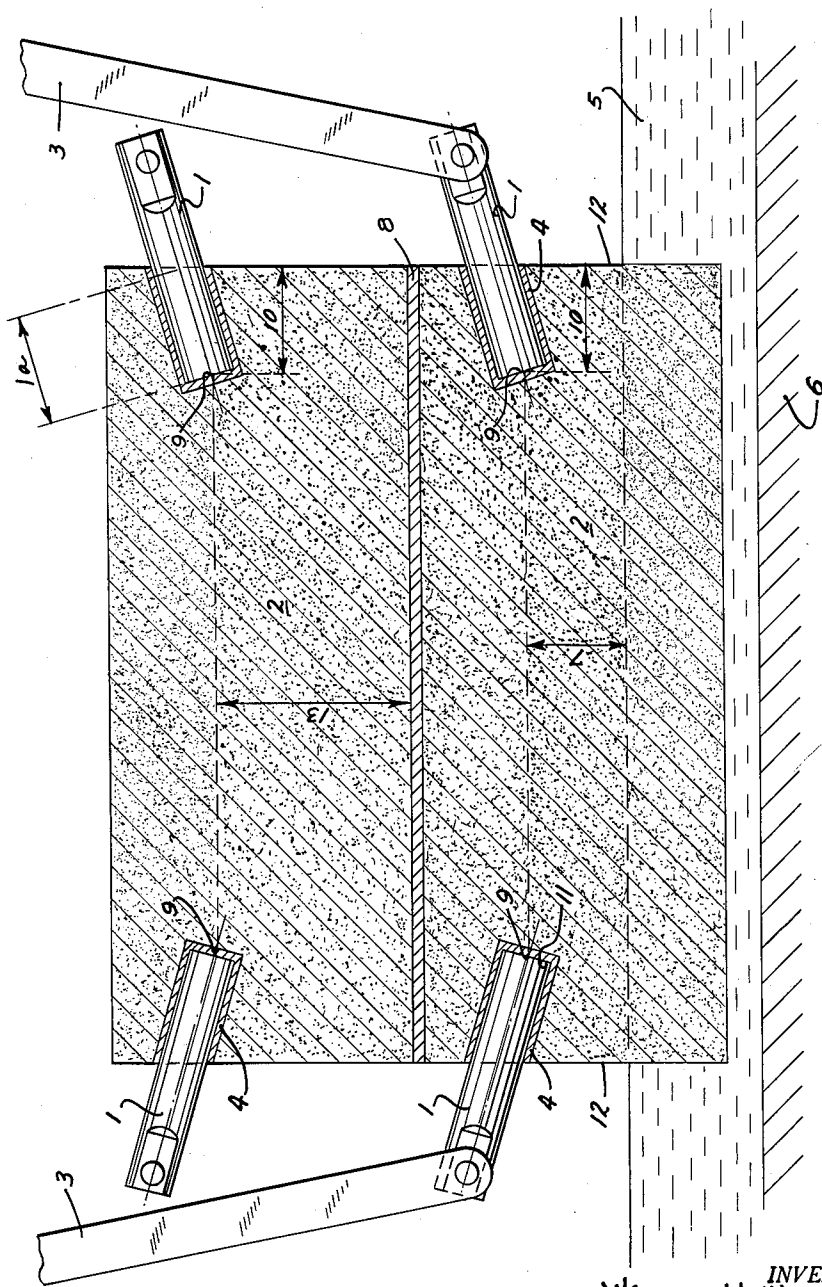


FIG. 1

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2 Sheets-Sheet 2

MINIMUM VERTICAL  
DISTANCE 7 BETWEEN  
INNER END 9 OF CONTACT  
MEMBER 1 AND UPPER  
SURFACE PLANE OF  
MOLTEN BATH OF  
ELECTROLYTE

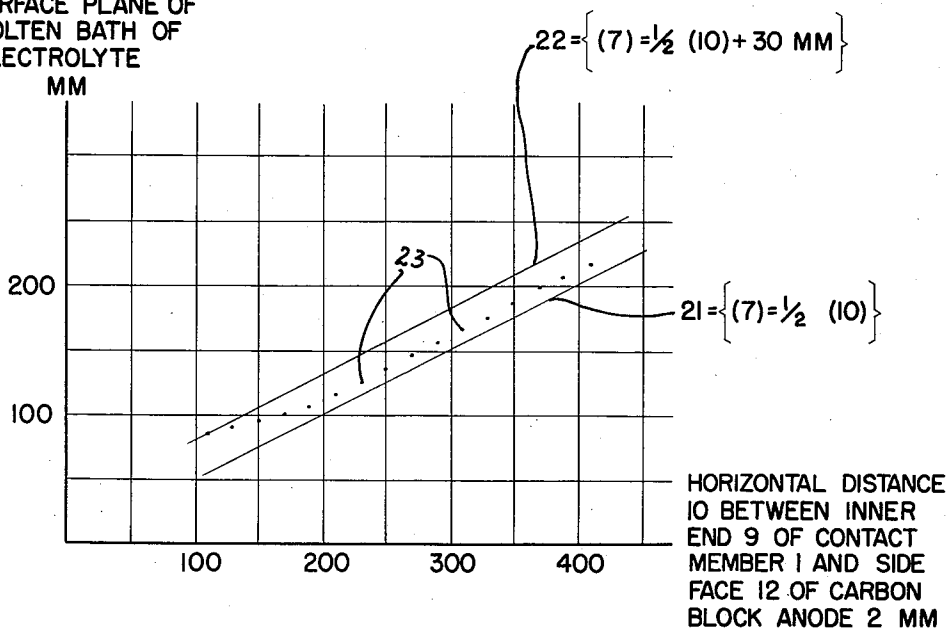


FIG. 2

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**ELECTROLYTIC APPARATUS AND PROCESS FOR PRODUCING ALUMINUM**

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Claims priority, application Germany Jan. 7, 1955

10 Claims. (Cl. 204-67)

The present invention relates to an arrangement and process for producing aluminum, and more particularly it relates to an arrangement and process for producing aluminum in an electrolytic cell utilizing pre-burned continuous carbon block anodes.

In electrolytic cells for the production of aluminum, carbon block anodes are vertically suspended and immersed with their lower portion in a molten bath of aluminum-containing electrolyte. The temperature of this molten bath is about 1,000° C. During the electrochemical reaction taking place in the electrolytic cell, the lower portions of the carbon anode which are immersed in the molten bath of electrolyte are continuously consumed, and consequently the carbon anode has to be mechanically lowered in order to keep the lower surface of the anode in the prescribed distance from the cathode formed by the bottom of the cell. The carbon anodes are supplied with electrical current by means of copper or aluminum conductors which are at least partly flexible so as to follow the downward movement of the carbon anode. These copper or aluminum conductors terminate in elongated iron members which are fastened to and extend partly into the carbon anode. The elongated iron contact members may be fastened to pre-burned anodes in various ways, for instance, by screwing the elongated iron member into the anode, or by pouring or tamping material in the space between the elongated iron member and the carbon anode. Regardless how the elongated iron contact members are connected with the carbon anode, the same move downwardly together with the anode and have to be withdrawn from the anode before they are lowered to the upper surface level of the molten electrolyte. In the case of discontinuous anodes, rather than removing the iron contact member, the entire discontinuous anode is removed from the bath when the same has been lowered to such an extent that the iron member comes close to the upper surface of the molten electrolyte. In the case of continuous anodes, the iron contact members are preferably extended into the carbon anodes from side faces thereof. The innermost portions of the iron contact members, i.e. the portions which extend farthest into the carbon anode, are exposed to considerably elevated temperatures. A great number of iron contact members are required for the aluminum production and it is important to reuse the same in order to prevent excessive costs. Reuse of the iron contact members is limited by corrosion effects which occur on their surface primarily when the same are exposed to very high temperatures, and especially when the same are exposed to high temperatures and to the action of carbon and sulphur from the surrounding carbon anode. It is then necessary to remove the corroded surface layers from the iron contact member before the same can be reused, since the presence of the corroded surface layers prevents proper transmission of electric current to the anode. The thickness of the corroded surface layers depends on the temperature to which the iron contact member is exposed and also on the degree to which it is exposed to the action of sulphur and sulphur compounds. The removal of the corroded surface layers is expensive and reduces the diameter of the elongated iron contact member, so that consequently the same can be reused

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only a limited number of times. The materials which are used for making continuous anodes consist overwhelmingly of carbon and always also contain sulphur. It is not possible to make continuous carbon anodes of materials which will not deleteriously affect the elongated iron contact members.

It is therefore an object of the present invention to overcome the before mentioned disadvantages in the use of elongated iron contact members for transmitting electric current to carbon anodes in the electrolytic aluminum production.

It is a further object of the present invention to provide an arrangement and method whereby iron contact members can be used for transmitting electric current to carbon anodes in an economical and efficient way.

It is yet another object of the present invention to provide an arrangement and method whereby exposure of iron contact members to excessive and corroding temperatures is prevented.

It is still another object of the present invention to provide an arrangement and method whereby the corroding influence of sulphur and sulphur compounds on iron contact members connected with carbon anodes is prevented.

Other objects and advantages of the present invention will become apparent from a further reading of the description and the appended claims.

With the above objects in view, the present invention consists in a carbon block arrangement for use in an electrolytic cell comprising, in combination, a carbon block having top and bottom faces and a pair of opposed side faces extending between the top and bottom faces, and a pair of elongated electrically conductive members carried by the block nearer to the top than the bottom face thereof and respectively extending partly into the block at the opposed side faces thereof, the elongated members respectively having inner ends located within the block respectively at distances from the bottom face thereof greater than one-half the distance of the inner ends from the opposed side faces, respectively, plus between 0 and 30 millimeters.

The present invention also comprises in a process for producing aluminum in an electrolytic cell from a molten aluminum-containing electrolyte, the steps of partly immersing in an electrolytic bath of molten aluminum-coating electrolyte a carbon block having at least one pair of elongated electrically conductive members extending partly into the same at opposed side faces thereof, respectively, lowering the block as it is consumed, and removing the elongated members from the block before the elongated members reach a predetermined temperature between about 700° C. to 750° C.

The present invention also comprises as a new composition of matter an intimate mixture essentially consisting of between 75 and 86% by weight of at least one finely divided substance belonging to the group consisting of carbon black, graphite, coke and aluminum, and of between 14 and 25% by weight of at least one binder liquid belonging to the group consisting of molasses, concentrated sulfite liquors and phenol-resol resins, the mixture containing less than 0.5% sulphur and being adapted to gas-tightly cover iron members and to prevent corrosion thereof.

In accordance with the present invention it has now been found that damage to the iron contact member can be substantially prevented and consequently the useful life span of the iron contact member substantially increased by preventing their being exposed to temperatures of 750° C. or more. Particularly it has been found that very little corrosion takes place as long as the temperature of the iron contact member is kept at or below 700° C. This is of particular importance when for the electrolytic production of aluminum continuous anodes are to be used,

that is, an anode arrangement whereby on top of the anode carbon block which is immersed in the molten electrolyte bath another similar anode carbon block is positioned and electrically conductive cemented to the lower carbon block. To the extent that the lower portion of the lowest carbon block which is immersed into the molten electrolyte bath is consumed, the combined structure of at least two superimposed carbon block anodes is lowered within the electrolytic cell. In such arrangements the elongated iron contact members extend through opposed vertical side faces of the carbon block into the same. The temperature within the carbon block increases in downward direction, i.e. in the direction towards the molten mass of electrolyte which, as stated above, is kept at a temperature of about 1,000° C., and the temperature also increases inwardly from the opposed side faces of the carbon block towards the center of the same. Since it is rather difficult to actually measure the temperature at various locations within the carbon block during operation of the cell, it was necessary in order to achieve the object of the present invention, to determine the lowermost and innermost position within the carbon block which the elongated iron contact member may reach without being exposed to temperatures in excess of about 700° C. According to the present invention it has now been found that the elongated iron contact member will not be exposed to such excessive temperatures as long as the vertical distance from the inner end of the elongated iron contact member located within the carbon block to the surface plane of the molten bath of electrolyte into which the carbon block is partly submerged is greater than one-half of the horizontal distance from the inner end of the elongated iron contact member within the carbon block to the side face of the carbon block through which the elongated contact member extends into the same, plus between 0 and 30 millimeters. In other words, the vertical distance from the innermost end of the iron contact member within the carbon anode to the surface plane of the hot molten electrolyte must be at least half as great as the horizontal distance from the innermost end of the iron contact member to the side face of the carbon block, but preferably the vertical distance exceeds a length of one-half of the horizontal distance by up to about 30 millimeters and most preferably by 20 millimeters.

Since the position of the inner end of the elongated iron contact member within the carbon block can easily be determined, both with respect to its horizontal distance from the side face of the carbon block and with respect to its vertical distance to the bottom face of the carbon block, it is now relatively simple to watch the slow submerging of the carbon block in the molten electrolyte and to remove the iron contact member when the vertical distance between the inner end thereof and the upper surface plane of the molten electrolyte has been reduced to the above defined minimum.

The elongated iron contact members are inserted into the carbon anode block in pairs from opposite side faces thereof so that in each one of two opposite side faces at least one iron contact member is inserted. However, especially in connection with larger carbon blocks frequently two or three elongated iron contact members are inserted in each of two opposed side faces of the carbon block. The present invention is in no way to be limited to any specific number of elongated iron contact members to be inserted in each of two opposed side faces of the carbon block. Preferably the elongated iron contact members are inserted into opposed side faces of the carbon block at a distance from the top face of the carbon block which is less than one-half of the distance between the elongated iron contact member and the bottom face of the carbon block, and most preferably the distance from the top face is kept between one-quarter and one-third of the entire height of the side face of the carbon block. Preferably the portion of the elongated iron contact members which is extended into the carbon block is of cylindrical

shape and has a circular cross section with a diameter of between 70 millimeters and 180 millimeters. Excellent results have been obtained with cylindrical elongated iron contact members having a diameter of about 100 millimeters. The elongated iron contact members are inserted into the carbon block anode in horizontal direction or inclined at angles of between 0° and 30° with a plane in which the top face of the carbon block anode is located. To position the elongated contact members within the carbon block under a slight downwardly inclined angle greatly facilitates both the insertion and the removal of the elongated contact members. The length of the part of the elongated iron contact member which is inserted into the carbon anode, measured along its axis is preferably kept between 150 millimeters and 400 millimeters. It depends, of course, also on the overall size of the carbon block in which the contact member is to be inserted. While optimum values as to the angle under which the contact member is to be inclined as well as to the length of the inserted portion of the contact member and to the diameter of the same vary with actual operating conditions, it has been found that in many cases the best results are obtained by inserting an elongated iron contact member having a cross-sectional diameter of about 100 millimeters to a length of about 250 millimeters into the carbon block anode inclined under an angle of about 20° with the plane in which the top face of the carbon anode is located.

As stated above, in accordance with the present invention, a critical minimum relationship exists between the horizontal distance from the innermost end of the elongated iron contact member to the side face of the carbon anode through which the contact member extends into the same, and the vertical distance from the innermost end of the iron contact member to the bottom face of the carbon anode, respectively the upper surface plane of the molten electrolyte into which the lower portion of the carbon anode is submerged. Throughout this application the inner end, or the innermost end of the elongated iron contact member is to be understood as the point at which the axis of the elongated iron contact member intersects the surface portion thereof which is farthest inside the carbon block anode.

As soon as during operation of the electrolytic cell the inner portion of the elongated contact member which is exposed to the highest temperatures has reached a temperature of between 700 and 750°, or as soon as the vertical distance from the inner end of the member to the surface plane of the molten bath of electrolyte has been reduced to the above defined critical length in relation to the horizontal distance from the inner end of the elongated iron contact member to the side face of the carbon anode, the elongated iron contact member is disconnected from the source of electric current and is pulled out of the carbon block anode. The pulling out of the iron contact member is accomplished with customary tools such as prongs, well known in the art. At the same time contact members which extend into a superimposed carbon block of the continuous anode are connected with the source of electric current so that the electrolytic process can proceed practically without interruption. During continuation of the electrolytic process, the lower anode carbon block is consumed and the superimposed carbon block which is now connected with the source of electric current becomes the lower block and another block is superimposed upon the same and the entire process of removing the elongated iron contact members from the carbon block when they have come into the proximity of the molten bath of electrolyte, and placing new iron contact members into superimposed carbon blocks is repeated at required intervals. The elongated iron contact members which are removed from the carbon anodes before having been exposed to a temperature of about 700 to 750° C. show very little corrosion and consequently can be reused without substantial

reduction of their diameter. Further means of reducing corrosion of the surface of the elongated iron contact members, according to the present invention, will be discussed further below.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. 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 view, partially in cross section, of a carbon block arrangement according to the present invention; and

FIG. 2 is a graphic illustration of the relationship between minimum vertical distance of the inner end of the iron elongated member from either the bottom face of the carbon anode block, or the upper surface plane of the molten electrolyte bath when the carbon block is partly immersed into the same, and the horizontal distance of the inner end of the elongated iron contact member from the side face of the carbon block through which the contact member extends into the same.

Referring now to the drawings and particularly to FIG. 1, a portion of the electrolytic cell for the production of aluminum is shown including the cathode 6 forming the bottom of the cell and the molten bath of aluminum-containing electrolyte 5 filling the lower portion of the cell. Two superimposed carbon block anodes 2 are shown which are electrically conductive cemented to each other by means of layer 8. Elongated iron contact members 1 are partially extending into the carbon block anodes. The part of contact members 1 which extends inside the carbon block anode is indicated by reference numeral 1a. Members 3 serve for transmitting electric current to elongated iron contact members 1 and also for suspending of the carbon anode block in the electrolytic cell, so as to permit the lowering of the carbon block into the molten bath of electrolyte at the same rate at which the immersed portion of the carbon block anode is consumed. The inner end of the elongated contact member, i.e., the point at which the axis of the elongated member 1 intersects the surface portion 11 thereof which is farthest inside the carbon block, is indicated by reference numeral 9. Elongated contact members 1 extend into the carbon block anode 2 through opposed side faces 12. The horizontal distance from the inner end 9 of elongated contact member 1 to side face 12 is indicated by reference numeral 10. The vertical distance from the inner end 9 of elongated contact member 1 to the surface plane of molten electrolyte 5 is indicated by reference numeral 7, and the vertical distance from the inner end 9 of elongated contact member 1 to the bottom face of carbon block anode 2 is indicated by reference numeral 13.

The relationship between vertical distances 7 and 13, and horizontal distance 10 is graphically illustrated in FIG. 2. Line 21 indicates the relationship wherein vertical distance 7 or 13 must not be less than one-half of horizontal distance 10. Obviously, when forming the carbon block arrangement vertical distance 13 must exceed one-half of horizontal distance 10 by a considerable amount, so that the thus formed arrangement can be used for a reasonable length of time in the electrolytic cell before distance 7 has been reduced to the minimum length of one-half of distance 10. Line 22 indicates the relationship between vertical distances 7 or 13 and horizontal distance 10, wherein vertical distances 7 or 13 must not be less than one-half of horizontal distance 10 plus 30 millimeters. A number of experiments under actual operating conditions were carried out in order to determine the most advantageous minimum distance 7 in relation to distance 10. The results of these experiments are indicated as point 23 lying between lines 21 and 22. These results are also recorded in the following table. It

will be noted that most of these most advantageous relationships between the vertical distance 7 and the horizontal distance 10 are indicated by a vertical distance 7 equal to one-half of horizontal distance 10 plus 20 millimeters.

TABLE I

Horizontal distance 10 from inner end 9 of elongated contact member 1 to side face 12	Minimum vertical distance 7 from inner end 9 of elongated contact member 1 to upper surface plane of molten electrolyte 5
110	85
130	90
150	95
170	100
190	105
210	115
230	125
250	135
270	145
290	155
310	165
330	175
350	185
370	195
390	205
410	215

It has also been found in accordance with the present invention that the corrosion of the part of the elongated contact member which extends into the carbon anode can be substantially prevented by a gas-tight, covering layer of low sulphur content. Especially when fastening iron contact members by tapping into pre-formed bores in the carbon anode, it is advantageous to prevent the formation of corroded surface layers on the elongated iron contact member by surrounding the same with a gas-tight mass of low sulphur content which covers the contact member and prevents access of carbon and sulphur compounds formed during operation in the pre-burned continuous carbon anode to the iron contact member. Preferably the gas-tight layer has a thickness of between 3 and 25 millimeters. Excellent results were obtained with a gas-tight layer having a thickness of 10 millimeters. The gas-tight layer according to the present invention is indicated in FIG. 1 of the drawings by reference numeral 4.

The following examples of mixtures of which the gas-tight layer according to the present invention may be formed are given as illustrative only, the present invention however not being limited to the specific details of the examples.

#### Example 1

21 parts by weight of molasses, 5 parts by weight of granulated carbon black having a particle size of between 0.0001 and 0.1 millimeter, and 0.2 part by weight of the sodium salt of isopropyl naphthalene sulphonic acid are homogenized in an emulsifying apparatus for about 30 minutes at about 50° C. The mixture is then cooled to about 20° C. and thereafter 42 parts by weight of low sulphur natural graphite flakes containing about 95% carbon and having a granule size of between 0.1 and 1.0 millimeter, together with 32 parts by weight of low sulphur, calcined petroleum coke containing about 0.3% ash and comprising a mixture of about 9% granules of 0.001 to 0.1 millimeter, 7% granules of 0.1 to 1.0 millimeter and 84% granules of between 1 and 3 millimeters, are combined with the first formed mixture and stirred until a homogeneous mixture is formed. The thus-formed homogeneous mixture is allowed to stand in closed containers for at least 14 days at room temperature and is then ready for use.

Various substitutions can be made in the individual components of the mixture described in Example 1, while generally following an identical procedure in preparing the material for the low-sulphur, gas-tight layer. The sulphur content of all of the mixtures formed according to Examples 1-11 is less than 0.5%.

The components used in Examples 2-11 are shown in the following table, in which all figures indicate percent by weight.

TABLE II

Example	2	3	4	5	6	7	8	9	10	11
Molasses	15	19	22	16			14	14	14	
Carbon black, granulation 0.0001-0.1 mm		4	3							
Sodium salt of isopropyl naphthalene sulphonic acid		0.3	0.3							
Natural graphite—95% carbon, low sulphur content, flake size 0.1-1.0 mm	64	40		48	70	54	60		56	30
Calcined petroleum coke low sulphur content (same as in Example 1)				34				26		
Coal tar pitch coke, low sulphur content, 0.5% ash, granulation 1-3 mm	20				16		26			
Linseed oil	1									
Electrographite, 0.2% ash, particle sizes: 30% 0.001-0.1, 30% 0.1-1, and 40% 1-3 mm		37								5
45% 0.001-0.1, 50% 0.1-1, and 5% 1-3mm 1-3 mm			75				18			
Purest hard coal coke, 0.5% ash, granulation 0.01-0.2 mm							8			
Aluminum powder, particle sizes: 0.001-0.1 mm								60		
0.1-1.0 mm									30	
0.01-1 mm										48
Stand oil				2						
Concentrated sulphite liquor (density 1.48)					14					16
Phenol resin (liquid)							20			
Trisodium phosphate										1

Three preferred embodiments of the present invention both as to the carbon block arrangement and as to the method disclosed herein are given in the following Table III. These examples obviously are given as illustrative only, the present invention not being limited to any of the details disclosed in the examples.

TABLE III

Example	12	13	14
Dimensions of carbon block anode:			
Length, mm	2,000	1,600	2,450
Width, mm	600	650	898
Height, mm	500	500	505
Bores in carbon block anode:			
Number	4	4	6
Diameter, mm	120	120	135
Depth, mm	260	230	340
Angle formed between axis of elongated iron contact member and top face of carbon block anode, degrees	18	28	22
Arrangement of bores:			
2 each in opposed side faces	600 x 500	560 x 500	
3 each in opposed side faces			898 x 505
Horizontal distance between the axes of adjacent bores, mm	300	340	290
Vertical distance from point where axis of bore hole intersect side face of carbon block anode to bottom face of carbon block anode, mm	380	380	385
Diameter of elongated iron contact member, mm	100	100	115
Length of axis of elongated iron contact member from inner end thereof to point where axis intersects side face of carbon block anode, mm	250	220	330
Composition of electrically conductive layer (or mixture) interposed between carbon block anode and part of elongated iron contact member extending into bore, as described in Example No.	2	6	8
Minimum vertical distance between point where axis of elongated iron contact member intersects inner end of the same, and upper surface plane of molten electrolyte mixture (ref. numeral 7 in FIG. 1), at which elongated iron contact member has to be pulled out of carbon block anode in order to prevent exposure to temperatures above between 700° and 750° C., mm	130	110	160

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 carbon block arrangements differing from the types described above.

While the invention has been illustrated and described as embodied in an arrangement and process of producing aluminum, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any 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 claims.

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

1. In a method of electrolytically producing aluminum from a molten aluminum-containing electrolyte, the steps of supplying current to, holding and lowering a first carbon electrode block into said aluminum-containing molten electrolyte only by engaging the side faces thereof and without obstructing the top face of said first carbon electrode block; superposing upon said unobstructed top face of said first carbon electrode block an upper preburnt carbon electrode block with a layer of unburnt carbonizable binder material between and contacting the thus superposed carbon electrode blocks, continuing the lowering of said first carbon electrode block, whereby during such lowering of said first carbon electrode block said layer of unburnt carbonizable material will harden when it reaches within said furnace a zone sufficiently hot to carbonize and harden said carbonizable material so that said first and said upper carbon electrode blocks will be firmly adhered to each other; supplying current to, holding and lowering said upper carbon electrode block only by engaging the side faces thereof and without obstructing the top face thereof after said two carbon electrode blocks have been firmly adhered to each other; and thereafter terminating supplying current to, holding and lowering said lower carbon electrode block.

2. In a method of electrolytically producing aluminum from a molten aluminum-containing electrolyte, the steps of supplying current to, holding and lowering a first carbon electrode block into said aluminum containing molten electrolyte only by engaging opposite side faces of said first carbon electrode block with at least one pair of holding members extending through said opposite side faces, respectively, into said first carbon electrode block, without obstructing the top face of said first carbon electrode block; superposing upon said unobstructed top face of said first carbon electrode block an upper preburnt carbon electrode block with a layer of unburnt carbonizable binder material between and contacting the thus superposed carbon electrode blocks, continuing the lowering of said first carbon electrode block, whereby during such lowering of said first carbon electrode block said layer of unburnt carbonizable material will harden when it reaches within said furnace a zone sufficiently hot to carbonize and harden said carbonizable material so that said first and said upper carbon electrode blocks will be firmly adhered to each other; supplying current to, holding and lowering said upper carbon electrode block only by engaging opposite side faces thereof with at least one pair of holding members extending through said opposite faces, respectively, into said upper carbon electrode block without obstructing the top face thereof after said two carbon electrode blocks have been firmly adhered to each other; and thereafter terminating supplying current to, holding and lowering said lower carbon electrode block.

3. In a method of electrolytically producing aluminum

from a molten aluminum-containing electrolyte, the steps of supplying current to, holding and lowering a first carbon electrode block into said aluminum-containing molten electrolyte only by engaging opposite side faces of said first carbon electrode block with at least one pair of holding members extending through said opposite side faces, respectively, into said first carbon electrode block inclined under angles of between 0° and 30° to the horizontal without obstructing the top face of said first carbon electrode block; superposing upon said unobstructed top face of said first carbon electrode block an upper preburnt carbon electrode block with a layer of unburnt carbonizable binder material between and contacting the thus superposed carbon electrode blocks, continuing the lowering of said first carbon electrode block, whereby during such lowering of said first carbon electrode block said layer of unburnt carbonizable material will harden when it reaches within said furnace a zone sufficiently hot to carbonize and harden said carbonizable material so that said first and said upper carbon electrode blocks will be firmly adhered to each other; supplying current to, holding and lowering said upper carbon electrode block only by engaging opposite side faces thereof with at least one pair of holding members extending through said opposite faces, respectively, into said upper carbon electrode block inclined under angles of between 0° and 30° to the horizontal without obstructing the top face thereof after said two carbon electrode blocks have been firmly adhered to each other; and thereafter terminating supplying current to, holding and lowering said lower carbon electrode block.

4. In a method of electrolytically producing aluminum from a molten aluminum-containing electrolyte, the steps of supplying current to, holding and lowering a first carbon electrode block into said aluminum-containing molten electrolyte only by engaging opposite side faces of said first carbon electrode block with at least one pair of holding members extending through said opposite side faces, respectively, into said first carbon electrode block inclined under angles of between 0° and 30° to the horizontal for a distance being of the magnitude of about 12% of the distance between said opposite side faces measured in axial direction of the portion of said holding member extending into said carbon electrode block without obstructing the top face of said first carbon electrode block; superposing upon said unobstructed top face of said first carbon electrode block an upper preburnt carbon electrode block with a layer of unburnt carbonizable binder material between and contacting the thus superposed carbon electrode blocks, continuing the lowering of said first carbon electrode blocks, whereby during such lowering of said first carbon electrode block said layer of unburnt carbonizable material will harden when it reaches within said furnace a zone sufficiently hot to carbonize and harden said carbonizable material so that said first and said upper carbon electrode blocks will be firmly adhered to each other; supplying current to, holding and lowering said upper carbon electrode block only by engaging opposite side faces thereof with at least one pair of holding members extending through said opposite faces, respectively, into said upper carbon electrode block inclined under angles of between 0° and 30° to the horizontal for a distance being of the magnitude of about 12% of the distance between said opposite side faces measured in axial direction of the portion of said holding member extending into said carbon electrode block, without obstructing the top face thereof after said two carbon electrode blocks have been firmly adhered to each other; and thereafter terminating supplying current to, holding and lowering said lower carbon electrode block.

5. In an electrolytic furnace, in combination, an electrode arrangement comprising a lower electrode block having an upper face and opposite side faces; an upper electrode block having a lower and a pair of opposite side faces and superposed with said lower face thereof upon said upper face of said lower electrode block and with

a layer of binder material between said upper face of said lower electrode block and said lower face of said upper electrode block; first combined holding and current conducting means including a pair of spaced holding means located only on said opposite side faces respectively of said lower electrode block, leaving the top face of said lower electrode block unobstructed; second combined holding and current conducting means including a pair of spaced holding means located only on said opposite side faces of said upper electrode block, leaving the top face of said upper electrode block unobstructed; and combined suspending and lowering means secured to said spaced holding means of at least one of said combined holding and current conducting means for suspending therefrom and lowering during operation of said furnace the respective electrode block.

6. In an electrolytic furnace, in combination, an electrode arrangement comprising a lower electrode block having an upper face and opposite side faces; an upper electrode block having a lower and a pair of opposite side faces and superposed with said lower face thereof upon said upper face of said lower electrode block and with a layer of binder material between said upper face of said lower electrode block and said lower face of said upper electrode block; first combined holding and current conducting means including a pair of spaced holding means located only on said opposite side faces respectively of said lower electrode block extending partly into the same, leaving the top face of said lower electrode block unobstructed; second combined holding and current conducting means including a pair of spaced holding means located only on said opposite side faces of said upper electrode block extending partly into the same, leaving the top face of said upper electrode block unobstructed; and combined suspending and lowering means secured to said spaced holding means of at least one of said combined holding and current conducting means for suspending therefrom and lowering during operation of said furnace the respective electrode block.

7. In an electrolytic furnace, in combination, an electrode arrangement comprising a lower electrode block having an upper face and opposite side faces; an upper electrode block having a lower and a pair of opposite side faces and superposed with said lower face thereof upon said upper face of said lower electrode block and with a layer of binder material between said upper face of said lower electrode block and said lower face of said upper electrode block; first combined holding and current conducting means including a pair of spaced holding means located only on said opposite side faces respectively of said lower electrode block composed essentially of iron and extending partly into the same, leaving the top face of said lower electrode block unobstructed; second combined holding and current conducting means including a pair of spaced holding means located only on said opposite side faces of said upper electrode block composed essentially of iron and extending partly into the same, leaving the top face of said upper electrode block unobstructed; and combined suspending and lowering means secured to said spaced holding means of at least one of said combined holding and current conducting means for suspending therefrom and lowering during operation of said furnace the respective electrode block.

8. In an electrolytic furnace, in combination, an electrode arrangement comprising a lower electrode block having an upper face and opposite side faces; an upper electrode block having a lower and a pair of opposite side faces and superposed with said lower face thereof upon said upper face of said lower electrode block and with a layer of binder material between said upper face of said lower electrode block and said lower face of said upper electrode block; first combined holding and current conducting means including a plurality of pairs of spaced holding means located only on said opposite side faces

respectively of said lower electrode block, leaving the top face of said lower electrode block unobstructed; second combined holding and current conducting means including a plurality of pairs of spaced holding means located only on said opposite side faces of said upper electrode block, leaving the top face of said upper electrode block unobstructed; and combined suspending and lowering means secured to said spaced holding means of at least one of said combined holding and current conducting means for suspending therefrom and lowering during operation of said furnace the respective electrode block.

9. In an electrolytic furnace, in combination, an electrode arrangement comprising a lower electrode block having an upper face and opposite side faces; an upper electrode block having a lower and a pair of opposite side faces and superposed with said lower face thereof upon said upper face of said lower electrode block and with a layer of binder material between said upper face of said lower electrode block and said lower face of said upper electrode block; first combined holding and current conducting means including a pair of spaced holding means located only on said opposite side faces respectively of said lower electrode block extending partly into the same under an inclination of between  $0^\circ$  and  $30^\circ$  to the horizontal, leaving the top face of said lower electrode block unobstructed; second combined holding and current conducting means including a pair of spaced holding means located only on said opposite side faces of said upper electrode block extending partly into the same under an inclination of between  $0^\circ$  and  $30^\circ$  to the horizontal, leaving the top face of said upper electrode block unobstructed; and combined suspending and lowering means secured to said spaced holding means of at least one of said combined holding and current conducting means for suspending therefrom and lowering during operation of said furnace the respective electrode block.

10. In an electrolytic furnace, in combination, an electrode arrangement comprising a lower electrode block having an upper face and opposite side faces; an upper electrode block having a lower and a pair of opposite side faces and superposed with said lower face thereof upon said upper face of said lower electrode block and with a

layer of binder material between said upper face of said lower electrode block and said lower face of said upper electrode block, first combined holding and current conducting means including a pair of spaced holding means located only on said opposite side faces respectively of said lower electrode block extending partly into the same, the length of the portion of said holding means, respectively, extending into said electrode block being of the magnitude of about 12% of the distance between said opposite side faces of said electrode block measured in axial direction of said portion of said holding means, leaving the top face of said lower electrode block unobstructed; second combined holding and current conducting means including a pair of spaced holding means located only on said opposite side faces of said upper electrode block extending partly into the same, the length of the portion of said holding means, respectively, extending into said electrode block being of the magnitude of about 12% of the distance between said opposite side faces of said electrode block measured in axial direction of said portion of said holding means, leaving the top face of said upper electrode block unobstructed; and combined suspending and lowering means secured to said spaced holding means of at least one of said combined holding and current conducting means for suspending therefrom and lowering during operation of said furnace the respective electrode block.

## References Cited in the file of this patent

## UNITED STATES PATENTS

1,733,866	Crossley	Oct. 29, 1929
1,757,695	Westly	May 6, 1930
2,010,608	Schumacher	Aug. 6, 1935
2,073,356	Torchet	Mar. 9, 1937
2,758,694	Liles	Aug. 14, 1956

## FOREIGN PATENTS

168,100	Australia	Sept. 24, 1956
1,080,982	France	June 2, 1954
262,722	Great Britain	June 9, 1927
368,777	Great Britain	Mar. 4, 1932
727,784	Great Britain	Apr. 6, 1955
121,661	Switzerland	Sept. 28, 1926