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REMOVAL, BY SUCTION, OF ANODIC GASES FORMED IN ELECTROLYTIC
CELLS EMPLOYED FOR ALUMINUM PRODUCTION
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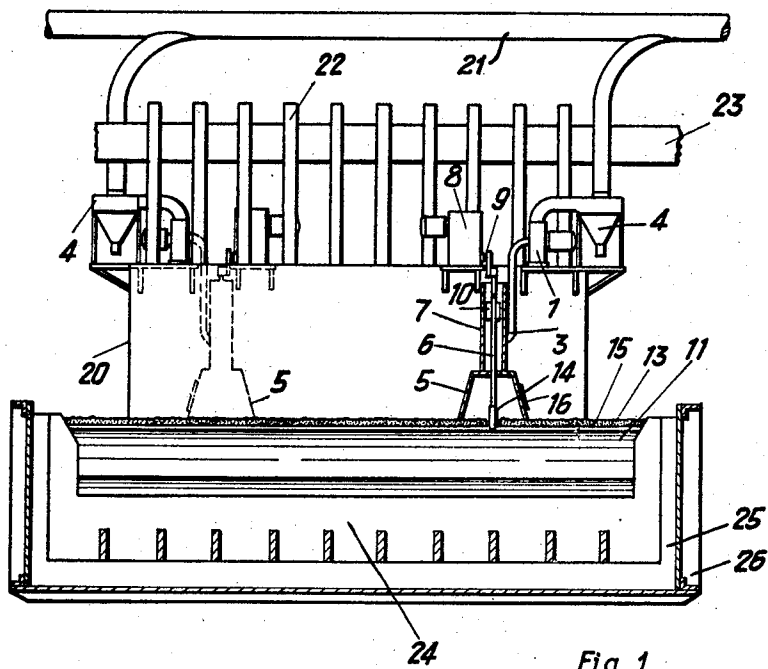


Fig. 1

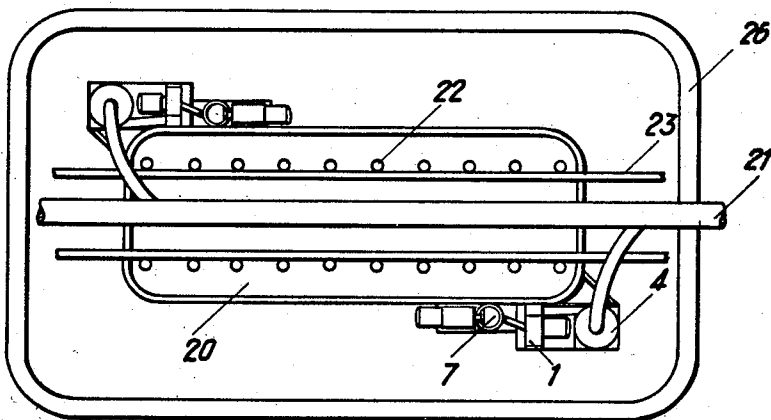


Fig. 2

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REMOVAL, BY SUCTION, OF ANODIC GASES FORMED IN ELECTROLYTIC CELLS EMPLOYED FOR ALUMINUM PRODUCTION

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11,388/60

2 Claims. (Cl. 204-67)

This invention relates to an improvement in the efficiency of production of aluminum by electrolytic reduction of alumina dissolved in a molten salt bath, such as cryolite. This is attained by rapid exhaustion of carbon dioxide formed on the carbon anode employed in the process, the exhaustion taking place primarily at a site, or at a plurality of sites, closely adjacent to the surface of a crust formed on the surface of the bath, and also preferably closely adjacent to the sides of the anode carbon block, and consequently as close as feasible to the submerged anodically active surfaces or surface of the anode block.

The amount of aluminum recovered in such prior processes, per unit of current per unit of time, is less than that theoretically calculated according to Faraday's law. The ratio between the amount of aluminum recovered and that corresponding to said calculation is defined as the current efficiency, which varies from 83 to 90%, depending upon the type of electrolytic cell employed.

In such cells, molten aluminum forms or separates directly upon the cathode surface, which may be horizontal, or inclined to the vertical and facing upwardly. Oxygen separates at the anode, which is formed of carbon or has a carbon surface. The oxygen combines with the anode carbon to form carbon dioxide, primarily.

The current efficiency, defined above, is always less than 100% because some of the aluminum liberated at the cathode is reoxidized. The exact mechanism is still in doubt.

It might be thought that the loss of efficiency is due to by-passing of current through the crust which normally forms as a top layer above the molten cryolite, in both alkaline and acidic baths. However, measures taken to diminish the electrical conductivity of the crust have removed this as a significant factor, the by-pass current being too small to appreciably affect the current efficiency.

The applicant's investigations indicate that a fraction of the carbon dioxide formed at the carbon anode is partially reduced by the anodic carbon, to carbon monoxide. Another fraction is reduced by the carbon powder in the bath. And still another fraction of the carbon dioxide reoxidizes some of the aluminum. The remainder of the carbon dioxide leaves the cryolite bath, to be dispersed into the atmosphere.

This invention is based in part upon the concept that a maximum increase in current efficiency is to be obtained by a maximal rate of exhaustion of carbon dioxide from the bath.

Also, the movement of gas bubbles at or along the electrode surfaces is controlled, so as to obtain minimal time of contact with said surface, especially the anode surface. For this purpose, the exhausting devices are, preferably, positioned closely adjacent the surface of the

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bath and adjacent the sides of the anode carbon or anode carbon blocks.

The invention is generally applicable to all types of furnaces used for electrolysis of alumina in a molten bath, including furnaces having opposed parallel horizontal anode and cathode surfaces, and those having opposed parallel anode and cathode surfaces which are inclined to the vertical, or even vertical.

The invention has its greatest application to the type of furnace in which the anodic surface is disposed above a lower cathodic surface, more or less horizontally, so that a gas layer may normally tend to form under the anode carbon. Formation of this gas layer is prevented, or minimized, by the action of a closely adjacent aspirating device applying a vacuum, preferably equivalent to a pressure depression of about 1 to 15 mm. of water, and advantageously between 5 and 10 mm. water. The drawing illustrates application of the invention to a furnace of this type for electrolysis of alumina in molten cryolite.

FIG. 1 is a vertical longitudinal section; FIG. 2 being a top view.

The furnace employs, for example, a Söderberg carbon anode. The general features of this type of furnace are well known. The carbon anode 20 is suspended in a pot 25 above a lower cathode structure formed by the carbonaceous bottom 24 of the pot. The pot is filled with molten cryolite 11, of alumina is fed thereto. The molten aluminum collects on the cathode bottom and is periodically removed. In this type of furnace, the anode-cathode distance is adjusted by raising or lowering the anode, to maintain the desired bath temperature. A crust 13 of solidified bath forms on the top surface, which may be partly covered with alumina (not shown), added as the next charge. During regular operation, the gas formed, primarily at the anode, is carbon dioxide, as explained above. A part of this gas reacts with metal in the bath, to oxidize the metal. This metal loss is a principal cause of diminished efficiency of the process, also explained above.

Beneath the crust 13 is a space 15 in which the anodic gases collect. Closely adjacent anode casing 20, and immediately above the crust 13, are one or more gas aspirating hoods 5, each provided with a window or port 16, for inspection purposes. Connected to the top of the hood is a pipe 7, through which the gas is exhausted, by conduit 3 and exhaust pump 1. Any powder removed with the gas is separated at 4, before passage to the main exhaust pipe 21.

Within pipe 7 is a metal rod 6 carrying a lower hammer-drill head 14. Rod 6 serves as a pneumatic drill, which is oscillated vertically to keep open the hole in the crust shown immediately below head 14. The drill may be operated by compressed air supplied by a pipe through a valve (not shown) or by a motor 8 through a crank-and-connecting rod system 9. At 10 is the sealing gasket for gas-tight reciprocating of the hammer-drill. When inspection through window or port 16 indicates that the hole in the crust is obstructed, the drill is set in motion for the short time required, and then stopped.

Connecting electric bus bars are shown at 23, and conductor stubs at 22. Numeral 26 designates the outer furnace wall.

The following test data is presented, comparing the efficiency of cells operated with and without forced aspiration of gases.

(A) Cells employing 12 kilo-amperes:

	Current effic., percent	Voltage, v.	Specific energy consump- tion, kwh./kg.
With forced aspiration.....	92	7	22.7
Without forced aspiration, normal.....	89	6.8	22.8

(B) Cells employing 25 kilo-amperes:

	Current effic., percent	Voltage, v.	Specific energy consump- tion, kwh./kg.
With forced aspiration.....	92.17	5.6	18.1
Without forced aspiration, normal.....	89.22	5.5	18.7

Measurements were carried out on individual cells as well as on systems of cells. In the cells employing forced aspiration there is a depression of 5-10 mm. of water in the aspiration zone; whereas in the conventional cells an over-pressure of several mm. water occurs in the vicinity of the outlet hole. By said depression is meant a lowering of the pressure below atmospheric, the lowering being equivalent to the pressure of a column of water 5 to 10 mm. high. For instance, said depression of 10 mm. is equivalent to a residual absolute pressure of 759.26 mm. Hg.

Test cells of 25,000 a. are provided with two aspirators; the delivery of each being 14 liters of gas per second. The indicated magnitude of the depression, 5-10 mm. water, is sufficient, that is to say it would serve no purpose to go beyond the value of 10 mm.

Whereas in the cells operated without forced aspiration the CO₂/CO ratio is usually between 3 and 4, in the ones with aspiration it is between 5 and 6. Thus, a lesser reduction of carbon dioxide occurs, so that the current efficiency is higher.

Although the drawing illustrates a cell having a single anode, it will be understood that the invention is applicable to a cell or cells having a plurality of anodes. In such case the aspirator or aspirators are disposed adjacent both opposite sides of each anode block.

I claim:

1. In a process of making aluminum by electrolytic reduction of aluminum oxide in a molten salt bath, in which a carbon anode surface is immersed, gas comprising an oxide of carbon forming in said process, and also a crust of solidified bath forming above the bath, the gas collecting in a space under the crust; the improvement comprising oscillatingly drilling a hole in said crust and applying suction directly through said hole to said space sufficiently to lower the pressure at said hole to below atmospheric pressure so as to prevent formation of a cushion of said gas against and beneath the surface of said anode, while the electrolysis is going on.

2. In an apparatus for producing aluminum by electrolysis of alumina in a molten electrolyte bath, the apparatus comprising a carbon anode and a cathode in contact with the bath, a crust of solidified electrolyte tending to form on the surface of the bath and a gaseous oxide of carbon forming and tending to collect in the space between said crust and the surface of said bath; the improvement comprising hood means having suction means and arranged so as to apply suction to said space sufficiently to lower the pressure at said hood to below atmospheric pressure and to remove the gaseous oxide of carbon so as to prevent formation of a cushion of said gas against and beneath the surface of said anode, said hood having a gas intake disposed adjacent to the surface of the bath and adjacent a side of the anode, and pneumatic reciprocating hammer-drill means within said hood means at said gas intake to drill a hole in the crust to permit application of said suction.

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