

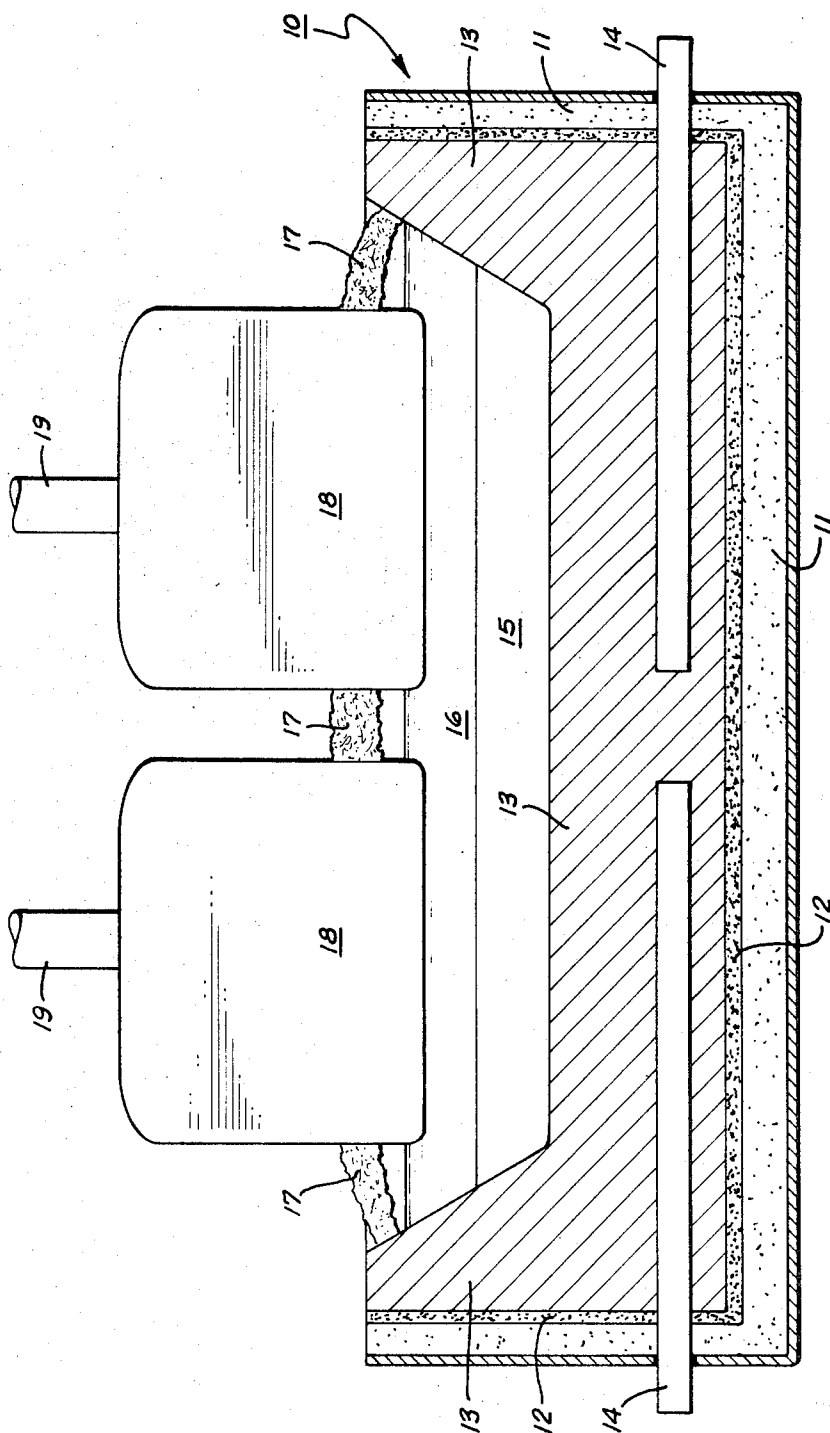
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ALUMINUM REDUCTION CELL

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ALUMINUM REDUCTION CELL

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10 Claims

ABSTRACT OF THE DISCLOSURE

The distortion of the carbonaceous cathode lining of an aluminum reduction cell is substantially reduced by incorporating a layer of salt selected from the group consisting of the chloride and fluoride salts of sodium, lithium, calcium and magnesium between the carbonaceous lining and the insulating layer of refractory material.

BACKGROUND OF THE INVENTION

The production of aluminum by electrolysis of alumina dissolved in a molten salt electrolyte such as cryolite is an old and well-known process commonly termed the "Hall-Heroult Process." The alumina which is dissolved in the electrolyte breaks down into its components, the oxygen being liberated at the anode and the metallic aluminum being deposited in a pool of molten metal which forms at the bottom of the electrolytic cell. The liberated oxygen combines with the carbon of the anodes to form a mixture of carbon dioxide and carbon monoxide which evolves from a cell. The pool of molten metal which is formed in the bottom portion of the cell in effect constitutes the cathode of the cell. Generally, there are two types of electrolytic cells, namely, one commonly referred to as a "prebake" cell one commonly referred to as a "Soderberg" cell. With either cell the reduction process involves precisely the same chemical reaction. The principal difference between the two cells is one of structure. In the prebake cell the carbon anodes are prebaked before being installed in the cell, whereas in the Soderberg cell, or continuous anode cell, the anode is baked in situ, that is, it is baked during the operation of the electrolytic cell, thereby utilizing part of the heat generated by the reduction process.

Between 80-90% of the electrolyte composition normally consists of cryolite, which is the mixture of sodium and aluminum fluoride (Na_3F_6). Sodium fluoride promotes the formation of cathodic metal fog and, therefore, it is the usual practice to add an excess of aluminum fluoride to prevent this formation. Due to its volatility, however, aluminum fluoride is usually added in restricted amounts, for example, up to 10% in excess of a stoichiometric amount of aluminum fluoride in cryolite. From about 5-15% of calcium fluoride (CaF_2) is added to lower the liquidus of the electrolyte. Lithium compounds such as lithium fluoride, lithium carbonate, and the like, are frequently added to the electrolyte to improve the conductivity thereof. The alumina concentration in the electrolyte is normally maintained between about 2-10% by weight. As aluminum metal is produced, the concentration decreases and must be periodically replenished. If the alumina concentration falls below about 1.5%, the electrolytic phenomena commonly termed the "anode effect" occurs, during which time the voltage of the cell, which normally runs between 4-5 volts, rises rapidly to a level about 30-40 volts. If the alumina concentration exceeds about 8-10%, the solid alumina tends to settle at the bottom of the cell detrimentally affecting the anodizing process. When this occurs, the cell is commonly termed "sick."

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The conventional aluminum reduction cell comprises a steel shell, a current-carrying carbonaceous lining disposed therein, and one or more movable anodes disposed within the cavity defined by the carbonaceous lining. The carbonaceous cathode lining may be a monolithic lining which is tamped into place and baked-in during the operation of the cell or it may be composed of carbonaceous blocks which have been baked prior to installation in the cell. Imbedded in the cathode lining are a plurality of conductor bars. Normally, insulating material such as granular alumina is disposed between the steel shell and the carbonaceous lining to conserve the heat generated during the electrolytic process. In many instances the insulating layer is provided only on the bottom portion of the steel shell.

As the electrolysis proceeds, forces are generated in and beneath the carbonaceous lining which cause the lining to expand, heave and buckle. This distortion of the carbon lining causes cracks in the carbonaceous lining which further accelerate the deterioration of the lining. The exact nature of the distortion of the carbonaceous material is presently not well understood. The more traditional theory is that sodium from the bath penetrates into the cathode material and incorporates into the carbon lattice causing it to swell. This in turn causes the sidewalls to be pushed out and eventually the bottom of the carbon lining to heave.

Another theory frequently used to describe this phenomenon is that during normal operating conditions the bath constituents penetrate into and through the carbon lining into the alumina insulation. When the bath reaches an isotherm at which one of the constituents freezes out, this constituent will crystallize and form columnar crystals growing at right angles to the isotherm surface. Over a period of time, the forces generated by crystal growth gradually exceed the strength of the carbon lining and the lining fractures and heaves.

The prior art generally has proposed modifications to the steel shell which will allow the carbonaceous lining to extend such as is shown in U.S. Pat. 3,494,851 (Cauvin), assigned to the present assignee.

One partial solution to the deformation of the carbonaceous cathode material of aluminum reduction cells was proposed by M. B. Rapoport et al. in Transactions of the All Union Aluminum, Magnesium Research Institute, No. 47, pp. 71-75 (1961). In this article it was suggested to incorporate certain salts such as sodium chloride into the carbonaceous lining to retard the expansion of the carbonaceous material. Reductions in cathode distortion have been confirmed by plant trials wherein sodium chloride was incorporated into the carbonaceous cathode material. However, this method did not prevent the penetration of electrolytic bath constituents through the carbonaceous lining to the interface between the carbonaceous lining and the insulating material of the cell. Thus, notwithstanding the inclusion of salts into the cathodic material, the crystallization of bath constituents in and below the carbonaceous cathode material still occurs causing the ultimate destruction of the cathodic material.

Another problem which occurs during the operation of a reduction cell is an increase in the resistance of the cathodic lining apparently due to carbide formation. By incorporating salt into the cathode lining, as proposed by Rapoport et al., some retarding of the resistance increase can be effected.

BRIEF DESCRIPTION OF THE DRAWING

The figure is a cross section of an embodiment of the present invention.

DESCRIPTION OF THE INVENTION

The present invention relates to the modification of an aluminum reduction cell which minimizes the distortion of the cathode lining material and the steel shell containing said material. Moreover, the modification of the present invention substantially reduces the increase in resistance of the cathode lining. Generally, the invention comprises incorporating a layer of salt between the carbonaceous cathode lining and the insulating material adjacent thereto. Suitable salts include the chloride and fluoride salts of sodium, lithium, calcium and magnesium. The cheapest, most readily available and most efficient salt is sodium chloride. The thickness of the salt must exceed 0.10-inch, preferably more than 0.5-inch. Salt in excess of 2 inches in thickness provides for no further improvement in the reduction of distortion and the like. The salt material can be in any convenient form but it is preferred to utilize a particulate salt less than 12 mesh in size (Taylor). For minimal cell distortion, it is preferred to also incorporate from 3 to 12% by weight of salt material into the carbonaceous cathode material whether the cathode lining is monolithic or made from prebaked carbon blocks. The salt material is selected from the salts described above.

The electrolytic cell of the present invention, as illustrated in the figure, comprises an outer steel shell 10, an intermediate insulating refractory lining 11 of suitable material such as alumina, a salt layer 12, and a cathode lining 13 of carbonaceous material. Embedded in cathode lining 13 are conductor bars 14 made out of suitable electrically conducting materials such as iron, copper and the like. A molten metal pad 15 is disposed in the bottom of the cavity defined by the carbonaceous lining below the molten electrolyte bath 16 which is covered by a crust 17 of frozen electrolyte and alumina which forms during the electrolysis. Vertically adjustable anodes 18 are disposed into the electrolyte and are suspended by anode rods 19 which are electrically connected to an anode bar (not shown). The carbonaceous material of the side walls of the lining 13 can be replaced in whole or in part by refractory bodies such as silicon nitride, silicon carbide and the like. Although preferred, it is unnecessary for improved results for the salt layer 12 to completely encase the current conducting lining 13. It is sufficient to underlay the bottom portion of the carbonaceous cell lining 13 with salt.

To illustrate the present invention, a commercial-sized (70,000 amps) aluminum reduction cell of the Soderberg type was modified in accordance with the present invention. One inch of insulating material was removed and replaced with one inch of —12 mesh sodium chloride salt. Ten percent by weight of sodium chloride was incorporated into the carbonaceous material of the cathode lining. The cell was placed into operation and has been continually run for over 1000 days. The sidewall distortion of the steel shell at 1000 days was 2.2 inches, and the voltage drop of the lining was 600 millivolts. This is to be compared with a typical sidewall distortion of 2.6 inches and a voltage drop of 700 millivolts across the cell lining for the same sized cell in which 10% by weight of sodium chloride was incorporated into the cathode lining. A sidewall distortion of 4.0 inches and a lining voltage drop of 850 millivolts are typical values for the

same sized cell having neither the salt incorporated into the cathode lining nor the salt layer beneath the cathode lining.

It is obvious that various modifications can be made to the present invention without departing from the spirit of the invention or the scope of the appended claims.

What is claimed is:

1. In an aluminum reduction cell comprising a steel shell, a layer of insulating refractory material disposed on at least the bottom portion of said shell, and a layer of electrically conducting, carbonaceous material disposed on said insulating layer, the improvement comprising a layer of salt material selected from the group consisting of chloride and fluoride salts of magnesium, sodium, lithium and calcium interposed between the layer of insulating material and a layer of carbonaceous material.
2. The aluminum reduction cell of claim 1 in which the salt layer is at least 0.1-inch thick.
3. The aluminum reduction cell of claim 1 in which the salt layer is at least 0.5-inch thick.
4. The aluminum reduction cell of claim 1 in which the salt is sodium chloride.
5. The aluminum reduction cell of claim 1 in which the salt is a particulate material less than 12 mesh in size.
6. In an aluminum reduction cell comprising a steel shell, a layer of insulating refractory material disposed on at least the bottom portion of said shell and a layer of electrically conducting, carbonaceous material disposed on said insulating layer, said carbonaceous material having incorporated therein from 3 to 12% of a salt selected from the group consisting of the chloride and fluoride salts of sodium, lithium, calcium and magnesium, the improvement comprising a layer of salt material selected from the group consisting of the chloride and fluoride salts of sodium, lithium, magnesium and calcium, interposed between the layer of insulating material and the layer of carbonaceous material.
7. The aluminum reduction cell of claim 6 in which the salt layer is at least 0.1-inch thick.
8. The aluminum reduction cell of claim 6 in which the salt layer is at least 0.5-inch thick.
9. The aluminum reduction cell of claim 6 in which the salt is sodium chloride.
10. The aluminum reduction cell of claim 6 in which the salt is a particulate material less than 12 mesh in size.

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