Dec. 29, 1970 C. H. ELLIOTT 3,551,319

CURRENT COLLECTOR

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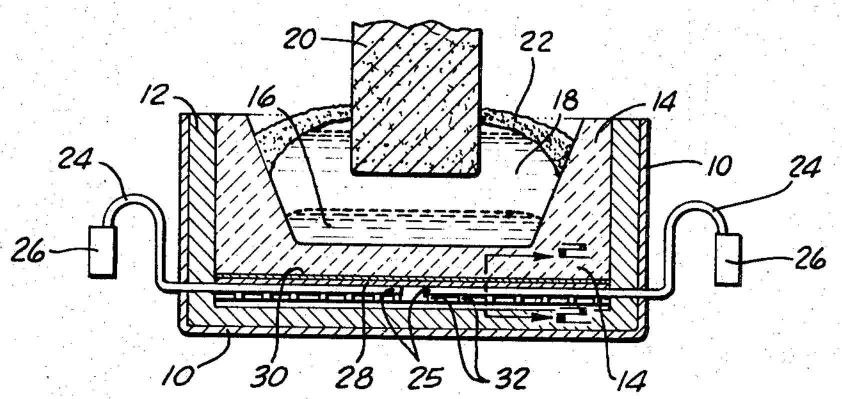

FIG_1

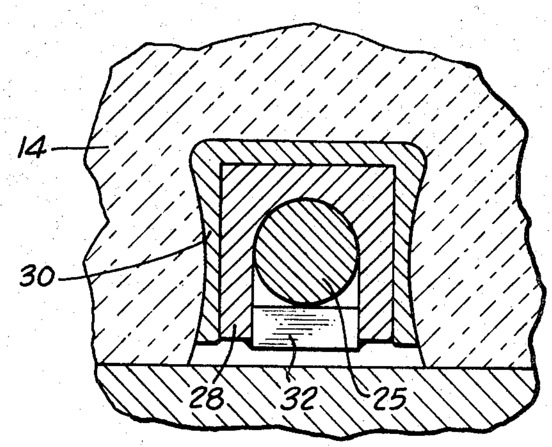

FIG_2

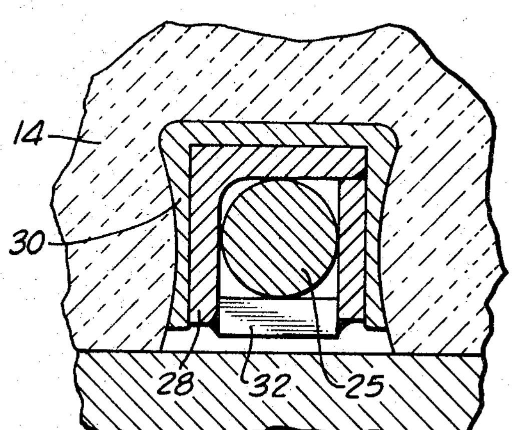

FIG_3

CHARLES H. ELLIOTT
INVENTOR.

BY William F. McDonald
ATTORNEY

United States Patent Office

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CURRENT COLLECTOR

Charles H. Elliott, Waveland, Miss., assignor to Kaiser Aluminum & Chemical Corporation, Oakland, Calif., a corporation of Delaware

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ABSTRACT OF THE DISCLOSURE

The instant invention relates to an electrolytic cell for the production of aluminum. The cell comprises a shell having an anode suspended therein. A carbonaceous lining is provided for the shell. One or more cathodic current collectors are embedded in the lining. A ferrous sheath having a copper core is utilized for the cathodic current collector so that the major portion of the current during cell operation will flow out of the cell in the copper core and the ferrous sheath functions as a shield to reduce magnetic field of the collector at the point of interaction with the molten metal pad which forms a lining during the operation of the cell. This reduces undesirable movements and unequal elevation of the molten metal pad formed on the lining during cell operation.

BACKGROUND OF THE INVENTION

The metal aluminum is extracted from aluminum-bearing compounds such as alumina (Al_2O_3) by electrolysis from a molten salt bath or electrolyte. In the production of aluminum by the conventional electrolytic process, commonly referred to as the Hall-Heroult process, the electrolytic cell comprises in general a steel shell having disposed therein a carbonaceous lining. The bottom of the carbonaceous lining together with a layer of electrolytically produced molten aluminum which collects thereon during operation serves as the cathode. One or more consumable carbon electrodes is disposed from the top of the cell and is immersed at its lower extremity into a layer of molten electrolyte which is disposed in the cell. The carbon electrodes are connected to an anode bus bar which in turn is connected to a source of current supply. In the bottom of the carbon lining are one or more cathodic current collectors which are connected to a cathode bus bar which in turn is also connected to the source of current completing the circuit. In operation, the electrolyte or bath which is a mixture of alumina and cryolite is charged to the cell and an electric current is passed through the cell from the anode to the cathode via the layer of molten electrolyte. The alumina is dissociated by the current so that aluminum is deposited on the liquid aluminum cathode and oxygen is liberated at the carbon anode, forming carbon monoxide and carbon dioxide gas. A crust of solidified electrolyte and alumina forms on the surface of the bath, and this is usually covered over with additional alumina.

In the conventional electrolytic process, use has been made of two types of electrolytic cells, namely that commonly referred to as a "pre-bake" cell and that commonly referred to as a Soderberg cell. With either cell, the reduction process involves precisely the same chemical reactions. The principal difference is one of structure. In the pre-bake cell, the carbon anodes are pre-baked before

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being installed in the cell, while in the Soderberg or self-baking anode cell, the anode baked in situ; that is, it is baked during operation of the electrolytic cell, thereby utilizing part of the heat generated by the reduction process. The instant invention is applicable to either cell.

The effects of magnetic fields upon the molten metal pad are well known and have long been a problem to the aluminum industry. A detailed discussion of them may be found in such prior art as U.S. Pat. 2,874,110 to Thayer. The current flow in the molten aluminum pad departs from a vertical path due to the relative resistances between itself and the carbon lining and the cathodic current collector, which normally has been a solid iron collector bar, thus creating a reaction force between the metal pad and the collector bar causing movements of the metal. The effects of the magnetic fields upon the metal pads result in varying elevations of metal, pinch effect, and possible motoring or rotary motion of the metal within the pot. These movements of the molten metal pad make it very difficult to control the anode-cathode distance for optimum operation of the cell.

Exactly why this occurs is not really known. However, as discussed in detail in the Thayer patent referenced above, it is believed that the principal contributor to this undesirable molten metal pad movement is the field from the cathode collector bars reacting with the fields of the metal pad. It is known that the resulting forces of reaction of two magnetic fields are a function of the flux intensity and the angle of incidence of the two fluxes. Because of this, it has been assumed that the field from the collector bars being very close to the metal pad would be the dominant influence.

The prior art contains references to many attempts to solve this problem. These various attempts have had varying degrees of success. The general approach to the problem seems to have been to try various arrangements of collector bars in the cell lining or shapes of collector bars to try to alleviate the situation.

SUMMARY OF THE INVENTION

The instant invention solves this problem which has so long plagued the industry by providing in an electrolytic cell for the production of aluminum which comprises a shell with a carbonaceous lining therein and anode suspended therein and having a cathodic current collector embedded in the lining, the improvement which comprises utilizing for the cathodic current collector a ferrous sheath having a copper core so that the major portion of the current will flow out of the cell in the copper core and the ferrous sheet functions as a shield to reduce the magnetic field of the collector at the point of interaction with the molten metal pad which forms on the lining during the operation of the cell. The undesirable movements and unequal elevation of the molten metal pad formed on the lining during cell operation are reduced by this invention. The ferrous sheath may be in the form of a hollow cylinder with the copper core in the form of a solid cylinder disposed within the ferrous sheath. However, for ease of assembly and disassembly, and to prevent magnetic saturation, it is desirable that the ferrous sheath have a substantially downwardly opening U shaped cross section and the copper core be disposed within the bight of the U. In this embodiment the cathodic current collector may be horizontally disposed in the conventional manner.

BRIEF DESCRIPTION OF DRAWING

FIG. 1 is a transverse elevation view in section of a reduction cell embodying principles of the instant invention. FIG. 2 is a sectional view of part of the cathode of the cell of FIG. 1 taken along line 2—2 of FIG. 1 showing one structure of the cathodic current collector according to the instant invention.

FIG. 3 is a view similar to FIG. 2 showing a variation on the structure of the cathodic current collector.

DETAILED DESCRIPTION

One embodiment of a reduction cell or pot illustrating the instant invention is shown schematically in FIG. 1. In this embodiment, **10** is a metal shell generally steel, within which is disposed in the usual manner an insulating layer **12** which can be any desired material, e.g., alumina, bauxite, clay, aluminum silicate brick, etc. Within the insulating layer **12** is disposed cell lining **14** which has to have carbon bottom when you use collector bars and can be of any desired material, e.g. carbon, alumina, fused alumina, silicon carbide, silicon nitride, bonded silicon carbide or other desired materials. At least the portion of the lining **14** in the bottom of the cell is of a current conducting material. Most commonly, the lining is madeup of a plurality of carbon blocks or is rammed carbon mixture or a combination of the rammed carbon mixture for the bottom of the lining with side and end walls constructed of blocks of carbon. Alternatively, the side and end walls can be constructed of blocks of silicon carbide or other suitable refractory. The lining **14** defines a chamber which contains a pool of molten aluminum **16** and a body of molten electrolyte or bath **18**, as described.

When the cell is in operation so that aluminum is being produced, electrolyte **18** and aluminum pool **16** are both in the molten state. Suspended from above the electrolyte, and partially immersed therein are one or more anode electrodes **20** of the conventional carbon type which can be either of the "pre-bake" or Soderberg (self-baking) type known to the art. Molten electrolyte **18** is covered by a crust **22** which consists essentially of frozen electrolyte constituents and additional alumina. As alumina is consumed in electrolyte **18**, the frozen crust is periodically broken and more alumina fed into the electrolyte.

The anode is connected by suitable means (not shown) to the positive pole of a source of supply of electrolyzing current. For purposes of completing the electric current, use is made of cathodic current conducting elements or collectors **24**. As shown herein the cathodic current collector **24** has a copper core **25**. The copper cores of the cathodic current collectors extend through suitable openings provided in the metal shell, insulation layer and lining with the inner end thereof projecting into the lining. The outer ends of each of the elements **24** are connected by suitable means to the negative or cathode bus bars **26**. With reference now also to FIG. 2 wherein the structure of the cathodic current collector assembly **24** can be seen in greater detail it will be seen that copper core **25** of the assembly is disposed with a ferrous sheath **28**.

As shown, ferrous sheath **28** has a substantially downwardly opening U shaped cross section and copper core **25** is disposed within the bight of the U. In the embodiments shown, cast iron **20** has been poured around ferrous sheath **28** in a cavity provided in lining **14** so that as it solidifies, it secures the ferrous sheaths **28** in proper position in lining **14**. Other suitable means of binding the sheath to the lining may be utilized however. For example, furane resins, or mixtures of furane resins and carbonaceous materials can be utilized. A block **32** may be provided at the opening of the U to help position copper core **25** within ferrous sheath **28**.

In the embodiments shown in FIG. 3, ferrous sheath

28 is made of two elements joined together in a suitable manner such as by welding to form the desired downwardly opening U shaped cross section.

Magnetic energy cannot be blocked in the sense that electrical currents can be by the interposing of an insulator in the conductor circuit. It can, however, be guided through a preferred path by shielding or the interposing of an insulator or the interposing of a low reluctance path between its source and the area from which it is desired to be excluded. This method, when correctly applied, can effectively reduce a given field and on the other hand, when unintentionally applied in the wrong positions, magnetic materials can increase by nearly two times the field intensity at a given place.

As shown in the drawings, an adequate shield is interposed, i.e. ferrous sheath **28** between the copper core **25** of the cathodic current collectors **24** and the molten metal pad **16**. At the same time, because of the greatly reduced resistance of the copper core **25** as compared to a conventional solid ferrous current collector, the current flow is persuaded in the metal pad to a more vertical path thus improving the angle of incidence.

Advantageously, a portion of the ferrous sheath **28** near the center of the cell will be above the Curie point thus losing its magnetic property. This increases the effectiveness of the instant invention. The Curie point is the temperature of transition for a ferro-magnetic substance at which the phenomena of ferro-magnetism disappears and the substance becomes merely paramagnetic.

In the embodiments shown, the copper core **25** may simply be slid into position within ferrous sheath **28**. The elements would become squeezed together at operating temperatures due to the difference in coefficients of expansion of the ferrous material and the copper. However, a return to room temperature would permit the copper core **25** to be pulled out for reuse and repair as necessary.

Thus, an additional benefit from the instant invention is that the side and end walls of the lining can be precast as part of the bottom blocks. This eliminates any ramming and requires only caulking of the seams. The copper cores can simply be removed from the sheaths and lining when the time comes to reline the pot.

In summation, the copper core reduces the resistance such that the current through a metal pad flows in a more vertical path.

The major portion of the current will flow in the copper core thus permitting the ferrous sheath of the cathodic current collector assembly to function as an effective shield to reduce the magnetic field of the assembly to a much lower value at the point of interaction with the metal pad.

While there has been shown and described hereinabove possible embodiments of this invention, it is to be understood that the invention is not limited thereto and that various changes, alterations and modifications can be made thereto without departing from the spirit and scope thereof as defined in the appended claims wherein—

What is claimed is:

1. In an electrolytic cell for the production of aluminum which comprises:

(a) A shell;

(b) An anode suspended therein;

(c) A carbonaceous lining for the shell;

(d) A cathodic current collector embedded in the lining; the improvement which comprises utilizing for the cathodic current collectors a ferrous sheath having a copper core so that the major portion of the current will flow out of the cell in the copper core and the ferrous sheath functions as a shield to reduce the magnetic field of the collector at the point of interaction with the molten metal pad which forms on the lining during the operation of the cell, whereby the undesirable movements and unequal elevation of the molten metal pad formed on the lining during cell operation are reduced.

2. The apparatus of claim 1 wherein the ferrous sheath has a substantially downwardly opening U shaped cross section and the copper core is disposed within the bight of the U.

3. The apparatus of claim 1 wherein the cathodic current collector is substantially horizontally disposed.

4. The apparatus of claim 1 wherein the ferrous sheath is in the form of a hollow cylinder and the copper core is in the form of a solid cylinder disposed within the ferrous sheath.

References Cited

UNITED STATES PATENTS

2,593,751	4/1952	Grolee	204—243
2,846,388	8/1958	Morel	204—243
3,244,611	4/1966	Pezzack	204—289

HOWARD S. WILLIAMS, Primary Examiner

D. R. VALENTINE, Assistant Examiner

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