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[54] **FURNACE STRUCTURE**

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[52] **U.S. Cl.** ..... **204/243 R,** 204/245

[51] **Int. Cl.** **C22d 3/02,** C22d 3/12

[58] **Field of Search** ..... 204/243 R, 244–247, 204/67

[56] **References Cited**

UNITED STATES PATENTS

2,198,733	4/1940	Leibig et al.	204/243 R X
2,349,083	5/1944	Farr, Jr.	204/242 X
3,405,043	10/1968	Barakat et al.	204/245 R X
3,556,974	1/1971	Day	204/243 R

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[57] **ABSTRACT**

Furnace having a chamber for holding molten salt, such as alkali metal chloride and alkaline earth metal chloride, in which contact of the molten salts with a perimetric shell around that chamber is prevented by a glass barrier between that shell and the aforesaid chamber.

2 Claims, 2 Drawing Figures

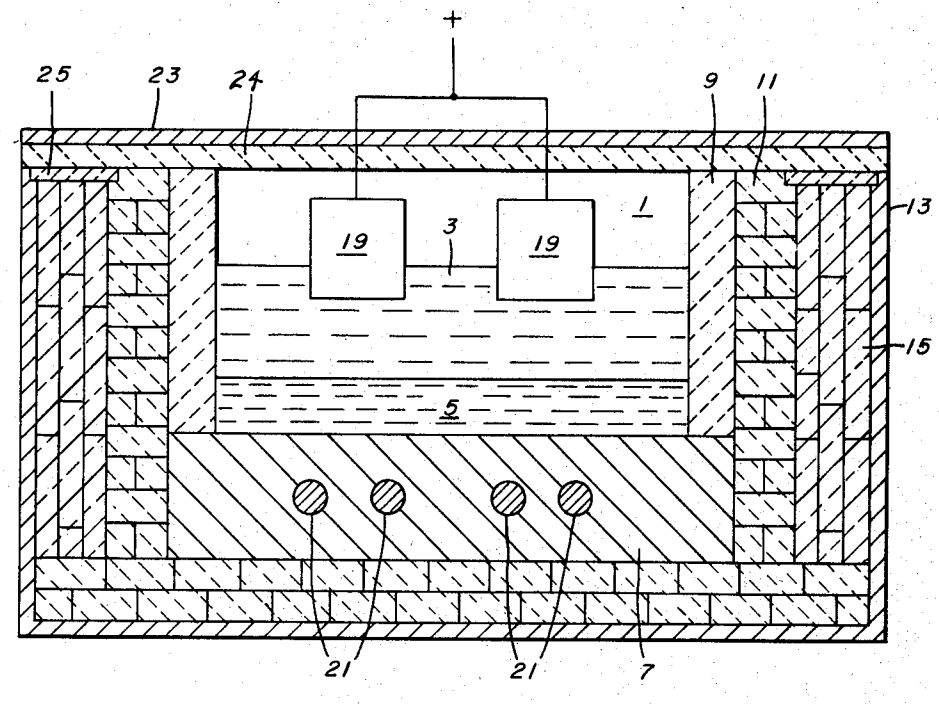


FIG. 1.

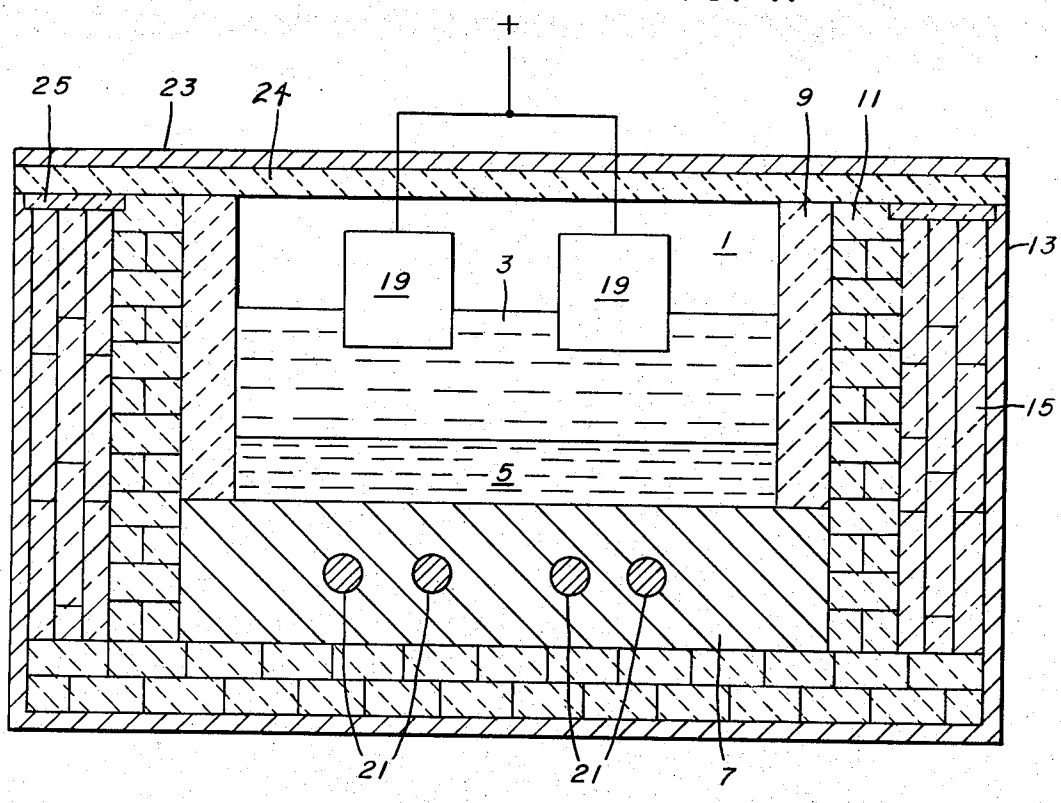
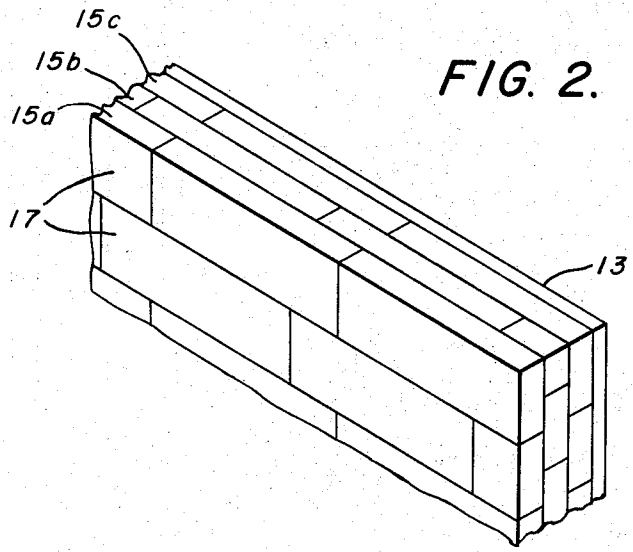


FIG. 2.



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FURNACE STRUCTURE

This invention relates to furnaces which contain molten salts of alkali metals or alkaline earth metals, and relates particularly to electrolytic cells or furnaces used in the production of aluminum by electrolysis of aluminum chloride dissolved in such salts.

Although the potential advantages of producing aluminum by electrolytic reduction of aluminum chloride dissolved in one or more molten alkali metal salts or alkaline earth metal salts have long been recognized, and procedures and equipment for such reduction have been described in the literature, commercial manufacture of aluminum from aluminum chloride has been precluded by a number of problems attendant thereon. One of the more serious problems that is accentuated by operating at elevated temperatures (e.g., above the melting point of aluminum) is relatively rapid seepage through the cell walls of electrolytic bath components with a melting point substantially below such temperature of operation with a concomitant reduction in the effective operating life of the cell. For example, alkali metal chlorides such as sodium chloride, potassium chloride, and lithium chloride, and mixtures thereof form eutectics with aluminum chloride having melting points as low as 100°–120°C and which are of a highly penetrant character. Although the electrolytic reduction cells are conventionally enclosed in an impervious perimetric shell such as steel, to provide mechanical strength and rigidity and which function to prevent leakage of bath, penetration of liquid bath to such shell not only results in excessive heat loss from the cell but also in detrimental corrosion and relatively rapid penetration of the shell by the bath. Moreover, when the cells are of the type employing bipolar electrodes and an electrically conductive cell shell, zones of opposite polarity are established in the shell by contact therewith of liquid bath, whereupon localized electrolysis of such bath not only impairs the electrical efficiency of the cell but also releases chlorine at such locations which rapidly attacks the shell with consequent deterioration thereof and materially shortened cell life.

It is an object of this invention to provide a solution to the problems described above, and more particularly to provide improved apparatus for use in electrolysis of aluminum chloride, in which contact with the outer shell of the apparatus by the electrolytic bath is prevented, with substantial improvement in cell life and the economics of operating the cell.

In accordance with the invention, between the electrolysis chamber of an electrolytic cell for the electrolysis of aluminum chloride, and a perimetric shell around the cell of a material which is subject to corrosive attack in contact with the electrolytic bath, is interposed a barrier wall of glass through which molten electrolytic bath in the electrolysis chamber cannot flow to reach the shell. By using such a barrier wall the cell can be operated for markedly extended periods of time without destructive penetration of the shell by the bath with consequent increase in effective operating life of the cell.

The invention will be described more particularly with reference to the accompanying drawings, in which FIG. 1 is a schematic view in vertical cross section of an electrolytic cell constructed in accordance with the principles of this invention, for use in electrolysis of aluminum chloride at a temperature above the melting point of aluminum (660°C), and FIG. 2 is an enlarged perspective view of a portion of the cell wall shown in FIG. 1.

Referring to the drawings, the cell comprises an electrolysis chamber **1** containing an electrolytic bath **3** of aluminum chloride dissolved in molten electrolyte, and a layer **5** of molten aluminum below the bath **3**, the aluminum having been produced in the bath by electrolysis of aluminum chloride in the bath. Molten aluminum produced may be withdrawn from the layer **5** by tapping, siphoning, or the like.

The chamber **1** consists of a base **7** of electrically conductive material, such as graphite, and side walls **9** of a refractory material which is not electrically conductive and which is inert to the molten bath, to aluminum and to the chlorine evolved during electrolysis. Such refractory materials are however not impermeable relative to the constituents of the bath **3**. For example, while the side walls **9** may consist of suitable refractory such as silicon oxynitride, aluminum nitride, or silica particles bonded with silicon nitride, such materials are pervious to the molten bath constituents.

Surrounding the chamber **1** is a layer **11** of insulation of suitable material, such as refractory bricks, and an outer perimetric metal shell **13**. Such refractory bricks, even in multilayer thicknesses thereof, or even refractory material rammed and fired in situ to form an integral insulating layer, are likewise pervious to the molten bath components. Disposed intermediate the shell **13** and the insulation layer **11** is a glass barrier wall **15** which peripherally encloses the chamber **1** and extends vertically from above the top to below the bottom of the bath **3**, and which is effectively impervious to penetration by molten bath which will seep laterally through the wall **9** and the insulation layer **11**.

As illustrated in FIG. **2**, the barrier wall **15** preferably consists of a plurality, as for example, three interfacially abutting layers **15***a*, **15***b*, and **15***c* of sheet glass. Each layer may suitably consist of a plurality of glass plates **17** disposed end-to-end, the adjacent edges thereof in each layer closely abutting each other. As shown, layer **15***a* is in interfacial contact with intermediate layer **15***b*, and similarly layer **15***b* is in interfacial contact with outer layer **15***c*, and the vertical and horizontal joints in laterally adjacent layers are offset or staggered, to thereby provide an elongate and tortuous path for minimizing the possibility of seepage of molten electrolytic bath entirely through wall **15** at such joints. The described use of a plurality of glass layers for the barrier wall has the further advantage that if one layer becomes cracked or otherwise penetrated, the other layers still function to prevent passage of the bath constituents. As will be now apparent, increasing the number of layers in the barrier wall increases the path length for possible seepage and more than three layers can be used, if found desirable.

It will be also desirable to use a glass which softens somewhat but without appreciable loss of integrity as the temperatures to which such glass is subjected in operation of the cell, so that abutting edges of the glass plates will unite or bond together during initial operation, thereby further forestalling seepage of electrolytic bath between such edges. Soda-lime window glass is suitable for the purpose. Further protection against seepage through joints in the barrier wall can be achieved by cooling the shell sufficiently to reduce the operating temperature at the barrier wall so as to freeze or solidify all electrolytic bath disposed within the

joints, thereby effectively sealing such joints against passage of bath constituents therethrough. Such cooling can be effected by circulating water or other coolant in passages (not shown) in the shell **13**.

The barrier wall **15** may alternatively consist of a unitary, molded glass shell, or of a strata or lamina of glass powder or compacted fiber which at the elevated temperature of the cell, softens and melds into a viscous, substantially unitary layer, which layer is not permeable by the molten bath.

Electric current for electroysis of aluminum chloride in the bath is conducted through the cell via anodes **19** of suitable electrically conductive material (such as carbon) extending into the bath **3**, and the base **7** which acts as a cathode, there being embedded metal rods **21** extending therefrom through the shell **13**, the barrier wall **15**, and the insulating layer **11** for conducting current from the cell. The cell is provided with a metal cover **23** lined with insulation **24** and having one or more outlets (not shown) therein for escape of chlorine formed during electrolysis.

In operation of the cell chlorides in the bath volatilize and may condense between the underside of the lid **23** and the composite side wall of the cell. To prevent such condensed chlorides from seeping through the wall **9** and insulating layer **11** and into deleterious contact with the shell **13**, it is desirable that the glass barrier wall **15** extend above the level of the bath **3** and even up to the top of the chamber **1**. Likewise, it is advantageous to have the barrier wall **15** extend well below the lower level of the bath, and preferably to the bottom of the cell, as shown in FIG. **1**, to prevent molten bath from settling through the insulating refractory layer **11** and into contact with the shell. Moreover, since chlorides in the bath volatilize in operation of the cell and may condense between the underside of the lid **23** and the side wall of the cell, it is advantageous to overlap the interface between the shell **13** and wall **15** with a glass shield **25**.

As is described in prior literature, the electrolyte in the bath **3** may consist of one or more molten salts of alkali metal chloride or alkaline earth metal, having a higher electrodecomposition potential than aluminum chloride, such as sodium chloride, potassium chloride, lithium chloride, magnesium chloride or calcium chloride, or mixtures of two or more such chlorides, as the essential ingredients; and with other components also possibly being present. Simimarly, such conditions as cell voltage and amperage, and concentrations of aluminum chloride in the bath, in operating cells for electrolysis of aluminum chloride in molten alkali metal chloride have been described in the literature and form no part of the invention.

The barrier wall **15** need not be located — as illustrated — immediately adjacent the inner wall of the perimetric shell **13**; and for example, it may be between the illustrated insulation layer **11** and a second and outwardly peripherally disposed insulation layer (not shown) or may be positioned between the side walls **9** and insulating layer **11**. Moreover, the glass barrier wall also desirably extends across the bottom of the cell, between the base **7** and the bottom of the shell **13** to protect against seepage of molten bath into contact with the shell bottom.

As already mentioned, soda-lime window glass can be used satisfactorily in the barrier wall **15**, although other forms of glass, including quartz, may be used. However, instead of making that wall entirely of glass, it can be made of glass-coated sheet metal, with the glass side facing the chamber **1**.

The use of a continuous glass barrier wall or layer in the walls of electrolytic cells for electrolysis of aluminum chloride in molten alkali metal chloride in accordance with the invention contributes materially to the solution of the problems described above which result from seepage of molten electrolytic bath through the walls of the electrolytic chamber and into contact with the shell of the cell and operates to markedly extend the effective operating life thereof. Consequently, it represents a valuable contribution to reducing the costs and to attaining the long-sought objective of providing a commercially viable method for recovering aluminum from aluminum chloride.

The invention is also applicable to non-electrolytic furnaces which have a refractory-lined chamber containing molten alkali metal — or alkaline earth metal salts, such as furnaces for treating or purifying molten aluminum in which the molten metal is reacted or treated with alkali metal — or alkaline earth metal chloride, or in which molten aluminum containing alkali metal or alkaline earth metal values is treated with chlorine, thereby forming molten chlorides in the melt. Interposing a glass wall between the chamber containing such molten chlorides and a perimetric metal shell around that chamber operates to minimize or prevent access to the metal shell by molten chlorides which seep through the refractory chamber lining, thereby protecting the metal shell from corrosion or attack by the molten salt.

While the invention has been described with reference to certain specific embodiments, it is to be understood that changes and modifications may be made without departing from the scope of the invention as defined in the appended claims:

We claim:

1. A furnace for electrolysis of aluminum chloride, comprising an electrolysis chamber for receiving a molten electrolytic bath consisting essentially of aluminum chloride dissolved in one or more molten salts of higher electrodecomposition potential than aluminum chloride, the said chamber having a wall which is contactable by the said bath and is permeable thereby, a shell around the said chamber and spaced from the said wall, a glass barrier intermediate the said chamber wall and the said shell, whereby contact with the said shell of bath which permeates the said wall is inhibited by the said glass barrier, and an anode and cathode for transmission of electric current therebetween through the said bath.

2. A furnace in accordance with claim **1**, which includes a layer of insulation between the said glass barrier and the said wall, the said insulation layer being permeable by the said bath.

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