June 25, 1968 C. J. McMINN ETAL 3,390,071

CATHODE CONSTRUCTION FOR ALUMINUM REDUCTION CELL

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FIG. 1.

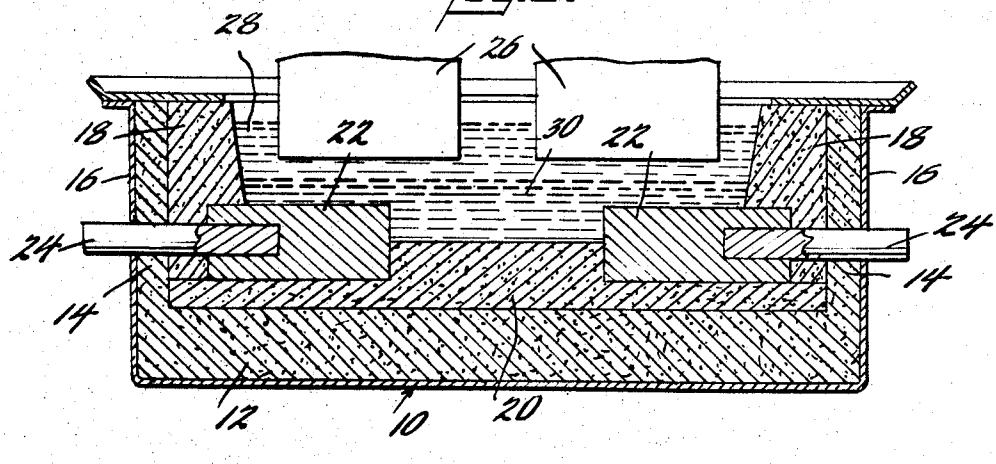


FIG. 2.

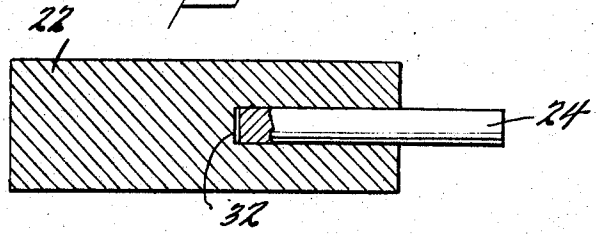
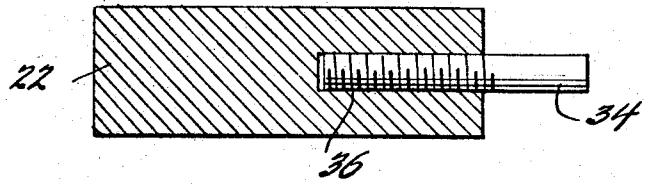


FIG. 3.



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CATHODE CONSTRUCTION FOR ALUMINUM REDUCTION CELL

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ABSTRACT OF THE DISCLOSURE

An electrolytic cell for the production of aluminum comprising a pot shell lined with insulating material supporting a graphite cathode block, and an improved oxygen-free copper current collector pin being electrically connected to the block.

This invention relates to electrolytic reduction cells provided with a graphite cathode element and having improved current collector pins connected to the cathode. More particularly, the invention concerns cells provided with collector pins made of gas-free high purity copper.

Aluminum metal is conventionally produced in electrolytic cells by passing a current through a bath of molten cryolite, containing dissolved alumina, in a large tank lined with carbon which serves as part of the cathode system. Large carbon blocks presented at the top of the bath function as the anode. Molten aluminum metal at a temperature of about 1800° F. collects as a metal pad at the bottom of the cell and is siphoned off periodically. The cell may have a bottom lining formed of alumina, in which horizontally disposed cylindrical or rectangular graphite cathode bars extend from the opposite sides of the cell. These cathode bars are connected to the cathode collector system by metal pins, the pins and the pin-connected ends of the graphite cathodes being anchored in a side lining of rammed carbon.

Experience has shown that the use of electrolytic tough pitch grade copper for collector pins in conjunction with graphite cathode blocks leads to problems of expansion and rupture of the copper at the temperatures to which the metal is exposed, namely about 750° C. to 950° C. The resulting excessive growth of the copper pins in turn leads to cracking of the graphite electrodes in which the copper pins are partly embedded. The use of steel pins is also disadvantageous because the steel-graphite interface has a much higher electrical resistance than copper-graphite, especially at low contact pressure.

It has been found that electrolytic tough pitch grade copper contains about 0.04% oxygen, and possibly other gases or gas-producing components as well, and that when this grade of copper is exposed to elevated temperatures, reactions take place within the metal which expand and rupture the copper structure, and which produce large voids in the metal surface.

In accordance with the invention, it has been found that the foregoing difficulties are avoided by employing as the material for collector pins in electrolytic reduction cells for aluminum and other metals, high purity copper which is substantially gas-free, particularly free from oxygen. The dimensional stability of this oxygen-free grade of copper, which is 99.96–99.99% Cu, allows for heating with substantially no gas evolution and no rupturing of the copper structure, although a minor amount of grain growth may occur. It permits further the use of pin designs which fully utilize the low electrical resistivity of high purity copper and the low carbon-to-copper contact resistance.

In comparison with mild steel (SAE 1020), the superior resistivity and contact resistance of high purity copper are shown by the following data:

ELECTRICAL RESISTIVITY

[Microohm-cm.]

Metal	Room Temperature	Average Bar Temperature	
		600° C.	700° C.
Cu 99.99%	1.85		6.1
Steel (SAE 1020)	16	75	

ROOM TEMPERATURE CONTACT RESISTANCE

[Ohms per sq. in.]

Joint Pressure	Graphite to Copper	Graphite to Steel
25 lbs./sq. in	0.000704	0.01309
50 lbs./sq. in	0.000315	0.00438

Thus, copper conducts about 8.6 times better than steel at room temperature and about 12.3 times better at estimated average collector bar temperature. The copper-graphite junction is 19 times better than the steel graphite junction at 25 p.s.i. and 14.6 times better at 150 p.s.i. Experiments have confirmed that these contact resistance relationships prevail at 900°–950° C.

The joints between graphite cathode blocks and the copper collector pins are not accessible after the reduction cell has been placed in operation, and hence it is important that the joints retain high conductivity while avoiding all danger of fracture of the graphite blocks. This is accomplished, in accordance with the present invention, by employing copper collector pins made of high purity, oxygen-free copper. This grade of copper is available commercially in two types: OFHC Brand Copper (minimum Cu 99.96%, P less than 3 p.p.m., Zn less than 10 p.p.m., Hg less than 1 p.p.m., S less than 40 p.p.m.), and Certified OFHC Brand Copper (99.99% Cu, P less than 3 p.p.m., Zn less than 1 p.p.m., Pb less than 10 p.p.m., Hg less than 1 p.p.m., S less than 18 p.p.m., Cd less than 1 p.p.m., sum of As, Sb, Bi, Se, Te, Sn, Mn not exceeding 40 p.p.m.). Both these types of copper meet the ASTM specifications B170–59 for oxygen free copper. They are produced by electrolytic refining employing special anodes to form cathodes which are then cast under conditions which prevent oxygen contamination.

In accordance with the present invention there is provided an alumina reduction cell comprising a shell, a graphite cathode block supported in the shell, and an oxygen or gas-free copper collector pin electrically connected to the cathode block, the block containing a socket at its outwardly facing end adapted to receive said collector pin. The pin may be connected to the cathode block by either a smooth or a threaded connection.

The invention will be more readily understood by reference to the accompanying drawings which illustrate present preferred embodiments, wherein:

FIGURE 1 is a sectional elevation of an alumina reduction cell incorporating the pins of the invention;

FIGURE 2 is a sectional elevation of a graphite cathode block receiving a collector pin with a smooth connection;

FIGURE 3 is a sectional elevation of a graphite cathode block receiving a collector pin via a threaded connection.

Referring to FIGURE 1, there is shown an alumina reduction cell having a steel shell **10**, the bottom wall of which is covered with a lining of insulating material **12**. The side walls of the steel shell **10** are covered with a lining of insulating material **14**. The side wall lining of insulation **14** is covered with a layer of rammed carbon **18**, while the cell bottom is covered with a layer of electrically and thermally insulative material **20**, such as powdered alumina. Cathode blocks **22** of graphite are connected to the cathode collector system by gas-free copper pins **24**. The pin-connected ends of cathode blocks **22** are anchored in side lining **18**, and the remaining por-

tions are embedded, except for their exposed upper surface, in insulative layer **20**. A cluster of prebaked carbon anodes **26** is suspended over the cell, the lower surfaces of the anodes being in contact with a bath **28** of molten alumina and cryolite. A pad **30** of molten aluminum extends beneath the bath **28**, covering insulative layer **20** and the exposed upper surfaces of cathode blocks **22**.

As shown in FIGURE 2, collector pin **24**, which extends through the side wall of the cell, is received in a socket **32** provided in graphite cathode block **22**, to form an electrical connection. The connection may take the form of a smooth cylindrical or frusto-conical copper pin in a smooth bore socket, as shown in FIGURE 2, or of a fine-threaded copper pin in a smooth bore socket. In another embodiment of the invention, as shown in FIGURE 3, the connection may be formed by providing a threaded pin **34** which is screwed into threaded socket **36** in the graphite block **22**, being thus automatically positioned and held in place in the graphite. An acme type thread has proved advantageous in that it provides low resistance contact at both low and high temperatures, and also prevents intrusion of alumina and other foreign materials between the copper and graphite during cell construction.

The use of oxygen-free copper collector pins in conjunction with graphite cathode blocks results in reduction of cathode voltage losses and hence in improved cell efficiency, as shown by comparative tests for oxygen-free copper and electrolytic tough pitch grade copper collector pins. Two 10,000 ampere cells having carbon sidewalls and alumina-cryolite bottom lining, and 8 inch diameter horizontal graphite cathodes were fitted, respectively, with copper collector pins having fine threads on the shank, 20 threads per inch. The pins had a major diameter of 2.375 inches. The graphite cathodes had a smooth bore socket of 2.408 inch diameter. The pins were, respectively, electrolytic tough pitch 99.9% copper (cell 3G), and oxygen free copper 99.96% grade OFHC (cell 4F).

The cathode voltage drop in cell 4F actually decreased during 33 days of operation, from 275 mv. on the third day to 200 mv. on the last day; while in cell 3G the voltage drop increased from 265 mv. on the third day to 367 mv. on the twentieth day.

Although the invention has been described with respect to the present preferred embodiment, it will be apparent to those skilled in the art that other embodiments may be employed falling within the scope of the appended claims.

What is claimed is:

1. An electrolytic reduction cell for the production of aluminum, wherein alumina dissolved in a molten salt bath is reduced to aluminum metal by passing an electric current through the bath, said cell comprising a pot shell having an interior lining adapted to contain the molten contents of the cell, at least one graphite cathode block being exposed at the interior surface of said lining for electrical contact with said molten contents, and an oxygen-free copper current collector pin electrically connected to said block, said block being provided with a socket to receive said collector pin.

2. The apparatus of claim **1** in which the collector pin is made of oxygen-free 99.96% copper.

3. The apparatus of claim **1** in which the cathode block is provided with a smooth bore socket.

4. The apparatus of claim **1** in which the cathode block is provided with a threaded bore socket.

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