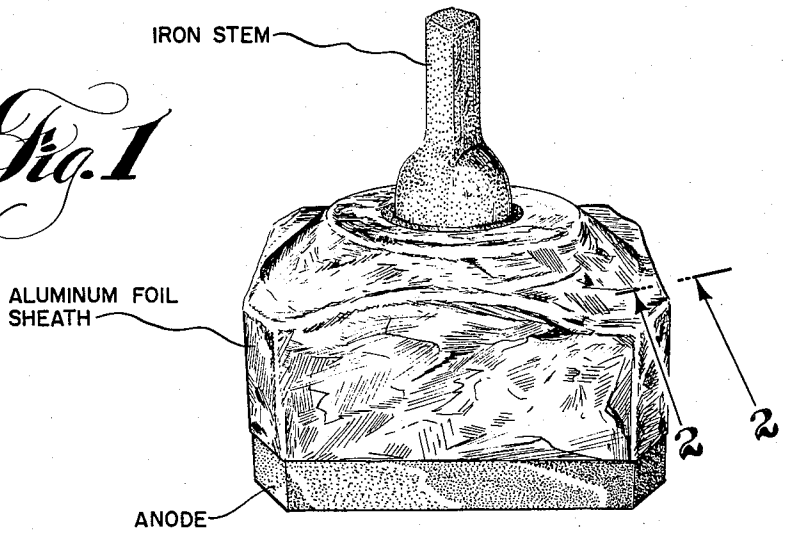
Oct. 23, 1962 W. E. HAUPIN ET AL 3,060,115

CARBON ANODE

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Fig. 1



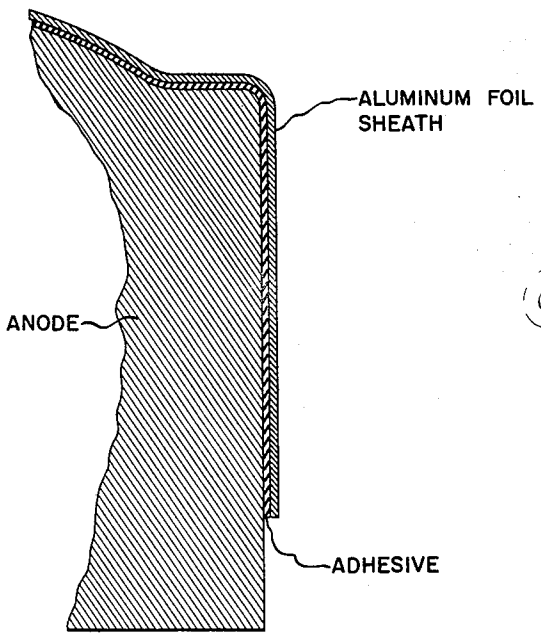


Fig. 2

INVENTORS
WARREN E. HAUPIN
EUGENE A. MADUK
BY

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CARBON ANODE

Warren E. Haupin and Eugene A. Maduk, New Kensington, Pa., assignors to Aluminum Company of America, Pittsburgh, Pa., a corporation of Pennsylvania

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This invention relates to baked carbon anodes, particularly those for use in an electrolytic cell for the production of aluminum. More specifically, this invention relates to affording increased protection to baked carbon anodes against severe air burning during operation of a cell of the above type.

In smelting aluminum by electrochemical decomposition of alumina, the conventional electrolytic cell comprises, in general, a steel shell provided with a carbon lining which serves as the cathode. Insulating material is generally used between the carbon lining and the shell. Current carrying bus bars are supported above the cavity of the cell, and a series of carbon anodes hang from these and dip into the molten electrolyte. The distance between electrodes is adjusted to properly divide the current among them.

In operation, a mixture of alumina and cryolite is charged to the cell, and an electric current is passed through the cell. The resistance of the charge to the passage of current generates sufficient heat to fuse the electrolyte which is a solution of alumina in molten cryolite or the like. Aluminum is electrolyzed out of the solution and deposits at the cathode while oxygen collects at the anode. A crust of solidified electrolyte and alumina forms on the surface of the bath, and this is usually covered over with additional alumina.

The oxygen deposited at the anode reacts with the hot carbon thereof to form carbon dioxide, which to some extent is subsequently reduced to carbon monoxide by the hot carbon. Actual operating conditions show that approximately 0.4 pound of carbon per pound of aluminum metal produced is necessarily consumed in this manner. Allowance is made for this loss by employing larger or taller anodes than required at the outset of operations, and therefore a portion only of the anode is initially submerged in the electrolyte. As the carbon anode is consumed, the anode is lowered into the bath, generally by mechanical or automatic means. The advantages in employing the large anodes thus include a decrease in the actual number of anodes manufactured, and minimizing the number of anode changes required in replacing consumed anodes.

As a consequence of employing large anodes, particularly with regard to height, the bonnet and upper portion of the side walls of the anode, which we will refer to hereinafter as simply the "head," protrude above the electrolytic bath during the initial period of operation. During operation of the cell the anode becomes heated, and the head being exposed to the oxygen of the air is subject to oxidation, this action being generally referred to as air burning. This adds substantially to the consumption of the carbon anode. The average net carbon consumption, which of course is somewhat dependent on the size, shape and quality of the anode, will as a general rule be not less than 0.5 pound of carbon per pound of aluminum metal produced (approximately 0.1 pound greater than that consumed by electrolysis per se). Net carbon consumption, as used herein, refers to the total pounds of baked carbon minus the weight of the unconsumed carbon butt.

To reduce air burning, the conventional practice is to cover the head of the anode with a blanket comprising solidified cryolite mixed with alumina, generally referred

to as an alumina blanket or ore blanket. The depth of such a blanket is obviously somewhat limited, and in order to adequately cover the side walls of the anode to reduce air burning, the height of the anode employed in the cell is restricted. Thus the side walls of taller anodes cannot be adequately protected against air burning. Moreover, the alumina blanket is somewhat permeable, and air therefore reaches the anode causing oxidation of the carbon.

In order to generate sufficient heat to maintain the electrolyte molten in the reduction cell, the power input must exceed that required for the electrochemical decomposition of the alumina. Under steady operating conditions, excess heat must be dissipated from the cell, for otherwise the carbon cathode lining and thermal insulation will become overheated and are likely to crack and disintegrate. The alumina blanket acts as a good insulator, and when used to cover the head of the anode, heat which normally might escape from the cell by radiation from the anode is partially restrained from doing so. On the other hand, it is known from Faraday's law of electrolysis that the amount of aluminum metal produced is proportional to the amperage passed through the cell. However, an increase in current to produce a corresponding increase in metal generates additional heat, part of which must be dissipated. Consequently, in the design and operation of the aluminum reduction cell, there must be a balance between such factors as power input and thermal insulation.

It is therefore the principal object of this invention to provide in a baked carbon anode for use in an electrolytic cell for the production of aluminum an improved means to substantially reduce carbon consumption resulting from air burning.

It is another object of the invention to obviate the need for maintaining an alumina blanket over the head of the anode, thereby rendering economical use of taller carbon anodes and further permitting increased amperage to the cell without modifying the cell design or installed facilities.

It has been found in accordance with the present invention that carbon anodes may be afforded increased resistance to air burning during operation of the reduction cell by means of an air-tight sheath of aluminum foil intimately bonded to the surfaces of the anode by an air-excluding stratum of adhesive. The anode, when initially set in place for operation in a cell, is only partially submerged in the electrolyte, the balance protruding above the bath and into the atmosphere. The foil sheath therefore is made to extend over the bonnet or top surface of the anode and along the upper side surfaces, preferably for a predetermined distance so that the foil sheath covers that portion of the anode that is exposed to the atmosphere. The sheath thus affords adequate protection against the action of air. In fact, we have found that a foil sheath employed in accordance with our invention reduces carbon consumption resulting from air burning by not less than 30% as compared to the same anode devoid of a foil sheath, and by not less than 20% when compared to the same anode protected from air burning by an alumina blanket under normal commercial operating conditions. The foil sheath may be applied in sections, or more desirably as a single, unitary sheet, and any overlapping margins bonded in place. Aluminum foil as used herein and in the industry refers to aluminum in sheet form less than 0.006 inch thick.

It is important in effecting a reduction in air burning that the aluminum foil sheath be in intimate contact with the surfaces of the anode, otherwise air may diffuse under the metal sheath in the channels between grains

of carbon and cause burning. To insure a tight sheath impervious to air, the aluminum foil, preferably in an annealed or soft temper, is bonded to the anode surface by means of an air-excluding stratum of adhesive. Foil in a hard temper has a tendency to crinkle or crease and consequently may not readily conform in an airtight manner to the anode surfaces. The adhesive is preferably applied to the entire foil surface, and the foil then applied to the anode. Where desired, the anode surfaces may be coated with adhesive, preferably in addition to coating the foil, and foil is then applied to the anode. The adhesive must resist the high temperature conditions created during operation of the electrolytic cell so as to retain a good airtight bond, and therefore should be a relatively non-combustible and non-volatile material. Adhesives found to be satisfactory for purposes of our invention include sodium silicate and Plibond 20 adhesive or similar synthetic resinous cement. In addition, the aluminum foil and adhesive should not contain elements or compounds which are detrimental to cell operations or which may cause undesirable or excessive contamination of the aluminum metal produced. Generally, the aluminum foil recommended in practicing our invention is of relatively high purity, preferably of not less than 99.45% purity.

To afford substantial increased protection against air burning of the carbon, we have found that the aluminum foil sheath should have a thickness of not less than about 0.001 inch. A sheath of lesser thickness may be easily torn or ripped, either during application of the foil to the anode or during installation of the anode to the cell or in operation thereof. Employing a sheath of greater thickness than foil is neither necessary nor desirable in that a substantially thicker sheath is required to attain any noticeable improvement against air burning while use thereof may only result in an excessive and uneconomical use of the metal, recovery of which is small. Further, a heavier sheath would require a special means of application, such as pressing, casting and the like to obtain a useful degree of exclusion of air from the anode-metal interface.

It will be observed that the aluminum foil sheath obviates the need for maintaining an alumina blanket over the anode. Consequently, with a reduced alumina blanket, a substantial amount of heat generated during operation of the cell will be radiated from the sheathed anode and dissipated into the surrounding atmosphere. To maintain the bath temperature, additional current input to the cell may be employed, and therefore the amount of aluminum metal produced per day is increased without modifying the cell design or installed facilities.

The heavy alumina blanket required to protect the anodes from air burning according to conventional practice results in an accumulation of frozen bath and ore between the anodes and sides of the cell which is commonly referred to as "high backs." The reduced alumina blanket therefore eliminates "high backs" from the cell thus making installation or setting of the anodes in the cell considerably easier. The invention further renders it economical to employ taller anodes in the reduction cell, for example anodes 23 inches in height as compared to the more normal 18 inch anode, and equally important, the taller anodes may be utilized without altering in any way present facilities.

For a better understanding of our invention reference is made herein to the accompanying figures where FIGURE 1 is a perspective view of a typical baked carbon anode having an aluminum foil sheath to protect its upper surfaces against severe air burning. FIGURE 2 is a fragmentary cross-sectional view taken on line 2—2 of FIGURE 1. The thickness of the foil sheath and adhesive coating is somewhat exaggerated to illustrate

the manner of adhesively bonding the sheath to the anode surface.

The invention may be further illustrated by the following example wherein carbon anodes 14" wide x 18" long x 12" high operated in a 7,000 ampere aluminum reduction cell having substantially no alumina blanket or other means to afford protection against air burning showed a net carbon consumption from air burning of 0.53 pound of carbon per pound of aluminum metal produced. The same anodes operating under substantially identical conditions provided with airtight aluminum foil sheaths 1, 2 and 3 mills in thickness bonded to the anode by sodium silicate showed a carbon consumption of 0.44, 0.41 and 0.44 pound carbon per pound aluminum metal produced, respectively. It will be observed that in comparing the sheathed anodes with anodes having substantially no protection, the decrease in carbon consumption resulting from air burning was greater than 50%. Because of the increased "life" of the foil sheathed anodes, the anode changing cycle for replacing consumed anodes was increased from 8 days to 10 days.

Table I below represents potline evaluations conducted on a larger scale, comparing foil sheathed anodes with anodes maintained with an alumina blanket. That is, the anodes employed in Line A were protected against air burning by means of an alumina blanket, and those in Line B by means of an aluminum sheath 0.002 inch thick bonded to the anode by sodium silicate. In both instances the anodes were 19" wide x 28" long x 18" high.

TABLE I

Potline Evaluation

Data	Line A	Line B
Net lbs. Al/Pot Day	1,019.0	1,033.0
Average Volts/Pot	4.80	4.84
Average Amperes	66,974	67,743
Kilowatts/Pot	322.2	327.8
Average Bath Temperature (° C.)	972	972
Lbs. Carbon/Lb. Al	0.521	0.495
No. Shifts in Pot	46.4	48.0
Average Burndown (inches)	1.30	0.58

The tabulated results clearly show that as a result of the better protection afforded by the aluminum sheath, there is not only a substantial savings in net carbon consumption of approximately 5%, but further an increase in metal produced. This dual improvement in cell operations results in an immense economic savings of several thousand dollars in view of the fact that a conventional reduction cell employs 20 anodes and there are approximately 100 to 150 cells to a line. Carbon burndown indicated in the table is a measurement in inches of the reduced height of the anode bonnet as a result of carbon consumption. The burndown decreased approximately 55% as a result of the aluminum foil sheath covering the anode. In addition, the foil sheathed anode had an increased "life" of 12.8 hours, there being 8 hours to a shift.

Having described our invention, we claim:

1. A baked carbon anode

adapted for use in an electrolytic cell for the production of aluminum from alumina dissolved in a molten electrolyte and

adapted in such use to have its bonnet and upper side surfaces protruding above the electrolyte where they are normally exposed to air burning and its lower portion submerged in the electrolyte,

said anode having, over its bonnet and upper side surfaces, a substantially airtight sheath comprised of aluminum foil 0.001 to 0.006 inch in thickness tightly and intimately bonded to the aforesaid surfaces by an air-excluding stratum of high temperature resistant adhesive,

said anode when used in an electrolytic cell as afore-

said being characterized by being so protected by said sheath against air burning as to obviate the need for maintaining the conventional alumina blanket over its upper side surfaces and permit increased current input therethrough to the cell with consequent increased aluminum production from the cell.

2. A baked carbon anode in accordance with claim 1 wherein said foil is annealed aluminum foil about 0.002 inch in thickness.

3. A baked carbon anode in accordance with claim 1 wherein said adhesive is sodium silicate.

4. A baked carbon anode in accordance with claim 1 wherein said adhesive is a synthetic resinous cement.

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