

(No Model.)

M. & E. BERNARD.
PROCESS OF AND APPARATUS FOR THE EXTRACTION OF ALUMINIUM.
No. 476,914. Patented June 14, 1892.

Fig. 1.

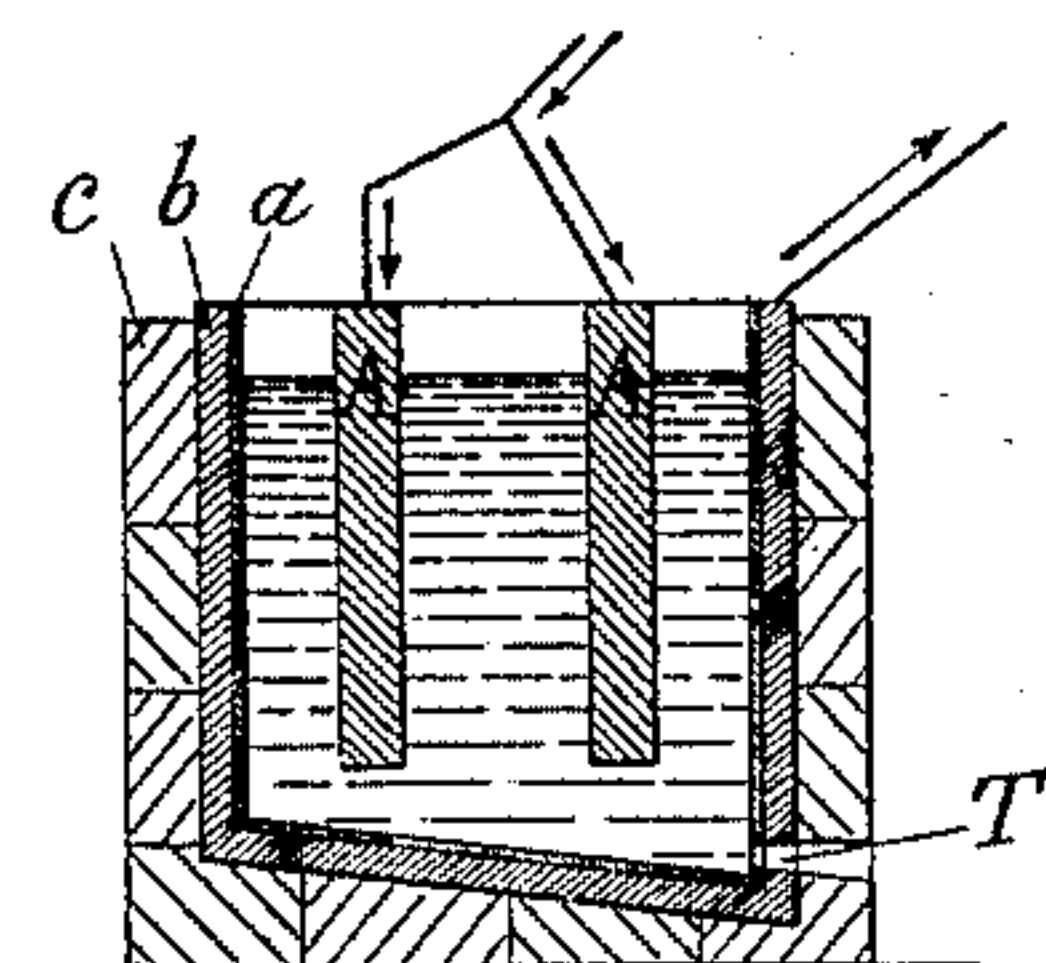
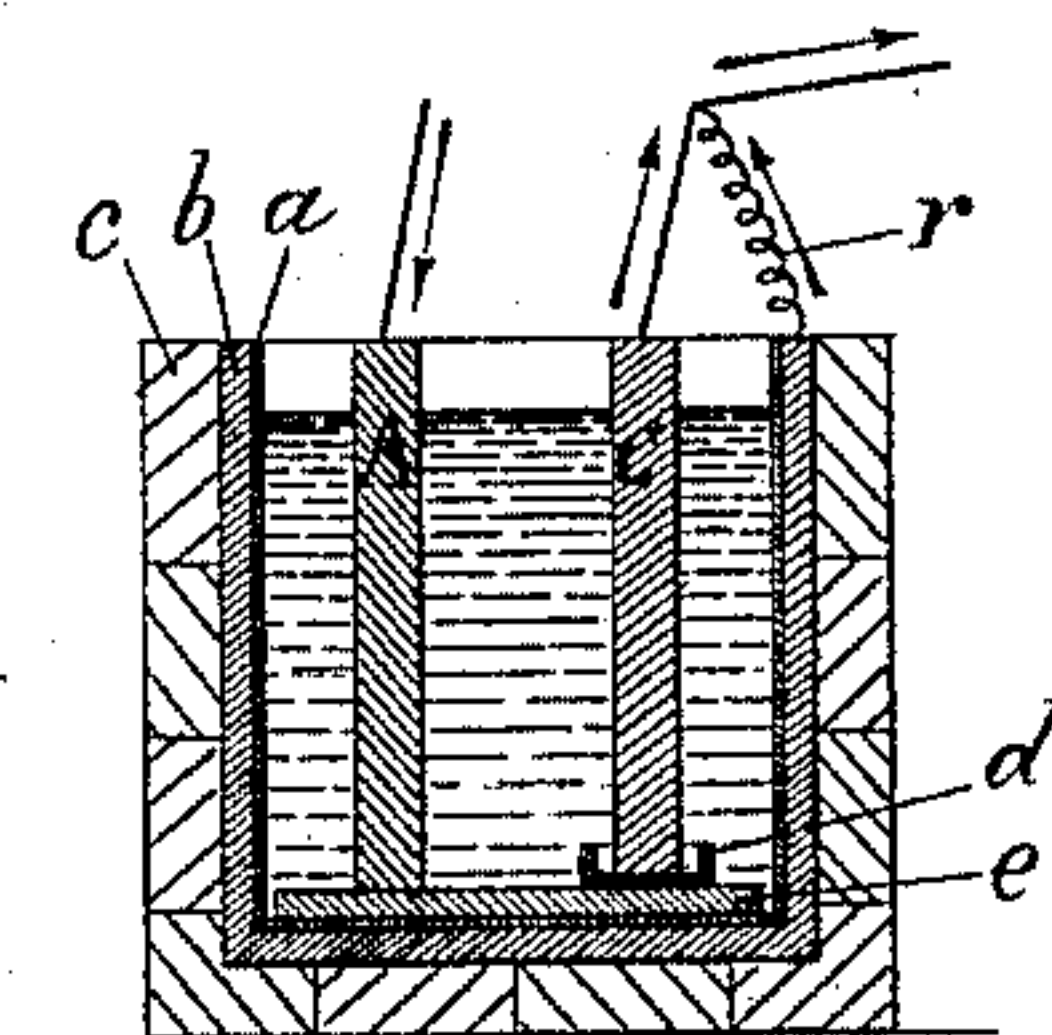


Fig. 2.



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MYRTHIL BERNARD AND ERNEST BERNARD, OF PARIS, FRANCE.

PROCESS OF AND APPARATUS FOR THE EXTRACTION OF ALUMINIUM.

SPECIFICATION forming part of Letters Patent No. 476,914, dated June 14, 1892.

Application filed January 20, 1888. Serial No. 261,378. (No model.) Patented in France May 17, 1887, No. 183,691 in Belgium July 14, 1887, No. 78,208; in Luxemburg July 14, 1887, No. 862, and in England July 18, 1887, No. 10,057.

To all whom it may concern:

Bet it known that we, MYRTHIL BERNARD and ERNEST BERNARD, citizens of the Republic of France, and residents of Paris, in the Republic of France, have invented certain new and useful Improvements in the Process of and Apparatus for the Extraction of Aluminium from its Fluorides by Electrolysis, (for which I have obtained patents in France May 17, 1887, No. 183,691; in Belgium July 14, 1887, No. 78,208; in Luxemburg July 14, 1887, No. 862, and in Great Britain July 18, 1887, No. 10,057,) of which the following is a specification.

Our invention has reference to improvements in the process of and apparatus for producing aluminium or aluminium alloys by electrolysis.

In the production of aluminium by electrolysis as heretofore practiced fluoride of aluminium has been melted with a suitable flux and has then been electrolyzed, whereby the aluminium was liberated at the cathode, and either combining with the latter, when of metal, and thus forming an alloy of aluminium with that metal, or rising along the face of the cathode to the surface of the bath, from which it had to be removed. This latter was the case when the cathode was non-metallic and usually of carbon or when it was made of a metal that could form no alloy with aluminium. In some cases the vessel or crucible containing the bath was either made entirely of or lined with metal to prevent the silicates in the body of ordinary crucibles from combining with the aluminium or aluminium alloy, since such combination renders the product brittle. When such metallic or metal-lined crucible was used, the same was sometimes utilized as the cathode, so that the product obtained was an alloy of aluminium with the metal of the containing-vessel.

In the processes so far described there are several inconveniences and defects which render the production of aluminium or aluminium alloy upon a large scale very expensive and unsatisfactory. In the first place, the fact that the electrolytic bath is specifically heavier than aluminium, so that the latter or its alloys rises to the surface of the bath, results in the burning of a portion of the pro-

duct upon contact with the air at a very high temperature. This rising of the product to the surface is also a great inconvenience, since it requires constant attention and manipulation for removing the liberated aluminium or aluminium alloy, which interferes with the feeding of the bath—that is to say, since from time to time the bath has to be replenished by the addition of cryolite and its flux, which are piled upon the surface of the bath, the removal of the aluminium which has risen to the surface becomes difficult. With a view of avoiding this difficulty our invention comprises the use of an electrolytic bath which is specifically lighter than aluminium or its alloys, so that as either of them is liberated it sinks to the bottom of the crucible and may be drained off without exposure to the air for any considerable time at the high temperature which it has when risen to the surface and without interfering with the feeding of the bath, so that the process may be continued for a very long time without sensible interruption. In the second place, when a metallic crucible was used as the cathode, whereby the crucible is consumed in the process and becomes an element of the product, pure aluminium could not be produced; but when it was attempted to produce pure aluminium by using a metallic crucible without making it the cathode it was found that the melted fluorides acted so corrosively upon the metal of the crucible that it soon became destroyed and in a measure combined with the aluminium, forming impure alloys where pure aluminium was aimed at. The metal platinum, which is not attacked by the fluorides, cannot be used for crucibles upon a commercial scale on account of its great cost. With a view of avoiding this difficulty our invention comprises the use of the metallic containing-vessel not as the cathode pure and simple, but as a fractional cathode—that is to say, an ordinary or regular cathode is being used, but the containing-vessel is made a branch thereof, through which only a small portion of the current passes, whereby the metal of the crucible becomes lined with a fine layer of aluminium alloy, by which it is protected against the corrosive action of the melted fluorides, while pure aluminium is deposited upon the cath-

ode proper. The branch of the cathode formed by the containing-vessel is made one of high electrical resistance, so that only a small fraction of the current passes through the same. All this will more fully appear from the following detailed description, with reference to the accompanying drawings, in which—

Figure 1 represents a vertical section of an electrolytic apparatus constructed in accordance with our invention for the production of aluminium alloys, and Fig. 2 is a like view of the apparatus as modified for the production of pure aluminium.

Like letters of reference indicate like parts in both figures of the drawings.

In pursuance of the object of our invention we form an electrolytic bath by melting together either native or artificial cryolite with chloride of sodium or common or marine salt in such proportions that the resulting mass has a specific gravity which is lower than that of aluminium.

As above stated, we may use artificial cryolite, and in so doing we are not obliged to adhere to the proportions of fluoride of aluminium and fluoride of sodium as found in native cryolite. Thus, for instance, we may use—

Fluoride of aluminium	35
Fluoride of sodium	10
Chloride of sodium	55
Total	100

An electrolytic bath formed by the melting together of cryolite and chloride of sodium in such proportions as to give a mass which is specifically lighter than aluminium also possesses two other characteristics which are of great value in the production of aluminium. One of these characteristics is its great fluidity, whereby the bath behaves under the action of the current with the same regularity as a salt in solution, and that at temperatures varying from 900° to 1,100° centigrade, which are the highest temperatures used by us. The second of these characteristics is that the bath is very little volatile, so that not more than about five percent. of the whole mass is lost in twenty-four hours.

In the practice of our invention for producing aluminium alloys we use an apparatus constructed in the manner indicated in Fig. 1. In this figure of the drawings there is shown a containing vessel or crucible *b*, made of the metal with which the alloy with aluminium is to be formed. It may therefore be made of any of the base metals which readily alloy with aluminium and which at the same time are refractory at the temperatures at which the bath melts. This containing vessel or crucible is embedded in fire bricks or clay *c* in such a manner that the flame of the furnace does not directly impinge upon the vessel, and it is formed with an inclined bottom, as shown, for a purpose which will presently

appear. At the side of the vessel, close to the lowest point of the bottom of the same, is formed an orifice *T*, which is ordinarily plugged up, but so that it may be opened readily. One or more electrodes *A A* are suspended within the bath and are used as anodes, while the containing-vessel is used or may be used as the cathode, so that the current, entering by the electrodes *A A*, traverses the bath and issues by a conductor connected with the containing-vessel, all as indicated by the arrows in the drawings. The anodes may be made of different materials, according to the product desired. If it is desired to obtain aluminium moderately alloyed with the metal of which the containing-vessel is made, then the anodes will be made of carbon. In this case a small percentage of the metal of the containing-vessel alloys with the aluminium liberated; but if it is desired to obtain an alloy containing a considerable quantity of the metal of which the containing-vessel is made then the anodes are also made of that metal.

The electrolytic bath being made, as above described, specifically lighter than aluminium, the alloy *a*, formed by the use of the apparatus represented in Fig. 1, will flow down along the sides of the containing-vessel and will accumulate upon the inclined bottom, and after a suitable quantity has thus accumulated it is drained off by opening the orifice *T*. The time when this is done—that is to say, the time when a sufficient quantity of the deposited metal has accumulated—is easily learned by experience, and may, in fact, be predetermined with great accuracy by computation, since, as above stated, our electrolytic bath behaves with the same regularity as a salt in solution. Knowing, therefore, the volume and electro-motive force of the current employed; knowing, also, the electrical resistance of the bath and the counter electro-motive force of the same, the amount of metal liberated within a certain time can be accurately computed.

For the production of pure aluminium an apparatus like that represented in Fig. 2 is used. It consists of the containing-vessel *b*, which in this case has a horizontal bottom and is embedded in fire bricks or clay *c*, substantially like the apparatus described with reference to Fig. 1. A plate *e*, made of either fused alumina or of fluoride of calcium, is placed upon the bottom of said vessel, and upon this plate *e* there is placed a small crucible *d*, made of the same material of which the plate *e* is made, and a cathode *C*, inserted in the bath, reaches down to the bottom of the crucible *d*, while the anode *A* rests upon the plate *e*. In this case both the anode and the cathode are made of carbon. With the apparatus so far described if the current were allowed to enter at the anode *A* and then pass through the bath to the cathode *C* and issue by the same entirely the bath would corrode the containing-vessel and the metal liberated

at the cathode would not be pure aluminium but an impure alloy, as hereinbefore stated. This we avoid by making the containing-vessel a fractional cathode—that is to say, the containing-vessel is connected by a high-resistance conductor r with the conductor leading from the cathode C to the source of current, as indicated in the drawings. This resistance r is made so great that only about five per cent. of the entire current passes through the containing-vessel, and at no time should there be allowed more than ten per cent. of the current to be diverted through the containing-vessel. The current thus diverted is not sufficient to produce a considerable quantity of alloy of aluminium with the metal of the vessel, but the effect is to deposit upon the walls of the vessel a thin layer a of such alloy, which effectively protects the vessel against the corrosive action of the bath, while pure aluminium is deposited upon the cathode C, along the face of which the aluminium flows down and accumulates in the crucible d . We are thus enabled to produce aluminium of great purity.

Having now described our invention, we claim and desire to secure by Letters Patent—

1. The method of electrolyzing molten aluminium compounds, which consists in passing the main portion of an electric current through the molten mass between electrodes immersed in the same and the remaining fraction of the current between the anode and the containing-vessel, substantially as described.

2. The process of producing aluminium by electrolysis, which consists in first making a molten bath containing fluoride of aluminium and then passing the main portion of an electric current through the bath between electrodes immersed in the bath and the remaining fraction of the current between the anode and the containing-vessel, substantially as described.

3. The process of producing aluminium by electrolysis, which consists in first making a melted bath which is specifically lighter than aluminium and which contains fluoride of aluminium and chloride of sodium and then passing the main portion of an electric current through the bath between suitable electrodes placed in the bath and the remaining fraction of the current through the anode, the bath, and containing-vessel, substantially as described.

4. The process of producing aluminium by electrolysis, which consists in melting together cryolite and chloride of sodium in such proportions as to form a bath which is specifically lighter than aluminium and then passing the main portion of an electric current through the bath between an anode and a cathode to the exclusion of the containing-vessel and the remaining fraction of the current through the bath between the anode and the containing-vessel as a fractional cathode, whereby pure aluminium is liberated at the cathode and aluminium alloy is formed upon the containing-vessel, substantially as described.

5. An apparatus for producing aluminium by electrolysis, consisting of a metallic containing-vessel or crucible for the bath, an anode, a cathode, a depositing-vessel or crucible for the same located within and insulated from the containing-vessel, and a branch conductor of high electrical resistance between the cathode and the containing-vessel, whereby the latter becomes a fractional cathode, substantially as described.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

MYRTHIL BERNARD.
ERNEST BERNARD.

Witnesses:

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