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J. BRODE ET AL
 PRODUCTION OF ALUMINUM
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Fig. 1.

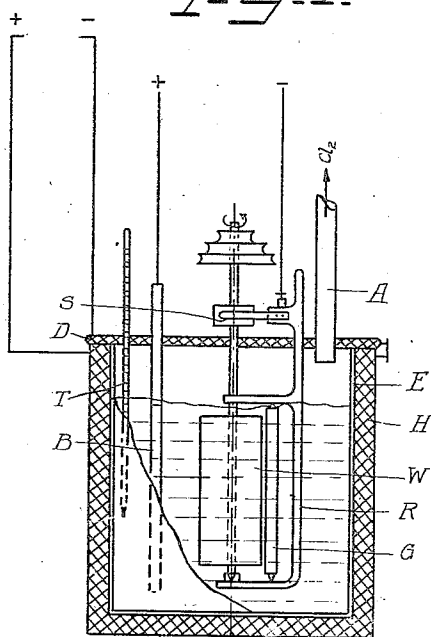
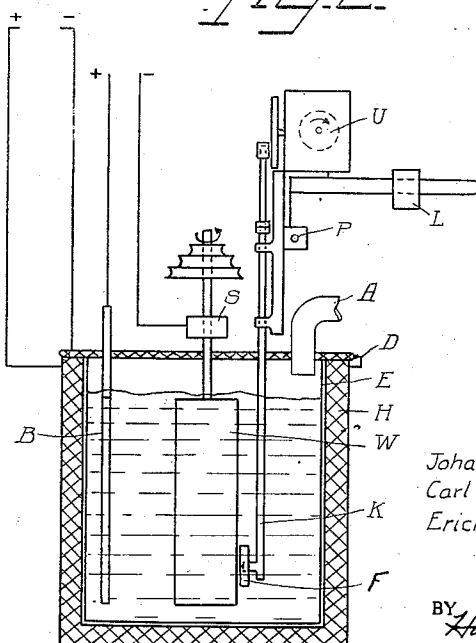


Fig. 2.



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PRODUCTION OF ALUMINUM

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The present invention relates to the production of aluminum by electrolysis.

It has already been proposed to prepare aluminum by the electrolysis of anhydrous aluminum halides, the aluminum halide being converted into a double aluminum halide by the addition of an equimolecular amount of alkali or alkaline earth metal halide in order to lower the melting point of the electrolyte.

We have now found that the electrolysis of the aluminum halide may be carried out in a particularly advantageous manner with a melt which has a greater content of aluminum halide than corresponds to the double salts heretofore described. In some cases it is especially advantageous not to admix to the aluminum halide a single alkali metal or alkaline earth metal halide but to admix an appropriate quantity of a mixture of several different halides of the said class. The molten mixture of the said halides preferably comprises from 2 to 4 molecular proportions of aluminum halide to 1 molecular proportion of an alkali metal or alkaline earth metal halide or a mixture of such halides. The chlorides of the said metals are preferably used. These mixtures with aluminum halides thus obtained have a very low melting point, in part even below 100° centigrade, and at the same time, contrary to expectation, have a very low vapor tension of aluminum halide so that the gas evolved at the anode carries with it only a very small amount of aluminum halide or none at all. Any aluminum halide which may be carried along may be readily recovered. This is particularly simple when the gas is to be employed for the conversion of fresh quantities of initial material containing alumina into aluminum halide. By employing such a cycle the process according to the present invention is very advantageous in every respect for the manufacture and production of metallic aluminum.

The separation of the aluminum with the usual current densities readily takes place in spongy form in which the aluminum only adheres to the cathode with difficulty and readily becomes dispersed in the bath and thus is partly lost. With somewhat smaller current

densities the separated aluminum grows to dendrites which have a tendency to fall from the cathode. Only with very low current densities can the metal be recovered in a firmly adherent, coherent form in which case an undesirably large apparatus is necessary.

We have also found that in quite a general manner compact well adherent aluminum may be obtained even with high current densities by taking care that the cathode and the electrolyte move relatively to each other, which may be effected for example by stirring the bath or by moving the electrode or the like. For example, it is very advantageous to cause the electrode to rotate more or less rapidly. By employing moving electrolytes or electrodes or by employing very small current densities it is possible to precipitate the aluminum directly in such a form that the precipitate may be employed for the purposes of galvanoplastics or electroplating. Working in this manner offers advantages when baths are employed which contain smaller amounts of aluminum halide than initially specified or when no gas is evolved at the anode but when soluble metal anodes, as for example aluminum anodes, are employed. Under the said conditions the aluminum is readily deposited in comparatively thin layers in a compact form. If it is attempted to precipitate the metal in thicker layers, for example as sheets or tubes of several millimeters thickness, by carrying on the electrolysis for a longer period of time, the deposited aluminum readily grows into dendrites as when working with stationary electrodes and a metal is obtained contaminated by enclosures of the melt which must be removed by melting. The melting process, however, apart from the increased cost of operation attendant thereon, is always attended by loss of metal.

This objection can be obviated and the aluminum can be directly obtained in the desired form with the avoidance of any formation of dendrites when care is taken that the metal which separates during the electrolysis is continuously pressed on to the electrode. For carrying out this process two or more engaging movable cathode rollers may for

example be employed which when arranged vertically may be pressed against each other for example by springs, and when arranged horizontally the pressure may be produced by merely allowing the upper roller, if desired weighted inside with lead, to rest on the lower roller. A uniform deposition of metal may be effected by causing one or more polishing stones to move backwards and forwards under pressure on the rotating rollers, the stones and the rollers being provided with individual power or being moved positively to each other.

The cathode rollers may themselves consist of aluminum or of other metals as for example of iron. In the latter case it is preferable to take care that the introduction of rollers into the melt or alternatively the introduction of the melt into the electrolyzing trough is carried out while the current is flowing so that iron is not dissolved in the melt thus causing the electrolyte to be contaminated.

The pressure rollers may also consist of non conducting material as for example of agate.

Apparatus suitable for carrying out the invention are shown in the accompanying drawings of which Figure 1 is a side view with the front wall in part broken away, and Figure 2 a side view with the front wall removed.

According to Figure 1 the molten mixture of aluminum halide and alkali or alkaline earth metal halide to be electrolyzed is heated in an enamelled vessel E provided with a cover D, the vessel and the cover being provided with electrical heating means H. Through the centre of the cover D passes a shaft to which the cathode roller W is secured rotatably mounted in an iron frame R which also bears the counter-roller G. The two rollers may be pressed against each other by means of a spring (not shown) provided in the said frame. The shaft of the roller W is connected to the cathode of a source of current by means of the sliding contact S. A non-corrosive anode B passes through the cover which is, moreover, provided with a pipe A for withdrawing the halogen formed. A thermometer T passes through the cover into the melt.

In Figure 2 an apparatus is shown similar to that shown in Figure 1 and the corresponding parts are referred to by the same reference letters. In this apparatus, however, the aluminum deposited on the cathode roller W is pressed thereon by means of an agate F held on a rod K set in an upwardly and downwardly reciprocating movement by means of the gear U. The rod and gear are pivoted at P and the agate pressed against the roller W by means of the weight L.

During the electrolysis the bath gradually becomes impoverished in aluminum halide

while the impurities become enriched. It has been found that in order that there may always be pure melts it is preferable to proceed by continuously or periodically removing a part of the melt from the bath, adding fresh aluminum halide to this and then purifying the mixture in a suitable manner, for example by adding metallic aluminum or other reducing agents which are capable of precipitating iron, or by electrolysis or otherwise, the melt then being introduced into the electrolyzing cell.

The following examples will further illustrate the nature of this invention, but the invention is not restricted to these examples.

Example 1

A melt consisting of about 14 per cent of sodium chloride, about 6 per cent of potassium chloride and about 80 per cent of aluminum chloride is electrolyzed at about 100° centigrade with the employment of a graphite body as anode and a cylindrical body consisting of metal or graphite as cathode. With a cathode current density of 1 ampere per square decimeter and with a stationary cathode aluminum is obtained as a badly adherent sponge whereas with a rotating cathode it is obtained as a compact, well adhering metal. Even with considerably higher current density the aluminum may be obtained as a well adhering metal by employing rotating electrodes.

Example 2

An anode consisting of an unattackable material, as for example tungsten, is immersed in a melt consisting of 82 parts of aluminum chloride and 18 parts of sodium chloride and having a temperature of about 160° centigrade together with a cathode consisting of an iron roller which has been previously degreased which is in the current circuit and which is arranged vertically in a frame in which another roller is pressed against it by spring pressure. The pair of rollers is set in slow rotation and the melt is then electrolyzed with a current density of 4.2 amperes per square decimeter at a tension of 3.2 volts. At the end of the passage of the current the cathode is taken out from the melt, any adherent melt is removed and an aluminum tube is obtained the internal diameter of which is equal to the diameter of the cathode roller and which may be obtained in any thickness according to the duration of the electrolysis. The metal is free from inclusions of melt and has a high degree of purity.

What we claim is:—

1. A process for the production of aluminum and halogen which comprises electrolyzing a melted mixture of an aluminum halide and less than an equimolecular amount of a halide of a metal selected from the group

consisting of alkali metals and alkaline earth metals.

2. A process for the production of aluminum and chlorine which comprises electrolyzing a melted mixture of aluminum chloride and less than an equimolecular amount of a chloride of a metal selected from the group consisting of alkali metals and alkaline earth metals.

3. A process for the production of aluminum and halogen which comprises electrolyzing a melted mixture of from 2 to 4 molecular proportions of an aluminum halide and 1 molecular proportion of a halide of a metal selected from the group consisting of alkali metals and alkaline earth metals.

4. A process for the production of aluminum and halogen which comprises electrolyzing a melted mixture of an aluminum halide and less than an equimolecular amount of a halide of a metal selected from the group consisting of alkali metals and alkaline earth metals, the cathode and the electrolyte being moved relatively to each other.

5. A process for the production of aluminum and halogen which comprises electrolyzing a melted mixture of from 2 to 4 molecular proportions of an aluminum halide and 1 molecular proportion of a halide of a metal selected from the group consisting of alkali metals and alkaline earth metals, the cathode and the electrolyte being moved relatively to each other.

6. A process for the production of aluminum and halogen which comprises electrolyzing a melted mixture of an aluminum halide and less than an equimolecular amount of a halide of a metal selected from the group consisting of alkali metals and alkaline earth metals, the cathode and the electrolyte being moved relatively to each other the deposited aluminum being pressed onto the cathode during electrolysis.

7. A process for the production of aluminum and halogen which comprises electrolyzing a melted mixture of an aluminum halide and less than an equimolecular amount of a halide of a metal selected from the group consisting of alkali metals and alkaline earth metals, branching off part of the electrolyte, adding fresh aluminum halide to this branched off part and reintroducing it into the process.

8. A process for the production of aluminum and halogen which comprises electrolyzing a melted mixture of an aluminum halide and less than an equimolecular amount of a halide of a metal selected from the group consisting of alkali metals and alkaline earth metals, branching off part of the electrolyte, adding fresh aluminum halide to this branched off part, freeing it from impurities and reintroducing it into the process.

9. A process for the production of aluminum and halogen which comprises electro-

lyzing a melted mixture of from 2 to 4 molecular proportions of an aluminum halide and 1 molecular proportion of a halide of a metal selected from the group consisting of alkali metals and alkaline earth metals, branching off part of the electrolyte, adding fresh aluminum halide to this branched off part to the initial concentration and reintroducing it into the process.

10. A process for the production of aluminum and halogen which comprises electrolyzing a melted mixture of from 2 to 4 molecular proportions of an aluminum halide and 1 molecular proportion of a halide of a metal selected from the group consisting of alkali metals and alkaline earth metals, branching off part of the electrolyte, adding fresh aluminum halide to this branched off part, freeing it from impurities and reintroducing it into the process.

In testimony whereof we have hereunto set our hands.

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