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ALUMINUM ALLOY AND METHOD OF MANUFACTURE.

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This invention relates to alloys of aluminum and more particularly to such alloys in which zirconium serves to neutralize the deleterious effect of certain impurities.

An object of my invention is the production of alloys of aluminum having high ductility, directly from impure aluminum ore.

Another object of my invention is to simplify the manufacture of aluminum, by using zirconium alloyed therewith, whereby it is unnecessary to purify the bauxite or other aluminum ore to obtain a product of high ductility.

A further object of my invention is the employment of zirconium to alloy with aluminum to neutralize the harmful effect of impurities such as iron, which render it brittle and nonductile, and form an alloy of greater strength than heretofore produced without using zirconium.

A still further object of my invention is the simultaneous electrolysis or reduction of impure bauxite and zirconium oxide to produce an alloy of aluminum, zirconium and other metal impurities, the harmful effect of the impurities being neutralized by the zirconium.

Other objects and advantages will become apparent as the description proceeds.

As is well known, aluminum is manufactured commercially by electrolysis of the fused ore and in order that the product may have ductility and not be too brittle, it is necessary when using ore containing impurities such as iron, to carefully purify the same.

According to the Heroult process, cryolite (Na_3AlF_6) mixed with alumina (Al_2O_3) or bauxite ($Al_2O_3 3H_2O$) is fused in an electric furnace between carbon electrodes. Aluminum fluoride, calcium fluoride, sodium chloride or other compounds, are sometimes added to reduce the melting point of the electrolyte and diminish the density, so as to facilitate the separation of the aluminum to the bottom of the fused bath. Any impurities in the aluminum ore, such as compounds of iron, will be reduced and alloy with the aluminum, resulting in a brittle and nonductile metal.

In using aluminum ore or bauxite containing such impurities, it has been necessary to submit the same to a careful and costly purification process in order to obtain aluminum having the desired properties.

According to my invention, I obviate the necessity of the usual purification process by adding to the fused electrolyte, a material which, upon reduction, furnishes a metal which neutralizes the effect of impurities such as iron.

My invention will be better understood by the more detailed description thereof which follows.

In general, one of the usual commercial processes, such as the Hall or the Heroult process, may be employed for making aluminum alloys, according to my invention with the modifications which will be pointed out during the description of the invention.

An electric furnace employing a carbon anode and a cathode of carbon is preferably employed. An electrolyte of cryolite or mixtures of the fluorides of sodium, aluminum and calcium in the proportion to give a low melting point product may be used in a fused condition. Impure bauxite or alumina, which may contain the usual quantities of compounds of iron and silicon, may be dissolved in the fused electrolyte, in such proportions, that the melting point thereof is a minimum or not excessively high, although the exact proportions used are not material. The proportion of alumina to cryolite or its equivalent in the mixture is preferably about 20% to secure a minimum fusing temperature.

A small proportion of zirconium oxide or other zirconium compound may be mixed with the bauxite or alumina before dissolving the same in the fused electroylte in the furnace or added separately The exact amount or the manner of adding the zirconium oxide is not material, but it is not necessary to use more than about one-half percent of the total of aluminum ore used and a smaller proportion than this may be employed if desired, provided the proportion of impurities, such as iron compounds, are small. For larger proportions of iron compounds, the proportion of zirconium oxide should be increased.

Direct current is passed between the electrodes through the fused mixture to electrolyze and cause reduction of the aluminum ore and zirconium oxide, which finally results in the formation of a molten alloy of

aluminum, zirconium, iron, silicon and perhaps other materials as impurities, which alloy separates out at the bottom of the furnace and may be allowed to run out through a tap hole therein and cast into pigs or in any desired shapes.

As zirconium oxide is soluble in fused cryolite and is more easily electrolyzed and reduced than alumina, the usual method of preparation, as heretofore described, may be employed, merely adding a small proportion of zirconium oxide prior to or during the reduction process for the aluminum.

The function of the zirconium oxide is to provide a small proportion of zirconium in the resulting product to neutralize the harmful effect of impurities, such as iron especially, and make it possible to prepare aluminum alloys, which are substantially all aluminum, without the necessity of purifying aluminum ore of deleterious substances, before subjecting it to electrolysis. That is, a small proportion of zirconium appears to neutralize a harmful effect of a much larger proportion of iron in the alloy and results in as good or better metal than pure aluminum.

An example of an alloy prepared according to my invention which is so ductile and workable, that it was rolled into sheets .0015" thick, is as follows:

Aluminum about 96.4%; iron about 2.6%; silicon about .7%; zirconium about .3%. Such an alloy, although containing a very small proportion of zirconium, is much better than a corresponding alloy without zirconium, because it lacks brittleness, may be worked like and is even stronger than pure aluminum, having a tensile strength of about 18,000 pounds per square inch before rolling. Without the zirconium content, such an alloy would be so brittle, that it would not be possible to roll it or work it to a great extent.

With larger proportions of zirconium in the alloy, the increase in strength is more marked than with small amounts and the harmful effects of much larger proportions of impurities may be neutralized. For example an alloy prepared as above described, with the following composition:

Aluminum about 76%; iron about 13%; silicon about 2%; zirconium about 9%, was found to have a Brinell hardness of about 166, indicating a tensile strength corresponding to that of steel or from 70,000 to 80,000 lbs. per square inch.

Although giving specific examples of alloys prepared according to and methods of practicing my invention, I do not wish to be limited thereto as they are merely illustrative and aluminum alloys with the desired properties, containing varying proportions of zirconium corresponding to varying proportions of impurities may be prepared by methods like that described in detail and employed without departing from the spirit and scope of my invention as defined by the appended claims.

What is claimed is:

1. The manufacture of ductile aluminum-zirconium alloys comprising the electrolysis of an unpurified bauxite mixture with zirconium oxide, the proportion of zirconium oxide being insufficient to produce in the finished alloy more than 10% of zirconium.

2. The manufacture of aluminum-zirconium alloys comprising dissolving an impure ore of aluminum in fused cryolite or the like, adding a small proportion of an ore of zirconium thereto, having a zirconium content insufficient to produce in the finished alloy more than 10% of zirconium, fusing the mixture in an electric furnace and electrolyzing out a ductile aluminum-zirconium alloy.

3. The method of manufacturing aluminum-zirconium alloys comprising mixing impure bauxite with a small proportion of zirconium oxide having a zirconium content insufficient to produce in the finished alloy more than 10% of zirconium, dissolving in fused cryolite and electrolyzing the mixture in an electric furnace to form an impure aluminum with a small proportion of zirconium alloyed therewith, whereby a strong and ductile alloy is produced.

4. The method of manufacturing aluminum-zirconium alloys comprising fusing alkali and aluminum fluorides, dissolving impure aluminum and zirconium ores therein in such proportion as to produce an alloy having more than 75% aluminum, up to 10% of zirconium and the remainder iron and silicon and electrolyzing out such alloy.

5. The method of manufacturing alloys comprising fusing alkali, alkaline earth and aluminum fluorides, dissolving impure bauxite or the like therein, dissolving zirconium oxide therein in such proportion as to produce in the finished alloy a zirconium content up to 10% and electrolyzing out the aluminum-zirconium alloy.

6. An alloy of aluminum with deleterious impurities and a small proportion of zirconium, the aluminum predominating and the zirconium being present in such quantity that the harmful effect of the impurities is neutralized.

7. An alloy of aluminum, iron and zirconium the aluminum predominating and the zirconium being present in such proportion that it neutralizes the harmful effect of the iron and a ductile alloy is secured.

8. An alloy of aluminum, zirconium, silicon and iron with the aluminum predominating and the zirconium being present only in sufficient proportion to neutralize the effect of the silicon and iron to result in the formation of a ductile metal.

9. An aluminum alloy comprising from 2% to 13% of iron as impurity and being rendered ductile by containing zirconium in an amount less than that of the iron but sufficient to neutralize the embrittling effect of the iron.

10. A ductile aluminum alloy of high tensile strength comprising about 75% to 98% aluminum, about 2% to 13% of iron and zirconium in an amount less than that of the iron but sufficient to neutralize the embrittling effect of the iron.

11. A ductile aluminum alloy comprising from 75% to 98% aluminum, from 13% to 2% of iron, .7% to 2% of silicon and from 9% to .3% zirconium.

12. An alloy of aluminum, iron and zirconium comprising more than 75% of aluminum and less than 10% of zirconium, the zirconium content being sufficient to neutralize the harmful effect of the iron and strengthen the alloy.

13. An aluminum alloy of improved strength comprising 75% to 80% of aluminum, about 13% of iron and about 9% of zirconium.

14. An aluminum alloy of improved strength comprising 75% to 80% of aluminum, about 13% of iron, about 2% of silicon and about 9% of zirconium.

In testimony whereof, I have hereunto subscribed my name this 2nd day of November 1923.

HENRY KNEELAND RICHARDSON.