

UNITED STATES PATENT OFFICE

2,085,697

METHOD FOR TREATING ALUMINUM AND ALUMINUM ALLOYS

John G. G. Frost and Walter Bonsack, Cleveland, Ohio, assignors to The National Smelting Company, Cleveland, Ohio, a corporation of Ohio

No Drawing. Application August 5, 1933, Serial No. 683,900. Renewed June 9, 1936

6 Claims. (Cl. 75—68)

Our invention relates to a method of treating aluminum or aluminum alloys to improve their physical properties, and more particularly to an improved process of treating aluminum or aluminum alloys with a normally liquid or solid boron compound which forms a gas at elevated temperatures.

An object of our invention is to provide an improved method of treating aluminum or aluminum alloys to improve their physical characteristics.

Another object of our invention is to provide an improved process of introducing boron in a dispersed state into aluminum or aluminum alloys to improve the physical properties of the metal.

A further object of our invention is to provide an improved method of treating aluminum or aluminum alloys in a molten or pasty state with a normally liquid or solid boron compound which, when heated, forms a gas at a temperature below approximately 700° C.

A still further object of our invention is to provide an improved process of treating aluminum or aluminum alloys with a normally solid compound containing boron and fluorine which, when heated, forms a gas at a temperature below the melting point of aluminum or the aluminum alloy being treated, and which gas is capable of effecting improvement in the grain structure of aluminum or aluminum alloys.

It is well known that aluminum and aluminum alloys having a fine, uniform grain structure are much superior for casting, forging, welding and other purposes than aluminum or aluminum alloys which do not have such physical characteristics.

In copending application Serial No. 479,790, filed on September 3, 1930, (issued August 8, 1933 as Patent No. 1,921,998) a process is disclosed of treating aluminum or aluminum alloys with a boron compound dissolved in a molten flux, whereby aluminum or aluminum alloys may be produced having a fine, uniform grain size which persists through repeated meltings and solidifications of the aluminum or aluminum alloys.

We have now made the discovery that if normally liquid or solid compounds containing both boron and fluorine, which, upon the application of heat, are capable of forming a gas at a temperature below the melting point of aluminum or the aluminum alloy being treated, are introduced into aluminum or aluminum alloys, the gas thus formed is capable of modifying aluminum or aluminum alloys, so that, upon solidification, the

aluminum shall have a fine, uniform grain structure.

In practicing our invention, we prefer to utilize hydrofluoboric acid, HBF_4 , or the fluoborates of ammonium or the alkali metals, such as potassium or sodium fluoborates, or a mixture of two or more of such compounds. These compounds contain both boron and fluorine and are characterized by the fact that they are liquid or solid at normal temperatures but form a gas when brought into contact with aluminum or an aluminum alloy in the molten or pasty state, which gas is capable of improving the grain structure of aluminum or aluminum alloys, so that, upon solidification, the aluminum is characterized by having a fine, uniform grain structure.

The compound, or mixture of compounds, is brought into intimate contact with the aluminum or aluminum alloy in any desired manner. For example, if the compound is liquid, it may be mixed with an absorbent material, as charcoal or sawdust, so that it may be handled as a solid and thus introduced into the body of molten aluminum or stirred in contact with the molten aluminum. The compound or compounds may be placed in a perforated container and held under the surface of the aluminum or aluminum alloy. Another method is to place the compound, or mixture of compounds, in a container with one or more openings, which may be suspended in the molten aluminum or aluminum alloy in any desired manner or allowed to rest on the bottom of the melting vessel or furnace in which the aluminum is being treated. The compound, or mixture of compounds, may also be wrapped in paper or aluminum foil and forced below the surface of the molten or pasty bath in any desired manner.

It will, of course, be understood that during the treating process, the aluminum or aluminum alloy may be covered with a suitable flux to prevent oxidation of the aluminum, and, if desired, the hydrofluoboric acid or fluoborate may be dissolved in the flux, in which case it is very desirable to agitate the metal and flux, so that the fluoborate compound will be brought into intimate contact with the molten aluminum or aluminum alloy. If the treating compound is dissolved in a flux, however, it is highly desirable to utilize a flux that is molten at the melting point of aluminum or the aluminum alloy being treated, or a flux which does not have a melting point substantially more than 100° C. higher than the melting point of aluminum.

A suitable flux for this purpose is one containing sodium chloride, potassium chloride and cryolite in such proportions that the composition is pasty or molten at the melting point of aluminum or at not substantially more than 100° C. higher than the melting point of aluminum. The eutectic composition containing approximately 32.5% sodium chloride, 62.5% potassium chloride and 5% cryolite is especially suitable, because it has a relatively low melting point.

During the treating process, it is desirable that the aluminum or aluminum alloy be maintained at a temperature relatively close to its melting point, and preferably should be in a somewhat pasty or thickened state, so that the bubbles formed will penetrate slowly through the molten metal.

While it is not desired to limit the invention to any particular theory, it is believed that when the liquid or solid compound or compounds containing boron and fluorine are brought into contact with aluminum or an aluminum alloy, it either reacts directly with the aluminum or forms a gas containing boron and fluorine, which, in turn, reacts with the aluminum. During the treatment, boron is introduced in a finely dispersed state through the aluminum or aluminum alloy.

The amount of hydrofluoboric acid or fluoborate which is employed at the time of treatment will, of course, depend upon the temperature of the molten metal and the amount of gas which is brought into reactive relationship with the aluminum. To obtain the best results the treatment should be continued for a sufficient length of time to introduce approximately .0005% to 0.1% of boron into the molten aluminum or aluminum alloy. If larger amounts of boron are introduced, the results are not so desirable, and if the treatment is discontinued before .0005% of boron is introduced, the aluminum or aluminum alloy will either not be completely modified, or, if completely modified, the modification will not persist through repeated meltings and solidifications. We have found that if the liquid or solid compound containing boron and fluorine is introduced into the metal to be treated in quantities ranging from approximately 0.1% to 3.0% by weight of the metal, good results will be obtained, especially if the aluminum or aluminum alloy is maintained in a somewhat pasty or thickened state, so that the gas bubbles will rise slowly and enter into intimate reactive relationship with the aluminum.

If the hydrofluoboric acid or fluoborate compound is dissolved in a molten flux, there should be sufficient flux present to dissolve the compound, and the metal and flux should be stirred or agitated so that the compound, or mixture of compounds, will be brought into intimate reactive relationship with the aluminum or aluminum alloy during the treating operation.

The following specific example will serve to illustrate and explain our invention, although it will be understood that we do not desire to be limited to the particular compounds or proportions of ingredients utilized.

Approximately ten pounds of an aluminum alloy containing about 8% of copper was melted in a suitable container and covered with a flux containing sodium chloride, potassium chloride and cryolite in approximately eutectic proportions. About 60 grams of ammonium fluoborate were placed in a pipe closed at one end, and the open end of the pipe was immersed in the molten bath.

The gas formed by the heating of the fluoborate rose slowly through the alloy, which was maintained at a temperature of approximately 730° C. The flux was then removed from the surface of the bath and the metal cast in the usual manner. A spectroscopic analysis indicated that the treated alloy contained approximately .005% of boron. The resulting alloy had a fine, uniform grain size and its physical properties, such as tensile strength, elongation and hardness, were materially improved.

As a further illustration of our invention, approximately ten thousand pounds of an aluminum alloy containing 8% of copper was melted and covered with approximately 140 pounds of a flux containing sodium chloride, potassium chloride and cryolite in approximately eutectic proportions. About 195 grams of ammonium fluoborate were introduced in the flux and the bath was agitated vigorously. The flux was then removed and the molten metal poured. A casting having a fine, uniform grain structure was obtained. The metal was remelted and cast at a temperature of approximately 800° C. and the fine, uniform grain structure still persisted. It was again remelted, and a test casting made from metal poured at approximately 760° C. was still well modified.

The foregoing example illustrates the fact that aluminum or aluminum alloys modified by our improved process may be repeatedly remelted and recast, and the fine, uniform grain structure produced by the treating process will persist throughout repeated meltings and solidifications.

Instead of treating the aluminum or aluminum alloy with hydrofluoboric acid or an alkali metal or ammonium fluoborate, ingredients which will react to produce these compounds may be utilized. For example, a mixture of boric acid and ammonium acid fluoride, which react to form ammonium fluoborate, may be employed, but we prefer to use the hydrofluoboric acid or an alkali metal or ammonium fluoborate. It will be understood, however, that when the terms "hydrofluoboric acid" or "fluoborates" are used in the claims it is intended to include compounds or ingredients which react to form hydrofluoboric acid or fluoborates of the type specified.

From the foregoing specification it will be apparent that we have provided an improved process of modifying or improving the grain structure of aluminum or aluminum alloys. For example, aluminum or aluminum alloys treated by our improved process have increased elasticity and greater tensile strength, elongation and resistance to fatigue than untreated metal. In addition, aluminum or aluminum alloys characterized by a fine, uniform grain structure have better casting properties and are more suitable for rolling, forging, welding, and other purposes than unmodified alloys.

It will also be seen that because the hydrofluoboric acid or fluoborate compound is in a liquid or solid form, it may be readily forced beneath the molten bath or dissolved in a flux, and because it forms a gas when heated to a temperature below that of molten aluminum, gaseous bubbles containing boron and fluorine are brought into intimate contact with the molten aluminum or aluminum alloy.

During the treatment of the aluminum or aluminum alloy by our improved process, it will also be seen that it is not necessary to heat the aluminum to a temperature substantially higher than its melting point, and excessive oxidation

of the aluminum will, therefore, be avoided. Since the molten metal is also maintained in a soft or somewhat pasty state, the bubbles formed by heating the solid or liquid compound containing boron and fluorine will rise slowly through the molten bath and will be maintained in intimate contact for a substantial length of time with the molten aluminum. The grain refinement or modification process may, therefore, be performed in an economical manner without utilizing a large excess of the modifying material.

To those skilled in the art many modifications of and widely differing embodiments and applications of our invention will suggest themselves without departing from the spirit and scope thereof. Our disclosure and the description herein are purely illustrative and are not intended to be in any sense limiting.

What we claim is:

1. The method of improving the characteristics of aluminum or aluminum alloys which comprises maintaining the aluminum or aluminum alloy in a pasty state and treating the metal with a normally liquid or solid boron compound containing boron and fluorine, which has a melting point below the melting point of aluminum or the aluminum alloy being treated, and permitting the gas which is formed to pass slowly through the soft or pasty metal into intimate contact with the aluminum or aluminum alloy being treated.

2. The method of improving the characteristics of aluminum or aluminum alloys which comprises maintaining the aluminum or aluminum alloy in a pasty state, forcing a normally liquid or solid boron compound containing boron and fluorine, which forms a gas below the melting point of aluminum or the aluminum alloy being treated, into intimate contact with the metal, and permitting the gas which is formed to rise slowly through the soft and pasty metal.

3. The method of improving the characteristics of aluminum or aluminum alloys which comprises maintaining the aluminum or aluminum alloy relatively close to its melting point so that it is in a pasty state, forcing a fluoborate compound below the surface of the metal, and permitting the gaseous bubbles which are formed to rise slowly upward through the pasty metal.

4. The method of improving the characteristics of aluminum or aluminum alloys which comprises maintaining the aluminum or aluminum alloy relatively close to its melting point so that it is in a pasty state, forcing an alkali metal fluoborate below the surface of the metal, and permitting bubbles formed to rise upwardly through the molten metal.

5. The method of improving the characteristics of aluminum or aluminum alloys which comprises mixing a normally liquid compound containing boron and fluorine with an absorbent material, bringing the absorbent material containing the boron and fluorine compound into contact with the aluminum or aluminum alloy in the pasty state, and permitting the gas which is formed to come into intimate contact with the metal being treated.

6. The method of producing aluminum and aluminum alloys of fine and substantially uniform grain structure which persists throughout repeated meltings and solidifications of such aluminum or alloys thereof, which comprises treating a bath of molten aluminum or aluminum alloy with .1 to 3% by weight of sodium fluoborate by disposing the sodium fluoborate near the bottom of the bath of molten metal, thereby forming bubbles of gas containing both boron and fluorine in chemical combination, which bubbles pass upwardly through the bath and react with the metal.

JOHN G. G. FROST.
WALTER BONSACK.