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ALUMINUM BASE ALLOY

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1 Claim. (Cl. 75—138)

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The present invention relates to aluminum alloys and more particularly to aluminum alloys containing titanium and boron, and to methods of regulating the grain refinement and castability of aluminum alloys. It has been proposed heretofore to add regulated amounts of titanium to aluminum alloys in order to control the castability of the molten aluminum alloy and also as an ingredient contributing to the grain refinement of the resultant casting. The addition of titanium in controlling amounts, and generally not in excess of about 0.2% by weight of the resultant alloy, has greatly facilitated the casting of aluminum alloys and has aided in increasing the percentage of sound castings produced in conventional aluminum foundry practice. It is also recognized that addition of too much titanium tends to nullify the desirable grain refinement effects in a manner similar to too much iron by increasing the size and number of objectionable dendrites. Good foundry practice with respect to aluminum dictates the remelting and re-use of gates and risers and, in such remeltings, additional titanium is usually added.

Attempts have also been made to intensify the grain refining effect of titanium by adding very small amounts of boron and in this way preserve the grain refining effect of titanium even upon remelting of gates and risers. However, the addition of boron to the aluminum alloy has been attended with many difficulties. The addition of usual boron alloys is restricted to those not adding objectionable alloy constituents to the aluminum; the use of usual aluminum boron alloys is attended with considerable loss of boron as only in a few instances is as much as ½ of the added boron recovered in the resultant alloy. Generally, therefore, other means of adding boron have been resorted to as, for instance, by bubbling a gaseous boron compound through the molten aluminum alloy or by reducing the boron from a flux containing a non-volatile boron compound such as borax or a complex boro fluoride. Due to the uncontrollable nature of most of these reactions and, therefore, the extreme difficulty of introducing predetermined amounts of boron into the aluminum alloy, controllable and reproduceable operations have not been possible heretofore. In some instances the desired grain refining effect could be obtained while, however, in most instances it could not be obtained.

It is an object of the present invention to provide means for introducing titanium and boron into the molten aluminum alloys in controllable and reproduceable amounts.

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It is also an object of the invention to employ a titanium boron alloy for controlling the grain refining effect of titanium and the intensifying effect of boron on aluminum alloys.

It is also an object of the invention to improve the quality and reproduceability of physical characteristics of articles made from aluminum alloys by adding to an aluminum alloy controlled amounts of titanium boron aluminum alloys in order to produce a resultant alloy of specified titanium boron composition.

It is also an object of the invention to prepare addition alloys of aluminum containing specified limits of titanium and boron.

In accordance with the present invention, a master alloy consisting of aluminum and relatively large amounts of titanium and boron is prepared and the master alloy added to aluminum to produce an addition alloy of desired composition. Although any method of preparation of the master alloy may be employed, generally the alumino thermic reduction, by the so-called Goldschmidt process, of titanium oxide ores, as for example, rutile and materials containing boron oxide, as for example fused borax in the presence of oxidizing and accelerating agents, such as sodium chlorate and barium peroxide is preferred. The method of preparing charges of this type and initiating the alumino thermic reaction are well known to metallurgists skilled in the art of alumino thermic reduction. The amount of titanium oxide ore and of boron oxide material together with aluminum shot is selected in order to produce a master alloy containing from about 30 to 50% titanium and from about 5 to 15% boron, with small amounts of attendant and usual impurities such as iron, silicon and copper, the remainder being aluminum. It will of course be understood that variations in the amount of titanium oxide, boron oxide containing material, and oxidizing agent can be made in order to produce the alloy within the composition range specified. The economy of the reaction, including cost of materials and recovery of the titanium and boron values, will generally dictate the production of an aluminum alloy containing 40 to 45% titanium and 6 to 10% boron.

The master alloy so produced is not of itself readily soluble in aluminum and aluminum alloys at the temperature at which aluminum and its alloys are melted for foundry and other purposes. Therefore, in accordance with the present invention, the master alloys containing from 30 to 50% titanium and from 5 to 15% boron, the balance being largely aluminum, are dissolved in

molten aluminum at temperatures from 2,000 to 2,400° F. For instance, a master alloy containing 43.8% titanium, 7.26% boron with small amounts of iron, silicon and copper, the balance being aluminum, when added to molten aluminum at 2250° F., dissolves readily therein and by regulating the amounts of molten aluminum and master alloy and the composition of the latter it is possible to produce addition alloys containing from about 0.05% to 1% boron and from about ½% to 6% titanium, the balance being largely aluminum with very small amounts of usual attendant impurities, alloys which could not heretofore be prepared. Thus, by first preparing titanium-boron-aluminum alloy of relatively high concentration of titanium and boron, it is possible to prepare addition alloys by dilution in which the boron and titanium are both found in a condition readily miscible and absorbable in molten charges of aluminum and aluminum alloys and in amounts making the alloy eminently suitable for this purpose.

As an example merely illustrative of the invention but not limitative thereof: 126 parts of an alloy containing 44.16% titanium, 6.94% boron, and the balance largely aluminum, was stirred into 2000 parts of primary molten aluminum at a temperature of 2200 to 2300° F. and cast into notched bars. The resultant alloy contained 2.60% titanium and 0.38% boron. The recovery of boron was 92% and titanium 99%, with a yield of useable alloy of 2100 parts. On the other hand, 67½ parts of an aluminum alloy containing 10.33% boron but no titanium, when stirred into 2000 parts of primary molten aluminum at 2200 to 2300° F. and cast into notched bars, showed less than 50% recovery of boron. It is believed that the presence of titanium and boron within the amounts and ratio specified for the master alloy protects the boron against loss when dissolved in molten aluminum and when once so protected and so introduced, the boron is in condition to be further added, without substantial loss, to molten aluminum at the temperatures used in foundry practice. The following examples are given merely as illustrative of this feature of the invention and are not deemed to be limitative thereof:

Four separate heats were made of 48 lbs. each of an alloy containing approximately 4% copper, 2% nickel, ½% magnesium, 0.3% manganese, less than 0.5% silicon, less than 0.5% iron and the balance aluminum. The charges were melted and brought to a temperature of 1425 to 1450° F. and titanium or titanium boron additions made at that time, if any, the alloy cooled to 1400° F. (plus or minus 10° F.) and cast into test bars ½" x 2" in sand molds. In those heats where alloy additions were made, the addition alloy dissolved almost immediately and without difficulty. The chemical and physical properties of the resulting test bars are given in Table 1:

Table 1

Heat No.	Alloy Addition	Calculated Addition		Chem. Analysis,		Avg. grain size, Inches
		Per Cent Ti	Per Cent B	Per Cent Ti	Per Cent B	
1	None			0.018		.053
2	2¼ lb., 2½% Ti-Al Alloy	0.113		0.143		.032
3	2 lb., 2.8% Ti, 0.37% B-Al alloy	0.112	0.015	0.090	0.013	.016
4	1 lb. 2.8% Ti, 0.37% B-Al Alloy	0.056	0.007	0.055	0.006	.021

The addition alloy of titanium and boron was made from a master alloy as outlined hereinabove. It will be noted that excellent average grain size was obtained and that there was little or no loss of boron and titanium from the addition as substantially all of these materials are to be found in the final cast product. It is believed that these excellent results are explained by reason of the fact that the boron in the master alloy and resultant addition alloy is protected by the presence of the titanium so that the boron is in soluble form and is readily miscible in molten aluminum in contrast with the almost insoluble form of boron normally found in aluminum boron alloys not containing titanium.

By regulating the amount of primary aluminum and master alloy, compositions within the range 0.05 to 1% boron, and ½% to 6% titanium are readily produced and find practical application in controlling the grain density and size in aluminum casting work. Alloys of particularly suitable compositions of from 0.25 to 1.0% boron and 2 to 3% titanium, the balance largely aluminum, find special application as addition alloys for controlling the composition of aluminum and its alloys. The addition alloys can be added at any convenient point in the production of the finished aluminum alloy, say in the furnace or in the ladle. When the addition is made to the latter, alloys containing 2 to 3% titanium and 0.25 to 1.0% boron find special application. In most cases the composition of the end product will dictate the place at which addition is made.

The following are examples of suitable addition alloy compositions:

Table 2

Titanium	Boron	Remainder
Per cent	*Per cent*	
2.8	0.37	Largely aluminum.
2.7	0.42	Do.
2.07	0.25	Do.
2.85	0.90	Do.

It will be seen from the foregoing that the present invention provides both a master alloy and an addition alloy wherein boron and titanium occur as alloy ingredients in aluminum and wherein the boron is in a chemical or physical condition to be readily soluble and miscible in molten aluminum. The invention is particularly suitable for the preparation of aluminum and aluminum alloys containing from 0.001 to 0.1% boron and up to about 0.2% titanium, alloys of exceptional properties. In general, such alloys are produced by dissolving the addition alloy in molten aluminum at temperatures of from about 1300° F. to 1500° F. more or less.

The present invention further provides an improved method for controlling the density and

grain size and castability of molten aluminum and its alloys. Wherever the term aluminum alloy is used in the appended claim, it designates molten aluminum or an alloy of aluminum containing 50% or more of aluminum.

What is claimed is:

The method of manufacturing an aluminum alloy suitable as an addition alloy to aluminum casting melts which comprises first preparing an alloy containing 30 to 50% titanium, 5 to 15% boron, the balance aluminum, by reduction of an oxygen compound of titanium and an oxygen compound of boron in the presence of aluminum and thereafter mixing said alloy with a molten charge containing aluminum at 2,000 to 2,400° F. in proportions to produce an alloy containing ½ to 6% titanium, 0.05 to 1% boron, the balance aluminum.

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