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REMOVAL OF SILICON FROM ALUMINUM
AND ALUMINUM ALLOYS

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My invention relates to the separation of excessive amounts of silicon from aluminum or aluminum alloys containing the same.

Numerous efforts have heretofore been made to remove silicon from aluminum or aluminum alloys containing the same but, to my knowledge, none of these efforts has proven to be fully satisfactory. Thus, for example, it has been proposed to treat the molten silicon-containing aluminum or aluminum alloy with zinc to form a zinc-aluminum alloy, the silicon freezing out as metallic silicon together with other impurities and the zinc-aluminum alloy being separated by filtration or the like. In place of zinc, the use of tin and mercury and alloys thereof has been suggested. In all cases, the zinc, tin or mercury, whichever is used, is eliminated from the alloy formed with the aluminum by distillation, electrolysis or extraction in accordance with known practices. While such procedures are somewhat effective in bringing about removal of silicon, they have certain marked disadvantages among which may be mentioned the necessity for using large amounts of zinc, tin or mercury in relation to the amount of the pure aluminum recovered.

In accordance with my invention silicon is very effectively removed from aluminum or aluminum alloys by providing a melt comprising said silicon-containing aluminum or aluminum alloy and not less than a certain minimum amount of magnesium, hereinafter set forth, allowing the melt to stand in a substantially quiescent state, at a temperature at which the aluminum-magnesium alloy which is formed remains fluid, until the silicon settles out in the form of solid magnesium silicide (Mg_2Si), and thereafter separating the fluid aluminum-magnesium alloy from the solid silicon compound. This latter separation may be effected in any suitable manner as, for example, by decantation or the like.

As I have stated, a certain minimum amount of magnesium must be added to the silicon-containing aluminum or aluminum alloy if the advantages obtainable by the practice of the invention are fully realized. I have found this minimum amount of magnesium to be such that the aluminum-magnesium alloy which is formed and separated in the fluid state from the solid silicide contains in excess of 60%, by weight, of magnesium. Especially satisfactory results are obtained where the aluminum-magnesium alloy which is recovered contains from about 70% to about 75%, by weight, of mag-

nesium. This requires the employment of materially greater amounts of magnesium that would, in theory, be needed to produce an aluminum-magnesium alloy containing the stated amounts of magnesium because of some losses due to oxidation and to the fact that the magnesium combines with the silicon to form a silicide. The amount of magnesium required may be determined by calculation or simple experiment. By way of calculation, the amount of magnesium employed is determined by using approximately 1.73 times the amount of silicon contained in the aluminum alloy to be treated plus the amount of magnesium required to be combined with that amount of aluminum contained in the aluminum alloy to be treated so as to obtain an aluminum-magnesium alloy containing in excess of 60% magnesium. It will, of course, as indicated, vary, depending upon the particular content of silicon in and the particular composition of the aluminum alloy to be treated. While the primary object of the invention is to effect the separation of silicon, other elements, depending on their nature, such as tungsten, vanadium, chromium and manganese, present in the silicon-containing aluminum or aluminum alloys may also settle out together or along with the magnesium silicide. Such, however, is incidental to the practice of my invention which, as stated, is concerned with the separation or removal of silicon.

The amount of magnesium required to be added to accomplish my results is important, as I have indicated hereinabove. Thus, for example, whereas it has been proposed to remove iron from aluminum or aluminum alloys by means of the addition to a molten mass thereof of from 5% to 60% magnesium, additions of magnesium in such proportions are ineffective to precipitate any appreciable amounts of silicon in a form where the same settles out on standing.

In order that those skilled in the art may more fully understand the nature and scope of my invention, the following examples of the practice of my invention are given. It will be understood that they are simply illustrative and are not limitative of the full scope of my invention which is set out in the claims. Thus, for example, different silicon-containing aluminum alloys may be treated, having varying proportions of silicon, the temperatures may be varied within limits, fluxes or protective atmospheres may be employed, the melt may be subjected to slight vibratory action to enhance settling out of the magnesium silicide, and other changes

or modifications may be made within the spirit of the invention in the light of the guiding principles which are disclosed herein.

Example I

To a molten aluminum alloy containing a high content of silicon, an amount of magnesium was added so that the melt analyzed, by weight, 20% aluminum, 70% magnesium, 9% silicon, and 1% iron. The resulting alloy was heated to 900 degrees C., cooled, and held for approximately one hour at a temperature between 550 and 600 degrees C. The top layer was poured out and the resulting alloy showed, on analysis, the following proportions by weight:

	Per cent
Aluminum -----	30.98
Silicon -----	0.08
Iron -----	0.02
Magnesium -----	68.92

Example II

To a molten aluminum alloy containing a high content of silicon, an amount of magnesium was added so that the melt analyzed, by weight, 18% aluminum, 71% magnesium, 10% silicon, and 1% iron. The resulting alloy was heated to 900 degrees C., cooled, and held for approximately one hour at a temperature between 550 and 600 degrees C. The top layer was poured out and the resulting alloy showed, on analysis, the following proportions by weight:

	Per cent
Aluminum -----	28.62
Silicon -----	0.09
Iron -----	0.02
Magnesium -----	71.27

As I have pointed out hereinabove, the melt comprising the silicon-containing aluminum or aluminum alloy and magnesium is maintained in a substantially quiescent state until the magnesium silicide has settled to the bottom in solid form. In general, the temperature at which the melt is held in such quiescent state should not be substantially less than 450 degrees C. I prefer, however, that the temperature be maintained at approximately 475 degrees C. to 575 degrees C. The temperature should be high enough so that the molten aluminum-magnesium alloy which is formed is sufficiently fluid to enable it to be separated efficaciously from the solids which settle to the bottom of the crucible or other vessel in which the melt is contained, and, of course, the temperature must be such that the magnesium silicide is in a solid condition. It is, of course, possible to allow the settling of the magnesium silicide to occur at temperatures slightly below 450 degrees C., after which the melt may be heated up to a temperature sufficient to allow the aluminum-magnesium alloy to be poured off.

It will be appreciated that the length of time that the melt is allowed to stand in a quiescent state before settling out of the magnesium silicide and such as other impurities may be present and settle out along with the magnesium silicide, is variable. In some cases only a few minutes standing is necessary whereas, in other cases, depending upon the size of the batch as well as other factors, the melt should be allowed to stand for one or more hours.

While I prefer to operate the process in the form of a batch process, first melting the silicon-containing aluminum or aluminum alloy and then adding thereto the magnesium, it is possible to operate the process as a continuous one. It is

also within the scope of my invention to melt the silicon-containing aluminum or aluminum alloy together with the magnesium or, alternatively, the magnesium may be initially melted and the silicon-containing aluminum or aluminum alloy may be added thereto. In general, it is within the scope of my invention to add the magnesium in solid or liquid form or even in the vapor state to the silicon-containing aluminum alloy.

From the aluminum-magnesium alloys which result from the practice of my invention, a high-purity aluminum may be recovered, for example, by distilling off the magnesium. The latter may, then, be reused in the process for the removal of silicon from additional quantities of silicon-containing aluminum or aluminum alloys.

While my invention is applicable to the treatment of aluminum or aluminum alloys containing various percentages of silicon which are deemed excessive, it has particular utility for the treatment of such alloys which contain upwards of 60% of aluminum, by weight, together with upwards of 2% of silicon, by weight. In the preferred practice of my invention, the aluminum-magnesium alloys which are obtained contain not substantially more than 0.1% of silicon and preferably substantially less.

In order to simplify the word definition of the invention, it will be understood that, wherever reference is made in the claims to the removal of silicon from aluminum alloys containing the same, such alloys may contain, in addition to the silicon and aluminum, other elements as well.

While I prefer to use commercially pure magnesium in the practice of my invention, I find that impure magnesium or magnesium-base alloys may be used effectively. Wherever magnesium is referred to in the claims in relation to its addition to the silicon-containing aluminum alloy, it will be understood that the term "magnesium" is intended to include impure magnesium and magnesium-base alloys.

Although my invention has been described in detail, it will be understood that it is not to be limited except as defined in the claims.

What I claim as new and desire to protect by Letters Patent of the United States is:

1. In a method of removing excessive amounts of silicon from aluminum alloys containing the same and simultaneously forming an aluminum-magnesium alloy containing in excess of 60% magnesium, the steps which include providing a melt containing said silicon-containing aluminum alloy and added magnesium, allowing the mass to stand in a substantially quiescent state under temperature conditions such that the resulting aluminum-magnesium alloy remains fluid and the silicon settles out in the form of solid magnesium silicide, and separating the fluid aluminum-magnesium alloy from the solid silicide, the amount of magnesium added to the silicon-containing aluminum alloy being such that the aluminum-magnesium alloy contains in excess of 60%, by weight, of magnesium.

2. In a method of removing excessive amounts of silicon from aluminum alloys containing the same and simultaneously forming an aluminum-magnesium alloy containing from about 70% to about 75% magnesium, the steps which include melting said silicon-containing aluminum alloy, admixing magnesium therewith, allowing the mass to stand in a substantially quiescent state under temperature conditions such that the re-

sulting aluminum-magnesium alloy remains fluid and the silicon settles out in the form of magnesium silicide, and separating the fluid aluminum-magnesium alloy from the solid silicide, the amount of magnesium added to the silicon-containing aluminum alloy being such that the aluminum-magnesium alloy contains from about 70% to about 75%, by weight, of magnesium.

3. In a method of removing excessive amounts of silicon from aluminum alloys containing the same and simultaneously forming an aluminum-magnesium alloy containing in excess of 60% magnesium, the steps which include melting said silicon-containing aluminum alloy, admixing magnesium therewith, allowing the mass to stand in a substantially quiescent state under temperature conditions such that the resulting aluminum-magnesium alloy remains fluid and the silicon settles out in the form of solid magnesium silicide, and separating the fluid aluminum-magnesium alloy from the solid silicide, the amount of magnesium added to the silicon-containing aluminum alloy being such that the aluminum-magnesium alloy contains in excess of 60%, by weight, of magnesium.

4. In a method of removing excessive amounts of silicon from aluminum alloys containing the same and simultaneously forming an aluminum-magnesium alloy containing from about 70% to about 75% magnesium, the steps which include providing a melt containing said silicon-containing aluminum alloy and added magnesium, allowing the mass to stand in a substantially

quiescent state under temperature conditions such that the resulting aluminum-magnesium alloy remains fluid and the silicon settles out in the form of solid magnesium silicide, and separating the fluid aluminum-magnesium alloy from the solid silicide while maintaining the mass at a temperature not substantially below 450 degrees C., the amount of magnesium added to the silicon-containing aluminum alloy being such that the aluminum-magnesium alloy contains from about 70% to about 75%, by weight, of magnesium.

5. In a method of removing excessive amounts of silicon from aluminum alloys containing upwards of 60% aluminum and upwards of 2% silicon and simultaneously forming an aluminum-magnesium alloy containing in excess of 60% magnesium, the steps which include forming a melt containing said silicon-containing aluminum alloy and added magnesium, allowing the melt to stand in a substantially quiescent state under temperature conditions such that the resulting aluminum-magnesium alloy remains fluid and the silicon settles out in the form of solid magnesium silicide, and thereafter separating the fluid aluminum-magnesium alloy from the solid silicide, the amount of magnesium added to the silicon-containing aluminum alloy being such that the aluminum-magnesium alloy contains in excess of 60%, by weight, of magnesium, and not substantially in excess of 0.1% silicon.

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