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ALUMINUM BASE ALLOY

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My invention relates to aluminum base alloys and more particularly to aluminum base alloys containing a substantial amount of iron.

In preparing castings from aluminum base alloys by casting in permanent or semi-permanent molds, or in die castings, considerable difficulty is experienced in obtaining satisfactory castings with alloys of high iron content. Iron occurs as a normal impurity in primary aluminum in amounts ranging up to .25% to .5% and is usually present in considerably larger quantities in secondary aluminum.

Furthermore, when the alloys are mixed in iron pots and cast in permanent or semi-permanent molds, the amount of iron dissolved in the aluminum from the melting and casting equipment is often considerable. When iron is present in more than small amounts in many alloys utilized for making castings, however, it lowers the strength and ductility of the alloy and adversely affects its casting properties. Castings having a high iron content which have been prepared from most aluminum alloys are consequently inferior to castings prepared from similar alloys having the desired minimum iron content, both with respect to finish and to physical properties.

Patent No. 1,997,494 granted to me on April 9, 1935, discloses the use of antimony to counteract the deleterious effects of the iron in aluminum alloys. As disclosed in that patent, the antimony serves to break up the large crystalline structure caused by the high iron content. The antimony also reduces the shrinkage of the alloy during solidification and increases the elongation and reduces the brittleness of the cast alloy. Furthermore, the antimony increases the corrosive resisting properties and lowers the thermal coefficient of expansion which renders such alloys very desirable for use in castings, such as pistons, where a low thermal coefficient of expansion is desirable.

I have made the discovery that if a metal of the tungsten group, such as tungsten, molybdenum or uranium, or a metal of the vanadium group, such as vanadium, columbian or tantalum, or a metal, such as beryllium, boron or zirconium, or a mixture, compound or alloy of two or more of such metals, is added to aluminum base alloys containing iron and antimony, an alloy will be produced that has a denser grain structure and better casting and machining properties than previous aluminum base alloys of this type, and this is especially true with respect to alloys which are seriously affected by the presence of more than a small amount of iron, such as aluminum base alloys containing nickel, copper, silicon, or two or more of such metals.

My improved alloy is especially suitable for use in preparing castings requiring a dense grain structure, such as pistons, cylinder heads, and the like, in which iron, silicon and antimony are present. In such alloys when both silicon and antimony are present, the silicon or the antimony appears to be precipitated out of solution and this is particularly true when the silicon is present in amounts greater than 3%. The addition of a special alloying ingredient of the type specified, however, counteracts this tendency and higher amounts of silicon may therefore be employed. Titanium, chromium and manganese also aid in this respect. For instance, titanium or chromium may be present in effective amounts up to 3% but is preferably maintained within a range of .05% to 1.5%. Manganese may also be present in amounts ranging up to 3%. Large amounts of manganese, however, cause the alloy to become brittle. It will be understood, however, that I do not desire to be limited to an alloy containing silicon because aluminum base alloys containing antimony have a low thermal coefficient of expansion and one or more of the special alloying ingredients will effect an improvement in such alloys, even though silicon is present in amounts less than 3% or is present in only such amounts that it may be considered an impurity.

My invention also contemplates the addition of one or more of the special alloying ingredients mentioned to aluminum base alloys which contain antimony and only the usual amount of iron. For instance, it may be employed with aluminum alloys containing virgin aluminum and antimony.

It is therefore an object of my invention to provide an aluminum base alloy containing iron and antimony in substantial amounts and a special alloying ingredient in an amount sufficient to diminish the deleterious effect of the iron so that an alloy will be produced having good casting properties, even when the amount of iron is relatively high.

Another object of my invention is to provide an aluminum base alloy containing antimony and a special alloying ingredient which alloy may be cast in sand, permanent molds or in dies and from which good castings or forgings may be produced.

A further object of my invention is to provide an aluminum base alloy containing a substantial amount of silicon and copper, together with a special alloying ingredient which serves to improve the casting properties of the alloy.

Another object of my invention is to provide an aluminum base alloy containing a substantial amount of iron, antimony and an additional metal which alloy is particularly adapted to be cast in a permanent mold or from which die and sand castings may be made.

A still further object of my invention is to provide an improved casting having a dense grain structure and a low thermal coefficient of expansion which is formed of an aluminum base alloy containing substantial amounts of iron.

In practicing my invention, a metal of the tungsten or vanadium groups, beryllium, boron, zirconium, or a mixture, compound or alloy of two or more of such metals, is added in amounts ranging from effective amounts up to 3% to an aluminum base alloy containing at least 75% aluminum, .05% to 15% antimony, and from 1.5% to 10% of iron.

The amount of aluminum, however, may range from 75% to 95% and is preferably maintained above 80%. The amount of the special alloying metal or ingredient which is added to the aluminum base alloy is dependent upon the iron and antimony content. For instance, if the aluminum utilized contains more than 2% of iron, say from 3% to 10%, and antimony is present in an amount sufficient to counteract the deleterious effect of the high iron content, more of the special alloying metal will be required than when the iron is below 3%. In preparing castings from secondary alloys, I prefer to utilize from approximately .05% to 3% of the special alloying ingredient.

The amount of antimony which is present is also dependent upon the amount of iron. Thus, for aluminum alloys containing more than 2% iron, say from 2% to 10%, the amount of antimony will be relatively high, say from .5% to 7%. The amount of antimony which is added to the casting alloy, however, will not usually exceed 7%, and the preferred amount ranges from .1% to 4%.

In addition to iron, antimony and the special alloying ingredient, my improved alloy may also contain copper or nickel, or a mixture of copper and nickel, in an amount ranging from 2% to 12%. Silicon may also be present in an amount ranging from more than incidental impurities up to 10%, either alone or in combination with copper or nickel, or a mixture of copper and nickel.

In preparing castings, the amount of magnesium, lead and tin should be maintained below .5%, respectively, and the amount of zinc should be below 3% and preferably below 2%. Magnesium in large amounts has a very pronounced effect upon the hot shortness of aluminum alloys; a property which is very deleterious in producing alloys in permanent or semi-permanent molds or by the die casting process. The magnesium also increases the hardness, which decreases the machinability and causes excessive breakage in trimming. In producing castings in dies, it is therefore essential that the amount of magnesium which is present should be maintained below .5% and preferably below .25%.

In castings requiring special hardness, it is advantageous, however, to have some magnesium present, say from approximately .1% to .35%.

My invention is especially adapted for use in castings which have a low thermal coefficient of expansion, such as pistons, cylinder heads and the like. In providing an alloy for preparing such castings, silicon is usually added to lower the thermal coefficient of expansion. When secondary aluminum alloys are utilized for such a purpose, however, and the amount of silicon is comparatively high, the results have not been entirely satisfactory even though antimony is added to the alloy to counteract the deleterious effects of the iron. The reason for this appears to be that the silicon or antimony is precipitated out of solution and although fairly satisfactory results have been obtained, the castings do not have the particularly fine grain structure desired. By adding one or more of the special alloying ingredients mentioned, or titanium, manganese or chromium to the alloys, or a mixture, compound or alloy of two or more of such metals, I have found that an alloy having considerably improved casting properties is obtained. When two or more of the special alloying ingredients are added or when one or more of such metals and one or more metals selected from a group consisting of manganese, titanium and chromium are added, they may be introduced in the form of a compound, mixture or alloy. When two or more metals selected from the group of metals consisting of manganese, titanium and chromium are added, they may be introduced in a similar manner. I have found that a metal of the tungsten group, or a mixture of two or more of such metals, or a mixture of a metal of the tungsten group and titanium, is especially effective in this respect.

The following specific example will serve to illustrate and explain my invention although it will be understood that I do not desire to be limited to the specific alloys or to the proportions specified. An aluminum base alloy was prepared containing the following ingredients in approximately the proportions specified:

	Per cent
Copper	7
Silicon	4
Iron	3
Antimony	2.5
Magnesium	.25
Tungsten	.25

Castings were prepared in a permanent mold having a fine grain structure and similar results are obtainable when the castings are prepared by the die casting process. When titanium was substituted for the tungsten, a dense casting was also obtained. Both of the alloys machined well and had good casting properties. The presence of the tungsten or the titanium in the alloy materially aided in providing an improved alloy in which both the antimony and silicon appeared to be retained in solution.

In preparing castings, such as pistons or cylinder heads, having a low thermal coefficient of expansion, the ingredients mentioned in the foregoing example may be varied substantially as follows:

	Per cent
Copper	4 to 10
Silicon	3 to 8
Iron	2 to 10
Antimony	.5 to 15
Tungsten	.05 to 1.5

while the magnesium should be maintained below .5% and preferably below .25%.

The alloy may be prepared in any desired manner, such as by melting the ingredients together and introducing the special alloying ingredient into molten aluminum, or if other metals are

present, the special alloying ingredient may be alloyed with such metals and introduced into the molten bath. Another convenient method is to prepare a rich alloy of the special alloying ingredient and aluminum and introduce the alloy into the molten aluminum. I may also add the special alloying ingredient in the presence of or in the form of a fluoride in a manner similar to that described for the addition of antimony in my former patent to which reference has been made. The antimony may also be introduced in the manner disclosed in my previous patent.

In specifying the percentage of alloying ingredients in my improved alloy, it will be understood that the range of percentage given refers to the finished castings as well as to the ingot. In order to produce good castings, it has heretofore been necessary to maintain the amount of iron in the castings below a certain percentage, which is the total amount in the original alloy as well as that dissolved in the casting operation.

My invention is especially suitable for producing alloys for sand, chill mold or die castings. It is well known that iron has a harmful effect upon castings as it causes the alloy to become sluggish in the casting operation and brittle in the finished product. By adding antimony and one or more of the special alloying ingredients specified, however, the deleterious effects of the iron may be minimized or prevented. My improved alloy also has the property of solidifying quickly which makes it especially desirable for use in preparing chill mold castings.

While the special alloying ingredient, or a mixture of two or more of such ingredients, is particularly valuable as an addition to aluminum base alloys in which secondary aluminum having a high iron content is employed, it also improves the grain structure of aluminum base alloys containing antimony and silicon, in which virgin aluminum containing iron as a normal impurity is utilized. For instance, castings may be prepared in which the antimony is present in amounts ranging from .05% to 15%, and preferably from .5% to 7% and in which the silicon is present in amounts ranging from effective amounts more than normal impurities up to 13% and preferably from 3% to 10%. Such alloys may contain both antimony and silicon and this is particularly true when castings, such as pistons or cylinder heads, are desired having a low coefficient of expansion. Copper or nickel, or a combination of copper and nickel, and magnesium within the ranges specified for alloys of high iron content are also preferably present in this alloy. When silicon is present in amounts greater than 3% and antimony is also present, titanium, manganese or chromium in amounts ranging from .05% to 3% also appear to be effective in maintaining the antimony and silicon in solution and may be utilized in place of one of the special alloying ingredients or in combination with it.

From the foregoing description of my invention, it will be seen that I have provided an improved alloy which counteracts or diminishes the deleterious effects of iron. I am therefore able to utilize a lower grade of aluminum in forming castings and this is particularly true in preparing castings in chill molds in which it has heretofore been necessary to maintain the amount of iron in the original alloy below a maximum of 2% and preferably below a maximum of 1.25%.

It will also be apparent that I have provided an improved alloy that is particularly adapted for use in castings in which a low coefficient of expansion is desired, and particularly for use in pistons, cylinder heads, and the like, in which both silicon and antimony are present.

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

What I claim is:

1. An aluminum-antimony-tungsten group metal alloy having a finer grain structure, higher tensile strength and better casting properties than an aluminum-antimony alloy of similar composition, said alloy consisting of antimony in amounts ranging from .05% to 15%, a metal of the tungsten group in effective amounts up to 3%, and the remainder of aluminum and any other metal or metals not subversive of the above characteristics.

2. An aluminum-antimony-tungsten group metal alloy having a finer grain structure, higher tensile strength and better casting properties than an aluminum-antimony alloy of similar composition, said alloy consisting of antimony in amounts ranging from .05% to 15%, a metal of the tungsten group in effective amounts up to 3%, from 1.5% to 10% iron, and the remainder aluminum and any other metal or metals not subversive of the above characteristics.

3. An aluminum-antimony-tungsten group metal alloy having a finer grain structure, higher tensile strength and better casting properties than aluminum-antimony alloys of similar composition, said alloy consisting of antimony in amounts ranging from .05% to 15%, a metal of the tungsten group in effective amounts up to 3%, iron in amounts ranging from 1.5% to 10%, silicon in effective amounts up to 13%, and the remainder aluminum and any other metal or metals not subversive of the above characteristics.

4. An aluminum-antimony-tungsten group metal alloy having a finer grain structure, higher tensile strength and better casting properties than aluminum-antimony alloys of a similar composition, said alloy consisting of .5% to 7% antimony, 1.5% to 10% iron, 3% to 10% silicon, a metal of the tungsten group in effective amounts up to 3%, and the remainder aluminum and any other metal or metals not subversive of the above characteristics.

5. An aluminum-antimony-tungsten alloy having a finer grain structure, a higher tensile strength and better casting properties than an aluminum-antimony alloy of a similar composition, said alloy consisting of .5% to 7% antimony, 1.5% to 10% iron, .05% to 3% tungsten, and the remainder of aluminum and any other metal or metals not subversive of the above characteristics.

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