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ALUMINUM ALLOY

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This invention relates to alloys, and more particularly aluminum base alloys having a low thermal expansion and high thermal conductivity.

This application is a continuation in part of our application Serial No. 43,635, filed October 4, 1935, for Aluminum alloy, and this application is directed to an alloy of aluminum, silicon, tin, magnesium and zinc.

In the making of cast articles, such as pistons, and other parts of internal combustion engines and motor constructions, it is desirable to make such articles from aluminum and alloys thereof because of their low specific gravity.

While aluminum and aluminum alloys in general have a high thermal expansion, some aluminum alloys have been developed with a considerably lower thermal expansion, making them more desirable for use in the manufacture of castings for motor parts.

It has been found, however, that in addition to having a low thermal expansion, aluminum alloys for use in making motor part castings should also have a high thermal conductivity, as well as good mechanical and physical properties, such as hardness, machinability and suitable strength at ordinary temperatures and at the elevated temperatures occurring in internal combustion engines.

It is, therefore, an object of this invention to provide a light weight aluminum base alloy having a comparatively low thermal expansion and a comparatively high thermal conductivity, and also having suitable mechanical and physical properties for the casting of motor parts and other similar articles requiring similar properties.

Another object of this invention is to provide such an aluminum base alloy which is readily machinable, which may be readily cast in the usual type of molds, and which has a fine, homogeneous grain structure, and which may be subjected to elevated temperatures without causing loss of strength.

While certain aluminum-silicon alloys are known to have a relatively low thermal expansion and relatively high thermal conductivity as compared to other aluminum alloys, it is necessary with these aluminum-silicon alloys to have the other desirable properties of hardness, machinability and good bearing qualities to make them more suitable for the production of pistons and other motor parts, and it is an object of this invention to provide such an aluminum-silicon alloy with such desirable mechanical properties and still maintain the relatively low thermal expansion and relatively high thermal conductivity of these alloys.

The addition of magnesium to aluminum-silicon alloys increases their hardness and tensile strength, and increases their elastic properties, and, in the amount desirable to give these properties, has little or no effect on the low thermal expansion and high thermal conductivity.

It has been discovered that if tin is added in proper proportions to aluminum base alloys containing silicon it will increase the thermal conductivity without materially affecting the thermal expansion of the alloy. Tin also improves the machinability of the alloy, and provides better bearing qualities in castings made therefrom.

The addition of zinc to aluminum-silicon alloys increases their tensile strength and hardness and improves the machinability as it tends to harden the aluminum crystals of the alloy. Zinc, when present in small amounts, does not tend to increase the thermal expansion of the alloy or reduce the thermal conductivity.

Castings, such as pistons or other motor parts, which are subjected to elevated temperatures may, therefore, be produced from an alloy of aluminum, silicon, magnesium, tin and zinc and have excellent properties for the manufacture of articles of this nature.

In preparing our improved aluminum base alloy, silicon is used as the predominating ingredient and may be present in amounts ranging from 7% to 20%. Proportions of silicon greater than 7% are more effective in reducing the thermal expansion of the alloy. It is desirable, however, to avoid the use of too large a proportion of silicon, since it has a tendency to segregate out in large crystals. It is, therefore, preferable to use silicon in an amount from 11% to 15%.

Tin is an important addition to the aluminum-silicon alloy in order to provide better thermal conductivity and bearing qualities, as well as to improve its machinability. In order to obtain these properties, tin may be present in the amount of .3% to 3%, and preferably in an amount from .5% to 1.5% or 2%. Tin, if present in too large amount, has a tendency to segregate and it is not desirable to have more than about 3% tin in the alloy.

In order to increase the hardness of the alloy when it is subjected to heat treatment, and to produce an alloy having desirable machinable qualities, it has been found that the addition of magnesium is advantageous. This may be in an amount from approximately .1% to 2%, and preferably magnesium is utilized in an amount up

to 1%, such as substantially .5% to .9%, as an excess of magnesium has a tendency to render the alloy brittle, and a tendency to reduce the thermal conductivity of the alloy to too great a degree.

When present in small amounts up to approximately 3%, zinc has the effect of improving the mechanical properties, such as increasing the tensile strength and hardness of the metal. When added in amounts such as 2% to 3% it tends to reduce the thermal conductivity of the alloy and to increase the thermal expansion. If relatively high thermal conductivity and relatively low thermal expansion are desired, it is preferable to have zinc present in amounts less than 2%, such as .5% to 1.5%, and when present in these amounts the thermal conductivity and the thermal expansion of the alloy are not materially affected.

Copper may be present in the alloy in small amounts, for in amounts such as .6% or less it does not seem to materially affect the thermal expansion of the alloy, and it is, therefore, not necessary, in making the alloy, to exclude base metals containing small amounts of copper. If copper is present in the alloy in the amount of approximately 1% or more, it has the effect of substantially reducing the thermal conductivity of the alloy.

If relatively high thermal conductivity of the alloy is desired, copper should not be present in an amount more than approximately .2%, but when such a high degree of thermal conductivity is not necessary, the copper may be present in amounts up to about .6% or more.

Chromium, manganese, nickel, cobalt and titanium tend to reduce the thermal conductivity of aluminum-silicon alloys. These metals also have a tendency to form compounds with aluminum at a high melting point, and such compounds tend to segregate from the molten metal before solidification occurs. When a relatively high thermal conductivity of the alloy is desired, the above metals should not be present in an amount sufficient to materially reduce the thermal conductivity, and, if present at all, should only be present in such minimum amounts as are practicable in the commercial manufacture of the alloy, or as will not reduce the thermal conductivity beyond the limit desired for the alloy. Iron also has the tendency to reduce thermal conductivity, but iron, as is well known, is usually present as an impurity in aluminum or aluminum alloys. However, it should not be present in an excessive amount, such as 1% or more.

As illustrations of our improved alloy, the following specific examples are given:

An alloy containing 12 to 13% silicon, about 1% tin, about .6% magnesium, and about 2% zinc, and the balance aluminum and minor impurities, was chill cast and aged for 15 hours at 175° C. Upon being tested it was found to have a thermal expansion of 19.9×10^{-6} inch per inch per degree centigrade between a temperature range of 20° and 100° C. It also had a thermal conductivity of .33 calorie per square centimeter per second at 30° C. This same alloy, when annealed at 480° C. for 7 hours and quenched in water, and aged for 15 hours at 175° C. had a thermal conductivity of .36 calorie per square centimeter per second at 30° C. The expansion was approximately the same.

In the example above given, with about 2% zinc present, and the alloy chill cast and aged for 15 hours at 175° C., the tensile strength averaged about 36,000 lbs. per square inch, whereas the same alloy, without the zinc present, had a tensile strength of about 30,000 lbs. per square inch.

In the alloys mentioned in the above examples the iron content was less than 1%, such as about .6%.

In an alloy containing between 12 and 13% silicon, about .6% tin, about 1% zinc, and about .7% magnesium, the coefficient of thermal expansion was substantially the same as that of the alloys given above, and the thermal conductivity was approximately .35 calorie per square centimeter per second at 30° C. when the metal was chill cast and aged for 15 hours at 175° C. and the tensile strength was about 37,000 lbs. per square inch. When annealed at 480° C. for 7 hours, quenched in water and aged at 175° C. for 15 hours, the thermal conductivity was about .37 calorie per square centimeter per second at 30° C.

With the above heat treatment the last mentioned alloy had an average tensile strength of about 40,000 lbs. per square inch, and a Brinell hardness of about 95 to 115, whereas substantially the same alloy without the zinc had a Brinell hardness of about 80 to 100.

It will thus be seen that the presence of zinc in aluminum-silicon-tin-magnesium alloys increases the tensile strength and hardness, thus giving the alloy better machining qualities, and with amounts of zinc less than 2% the alloy has relatively high thermal conductivity and relatively low thermal expansion.

It will also be seen that the alloy disclosed in this application is valuable for pistons for internal combustion engines and the like as it is readily machinable and has a relatively high thermal conductivity and a relatively low coefficient of expansion. These, together with the tensile strength, make it desirable for pistons and for castings for internal combustion engines, elements of motor construction, and other articles requiring similar properties.

As previously stated, our invention contemplates that copper may be present in small amounts in the alloy and it is also to be understood that minor impurities may be present without departing from the scope of the invention set forth in the claims.

Aluminum base alloys having low thermal expansion and high conductivity, and containing aluminum, silicon, tin and zinc, are described and claimed in our copending application, Serial No. 96,519, filed August 17, 1936; and alloys of a similar character, containing aluminum, silicon and tin, are described and claimed in our copending application, Serial No. 96,517, filed August 17, 1936.

Furthermore, it will be understood that the present invention is not limited to the specific details set forth in the foregoing examples, which should be construed as illustrative, and not by way of limitation, and in view of the numerous modifications which may be effected therein without departing from the spirit and scope of this invention, it is desired that only such limitations be imposed as are indicated in the appended claims.

What we claim is:

1. An aluminum base alloy having a low coefficient of expansion and high thermal conductivity, comprising 7% to 20% silicon, .3% to 3% tin, .1% to 2% magnesium, .5% to 3% zinc, and the balance substantially all aluminum.

2. An aluminum base alloy having a low coefficient of expansion and high thermal conductivity, comprising 7% to 20% silicon, about .5%

to 2% tin, .1% to 1% magnesium, and .5% to 3% zinc, and the balance substantially all aluminum.

3. An aluminum base alloy having a low coefficient of expansion and high thermal conductivity, comprising 7% to 20% silicon, .3% to 3% tin, .1% to 1% magnesium, .5% to 2% zinc, and the balance substantially all aluminum.

4. An aluminum base alloy having a low coefficient of expansion and high thermal conductivity, comprising about 11% to 15% silicon, .3% to 3% tin, .1% to 2% magnesium, .5% to 3% zinc, and the balance substantially all aluminum.

5. An aluminum base alloy having a low coefficient of expansion and high thermal conductivity, comprising about 11% to 15% silicon, about .5% to 2% tin, .1% to 1% magnesium, .5% to 3% zinc, and the balance substantially all aluminum.

6. An aluminum base alloy having a low coefficient of expansion and high thermal conductivity, comprising about 11% to 15% silicon, about .5% to 2% tin, .1% to 1% magnesium, .5% to 2% zinc, and the balance substantially all aluminum.

7. A piston formed from an aluminum base alloy having a low coefficient of thermal expansion and high thermal conductivity, comprising about 11% to 15% silicon, about .5% to 2% tin, .1% to 1% magnesium, .5% to 2% zinc, and the balance substantially all aluminum.

8. A chill casting formed from an aluminum base alloy having a low coefficient of thermal expansion and high thermal conductivity, comprising about 11% to 15% silicon, .5% to 3% tin, .5% to 2% magnesium, .5% to 2% zinc, and the balance substantially all aluminum.

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