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ALUMINUM-COPPER PISTON ALLOY

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This invention relates to aluminum-base alloys designed to meet the problems encountered in the manufacture of articles which must withstand high temperatures without plastic deformation or a comparatively large loss of strength, as for example the manufacture of pistons for internal combustion engines.

While it is a principal object of this invention to provide alloys suitable for use as aforesaid, the invention also has as an object the provision of alloys which combine a relatively high modulus of elasticity with good machining qualities, a relatively low thermal expansivity and a superior resistance to high temperatures.

Such properties as high elastic modulus, machining qualities permitting commercial operation, low thermal expansivity, and high strength, hardness, and toughness, have been attained in different degrees and combinations in various alloys. But aluminum alloys presenting a relatively high elastic modulus and a relatively great strength at elevated temperatures in combination with low thermal expansivity and other acceptable or superior qualities have not been readily available. Thus for instance certain aluminum alloys which represent a considerable advance in this art, namely the alloys which are the subject of our copending application, Serial No. 328,046, now Patent No. 1,799,837, issued April 7, 1931, and which contain a predominant amount of aluminum together with 7 to 15 per cent silicon, 0.2 to 3.0 per cent magnesium, 0.5 to 7.0 per cent nickel and 0.3 to 7 per cent copper, have a remarkable combination of thermal expansivity and machining qualities and are not lacking in favorable elastic modulus and strength at high temperatures, though they do not represent the ultimate in these latter two qualities.

It is therefore an important object of this invention to provide aluminum alloys superior in these characteristics to other similar alloys but without material sacrifice of other properties found so desirable in practice.

The extensive use of aluminum-base copper alloys is well known in the art. To consider a specific example, aluminum-copper alloy pistons for internal combustion engines have come into general use wherever low weight has been a determining factor in design and operation, as in the case of automobile and aircraft engines. A fairly high copper content has usually been used, as much as 10 or 12 per cent copper being found to be the best average. Since a piston may be required to operate at a high temperature, say about 600° F., need has been felt for an alloy of higher

elastic modulus and greater strength at elevated temperatures. Such an alloy should also possess good machining properties and low thermal expansivity.

We have devised certain alloy combinations which are characterized by an exceptionally high tensile strength at elevated temperatures and an unusually high modulus of elasticity, and in which the thermal expansivity and machining qualities are entirely satisfactory for commercial use. In addition, they may be readily cast in sand or in permanent molds, and are not subject to cracks such as often result in casting some of the prior aluminum-copper alloys.

We have found that certain combinations of aluminum with lesser quantities of silicon, copper and nickel obviate many of the difficulties heretofore encountered, and at the same time possess other advantages. With these constituents there may be present the usual amount of commercial impurities some of which may even have a beneficial effect.

The usual effect of silicon in amount from say about 4 per cent up to a maximum of about 30 per cent is to decrease specific gravity and thermal expansivity but we have found that when accompanied by nickel silicon from about 6 to 8 per cent raises the elastic modulus and also increases the tensile strength at high temperatures. Nickel in general lowers the thermal expansivity, but in this invention, in combination with the silicon and copper, it produces exceptional high temperature properties. At the same time it does not unduly decrease the thermal expansivity. With this in view the nickel content may be varied from about 6 per cent up to 8 per cent or more with consequent beneficial effect. Addition of copper from about 6 per cent to about 8 per cent will add materially to the hardness and resistance to wear.

We have found that an alloy composed of about 79 per cent commercial aluminum and about 7 per cent each of the constituents copper, silicon, and nickel will have a modulus of elasticity of about 13,000,000 as compared with about 11,000,000 for aluminum alloy of the kind customarily used in the manufacture of pistons for internal combustion engines, containing approximately 10 per cent copper and 1 per cent iron with about 0.25 per cent magnesium. This represents a difference of around 2,000,000 pounds per square inch in the modulus of elasticity, or a gain of about 20 per cent in favor of our alloy, and means that with equal section thicknesses our alloy will be about 20 per cent

stiffer. Moreover, the section thickness of piston walls made from our alloy may be decreased so as to effect an important saving in weight while meeting the elastic deformation standards already established.

With the new composition mentioned above, it is possible to secure at elevated temperatures a tensile strength very materially higher than that heretofore possible with former compositions. Tests of our alloy at 600° F. showed a tensile strength of 18,750 pounds per square inch as compared with a strength of 13,580 pounds per square inch for the old widely used alloy described above, a gain of almost 40 per cent. These figures are the average of such a number of tests as to render them quite reliable.

At 700° F. the old alloy described above had a tensile strength of 7450 pounds per square inch and a yield point of 4750. Our alloy had a tensile strength of 12,770 pounds per square inch and a yield point of 5000. This is an increase of more than 70 per cent in tensile strength in favor of our alloy.

At 800° F. the old alloy had a tensile strength of 4070 pounds per square inch and a yield point of 2250. Our alloy had a tensile strength of 7110 pounds per square inch and a yield point of 2750, representing an increase in tensile strength in favor of our alloy of more than 70 per cent.

At 900° F. the old alloy had a tensile strength of 2430 pounds per square inch and our alloy a strength of 3500 pounds per square inch, an increase of more than 40 per cent. Beyond this temperature further testing became impracticable, but the results given clearly show the notable improvement attained as regards high temperature tensile properties.

The alloys which are the subject of the present invention may be heat-treated for the purpose of improving their tensile and hardness properties or they may be otherwise thermally treated for the purpose of removing strains or stabilizing volume changes. For such purposes, we have utilized the heat-treatment and other thermal processes which are well known to those skilled in the art.

The Brinell hardness of an aluminum alloy

containing 7 per cent silicon, 7 per cent copper and 7 per cent nickel, is about 110 in the "as cast" condition. If the alloy is subjected to a low temperature aging treatment in the neighborhood of 150° C. for about 24 hours, this hardness may increase to about 120, though with a slight decrease of toughness.

It is to be understood that the invention is not limited to the specific composition herein described but can be carried out in other ways without departure from its spirit.

We claim—

1. An aluminum-base alloy containing from about 6 per cent to 8 per cent silicon, about 6 per cent to 8 per cent nickel, about 6 per cent to 8 per cent copper, and characterized by high tensile strength at elevated temperatures and high modulus of elasticity.

2. An aluminum-base alloy containing about 7 per cent silicon, 7 per cent copper, and 7 per cent nickel, and the balance aluminum.

3. A piston formed from an aluminum-base alloy containing about 7 per cent silicon, 7 per cent copper, and 7 per cent nickel, and the balance aluminum.

4. A piston formed from an aluminum-base alloy containing from about 6 per cent to 8 per cent of silicon, about 6 per cent to 8 per cent of nickel, and about 6 per cent to 8 per cent of copper, and the balance aluminum.

5. A heat-treated piston formed from an aluminum base alloy containing about 7 per cent silicon, 7 per cent copper, and 7 per cent nickel, characterized by a modulus of elasticity not less than about 13,000,000 pounds per square inch, and a tensile strength not less than about 18,000 pounds per square inch at 600° F., and a yield point not less than about 2,000 pounds per square inch at 800° F.

6. A piston made of a heat-treated aluminum base alloy containing about 7 per cent silicon, 7 per cent copper, and 7 per cent nickel, and having the alloy structure characteristic of low temperature aging at about 150° C. for about 24 hours.

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