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ALUMINUM ALLOY

Howard J. Rowe, Lakewood, Ohio, assignor to Aluminum Company of America, Pittsburgh, Pa., a corporation of Pennsylvania

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2 Claims. (Cl. 75—1)

The invention relates to aluminum base alloys, and more specifically to such alloys containing substantial amounts of silicon and lesser amounts of copper and magnesium.

This application is a division of my copending application Serial No. 634,172.

The invention is particularly concerned with aluminum base alloys containing from about 3 per cent to about 8 per cent of silicon, from about 0.5 per cent to about 3.0 per cent of copper, and from about 0.2 per cent to about 1.5 per cent of magnesium.

It is the principal object of this invention to effect an improvement in alloys in the above range by the addition of manganese and nickel either separately or in combination. The manganese may be added in amounts between about 0.3 per cent and 2.0 per cent. The nickel may be added in amounts between about 0.3 per cent and 3.0 per cent. If manganese and nickel are added in combination, the amount of each should not exceed the amount disclosed immediately hereinabove for each element, and the sum total of both elements should be between 0.3 per cent and 4.0 per cent.

The group of aluminum base alloys containing silicon, copper, and magnesium in amounts as indicated hereinabove forms an extremely useful series of alloys. In the molten condition at about ordinary pouring temperatures they exhibit a high degree of fluidity and such other characteristics as go to make up a good casting alloy. They have an exceptionally high elongation and their other physical properties, such as tensile strength and hardness are satisfactorily commensurate with the improved elongation. They exhibit a relatively high resistance to corrosion.

These alloys are susceptible to such varied commercial adaptations that they have come to be used in many forms, some of them involving service at fairly elevated temperature. They have been formed, for instance, into cylinder heads, or other parts for internal combustion engines where temperatures up to, and perhaps exceeding 600° Fahrenheit are encountered.

I have found that the strength of the aluminum-silicon-copper-magnesium alloys as disclosed hereinabove, while heretofore regarded as adequate for ordinary needs, may be improved particularly in the higher temperature ranges, by the addition of manganese and nickel or by either alone. From a consideration of alloying ingredients or room temperature properties it is extremely difficult if not impossible to predict the behavior of an aluminum base alloy at elevated temperatures, for instance at 400° Fahrenheit or 600° Fahrenheit. Experience has shown that many alloys of excellent casting characteristics and good room temperature properties fall off very rapidly in strength as the temperature is raised. It is only very rarely that an alloy is discovered which combines favorable properties under all temperature conditions and is at the same time characterized by excellent casting properties.

An alloy was made up to contain 5.0 per cent of silicon, 1.3 per cent of copper and 0.5 per cent of magnesium, the balance being commercial aluminum. For convenience this alloy is termed "alloy A". Test specimens were cast in sand from this alloy and were then given a homogenizing treatment of 2 hours at 550° Fahrenheit. They were then heated to 600° Fahrenheit and tested at that temperature. The average of a number of tensile tests showed a tensile strength of 8,490 pounds per square inch. Other test specimens identical in all respects except that they contained 0.6 per cent manganese were tested under similar thermal conditions and had an average tensile strength of 8,770 pounds per square inch. Another set of test specimens without manganese but with 0.8 per cent of nickel in addition to the silicon, copper and magnesium as in alloy A, had an average tensile strength of 8,950 pounds per square inch after an identical thermal treatment. A set of specimens of identical silicon, copper and magnesium as alloy A, but containing 0.6 per cent manganese and 0.8 per cent nickel after the disclosed thermal treatment had a tensile strength of 10,510 pounds per square inch.

Another set of sand cast specimens of aluminum base alloy were made up to contain silicon, copper, and magnesium as in alloy A. They were given a thermal treatment of 8 hours at 440° Fahrenheit, 2 hours at 550° Fahrenheit, and 10 days at 600° Fahrenheit, being tested at the latter temperature. They had an average tensile strength of 6,282 pounds per square inch. Another set of similar composition and similarly treated thermally but containing 0.6 per cent manganese had a tensile strength of 8,620 pounds per square inch. By a comparison with the last paragraph it can be observed that whereas alloy A, without manganese, lost 2,280 pounds per square inch after an extended period at elevated temperatures, the same alloy with 0.6 per cent added manganese lost only 150 pounds per square inch.

An alloy similar in all respects to alloy A except that it contained 0.6 per cent manganese and 0.8 per cent nickel was given a thermal treatment

of 2 hours at 550° Fahrenheit followed by varying times at 600° Fahrenheit. After 3 days at 600° Fahrenheit the average strength was 8,880 pounds per square inch, after 10 days at 600° Fahrenheit it was 8,970 pounds per square inch, and after 30 days at this temperature the strength was 9,240 pounds per square inch. It is not to be expected that by lengthening the time of treatment the strength will keep ascending as the tendency seems to hold in this last example. As a matter of fact the ordinary effect of increasing the time at temperature is to weaken the specimen and alloy A after 30 days at 600° Fahrenheit had a tensile strength of only 5,957 pounds per square inch as compared with 9,240 pounds per square inch for alloy A with added nickel and manganese. The differences between 8,880, 8,970, and 9,240 pounds per square inch for 3, 10 and 30 days respectively at 600° Fahrenheit are all within the variation which might well be expected between specimens identical in every respect, and the results are given merely to illustrate that by the addition of nickel and manganese an aluminum base alloy containing silicon, copper and magnesium within the disclosed range becomes much more resistant both to the deteriorating effect of elevated temperatures and the additional weakening effect of extended time at these temperatures. By actual test the tensile strength of alloy A decreased from 9,577 pounds per square inch to 5,957 pounds per square inch on a series extending from 30 minutes at 600° Fahrenheit to 30 days at 600° Fahrenheit while alloy A, with manganese and nickel in excess of 0.6 per cent of each, decreased from 10,330 to 9,240 pounds per square inch. In other words, alloy A lost about 37 per cent of its strength between 30 minutes and 30 days at 600° Fahrenheit, while alloy A with manganese and nickel lost only 10 per cent of its strength over the same period.

These tests and others within my experience indicate a double advantage in favor of the addition of manganese and nickel to aluminum base alloys containing silicon, copper and magnesium. The addition of manganese and nickel increases the strength of the alloy at room temperature and elevated temperatures. In addition the presence of manganese and nickel in the alloy lessens the tendency of the alloy to deteriorate on extended exposure to elevated temperatures. In other words while the advantage of the addition of manganese and nickel becomes immediately apparent, this advantage becomes more obvious with increasing time at temperature.

In actual production I prefer the alloy disclosed in connection with the results given, namely, 5.0 per cent of silicon, 1.3 per cent of copper, 0.5 per cent of magnesium, 0.6 per cent of manganese, and 0.8 per cent of nickel, the balance being aluminum of any of the grades available commercially but preferably of the grades of higher purity. The beneficial effects of the invention are observable over a range of from about 3 per cent to about 8 per cent of silicon, from about 0.5 per cent to about 3.0 per cent of copper, from about 0.2 per cent to 1.5 per cent of magnesium, from about 0.3 to 2.0 per cent of manganese and from about 0.3 to 3.0 per cent of nickel. The alloying constituents silicon, copper, and magnesium may be varied to suit the purposes of the user, such variations affecting the casting properties and other physical characteristics such as susceptibility to improvement by thermal treatments. The general effect of increasing the nickel and manganese content is to increase the strength and hardness of the alloy and decrease its ductility.

The alloys herein disclosed are susceptible to variation of properties and internal structure by thermal treatments known to the art. The effect of the so-called "solution treatment", namely, a soaking treatment at 980° Fahrenheit or thereabouts followed by rapid cooling is to improve the room temperature properties, but the effect induced by a treatment of this type is counteracted by extended exposure to temperatures above about 400° Fahrenheit.

The alloying constituents may be added to the molten aluminum in the customary manner, the silicon, copper, magnesium, and nickel by means of "rich alloys" and the magnesium either in this manner or in the pure state. The technique may be varied to suit foundry practice.

In the appended claims the term alloy includes the alloy in any condition whether cast in sand or other type of mold, whether heat-treated or unheat-treated and whether modified by ingredients familiar in the use of alloys containing silicon, or unmodified.

What I claim is:

1. A metallic alloy consisting of 3.0 to 8.0 per cent by weight of silicon, 0.5 to 3.0 per cent by weight of copper, 0.2 to 1.5 per cent by weight of magnesium, and 0.3 to 2.0 per cent by weight of manganese, the balance being substantially aluminum.

2. A metallic alloy consisting of 5.0 per cent by weight of silicon, 1.3 per cent by weight of copper, 0.5 per cent by weight of magnesium, and 0.6 per cent by weight of manganese, the balance being substantially aluminum.

HOWARD J. ROWE.