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ALUMINUM ALLOYS

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This invention relates to aluminum base alloys which have excellent properties at elevated temperatures, which are generally adapted to foundry purposes and which are insensitive to the common impurities found in commercial aluminum.

A good foundry alloy which will retain a substantial proportion of its physical and tensile properties at elevated temperatures is constantly being searched for in the field of light metals. By light metals are not meant the ordinary aluminum base alloys but only such of those alloys as contain substantial amounts of a metal lighter than aluminum so as to compensate in the alloy for the addition of metals heavier than aluminum. To provide such an alloy of good foundry characteristics and excellent strength at high temperatures is the object of this invention.

The aluminum base alloys containing magnesium are lighter than aluminum. They should therefore be excellent material from which to manufacture reciprocating parts which operate at elevated temperatures were it not for the fact that these alloys at elevated temperatures (such as 400° to 700° Fahrenheit) do not have the strength, the ductility and the hardness which are so often necessary. Moreover, the binary aluminum-magnesium alloys are somewhat lacking in the required foundry characteristics.

We have discovered, after extensive experimentation, an aluminum base alloy containing magnesium which fulfills, to a surprising extent, the requirements above mentioned. This alloy is one containing 3.0 to 8.0 per cent by weight of magnesium, 0.5 to 4.0 per cent by weight of manganese, and 0.5 to 4.0 per cent by weight of nickel, the balance being principally aluminum. This alloy, we have discovered, has excellent foundry characteristics, being capable of use either in sand or permanent molds. The alloy is light, is strong and hard and possesses these latter properties to a substantial extent at high temperatures. The alloy is, moreover, stable in its properties over long periods at high temperature and is therefore a very dependable engineering material. Also the alloy is insensitive to impurities, which is to say that its properties are not materially affected by the varying amount of impurities, such as iron, which may be found in the commercial aluminum from which it is usually made.

The tensile strength of the alloy is high at elevated temperature and its elongation, a measure of ductility, is adequate. It retains this high strength at elevated temperatures over long periods without substantial change and does not become brittle. Examples of the strength and ductility of the alloys will be found in Table I where are listed the tensile strength and elongation of three sand castings made of the alloy, annealed for 4 hours at 700° Fahrenheit, 20 days at 600° Fahrenheit, and finally tested at the latter temperature.

Table I

Alloy composition			Tensile strength pounds per square inch	Percent elongation in 2 inches
% Mg	% Ni	% Mn		
6	1.5	1.0	18,000	3.0
6	2.0	1.5	19,200	3.2
6	1.5	1.5	19,000	2.2

For comparison it may be stated that a binary aluminum-magnesium alloy containing 6 per cent magnesium and in sand cast form had, after a similar thermal treatment, a tensile strength of only 15,000 pounds per square inch and an elongation of 5 per cent in 2 inches.

The stability of the properties of our new alloys is well illustrated by a comparison of one of the alloys in sand cast form with a sand casting made of a well known aluminum alloy containing copper. Sand castings made of an alloy containing 6 per cent magnesium, 1.0 per cent manganese, and 1.5 per cent nickel, balance aluminum, were annealed for 2 hours at 550° Fahrenheit, the temperature was then increased to 600° Fahrenheit and the alloys tested at that temperature and then again tested at the expiration of 20 days at 600° Fahrenheit. Similar treatment was afforded sand castings made of an alloy containing 10 per cent copper, 0.2 per cent magnesium, 1.2 per cent iron, balance aluminum, and these castings were similarly tested. The results are shown in Table II.

Table II

Alloy composition			Tensile strength pounds per square inch	Percent elongation in 2 inches	Days at 600° F.
6% Mg	1.5% Ni	1.0% Mn	15,740	6.7	0
6% Mg	1.5% Ni	1.0% Mn	14,700	11.0	20
10% Cu	0.2% Mg	1.2% Fe	16,200	3.2	0
10% Cu	0.2% Mg	1.2% Fe	9,400	11.2	20

A comparison of the values given in Table II will demonstrate that the aluminum-copper alloy lost about 42 per cent of its tensile strength in 20 days at 600° Fahrenheit while the tensile strength of the aluminum-magnesium-manganese-nickel alloy remained practically constant, losing only about 7 per cent.

The aluminum-magnesium-manganese-nickel alloys to which this invention refers have certain

preferred forms. Within the composition limits above described, the alloys are satisfactory for most purposes, but we have found the best combination of properties in alloys containing 3.5 to 6.5 per cent by weight of magnesium, 0.5 to 2.0 per cent by weight of manganese, and 0.5 to 3.0 per cent by weight of nickel, balance principally aluminum. Excellent casting characteristics are found in an alloy containing 6 per cent by weight of magnesium, 1 per cent by weight of manganese, and 1.5 per cent by weight of nickel, balance principally aluminum.

The alloys which are herein described may be made by any of the usual methods of compounding alloys, care being taken, of course, not to overheat or dross the metal during alloying.

Another property of these alloys is their improved fluidity as compared with the alloys which have, heretofore, been widely used as material for parts operating at elevated temperatures. Comparative tests, based upon the distance that the molten alloy, originally heated to a given temperature, will flow through a spiral in a sand mold, have determined the above. For instance, an aluminum alloy containing 4 per cent by weight of copper, 2 per cent by weight of nickel, and 1.5 per cent by weight of magnesium, when heated to 1250° Fahrenheit and poured into a spiral formed in a sand mold ran through 18 inches of the spiral. Under the same conditions and at the same temperature, an aluminum alloy containing, in accordance with our invention, 6 per cent by weight of magnesium, 1.5 per cent by weight of nickel, and 1 per cent by weight of manganese ran through 26 inches of the spiral. When the alloys immediately above described were originally heated to 1450° Fahrenheit, the lengths of travel through the spiral were 49 inches and 55 inches, respectively.

The aluminum used in the manufacture of the alloys may be of the highest purity or it may contain amounts of usual impurities, and the term "aluminum" as used herein and in the claims designates the aluminum of commerce. It is an incidental property of our alloys that the presence of iron in amounts as high as 2 per cent by weight is not harmful to the high temperature properties of the alloys and, therefore, a wide choice between the various grades of commercial aluminum is possible.

We claim:

1. A metallic alloy characterized by high physical and tensile properties at elevated temperatures and good fluidity and consisting of 3.0 to 8.0 per cent by weight of magnesium, 0.5 to 4.0 per cent by weight of manganese and 0.5 to 4.0 per cent by weight of nickel, the balance being aluminum.

2. A metallic alloy characterized by high physical and tensile properties at elevated temperatures and good fluidity and consisting of 3.5 to 6.5 per cent by weight of magnesium, 0.5 to 2.0 per cent by weight of manganese, and 0.5 to 3.0 per cent by weight of nickel, the balance being aluminum.

3. A metallic alloy characterized by high physical and tensile properties at elevated temperatures and good fluidity and consisting of 6.0 per cent by weight of magnesium, 1.0 per cent by weight of manganese, and 1.5 per cent by weight of nickel, the balance being aluminum.

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