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# UNITED STATES PATENT OFFICE

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## ALUMINUM ALLOYS

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1 Claim. (Cl. 75—1)

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 allow 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 cer-

tain preferred forms. Within the composition limits above described, the alloys are satisfactory for most purposes, but we have found that 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. We have likewise discovered that certain other elements may be added to the alloy to effect particular purposes without materially harming the leading properties of the alloy. For instance:

If a higher hardness and tensile strength is required in the aluminum-magnesium-manganese-nickel alloys which form the subject of this invention and this increase in hardness and tensile strength is desired without substantial impairment of the ductility or increase in the specific gravity of the alloy, we have found that the addition of 0.1 to 0.75 per cent of one or more of the high melting point elements titanium, zirconium, vanadium, molybdenum, and tungsten will achieve this purpose. In total, however, these elements should not exceed about 0.75 per cent by weight of the total alloy. We have likewise found that these metals may be added in such amounts without substantial impairment of the novel properties of our alloys.

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 a 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 formed in a sand mold, have shown that our novel alloys are very superior with respect to fluidity.

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 claim 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:

A metallic alloy characterized by high physical and tensile properties at elevated temperatures and by 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 nickel, 0.5 to 4.0 per cent by weight of manganese, and 0.1 to 0.75 per cent by weight of at least one of the class of metals titanium, zirconium, vanadium, molybdenum and tungsten, the balance being aluminum.

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