

[54] **ALUMINUM BASE ALLOY**

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[56] **References Cited**

UNITED STATES PATENTS

3,392,015 7/1968 Badia **75/141**

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[57] **ABSTRACT**

There is provided an aluminum base alloy characterized by a substantial amount of silicon and nickel together with smaller amounts of copper and magnesium, and further characterized by the presence therein of beryllium and titanium, said alloy being useful in making molds where hardness and replication of fine detail is required. Latent within the as-cast alloy is developable hardness, fine grain structure, and freedom from microporosity obtained by submitting the alloy cast at from 1,000° to 1,100° F. to a further thermal history.

8 Claims, No Drawings

ALUMINUM BASE ALLOY

BACKGROUND OF THE INVENTION AND PRIOR ART

High silicon aluminum base alloys are well known. A typical example of an aluminum base alloy is that which is shown and described in U.S. Pat. No. 2,380,173. Very often the introduction of materials which reduce the grain size do so at the sacrifice of hardness. Also, materials added for one purpose adversely affect another. Maintenance of relatively high as-cast hardness is important, particularly in the production of molds characterized by fine detail such as for example a wood grain pattern. Replicability of pattern detail depends upon not only the hardness but also the ability of the alloy to reproduce fine detail. It is a principal object of the present invention, therefore, to provide a readily castable aluminum base alloy exhibiting good replicability in an investment mold and a hardness of R_E 88 and higher. These alloys are particularly useful in producing a cast-to-shape mold for foam molding of plastics to make simulated wood grain furniture parts and develop desirable properties upon submission to a thermal history hereinafter more particularly described. The hardness of these alloys both at room temperature and after extended exposure to temperatures of the order of 600° F. provides a material which has excellent durability in actual molding operations performed at temperatures of the order of 300° to 500° F. These alloys are light in weight and therefore provide more volume per unit cost and greater ease of transport and handling in molding operations. The ingredients of the alloy are sufficiently inexpensive to make the cost attractive to plastic mold fabricators and plastic molders.

BRIEF STATEMENT OF THE INVENTION

Briefly stated, the present invention is in an aluminum base alloy suitable for casting composed of from 8 - 13 percent silicon, 0.2 to 1.5 percent iron, 1.5 to 5.5 percent copper, 0.1 to 1.5 percent magnesium, 3.0 - 7.0 percent nickel, 0.01 - 0.2 percent beryllium, 0.01 - 0.3 percent titanium, balance aluminum. This invention also relates to a cast aluminum base alloy of the above composition cast at a temperature of from 1,000° to 1,100° F. and thermally conditioned by solution treating for from 4 to 16 hours at a temperature of from 900° to 1,000° F., preferably 940° to 975° F., quenching from the solution treatment temperature with water, boiling water, oil, or other suitable liquid, and aging for a period of from 1 to 24 hours at a temperature of from 300° to 600° F., preferably 300° to 450° F.

In referring to aluminum base alloys herein, we refer to those aluminum alloys which contain at least 70 percent aluminum. The term "aluminum" as herein employed refers to the metal as commercially produced, which does contain some impurities, or to the elemental material. Where in the appended claims the balance of an alloy is said to be "aluminum," it is intended that this expression shall permit the inclusion in the alloy composition of other elements which do not adversely affect the properties herein set forth as well as the usual impurities associated with aluminum. The term "trace" as used herein contemplates 0.005 to 0.5 percent by weight.

DETAILED DESCRIPTION OF THE INVENTION

A specific example of an alloy in accordance herewith has the following composition and is compounded as a melt at from 1,100° to 1,300° F. in an induction furnace:

EXAMPLE I

	Silicon	9.93%
	Nickel	4.62
10	Magnesium	.94
	Copper	2.06
	Beryllium	.05
	Titanium	.10
	Iron	Trace
	Manganese	Trace
15	Zinc	Trace
	Aluminum	Balance

This alloy when cast at 1,100° F. into a graphite mold has an as-cast hardness of R_E (Rockwell E) 89. When solution treated for 8 hours at 960° F. and water quenched, the hardness is R_E 93. After aging for 20 hours at 340° F., the hardness is R_E 105. The hardness of the solution treated and aged alloy as produced above and held for 1, 3, and 24 hours at 600° F. drops only to R_E 82, 79, and 75, respectively. When cast in a silicon investment mold, its replicability of a wood grain pattern is comparable to the more expensive Cu-2% Be alloys. The inclusion of beryllium in the very small amounts used herein causes the alloy to be clean, more fluid, and to demonstrate improved replicability of pattern details.

Additional examples are provided in the following table:

	II	III	IV	V	VI
35	10.11	9.68	10.06	10.13	10.0
	4.66	4.84	4.73	4.80	4.5
	1.00	0.98	0.92	0.94	1.0
	2.04	1.88	2.28	4.16	5.2
	0.045	0.11	0.06	0.07	0.05
	Trace	0.18	0.19	0.19	0.15
	Trace	Trace	Trace	Trace	Trace
40	Trace	Trace	Trace	Trace	Trace
	Trace	Trace	Trace	Trace	Trace
	Trace	Trace	Trace	Trace	Trace
	Balance	Balance	Balance	Balance	Balance

With Examples II through VI, as-cast hardness of R_E 89, 90, 86, 88, and 100, respectively, are obtained. When copper is omitted from these alloys, an as-cast hardness of only R_E 60 is obtained. Higher copper contents of 4.16 and 5.2 percent, respectively, bring the as-cast hardness up to R_E 97 and 100, respectively, compared to R_E 86-90 for a normal 2 percent copper content. The addition of titanium in the amounts indicated produces a fine grain size and drastically reduces the size and frequency of microporosity and surface pitting without significantly affecting as-cast hardness. In the foregoing examples, the elements indicated as being present in "trace" amounts are optionally present, or are found as impurities in the aluminum, beryllium, or other ingredients, or the master batches used.

The raw alloys of the present invention may be produced by known means. Thus, the components in their elemental form may be melt-blended at 1,100° - 1,300° F. in an induction furnace or in a gas-fired furnace with mechanical agitation. Often it is convenient to add the elements from master batches of two or more of the components present in a concentration which is higher than contemplated for the final alloy and, where two or more are present in the same master

batch, desirably with the minor components being present in the ratio by weight in which they will ultimately appear.

In general, it is contemplated to begin with a commercial aluminum melt and to add to it a master batch of silicon and aluminum containing 13 percent silicon, until a percentage of silicon in the combined melt yields the desired amount of silicon, e.g., an ultimate concentration of 10 percent by weight of silicon. Beryllium can be added as Al-5Be or Cu-4Be master alloys or as copper-beryllium scrap. Titanium can be added as Cu-6Ti master alloy. The other elements are frequently added as elemental materials.

In commercial practice, the raw alloy may be cast into "pigs" at a temperature in the range of from 1,100° to 1,300° F. When the pigs are remelted and cast into mold components, they undergo a thermal history such as that described above in order to develop within the alloy the desired properties brought about by the combination of various elements present in these improved alloys. The thermal history includes casting the material into the master mold at a temperature generally between 1,000° and 1,100° F. and preferably in the range of 1,025° and 1,050° F. The cast product may then be solution treated in accordance with known practice for a period of from 4 - 16 hours, for example 8 hours, at a temperature in the range of from 900° to 1,000° F., e.g., 960° F., and thereafter liquid quenched from the solution treating temperature. Although some spontaneous cooling before quench may be tolerated, it is preferred to quench directly from the solution treatment temperature. The liquid quenching agent may be water, ice water, boiling water, or oil. The cast product may then be aged for a period of from 1 to 24 hours, e.g., 20 hours, at a relatively mild temperature in the range of from 300° to 600° F., e.g., 340° F.

The manner in which the several elements coact to produce a product which has good hardness for durability and an enhanced degree of replicability of fine detail is unknown. It is known that copper if removed from the system very greatly adversely affects hardness. The nickel ingredient in combination with the copper in the amounts used enhances hardness, but in the absence of the other modifying elements tends also to increase brittleness. Silicon improves the flow characteristics of the alloy during casting. Copper is effective in adding hardness as is nickel, the combination of the two seeming to enhance the overall hardness effect without inducing undue brittleness. The presence of titanium is critical inasmuch as it controls the grain size. Magnesium also contributes to hardness. The several ingredients apparently coact in the alloy composition to intensify the desired properties without introducing deleterious properties; and the resulting alloy is characterized by high hardness, good fluidity during cast, and excellent reproduction of detail.

In order to develop increased hardness above that latently present in the alloy composition, it is necessary after initial casting to submit the product to a thermal history. It is desirable that the casting temperature not

exceed 1,100° F. Best results are secured if the final casting temperature is within the range of 1,025° to 1,050° F.

What is claimed is:

1. An aluminum base alloy consisting of 8 - 13 percent silicon, 0.2 - 1.5 percent iron, 1.5 - 5.5 percent copper, 0.1 - 1.5 percent magnesium, 3.0 - 7.0 percent nickel, 0.01 - 0.2 percent beryllium, 0.01 - 0.30 percent titanium, balance aluminum.
2. An aluminum base alloy consisting of 10 percent silicon, 4.6 percent nickel, 0.9 percent magnesium, 2.1 percent copper, 0.05 percent beryllium, 0.1 percent titanium, optionally a trace of iron, optionally a trace of manganese, optionally a trace of zinc, and balance aluminum.
3. An aluminum base alloy consisting of 10 percent silicon, 4.8 percent nickel, 1 percent magnesium, 4.2 percent copper, 0.07 percent beryllium, 0.2 percent titanium, optionally a trace of iron, optionally a trace of manganese, optionally a trace of zinc, balance aluminum.
4. An aluminum base alloy consisting of 10 percent silicon, 4.5 percent nickel, 1.0 percent magnesium, 5.2 percent copper, 0.05 percent beryllium, 0.15 percent titanium, optionally a trace of iron, optionally a trace of manganese, optionally a trace of zinc, balance aluminum.
5. A cast aluminum base alloy consisting of from 8 - 13 percent silicon, 0.2 - 1.5 percent iron, 1.5 - 5.5 percent copper, 0.1 - 1.5 percent magnesium, 3.0 - 7.0 percent nickel, 0.01 - 0.2 percent beryllium, 0.01 - 0.3 percent titanium, balance aluminum, and having the hardness obtained by casting the alloy at a temperature between 1,000° and 1,100° F., solution treating for a period of from 4 to 16 hours at a temperature of from 900° to 1,000° F., water or oil quenching from the solution treatment temperature, and aging for a period of from 1 to 24 hours at a temperature of from 300° to 600° F.
6. A cast aluminum base alloy in accordance with claim 5 wherein the alloy consists of 10 percent silicon, 4.6 percent nickel, 0.9 percent magnesium, 2.1 percent copper, 0.05 percent beryllium, 0.1 percent titanium, optionally a trace of iron, optionally a trace of manganese, optionally a trace of zinc, and balance aluminum.
7. A cast aluminum base alloy in accordance with claim 5 wherein the alloy consists of 10 percent silicon, 4.8 percent nickel, 1.0 percent magnesium, 4.2 percent copper, 0.07 percent beryllium, 0.2 percent titanium, optionally a trace of iron, optionally a trace of manganese, optionally a trace of zinc, and balance aluminum.
8. A cast aluminum base alloy in accordance with claim 5 wherein the alloy consists of 10 percent silicon, 4.5 percent nickel, 1.0 percent magnesium, 5.2 percent copper, 0.05 percent beryllium, 0.15 percent titanium, optionally a trace of iron, optionally a trace of manganese, optionally a trace of zinc, and balance aluminum.

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