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ALUMINUM BASE ALLOY

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ABSTRACT OF THE DISCLOSURE

There is provided an aluminum base alloy characterized by a substantial amount of silicon and zinc together with copper and minor amounts of magnesium, beryllium, titanium, and impurities. This alloy is useful in making molds where hardness and replication of fine detail is required. Latent within the as-cast alloy are developable hardness, fine grain structure, and freedom from microporosity obtained by submitting the as-cast alloy to a further thermal history.

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 Pat. No. 2,830,173 and in Ser. No. 185,440 filed Sept. 30, 1971, now Pat. No. 3,716,355 dated Feb. 13, 1973. Very often, the introduction of materials which reduce the grain size do so at the sacrifice of other properties. Also, materials which are added for one purpose may adversely affect another desired property. 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 the pattern detail depends upon not only the hardness but also the ability of the alloys 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 an as-cast hardness of R_E 95 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 development of desirable properties upon submission to a thermal history hereinafter more particularly described. The hardness of these alloys both at room temperature and after exposure to temperatures below 1,000° F. provides material which has excellent durability in actual molding operations performed at temperatures of the order of 300° F. 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. These alloys do not depend upon the use of any nickel component as in the case of Ser. No. 185,440 above described. The ingredients of the alloy are sufficiently inexpensive to make the cost attractive to plastic mold fabricators and plastic molders. The achievement of hardness levels of the order of R_E 95 without heat treatment is attractive as it eliminates a cost producing operation and does not involve risk of distortion or oxidation of a finished part.

BRIEF STATEMENT OF THE INVENTION

Briefly stated, the present invention is in an aluminum base alloy characterized by high as-cast or initial hardness. These alloys are composed of from 8–13% silicon, 1.5 to 5.0% copper, 5.0 to 8.0% zinc, 0.5 to 1.5% magnesium, 0.01 to 0.20% beryllium, 0.01 to 0.30% titanium, trace amounts of impurities, and balance aluminum. This invention also relates to a cast aluminum base alloy of

the above composition cast at a temperature of from 1000° F. to 1300° F. and thermally conditioned by solution treating for a period of 8–24 hours at a temperature above 900° F., preferably 935° F.; quenching from the solution treatment temperature with water, boiling water, oil, or other suitable liquid; and aging for a period of from 1–24 hours at a temperature of from 300° F. to 600° F., preferably 300° F. to 450° F.

In referring to aluminum base alloys herein, we refer to those aluminum alloys which contain at least 70% 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% 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 in air at a temperature of from 1200° F. to 1450° F. maximum temperature in an induction furnace:

Example 1

	Percent
Silicon	10.38
Copper	2.56
Magnesium	0.63
Zinc	7.26
Beryllium	0.12
Titanium	0.08
Aluminum	Balance

The foregoing metals are air melted in the induction furnace at a temperature which does not exceed 1450° F. This alloy when cast at 1250° F. into a graphite mold and naturally aged has hardness of R_E (Rockwell E) 95. The Brinell number at 500 kg. is 113; the ultimate strength in k.s.i. 35,000; the yield at 0.2% offset in k.s.i. 32,000; the percent elongation 1.0%; the percent IACS conductivity is 21. When solution treated for 16 hours at 935° F., quenched in water, and aged for 16 hours at 340° F., this alloy shows a Rockwell E hardness of 105, a Brinell 500 kg. of 130, an ultimate strength in k.s.i. of 48,000, a percent elongation of 0.5%, and a percent IACS conductivity of 25. When cast in silicon investment mold, its replicability of a wood grain pattern is comparable to the more expensive copper beryllium alloys containing 2% beryllium. The inclusion of beryllium in the very small amounts used herein causes the alloy to appear cleaner and more fluid and to demonstrate improved replicability of pattern details.

Additional examples are provided in the following table:

Example	Cu	Si	Mg	Zn	Be	Ti	Hardness—R_E naturally aged
2	2.20	10.18	0.61	6.50	0.12	0.16	96
3	2.22	10.14	0.59	6.80	0.13	0.16	95
4	3.90	9.82	0.50	8.16	0.14	0.11	99
5	2.88	10.29	0.64	6.75	0.18	0.16	99

The raw alloys of the present invention may be produced by known means. Thus, the components in their elemental form may be melt-blended in air at temperatures of from 1200° to 1500° 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 that 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 50% silicon until a percentage of silicon in the combined melt yields the desired amount of silicon, e.g. an ultimate concentration of 10% 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 1200° to 1500° 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. This thermal history includes casting the material into the master mold at a temperature generally between 1100° and 1300° F. and preferably in the range of from 1225° to 1275° F. The cast product may then be solution treated in accordance with known practice for a period of 8 to 24 hours, for example 16 hours, at a temperature in the range of from 900° F. to 1000° F., for example 935° F., and thereafter liquid quenched, for example in water, 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 8 to 24 hours, e.g. 16 hours, at a relatively mild temperature in the range of from 300° F. to 600° F., for example 340° F.

The manner in which the several elements coact to produce a product which has good as-cast 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. Silicon improves the flow characteristics of the alloy during casting. 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 about 1400° F. Best results are secured if the final casting temperature is within the range of from 1200° F. to 1400° F.

What is claimed is:

1. An aluminum base alloy consisting of 8–13% silicon, 1.5 to 5.0% copper, 5 to 8% zinc, 0.5 to 1.5% magnesium, 0.01 to 0.20% beryllium, 0.01 to 0.30% titanium, impurities, and balance aluminum.

2. An aluminum base alloy consisting of 10.38% silicon, 2.56% copper, 7.26% zinc, 0.63% magnesium, 0.12% beryllium, 0.08% titanium, impurities, and balance aluminum.

3. An aluminum base alloy consisting of 10.18% silicon, 2.20% copper, 6.50% zinc, 0.61% magnesium, 0.12% beryllium, 0.16% titanium, impurities, and balance aluminum.

4. An aluminum base alloy consisting of 10.14% silicon, 2.22% copper, 6.80% zinc, 0.59% magnesium, 0.13% beryllium, 0.16% titanium, impurities, and balance aluminum.

5. An aluminum base alloy consisting of 9.82% silicon, 3.90% copper, 8.16% zinc, 0.50% magnesium, 0.14% beryllium, 0.11% titanium, impurities, and balance aluminum.

6. An aluminum base alloy consisting of 10.29% silicon, 2.88% copper, 6.75% zinc, 0.64% magnesium, 0.18% beryllium, 0.16% titanium, impurities, and balance aluminum.

7. A cast aluminum base alloy consisting of from 8–13% silicon, 1.5 to 5.0% copper, 5 to 8% zinc, 0.5 to 1.5% magnesium, 0.01 to 0.20% beryllium, 0.01 to 0.30% titanium, impurities, and balance aluminum, and having the hardness obtained by casting the alloy at a temperature between 1100° F. and 1300° F., solution treating for a period of from 8 to 24 hours at a temperature of from 900° to 1000° F., water or oil quenching from the solution treatment temperature, and aging for a period of from 8 to 24 hours at a temperature in the range of from 300° F. to 600° F.

8. A cast aluminum base alloy in accordance with claim 7 wherein the alloy consists of 10.38% silicon, 2.56% copper, 7.26% zinc, 0.63% magnesium, 0.12% beryllium, 0.08% titanium, impurities, and balance aluminum.

9. A cast aluminum base alloy in accordance with claim 7 wherein the alloy consists of 10.18% silicon, 2.20% copper, 6.50% zinc, 0.61% magnesium, 0.12% beryllium, 0.16% titanium, impurities, and balance aluminum.

10. A cast aluminum base alloy in accordance with claim 7 wherein the alloy consists of 10.14% silicon, 2.22% copper, 6.80% zinc, 0.59% magnesium, 0.13% beryllium, 0.16% titanium, impurities, and balance aluminum.

11. A cast aluminum base alloy in accordance with claim 7 wherein the alloy consists of 9.82% silicon, 3.90% copper, 8.16% zinc, 0.50% magnesium, 0.14% beryllium, 0.11% titanium, impurities, and balance aluminum.

12. A cast aluminum base alloy in accordance with claim 7 wherein the alloy consists of 10.29% silicon, 2.88% copper, 6.75% zinc, 0.64% magnesium, 0.18% beryllium, 0.16% titanium, impurities, and balance aluminum.

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