Patented Dec. 3, 1935

2,022,686

UNITED STATES PATENT OFFICE

2,022,686

ALUMINUM ALLOY CASTING AND METHOD OF MAKING THE SAME

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No Drawing. Application April 21, 1932, Serial No. 606,755

6 Claims. (Cl. 148—21.1)

This invention relates, in general, to aluminum-copper alloys, with or without certain other alloying elements; the alloys being free from magnesium except as that metal may occur as in inconsequential impurity in amount not more than about 0.1 of 1 per cent.

A property most difficult to obtain in metal castings is ductility. The structure of cast metal is such as to inherently disfavor the development of a ductility approximating that of worked metal. This is true of castings made of aluminum-copper alloys containing substantial amounts of copper, and particularly in castings made of such alloys which also contain substantial amounts of other alloying elements. Since ductility is usually increased in castings made of aluminum-copper alloys by thermal treatment at relatively high temperatures, the heat-treated castings are preferred and widely used.

The principal object of this invention is the provision of heat-treated castings made of aluminum-copper alloys having improved high ductility. Another object of the invention is the provision of heat-treated ductile castings made of aluminum-copper alloys which, besides copper, likewise contain considerable amounts of other alloying elements. Other objects of the invention will appear in the following description thereof.

I have discovered that the addition of very small amounts of tin, 0.005 to 0.1 per cent, to aluminum-copper alloys containing 2 to 12 per cent of copper, provides an alloy which will, under suitable thermal treatment without artificial aging, develop ductility of an order considerably greater than that produced by the same thermal treatment in an alloy not containing tin but otherwise the same. I have likewise determined that this increase in ductility is not appreciable when magnesium is present in the alloy, or at least when magnesium is present as more than an impurity. I have also discovered that this increase in ductility is obtained even when the alloy contains other alloying elements such as nickel, silicon, and zinc, or the alloying elements herein defined as the so-called "hardening elements", such as titanium, chromium, boron, zirconium, manganese, molybdenum and beryllium.

My invention contemplates, therefore, heat-treated castings made of an aluminum-copper alloy containing 2 to 12 per cent of copper, 0.005 to 0.1 per cent of tin, free from magnesium but containing, if desired, one or a number of other alloying elements of the classes defined above. The aluminum in the alloy should not be less than 75 per cent and may contain impurities, such as iron in amounts up to 1.5 to 2.0 per cent. In the practice of my invention the alloy is prepared in a usual manner as by adding to molten aluminum the desired amounts of the alloying elements, either as the element or in the form of intermediate alloys. The molten alloy may be directly cast, if desired, into the mold to produce the final casting. The casting is then subjected to heat treatment, which, as is well understood in the art, consists in heating the casting for a suitable period to a temperature above about 400° C., but below the temperature at which incipient fusion or melting of the most fusible constituent or eutectic in the alloy takes place, and then quenching (cooling rapidly) to room temperature.

When a casting is made of the alloys above mentioned and is heat-treated, the ductility of the heat-treated product is considerably higher than that of a similar casting made of similar alloy, similarly treated, but not containing tin in the amount above described. For instance, a casting made of an aluminum-copper alloy containing 4.25 per cent of copper, after heat-treatment for 16 hours at 515° C., had an elongation of 5 per cent in two inches, while a similar casting, similarly treated, but containing 0.03 per cent of tin, had an elongation of 8.4 per cent in two inches; an increase in ductility, as measured by the elongation, of about 68 per cent.

While my invention is highly useful in connection with castings made of aluminum-copper alloys containing, besides a small amount of tin, copper as the only other alloying element, it has a particular application in connection with castings made of aluminum-copper alloys which in addition to copper and a small amount of tin contain substantial amounts of other added alloying elements. The effect of the addition to aluminum-copper alloys of other alloying elements such as nickel, silicon, zinc, and "hardening elements" such as above mentioned, is to decrease the ductility of the alloys. The ductility of the cast alloys is not high and the operator, desiring to add alloying elements to aluminum-copper alloys to produce therein certain specific properties, is often faced with the possibility of obtaining such properties only at the expense of ductility. On the other hand, the presence of 0.005 to 0.1 per cent of tin in heat-treated castings which do not contain magnesium counteracts to an appreciable extent the loss of ductility resulting from the addition of these alloying elements. Moreover, this result is obtained without introducing into the alloy large amounts of an alloying element which is otherwise of no particular benefit or has an unfavorable effect on some other useful property of the alloy.

Thus, for instance, a casting made of an aluminum-copper alloy containing about 4.0 per cent of copper when heat-treated 16 hours at 515° C. had an elongation of 5 per cent in two inches. A casting of an aluminum-copper alloy containing 4.0 per cent copper and 5.0 per cent silicon had, after the same heat-treatment, an elongation of 1.6 per cent in two inches. But a casting made of an alloy containing 4.0 per cent copper, 5.0 per cent silicon, and 0.05 per cent tin had, after the same heat-treatment, an elongation of 5.4 per cent in two inches; an increase in ductility, as measured by elongation, of 237 per cent over the same casting not containing tin.

Similar effects, I have determined, may be produced in castings made of aluminum-copper alloys, free from magnesium, but containing other alloying elements so long as 0.005 to 0.1 per cent of tin is added to the alloy and the casting is heat-treated. The alloys which are to be preferred are those composed of at least 75 per cent of aluminum, 2 to 12 per cent of copper, 0.005 to 0.1 per cent of tin, 0.02 to 2.0 per cent of the group of hardening elements above defined and/or 0.1 to 12 per cent of a group of elements defined to be zinc, nickel, and silicon. While the total amount of "hardening elements" may be from 0.02 to 2.0 per cent, the individual elements, when present singly or in combination, should not exceed greatly the following limits:

	Per cent
Chromium	0.1 to 1.0
Boron	0.02 to 0.5
Beryllium	0.02 to 1.0
Titanium	0.03 to 0.5
Molybdenum	0.1 to 1.0
Manganese	0.2 to 1.5
Zirconium	0.03 to 0.5

Likewise, while the class of elements defined to be nickel, zinc, and silicon may be present in total amounts of 0.1 to 12.0 per cent, the nickel content of the alloy should not exceed 7 per cent, although in the absence of nickel the silicon or zinc may be present in any amount within the range named.

I claim—

1. Process of making castings of magnesium-free aluminum-copper alloy containing 2 to 12 per cent copper, the remainder essentially aluminum, which comprises adding to the alloy from 0.005 to 0.1 per cent of tin, casting the alloy, and without artificial aging, heat-treating the casting by heating the same between 400° C. and incipient fusion and cooling rapidly; the tin serving to materially increase the ductility of the alloy above that of a like alloy devoid of tin and similarly heat-treated.

2. In a process of making castings of magnesium-free aluminum-copper alloy containing 2 to 12 per cent copper and 0.005 to 0.1 per cent of tin, the remainder essentially aluminum, the steps which comprise casting the alloy, and without artificial aging, heat-treating the casting by heating the same between 400° C. and incipient fusion and cooling rapidly; the tin serving to materially increase the ductility of the alloy above that of a like alloy devoid of tin and similarly heat-treated.

3. Process of making castings of magnesium-free aluminum-copper alloy containing 2 to 12 per cent copper; and hardening material of the class composed of beryllium 0.02 to 1.0 per cent, boron 0.2 to 0.5 per cent, chromium 0.1 to 1.0 per cent, manganese 0.2 to 1.5 per cent, molybdenum 0.1 to 1.0 per cent, titanium 0.03 to 0.5 per cent, and zirconium 0.03 to 0.5 per cent, the maximum amount of hardening material being 2.0 per cent; the remainder of the alloy being essentially aluminum; which comprises adding to the alloy from 0.005 to 0.1 per cent of tin, casting the alloy, and without artificial aging, heat-treating the casting by heating the same between 400° C. and incipient fusion and cooling rapidly; the tin serving to materially increase the ductility of the alloy above that of a like alloy devoid of tin and similarly heat-treated.

4. In a process of making castings of magnesium-free aluminum-copper alloy containing 2 to 12 per cent copper, 0.005 to 0.1 per cent tin, and hardening material of the class composed of beryllium 0.02 to 1.0 per cent, boron 0.2 to 0.5 per cent, chromium 0.1 to 1.0 per cent, manganese 0.2 to 1.5 per cent, molybdenum 0.1 to 1.0 per cent, titanium 0.03 to 0.5 per cent, and zirconium 0.03 to 0.5 per cent, the maximum amount of hardening material being 2.0 per cent; the remainder essentially aluminum; the steps which comprise casting the alloy; and without artificial aging, heat-treating the casting by heating the same between 400° C. and incipient fusion and cooling rapidly; the tin serving to materially increase the ductility of the alloy above that of a like alloy devoid of tin and similarly heat-treated.

5. A heat-treated non-artificially aged casting of magnesium-free aluminum-copper alloy containing 2 to 12 per cent of copper, and 0.005 to 0.1 per cent of tin, the remainder essentially aluminum; the alloy of the casting having the internal structure produced by heating between 400° C. and incipient fusion and cooling rapidly.

6. A heat-treated non-artificially aged casting of magnesium-free aluminum-copper alloy containing 2 to 12 per cent of copper, 0.005 to 0.1 per cent of tin, and hardening material of the class composed of beryllium 0.02 to 1.0 per cent, boron 0.2 to 0.5 per cent, chromium 0.1 to 1.0 per cent, manganese 0.2 to 1.5 per cent, molybdenum 0.1 to 1.0 per cent, titanium 0.03 to 0.5 per cent, and zirconium 0.03 to 0.5 per cent, the maximum amount of hardening material being 2.0 per cent, the remainder of the alloy being essentially aluminum; the alloy of the casting having the internal structure produced by heating between 400° C. and incipient fusion and cooling rapidly.

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