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ALUMINUM ALLOY CONTAINING COPPER, IRON, AND COLUMBIUM

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3 Claims. (Cl. 75—139)

This invention comprises improvements in aluminum base alloys and in particular aluminum alloys of the classes containing copper, or nickel, or copper together with nickel, or copper with nickel and magnesium, or copper with nickel, magnesium, iron and silicon, or nickel with magnesium, iron and silicon. This application is a division of our application Serial No. 137,280, filed April 16, 1937.

In the production of cast pieces of aluminum base alloys, by which may be understood alloys containing more than 70% of aluminum, it is desirable to secure the finest possible size of grain. The grain referred to is the macrostructure, which is recognizable by the naked eye on smooth surfaces or sections of the cast pieces after they have been etched in suitable reagents, such as an aqueous solution of caustic soda, or hydrofluoric acid.

In castings a diminution in grain size improves the mechanical properties. The finer the grain size characteristic of an aluminum alloy, other things being equal, the better its founding properties in that the tendency to cracking in the mold is reduced and the production of sound castings is facilitated. In cast pieces intended to be forged, pressed, extruded or otherwise worked mechanically, a fine grain size is desirable because it assists the attainment of good mechanical properties in the subsequent working.

The object of the invention is to produce aluminum alloys having a fine grain, and possessing in consequence of this fine grain superior mechanical properties in the cast condition and also when forged and also after heat-treatment of the castings and forgings according to known processes.

According to this invention, a relatively small proportion of columbium, also known sometimes as niobium, is added to an aluminum alloy, particularly an alloy of one of the classes referred to, the alloy thereby acquiring a fine grain, which is maintained over a wide range of conditions of melting, casting and working. We have found it convenient to make the proportion of columbium 0.1% to 0.2% of the total weight of the alloy. We have observed appreciable grain refinement with as little as 0.05% of columbium, and on the other hand we have not found it generally necessary or desirable to exceed 0.5% of columbium.

We have discovered that these beneficial effects are exhibited in the classes of alloy mentioned above containing the elements set out below in the proportions stated by way of example:

	Per cent
Copper	0.5 to 12
Nickel	0.5 to 5
Magnesium	0.1 to 3
Silicon	0.2 to 2.5
Iron	0.2 to 2
Columbium	0.05 to 1

The beneficial effect of the columbium is not dependent upon the manner in which it is incorporated in the alloy, but a convenient procedure is to add it in the form of a "hardener" or "mother" alloy or prealloy relatively rich in columbium. According to one practical process, the first stage in the incorporation of the columbium in the aluminum alloy is the preparation of an aluminum alloy relatively rich in columbium from ferro-columbium and aluminum. The ferro-columbium may be in the form of an alloy containing approximately equal parts of iron and columbium with impurities such as tantalum, silicon and carbon in small proportions. In preparing the columbium "hardener" alloy, aluminum is melted in a crucible and its temperature raised to 1100° to 1200° C. A weight of ferro-columbium equal to approximately one-tenth of the weight of aluminum is stirred into the molten aluminum, or is carried in a perforated container which is moved up and down in the aluminum, until the addition is entirely dissolved. In this way an alloy containing approximately 5% columbium, 5% iron, with the balance substantially aluminum, is obtained. This is cast into molds, remelted in a crucible, allowed to solidify and remelted without unnecessary superheating, in order to eliminate gases which may have become absorbed through the heating to high temperatures in the initial operation. After this "pre-solidification" treatment, the alloy is cast into suitable ingot molds.

One practical process for making up an alloy using the aluminum "hardener" alloy relatively rich in columbium may be described. The final alloy to be made according to this example has the following nominal composition:

	Per cent
Copper	2.5
Nickel	1.5
Magnesium	0.8
Silicon	1.2
Iron	1.2
Columbium	0.1
Aluminum	Remainder

The "hardener" alloys employed are: aluminum-nickel with 20% nickel, aluminum-iron-columbium with 5% iron and 5% columbium, aluminum-iron with 10% iron, aluminum-copper with 50% copper, aluminum-silicon with 20% silicon. Aluminum is melted in a crucible and the calculated quantities of "hardeners" are stirred in successively in the order in which they are mentioned above, care being taken that each addition is dissolved before the next is introduced. The final addition is the magnesium in the form of the pure metal. By this procedure it is not necessary to raise the temperature of the metal above 750° C. at any stage during the manufacture of the alloy, which is advantageous from the point of view of avoiding absorption of gas.

The alloy described is suitable for the manufacture of castings and forgings, and responds effectively to the known processes of heat-treatment applicable to aluminum alloys containing copper, nickel, magnesium, silicon and iron. For example, a large improvement in mechanical properties of forgings of the alloy is obtained by a two-stage heat-treatment in which the parts are first heated for 4 hours at 530° C., then quenched in water, reheated for 16 hours at 165° C. and finally quenched in water again.

A valuable feature of the grain refining action of columbium is that it is effective even when the aluminum alloy is raised to a high temperature before casting. As an illustration of the efficacy of the grain refining action of columbium, it may be mentioned that, when an alloy of the composition stated above is cast at 800° C. into a dried sand mold to form a cylindrical block 3'' high and 3'' diameter, the grains visible in the macrostructure after etching have diameters of 0.2 to 1 mm., whereas the same alloy not containing columbium, cast under the same conditions, shows a grain diameter of 2.5 to 5 mm.

As compared with a similar alloy not containing columbium, the alloy described above has the advantage, due to the fine grain structure which columbium confers, that the ductility associated with a certain tensile strength is greater.

In the simple alloys of aluminum with copper, such as that containing 7% copper, the incorporation of columbium in the form of an aluminum-columbium alloy refines the grain and improves the strength and ductility of castings.

We claim:

1. Aluminum base alloy containing 0.5% to 12% copper, iron in a proportion not over 2%, 0.05% to 1% columbium, remainder aluminum.

2. Aluminum base alloy containing 0.5% to 12% copper, iron in a proportion not over 2%, 0.1% to 0.5% columbium, remainder aluminum.

3. Alloy as defined in claim 2, wherein the proportion of copper is about 7% and the proportion of columbium is 0.1% to 0.2%.

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