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FREE CUTTING ALLOYS

Louis W. Kempf and Walter A. Dean, Cleveland, Ohio, assignors to Aluminum Company of America, Pittsburgh, Pa., a corporation of Pennsylvania

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5 Claims. (Cl. 75—142)

The invention relates to aluminum base alloys and is particularly concerned with aluminum base alloys containing copper and magnesium.

Aluminum base alloys containing between 3 per cent and 12 per cent of copper have been widely used heretofore. The copper imparts good casting characteristics and increases the tensile strength, yield strength, and hardness of the alloy. In the lower portion of the copper range the alloy may be mechanically deformed by the well known commercial processes such as rolling, forging, drawing, or extrusion. Alloys containing more than about 6 per cent copper are generally used in the cast condition. Throughout the entire range of 3 to 12 per cent copper, however, the alloys are susceptible to variations and improvements in their physical properties by thermal treatments.

The addition of magnesium to the foregoing aluminum-copper alloys in amounts of from 0.1 to 1 per cent causes the alloy to age spontaneously at room temperature after a solution heat treatment. Alloys of this nature develop a much higher strength and hardness by heat treatment than it is possible to obtain by cold working alone. An even higher strength can be obtained by reheating the alloy to a relatively low temperature after solution heat treatment. These alloys are particularly adapted to use in structures that are highly stressed in service. Because of the high strength which is attainable in these alloys when heat treated and aged, they are generally used in this condition. Our invention which is described hereinbelow, is directed to improving the machining quality of such alloys.

There are, however, some applications wherein aluminum-copper-magnesium alloys as hereinabove disclosed might be conveniently and profitably used except for an inherent disadvantage which militates against their use in the production of certain articles requiring exacting machining operations. Mechanical cutting operations such as drilling, shaping, or lathe-cutting are successfully carried out only by using certain precautions which increase the cost of production and perhaps favor the choice of another metal or alloy which can be machined more readily but which is not so desirable in other respects, as for example, in physical properties. When alloys are difficult to machine this disadvantage becomes evident, in many cases, through rapid wear of the cutting tool edge, so that frequent tool re-sharpening is required. Despite continual lubrication the machined surface is rough and irregular, and the chip has a tendency to form a continuous curl or spiral which often fouls the tool or the moving parts of the machine. It is immediately apparent that there is need for an alloy of good working characteristics and satisfactory physical properties, yet possessing such favorable machining properties that the complete machining operations may be performed economically and successfully, and may be productive of a pleasing surface appearance.

Accordingly an object of our invention is the provision of an aluminum base alloy containing from about 3 per cent to about 12 per cent of copper and from about 0.1 to about 1 per cent of magnesium which may be readily and economically machined.

Our invention resides in the discovery that the foregoing object is effected by the addition of two or more of the elements lead, tin, thallium, cadmium or bismuth. The aluminum-copper-magnesium alloys to which these elements are added in the proportions specified below, are known as free cutting or free machining alloys because they can be machined more rapidly than similar alloys without these elements and yet have as good or a better finished surface. After an extended series of investigations we have discovered that these five metals when added to aluminum-copper-magnesium alloys, form a class of alloying elements by reason of their favorable effect upon the machining properties of these alloys. In recognition of this effect we term lead, tin, thallium, cadmium and bismuth "free machining" elements. We have further discovered that the simultaneous presence of two or more of these elements is productive of an improvement in free machining characteristics which is considerably greater than that caused by the presence of the same total amount of a single free machining element. For example, the addition of 0.5 per cent of lead and 0.5 per cent of bismuth to an aluminum base alloy containing about 5 per cent of copper, 0.5 per cent magnesium, effects a greater improvement in machining quality than does the addition of 1.0 per cent of either lead or bismuth singly.

These five elements, we believe, are unique with respect to their effect on the machining characteristics of aluminum-copper-magnesium alloys. It is a fortunate circumstance, therefore, that they are also of relatively low melting point, a fact which makes possible their addition to molten aluminum in the pure state, without the intervention of so-called "rich alloys". As a matter of fact, we have observed that of all the metals whose melting point is lower than about

327° C., the melting point of lead, the five elements we have selected are the only ones which are commercially suitable and that impart free cutting characteristics but do not have undesirable effect on the fundamental physical properties of the base alloy.

The total amount of free machining elements should not be less than about 0.05 per cent since below this amount there is scarcely any advantageous effect. We have determined that a maximum limit of about 6 per cent total of two or more of the free machining elements is sufficient for satisfactory commercial results, since although the free machining effect persists beyond this amount, certain of the other physical properties may be unfavorably affected.

Aluminum-copper-magnesium alloys containing two or more of the free machining elements, lead, tin, thallium, cadmium and bismuth may be machined more rapidly, with less tool wear, less tool sharpening, better quality of chip and better machined surface than the same base alloys without the free machining additions, and in fact better than the same base alloys containing an equivalent total amount of a single free machining element.

Since aluminum base alloys containing from 3 to 12 per cent of copper have a wide variety of applications we list several alloys each of which may be said to be preferred for a particular purpose. As an alloy for mechanical deformation we suggest an aluminum base alloy containing 5 per cent of copper, 0.5 per cent of magnesium, and a total of 1 per cent of free cutting constituents, for example, 0.5 per cent of bismuth and 0.5 per cent of cadmium, the balance being aluminum. For an alloy with excellent casting characteristics to be used in the unworked condition we suggest an alloy containing 10 per cent of copper, 0.5 per cent of magnesium and a total of 3 per cent of free machining elements, the balance being aluminum.

For certain purposes, notably the improvement of tensile strength, hardness and grain structure, the alloys as hereinabove disclosed may be improved by the addition of molybdenum, vanadium, titanium, tungsten, zirconium and chromium. From 0.05 to 1 per cent of any one of these elements may be used alone, but if more than one is employed the total amount should not exceed about 2 per cent.

It is characteristic of the five elements lead, tin, thallium, cadmium and bismuth that they form with aluminum a series of alloys of limited liquid solubility. We have reason to believe that the free machining elements are the only elements which exhibit this characteristic, with the possible exception of several metals which are not regarded as having any commercial promise as additions to aluminum base alloys. Within the range disclosed and claimed however the free machining elements may be added without unusual difficulty. We suspect that this characteristic feature of the disclosed elements may be one of the significant factors which contribute to their free machining effect. We believe that this effect is further strengthened by distributing the free machining constituent relatively homogeneously throughout the solid matrix, since these free machining constituents are also practically insoluble in the solid aluminum base.

The free machining alloys which have been described hereinabove may be subjected to the thermal treatments well known in the art to improve their strength and hardness. We have found that a solution heat treatment and subsequent aging does not impair the free machining quality of the alloys and in many instances the treatment even tends to improve this property. For many purposes a relatively high strength and hardness are necessary to the successful performance of the machined article and hence the alloy must be heat treated. This treatment is generally applied prior to the machining operation.

As hereinabove indicated the free machining elements, by reason of their low melting point, may be added to the molten aluminum alloy in pure metallic form. However, since some difficulty may be encountered in introducing them in the higher percentages of our disclosed range we prefer to use the method which is more fully described in U. S. Patent No. 1,959,029, issued March 15, 1934. Briefly it involves heating the melt to a somewhat higher temperature than is customary, and vigorously stirring it in excess of a critical period of time.

The term "aluminum" as used herein and in the appended claims embraces the usual impurities found in aluminum ingot of commercial grade or picked up in the course of the ordinary handling operations incident to melting practice.

We claim:

1. An aluminum base alloy consisting of about 5 per cent copper, 0.5 per cent magnesium, 0.5 per cent lead and 0.5 per cent bismuth, the balance being aluminum.

2. An aluminum base alloy consisting of about 5 per cent copper, 0.5 per cent magnesium, 0.5 per cent bismuth and 0.5 per cent cadmium, the balance being aluminum.

3. A free cutting alloy containing from 3 to 12 per cent of copper, from 0.1 to 1 per cent of magnesium, and a total of from 0.05 to 6 per cent of at least two of the elements from the following metals, lead, tin, thallium, cadmium, and bismuth, to improve its machining properties, the balance being substantially aluminum.

4. A free cutting alloy containing from 3 to 12 per cent of copper, from 0.1 to 1 per cent of magnesium, from 0.05 to 2 per cent of hardening metal from the group composed of molybdenum, vanadium, titanium, tungsten, zirconium and chromium, and a total of from 0.05 to 6 per cent least two of the elements from the following metals, lead, tin, thallium, cadmium, and bismuth, to improve its machining properties, the balance being substantially aluminum.

5. An aluminum base alloy consisting of about 5 per cent copper, 0.5 per cent magnesium, 0.5 per cent cadmium, and 0.5 per cent lead, the balance being aluminum.

LOUIS W. KEMPF.
WALTER A. DEAN.

CERTIFICATE OF CORRECTION.

Patent No. 2,076,573. April 13, 1937.

LOUIS W. KEMPF, ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, second column, line 56, claim 4, after "per cent" insert the words of at; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 1st day of June, A. D. 1937.

Henry Van Arsdale
Acting Commissioner of Patents.

(Seal)