

UNITED STATES PATENT OFFICE

1,974,970

ALLOY

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No Drawing. Application August 17, 1933,
Serial No. 685,644

2 Claims. (Cl. 75-1)

This invention relates to aluminum base alloys adapted to being mechanically worked. It is particularly concerned with an improvement in wrought aluminum-manganese alloys.

Aluminum base alloys containing manganese as the predominant alloying ingredient have been widely used for making wrought articles where severe forming operations are performed, such as cooking utensils and tanks. In the production of sheet from which the articles are subsequently fabricated, the sheet is subjected to alternate annealing and mechanical working operations in order to obtain the desired thickness and temper in the final product. Unless these operations are carefully controlled, the metal will, upon annealing in the usual manner, immediately prior to fabricating the desired articles, develop an undesirable coarse-grained structure which is deleterious to the uniformity and appearance of the sheet. The development of a coarse-grained structure is particularly favored under the thermal conditions commonly existing in commercial practice where a large lot of material is slowly cooled from the annealing temperature after annealing. The coarse-grained material is quite undesirable for producing shaped articles such as cooking utensils by reason of the irregular extension of the metal when subjected to stretching as in a drawing operation. A fine-grained sheet on the contrary stretches uniformly over the stressed area. The irregular stretching of the coarse-grained material produces a roughened surface which cannot be satisfactorily polished. For this reason articles exhibiting the roughened surface must be discarded.

One of the objects of my invention is to eliminate the coarse grain non-uniform structure commonly occurring in annealed aluminum-manganese alloys which have been previously worked. A further object is to improve the grain structure of worked aluminum-manganese alloys without adversely affecting the tensile properties or corrosion resistance of the alloy.

I have discovered that when small amounts of the elements of the class composed of molybdenum and/or tungsten are added to aluminum-manganese alloys, the coarse non-uniform grain structure characteristic of this type of aluminum base alloy is eliminated. The ordinary aluminum-manganese alloys containing from 0.75 to about 3 per cent manganese are especially benefited by the addition of molybdenum and tungsten in small amount. The alloy containing from 1 to 1.5 per cent manganese which is widely used for the manufacture of cooking utensils is par-

ticularly susceptible to improvement according to my invention.

The amount of molybdenum and tungsten which I have found necessary to add to the aluminum-manganese alloys to avoid the coarse grain structure varies from about 0.02 to 0.5 per cent for each of the metals when used alone, or from about 0.05 to 0.5 per cent when both metals are present. In my preferred practice I use from about 0.05 to 0.2 per cent of each of the metals alone or in combination. In smaller amounts than 0.02 per cent I have observed that the elements molybdenum and tungsten are not so effective in reducing the size of the grains or improving the tensile properties. When employed in amounts in excess of 0.5 per cent there is no substantial increase in effectiveness and there is a marked decrease in ductility of the alloy which may render it unfit for the purpose to which the alloy is ordinarily adapted.

The alloys containing molybdenum and/or tungsten which have been tested possessed a fine grain structure and upon drawing into the shape of pans no roughened surface was developed such as is commonly found in coarse-grained material.

The addition of molybdenum and/or tungsten to aluminum-manganese alloys improves the tensile properties of the alloy as well as diminishing the grain size. An alloy of this type containing 1.25 per cent manganese in the cold worked condition has a tensile strength of about 29,000 pounds per square inch and a yield strength of about 25,500 pounds per square inch. When 0.05 per cent molybdenum is added, the tensile strength is raised to about 29,940 pounds per square inch, and the yield strength to about 27,000 pounds per square inch. When 0.05 per cent tungsten is added in place of molybdenum the tensile strength is 31,510 pounds per square inch and the yield strength is 28,150 pounds per square inch. The elongation of the alloys containing molybdenum and tungsten is substantially the same as that of the alloy without either of the added elements.

This cold worked material has a low ductility and should be annealed before any severe bending or shaping operations are performed. The 1.25 per cent manganese alloy without molybdenum or tungsten must usually be annealed at around 775° Fahrenheit, whereas the same alloy with either molybdenum and/or tungsten can be successfully annealed at 650° Fahrenheit and be very satisfactorily worked thereafter. The lower annealing temperature is of considerable economic advantage in saving cost of heating, time required for

heating, and in lessening the tendency to degree of grain growth occurring at higher temperatures.

In the annealed condition an aluminum base alloy containing 1.25 per cent manganese usually has a tensile strength of about 15,000 pounds per square inch and a yield strength of about 5,500 pounds per square inch. Such an alloy with 0.05 per cent molybdenum has a tensile strength of about 15,200 pounds per square inch and a yield strength of 5,400 pounds per square inch. When 0.05 per cent tungsten is substituted for the molybdenum, the alloy has a tensile strength of about 15,350 pounds per square inch and a yield strength of 5,950 pounds per square inch. It is thus apparent that the addition of molybdenum and tungsten does not substantially harden the annealed alloy and render it less suitable for shaping operations. These elements, however, are used with a view to the advantageous effect on the grain size, surface finish, and annealing temperature.

Molybdenum and tungsten may be added to the aluminum by any of the means known in the art, conveniently in the form of a "rich alloy" or "hardener" containing about from 2 to 5 per cent

of molybdenum or tungsten, the balance commercial aluminum.

It is to be understood, of course, that the alloys disclosed and claimed herein contain the usual impurities, such as copper, iron, and silicon in amounts not in excess of their usual occurrence as impurities.

I claim:

1. An aluminum-manganese alloy containing about 0.75 to 3.0 per cent of manganese and about 0.02 to 0.5 per cent of at least one of the class of alloying elements composed of tungsten and molybdenum, the alloy being of a fine-grained and uniform-grained structure such as is capable of being worked without substantial roughening of the metal surface.

2. An aluminum-manganese alloy containing about 1.0 to 1.5 per cent of manganese and about 0.02 to 0.5 per cent of at least one of the class of alloying elements composed of tungsten and molybdenum, the alloy being of a fine-grained and uniform-grained structure such as is capable of being worked without substantial roughening of the metal surface.

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