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ALUMINUM ALLOYS

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1 Claim. (Cl. 75—142)

This invention relates to aluminum alloys and more particularly to those which have an aluminum content of about 97% or higher

The main object of the invention is to provide an aluminum alloy which has a unique and highly important combination of desirable properties adapting it to a wide variety of uses. My improved alloy has as its general physical properties, hardness, ductility, great strength, marked elongation and high yield point under tensile stresses, low modulus of elasticity, extreme lightness, high resistance to corrosion, ability to attain brilliancy and whiteness, high electric conductivity, and high thermal conductivity.

It welds easily, extrudes into all shapes, spins with ease, may be readily rolled into all shapes or drawn into wire, is heat treatable, machines easily and satisfactorily and may be worked either hot or cold. It may be sand cast or precision cast and the castings may be readily welded, and the welds have great strength and ductility. The alloy shows, under the microscope, an extremely fine grain structure and an interlocking of the individual components of the structure. The fracture of cast test bars is fine grained, ragged and silky, and without being heat treated, has a tensile strength in excess of 45,000 pounds per square inch and a yield in excess of 40,000 pounds per square inch, with an elongation of 5%.

The wrought alloys have even higher values and cold rolled sheets without thermal treatment have exceeded a tensile strength of 65,000 pounds per square inch, and an elongation of 5%.

The combination of the various characters above referred to renders the alloy particularly suitable for a wide variety of uses such as for aircraft parts, for fuselage, fuel tanks, sidings, etc., for welded containers or cooking utensils, etc.

In my improved alloy, a considerable number of elements are employed. The percentage of each (other than the aluminum) does not exceed 1% and the total percentage of all of the added metals does not exceed about 3%.

The invention is based on the discovery that when a considerable number of certain elements in very small proportions are alloyed with aluminum, the resultant alloy is more ductile and more corrosion resistant than when fewer of the same elements are alloyed but having an equivalent total percentage. It is also based upon the discovery that when a group of corrosion resistant high melting point elements are alloyed with aluminum in such proportions that the solid solubility of the individual elements is not appreciably exceeded, the resultant alloy is superior in ductility, yield point, and grain structure than an alloy having a fewer number of the same elements but of equivalent total percentage. It has been discovered that silver imparts a corrosion resistance to multi-element aluminum alloys and makes the alloy particularly suited for damp, salty atmospheres and for use with food products in cooking operations.

As an example of an alloy embodying my invention, I give the following in percentages by weight of added ingredients where the total equals about 2.25% and the proportions by ounces in a 100 pound batch where the total may be more or less than 2.25% of the alloy. The remainder of the alloy is aluminum with possible traces of impurities not present to such an extent as to render the amount readily determinable by ordinary chemical analysis but possibly detectable by use of the spectroscope. The following is exemplary of the preferred composition and proportions of my alloy.

	Percentage	Ounces
Copper	.44 to .65	7 to 10½
Cobalt	.31	5
Nickel	.31	5
Molybdenum	.25	4
Magnesium	.25	4
Cadmium	.25	4
Silver	.19	3
Vanadium	.06	1
Tungsten	.06	1
Titanium	.06	1
Chromium	.06	1
	2.24	2.25 lbs.

Balance, aluminum, 97.75 lbs.

The cadmium is added to increase the machineability and also to impart the quality of corrosion-resistance.

Magnesium is a desirable element where it is desired to have the alloy heat treatable. It also acts to whiten the alloy, and by reason of its low specific gravity, it tends to neutralize the tendency toward increase in specific gravity due to certain of the heavier elements employed. Magnesium is a very important element of the alloy from the point of view of either artificial ageing or heat treatment. It should be understood that, while heat treatment is not necessary, the physical characteristics can be improved still further by means of heat treatment.

The silver and copper perform some of the same functions in the alloy but the silver is of very much lighter color and is very much more expensive. The copper, nickel and cobalt are im-

portant to secure solubility of the higher melting point elements. The silver imparts some of the silvery color to the alloy and from a color standpoint, compensates for other elements which tend to darken and is superior to copper from a corrosion resistant standpoint, particularly from salt spray and gives greater tensile strength.

Nickel and cobalt have somewhat similar properties in the alloy in that they impart strength, toughness, and hardness. They are also of value in that they are readily soluble in aluminum and are solvents for other elements such as molybdenum, tungsten, and vanadium, and therefore when used, the last mentioned elements are more easily dissolved in and uniformly disseminated throughout the alloy. From the standpoint of strength, toughness, and hardness, the values obtained from the use of nickel are slightly lower than from the use of cobalt.

It is important that both cobalt and nickel be employed. It is believed that the cobalt tends to neutralize injurious effects of iron or other impurities found in commercial aluminum. It also acts to effect and maintain a better dispersion of the molybdenum and the addition of even .1% imparts a marked improvement to the alloy.

Cobalt is employed as a solvent for the molybdenum and to effect the distribution of the latter in the alloy, and the resulting product is finer grained, the fracture is ragged and silky, and the alloy exhibits higher mechanical and endurance values. When but small amounts of cobalt and nickel are used to dissolve the required amount of molybdenum and other high melting elements, the resulting compounds dissolve slowly in aluminum at the usual temperatures. Cobalt is a better solvent for tungsten, vanadium, molybdenum and chromium than is nickel, and also increases the tensile strength.

By dissolving the molybdenum cobalt nickel compound in either silver or copper or both of these metals, the resultant poly metal compound dissolves in aluminum and the silver acts to increase the hardness and improves the color and corrosion resistance.

A small amount of cadmium should be used as it improves the machinability and the corrosion resistance of the alloy against salt spray. Cadmium offers a strong resistance to corrosion by alkalies.

The molybdenum increases the toughness and tensile strength. Furthermore, it gives high ductility. The chromium, titanium, tungsten and vanadium impart hardness.

Tungsten increases the hardness, yield point, and tensile strength, but darkens the color. Vanadium increases the tensile strength noticeably but as pure vanadium is of relatively high price, it is preferable to use only small amounts. Chromium increases the hardness without appreciably altering the other mechanical properties and also compensates by its whiteness the darkening effect of tungsten and vanadium.

The combined effect of tungsten, vanadium, and chromium increases the tensile strength, the yield point and the hardness in addition to raising the tensile strength at elevated temperatures.

Various different procedures may be employed in making the alloy. If all of the metals other than cadmium and magnesium are added to the aluminum at the same time, a very considerable amount of time is required to effect the proper solution of the higher melting point ingredients in the aluminum and it is therefore preferable to prepare an alloy of some of these metals and thereafter, add such alloy to the molten aluminum.

One procedure would be to place all of the alloying elements in powder form in the crucible, then adding aluminum and maintaining the heat until all of the elements are thereby dissolved. During the melting suitable precautions should be taken in preventing oxidation. When all of the ingredients are in solution the magnesium and cadmium may be added with a suitable deoxidizing scavenger and injected beneath the surface of the molten alloy. After skimming the dross the final alloy is ready to be poured into the mold.

Another procedure which may be employed is to melt the copper, silver, nickel and cobalt together and subdivide this alloy into equal proportions according to the number of other elements employed. To the separate portions of the copper, nickel, silver, cobalt alloy in molten condition, there are added a separate one of the other elements making a copper, silver, nickel, cobalt alloy with each element. These separate alloys may be carried in stock and weighed out according to the amount required in the final alloy and subsequently added to the molten aluminum to obtain the final product. Thereafter, there is employed the usual deoxidizing or scavenging steps followed by fluxing and skimming.

In the formula heretofore given, the added ingredients constitute approximately 2¼ pounds and may be used in making 100 pounds of alloy. In other words, the aluminum constitutes approximately 97¾%, and the 2¼ pounds constitute 2½% of the total.

One of the most important features of the alloy is the fact that solution heat treatment is not necessary to secure physical properties that are even higher than those secured in the alloys of the prior art even when the latter have been subjected to solution heat treatment. In order to secure the best results, all of the elements and substantially the proportions specified are important and critical.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

An aluminum alloy made by alloying the following constituents in substantially the following proportions:

	Per cent
Copper from	0.44 to 0.65
Cobalt	0.31
Nickel	0.31
Molybdenum	0.25
Magnesium	0.25
Silver	0.19
Vanadium	0.06
Tungsten	0.06
Chromium	0.06
Cadmium	0.25

and the balance of aluminum.

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