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ANODIZABLE ALUMINUM DIE CASTING ALLOY

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The present invention relates to aluminum alloys, and is particularly concerned with aluminum alloys of high purity which can be die cast and color anodized.

The aluminum alloys of the prior art may be anodized successfully when they are used in making sheet metal products or wrought metal products; but so far as I am aware, there is no aluminum alloy except the present invention which is adapted to be used successfully for providing aluminum die castings or other castings that can be anodized without defects.

The aluminum die castings of the prior art are generally characterized by the presence of pin point porosity and by the development of smut on the surface of the die cast alloy when anodized. The smut is evidenced by the fact that it rubs off the die casting; and the pin point porosity results in defects in the surface finish when anodized, producing streaks of varying color, whereas when the present alloy is used, the anodized products take color anodization in a uniform manner with a high brilliance and substantially free of any defects or smut.

The present invention may be said to be an improvement over the prior art patent to John A. Toleik, No. 2,383,026, issued August 21, 1945, on Aluminum Alloys, the improvement residing in the fact that the present aluminum alloy is of such high purity and is so constituted that it can be die cast and color anodized with substantial uniformity in the result.

The present improvement, however, does not comprehend or include the alloy covered by said prior patent, which is owned by the applicant herein, because the present invention comprises an entirely new alloy, having only some similar constituents and only six of these in the same percentage, while four of the same constituents are included in a substantially different percentage; and seven entirely new constituents, some of which are optional, are included in the present alloy.

It is to be understood that the essential constituents of the present alloy involve an intimate inter-relationship between the ingredients, which act chemically, each one upon the others, producing a new alloy, having new characteristics.

One of the objects of the invention is the provision of a new aluminum alloy of high purity which is adapted to be used for making die castings or other castings which can be color anodized with substantial uniformity and absence of defects in the product.

Another object of the invention is the provision of improved die cast products that can be color anodized successfully in a multiplicity of colors, including practically every color, hue, or shade, and in which the colors may be matched with any others to meet requirements of the user or purchaser.

Another object of the invention is the provision of an improved aluminum alloy for die casting which melts at a convenient die casting temperature, which has sufficient fluidity, which has a single melting and freezing point, which is not drossy in the pot, which is substantially free of soldering characteristics on a steel die that has been broken in, which may be reused in succeeding melts, and which has no element in such percentage that it precipitates out within the temperature ranges employed.

Another object of the invention is the provision of an improved die casting alloy which has excellent mechanical properties, such as high tensile and compressive strength, high ductility, good corrosion resistance, high malleability, lack of brittleness, freedom from pin point porosity and smut, self age hardening, and adapted to be anodized with substantial uniformity of finish.

Another object of the invention is the provision of an improved aluminum alloy which is substantially free of silicon and with which a standard anodizing process can be used to produce a die cast aluminum with a "hardware" finish, and in which the methods of handling in the die casting process are substantially normal, provided due attention is given to the proper gating, venting, and die layout.

The preferred formula for my aluminum alloy consists in substantially the following ingredients in the following amounts:

The higher the purity of the metal, the better the results are regarding anodizing but the preferred proportions give the best over-all results.

Ingredients	Ounces	Percentages by Weight Relative to 100% Aluminum Equals 1,600 Ounces	
		Approximate	Calculated
Cobalt	5	0.31	0.3125
Nickel	3½	0.22	0.21875
Molybdenum	5	0.31	0.3125
Magnesium	8	0.50	0.5000
Zinc	2	0.12	0.1250
Vanadium	1	0.06	0.0625
Chromium	1	0.06	0.0625
Iron	2	0.12	0.1250
Tungsten	1	0.06	0.0625
Titanium	1	0.06	0.0625
Boron	1	0.06	0.0625
Cadmium	2	0.12	0.1250
or	or		
Silver	2	0.12	0.1250
Copper	5	0.31	0.3125
Gallium	1	0.06	0.0625
Aluminum (99.7 percent pure)	1,600 to 2,400	100.00	100.0000

Gallium is optional, and may be omitted due to excessive cost, although it improves the alloy.

The purity of the aluminum may vary from 99.3 to 99.8 percent, but is preferably 99.7 percent.

The amount of aluminum may vary from 1600 ounces to 2400 ounces, but is preferably 1600 ounces.

The beryllium copper may be omitted if strength is not an important factor, but is preferably included for best characteristics.

Alternatively, boron may be omitted and replaced with an equal amount of titanium; or titanium may be omitted and replaced with an equal amount of boron; but the use of both of these elements is preferred in the proportions stated above.

The proportions of the ingredients and the temperatures used are critical for best results; and the list of elements employed is also critical for best results, with the foregoing and following exceptions, as the omission of any one of the essential ingredients will defeat the purpose of the alloy, but there is a range of proportions and there are limits of temperature which produce good results.

For example, silvrr or cadmium should be employed for providing a high luster when buffed; but silver will give a higher buffed luster than cadmium.

Tungsten and iron are essential because tungsten combines with the silicon residual impurities in the aluminum and with some of the iron constituents, and forms carbontungsten silicides, which drop to the bottom of the pot and remain as a sludge that is later removed.

Copper is essential for increasing the tensile strength, while beryllium also boosts the tensile strength, but may be omitted for sand casting or other castings, where a portion of the tensile strength may be sacrificed.

It is believed that the beryllium also prevents rapid oxidation of the surface.

Titanium and boron are considered essential for providing such a refined grain that pin point porosity is eliminated.

Magnesium and zinc act as hardeners and combine with the other elements to provide a hard surface condition which facilitates the application and preservation of the uniform anodized surface.

The other elements not specifically mentioned are combined with the ingredients of the alloy to provide an alloy having all of the desirable characteristics of high tensile strength, high ductility, high malleability, self-aging, machinability, fluidity for casting, lack of soldering, easier buffing and polishing, retention of high luster, uniform anodizability, elimination of smut.

The purity of the alloy, which is brought about by the elimination of residual impurities, aids in eliminating pin point porosity and increasing the electrical conductivity and heat conductivity.

The preferred method of compounding the alloy is as follows:

All of the ingredients, except aluminum, magnesium, cadmium, and boron are placed in a separate crucible and brought to a molten state. To accomplish this, the ingredients must be heated to a sufficiently high temperature so that all of the ingredients go into solution.

The last ingredient to go into solution is cobalt; and for this the temperature is estimated at 3300 degrees F., so that the melted ingredients in the separate pot are much hotter than the aluminum; but there is a larger volume or mass of aluminum, which tends to bring down the temperature of the mixture.

To determine when the cobalt has been melted into solution, the operator may probe in the mixture with a stainless steel rod to determine the absence of any lumps, which would be in the bottom of the pot, and which will be found to soften and to disappear as the cobalt melts.

1600 ounces of 99.7 percent pure aluminum is placed in a pot, preferably of clay graphite, and rapidly brought to a temperature of 1300 degrees F. As soon as the ingredients in the separate pot have become fluid they are poured into the molten aluminum and allowed to remain until completely absorbed, which may involve a period of approximately twenty minutes, without stirring. During the introduction of the ingredients from the separate pot the temperature tends to rise; but the temperature must not exceed 1400 degrees F., because above 1400 degrees F. the molten metal tends to absorb oxygen from the air, producing oxides.

As an example of permissible variation in temperatures, it should be noted that the temperature listed is an approximation only, and the preferred temperature is the minimum at which all elements drop into solution.

In the event the temperature of the aluminum should exceed 1400 degrees, the melt may be chilled by the insertion of a pig of pure aluminum, thereby degasifying the melt sufficiently to prevent destruction of the desired characteristics of the melt. This would increase the proportion of aluminum in the particular melt containing 1600 ounces of aluminum, but is permissible and shows that there is a variation permissible in the amount of aluminum.

After the first mixture of ingredients has been completely absorbed, as stated above, the magnesium and cadmium are together introduced into this combined melt until they, too, are completely absorbed, while maintaining the temperature at approximately 1300 degrees F.

The boron is then added as a grain refiner, and in certain instances, where a higher tensile strength is required, an additional 5 ounces of pure electrolytic copper is added.

The alloy is now ready for mixing and pigging. Fluxing and mixing should be accomplished either by bubbling pure oil filtered nitrogen through the melt for three minutes or chlorine gas for two minutes. Chlorine is preferable, but is more dangerous to handle.

The purpose is to mix the ingredients in the melt and to float or loose oxides and precipitate all hard particles to the bottom of the pot. The pot is now skimmed; and the alloy is poured into ingot molds to cool.

The result is an aluminum die casting alloy having high tensile strength, good corrosion resistance, high ductility, which can be bent over 180 degrees or twisted 90 degrees without fracture, lack of brittleness, highly malleable, self-age hardening, freedom from pin point porosity, high luster with minimum polishing, capable of being anodized in any color with uniformity, and freedom from defects, and a minimum amount of soldering characteristic with respect to the pots and dies.

Regarding variation in the proportions of the ingredients, a slight variation in the amount of any ingredient, except aluminum, may be permitted, such as 1 percent plus or minus of the total weight of that ingredient, but for optimum results the preferred proportions should be employed and controlled as described.

An exception in the use of ingredients is that of copper. If strength is not a determining factor in the end use of the casting, all the copper may be omitted, while still securing excellent results in anodizing.

If anodizing is not an important factor, up to two ounces of silicon may be tolerated, but if anodizing is the prime purpose of the casting, silicon must be eliminated.

Another exception is in the amount of pure aluminum used. Up to 2400 ounces of aluminum may be used in the formula with excellent results in anodizing, but the richer the alloy is in aluminum, the less desirable results are secured in other physical characteristics.

The amounts of the ingredients other than aluminum cannot be increased without going out of a eutectic into a supersaturated solution, but a variation of 1 percent of the amount stated plus or minus is permissible.

For example, the tungsten may weigh 99 percent of an ounce or 101 percent of an ounce, and the same is true of the other ingredients except aluminum and copper.

The proportions of the ingredients and the list of ingredients and the temperatures employed have been determined by trial and error and have been found to be critical to secure all of the good results and desirable characteristics described.

For example, the alloy has shown the following physical and mechanical properties when sand cast and heat treated or die cast, representing in every case a substantial increase over that of other die casting alloys on the market:

Ultimate tensile strength	39,700 p.s.i.
Yield strength	34,300 p.s.i.
Hardness	89 Rockwell "*e*" scale.
Young's modulus	13,000,000 p.s.i.
Elongation in 2 inches	4.0 percent.

It will thus be observed that I have invented a new aluminum alloy of such high purity that die castings made of this alloy can be color anodized with uniform freedom from defects.

The present alloy has substantially all the other desirable characteristics considered important for die casting and for anodizing, and incorporates the proportions of elements in an amount which is below the saturation point of each particular ingredient in aluminum, so that there is no element which tends to precipitate out of the finished alloy.

The alloy may be self-aged to provide maximum strength and hardness in about ninety days without dimensional changes.

In order to permit the handling of the castings they are preferably quenched in water on removal from the die or mold, and then aged at 420 degrees F. for eight hours to expedite the completion of the product.

This may increase the Rockwell "e" hardness from 60 as cast to 90 after aging.

There is an alternative method of compounding the alloy as follows:

A portion of the aluminum, such as, for example, 100 ounces, may be alloyed with the 1 ounce of tungsten.

Another suitable portion of aluminum may be allowed with the 1 ounce of chromium.

Additional portions of aluminum may be alloyed separately with all of the other ingredients until all of the 1600 ounces of aluminum have been combined separately with the other ingredients in the form of hardeners. All of these hardener ingots may be placed into a pot cold and brought up to a temperature of 1400 degrees F. to make the alloy.

This method of alloying gives passable results and is a common method of making alloys.

Another alternative method comprises the mixing of all the ingredients by adding them to 1600 ounces of pure aluminum in a cold state, and the entire cold metal mixture is brought up to the alloying temperature of 1400 degrees F. This method requires much more time for all of the elements to go into solution and is not the preferred way of making the alloy.

While I have described a preferred embodiment of my invention, many modifications may be made without departing from the spirit of the invention, and I do not wish to be limited to the precise details set forth, but desire to avail myself of all changes within the scope of the appended claims.

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

1. An aluminum alloy made by alloying the following constituents in substantially the following proportions and percentages.

	Ounces	Percentages by Weight Relative to 100% Aluminum Equals 1600 Ounces
Cobalt	5	0.31
Nickel	3½	0.22
Molybdenum	5	0.31
Magnesium	8	0.50
Zinc	2	0.12
Vanadium	1	0.06
Chromium	1	0.06
Iron	2	0.12
Tungsten	1	0.06
Titanium	1	0.06
Boron	1	0.06
Aluminum	1,600 to 2,400	100.00

2. An aluminum alloy according to claim 1, in which two ounces of cadmium are added, amounting to approximately 0.12 percent, to improve the luster of the alloy.

3. An aluminum alloy according to claim 1, in which two parts of silver are added, amounting to 0.12 percent, for improving the luster of the alloy.

4. An aluminum alloy according to claim 1, to which five ounces of copper are added, amounting to approximately 0.31 percent, for improving the strength of the alloy.

5. An aluminum alloy according to claim 4, in which the copper is four percent beryllium copper.

6. An aluminum alloy according to claim 5, in which one percent of gallium is added, amounting to approximately 0.06 percent, for the purpose of improving the strength of the alloy.

7. The method of compounding an aluminum alloy according to claim 2, in which all of the constituents, except aluminum, magnesium, cadmium, and boron, are separately brought to a molten state by being heated to a temperature sufficiently high to cause all of the ingredients to go into solution, after which the previously melted ingredients are poured into the molten aluminum and permitted to be absorbed without stirring, while maintaining a temperature at approximately 1300 degrees F. by adding extra aluminum, if necessary, and thereafter introducing the magnesium, cadmium, and boron into the melt.

8. The method of compounding an alloy according to claim 6, in which each of the ingredients is alloyed separately with approximately 100 ounces of aluminum and cast into ingots, the ingots being brought together from a cold temperature to a temperature of 1400 degrees F. to make the alloy.

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