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TREATING ALUMINUM-MAGNESIUM ALLOYS

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9 Claims. (Cl. 148—3)

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This invention relates to metallurgical processes and more particularly to metal heat-treating processes, and has for its object the provision of a method of heat-treating cast articles comprised of an alloy consisting of magnesium 9–12%, beryllium .20–.50%, boron .001–.05%, balance substantially all aluminum, whereby the physical properties of the alloy are greatly improved and the aging time subsequently to heat-treatment to obtain the maximum values of said physical properties is materially shortened.

Another object is to provide a method of heat-treating castings comprised of alloys of the above composition to develop therein consistently uniform physical properties within a minimum aging time interval.

Still another object is to provide cast products comprised of the above composition having consistently uniform high physical properties.

Other objects and advantages will be apparent as the invention is more fully hereinafter disclosed.

In co-pending applications Serial Nos. 631,231 and 631,232 filed on November 27, 1945, which applications are assigned to the same assignee as the present application, I have disclosed and claimed the improved alloy composition resulting from the degasification of aluminum-magnesium alloys containing 9–12% magnesium, and the addition to the degasified alloy of .001–.05% boron and of this amount of boron with beryllium .10–1% (respectively).

I have discovered that the function of the boron in the degasified aluminum-magnesium alloy in the low percentage range specified is essentially that of a grain refining agent and that by limiting the beryllium content to below that amount which is retained in solid solution in the alloy at or about its solidification temperature the function of the beryllium in such an aluminum-magnesium alloy thereby is essentially limited to that of a precipitated phase dispersing agent.

It is well recognized in the art that beryllium is substantially insoluble in solid aluminum and that in molten aluminum the Al·Be eutectic melting at 1193° F. contains about .87% Be, otherwise the information available as to the constitutional diagram of such Al·Be alloys is scant and in the main unreliable. Magnesium additions to the Al·Be alloy have been reported to have the general effect of increasing the solubility of Be in the aluminum although this solubility increase is relatively small and the information available as to these ternary alloys also is scant and unreliable.

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My researches have indicated that at temperatures approximating the solidification temperature of aluminum-magnesium alloys containing from 9% to 12% magnesium, a beryllium content within the range .10–.50% definitely remains or is retained in solid solution, and that with Be within this range the major portion of the Be held in solid solution at the solidification temperature precipitates out of solution as finely dispersed platelets within the grain interior as the temperature falls somewhat below the solidification temperature forming nuclei for the subsequent precipitation thereon and therearound of the greater portion of the precipitating Al·Mg compounds forming the hardening and strengthening precipitated phase characteristic of these Al·Mg alloys.

I have further discovered that the provision of a fine grain structure in these alloys by reason of the boron addition to the alloy and the provision of a finely dispersed precipitated phase within the grain as well as along the grain boundaries by reason of this limited and critical amount of Be additions to the alloy, markedly shortens the time intervals required for subsequent solution-anneal heat-treatment to redissolve the precipitated phase, for reprecipitation of the redissolved precipitated phase, and for subsequent aging, as well as providing for the obtainance in said alloys on such solution-anneal, precipitation hardening and aging of consistently uniform relatively high physical properties well beyond any heretofore obtainable in such Al·Mg alloys.

I have further discovered that by a particular method of solution-annealing and precipitation hardening, as will be hereinafter described, these uniformly high physical properties may be consistently obtained in these Al·Mg alloys, thereby greatly enlarging the field of utility of the alloys as heat-treatable casting alloys.

As one specific embodiment of the present invention but not as a limitation of the same I will describe the present invention as it has been adapted to the alloy containing approximately 10% Mg or one containing between 9.5–10.5% Mg.

This particular alloy within the broad range of magnesium content of 9–12% appears to possess the best combination of physical properties adapting it for the widest utility in the art.

This type of Al·Mg alloy has heretofore been made and the standard values for tensile strength, yield point and elongation, for example, obtain-

able in accordance with best prior art practice, has been reported as being 42,000–45,000 p. s. i.; 25,000 p. s. i.; and 12–14% respectively (Metals Handbook, 1939 edition). However, while these values are obtainable, they are obtainable infrequently and the greater proportion of castings made evidence values considerably less than these maximum values.

In accordance with the practice of the present invention, these values may be increased to 55,000–65,000 p. s. i. (T. S.); 30,000–40,000 p. s. i. (Y. S.) and 12–25% (elongation) and such values may be consistently and uniformly obtained.

This marked and consistently obtainable increase in physical properties in this type of Al·Mg alloy (Mg approximately 10%) is obtained in the following manner:

To the Al·Mg alloy in its molten state a beryllium content within the range .10–.50% is added. Preferably a beryllium content closely approximating .25% is employed. The molten alloy then is treated with boron trichloride (BCl_3) in accordance with the invention disclosed and claimed in my prior Patent #2,369,213, issued February 13, 1945, which patent is assigned to the same assignee as the present application, using a strong free flow of the BCl_3 for a time interval approximating 2 seconds per pound of molten metal to provide a sufficient excess of the boron trichloride to incorporate in the molten Al·Mg alloy an amount of boron within the range .001–.05%. Preferably an amount approximating .01% is desired in the alloy and in the absence of excessive amounts of gas and non-metallic inclusions in the molten metal treatment of the molten Al·Mg·Be alloy in this manner usually provides approximately this desired amount of .01% boron in the alloy.

The treated alloy is then permitted to stand quiescent for a time interval required for the melt to cool down to the desired casting temperatre to permit the residual gases contained therein to escape to the atmosphere and the alloy is cast into cast articles of desired size, shape and configuration, in accordance with standard practice.

After cooling to atmospheric temperatures, the cast article is removed from the mold, placed in a suitable annealing furnace and is reheated slowly to the usual solution-anneal temperature of approximately 820° F. After a time interval of approximately 3 to 4 hours at temperature, the solution-annealed article is quenched into an aqueous solution containing about 25% sodium chloride having a boiling point approximating 220° F. which solution is heated to its approximate boiling point, and the quenched article is permitted to remain in the solution for a time interval required for the solution and article to attain thermal equilibrium at 220° F.

The quenched article then is permitted to cool naturally in air to prevailing room temperatures approximating 60° F. and is aged at this temperature for a period of time approximating 90 days.

So treated the boron and beryllium-containing Al·Mg alloy containing about 10% Mg, will consistently and uniformly show a tensile strength, yield point, and elongation, within the broad ranges above given and about in the middle of the said ranges.

As another example, the same alloy containing 11% Mg, instead of 10% as in the above specific example, will consistently and uniformly show a tensile strength, yield point, and elongation more closely approximating maximum values of the range of values given for the 10% Mg alloy.

On the other hand, the same alloy having 9% Mg, instead of 10% as in the specific embodiment given, will consistently and uniformly show a tensile strength, yield strength and elongation more closely approximating the minimum value of the range of values given for the 10% Mg alloy.

In general, as the Mg content of the alloy increases I prefer to slightly increase the Be content using about .30% Be for the 11–12% Mg. Conversely, as the Mg content decreases to 9% Mg, I prefer to decrease the Be content to about .20% Be. The boron content of the alloy is preferably maintained consistently at about .01% as this percentage appears to provide the best grain size in the cast alloy for the purposes of the present invention. Higher boron percentages give a somewhat smaller grain size and lower boron percentages give a somewhat larger grain size.

From the above disclosure it is believed apparent that the invention may be widely varied without essential departure therefrom and all such modifications and departures thereof are contemplated as may fall within the scope of the following claims.

What I claim is:

1. The method of forming and treating cast articles comprised of an aluminum-magnesium alloy containing 9–12% magnesium balance aluminum to obtain therein consistently uniform high physical properties, which comprises forming a melt consisting of said alloy, degasifying and scouring the said melt and incorporating therein small fractional percentages of a grain refining element and a precipitating phase dispersing agent, casting the alloy into said cast article and cooling the same to atmospheric temperatures, reheating said cast article to its normal solution-anneal temperature for a time interval adapted to redissolve substantially all of the precipitated phase therein, cooling the solution-annealed article to a temperature approximating 220° F. at a rate equivalent to that obtained by the immersion of the article into an aqueous solution of sodium chloride having a boiling point of about 220° F. and heated to said boiling point for a time interval required to obtain thermal equilibrium between the immersed article and bath at 220° F. air-cooling the quenched article to room temperatures and aging the article at room temperatures for a time interval adapted to obtain equilibrium values of said physical properties.

2. The method of claim 1, wherein said grain refining element consists of boron within the range .001%–.05%; said precipitating phase dispersion agent consists of beryllium within the range .10%–.50%; the said solution-anneal temperature and time at solution-anneal temperature approximate 820° F. and 3 to 4 hours respectively; and said aging time interval approximates 90 days.

3. The method of treating cast articles comprised of an alloy consisting of from .001%–.05% boron, .10%–.50% beryllium, 9%–12% magnesium, and the balance substantially all aluminum, said alloy prior to casting having been degasified and scoured to the extent required to remove therefrom voids and non-metallic inclusions in the as-cast condition, said method comprising reheating the cast article to a solu-

tion-anneal temperature approximating 820° F. for a period of time approximating 3 to 4 hours, cooling the solution-annealed article to a temperature approximating 220° F. at a rate obtained by the immersion of the heated article in an aqueous solution of sodium chloride having a boiling point approximating 220° F. heated to said boiling point and leaving the same therein until the article and bath have attained an equilibrium temperature approximating 220° F., air-cooling the article to room temperatures and thereafter aging the same at room temperatures for a time interval required to attain a condition of constant physical properties.

4. The method of claim 3, wherein said aging time interval approximates 90 days.

5. The method of claim 1, wherein said alloy contains boron approximately .01%, beryllium approximately .25%.

6. Articles comprised of the alloy composition defined by claim 3, treated in accordance with the method of claim 3, characterized by consistently uniform physical properties of relatively higher values as compared to those characteristic of the same Al·Mg alloy without the boron and beryllium content treated by the same method and by prior art solution-anneal—precipitation hardening methods.

7. Cast articles comprised of an Al·Mg alloy containing 9% Mg, .001%–.05% B, .20%–.50% Be, balance Al, treated in accordance with the method of claim 3, said articles being characterized by a fine grained structure and by a uniform dispersion of the precipitated phase within the grains as well as along the grain boundaries and by a tensile strength approximating 60,000 p. s. i., a yield point approximating 35,000 p. s. i., and an elongation approximating 12%.

8. Cast articles comprised of an Al·Mg alloy containing 10% Mg, .001%–.05% B, .20%–.50% Be, balance Al, treated in accordance with the method of claim 3, said articles being characterized by a fine grained structure and by a uniform dispersion of the precipitated phase within the grains as well as along the grain boundaries and by a tensile strength within the range 60,000–65,000 p. s. i., a yield point within the range 35,000–40,000 p. s. i., and an elongation within the range 12%–20%.

9. Cast articles comprised of an Al·Mg alloy containing 11% Mg, .001%–.05% B, .20%–.50% Be, balance Al, treated in accordance with the method of claim 3, said articles being characterized by a fine grained structure and by a uniform dispersion of the precipitated phase within the grains as well as along the grain boundaries and by a tensile strength approximating 65,000 p. s. i., a yield point approximating 40,000 p. s. i., and an elongation approximating 20%.

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