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MAGNESIUM BASE ALLOY

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This invention relates to magnesium and magnesium base alloys containing at least 50 per cent by weight of that metal and retaining the easily oxidizable characteristics of magnesium. The invention also relates to methods of preventing oxidation of magnesium and such magnesium base alloys. Its general object is the provision of improvements which mitigate difficulties arising from the propensity of magnesium to oxidize when in contact with air, moisture or with other media containing oxygen. Commercial usefulness of a metal, such as magnesium, depends not alone upon its essential properties, or those which may be imparted to it by alloying it with lesser quantities of other metals, but also upon the ease with which the metal, or such alloys, may be remelted, cast, worked or otherwise formed into the various conditions and shapes necessary to ultimate use. The propensity of magnesium to destructively oxidize when in the molten state is great. Under many conditions, normal to the handling of other molten metals, molten magnesium burns or otherwise reverts to the oxide in very substantial part. When in the solid state, magnesium base alloys oxidize, under some conditions, to a comparatively severe extent. Since extensive handling of magnesium and magnesium base alloys in the molten condition is a necessary preliminary to operations designed to shape or work the metal, the difficulties presented by this pronounced tendency to oxidize are encountered in almost every instance and are universal in the magnesium industry.

Confronted with these problems the industry has devised methods and devices by which to shield molten magnesium and magnesium base alloys from contact with air and moisture, or other deleterious media, during manufacturing operations. One such method is to envelop the molten metal in a protective gas. Another is to constantly protect its exposed surfaces with a salt flux. Other more elaborate methods and devices are frequently necessary. Other means have also been sought to minimize the tendency of magnesium and magnesium base alloys to oxidize and to thus reduce the necessity for the expensive protective measures above mentioned. Calcium has been alloyed with the magnesium for this purpose, and while the magnesium or magnesium base alloy thus alloyed does not oxidize as severely as before the total effect is not sufficient to do more than supplement the usual protective measures. Better results have been obtained when beryllium has been added to magnesium or magnesium base alloys, it having been found that the effect of beryllium in minimizing the oxidation of magnesium is much greater than that of a corresponding amount of calcium. However, the use of beryllium as an alloying element in the amounts hitherto proposed has created other difficulties. It has been observed that when beryllium is present in a magnesium base alloy, the grain structure of the metal may be undesirably coarsened and the strength of the alloy substantially reduced. To cure these difficulties it has been suggested that an amount of zirconium be simultaneously added to the magnesium to prevent coarsening of the grain of that metal by the beryllium. However, zirconium alloys with difficulty with magnesium and tends to segregate in the alloys, and in many cases its use is considered expensive. Prior to the present invention there was no satisfactory means whereby it was possible to take advantage of the known effect of beryllium in a satisfactory and commercially effective way.

We have found that the hitherto unsatisfactory attempts to use beryllium for the above-described purposes result from previous misconceptions as to the amount of beryllium to be added to the magnesium or magnesium alloy and that successful use of beryllium depends upon the addition of a carefully controlled and minute amount of beryllium representing between 0.00005 and 0.001 per cent by weight of the total alloy. When these amounts are used it is possible to produce magnesium base alloy having a resistance to oxidation greater than, but grain size and physical properties substantially equal to, the same alloy devoid of beryllium. The amounts hitherto suggested—usually about 0.005 to 2.0 per cent by weight—are entirely too great. The minute amounts used in accordance with our invention are, despite the fact that they are of an order usually disregarded as a "trace" of an element, not present in primary magnesium metal and must be positively added thereto. Where secondary magnesium metal or alloy is available and contains beryllium in larger amount, it may of course be diluted with other magnesium to reduce the amount of beryllium in the final mixture to within the range postulated by this invention. The manner in which these minute quantities of beryllium may be added to primary magnesium metal is a matter of expediency governed mainly by considerations of accuracy and cost. The factor of importance is that the amount in the total final mixture be between 0.00005 and 0.001 per cent by weight of the whole. There may be used as an addition agent an intermediate alloy of beryllium and

magnesium or of beryllium and one or more of the other elements of which the alloy is to be composed because in this way the amount of beryllium added can be readily controlled. However, a beryllium salt decomposable at the alloying temperature to produce metallic beryllium may be also used as may any other means which affords control of the amount of beryllium finally present in the mixture.

While the benefits of our invention will be realized in substantial part when the beryllium is present in the magnesium in an amount which is between 0.00005 and 0.001 per cent by weight of the total alloy, we prefer in practice to add beryllium in amounts between 0.0001 and 0.001 per cent by weight, and by the use of amounts within this range we have obtained excellent commercial results. The reasons why the use of beryllium as an anti-oxidant in magnesium and magnesium base alloys has not been previously successful are more readily understood when it is realized that an addition of as small amount of beryllium as 0.0025 per cent by weight (prior workers have not suggested less than about 0.005 per cent) may decrease the tensile strength of a commercial magnesium base alloy by as much as 4000 pounds per square inch, which is often a decrease of 10 per cent or more in total strength, and the elongation by as much as 25 per cent of the total. Such an amount of beryllium in one instance reduced the number of microscopically observable metal grains per square millimeter of observed surface from about 100 to 2, which reduction is so great as to be a positive qualitative measure of a very substantial grain-coarsening effect. However, the addition of amounts of beryllium in accordance with the precepts of our invention often results in no decrease in either strength or elongation of the magnesium alloy and has not been observed to cause substantially harmful effects of this nature at any time. Moreover, the presence of beryllium in amounts between 0.00005 and 0.001 per cent by weight leads to no substantial coarsening of grain of the magnesium alloy as evidenced by the fact that the microscopically observable effect is usually of the order of a reduction of from, say, 100 observable grains per mm.^{2} of observed surface to 50 to 90 grains.

The beneficial effects of the addition of beryllium to magnesium in amounts in accordance with this invention are obtained in the various magnesium base alloys formed by adding to magnesium amounts of such alloying elements as aluminum, manganese, zinc, cadmium, silicon, copper, silver, cerium, calcium, zirconium and other elements usable or used in commercial magnesium base alloys.

The practice of this invention is particularly useful and beneficial in connection with magnesium base alloys containing about 2 to about 12 per cent by weight of aluminum either as the sole added alloying element (apart from the beryllium) or as but one of the alloying elements present. These alloys are very susceptible to grain coarsening caused by the presence of beryllium in the amounts used prior to this invention, and the benefits obtained by the addition and presence of the minute amounts of beryllium postulated by this invention are particularly striking. On the other hand the binary magnesium-manganese alloys, such as those containing 1 to 2 per cent of manganese, are generally coarse grained and the addition to them of beryllium, even in larger amounts than are contemplated by our invention, does not appreciably affect their grain structure. The amounts of beryllium which we add in accordance with our invention, however, may be provided to increase the resistance of these alloys to oxidation. Mention of these specific alloys is but illustrative of magnesium base alloys in the practice of this invention. The invention is limited only as expressed in the appended claims and is not intended to be limited to these specific alloys. The term "magnesium base alloys" as used herein and in the appended claims is intended to include alloys containing more than 50 per cent by weight of magnesium which exhibit, as most of them do, the pronounced oxidizing tendencies of pure magnesium.

We claim:

1. The process of handling molten magnesium and magnesium base alloy which consists in increasing the resistance to oxidation of the molten metal by providing in the metal an amount of beryllium equal to between 0.00005 and 0.001 per cent by weight of the total composition.

2. The process of handling molten magnesium and magnesium base alloy which consists in increasing the resistance to oxidation of the molten metal by providing in the metal an amount of beryllium equal to between 0.0001 and 0.001 per cent by weight of the total composition.

3. Magnesium base alloy containing beryllium in amount between 0.00005 and 0.001 per cent by weight of the total alloy and characterized by a resistance to oxidation greater than, and grain structure and physical properties substantially equal to, that of the same alloy devoid of beryllium.

4. Magnesium base alloy containing about 2 to about 12 per cent by weight of aluminum and beryllium in amount between 0.00005 and 0.001 per cent by weight and characterized by a resistance to oxidation greater than, and grain structure and physical properties substantially equal to, that of the same alloy devoid of beryllium.

5. Magnesium base alloy containing about 2 to about 12 per cent by weight of aluminum and beryllium in amount between 0.0001 and 0.001 per cent by weight and characterized by a resistance to oxidation greater than, and grain structure and physical properties substantially equal to, that of the same alloy devoid of beryllium.

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