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MAGNESIUM BASE ALLOY

John A. Gann, Midland, Mich., assignor to The Dow Chemical Company, Midland, Mich., a corporation of Michigan

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2 Claims. (Cl. 75—168)

The present invention relates to magnesium alloys and particularly to those in which magnesium predominates.

Binary alloys of magnesium and copper have been known for a long time, but they have not been used commercially because of their relatively low mechanical properties and their poor corrosion resistance.

The primary object of this invention is to produce magnesium alloys containing copper, having improved mechanical properties and corrosion resistance. Another object is to produce magnesium alloys containing copper that are amenable to heat treatment. Other objects and advantages will appear as the description proceeds.

The invention is based on the discovery that the properties and characteristics of the binary magnesium-copper alloys can be enhanced very materially by the addition of definite amounts of lead and that these ternary magnesium-copper-lead alloys can be further improved by the addition of definite amounts of at least one of the low-melting metals tin and zinc.

I have discovered that beneficial effects due to the addition of lead to the binary magnesium-copper alloys are obtained in general in alloys containing from about 0.5 to 15 per cent of copper to which has been added from about 0.5 to 20 per cent of lead. The amount of improvement depends on the relative percentages of copper and lead and on the condition of the alloy, whether cast, heat treated, or wrought. I have also discovered that additional improvements in properties and in corrosion resistance can be obtained by adding certain percentages of tin and/or zinc to these ternary magnesium-copper-lead alloys. Such quaternary and quinary magnesium alloys may contain from about 0.5 to 15 per cent of copper, from about 0.5 to 20 per cent of lead, from about 0.5 to 10 per cent of tin, and from about 0.5 to 10 per cent of zinc. For many purposes I prefer to use an alloy containing 80 per cent or more of magnesium and 20 per cent or less of total added metals.

The following examples serve to illustrate the property improvements obtainable in these magnesium-copper-lead alloys. A casting alloy containing 2 per cent of copper had the following properties—

Tensile strength	lb./sq. in.	12,200
Yield strength	lb./sq. in.	5,100
Elongation	per cent	3

The addition of lead in amounts varying from 3 to 8 per cent gave alloys with the following improved properties:

Tensile strength	lb./sq. in.	13,500–16,700
Yield strength	lb./sq. in.	5,300– 5,900
Elongation	per cent	3.0–4.7

Similar property improvements were likewise obtained in the higher percentage copper alloys. For example, a binary magnesium-copper alloy containing 6 per cent of copper had the following properties:

Tensile strength	lb./sq. in.	18,800
Yield strength	lb./sq. in.	8,700
Elongation	per cent	2.9

The addition of 2 to 6 per cent of lead gave the following improved properties:

Tensile strength	lb./sq. in.	20,500–21,200
Yield strength	lb./sq. in.	9,500– 9,800
Elongation	per cent	3.5–4.5

The additional property improvements obtained by adding at least one of the low melting metals, tin and zinc, to the above described ternary magnesium-copper-lead alloys are exemplified by the following illustrations. A ternary magnesium alloy containing 2 per cent of copper and 8 per cent of lead had a yield strength of 5,900 pounds per square inch and a Brinell hardness of 37.0. The addition of 2 and 4 per cent of tin raised these values to 6,400 and 7,200 pounds per square inch respectively and to 38.1 and 42.2 Brinell hardness respectively. Another ternary magnesium alloy containing 6 per cent of copper and 6 per cent of lead had a yield strength of 9,800 pounds per square inch and a Brinell hardness of 41.1. The addition of 3, 5, and 8 per cent of tin raised these values to 10,400, 12,600, and 13,000 pounds per square inch respectively, and to 42.8, 46.9, and 48.4 Brinell hardness respectively. In another instance, a quaternary magnesium alloy containing 2 per cent of copper, 8 per cent of lead, and 4 per cent of tin had a yield strength of 7,200 pounds per square inch and a Brinell hardness of 42.2. The addition of 2, 4, and 8 per cent of zinc raised these properties to 8,700, 9,200, and 11,300 pounds per square inch respectively, and to 44.3, 45.6, and 48.9 Brinell hardness respectively. Again, the ternary magnesium alloy containing 2 per cent of copper and 2 per cent of lead had a tensile strength of 12,400 pounds per square inch, a yield strength of 5,200 pounds per square inch, and a Brinell hardness of 35.9. The addition of 8 per cent of zinc raised these properties to 22,600 pounds per square inch, 8,600 pounds per square inch, and a Brinell hardness of 44.3 respectively. Similar property improvements were likewise obtained in alloys containing higher percentages of copper and/or lead.

Many of the specific alloy compositions falling within the scope of this invention are amenable to heat treatment. A solution heat treatment (S. H. T.) consisting of 16 hours at 425°–450° C., for example, produced a marked increase in the percentage elongation and impact toughness of most of the alloys. Improvements amounting to

20–300 per cent were obtained, the amount of property improvement depending on the composition of the alloy. This treatment likewise resulted in a 10 to 30 per cent improvement in the tensile strength of some of the alloys, particularly those containing appreciable amounts of zinc; and a subsequent precipitation heat treatment or aging (S. P. H. T.) for 16 hours at 175° C. resulted in still further property improvement, particularly in yield strength and hardness. This can be illustrated by the following examples:

Mg+2Cu+4Pb+8Zn—

Property	Sand cast	S. H. T.	S. P. H. T.
Tensile strength lb./sq. in.	21,200	28,400	28,200
Yield strength lb./sq. in.	8,500	8,100	16,100
Elongation percent	4.2	8.3	3.0
Impact toughness ft.-lb.	2.9	8.9	4.3
Brinell hardness	44.3	44.0	56.5

Mg+2Cu+8Pb+4Sn+8Zn—

Property	Sand cast	S. H. T.	S. P. H. T.
Tensile strength lb./sq. in.	19,900	26,600	30,300
Yield strength lb./sq. in.	11,300	10,300	21,600
Elongation percent	1.9	5.5	1.6
Impact toughness ft.-lb.	1.3	5.6	2.2
Brinell hardness	48.9	49.4	66.8

I have likewise discovered that the corrosion resistance of the magnesium-copper alloys may be markedly improved by the addition of lead and that the corrosion resistance of these ternary magnesium-copper-lead alloys may be still further improved by the addition of at least one of the metals, tin and zinc. In these investigations, the alloy specimens were subjected to an alternate immersion treatment in a 3 per cent solution of common salt (NaCl). The samples were in the salt solution approximately 15 seconds and then withdrawn and exposed to the air for approximately 2 minutes. This cycle was repeated continuously throughout the entire test. The loss weight was measured at the end of definite time intervals, usually 24 hours, and the results expressed as a decrease in the corrosion rate. The addition of lead, for example, in amounts varying from 2 to 8 per cent resulted in a 55 to 70 per cent reduction in the corrosion rate of the binary magnesium alloy containing 2 per cent of copper. In another instance the addition of 6 per cent of lead to a magnesium alloy containing 6 per cent of copper reduced the corrosion rate of the heat treated alloy by 68 per cent. It should be noted that heat treatment improved the corrosion resistance of the binary magnesium-copper alloys, but that this effect appears to be carried over to the magnesium-copper-lead alloys where it is augmented by the beneficial effect due to the presence of lead.

It has likewise been discovered that the corrosion resistance of the new ternary magnesium-copper-lead alloys can be further improved by the addition of small amounts of at least one of the low melting metals, tin and zinc. For example, the addition of 2 per cent of tin to a magnesium alloy containing 2 per cent of copper and 8 per cent of lead reduced the corrosion rate by about 47 per cent, or about 83 per cent as compared to the original magnesium alloy containing 2 per cent of copper. The addition of 3 per cent of tin to a magnesium alloy containing 6 per cent of copper and 6 per cent of lead was found to reduce the corrosion rate approximately 50 per cent, or about 84 per cent as compared to the original magnesium-copper alloy. Likewise, the addition of 8 per cent of zinc to a magnesium alloy containing 2 per cent of copper, 8 per cent of lead, and 4 per cent of tin reduced the corrosion rate by 84 per cent, or 98 per cent as compared with the original magnesium alloy containing 2 per cent of copper. Again, the addition of 8 per cent of zinc to a magnesium alloy containing 2 per cent of copper and 2 per cent of lead reduced the corrosion rate by about 98 per cent or about 99 per cent as compared with the original magnesium alloy containing 2 per cent of copper. Solution and precipitation heat treatments have likewise been found beneficial in the case of these quaternary and quinary alloys.

The use for which the alloy is intended is an important factor in establishing its composition. Alloys with relatively high percentages of copper and relatively low percentages of lead, or of lead plus at least one of the metals tin and zinc, are best where high thermal properties are required. On the other hand, if corrosion resistance and properties obtainable by heat treatment are more important the alloys should, in general, contain a smaller percentage of copper than of lead, tin, and zinc. Alloys containing 2 to 10 per cent of copper and 2 to 10 per cent of lead; or 2 to 8 per cent of copper, 2 to 8 per cent of lead, and 2 to 8 per cent each of at least one of the metals tin and zinc are in general suitable for the production of castings. For extruded shapes, the alloy should preferably contain less than 12 per cent total added metal.

The above alloys may be prepared by the well known methods of melting magnesium with a protective flux and adding thereto the respective alloy ingredients, either singly or simultaneously. Cast products therefrom are made in dies or in sand containing an oxidation inhibitor, such as ammonium fluoride compounds. Heat treatment of the magnesium-copper alloys containing lead and lead plus tin may be conducted at 450° C. for approximately 15 to 30 hours, while the zinc-bearing alloys should be heat treated for the same time at approximately 425° C. Aging or precipitation heat treatment may be conducted for 18 to 24 hours at 150° to 175° C. Extruded shapes are produced by die extrusion at temperatures of 250° to 400° C.

This application is a division of my co-pending application Serial No. 120,426, filed January 13, 1937.

Other modes of applying the principle of my invention may be employed instead of those explained, change being made as regards the ingredients and the steps herein disclosed, provided those stated by any of the following claims or their equivalent be employed.

I therefore particularly point out and distinctly claim as my invention:—

1. An alloy containing from about 0.5 per cent to 15 per cent of copper, from about 0.5 per cent to 20 per cent of lead, and from about 0.5 per cent to 10 per cent of zinc, the balance being magnesium.

2. An alloy containing from about 2 per cent to 8 per cent of copper, from about 2 per cent to 8 per cent of lead, and from about 2 per cent to 8 per cent of zinc, the balance being magnesium.

JOHN A. GANN.