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MAGNESIUM BASE ALLOY

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The invention relates to magnesium base alloys and more particularly concerns an alloy of this nature having a high degree of formability associated with other desirable physical properties, such as high tensile and yield strengths.

Magnesium base alloys are being widely used in various structural and mechanical arts where a light weight metal is highly desirable, such as for use in making castings, forgings, and the like. However, the use of these alloys in the rolled form to make sheet metal articles requiring forming operations, such as bending, drawing, and the like, has not progressed as rapidly due to the fact that in general alloys having good formability, permitting relatively sharp bends to be made without the article developing external cracks, usually have inferior strength characteristics.

It is, accordingly, the principal object of the invention to provide a magnesium base alloy which can be made into a rolled sheet or the like possessing a sufficient degree of ductility or formability to be sharply bent, drawn, or otherwise shaped, while having excellent tensile and yield strengths.

Other objects and advantages will be apparent as the description of the invention proceeds.

Our invention resides in the discovery that a magnesium base alloy composed of from about 1 to 10 per cent of nickel and from about 0.01 to 1 per cent of calcium, the balance being substantially all magnesium, is endowed with the aforementioned properties. While the properties of good formability or ductility associated with high tensile and yield strengths are manifest over the entire range of composition indicated, we have found that in general the preferred combination of properties, such as the most desirable ductility for forming operations, as well as exceptionally high tensile and yield strengths, is obtained when the alloy contains from about 2 to 6 per cent of nickel and from about 0.1 to 0.3 per cent of calcium.

The specific proportion of each alloying metal and the total amount of alloying metals to be employed in the new alloy depends upon the use for which the alloy is intended. For example, in alloys where exceptionally high ductility or formability associated with good tensile and yield strengths is of principal importance, the alloy should contain from between about 2 to 4 per cent of nickel and from about 0.1 to 0.3 per cent of calcium. While in those instances where high yield and tensile strengths are of more importance, the nickel content of the alloy may be in the order of from 6 to 10 per cent.

The following table lists some of the properties of rolled sheet metal made from our new ternary alloy and compares these properties with those of rolled sheet made from related binary alloys. A comparison of the properties illustrates the improvement in ductility and strength characteristics of the new alloy over that of the closely related binary alloys. In the table, the per cent elongation is to be regarded as a measure of the ductility or formability of the specimen.

Table

Nominal composition in percent (magnesium= remainder)		Annealed			Cold rolled	
Ni	Ca	Yield strength in lbs./sq. in.	Tensile strength in lbs./sq. in.	Percent elongation in 2 inches	Yield strength in lbs./sq. in.	Tensile strength in lbs./sq. in.
------	0.3	17,000	30,000	13	27,000	32,000
0.8	------	17,000	32,000	11	23,000	31,000
0.8	0.3	21,000	34,000	19	34,000	40,000
2.0	------	20,000	34,000	10	25,000	33,000
2.0	0.3	23,000	35,000	13	36,000	43,000
6.0	------	29,000	39,000	6	32,000	38,000
6.0	0.3	26,000	37,000	10	39,000	46,000
9.0	------	36,000	42,000	2	37,000	42,000
9.0	0.3	29,000	39,000	10	41,000	47,000

The properties in the above table listed under the section headed by the term "annealed" were obtained by first rolling the alloys at a temperature between about 600°–800° F. and thereafter annealing them at various temperatures in the temperature range from 400° to 800° F. The properties selected for the table were those of the annealed specimens which exhibited the

maximum elongation. The properties listed under the section headed by the term "cold rolled" were obtained by subjecting specimens of the alloys which had been hot rolled at from 600° to 800° F. to additional rolling in the cold state to bring about a total reduction of from 2 to 10 per cent. The properties selected for the table were those of the cold rolled specimens which showed the greatest tensile and yield strengths, while having at least a 1 per cent elongation in 2 inches.

By a comparison of the properties listed in the above table, it will be observed that the combined properties of the new ternary alloy are superior to those of the related binary alloys having similar percentages of alloying ingredients. For example, it will be noted that the compositions containing the lower percentages of alloying ingredients show a maximum elongation or ductility, while having good yield and tensile properties in the annealed state; while those having higher percentages of alloying ingredients show good ductility coupled with exceptionally high yield and tensile strengths. Similarly, it will be noted that the properties of the cold rolled specimens made from our new alloy show improved strength characteristics. These improvements are characteristic of the new alloy throughout the range of alloying ingredients indicated.

While the new alloy is most useful in the wrought form, such as sheets, due to its formability characteristics, it may also be suitably used for making castings, forgings, extruded forms and the like.

The alloy may be compounded in any of the ways known to the art, such as by adding the alloying ingredients to molten magnesium under a suitable flux. The flux should be substantially free of magnesium chloride if the calcium content in the alloy is to be above 0.3 per cent. In those instances where an alloy is to be compounded containing less than 0.3 per cent of calcium, magnesium chloride may be present in the flux without exerting undue deleterious effects, but in this case it is usually preferable to add the calcium last without too much stirring or agitation in order that loss of calcium into the flux may be substantially prevented.

We claim:

1. A magnesium base alloy containing from about 1 to 10 per cent of nickel and from 0.01 to 1 per cent of calcium the balance being magnesium.

2. A magnesium base alloy containing from 2 to 6 per cent of nickel and from 0.1 to 0.3 per cent of calcium, the balance being magnesium.

3. A magnesium base alloy containing from 6 to 10 per cent of nickel and from 0.1 to 0.3 per cent of calcium, the balance being magnesium.

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