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COPPER-MAGNESIUM ALLOYS OF IMPROVED PROPERTIES

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This invention relates to alloys and more particularly to copper alloys of improved characteristics.

The object of the invention is to produce an improved copper base alloy.

Another object is to produce an age-hardened copper-magnesium alloy.

Another object is to produce a copper alloy which has an excellent combination of hardness, electrical conductivity and resistance to annealing.

Other object of the invention will be apparent from the following description taken in connection with the appended claims.

The present invention comprises a combination of elements, methods of manufacture and the product thereof, brought out and exemplified in the disclosure hereinafter set forth, the scope of the invention being indicated in the appended claims.

The invention relates to the alloys of copper-magnesium and a metal taken from the iron group, characterized by the addition of silicon adapted to form silicides with an element taken from the iron group. While these alloys may vary in their physical characteristics with the type of treatment received and the proportion of various ingredients, they will generally be characterized by high conductivity and hardness and by heat and oxidation resistance.

According to the preferred method of carrying out our present invention, an alloy is made containing copper, magnesium, an element from the iron group and silicon in approximately the following proportions:

	Per cent
Magnesium	0.1 to 3
Material from the group: nickel, cobalt, iron	0.1 to 5
Silicon	0.1 to 3
Copper	Balance.

It is possible likewise to improve the alloys consisting primarily of the composition described above, but also containing small percentages of additional ingredients, such as silver, zinc, cadmium, tin, zirconium, calcium, lithium, titanium and manganese. In some instances phosphorus, aluminum or beryllium may be substituted, in whole or in part, for the silicon since they also form intermetallic compounds with the iron group metals.

In carrying out the present invention, a copper-magnesium alloy may first be made, according to the conventional alloy making procedure of the prior art, and then the hardening elements consisting of a metal taken from the iron group, in combination with the compound forming element silicon, may be added. It is also possible, however, to produce first a copper alloy containing an element taken from the iron group. The metal from the iron group may be added as such, or in the form of a hardener alloy or in the form of a compressed briquette, consisting of various proportions of copper powder and powder of the element taken from the iron group. After the melt, consisting of the above ingredients, reaches a certain temperature, the magnesium may be added, preferably in the form of a hardener alloy. The silicon may be added, either before the addition of the magnesium or afterwards.

After the alloy has been prepared according to such alloying methods as described above, the heat treatment may be carried out as follows: The alloy in the form of a billet or a sand casting or any form, is raised in temperature to above 700 degrees C., and preferably to a temperature in the order of 800 to 1000 degrees C. The alloy is then quenched from this high temperature and subsequently aged at a temperature below 700 degrees C., and preferably in the range between 300 and 600 degrees C. This heat treatment results in considerable improvement in the hardness of the alloy. For example, an alloy containing

	Per cent
Magnesium	0.5
Nickel	2.25
Silicon	0.5
Copper	Balance.

will have a Rockwell B hardness in the quenched condition, of 10 to 25. After aging for 16 hours at 450 degrees C., this hardness can be raised to 95 Rockwell B.

An alloy of

	Per cent
Magnesium	0.55
Nickel	2.14
Silicon	0.22
Copper	Balance.

had a zero Rockwell B hardness after quenching from 950 degrees C. It was hardened to 80 Rockwell B by aging for about 16 hours at 450 degrees C. The hardness was further increased to 91 Rockwell B by a cold reduction of 50% after aging.

Excellent properties have also been obtained with alloys which in addition to copper and magnesium, contain other elements taken from the

iron group in combination with silicon, adapted to form silicides with such metals of the iron group.

For example, an alloy of

	Per cent
Magnesium	0.70
Cobalt	2.11
Silicon	0.21
Copper	Balance.

was hardened to 68 Rockwell B after quenching from 950 degrees C., and aging 32 hours at 450 degrees C., and had an electrical conductivity of 45% of that of copper at this hardness. By cold working the material 60% between quenching and aging the hardness obtained after a short aging (½ hour) was increased to 88 Rockwell B. This hardness is higher than that obtained by cold working this material after aging. The best results are obtained if the cold working is quite severe such as 50 to 60%.

Our experiments have shown that if alloys are being made which do not contain magnesium, very heterogeneous products are obtained. This is particularly true if the materials are used for pouring into sand molds and are afterwards heat treated without any further hot or cold working. A great number of test pieces have been made and tensile test results varied from 2,000 p. s. i., to over 60,000 p. s. i. No apparent reason could be found for such great differences. Apparently, the melting conditions and the pouring temperature must affect the materials adversely, if they do not contain magnesium. The molten metals absorb gases which are given up during solidification and which are contained within the grain boundaries of such materials. In heat treating, these gases or other impurities expand and either fracture the grain boundaries completely or weaken same considerably.

The addition of magnesium to copper has completely eliminated such deleterious effects, the magnesium acting in various ways. It first completely deoxidizes the melt, it acts as a strong grain refining element and it makes materials more stable during subsequent heat treatments. It also produces a layer of oxide if heated in air, which protects the metal from further oxidation and in this respect alloys containing approximately 1% magnesium are found to be as good as aluminum bronzes containing as much as 5 to 10% aluminum. While it therefore was impossible to produce a satisfactory and commercial product with copper alloys of the type described, but free of magnesium, the present invention has overcome all of these inconsistencies and has resulted in the development of a metal which can be reproduced within close limits of tolerances as far as the physical properties are concerned.

The sand cast alloys containing substantial percentages of magnesium, such as 0.25% to 2%, were all found to have a high tensile strength exceeding 65,000 p. s. i. Furthermore, these alloys show a considerable amount of elongation and a reduction in area. Such ductility in cast alloys is a factor which contributes greatly to safety in operation, because a material which shows a high reduction in area will yield locally, and not fracture if excessive stresses are applied.

It was further found that these new improved alloys have electrical conductivities exceeding 35% of that of pure copper. The new alloys, therefore, will make ideal sand casting materials which may be used for a large variety of applications such as structural parts in electrical machinery, or parts which have to withstand heat and oxidation. Alloys of this type were found to be very satisfactory for large castings, particularly large wheels such as are used for feeding rolls, in electric welding of pipe. The alloys are also proposed for electric contacting elements of the type comprising pressure exerting welding electrodes and the like.

It also has been found that materials free of magnesium, have a tendency to fire crack at temperatures in the approximate range of 350 to 800 degrees C. Materials which have been previously hardened and are re-heated to such a range, have a decided tendency to form cracks. With our new material, this tendency has been very much decreased, because we provided a material of higher and more uniform strength of a very homogeneous and fine grained texture.

While the present invention as to its objects and advantages has been described herein as carried out in specific embodiments thereof, it is not desired to be limited thereby but is intended to cover the invention broadly, and within the spirit and scope of the appended claims.

What is claimed is:

1. An alloy composed of 0.1 to 3% magnesium, 0.1 to 5% of a material selected from the group consisting of nickel, cobalt and iron, 0.1 to 3% silicon, and the balance copper.

2. An age-hardened alloy composed of 0.1 to 3% magnesium, 0.1 to 5% of a material selected from the group consisting of nickel, cobalt and iron, 0.1 to 3% silicon and the balance copper characterized by high hardness and tensile strength, said alloy having the property of resisting the effects of heat at elevated temperatures for extended periods of time.

3. An electrical contacting element formed of an alloy composed of 0.1 to 3% magnesium, 0.1 to 5% of a material selected from the group consisting of nickel, cobalt and iron, 0.1 to 3% silicon, and the balance copper.

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