Patented Sept. 12, 1939

2,172,639

UNITED STATES PATENT OFFICE

2,172,639

COPPER BASE ALLOYS

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No Drawing. Application July 19, 1938, Serial No. 219,999. In Germany November 1, 1935

4 Claims. (Cl. 75—153)

This invention relates to copper base alloys and the invention is particularly concerned with a copper-beryllium alloy containing an addition element adapted to give the copper-beryllium alloy a number of improved characteristics.

Copper-beryllium alloys have been known for some time and are of advantage for many purposes because of the hardenability or heat treatability thereof, as well as other desirable physical properties.

For certain purposes a third metal has been added to copper-beryllium alloys to further improve the characteristics thereof, in some cases to meet certain special requirements. By the addition of some other ingredient such, for instance, as nickel, iron and silicon, certain improvements were effected, notably refinement of grain structure. Such ternary alloys have been of advantage for a number of purposes, but have also had some disadvantages, the nature of which will appear more fully hereinafter, although it may here be noted that the electrical conductivity of these prior ternary alloys was somewhat impaired.

I have found that by employing cobalt as an addition element to make a ternary copper-beryllium alloy, especially where the quantity of cobalt used lies within the ranges hereinafter specified, a number of substantial advantages are obtained in comparison with other ternary alloys of this general type.

One of the outstanding improvements of the present invention is maintenance of relatively high electrical conductivity even when the alloy is hardened to a high degree.

I have further found that cobalt not only makes possible the production of a fine grain structure, but still more important, affords improved controllability as to grain size. These characteristics are afforded, moreover, while maintaining a higher degree of electrical conductivity than has been possible heretofore when using other addition ingredients.

The alloy of the present invention is also improved as compared with prior alloys of the type under consideration because of increased tensile strength, especially after substantial cold working, such as drawing of a wire or similar piece.

An important consideration in alloys of the general type here involved is the employment of the lowest possible beryllium content, particularly in view of the relatively high price of beryllium. The amount of beryllium required may be reduced in accordance with the present invention by the addition of the cobalt.

As brought out in my copending application Serial No. 107,948, of which the present application is in part a division, heat treatment suitable for alloys of the type here under consideration may be effected by quenching from temperatures ranging between 500° C. and 800° C., and subsequently tempering at temperatures between 250° C. and 500° C. Between the quenching and the tempering or after the tempering the alloys can also be cold worked if desirable.

By variations in heat treatment some changes in physical properties may be brought about, and, as noted above, the improved alloy of the present invention is more controllable as to grain size by variation of the heat treatment than prior alloys of the general type in question.

In connection with the cobalt and its effect to retain high electrical conductivity, it may be noted that the reason for this may be that cobalt has very low solubility in copper, in view of which the cobalt is combined with the beryllium and does not go directly into solution in the copper.

This is in contrast with some other addition elements which have been employed in copper-beryllium alloys and as an illustration, reference is made to nickel-containing beryllium-copper alloys by way of comparison. In Table A just below are given comparative electrical conductivity figures for two different alloys, one of which contains cobalt and the other nickel. The figures represent percentage of conductivity in comparison with pure copper.

Table A

Temper	Be 2% Co .5% Cu balance	Be 2% Ni .5% Cu balance
(a) Annealed soft	19.3	17.8
(b) Heat treated from soft condition	24.1	22.2
(c) Cold drawn	18.4	15.1
(d) Heat treated from cold drawn condition	24.6	20.0

From the above table it will be seen that the alloy with the cobalt addition has materially improved electrical conductivity, especially in the heat treated condition. While some fluctuation in conductivity will result from certain changes in composition, in accordance with the present invention, the composition is preferably maintained at such figures that the electrical conductivity in the hardened condition equals at least 22% that of copper.

In Table B just below are given comparative figures for beryllium-copper alloys containing co-

balt and beryllium-copper alloys containing nickel as to tensile strength of drawn wire with increasing amounts of cold reduction.

Table B

Percentage reduction in area	Be 2% Co .4% Cu balance	Be 2% Ni .4% Cu balance
	Kg. per mm.	*Kg. per mm.*
0%	56	55
10%	76	78
20%	88	88
30%	103	103
40%	116	112
50%	122.5	117
60%	132.5	124

From the above table it will be seen that the beryllium-cobalt-copper alloy is noticeably improved as to tensile strength, especially after extensive cold working.

In carrying out the invention I prefer to operate within the ranges indicated in Table 1 just below:

Table 1

	Per cent
Be, from	.5 to 2
Co, from	.1 to 1
Cu	Balance

With regard to the foregoing table, it may be noted that in most instances the beryllium should be within from about 1% to about 2%, although for certain special purposes it may be carried up to about 2.5%.

The ranges of ingredients within which I have secured the best results, especially as to electrical conductivity, are as follows:

Table 2

	Per cent
Be, from	1.25 to 2
Co, from	.2 to .5
Cu	Balance

A specific example of an alloy which I have found to be unusually satisfactory from the standpoint of many physical characteristics, including electrical conductivity, is as follows:

Table 3

	Per cent
Be	2
Co	.25
Cu	Balance

With regard to the reference in the above tables of composition to the copper content, i. e., "Cu balance", it is to be understood that this definition as used above and in the appended claims is intended to include small amounts of addition ingredients and characteristic impurities of copper, such for example as silicon, iron and aluminum. Elements of this type may be present either as addition ingredients or merely as impurities, and in amounts even up to a total of about .3% do not materially alter the characteristic properties of the alloy. I have found, however, that to obtain the maximum conductivity, these other ingredients or impurities should be kept as low as possible and preferably below .1%.

The improved alloy of the present invention is also particularly useful for sand castings which, with other alloys of this general type have had a tendency to develop surface cracks during hardening treatment. With the alloy of the present invention this cracking is very greatly reduced.

For sand casting purposes the beryllium range is preferably from about 1.75% to about 2.25% and the cobalt between about .3% and 1%. Such castings may also be hardened to a very high degree,

What I claim is:

1. An alloy composed of the following ingredients in the proportions indicated:

	Per cent
Beryllium	.5 to 2.5
Cobalt	.1 to 1
Copper	Balance

2. An alloy composed of the following ingredients in the proportions indicated:

	Per cent
Beryllium	1 to 2
Cobalt	.1 to 1
Copper	Balance

3. An alloy composed of the following ingredients in the proportions indicated:

	Per cent
Beryllium	1.25 to 2
Cobalt	.2 to .5
Copper	Balance

4. An alloy composed of the following ingredients in the proportions indicated:

	Per cent
Beryllium	2
Cobalt	.25
Copper	Balance

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