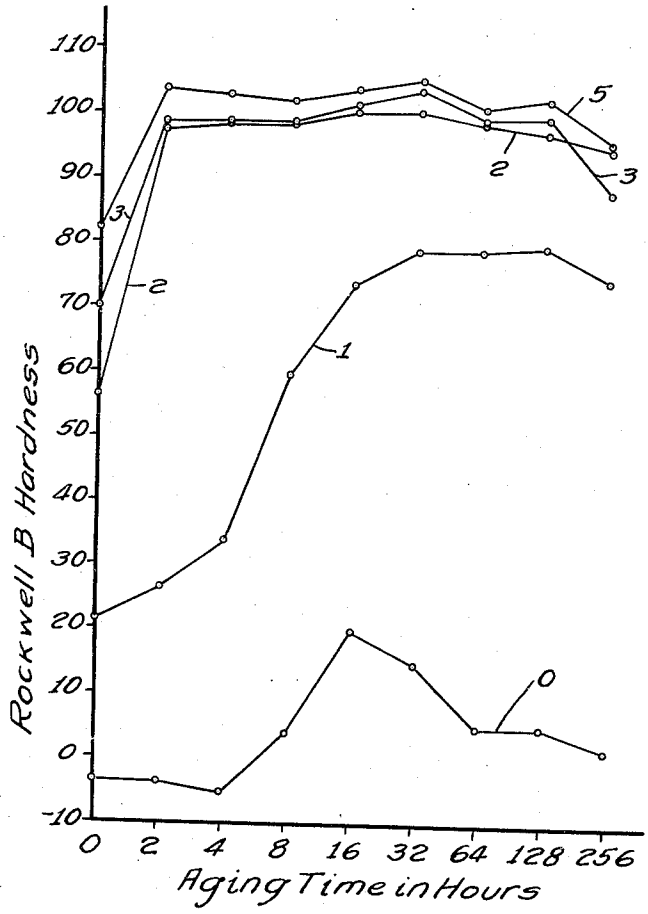
Aug. 6, 1940. J. M. KELLY 2,210,671

COPPER BASE ALLOY

Filed March 16, 1940



WITNESSES:

E. A. McCloskey

James N. Ely

INVENTOR

James M. Kelly.

BY

Ezra D. Savage

ATTORNEY

Patented Aug. 6, 1940 2,210,671

UNITED STATES PATENT OFFICE

2,210,671

COPPER BASE ALLOY

James M. Kelly, Trafford, Pa., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application March 16, 1940, Serial No. 324,433

5 Claims. (Cl. 75—159)

This invention relates to copper base alloys, and, particularly, to copper alloys of the aluminum bronze type.

Alloys of aluminum and copper are well known and are widely employed in industry. The aluminum copper alloys are generally classified as alpha-bronze or beta-bronze alloys, the alpha-bronze alloys containing up to 7.5% of aluminum, whereas the beta-bronze alloys contain from approximately 8% to 14% of aluminum.

Each of these alloys has distinct characteristics, the alpha-bronze alloys being resistant to oxidation and having a high strength, while at the same time having sufficient ductility to render them responsive to hot and cold working. The alpha-bronze alloys, however, are usually employed only in the wrought condition, since they cannot be hardened by heat-treatment.

As distinguished from the alpha-bronze alloys, the beta-bronze alloys containing from about 8% to 14% of aluminum have higher strength and can be heat-treated to control their hardness. The beta-bronze alloys, however, have the disadvantage that they cannot be cold worked, but are generally limited to use as casting alloys. Thus, each of the oxidation resistant aluminum bronze alloys are definitely limited to a particular class of uses.

It is an object of this invention to provide a copper base alloy of the aluminum bronze type which will have high physical strength, possess cold forming characteristics, and be susceptible to heat-treatment.

Another object of this invention is to provide a copper base alloy of the aluminum bronze-alpha type which will have desired characteristics of both the alpha-bronze and the beta-bronze alloys.

Other objects of this invention will become apparent from the following description when taken in conjunction with the accompanying drawing, the single figure of which is a graph, the curves of which illustrate the hardness values obtained for different representative alloys of this invention.

The alloys of this invention are prepared in accordance with standard melting practice from copper, aluminum, and cobalt. Sufficient aluminum is employed to give an aluminum content of up to 7.5% in the resulting alloy, whereby the resulting alloy is of the alpha-bronze classification, while from .5% to 5% of cobalt is employed for cooperating in the alloy to impart certain desired characteristics as will be explained more fully hereinafter.

With the aluminum content ranging from .5% to 7.5% and the cobalt content ranging from .5% to 5% and the balance substantially copper, it is found that the alloying elements are uniformly distributed throughout the alloy and that the alloy may be employed as a casting alloy or in the wrought condition.

In order to develop the mechanical strength of the alloy, it may be subjected to a precipitation hardening treatment comprising subjecting the alloy to a high temperature below the melting point of the alloy for obtaining a high solid solution of the cobalt in the alloy, quenching the alloy from the high temperature to retain the cobalt in solid solution and then reheat or age the alloy at a lower or ageing temperature for a period of time sufficient to precipitate the cobalt or one of its compounds from the solid solution of state. In practice heating the alloy at a temperature of between 750° and 1025° C. is found to effect a high solid solution of the cobalt in the copper, while reheating at a temperature of between 350° C. and 650° C. effects the precipitation of cobalt or cobalt compounds to impart desired characteristics to the resulting alloy.

As a specific example of the improved hardness characteristics obtained with the alloy of this invention, reference may be had to the drawing, the curves of which represent the values obtained for different representative alloys illustrating this invention. In the drawing, the abscissa represents the ageing time in hours, and the ordinate represents the Rockwell B hardness values obtained. The curves of the figure are based on hardness values obtained employing the five alloys of the following table, the aluminum alloying content of these alloys being maintained a constant in order to better illustrate the beneficial effects of cobalt as an alloying element in alpha-bronzes of the copper aluminum type.

Alloy No.	Composition		
	Percent Co	Percent Al	Percent Cu
3869		7	93
3867	1	7	92
3871	2	7	91
3872	3	7	90
3873	5	7	88

In the drawing curves 0, 1, 2, 3, and 5 represent the results obtained on the alloys in the order given in the table and containing 0, 1, 2,

3, and 5% of cobalt, respectively, after they were subjected to a heat-treatment consisting of quenching them from a temperature of 950° C. and ageing them at a temperature of 500° C. for different periods of time. From these curves, it is quite apparent that the cobalt is effective in cooperating with the aluminum in the copper base to give an alloy of improved characteristics. This is quite apparent in comparing curves 1, 2, 3, and 5 which represent the results obtained with the ternary alloy as against the results shown by curve 0 which represents results obtained with binary copper-aluminum alloy.

The alloys of this invention have very good thermal endurance characteristics, that is, the characteristic to retain its hardness at elevated temperatures as is evident from an examination of the curves 2, 3, and 5 of the drawing as distinguished from the poor thermal endurance characteristics of the binary copper aluminum alloys represented by curve 0.

With the copper, cobalt, and aluminum alloy of this invention, it is found that high tensile strengths are obtained and that, further, the alloy can be employed in both the cast condition or in the wrought condition, the alloy being susceptible to cold deformation without damage thereto. As illustrative of the high tensile strengths obtained both in the heat-treated cast condition, and also in the heat-treated and cold-worked condition, reference may be had to the following table in which the results obtained in the alloys identified in the table given hereinbefore are given:

Alloy No.	Tensile strength, pounds per square inch	
	Treatment A	Treatment B
3869	31,400	48,000
3867	54,200	74,500
3871	106,000	110,000
3872	106,500	107,600
3873	112,000	118,700

In obtaining the results listed in the foregoing table, each of the alloys was subjected to each of two treatments, Treatment A, consisting of quenching the alloy from a temperature of 1000° C. and ageing it for 20 hours at a temperature of 500° C., while Treatment B consists of a similar heat-treatment with the addition of supplementary cold work in the amount of a 25% reduction in area. As is quite apparent from the results given, the tensile strength of the copper base alloy containing cobalt is appreciably larger than the tensile strength of the binary copper aluminum alloys. Further, the alloys of this invention have sufficient ductility to permit the cold working of the alloys even in the "as hardened" state.

As a further advantage of the alloys of this invention, it is found that the oxidation resistant characteristics of the ternary alloys surpass those of the binary alloys. As a specific example of the improvement in the oxidation resistant characteristics, where identical articles formed from the binary copper aluminum alloys and from the ternary copper aluminum alloys of this invention were placed in a large electric furnace in which there was a free circulation of air and heated at a temperature of 850° C. for a period of time of 60 hours, it was noted that the binary alloy article had a very thin, dark oxide film on its surface, while the articles formed of the alloy of this invention remained in the bright condition without any evidence of the formation of oxide films thereon. This characteristic of being resistant to oxidation is especially noted for the ternary copper base alloys containing from 4% to 7.5% of aluminum and from 2% to 5% of cobalt.

While from the drawing, it appears that very good results will be obtained from the ternary alloy containing at least 2% of cobalt, it has been found that smaller additions of cobalt are quite effective in improving the hardness characteristic of the alloy. Further, it is found that the small additions of cobalt are quite effective when employed with lower aluminum contents of .5% to 3% for producing an alloy having the strength and hardness approaching that of standard aluminum bronze, while at the same time obtaining improved conductivity. In a specific example, a copper base alloy containing 2% of cobalt and 1% of aluminum is found to have a conductivity of 60% of that of pure copper, while having a higher strength than a similar binary copper aluminum alloy.

From the foregoing, it is quite apparent that an alloy containing copper, aluminum, and cobalt is produced which has the desired characteristics of both the alpha-bronze and beta-bronze copper-aluminum alloys in that it has excellent oxidation resistant characteristics, superior strength, and is sufficiently ductile to permit both hot and cold work. Further, the alloy is susceptible to precipitation hardening heat-treatment, and can be employed in either the cast or wrought condition as desired. Thus, an alloy is produced which, while possessing the cold forming characteristics of the alpha-bronze alloys, can at the same time be hardened by heat-treatment to obtain the physical properties of the beta-bronze alloys.

Although this invention has been described with reference to a particular embodiment thereof, it is, of course, not to be limited thereto except insofar as is necessitated by the description hereof and the appended claims.

I claim as my invention:

1. An alloy comprising from .5% to 7.5% of aluminum, from .5% to 5% of cobalt, and the balance substantially all copper.

2. An alloy comprising from 5% to 7% of aluminum, from 2% to 5% of cobalt, and the balance substantially all copper, the alloy being resistant to oxidation.

3. An alloy composed of about 7% of aluminum, about 2% of cobalt and the balance copper.

4. An alloy composed of from 5% to 7% of aluminum, about 3% of cobalt, and the balance copper.

5. As an article of manufacture, an alloy comprising from 5% to 7% of aluminum, from 2% to 5% of cobalt, and the balance substantially all copper, formed to a predetermined shape and precipitation hardened to give high physical strength, said article being resistant to oxidation.

JAMES M. KELLY.