March 10, 1936. F. R. HENSEL ET AL 2,033,709

COPPER ALLOY

Filed Feb. 8, 1935

Fig. 1.

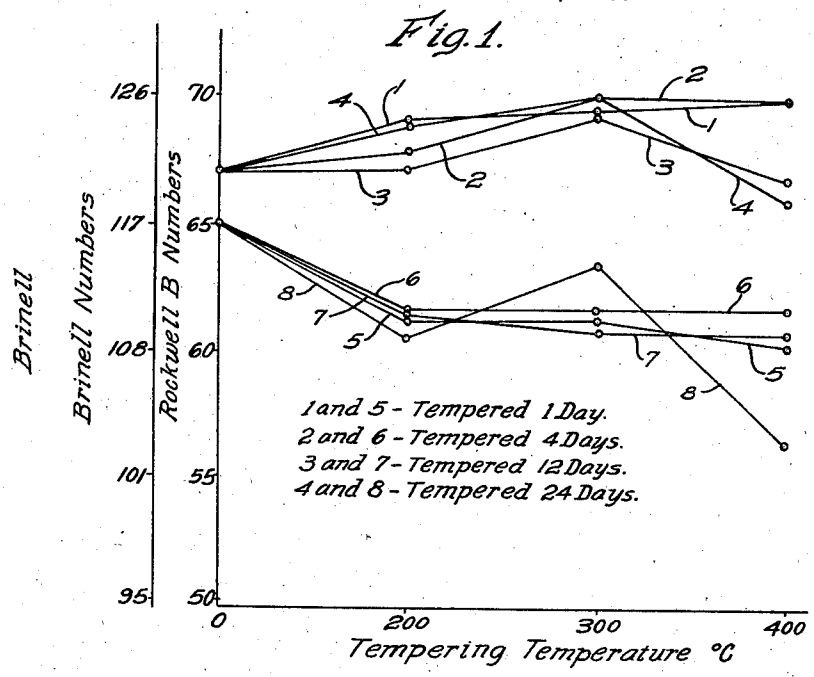
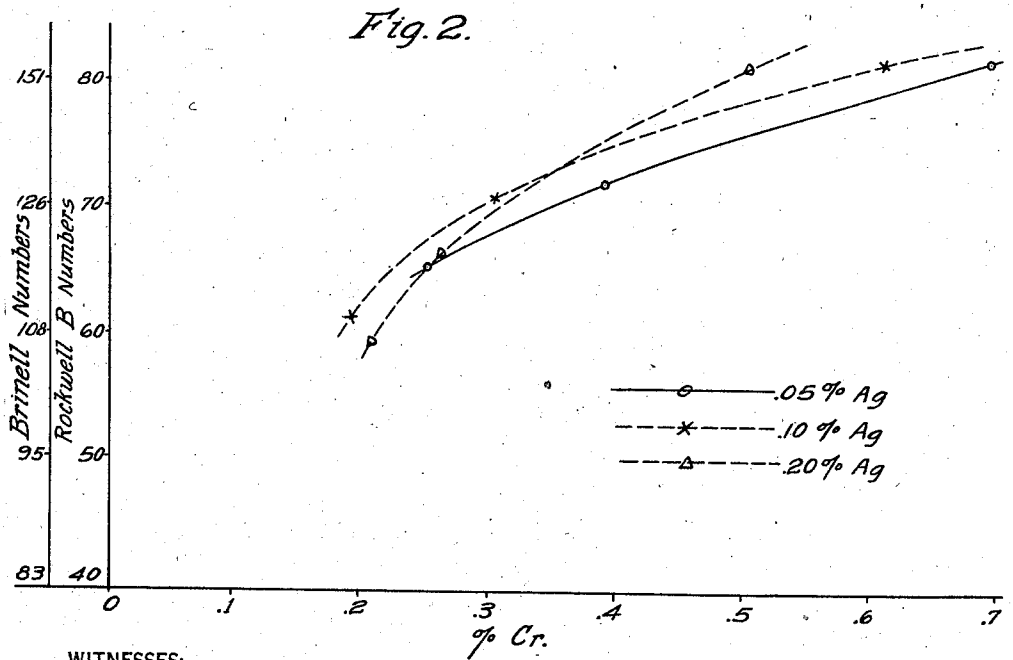


Fig. 2.



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COPPER ALLOYS

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7 Claims. (Cl. 148—32)

This invention relates to alloys and particularly to copper base alloys which have improved mechanical thermal and electrical properties.

Certain metals have been alloyed with copper to produce an alloy having better mechanical properties, but generally such alloys have been quite inferior to copper as conductors of electricity and it has been difficult to duplicate the resulting characteristics. Further, it has been found that these alloys have an upper limit of stability for maintaining their hardness and tensile strength of approximately 300° C.

An object of this invention is to produce an alloy of copper in which hardening elements are distributed throughout the resulting alloy in a finely divided state, improving the mechanical properties of the alloy and maintaining a high electrical and thermal conductivity comparable to that of copper.

Another object of this invention is to produce a copper base alloy having good mechanical properties and good conductivity and which will retain its desirable characteristics after being maintained at high working temperatures for long periods of time.

This application is a continuation in part of Serial No. 714,614, filed March 8, 1934, and directed to Copper alloys.

This invention may be better understood from the following description when read in conjunction with the accompanying drawing, in which:

Figure 1 is a graph illustrating the stability of the alloys containing silver which have been prepared in accordance with this invention and subjected to different tempering temperatures for different lengths of time as compared to an alloy in which the silver content is negligible and which has been subjected to the same tempering tests; and

Fig. 2 is a graph illustrating the effect of silver additions as affecting the hardness of the resulting alloy.

It has been discovered that by the addition of silver to a copper base containing from .1% to 5% chromium, an alloy may be produced which, upon being subjected to a suitable heat treatment, has excellent mechanical and electrical properties. It has been further discovered that the resulting alloys, containing between .01% and 5% silver, .1% and 5% chromium with the balance copper, have a higher limit of stability than other copper base alloys. Because of this high limit of stability, the copper chromium silver alloys retain their excellent characteristics even after being heated to temperatures above 300° C. for indefinite periods.

The introduction of the chromium into the molten copper to form a solution is difficult for chromium, because of its high melting point, dissolves but slowly in copper and the amount finally dissolved is small. Moreover, chromium being lighter than copper, it is difficult to keep the chromium submerged for the time required to dissolve it. The chromium tends to rise to the surface of the melt where oxides are formed that contaminate the product. The free chromium differs in density from copper and tends to segregate, either during melting or during freezing, particularly if the amount of chromium exceeds the solid solubility limit of chromium in copper and thus causes lack of homogeneity in the resulting solid product.

In practice, finely divided chromium may be added to the copper melt in the form of a compacted mass or mixture of intermixed copper and chromium powders, molded, pressed or sintered into a cake, pellet or rod, as described in the hereinbefore identified copending application. The silver may be added either in the form of pure silver or as a finely divided powder intermixed with the copper and chromium powders and compacted into the hereinbefore mentioned cake, pellet or rod.

The copper base alloys which have between .01% and 5% silver and .05% and 5% chromium content may be employed in making sand castings of complicated design. In cast alloys where the chromium content is above 1.5%, there is a tendency for the chromium to segregate and to thus produce unsound castings. This segregational effect of the chromium content of the alloy may be reduced by the use of rapidly cooled types of molds. Slower cooled types of molds may be employed where the chromium content of the alloy is about .5%. The alloys formed by such an addition have good pouring qualities and, when suitably heat treated, have excellent mechanical and electrical properties.

In practice, the castings made from the copper base alloys are aged by a suitable heat treatment to develop the mechanical and electrical properties of the alloy. A heat treatment which has been found to be satisfactory for developing the properties of the alloy is to heat the casting to between 900° and 1075° C., quench or quickly cool it and then reheat it to, and age it at, a temperature of between 250° and 600° C. to develop the hardness and conductivity.

A modification of the heat treatment of the

alloy is to age it for a time at a temperature of between 425° and 600° C. and then to continue the ageing for a longer period of time at a temperature between 250° and 425° C.

Alloys produced in accordance with this invention and quenched from a temperature of 1050° C. which have been aged for 16 hours at a temperature of 450° C. and then further aged for a period of 32 hours at 400° C. have been found to have extremely high hardness, excellent tensile strength and good conductivity and remain ductile with a high resistance to creep. The time of ageing may be varied. Where feasible, an intermediate cold working step may be interposed between the quenching and ageing steps.

It is, of course, understood that not all of the added and dissolved metals enter into solid solution in the copper but that the degree of solid solution of the chromium and silver in the copper is high relative to the ultimate solubility of each metal in the copper solvent. The quenching of the alloy appears to create a condition of super-saturation or metastability at normal temperatures. The reheating or ageing of the alloy precipitates the excess of dissolved metals from solid solution in the copper and distributes them in extremely small particles throughout the copper and with such relation to the matrix crystals as to harden and strengthen the entire solid. This removal of the solute from solution further increases the electrical and terminal conductivity of the resulting alloy.

Alloys comprising copper chromium and silver within the ranges hereinbefore given when heat treated by this method have a high Brinell hardness and good conductivity comparable to that of copper. As specific examples of the alloys thus prepared and heat treated, the following results are given. The copper content is omitted, it being understood that the balance of the alloying content comprises copper with possible incidental impurities occurring during the alloying process of not more than .007%.

Alloy No.	Percent Cr.	Percent Ag.	Cond.	Brinell hardness
3187	1.15	.60	85%	148
3184	.49	.401	91%	151
3183	.54	.199	89%	152
3189	.75	1.52	80%	169
	.65	2.00	82%	128
3177	.31	.103	96%	128
3176	.39	.044	90%	136

Referring to the drawing and specifically to the graphs of Fig. 2, the effect of the silver addition in the copper-chromium alloy is evident. These curves are illustrative of alloys containing .05%, .10% and .20% silver, as indicated on the drawing, and which have been subjected to the hereinbefore mentioned method of heat treatment. From these curves, it is apparent that those copper-chromium alloys containing from about .05% to .2% silver are desirable alloys. The slope of the curves illustrate the fact that with an increase in the silver content the hardness of the alloy increases at a faster rate for a corresponding increase in the chromium content.

Fig. 1 of the drawing illustrates the effect of the silver content on the stability of the copper-chromium alloy when subjected to high working temperatures over prolonged periods. Curves 1, 2, 3 and 4 are illustrative of an alloy comprising .36% chromium and .064% silver with the balance substantially copper, while curves 5, 6, 7 and 8 are illustrative of a similar alloy, but containing a negligible silver content of only .007%. As illustrated, the alloys containing .064% of silver remain fairly stable and retain a hardness value comparable to their initial value even after a prolonged heating at 400° C. for a period of twenty-six days. As illustrated by curves 5, 6, 7 and 8, the copper-chromium alloys containing a negligible amount of silver decrease in hardness after a similar exposure to high working temperatures for the prolonged period. These curves when compared indicate that it is the silver content of the alloy which increases the stability of the resulting alloy.

The relative amounts of the silver and chromium content in the copper base alloy is adjusted according to the hardness or strength and conductivity desired, it being found that the silver addition has a negligible tendency to lower the conductivity of the resulting alloy while substantially increasing its hardness. Although the alloys produced in accordance with this invention have an extremely high Brinell hardness, they yet remain ductile, and, where desired, may be worked into the shape or form desired, while maintaining their high physical properties.

Alloys prepared from the different alloying elements and within the ranges given above are particularly useful in the manufacture of large castings, such as commutator segments and collector rings for dynamo electric machines. These alloys having high strength and high conductivity are particularly adapted to be employed as the tips for mechanically operated welding electrodes, or as welding wheels, or as current collecting nozzles on automatic arc welding heads. An important use for these high strength alloys is as cylinder heads for internal combustion motors such as for automobile engines. These fields require a metal of high electrical or thermal conductivity combined with high strength at somewhat elevated temperatures. These alloys are also suitable for use at normal or low temperatures such as required for transmission wires.

It is, of course, to be understood that various modifications may be made in the alloying constituents as above described without in any way departing from the spirit of the invention as set forth in the appended claims.

We claim as our invention:

1. An alloy comprising from .01% to 5% silver from .05% to 5% chromium with the balance copper.

2. A alloy comprising from .04% to .6% silver, from .1% to 2.5% chromium with the balance copper.

3. An alloy comprising about .045% silver, about .4% chromium and the balance copper.

4. An age hardened alloy comprising from .01% to 5% silver, from .05% to 5% chromium with the balance copper which has been quenched from a temperature of between 900° and 1075° C. and aged at a temperature of between 250° and 600° C.

5. An age hardened alloy comprising from .01% to 5% silver, from .05% to 5% chromium with the balance copper which has been quenched from a temperature of between 900° and 1075° C. and aged for a period at a temperature of between 425° and 600° C. and then aged for a longer period at a temperature between 250° and 425° C. to develop hardness and conductivity.

6. An age hardened alloy comprising from .01% to 5% silver, from .05% to 5% chromium with the balance copper which has been quenched from

a temperature of 1050° C. and aged for a period of about 450° C. and then aged for a longer period at a temperature of about 400° C. to develop hardness and conductivity.

7. An age hardened alloy comprising from .01% to .6% silver, from .05% to 5% chromium with the balance copper which has been quenched from a temperature of between 900° and 1075° C., cold worked, and then aged at a temperature of between 250° and 600° C.

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