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ALLOYS

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

The present application comprises a continuation in part of my copending applications, Serial Number 6,857, filed February 16, 1935, and Serial Number 28,303, filed June 25, 1935.

An object of the invention is to improve the strength, hardness and temperature-resistant properties of copper base alloys of the type disclosed.

Another object is to improve the electrical characteristics of such an alloy, including its conductivity and its arc-snuffing properties.

Further objects are to prevent oxidation of the alloy both during and after formation thereof.

Still further objects are to improve the handling characteristics of the alloy during casting, forging, cold working or other subsequent operations.

A specific object is to produce an alloy for welding electrodes, contacts, trolley shoes and wheels, electrical conductors, bearings, castings and structural purposes and parts for equipment where high strength and high electrical conductivity are required and for applications where corrosion resistance is important.

The present invention comprises the 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.

While a preferred embodiment of the invention is described herein, it is contemplated that considerable variation may be made in the method of procedure and the combination of elements without departing from the spirit of the invention.

The invention contemplates the provision of an alloy of copper, chromium, zinc, and silver. This alloy as will be apparent from the following description has certain advantages over the copper-chromium-zinc alloy brought out in my above mentioned copending application, Serial Number 28,303.

The completed copper-chromium-zinc-silver alloy to have the most desirable characteristics should contain the component ingredients in the following ranges of proportions:

Zinc	0.1 to 5.0%
Chromium	0.1 to 2.5%
Silver	0.05 to 10%
Copper	Remainder

The selection of the exact composition to be used for any purpose will, of course, depend upon the degree of hardness, workability, corrosion resistance, electrical conductivity, strength and other properties desired for the application contemplated. The following alloy compositions are given as specific examples of preferable proportions for certain specific purposes:

a—Chromium	0.5%	
Zinc	0.5%	
Silver	0.05%	
Copper	Balance	
b—Chromium	0.5%	
Zinc	0.25%	
Silver	0.50%	
Copper	Balance	
c—Chromium	0.5%	
Zinc	0.25%	
Silver	1.0%	
Copper	Balance	
d—Chromium	0.5%	
Zinc	1.25%	
Silver	0.05%	
Copper	Balance	

The alloy with the higher silver content will in general have higher hardness values than those with lower silver content but will have a somewhat lower electrical conductivity. Likewise the higher silver content compositions will in general be more susceptible to cold working. The high silver content likewise brings about greater resistance to corrosion. The alloys with the higher zinc contents, as for example, the alloy (*d*) above, are particularly notable for their superior arc-quenching characteristics.

In producing the alloy of the present invention part of the zinc and chromium is ordinarily lost through oxidation and volatilization during melting, pouring and other handling. It is necessary, therefore, to introduce an excess of zinc and chromium into the melt in order that the finished alloy will have the composition given above.

The zinc, chromium and silver may be introduced into the copper in a variety of ways, care being taken to avoid unnecessary oxidation and volatilization of zinc and chromium. According to one method a copper-zinc-silver alloy is first made according to the conventional alloy-making procedure. The chromium is then added in finely divided form, preferably combined with copper powder in the form of a briquette, and intimately mixed therewith. The chromium may also be added as a copper-chromium hardener contain-

ing 10 to 25% chromium. This hardener can be prepared by melting together copper and chromium under a protective atmosphere. The zinc is preferably added to the melt before the chromium in order to avoid chromium losses.

In many cases it will be found preferable to make a master alloy having relatively high percentages of chromium, zinc and silver alloyed with copper. This alloy may then be diluted with copper to form lower percentage alloys.

The master alloy is a convenient form for supplying with material to foundries where it may be diluted with copper to produce a finished alloy of the proportions desired for the application contemplated.

The zinc used in producing the present alloy is utilized in two ways. Part of it is used up as a deoxidizer and part of it remains as an ingredient in the finished alloy. In order to have 0.5% zinc in the finished alloy, for example, it is necessary to introduce 0.55% to 0.65% of zinc into the original melt. About half of the excess zinc is consumed as a deoxidizer, the zinc being converted to zinc oxide and separating as a slag. The rest of the excess is volatilized due to the low boiling point of the zinc. This volatilized zinc, when it comes into contact with the air, at a high temperature forms zinc oxide which leaves the crucible in the form of a white smoke.

Some of the chromium likewise oxidizes during the alloying process and accumulates on the top of the melt as part of the slag. In order to obtain 0.5% chromium in the finished alloy it is necessary to add approximately 1.0% chromium to the melt.

In the further treatment of the alloy after solidification it may be first heated to a temperature of 600° C. to 1050° C., and preferably above 700° C. for a short time, such as from 10 to 30 minutes. After the metal has reached the desired temperature it may be cooled quickly from the high temperature (quenched). The next step is preferably to heat treat the quenched alloy at a temperature of 350° C. to 600° C. for a period of from 10 minutes to 30 hours, depending on the temperature, the percentage of hardener used, and the results desired.

The alloy may then be cold worked to obtain a cold reduction of approximately 20% and further cold reduction, up to 50% or more, may be applied to further increase the hardness. It has been found that the conductivity will not be appreciably decreased by these further reductions.

For maximum hardness and conductivity, however, it is preferable to apply a series of cold reductions alternated with relatively low temperature heat treatment, preferably within the range 400° C. to 500° C. The number of cold workings with intermediate heat treatments may vary with the properties desired in the finished product.

The presence of silver improves the working properties of the alloy. The present alloy also has a higher recrystallization temperature than the alloy without silver. The silver may increase this temperature as much as 100° C. and does not impair the other valuable properties of the alloy, such as electrical and heat conductivity. This makes the alloy of the present invention considerably more stable after severe cold working.

Likewise the silver content will make the alloys respond more easily to heat treatments consisting in quenching from a relatively high temperature and subsequently aging at a lower temperature.

Since the zinc acts as a strong deoxidizer it is not necessary to add other deoxidizers commonly used, such as silicon, aluminum or magnesium, for this purpose.

The addition of silver to the copper-chromium-zinc alloy increases the Brinnell hardness from 2 to 20 points, depending upon the percentage of silver and the heat treatment. The additional hardness is gained without affecting the electrical conductivity. It has been found, for example, that an addition of 1% of silver may reduce the conductivity only 2%. Thus an alloy having 0.3% zinc and 0.5% chromium may have an electrical conductivity after heat treatment of approximately 70 to 85% that of pure forged copper and a Brinnell hardness of 132 to 150 or greater, depending upon the proportion of silver.

The hardness and electrical conductivity of the present alloy are maintained indefinitely at temperatures in the order of 400° C. to 475° C. or greater.

The good casting qualities of the copper-chromium-zinc alloy covered in the copending application above referred to are still further improved by the addition of silver as brought out in the present application. The present alloy is fluid and may be readily cast resulting in clean, sound castings with a marked absence of irregularities.

The presence of the zinc likewise tends to prevent excessive surface oxidation in the finished, solidified alloy and is particularly advantageous where they are heated to high temperatures. The surface oxidation in copper-chromium alloys is quite serious since the oxygen penetrates along the grain boundaries and tends to make the alloy brittle. In the present alloy, the chromium is protected by the zinc, which will oxidize in preference to the chromium.

As is well known, zinc added to pure copper tends to decrease its conductivity quite considerably. It is surprising, therefore, to find that the present alloy exhibits comparatively high electrical conductivity in the cast and heat treated state. With the addition of 0.5% or less of zinc the conductivity is not reduced below 75% to 80% and with even 1.5% zinc the conductivity is found to be at least 65% that of copper when the alloy is in the cast, heat treated condition.

The alloy likewise has improved arc-snuffing properties, due to the presence of the zinc. This is highly advantageous for the electrical applications, such as in the use of the alloy for pressure welding electrodes and as a contact material. The low-boiling zinc (930° C.) tends to produce a gaseous phase which extinguishes the arc. These arcing characteristics are improved by increasing the proportions of zinc.

This alloy is further characterized by small grain size. Copper-chromium materials must be heated to above 900° C. before quenching the water. That elevated temperature, however, is normally very conductive to grain growth, the size of the grains usually depending on the length of time the material is held at the elevated temperature. With the present alloy, containing zinc and silver, the grain size appears to be considerably reduced from that found in other copper-chromium alloys.

In the present alloy the proportions of zinc are kept below 5% and accordingly no low-melting point phase is formed, such as that formed in alloys containing zinc in high proportions. This allows a wider range of forging or hot working temperatures and presents a decided improvement over such alloys as copper-chromium-cadmium in which the forging range is very small.

The absence of a low-melting phase decreases the hazards in forging and the danger of loss of material during forging. It also cheapens the manufacture of forged pieces since it allows working one piece to almost finished dimensions without reheating. With copper-chromium-cadmium alloys the material must be reheated frequently during forging.

The alloy can be cast in chill molds or sand cast with ease and can be mechanically worked in the hot or cold state with the same ease as the above mentioned alloys of the prior art. It is likewise well adapted to machining.

This alloy is exceptionally well adapted, because of the above properties, to the production of resistance welding electrodes contacts, trolley shoes, trolley wheels, contactors, electrical conductors, and the like. For each application the hardener may be used in such proportions as to obtain the desired hardness and conductivity.

Due to the higher hardness and resistance to corrosion of the present alloy containing silver it is also adaptable for structural purposes or parts of equipment where high strength and high electrical conductivity are required and it is also adapted for use in applications where a considerable resistance to corrosion is desirable. The corrosion resistance properties of the present alloy may in some cases be even better than that of pure copper.

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 it is intended to cover the invention broadly within the spirit and scope of the appended claims.

What is claimed is:

1. An alloy containing about 0.1 to 5.0% zinc, 0.1 to 2.5% chromium, 0.05 to 10% silver and the remainder copper.

2. An alloy containing about 0.1 to 5.0% zinc, 0.1 to 2.5% chromium, 0.05 to 10% silver and the remainder substantially all copper, characterized by a combination of high hardness and high electrical conductivity, and further characterized by the ability to maintain its hardness and high conductivity at temperatures in the order of 400° C.

3. An age hardened alloy containing about 0.1 to 5.0% zinc, 0.1 to 2.5% chromium, 0.05 to 10% silver and the remainder substantially all copper, characterized by a combination of high hardness and high electrical conductivity, and further characterized by the ability to maintain its hardness and high conductivity at temperatures in the order of 400° C.

4. An alloy containing 0.5% zinc, 0.5% chromium, 0.05% silver and the remainder copper.

5. An alloy containing 0.25% zinc, 0.5% chromium, 1.0% silver and the remainder copper.

6. An alloy containing 1.25% zinc, 0.5% chromium, 0.05% silver and the remainder copper.

7. A welding electrode composed of 0.1 to 5.0% zinc, 0.1 to 2.5% chromium, 0.05 to 10% silver and the remainder copper.

8. A welding electrode composed of about 0.1 to 5.0% zinc, 0.1 to 2.5% chromium, 0.05 to 10% silver and the remainder substantially all copper, characterized by the combination of high hardness and high electrical conductivity.

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