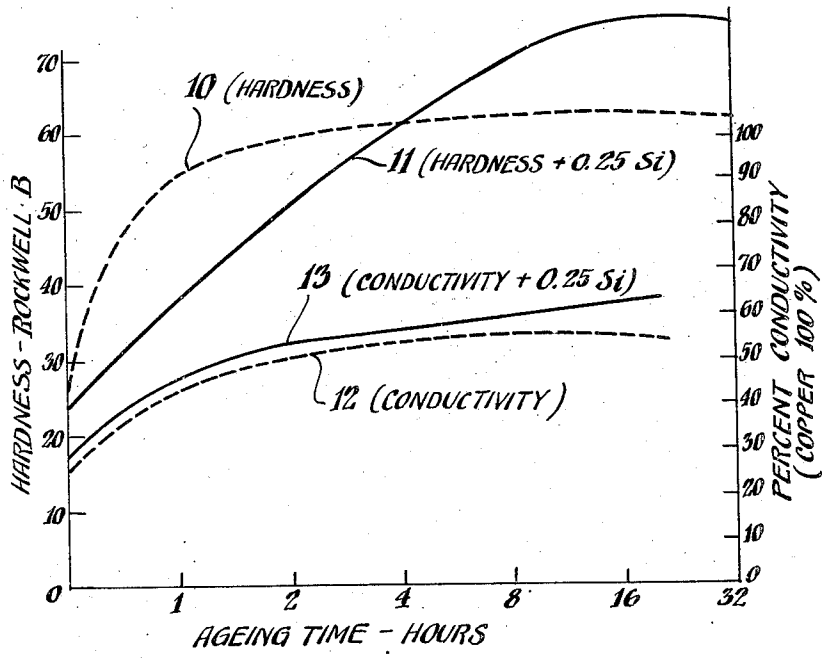
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COPPER BASE ALLOY

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HARDNESS VS. AGEING TIME
CONDUCTIVITY VS. AGEING TIME



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COPPER BASE ALLOY

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1 Claim. (Cl. 219—4)

This invention relates to copper base alloys, the present application comprising a continuation in part of our copending application, Serial No. 90,865, filed July 16, 1936, since matured into Patent No. 2,123,629, dated July 12, 1938.

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

A further object is to provide an alloy, the physical properties of which can be improved by heat treatment.

An additional object of the invention is to improve the hardness and other characteristics of a precipitation hardened copper alloy.

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

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 claim.

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

The figure is a graph illustrating the improvement in hardness and conductivity obtained during the age hardening of an alloy made according to the present invention as compared with another alloy.

The present invention relates to an improved copper base alloy containing cobalt, phosphorus and silicon. It has been found that by adding cobalt and phosphorus to copper an intermetallic compound of cobalt phosphide can be formed which has a variable solid solubility in the copper matrix. We have discovered that the addition of silicon improved these alloys, the improvement in hardness and electrical conductivity obtained by the additions of silicon being accentuated by a suitable age hardening process.

The alloy may be produced as follows:

Copper is melted under glass or charcoal slag and superheated. A hardener containing 75% cobalt and 25% copper is added as a convenient means to incorporate cobalt. The silicon may be similarly added. Phosphorus is then added in the form of phosphor copper or some other suitable means.

In the molten condition, the alloy is extremely fluid and pours very easily.

The proportions of cobalt and phosphorus may each be varied over a considerable range of values and there may be an excess of either in some instances without deleterious effects on the alloy. The preferred weight ratio of phosphorus to cobalt is approximately 1 to 6. However, considerable age-hardening is obtained with the ratio of 1 to 3 and also with a ratio as high as 1 to 10.

A slight excess of phosphorus above the amount required to form certain intermetallic compounds of cobalt phosphide will ordinarily serve as a deoxidizing agent during the production of the alloy.

The cobalt phosphide is suitable as an age hardening ingredient for copper or certain copper alloys. The silicon produces additional beneficial effects in this regard.

Where the cobalt, phosphorus and silicon are added to copper the ingredient may be present in the following permissible ranges of proportions:

	Percent
Cobalt	0.05 to 5
Phosphorus	0.01 to 2
Silicon	0.01 to 1.0
Copper	Balance

The preferred proportions, however, are substantially as follows:

	Percent
Cobalt	2 to 3
Phosphorus	0.2 to 0.75
Silicon	0.01 to 0.5
Copper	Balance

After the alloy has been produced it may be heated to a relatively high temperature above 700° C. and preferably in the order of 800° C. to 1000° C. and then rapidly cooled from that temperature to room temperature or below, preferably by quenching in water. After the quenching operation the alloy, in such form as may be desired, may be given an aging treatment by baking at a temperature below 700° C. and preferably at a temperature in the order of 350° C. to 650° C. The aging may proceed for a considerable length of time according to the temperature used. The most rapid improvement in hardness and electrical conductivity will be obtained during the first two or three hours if 450° C. is used as aging temperature but further improvement will be obtained upon continuing the aging for 8 to 16 hours or more.

The improvement in hardness and electrical

conductivity during aging is shown in the graphs of the figure for a representative alloy made according to the present invention in comparison with an alloy of similar composition except for the absence of silicon. The representative alloy has the following composition:

	Percent
Cobalt	2.37
Phosphorus	0.63
Silicon	0.25
Copper	Balance

The proportions of ingredients in the comparison alloy are the same with the exception that silicon is absent.

In the figure, curve 10 represents the increase in Rockwell B hardness of specimens of the comparison alloy in which no silicon is present, quenched from 950° C. in water and aged at 450° C. in air. It will be noted that that hardness was increased from about 26 Rockwell B immediately after quenching to about 62 Rockwell B after aging for 8 or more hours at 450° C. Curve 11 represents the increase in hardness of the representative alloy given above containing 0.25% silicon. It will be noted that the hardness of the silicon-containing alloy, while initially less eventually reaches a higher value than the hardness of the alloy without silicon. The hardness of the silicon-containing alloy increases from about 24 Rockwell B immediately after quenching to about 74 Rockwell B after aging for about 16 hours.

Curve 12 in the figure represents the improvement in electrical conductivity of the comparison alloy during the age hardening treatment. It will be noted that the conductivity increased from about 27% of that of copper after quenching to 55 or 56% after aging for 4 or more hours. Curve 13 represents the increase in conductivity of the alloy containing 0.25% silicon. It will be noted that the conductivity of the silicon-containing alloy is somewhat greater regardless of the aging time, the conductivity increasing from about 31% of that of copper after quenching to above 64% after aging about 16 hours.

While the comparison alloy containing no silicon exhibited little change in hardness or conductivity after 4 to 8 hours aging the silicon-containing alloy increased considerably in hardness upon further aging, the maximum being reached after aging for more than 16 hours.

By varying the proportions of the ingredients in the alloy, it is possible to obtain even higher electrical conductivity and hardnesses.

After the aging treatment the material may be cold worked by rolling, for example. The hardness will be increased by cold working while the electrical conductivity is not materially changed thereby.

The alloy of the present invention is able to withstand high temperatures without losing its hardness or high conductivity. The hardness and conductivity of the age-hardened alloy may be maintained at temperatures considerably above the aging temperatures used and that of the cold worked alloy may also be maintained at relatively high temperatures such as at 400° C. or greater.

The present alloy is easy to produce. In pouring the alloy it shows a clean stream and great fluidity.

No difficulty due to cracking or checking is encountered in hot rolling and cold working of this alloy.

In the binary copper-cobalt system the solubility of cobalt in copper decreases with decreasing temperature, the cobalt being soluble in copper in the solid state only to a very limited extent. At 1000° C. 3.5% cobalt is held in solid solution by copper. At 600° C. only 0.9% cobalt is held in solid solution and at room temperature this percentage decreases to approximately 0.35%.

By adding phosphorus, cobalt phosphide is formed and this compound has a lower solid solubility in copper than does cobalt. The precipitation hardening effect is therefore greater. In age hardened alloys the hardening ingredients greatly decrease the electrical conductivity to the extent in which they are held in solid solution. Cobalt phosphide, therefore, produces a higher electrical conductivity for the same amount of hardening than does straight cobalt since less of the phosphide is held in solid solution.

Another advantage accrues from the fact that the precipitated phase, consisting of cobalt phosphide or copper cobalt phosphide has in itself a substantial hardness. The hardness of this phase is much greater than the precipitated phase in binary copper-cobalt alloys. This makes for greater strength and higher hardness in the hardened alloy.

The alloy is particularly suitable for pressure exerting welding electrodes such as spot welding electrodes because of its combination of high hardness and electrical conductivity. This results in greater freedom from mushrooming in service. The electrodes are well adapted for the welding of terne and tin plate.

The alloy also makes excellent soldering iron tips due to its freedom from intercrystalline penetration of liquid metals. We have found it superior in this respect to most of the present copper base alloys.

The alloy is likewise well adapted to other applications where the combination of relatively high electrical conductivity combined with high strength and hardness at room or elevated temperature is required.

It is apparent from the curves of the drawing that the silicon makes possible alloys of considerably greater hardness and surprisingly, the silicon also appears to improve the electrical conductivity.

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 claim.

What is claimed is:

An electrical contacting element of the type comprising pressure exerting welding electrodes and the like composed of an alloy containing about .05 to 5% cobalt, .01 to 2% phosphorus, .01 to 1% silicon and the remainder substantially all copper.

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