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COPPER BASE ALLOY

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This application is a continuation-in-part of our application Serial No. 269,780 filed April 24, 1939.

This invention relates to improvements in copper-base alloys.

One object of this invention is to produce an improved copper-base alloy having a combination of high resiliency and low stress-relaxation.

With the above and other objects in view, as will appear to those skilled in the art from the present disclosure, this invention includes all features in the said disclosure which are novel over the prior art.

We have discovered an improved copper-base alloy consisting substantially of nickel, phosphorus, tellurium and copper in certain particular percentage ranges hereinafter set forth, which is characterized by a combination of high resiliency with low stress-relaxation, that is, characterized by the fact that a member made of the alloy and having one end rigidly held, and the remainder of the member subjected to deflection or distortion through an angle, is capable of withstanding considerable distortion and is capable of being held in such distorted position for long periods of time without being subject to taking a serious amount or degree of permanent set, so that when the member is finally released from its distorted position, it will return to a position nearly that from which it was originally distorted, notwithstanding that the member may have been held in such distorted position for a long period of time. This property of permanent high resiliency is extremely important in the making of electrical elements such, for example, as electrical connectors or contacts of the plug and jack type, and knife switches, as internal elastic stress within the parts is relied upon to maintain the necessary contact pressure.

In addition to the foregoing outstanding characteristic of our alloy, it also permits of obtaining a high combination of electrical conductivity and tensile strength, is capable of being readily fabricated by all the usual fabricating methods, has good abrasion or wear resistance which is especially important in prolonging the useful service life of electrical elements which have a sliding action in the making and breaking of electrical contacts, and also has good oxidation or corrosion resistance which prevents the formation of oxide films or scale or other corrosion products which would interfere with the proper electrical contact or other operation of coacting parts.

Our improved alloy also is suitable for making various other metallic articles such, for instance, as extruded rod, cold-drawn rod, wire and other shapes, hot forged articles, fluid-conducting pipe, elbow adapters, T's and other tube-fittings, various items of hardware, connectors, lamps, and so forth, where a combination of desirable physical and working properties is desired which has not heretofore been realized. Such desirable properties include: high strength and hardness, abrasion resistance, hot and cold workability, machinability, corrosion resistance, stress and corrosion cracking resistance, immunity to fire cracking, ability to be joined by sweating with soft solders, and, in some instances, relatively-high thermal conductivity. Heretofore, a compromise between certain mutually exclusive properties had to be made, but with our improved alloy all the foregoing enumerated properties can be obtained to an unusually and remarkably high degree. This permits of improvement and economy in fabricating methods and the obtaining of finished products in such condition as to be better suited to their normal use than generally similar products made from other alloys.

Our improved alloy is of high copper content which can be as readily hot forged as pure copper or more rapidly than other alloys of equal or greater copper content; can be cold worked extensively either before or after being hardened by heat treatment; can be sweated with soft solders, or hard solders such as silver solder; and has higher electrical and thermal conductivity than other forgeable copper alloys of equal strength and hardness.

Our improved alloy is substantially composed of nickel from 0.3% to 2%, phosphorus from .04% to 0.4%, the phosphorus being from $\frac{1}{3}$ to $\frac{1}{6}$ of the amount of nickel and preferably about $\frac{1}{5}$ the amount of nickel, tellurium from 0.1% to 1%, and the balance substantially of copper and constituting at least 95% of the alloy, with or without substantially innocuous elements as silver, zinc, etc., in such amounts as do not essentially change the nature of the alloy, and such expressions as "the balance substantially of copper," etc., are intended to cover alloys including such amounts of additional elements. For good forgeability, the alloy should not contain more than 0.1% of lead, if any, or more than 0.25% of cadmium, if any. Aluminum, if present, should not exceed 0.1% in order to avoid undue lowering of the electrical conductivity. Tin, if present, should not exceed 0.2% in order to avoid undue difficulty in working.

A more preferred range for our improved alloy is to have the nickel from 0.5% to 1.5%, phos-

phorus from 0.1% to 0.3%, tellurium from 0.25% to 0.75%, and the balance substantially of copper and at least 96%, the relationship between the phosphorus and nickel being the same as in the first alloy range above given.

Our most preferred alloy consists of nickel about 1%, phosphorus about ⅕%, the tellurium about ½%, and the balance substantially of copper and at least 96½%.

Heat treatment after forging is preferably carried out within the range of from about 700° F. to about 1100° F., and more preferably within the range of from about 800° F. to about 900° F. Our improved alloy can be heat treated to have a Rockwell F hardness greater than 80 and an electrical conductivity greater than 50% I. A. C. S.

Our improved alloy possesses unusual fabrication and working properties. For instance, we have found that this alloy can be severely forged over a considerable range of temperature. As an example, an electrical contact element was readily forged in one operation on a screw press from a one-inch diameter rod, the contact consisting essentially of a disk 2¾ inches in diameter, and less than 0.1 inch thick with a central projection one-half inch in diameter and one inch high.

The forging operation, in effect, gives a sufficient equivalent of a heating and quenching or solution treatment so that all that is necessary after forging is to age harden the pieces, in order to obtain practically as great hardness as would occur if a complete solution treatment were applied in the ordinary manner followed by an aging treatment.

Some forgings when given a solution treatment by quenching in water after heating to 1450° F. for one-half hour showed a Rockwell F hardness of 48, and after aging for three hours at 800° F. the hardness was increased to 98.

Other similar forgings as coming from the forging press were found to have a Rockwell F hardness of from 54 to 71. When these were aged for three hours at 800° F. the hardness was found to have increased to from 98 to 100 Rockwell F hardness. This shows that even though a considerable variation might exist as forged, the aging treatment eliminates this variation and produces a uniform hardness as great as can be obtained by the more normal and complete heat treatment.

Articles made of our improved alloy and age hardened, are characterized by only insignificant or very slight change in size or dimensions as a result of the age hardening, thus permitting of fabricating articles or parts to finished form and size before age-hardening them. Thus, for many uses, it is unnecessary to re-size or refinish articles after age hardening them.

Most copper alloys cannot be sweated with soft solders as readily as copper itself. We have found, however, that our improved alloy can be sweated very readily. Tests were made on ½ inch copper water tubing sweated with 50–50 tin lead solder and using in one case copper couplings and in the other, couplings made of our improved alloy herein set forth. When pulled in tension, the tube broke beyond the fitting in all cases and the sweated joint was not injured, thus showing that our new alloy is well suited for making joints between parts formed of our improved alloy.

The invention may be carried out in other specific ways than those herein set forth without departing from the spirit and essential characteristics of the invention, and the present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

We claim:

1. An age-hardened copper-base alloy characterized by good forgeability and a combination of high resiliency with low stress-relaxation and a high combination of electrical conductivity and tensile strength and consisting of: nickel from 0.3% to 2%; phosphorus from .04% to 0.4%; tellurium from 0.1% to 1%; and the balance substantially of copper and at least 95%.

2. An age-hardened copper-base alloy characterized by good forgeability and a combination of high resiliency with low stress-relaxation and a high combination of electrical conductivity and tensile strength and consisting of: nickel from 0.5% to 1.5%; phosphorus from 0.1% to 0.3%; tellurium from 0.25% to 0.75%; and the balance substantially of copper and at least 96%.

3. An age-hardened copper-base alloy characterized by good forgeability and a combination of high resiliency with low stress-relaxation and a high combination of electrical conductivity and tensile strength and consisting of: nickel about 1%; phosphorus about ⅕%; tellurium about ½%; and the balance substantially of copper and at least 96½%.

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