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METHOD OF TREATING COPPER BASE ALLOYS

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FIG. 1

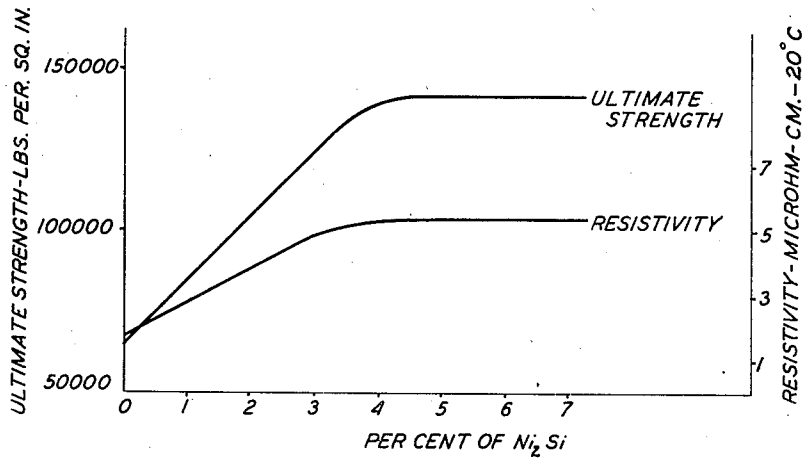
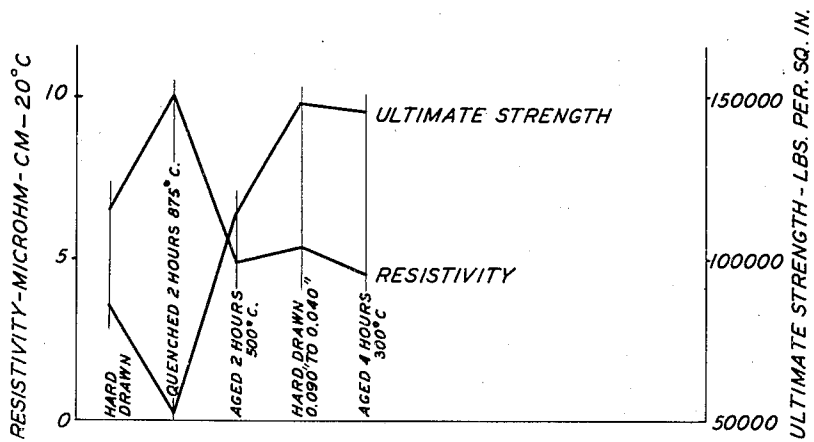


FIG. 2



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METHOD OF TREATING COPPER BASE ALLOYS

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6 Claims. (Cl. 148—21.2)

This invention relates to methods of treating copper base alloys and particularly to a method of treating copper conductors to bring out desired physical and electrical characteristics.

It is well known that alloys containing high percentages of copper can be improved in certain physical characteristics by a so-called dispersion hardening process in which silicides of certain hardening metals are employed in the alloy which is then heat-treated to bring out the desired characteristics. As a hardening metal, nickel has, in general, been found to be the most satisfactory although satisfactory results have also been obtained with cobalt, iron and chromium.

In accordance with the present invention, greatly improved results are obtained by cold working an alloy which has been previously subjected to a dispersion hardening process and then subjecting it to further heat treatment. By this additional treatment, not only is the ultimate strength of the material increased to a high degree, but this increase is obtained without an objectionable increase in the resistivity of the material. Furthermore, these improved characteristics are not appreciably altered by time. This improvement is of particular importance when the process is applied to electrical conductors used under conditions where both high ultimate strength and low resistivity are essential.

The invention may be more clearly understood by reference to the accompanying drawing in which Fig. 1 shows the variation in ultimate strength and resistivity of a copper alloy for different percentages of nickel silicide and Fig. 2 shows the changes in the properties of a hardenable copper alloy containing 4% of nickel silicide when subjected to the various steps of the preferred process for treating hardenable copper alloys.

Referring to Fig. 1 there is shown the variation in ultimate strength and resistivity of hardenable copper alloys resulting from the addition to commercial copper of varying amounts of nickel silicide. In obtaining these results, the alloys were drawn into wire .100" diameter then given a heat treatment, to be described later, after which they were hard drawn to wire .045" diameter. It will be noted that the alloy containing 4% nickel silicide attains practically the maximum ultimate strength as well as the maximum resistivity.

In Fig. 2 there is shown a chart illustrating the change in the properties of a copper wire during

the various steps of the treatment in accordance with this invention. This wire was prepared by melting cathode copper in an electric resistance furnace and adding sufficient nickel-silicon-copper alloy to bring the nickel silicide content to 4%. The alloy was then cast into suitable bars and hot rolled to .250" rod. The rod was then drawn through suitable dies to .090" wire at which time samples tested showed an average ultimate strength of 86,000 pounds per square inch and a resistivity of 6.5 microhm centimeters. The wire was next subjected to a heat treatment to bring the silicon and nickel into solid solution with the copper, this treatment consisting in heating the material for a period of two hours at a temperature of 875° C., after which it was water quenched and subjected to an aging treatment at a temperature of 500° C. for a period of two hours. Upon quenching the material, there resulted a large decrease in ultimate strength and increase in resistivity, but after the aging treatment, the ultimate strength was increased to approximately 115,000 pounds per square inch and the resistivity decreased to slightly less than 5 microhm centimeters.

To further increase the ultimate strength the .090" wire was then cold drawn through a series of ten suitable dies to a diameter of .040". By this operation the ultimate strength was increased to nearly 150,000 pounds per square inch but the resistivity was also increased slightly. The wire was next subjected to a second aging treatment which consisted in maintaining it at a temperature of 300° C. for a period of four hours. As the result of this operation the resistivity was decreased to 4.6 microhm centimeters with only a slight decrease in the ultimate strength. The ductility of the wire remained satisfactory, permitting it to be wrapped about binding posts and otherwise twisted in a manner similar to which it would be treated in service. Furthermore, the ultimate strength and resistivity characteristics of the .040" wire (No. 18 B and S gage) were such as to meet the standard specification requirements for .045" wire (No. 17 B and S gage) which are that the wire withstand a breaking strength of 170 pounds and have a resistance not greater than 92 ohms per mile at 68° F. It thus becomes possible for certain purposes to use a wire one size smaller in gage and thereby bring about a considerable saving in cost.

By varying the temperature of the final heat treatment it is possible to alter the characteristic of the alloy to a considerable extent. For

example with the alloy referred to above, if the final heat treatment is carried on at a temperature of 100° C., the ultimate strength is further increased but there is a smaller drop in the resistivity. On the other hand, if the temperature of the final heat treatment is maintained at 500° C. the ultimate strength is decreased below the value given in Fig. 2 while the drop in the resistivity curve is considerably greater. For a given temperature, it was also found possible to cause considerable variation in the properties of the alloy by varying the period of the final heat treatment. Under all the conditions mentioned the final heat treatment also served to increase the proportional limit of the alloy.

In the examples referred to above, the material subjected to the heat treatment in accordance with this invention was commercial copper to which was added 4% of nickel silicide. The invention, however, is not limited to a method of treating copper alone since satisfactory results have also been obtained with brass and bronze alloys in which the copper constituent predominates. For example, a brass containing approximately 30% zinc when subjected to a similar heat treatment combined with mechanical working was found to possess greatly improved properties. This material which contained 4% nickel silicide was first hardened by heating at 800° C. for one hour, quenching and then aging at a temperature of 400° C. for a period of two hours. The hardened material was then cold-rolled eight B and S gage numbers after which it was given an additional heat treatment to further improve its properties, this improvement being due presumably to further precipitation of nickel silicide. In the case of this alloy when aged for one hour at a temperature of 300° C. the ultimate strength was increased from 123,000 to 132,000 pounds per square inch, and the proportional limit raised from 36,000 pounds per square inch to 57,000 pounds per square inch. The addition of zinc to the alloy makes it desirable to use a lower quenching temperature than that which gives the best results with copper alone and also lowers the aging temperatures at which the most satisfactory results are obtained.

What is claimed is:

1. The method of improving the properties of copper base alloys containing approximately 4 per cent metal silicides, a large proportion of which have been precipitated by a dispersion hardening process out of solid solution which consists in cold working the alloy and then subjecting it to a heat treatment at a temperature of from 100° to 500° C. for a period of approximately one to four hours to cause additional precipitation of silicides, said silicides being of a hardening metal of a group consisting of chromium, cobalt, iron and nickel.

2. A method of treating copper base alloys containing approximately 4 per cent metal silicides said metal being a hardening metal of a

group consisting of chromium, cobalt, iron and nickel which consists in heating the material at a temperature of approximately 875° C. for approximately two hours to produce a solid solution of the copper silicon and hardening metal, quenching, heating at a reduced temperature of approximately 500° C. for a period of approximately two hours thereby causing the precipitation of a substantial proportion of the silicide which will precipitate out of solid solution under such conditions, cold working the material and then subjecting the material to a temperature of approximately 300° C. for a period of four hours.

3. A method of treating copper base alloys containing approximately 4 per cent metal silicides said metal being a hardening metal of a group consisting of chromium, cobalt, iron and nickel which consists in heating the material at a temperature of approximately 875° C. for approximately two hours to produce a solid solution of the copper silicon and hardening metal, quenching, heating at a reduced temperature of approximately 500° C. for a period of approximately two hours, cold working the material and then subjecting the material to a temperature of from 100° to 500° C. for a period of approximately one to four hours.

4. A method of treating copper base alloys containing silicon and hardening metal of a group consisting of chromium, cobalt, iron and nickel which consists in heating the alloy at a temperature such as to produce a solid solution of the constituent members, quenching, heating at a reduced temperature of approximately 500° C. for a period of approximately two hours, thereby precipitating a substantial proportion of the silicide which will precipitate out of solid solution under such conditions, cold working and aging at a further reduced temperature.

5. The method of improving the properties of copper base alloys which consists in adding approximately 4% nickel silicide to commercially pure copper, heating for a period of approximately two hours at a temperature of approximately 875° C., quenching, heating for a period of approximately two hours at a temperature of approximately 500° C., cold-working, and heating for a period of approximately four hours at a temperature of approximately 300° C.

6. The process which comprises hot rolling into wire rod, a copper base alloy containing a minor amount of silicon and a minor amount of metal of the group consisting of chromium, cobalt, iron and nickel, balance of the alloy being copper, heating the rod to a temperature sufficiently high to form a solid solution of the alloying elements with copper, said temperature being approximately 850° C., quenching the rod, reheating it to approximately 500° C. to effect precipitation hardening, cold drawing the rod to reduce its diameter and then reheating it to approximately 400° C.

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