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(54) **Copper alloys**

(57) Two copper alloys are provided. The first copper alloy may have a composition in the range of from 0.2 to 0.6 wt% chromium, from 0.005 to 0.25 wt% silver, and the balance copper. The second copper alloy may have a composition in the range of from 0.2 to 0.6 wt% chromium, from 0.01 to 0.12 wt% magnesium, and the balance copper. The copper alloys of the present invention

may also include zirconium to provide additional softening resistance. These copper alloys can easily be drawn or rolled to fine and ultra fine sizes (0.010 inch and smaller) to be used as a single end wire and constructions made therefrom.

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Description

[0001] The present invention relates to two copper alloys containing chromium and silver or chromium and magnesium and to a process of manufacturing fine wire less than 0.010 inches in diameter.

[0002] Copper and its alloys are the principal material used as conductors. Copper alloys are used where the properties of unalloyed copper are insufficient. ASTM B624 describes a set of properties for one of these applications. ASTM B624 specifies the properties of a useful conductor alloy as follows: tensile strength of at least 60 ksi; minimum electrical conductivity of 85% IACS; and minimum elongation 7% to 9% depending on diameter, such as 8% elongation for a 0.010 inches diameter. These properties have been established based on the performance of an existing alloy, C18135. In addition to the above-mentioned properties, other characteristics such as a softening resistance and flex life are important factors and must be considered.

[0003] The original alloy meeting the requirements of ASTM B624 is copper alloy 18135 with a nominal composition of 0.4 wt% cadmium, 0.4 wt% chromium, and balance copper. Due to the hazardous nature of cadmium, search has been ongoing for a replacement for this alloy. A copper-chromium-zirconium alloy sold under the trade name PERCON 24 has been introduced and has been able to exceed the requirements of ASTM B624. Although this Cu-Cr-Zr alloy has been commercially available, casting and manufacture of alloys containing zirconium is quite complex. Therefore, it would be beneficial to conceive a new alloy which meets the requirements of ASTM B624 without hazardous cadmium and difficult to add zirconium.

[0004] The Copper Development Association (CDA) lists several copper alloys containing chromium. Copper chromium alloys C182 and 184 contain up to 1.2% chromium. Copper chromium alloys are precipitation hardening alloys. Chromium must be first dissolved in the copper matrix (solid solution) in order to take advantage of the strengthening effect of chromium. Following a solid solution treatment, a precipitation hardening alloy undergoes a heat treatment to produce fine particles to strengthen the alloy. The maximum amount of chromium soluble in copper is 0.65% and that is at 1076 degrees Centigrade where the alloy starts to melt. Practically, the maximum amount of chromium soluble in copper is less than 0.65%. Excess amount of chromium, beyond what has been dissolved in the copper matrix, will remain as large particles (5-10 micron or larger) and will not contribute to the strength of the alloy. The large chromium particles may not have an adverse effect for larger diameter wire (greater than 0.020 inches). However, the large particles in a conductor, where the single end wire is typically from 0.003 to 0.005 inches, and may be down to 0.001 inches or even smaller, will cause wire breaks, a major impediment. Therefore, the amount of chromium in a copper chromium alloy suitable for conductor appli-

cations where typical single end wire diameters are 0.001 to 0.010 inches must be limited to less than 0.65%. In fact, the maximum amount of chromium which can be practically dissolved in copper is about 0.5%.

[0005] Although a copper-chromium alloy could provide high strength, its softening resistance would not be acceptable and measures to improve the softening resistance are necessary. Silver, magnesium, and zirconium are known to improve the softening resistance of copper alloys. Zirconium is one of the most effective elements for increasing the softening resistance of copper. Zirconium, however, is a highly reactive element and its addition to copper requires special equipment and techniques. Silver, on the other hand, is an effective element for increasing softening resistance of copper and it is quite easy to add to the copper alloy. An additional advantage of silver is that it does not adversely affect electrical conductivity. Alloy C107 is an example of a silver bearing copper with improved softening resistance relative to alloy C102. Only a small addition of silver is needed to effect the increase in softening resistance. Additions of more than 0.2% silver, although not harmful, would be a waste of a relatively expensive element.

[0006] CDA alloy C18500 describes a copper-chromium-silver alloy. Due to a lack of interest, this alloy has been abandoned since 1992 and has been removed from the list of current copper alloys. C18500 contained 0.4 to 1.0% chromium and 0.08 to 0.12% silver. Although the high chromium in this alloy may not be detrimental in large diameter wire and rod, it will interfere in drawing fine and ultra fine wire of interest (wire typically smaller than 0.010 inch). In fact, the minimum amount of chromium listed for C18500 is the optimum amount of chromium needed for the alloy of the present invention. Silver is a relatively expensive element and it must be limited to the amount required to improve softening resistance. The nominal amount specified in C18500 is 0.1%.

[0007] As an alternative, magnesium may also be added to copper chromium to improve the softening resistance of the alloy. Since the addition of magnesium to copper results in the reduction of electrical conductivity, the amount of added magnesium must be limited to the minimum required for improved softening resistance. For this reason, the amount of magnesium must be limited to 0.1%.

[0008] In accordance with the present invention, there is provided two copper alloys which can be drawn into fine and ultra fine wires (wires typically smaller than 0.010 inch).

[0009] The first copper alloy may have a composition consisting essentially of from 0.2 to 0.6 wt% chromium, from 0.005 to 0.25 wt% silver, up to 0.015 wt% zirconium, and the balance copper.

[0010] The second copper alloy may have a composition consisting essentially of from 0.2 to 0.6 wt% chromium, from 0.01 to 0.12 wt% magnesium, up to 0.015 wt% zirconium, and the balance copper.

[0011] The present invention also relates to a process

of manufacturing a copper alloy wire. The process broadly comprises the steps of providing a copper alloy material containing chromium, subjecting said copper alloy material to a solutionizing treatment to solutionize a majority of said chromium, rapidly quenching said copper alloy material after said solutionizing treatment to keep said chromium in solution, forming said copper alloy material into a wire of an intermediate gauge, aging said copper alloy material wire to obtain submicron size for precipitated chromium particles, and forming said copper alloy material wire to a wire having a finish gauge optionally followed by a relief anneal to obtain desired tensile strength and elongation.

[0012] Other details of the copper alloys of the present invention, as well as other objects and advantages attendant thereto, are set forth in the following detailed description.

[0013] In accordance with the present invention, there is provided two copper alloys which can be drawn into fine and ultra fine wires (wires having a diameter smaller than 0.010 inch) .

[0014] In a first embodiment of the present invention, the copper alloy comprises from about 0.2 to 0.6 wt% chromium, preferably from 0.3 to 0.5 wt% chromium, from 0.005 to 0.25 wt% silver, preferably from 0.05 to 0.20 wt% silver, and the balance copper. The alloy may also contain up to 0.015 wt% zirconium to further improve softening resistance. When present, zirconium is preferably added in an amount from 0.005 to 0.015 wt%.

[0015] In a second embodiment of the present invention, the copper alloy comprises from about 0.2 to 0.6 wt% chromium, preferably from 0.3 to 0.5 wt% chromium, from 0.01 to 0.12 wt% magnesium, preferably from 0.05 to 0.1 wt% magnesium, and the balance copper. These alloys may also contain up to 0.015 wt% zirconium to further improve softening resistance. When present, zirconium is preferably added in an amount from 0.005 to 0.015 wt%.

[0016] The alloys of the present invention may be cast using any suitable continuous or non-continuous casting technique known in the art. Following casting, the alloy may be processed into wire having a convenient diameter. This processing may include a high temperature solution treatment to solutionize all or the majority of the chromium followed by a rapid quench (such as in water) to keep the chromium in solution. This processing is important in order to be able to properly utilize the chromium. Large particles (5-10 micron or larger) remaining following the solution treatment are the harmful ones which will cause wire breaks when drawing to fine and ultra fine diameters. A solution treatment temperature which may be used is from 925 to 1000 degrees Centigrade (from 1700 to 1830 degrees Fahrenheit) for 5 minutes to 5 hours. A preferred solution treatment dissolves most or all chromium particles. After the solution treatment and the rapid quench, the copper alloy may then be drawn to an intermediate gauge wire, typically from 0.036 to 0.064 inches in diameter, using any suitable drawing technique

known in the art. After being drawn to a wire of an intermediate gauge, the copper alloy wire is aged to obtain sub-micron size for the precipitated chromium particles. A heat treatment temperature which may be used at this point for aging is typically from 450 to 565 degrees Centigrade (from 850 to 1050 degrees Fahrenheit) for 1 to 5 hours. The copper alloy wire may then be drawn to a finish single end size, using any suitable drawing technique known in the art, followed by a heat treatment to obtain the required tensile strength and elongation. Desired tensile strength is greater than 60 ksi and desired elongation is greater than 6-8%. The heat treatment is performed at a temperature in the range of from 350 to 510 degrees Centigrade (from 650 to 950 degrees Fahrenheit) for about 1 to 5 hours.

[0017] The wire formed from the copper alloys of the present invention may be used in round (drawn) or flat (rolled) shape. The wire may be used as a single end wire or constructions made therefrom such as stranded as a multi-end wire, rope, bobbin, etc.

[0018] It is apparent that there has been provided in accordance with the present invention two copper alloys which fully satisfy the objectives, means, and advantages set forth hereinbefore. Other unforeseen alternatives, modifications, and variations may become apparent to those skilled in the art having read the foregoing description. Accordingly, it is intended to embrace those alternatives, modifications, and variations which fall within the broad scope of the appended claims.

Claims

1. A copper alloy consisting essentially of from 0.2 to 0.6 wt% chromium, from 0.005 to 0.25 wt% silver, up to 0.015 wt% zirconium, and the balance copper.
2. The copper alloy of claim 1, wherein said chromium is present in an amount from 0.3 to 0.5 wt%.
3. The copper alloy of claim 1, wherein said silver is present in an amount from 0.05 to 0.20 wt%.
4. The copper alloy of claim 1, wherein said zirconium is present in an amount from 0.005 to 0.015 wt%.
5. A copper alloy consisting essential of from 0.2 to 0.6 wt% chromium, from 0.01 to 0.12 magnesium, up to 0.015 wt% zirconium, and the balance copper.
6. The copper alloy of claim 5, wherein said chromium is present in an amount from 0.3 to 0.5 wt%.
7. The copper alloy of claim 5, wherein said magnesium is present in an amount from 0.05 to 0.1 wt%.
8. The copper alloy of claim 5, wherein said zirconium is present in an amount from 0.005 to 0.015 wt%.

9. A wire formed from a copper alloy consisting essentially of from 0.2 to 0.6 wt% chromium, from 0.005 to 0.25 wt% silver, up to 0.015 wt% zirconium, and the balance copper, and said wire having a diameter less than 0.010 inches. 5
10. The wire of claim 9, wherein said chromium is present in an amount from 0.3 to 0.5 wt%.
11. The wire of claim 9, wherein said silver is present in an amount from 0.05 to 0.20 wt%. 10
12. The wire of claim 9, wherein said zirconium is present in an amount from 0.005 to 0.015 wt%. 15
13. A wire formed from a copper alloy consisting essentially of from 0.2 to 0.6 wt% chromium, from 0.01 to 0.12 wt% magnesium, up to 0.015 wt% zirconium, and the balance copper, and said wire having a diameter less than 0.010 inches. 20
14. The wire of claim 13, wherein said chromium is present in an amount from 0.3 to 0.5 wt%.
15. The wire of claim 13, wherein said magnesium is present in an amount from 0.05 to 0.10 wt%. 25
16. The wire of claim 13, wherein said zirconium is present in an amount from 0.005 to 0.015 wt%. 30
17. A process of manufacturing a copper alloy wire comprising the steps of:
- providing a copper alloy material containing chromium; 35
 - subjecting said copper alloy material to a solutionizing treatment to solutionize a majority of said chromium;
 - rapidly quenching said copper alloy material after said solutionizing treatment to keep said chromium in solution; 40
 - forming said copper alloy material into a wire of an intermediate gauge;
 - aging said copper alloy material wire to obtain submicron size for precipitated chromium particles; and 45
 - forming said copper alloy material wire to a wire having a finish gauge.
18. The process of claim 17, wherein said copper alloy material providing step comprises providing a material consisting of from 0.2 to 0.6 wt% chromium, from 0.005 to 0.25 wt% silver, up to 0.015 wt% zirconium, and the balance copper. 50
19. The process of claim 17, wherein said copper alloy material providing step comprises providing a material consisting of from 0.2 to 0.6 wt% chromium, from 0.01 to 0.12 wt% magnesium, up to 0.015 wt% zirconium, and the balance copper. 55
20. The process of claim 17, wherein said solutionizing step comprises subjecting said copper alloy material to a temperature in the range of from 925 to 1000°C.
21. The process of claim 17, wherein said step of forming said material into a wire of intermediate gauge comprises drawing said material into a wire having a diameter in the range of from 0.036 to 0.064 inches.
22. The process of claim 17, wherein said aging step comprising subjecting said wire to a temperature in the range of from 450 to 565 °C.
23. The process of claim 17, wherein said step of forming said wire into a finish gauge comprises drawing said wire to a wire having a diameter less than 0.010 in.
24. The process of claim 17, further comprising subjecting said wire at finish gauge to an additional heat treatment at a temperature in the range of from 350 to 510°C.



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EUROPEAN SEARCH REPORT

Application Number
EP 06 29 1549

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 20 March 2007	Examiner Brown, Andrew
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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