Patented Jan. 11, 1944

2,338,756

UNITED STATES PATENT OFFICE

2,338,756

COPPER-BASE ALLOY

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No Drawing. Application August 22, 1942, Serial No. 455,683

6 Claims. (Cl. 148—32)

This invention relates to improvements in age-hardenable copper-base alloys.

One object of this invention is to produce improved age-hardenable copper-base alloys.

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 of the said disclosure which are novel over the prior art.

Although if manganese is used alone with copper, it requires more than 22% of manganese to give even a slight, commercially useless degree of age-hardness to copper, and if arsenic is used alone with copper, it requires more than 7½% of arsenic to give even a slight, commercially useless degree of age-hardness to copper, we have discovered that when both manganese and arsenic are present in copper within certain ranges, that a large, commercially valuable degree of age-hardness can be given to copper by a total of manganese and arsenic which can even be far less than 7½%, thus showing that manganese and arsenic together have a true combinational age-hardening action.

We have found that advantageous age-hardenable copper-base alloys can be made when the alloys contain manganese from 0.5% to 20%, arsenic from 0.1% to 5%, and copper at least 67%.

Other advantageous age-hardenable copper-base alloys can contain manganese from 0.5% to 20% and arsenic from 0 1% to 5%, with the total of the manganese, arsenic and copper at least 90%.

Other advantageous age-hardenable copper-base alloys can contain manganese from 0.5% to 10% and arsenic from 0.5% to 5%, with the total of the manganese, arsenic and copper at least 95%.

And other advantageous age-hardenable copper-base alloys can contain manganese from 1% to 7% and arsenic from 0.5% to 4%, with the total of the manganese, arsenic and copper at least 95%.

To illustrate in a general way the relative proportions of manganese and arsenic which may be present in various types of alloys within the present invention, where, for example, the total manganese plus arsenic content remains constant at about 2%, the relative proportions of manganese and arsenic may range from about 1.7% manganese and about 0.3% arsenic, to about 0.5% manganese and about 1.5% arsenic. Where, for example, the total manganese plus arsenic content remains constant at about 10%, the relative proportions of manganese and arsenic may range from about 9.7% manganese and about 0.3% arsenic, to about 5% manganese and 5% arsenic. And where, for example, the total manganese plus arsenic content remains constant at about 20%, the relative proportions of manganese and arsenic may range from about 19.9% manganese and 0.1% arsenic, to about 19% manganese and 1% arsenic.

In alloys having a small total of manganese and arsenic, the most useful alloys are those containing manganese and arsenic in proportion approximating that in the compound MnAs, namely 0.73 to 1 by weight. As the total content of manganese and arsenic increases appreciably, alloys having this ratio tend to become brittle so that a smaller proportion of arsenic is desirable, especially for wrought alloys, which means a higher manganese to arsenic ratio.

We have found that for a given copper content, maximum hardness is obtained in aging when the manganese and arsenic are present in proportion approximating that in the compound MnAs. While this would indicate that this compound is the hardening constituent, desirable alloys can be made in which the proportion deviates far from this value. Indeed, alloys with a manganese to arsenic ratio appreciably different from this value may have even better combinations of tensile strength and elongation than with the ratio for maximum hardenability. Thus, a wrought alloy containing 2.01% Mn, 3.07% As, and the balance of copper, with a Mn/As ratio equal to 0.66 to 1, approximating the ratio for maximum hardenability, had a tensile strength of 38,500 p. s. i. as quenched from 1400° F., and a tensile strength of 65,000 p. s. i. and elongation of 3% when aged at 800° F. A wrought alloy containing 2.70% Mn, 1.87% As, and the balance of copper, with a Mn/As ratio equal to 1.44 to 1 had a tensile strength of 39,000 p. s. i. when similarly quenched, and a tensile strength of 69,000 p. s. i. and elongation of 7% when similarly aged, thus having a better combination of properties in the age-hardened condition, particularly with respect to elongation which is a measure of ductility and malleability. A wrought alloy of somewhat higher total manganese plus arsenic content, containing 6.64% Mn, 1.55% As, and the balance of copper, with a still higher Mn/As ratio of 4.28 to 1, had the still better combination of properties when given similar heat treatments, of a tensile strength of 41,500 p. s. i. when quenched, and a tensile strength of 71,000 p. s. i. and elongation 12% when aged, and when this alloy was cold

rolled between the quenching and aging operations, to give it about a 50% reduction in thickness, it had a tensile strength of 87,000 p. s. i. and elongation of 9% when aged.

Solution treatment may be accomplished by heating above about 1200° F. but below the melting point of any alloy in question, and quenching or otherwise rapidly cooling. Hardening is then accomplished by reheating or aging at some temperature below about 1200° F., but preferably in the range from 700° F. to 1000° F., for a suitable time, which will preferably be in the range of from ½ hour to 24 hours.

Electrical conductivity and thermal conductivity are improved by the aging process. The alloys may advantageously be subjected to cold working between the high temperature and low temperature heat treatments to secure higher tensile strength.

If any lead is to be present in the alloy, it should not exceed 5%, as in higher amounts it renders the alloy brittle and low in tensile strength. If more than 5% lead were present, segregation of the lead would occur to such a harmful extent as to cause serious sweating or exuding of the lead from the alloy when the alloy is heated up to the melting point of lead (621° F.) or higher, and the alloy would be liable to crack when quenched, and these harmful properties become more pronounced, the higher the percentage of lead. If lead is to be present in a wrought alloy, the lead content should not exceed 2½%, as higher amounts seriously impair workability of the alloy.

If any of the elements antimony, bismuth, phosphorus, silicon, selenium, tellurium are present in too high an amount, the alloy is rendered brittle, and therefore the upper limits for these elements, if any of them is to be present, is antimony ½%, bismuth $\frac{1}{10}$%, phosphorus ¼%, silicon 3%, selenium 1% and tellurium 1%. More than 2% of either chromium or iron in the alloy causes segregation, and therefore not more than 2% of either of these metals should be present, if any. Not more than 4% of cobalt, if any, should be present as it causes undue hardness which renders the alloy less workable. Not more than 1% of either titanium or zirconium, if any, should be present, as these elements increase casting difficulties because of oxide and slag formation. And generally speaking, where more than one of the elements mentioned in this paragraph are present in an alloy, the maximum permissible amounts of such elements will be substantially less than if only one of these elements were present.

The invention also applies to alloys of copper, manganese and arsenic with additions of up to 30% of certain elements which form appreciable ranges of solid solution with copper and which remain in solid solution in the alloy regardless of heat treatment. Whether an alloy consists only of copper, manganese and arsenic, or of copper, manganese and arsenic with the addition of one or more other elements, the manganese and arsenic must possess different degrees of solubility in the solid alloy at different temperatures in order that a portion of the manganese and arsenic may be capable of being precipitated out of solid solution by heat treatment at a suitable age-hardening temperature. Such additional elements may be zinc, tin, aluminum and cadmium. In other words, advantageous age-hardenable alloys can be made by adding manganese and arsenic to brass, tin-bronze, aluminum-bronze and cadmium bronze. Depending upon the total amount of manganese and arsenic present in such alloys, the zinc content may range up to 30%, the tin up to 8%, the aluminum up to 8%, and the cadmium up to 1%, and the copper should be at least 67%. And generally speaking, where more than one of the elements zinc, tin, aluminum and cadmium are present in an alloy, the maximum permissible amounts of such elements will be substantially less than if only one of these elements were present.

The maximum total amount of manganese and arsenic which may be present in such alloys decreases as the amount of additional elements increases. Thus, a brass containing 30% of zinc should not have more than a total of 3% of manganese plus arsenic, whereas if only 20% zinc be present in the alloy considerably more manganese plus arsenic can be tolerated, and a similar situation holds true with regard to tin, aluminum and cadmium. Also, if more than one of the elements zinc, tin, aluminum and cadmium are present, this tends still further to limit the amount of manganese plus arsenic which should be present.

The manganese and arsenic age-hardening constituent can also be employed in copper-base alloys in conjunction with other age-hardening constituents.

Wrought alloys made according to our invention can be age hardened to readily give them a tensile strength of more than 50,000 p. s. i., and can be hot and cold worked satisfactorily.

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-hardenable copper-base alloy having not more than 5% of lead, if any, and comprising: essential age-hardening amounts of manganese and arsenic, the manganese being in the range from 0.5% to 20% and the arsenic being in the range from 0.1% to 5%; and copper at least 67%; the alloy being characterized by considerably greater age-hardenability than the same alloy without the said manganese and arsenic.

2. An age-hardenable copper-base alloy having not more than 5% of lead, if any, and comprising: essential age-hardening amounts of manganese and arsenic, the manganese being in the range from 0.5% to 20% and the arsenic being in the range from 0.1% to 5%; and copper, the total of the manganese, arsenic and copper being at least 90%; the alloy being characterized by considerably greater age-hardenability than the same alloy without the said manganese and arsenic.

3. An age-hardenable copper-base alloy having not more than 5% of lead, if any, and comprising: essential age-hardening amounts of manganese and arsenic, the manganese being in the range from 0.5% to 10% and the arsenic being in the range from 0.5% to 5%; and copper, the total of the manganese, arsenic and copper being at least 95%; the alloy being characterized by considerably greater age-hardenability than the same alloy without the said manganese and arsenic.

4. An age-hardenable copper-base alloy having not more than 5% of lead, if any, and comprising: essential age-hardening amounts of manganese and arsenic, the manganese being in the range from 1% to 7% and the arsenic being in the range from 0.5% to 4%; and copper, the total of the manganese, arsenic and copper being at least 95%; the alloy being characterized by considerably greater age-hardenability than the same alloy without the said manganese and arsenic.

5. An age-hardened copper-base alloy having not more than 5% of lead, if any, and comprising: essential age-hardening amounts of manganese and arsenic, the manganese being in the range from 0.5% to 20% and the arsenic being in the range from 0.1% to 5%; a substantial amount up to 30% of metal which forms a solid solution with copper and which remains in solid solution in the alloy regardless of heat treatment; and copper at least 67%; the alloy having been given a solution treatment by having been suitably cooled from temperature above 1200° F. and below the melting point of the alloy, and having been age-hardened by having been given a precipitation treatment at temperature below 1200° F. and at least as high as 700° F., and the alloy being characterized by considerably greater age-hardenability than the same alloy without the said manganese and arsenic.

6. An age-hardened copper-base alloy having not more than 5% of lead, if any, and comprising: essential age-hardening amounts of manganese and arsenic, the manganese being in the range from 0.5% to 20% and the arsenic being in the range from 0.1% to 5%; zinc in substantial amount up to 30%; and copper at least 67%; the alloy having been given a solution treatment by having been suitably cooled from temperature above 1200° F. and below the melting point of the alloy, and having been age-hardened by having been given a precipitation treatment at temperature below 1200° F. and at least as high as 700° F., and the alloy being characterized by considerably greater age-hardenability than the same alloy without the said manganese and arsenic.

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