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METHOD FOR WORKING AND HEAT-TREATING A COPPER BASE ALLOY

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This invention relates to a copper base alloy which may be used as an overlay material and also as a joining material.

The principal object of the invention is to provide such an alloy which is particularly adaptable for use as a metal spray and as a weld metal which is applied automatically.

Another object of the invention is to provide such an alloy which possesses excellent bearing and wear resistant qualities, and at the same time, is sufficiently ductile so that it may be easily handled in a metal spray gun and also in automatic welding machines.

Another object of the invention is to provide a metallurgical treatment for such an alloy whereby the alloy is made sufficiently ductile and is set in this condition thereby making the same commercially desirable for its intended use.

Other objects and advantages of the invention will appear hereinafter.

In the art of metal spraying and automatic welding, only certain alloys have been generally suitable; for instance, regular brass of a composition 85% copper and 15% zinc, regular mild steel SAE 1015, and stainless steel known as 18–8 type. However, these alloys do not possess certain desirable characteristics of aluminum bronzes such as wear resistance, high tensile strength, high hardness values and good bearing properties.

Generally aluminum bronze alloys of high aluminum content have excellent wear resistant characteristics as well as high tensile strength and high hardness values. At the same time these alloys do not ordinarily possess the proper characteristics to make them suitable for use in a metal spray gun or in automatic welding equipment.

According to the invention, the aluminum bronze alloy is composed of copper, aluminum, iron and other ingredients in substantially the following ranges of compositions for the corresponding ingredients:

	Per cent
Aluminum	7.0 to 10.5
Iron	0.0 to 3.5
Others	0.5
Copper	Balance

A preferred composition is as follows:

	Per cent
Aluminum	9.2 to 9.8
Iron	1.25 maximum
Others	0.5 maximum
Copper	Balance

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It will be understood that various other ingredients such as silicon, nickel, manganese, etc. may be included in the composition of the aluminum bronze alloy of the invention, and that the hereinafter described heat treatment may be used successfully in connection with these alloy compositions.

In order to produce an aluminum bronze alloy of the above composition that would serve successfully for metal spraying or automatic welding it has been found necessary to subject the alloy to a high temperature soak following by furnace cooling to a predetermined temperature. The alloy is next given a water quench and then a low temperature soak.

As a specific example, if a 0.125" aluminum bronze spray or automatic weld wire is desired, a preferred practice is to start with 0.225" stock, preferably extended, and draw it down to approximately 0.128". The stock could, of course, be hot swaged, but the cost of this method of reduction is substantially prohibitive and the tolerance limits required make this method unsuitable for the purpose. The partially worked wire is coiled as it comes from the extension press and the coils are placed in a furnace at a temperature of approximately 1600° F. After soaking for about 15 to 30 minutes at this temperature, the temperature of the furnace is reduced about 200° to 300° F. per hour until it reaches approximately 1100° F. At this temperature, which is above the eutectoid transformation point, the maximum amount of alpha will precipitate.

After the above treatment, the coils of aluminum bronze alloy wire are given a quench to prevent the formation of any detrimental eutectoid phase. The quench may be by submerging the coils in plain water or salt water.

The wire is then given a final draw which reduces its diameter to the diameter desired in the final product. In the example given, the draw would be 0.003" and the final diameter of the wire, 0.125".

The wire is next given a low temperature heat treatment at a temperature below that of the eutectoid transformation. This temperature may be from 400° to 600° F. but the preferred temperature is approximately 500° F. This will set the wire so that it will not be wild when released from the coils for easy manipulation in a spray gun or automatic welding apparatus.

It is preferable that the wire then be cleaned so that the deposited metal, whether it be from a spray gun or from automatic welding apparatus, will be free from oxides that are of a detrimental nature.

The high temperature treatment of the coils of aluminum bronze alloy wire, followed by slow cooling to a temperature above the temperature for eutectoid transformation, puts the wire in a condition so that the final draw can be accomplished in one pass through the drawing die. The wire is not subject to breakage as would be generally the case if the above steps of treating were not followed. During the final drawing operation it has been found that exceedingly close tolerances of diameter may be obtained.

The physical properties of an aluminum bronze sprayed deposit of the preferred alloy composition treated as above described are:

85–90 Rockwell B
90,000–100,000 p. s. i. compressive strength
25,000–35,000 p. s. i. ultimate tensile strength
0.5% elongation in 2''

The sprayed deposit is hard, tough and easy to machine. It is particularly free from cracking when applied to large areas and in this respect is markedly different than most aluminum bronze alloys.

The physical properties of an aluminum bronze weld deposit of the preferred alloy composition treated as above described are:

80,600–91,700 p. s. i. ultimate tensile strength
46,000–47,000 p. s. i. yield 0.5% elongation
13.5–25.0% elongation in 2''
6.5–16.0% reduction of area
235–245 Brinell-hardness on steel overlay.

The method of this invention may be used with any aluminum bronze alloy composition in which there is a substantial alpha plus beta range existing between the temperature for beta formation and the temperature for eutectoid formation. The controlled slow cooling from the high soaking temperature of substantially 1600° F. to a temperature above the temperature of eutectoid transformation permits the maximum amount of alpha to precipitate. The microstructure of an aluminum bronze alloy of the above type, when treated according to the invention, will be very uniform both in longitudinal and transverse section and will show a large uniform grain size. The alpha size is generally about .045 milimeter.

The invention is generally applicable to the above type aluminum bronze alloy which has been worked such as being drawn, extruded, rolled or forged as distinguished from such an alloy in the as cast condition.

Various embodiments of the invention may be employed within the scope of the accompanying claims.

I claim:

1. The method of heat treating a worked aluminum bronze alloy having a substantial alpha plus beta temperature range disposed between a beta temperature range and a range of temperatures for eutectoid transformation, which comprises heating said alloy to within the beta temperature range, gradually reducing said temperature to above the range of temperatures for eutectoid transformation to obtain alpha precipitation quenching said alloy, and thereafter heating said alloy to a predetermined temperature below the range of temperatures for eutectoid transformation.

2. The method of heat treating a worked aluminum bronze alloy having a substantial alpha plus beta temperature range disposed between a beta temperature range and a range of temperatures for eutectoid transformation, which comprises heating said alloy to within the beta temperature range, gradually reducing said temperature to above the range of temperatures for eutectoid transformation to obtain alpha precipitation, and thereafter quenching said alloy.

3. The method of imparting ductility to a worked aluminum bronze alloy having an aluminum content of from 7.0 to 10.5% and of high wear resistant characteristics, which comprises heating said alloy to approximately 1600° F., gradually reducing said temperature to above the range of temperatures for eutectoid transformation, quenching said alloy, and thereafter heating said alloy to a temperature of approximately 500° F.

4. The method of heat treating an aluminum bronze alloy for use as a welding or overlay material having an aluminum content of from 7.0 to 10.5% and of high wear resistant characteristics to impart ductility thereto, which comprises heating said alloy to approximately 1600° F., gradually reducing said temperature to a predetermined temperature above the range of temperatures for eutectoid transformation, quenching said alloy and thereafter heating said alloy to a predetermined temperature below the range of temperatures for eutectoid transformation.

5. The method of heat treating a worked aluminum bronze alloy having an aluminum content of from 7.0 to 10.5% and of high wear resistant characteristics to impart ductility thereto, which comprises subjecting said alloy to a high temperature soak of approximately 1600° F., gradually reducing said temperature to a predetermined temperature above the range of temperatures for eutectoid transformation to permit a maximum amount of alpha to precipitate, and thereafter quenching said alloy to prevent formation of the eutectoid phase.

6. The method of heat treating an aluminum bronze alloy for use as a welding or overlay material having an aluminum content of from 7.0 to 10.5% and of high wear resistant characteristics to impart ductility thereto, which comprises subjecting said alloy to a high temperature soak of approximately 1600° F., gradually reducing said temperature to a predetermined temperature above the range of temperatures for eutectoid transformation to permit a maximum amount of alpha to precipitate, quenching said alloy to prevent formation of the eutectoid phase, and thereafter heating said alloy to a predetermined temperature below the range of temperatures for eutectoid transformation to impart a set to said alloy.

7. The method if heat treating an aluminum bronze alloy having an aluminum content of from 7.0 to 10.5% and of high wear resistant characteristics, which comprises applying to said alloy a high temperature furnace soak at approximately 1600° F., gradually reducing said temperature to a predetermined temperature of approximately 1100° F. to impart ductility to said alloy, quenching said alloy, and thereafter heating said alloy to a predetermined temperature below the range of temperature for eutectoid transformation to increase the yield strength thereof and to impart a set to said alloy and to retain said ductility.

8. The method of heat treating an aluminum bronze alloy wire having an aluminum content of from about 7% to about 10.5% and of high wear resistant characteristics and adapted for use in metal spray and automatic welding equipment, which comprises heating said wire to a temperature of approximately 1600° F., reducing said

temperature at a rate of about 200°–300° F. per hour to about 1100° F. to impart ductility to said wire, quenching said wire, and thereafter heating said wire to approximately 500° F. to impart a set to said wire and thereby retain ductility in said wire.

9. In the manufacture of an aluminum bronze alloy wire having an aluminum content of about from 7% to about 10.5% and of high wear resistant characteristics and adapted for use as a metal spray and in automatic welding equipment, the steps which comprise imparting a plurality of alternate breakdown draws and anneals to wire stock, forming said stock into coils of suitable length, heating said coils to a temperature of approximately 1600° F., gradually reducing the temperature of said coiled wire to above the range of temperatures for eutectoid transformation, quenching said coils, imparting a final drawing to said wire, forming said wire into coils, and thereafter heating said coils to a temperature below the range of temperatures for eutectoid transformation to impart a set to said coiled wire.

10. The method of heat treating a high strength aluminum bronze alloy wire of the following constituents in substantially the percentage ranges given:

	Per cent
Aluminum	7.0 to 10.5
Iron	0.0 to 3.5
Others	0.0 to 0.5
Copper	balance

to impart ductility thereto preparatory to drawing the same to diameters of approximately ⅛ inch or less with diameter tolerances of .0005 inch plus or minus, which comprises heating said wire to a temperature of approximately 1600° F., reducing said temperature at a rate of about 200°–300° F. per hour to approximately 1100° F. which is just above the eutectoid transformation point, and then quenching said wire from said 1100° F.

11. The method of producing a drawn high strength bronze alloy wire having a diameter

tolerance less than about .0005 inch plus or minus and for use in metal spray and automatic welding equipment, comprising first producing a roughly drawn wire of excess diameter and of the following constituents in substantially the percentage ranges given:

	Per cent
Aluminum	7.0 to 10.5
Iron	0.0 to 3.5
Others	0.0 to 0.5
Copper	balance

then subjecting the wire to a high temperature soak at approximately 1600° F., gradually reducing said temperature to a predetermined temperature above the range of temperatures for eutectoid transformation to obtain a substantial precipitation of alpha, then quenching the wire to prevent formation of the eutectoid phase, drawing the wire to final tolerance dimensions, and thereafter heating the wire to a predetermined temperature below the range of temperatures for eutectoid transformation to impart a set to the alloy.

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