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COPPER-TITANIUM ALLOY

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My invention relates generally to copper alloys in which copper is the major constituent, and particularly to alloys containing copper, titanium and silicon which have been subjected to temper-hardening treatments that develop increased hardness, strength and electrical conductivity, particularly in respect to these ternary copper alloys in the form of castings.

The object of my invention is, among other things, to improve both the hardness and the electrical conductivity of copper-titanium alloys, so that heat-treated castings of this material may preferably serve with satisfaction as electrodes in welding machines.

The machines referred to are those usually employed for the fabrication of automobile bodies from steel sheets, or for closing the seams of tubes made of steel strips, or similar purposes. The welding tips on these machines which convey electric current through the steel sheets to fasten them together by heat and pressure must be hard enough not to deform, and must also have sufficient electrical conductivity so as not to become overheated by the passage of the current which would also be likely to lead to deformation and poor welding.

Copper-titanium alloys containing from about 0.75% to about 2% or more titanium are known to be hardenable by heat treatment to above 100 on the Brinell scale, which is sufficient for the welding tips referred to, but in the form of castings at least they are too low in conductivity. The copper-titanium-silicon alloy described in my U. S. Patent No. 2,086,604 of July 13, 1937 has sufficiently high conductivity for this purpose, but is slightly deficient in hardness in the form of heat-treated castings.

I have now discovered that by the addition of about 0.2 to 0.5% chromium to that alloy containing about 0.8 to 1% titanium, 0.2 to 0.45% silicon, and balance copper, castings may be made which, after proper heat-treatment, are sufficiently hard and high in conductivity to serve with satisfaction as tips in certain kinds of welding machines.

The heat-treatment required to secure the best properties in castings of this new and improved alloy is generally a quench in water after holding at 1650° F. for about 1 to 2 hours, followed by tempering at 900 or 950° F. for 16 to 24 hours. The hardness after this treatment is about 105 to 115 Brinell, and the conductivity about 40 to 50%. The iron content however must be very low to reach 50% conductivity, as if such iron content approaches 0.2%, the conductivity may not be over 30%. Other impurities such as tin, zinc, aluminum, etc. also impair seriously the conductivity.

If high conductivity is desirable and the hardness need not be over 100 Brinell, the castings of this improved alloy may be merely tempered as it comes from the sand without an intervening quench. For example, alloys containing 0.79 to 1.01% titanium, 0.26 to 0.41% silicon, 0.17 to 0.19% chromium, and 0.034 to 0.05% iron, and the balance copper, merely tempered 15 to 35 hours at 900 to 950° F. were found to have 51.5 to 61% conductivity, and Brinell hardness of 90 to 95.

With lower silicon, or higher titanium, and tempering for a longer time at 750° F. after quenching, Brinell hardness may be secured in these alloys, but at the expense of conductivity. For example, these copper alloys containing either 0.85% titanium, no silicon, and 0.15% chromium; or 1.24% titanium, 0.18% silicon, and 0.16% chromium showed after quenching from 1650° F. and tempering 41 to 62 hours at 750° F., Brinell hardness of 130 to 143 and conductivity of 27 to 28%. If tempered at 900° F., these copper-titanium alloys with low silicon lose both hardness and conductivity, whereas the alloys with the herein specified silicon content have the best properties after tempering at about 900° F.

My preferred improved alloy to obtain the best combination of hardness and conductivity may be set as about 0.9% titanium, 0.4% silicon, and 0.4% chromium, with the balance copper, but considerable variation from these proportions may be desirable depending on whether hardness or conductivity is most important. Impurities such as iron, tin, etc. should be less than 0.1%. If hardness is desired more than conductivity, the titanium may be raised and the silicon reduced. Chromium above 0.6% is not generally desirable in this improved alloy. The permissible range of composition of the alloys embraced by my invention may, therefore be specified as about 0.6 to 1.5% titanium, 0.1 to 0.6% silicon, 0.1 to 0.6% chromium and the balance copper, and preferably with no impurity above about 0.1%.

As examples of the commercial production of castings of my new and improved alloy which have been used successfully in welding machines, the following manfacturing records are presented as typical of my invention:

Example A.—A charge of 138 lbs. of pure copper was first melted in a Tercod crucible using a glass flux in an oil-fired furnace. After superheating the glass was removed, and the copper

was deoxidized with ½ lb. of a silicon-calcium-magnesium-copper alloy, and 10.2 lbs. of 10% chromium copper, and then 0.6 lb. of refined silicon were stirred in. Then 1.7 lbs. of metallic titanium were added by means of a graphite "phosphorizer" or inverted cup; when this addition of titanium had dissolved completely, the crucible was withdrawn from the furnace and its contents poured into molds. The analysis of these castings showed 0.79% titanium, 0.41% silicon, 0.19% chromium, and about 0.05% iron and the balance copper; after heating same at 1650° F. for 1½ hours, quenching in water, reheating at 950° F. for 16 hours and cooling in air, a casting was found to have 48.9% conductivity and a Brinell hardness of 109.

Example B.—Another casing of my improved alloy was much larger, and required the contents of seven crucibles mixed in a large ladle before the mold was poured. The charge consisted of 1220 lbs. of gates and risers from previous castings of this same alloy, 1440 lbs. copper deoxidized by 12 lbs. of the same Si-Ca-Mg-Cu alloy referred to in Example A., and treated with 149 lbs. 10% chromium-copper, 3.2 lbs. metallic silicon, and 24 lbs. of titanium. A glass flux was used in each pot when melting and superheating, and was removed before making the alloy additions. This casting and a test-bar from the same ladle were heated to 1650° F. for 1½ hours, quenched in water, reheated to 900° F. for 16 hours and then cooled in air. The test-bar then showed 105 Brinell hardness and about 32% conductivity. It analysis was 0.92% titanium, 0.39% silicon, 0.54% chromium, and 0.183% iron, with the balance copper; the iron content was too high for the best conductivity.

Although these examples refer to castings, my improved alloy has also been forged successfully, and my invention, involving only a new and improved composition, may be applied also to rolled or forged bars, wire, or sheets, which may be heat-treated either before or after fabrication.

I claim as my invention:

1. A heat-hardened copper alloy containing titanium from about 0.6 to 1.5%, silicon from about 0.1 to 0.6%, chromium from about 0.1 to 0.6%, and the balance consisting substantially entirely of copper.

2. A heat-hardened copper alloy containing titanium about 0.9%, silicon about 0.4%, chromium about 0.4% and the balance consisting substantially entirely of copper.

3. A tempered copper alloy containing from about 0.79 to 1.01% titanium, 0.26 to 0.41% silicon, 0.17 to 0.19% chromium, with the balance consisting substantially entirely of copper, and having from about 51.5 to 61% electrical conductivity and Brinell hardness of 90 to 95.

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