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COPPER-BASE ALLOYS

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1 Claim. (Cl. 75—162)

This invention concerns improvements relating to copper-base alloys. It is particularly concerned with such alloys intended for making castings and with castings made of these alloys, especially heavy section castings such, for instance, as marine propellers. However, alloys in accordance with the invention can also be used with advantage in the wrought condition.

The more complex aluminium bronzes, generally containing nickel and iron and, less frequently, small proportions of manganese, have many good properties such as high strength and ductility and good resistance to fatigue and corrosion, but are at a particular disadvantage in comparison with other copper-base alloys for casting purposes. The principal difficulties arise from the high temperatures at which the alloy has to be melted and poured and there are strong tendencies for the alloy to take up gas when melted on the large scale (particularly in reverberatory furnaces) and for dross and oxide inclusions to be formed in the mould and entrapped in the casting. Thus, for example, such serious difficulties are encountered if the high-strength aluminium bronze containing 10% Al, 5% Ni and 5% Fe (D. T. D. 412) is used for very large or heavy castings. These difficulties have largely held back the application of this class of alloy to heavy castings.

An object of the present invention is to provide an alloy having the good properties of the aluminium bronzes containing nickel and iron, especially good resistance to fatigue and to corrosion, but without the disadvantages for casting purposes of a high melting point.

According to the invention, aluminium bronze, or a casting or forging of such bronze, comprises 10 to 15% (preferably 11 to 14%) of manganese, 6½ to 9% of aluminium, 2 to 4% (preferably 2.5 to 3.5%) of iron and 1.5 to 6% (preferably 2 to 5%) of nickel, the rest being copper (at least of the order of 70%) apart from the impurities or small quantities of other elements usually found in ordinary aluminium bronzes. Conversely those elements which are known to be objectionable in such bronzes should generally be avoided. Thus materially more than about 0.2% silicon or 0.02% phosphorus is deleterious.

An example of a composition which has been found to have good casting qualities as well as good tensile properties, good resistance to fatigue and corrosion fatigue in sea water and good resistance to corrosion and cavitation erosion (a combination of properties suitable for marine propellers) is as follows:

	Per cent
Manganese	11.7
Aluminium	7.2
Iron	3.3
Nickel	2.2
Copper	Remainder

A tested sample of this composition had the following properties:

0.15% proof stress	18.0 tons per sq. in.
Ultimate tensile stress	42.5 tons per sq. in.
Elongation	28% on 2 inches.
Fatigue strength	±17.7 tons per sq. in.
Melting point	960° C.

The alloy according to the invention casts well in both sand and metal moulds. It is clean-running and free from troubles associated with dross formation in the mould. Furthermore, its properties, including tensile strength and fatigue strength, are not seriously reduced when it is cast in heavy sections, this advantageous feature being especially surprising.

The alloy has been found to cast well in die moulds and gives gravity die castings which have the strength and toughness expected of standard aluminium bronzes and which can be employed for equally arduous duties. By reason of its lower melting point, however, the alloy according to the invention shows less tendency than the said bronzes to produce crazing of the dies.

Finally, the alloy also has further useful properties in the wrought condition. Although it may have the same strength as a standard high-strength aluminium bronze, it is more easily forgeable and can be worked at lower temperatures with the further advantage of lower wear of the forging dies. An example of a forgeable composition with high corrosion resistances is as follows:

	Per cent
Manganese	12
Aluminium	7.25
Iron	3.0
Nickel	5.0
Copper	Remainder

The qualities and properties of the alloy according to the invention are thus such as to make it useful to designers in several fields.

Copper-aluminium alloys containing substantial proportions of manganese have been studied by various workers, but practical interest in these alloys appears to have been largely confined to the wrought form and to a few compositions having special electrical or magnetic properties. At any rate little or no practical use has been made of such alloys for castings. Indeed it is most surprising that the composition in accordance with the invention has proved to have good casting qualities, as alloys with a high manganese content have generally enjoyed a bad reputation with regard to these qualities. Furthermore, little or no information was available as to the practical properties, for example the fatigue properties, of such copper-aluminium alloys containing substantial proportions of manganese.

In the composition according to the invention, low melting point is associated with the presence of the manganese, whilst grain refinement and considerable improvement in mechanical properties appear to be imparted by the iron content. Corrosion resistance is associated with the nickel content and it is a matter for surprise that a useful improvement can be secured with a relatively small content, this moreover without sensibly increasing the melting points of the alloy.

For purposes requiring a moderate degree of corrosion resistance, an alloy containing 2% (or at least 1½%) of nickel will normally be employed. For example, an advantageous such alloy comprises approximately 12% of manganese, 7½% of aluminium, 3% of iron and 2% of nickel, the rest being substantially copper. Increase in the nickel content results in improvement in the corrosion resistance without appreciable variation of the mechanical properties of the alloy. With a nickel content of 5% (or between 4 and 6%), corrosion resistance equivalent to that of the best manganese-free aluminium bronzes can be obtained. Small additions of tin may also

be made for the purpose of improving the corrosion resistance.

We claim:

An aluminum bronze containing not less than 6½% nor more than 9% aluminum, and manganese in an amount corresponding approximately to a manganese to aluminum ratio of 1.6 to 1, 1.5 to 6% nickel, 2 to 4% iron, the rest being essentially copper, the said bronze having an alpha-beta microstructure with minor quantities of other microstructural constituents, and the said bronze having a melting point of about 960° C.

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