Patented Feb. 3, 1942 2,271,969

UNITED STATES PATENT OFFICE

2,271,969

ALLOY

Charles H. Davis, Cheshire, and Elmer L. Munson, Naugatuck, Conn., assignors to The American Brass Company, a corporation of Connecticut

No Drawing. Application October 21, 1939, Serial No. 300,584

1 Claim. (Cl. 75—160)

This invention relates to alloys and has for its principal object the provision of an improved copper-base alloy of the copper-aluminum-silicon type.

Copper-aluminum-silicon alloys have been known for many years. These alloys are hard and strong, they are resistant to corrosion under a wide variety of conditions, and they are lighter in weight than alloys of copper and silicon containing no aluminum. They are, however, somewhat difficult to machine, and for this reason are not wholly satisfactory for use in the manufacture of machined parts on automatic screw machines.

We have found that the machinability of alloys comprising chiefly copper with relatively small amounts of silicon and aluminum is materially improved by the addition of a small amount of lead. The presence of lead in the alloy does not appreciably impair its hot and cold working properties, and the improved machinability imparted by the lead greatly increases usefulness of the alloy.

Copper-base alloys of aluminum and silicon usually contain from 0.25% to 11% aluminum, from 0.1% to 3.5% silicon, and the balance chiefly copper. These percentages and others throughout this specification and the appended claims are by weight of the alloys. An alloy of this general type embodying our invention may comprise from 0.25% to 11% aluminum, from 0.1% to 3.5% silicon, from 0.1% to 3% lead, and about 75% or more copper, with or without other alloying metals as hereinafter more particularly pointed out. Such an alloy is considerably easier to machine than the alloy containing no lead, and so is much more suitable stock for use in automatic screw machines.

The following tabulation indicates the improved machinability of the new lead-bearing alloy:

Alloy	A	B	C	D
Percent Al	8	8	3	3
Percent Si	1	1	1.5	1.5
Percent Pb		1		1
Cu	Balance	Balance	Balance	Balance
Machinability	Fair	Excellent	Fair	Excellent

Machinability as set forth in the above tabulation was determined by drilling into test bars (rolled and drawn from cast shapes of the alloy) and noting the ease and speed with which the metal could be cut, and the character of the chips and of the hole formed. The bars containing no lead could not be drilled as rapidly as the lead-bearing bars, and were discolored near the point of drilling when the drill was forced. The chips from the lead-bearing bars came away more cleanly than from the bars containing no lead, and the hole formed was smooth and free of burrs.

The four alloys listed in the above tabulation were tested for forgeability. Alloys A and B, containing a relatively high proportion of aluminum, both displayed excellent forging properties, but alloys C and D, containing a lower percentage of aluminum, were less satisfactory in this respect. Alloy B, therefore, was the most satisfactory of these four alloys for general use.

Other metals may be incorporated in the alloy for the purpose of imparting special properties, such as improved casting, forging and working properties. Manganese is a particularly desirable addition, for it improves the casting qualities of these alloys, apparently by increasing fluidity of the melt and bringing about suitable shrinkage during solidification. Manganese also increases the strength and toughness of the alloy, and improves its hot working (forging, rolling, extruding, etc.,) properties by preventing the appearance of minute edge cracks in the hot-wrought article. From 0.1% to 3% manganese may be added to the lead-bearing alloys described above to secure these benefits.

Iron may be incorporated in the alloy to increase its hardness and tensile strength and also to make the alloy easier to hot work by increasing the hot working temperature range. Iron refines the grain structure of the new alloy, keeping it uniform and fine. These benefits may be achieved by incorporating from 0.25% to 4% iron in the lead-bearing alloys described above. Such amount of iron does not appreciably impair the machinability of the alloy.

~~Nickel may be present in the alloy in amounts up to 5%~~, but it does not particularly improve the alloy. The presence of a small amount of zinc in the alloy is not objectionable. Tin also may be present in the alloy in small amounts of the order of 0.25%, but experience indicates that larger amounts of tin are likely to make the alloy subject to cracking. The alloy may in addition contain small amounts of impurities, such as elements commonly present in commercial copper and other components of the alloy, without detrimental effect.

Particularly satisfactory free-machining alloys for general use as screw machine stock comprise from 5% to 9% aluminum, from 0.5% to 2.5% silicon, from 0.75% to 1.75% lead, and the balance chiefly copper. If manganese is employed, it is generally preferred to use it in amount from 0.5% to 1.5%, and iron, if employed, preferably is added in amount from 0.5% to 4%. Alloys prepared within these preferred percentage limits possess the best balance of properties for general use where a strong, corrosion-resistant relatively light, free-machining metal is desired.

The maximum amount of silicon it is desirable to employ in order to obtain alloys having optimum hot and cold working properties varies inversely with the amount of aluminum present. For example, an alloy containing as little as 0.25% aluminum may contain as much as 3.5% silicon, whereas an alloy containing as much as 10% aluminum preferably contains only about 0.5% silicon. Manganese and iron, if present in the alloy, are additive to the aluminum in so far as determining the optimum maximum silicon content is concerned. In the following tabulation preferred maximum ratios of silicon to aluminum (plus manganese and iron, if present) are set forth by way of example:

Percent Al (+Mn+Fe, if present)	Preferred max. percent Si	Percent Cu+Pb
5	3.5	Balance.
6	3.0	Do.
7	2.5	Do.
8	2.0	Do.
9	1.5	Do.
10	0.5	Do.

Alloys according to the invention may be worked at a red heat by rolling, forging, extruding, pressing and stamping operations and therefore may be fabricated into various articles at moderate expense. The new alloys may be cold-rolled or cold-drawn to a limited extent by the usual procedures for cold working the more refractory copper-base alloys. The amount of reduction attainable by cold working may be increased if the alloy is hot worked and then allowed to cool slowly in air before subjecting it to the cold working operation. The alloys are hardened by cold working, but may be annealed by heating, for example, for about two hours at about 600° C. If maximum hardness is desired without resort to cold working, it may be obtained by quenching the alloy in water from temperatures in the neighborhood of 850° C. As in the case of several of the so-called aluminum bronzes, prolonged heating of the new alloys at relatively low temperatures, for example at about 300° C. to 400° C., results in some increase in hardness.

Following is an example of an alloy prepared according to the invention:

	Per cent
Copper	88.75
Aluminum	8.50
Silicon	0.75
Lead	1.00
Manganese	1.00

This alloy was prepared by melting together weighed quantities of the several components. The molten alloy was cast into a suitable shape which was extruded hot and then drawn cold into a round rod of 1¼ inches in diameter. In this form it possessed the following properties:

Tensile strength	84,000 to 98,000 lb./sq.in.
Yield strength in 0.5% extension	60,000 lb./sq. in.
Elongation in 2''	12%.
Rockwell hardness ("B" scale)	100.
Brinell hardness	210.
Density	7.43 gm./cc.

This alloy was found to machine easily at commercial speeds without overheating and without burring or tearing. It possessed good hot-forging properties.

The beneficial effect of iron on the forgeability of the new alloy is indicated by the following example. Three alloys containing different amounts of iron were prepared, as follows:

	Alloy		
	A	B	C
	Percent	*Percent*	*Percent*
Copper	88.00	86.75	84.75
Aluminum	8.50	8.50	8.50
Silicon	0.75	0.75	0.75
Lead	1.00	1.00	1.00
Manganese	1.00	1.00	1.00
Iron	0.75	2.00	4.00

Discs one inch long were cut from one inch diameter bars formed from each of these alloys and were hot-forged at 750° C. and at 850° C. into lozenges approximately one-quarter inch thick. The hot-forgeability of these alloys, and their machinability, is indicated in the following tabulation:

	Alloy		
	A	B	C
Forgeability at 750° C	Good	Very good	Excellent.
Forgeability at 850° C	Fair	Good	Do.
Machinability (cold)	Very good	Very good	Very good.

We claim:

A copper-base alloy comprising about 8.5% aluminum, about 0.75% silicon, about 1% lead, about 1% manganese, and the balance substantially all copper.

CHARLES H. DAVIS.
ELMER L. MUNSON.