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COPPER ZINC SILICON ALLOYS

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This invention relates to alloys of copper, zinc and silicon, and particularly to alloys of this group of metals containing relatively large proportions of copper and silicon. That is, it relates more especially to alpha brasses containing relatively large amounts of silicon.

The chief object of the invention is to provide a series of copper, zinc, silicon alloys which will produce strong, sound alloys which can be readily cast, worked either hot or cold, and which are highly resistant to the corrosion of certain mineral acids, organic acids, alkalies and other corrosive liquids.

It is also an object of the invention to produce a series of alloys which are harder, stronger, tougher and more elastic than the common brasses.

Zinc forms homogeneous solid alpha solutions with copper in amounts up to about 30 percent of zinc, and we have discovered after extended research that by adding relatively large amounts of silicon (from about $\frac{1}{2}$ percent to about 6 percent) to these alpha brasses, particularly those with the higher copper contents, very material improvements in certain characteristics and properties are secured.

The exact properties of the alloys depend upon the composition. Alloys high in copper and relatively low in zinc and silicon are hard malleable ductile and tough. As an alloy of this type we may mention an alloy composed of about 88 percent copper, 10 percent zinc and 2 percent silicon. Such an alloy has a Brinell hardness of 80, a tensile strength of about 38,000 pounds per square inch and an elongation of about 32 percent.

We have found that by increasing the zinc and silicon contents, alloys are obtained which are harder, stronger and more elastic but less malleable. Thus for example an alloy containing about 82 percent copper, 15 percent zinc and 3 percent silicon has a Brinell hardness of 135, a tensile strength of about 42,000 pounds per square inch with an elongation of about 10 percent.

When the amount of silicon is increased to about 4 percent with about 12 percent zinc and 84 percent copper the alloys are unusually hard and strong but are much less malleable. Their Brinell hardness is about 185, tensile strength about 60,000 pounds per square inch with about 8 percent elongation.

Alloys with much higher zinc and lower copper contents are also valuable for certain purposes. For example, an alloy of copper about 75 percent, zinc 23.5 percent and silicon 1.5 percent is hard, strong and somewhat malleable. Its

Brinell hardness is about 140, its tensile strength about 40,000 pounds per square inch, and its elongation about 12 percent.

When the silicon content is increased above about 3 percent the alloys become quite brittle unless the proportion of copper is made quite high. Thus if 6 percent of silicon were added to a brass containing 80 percent copper and 20 percent zinc that would be too much and the resultant alloy would probably not be practical as it would be too brittle and unworkable. However, by increasing the copper content of the brass to about 93 percent the silicon content can be increased to as high as about 6 percent, the percentage of zinc being correspondingly decreased, and valuable alloys can be obtained which are strong, and may be readily worked. This represents about the maximum solubility for silicon. With the 80 percent copper a silicon content of from about 0.5 percent to about 4.0 percent and the balance zinc, would be a reasonable addition of silicon, and would produce strong workable alloys.

With a copper content above 93 percent we can secure easily workable alloys which are very valuable for certain purposes. Thus with a copper content as high as 98 percent, silicon about 1.0 percent and zinc about 1.0 percent we secure a very useful alloy. The proportions can be varied considerably without getting out of the useful alloy range. Thus as indicated above, the copper can vary down to about 80 percent, the silicon ranging from about 0.5 percent to about 6.0 percent and the zinc from about 1.0 percent to about 20 percent.

We have found that silicon forms solid alpha solutions (alloys) with 85—15 brass (about 85 percent copper and about 15 percent zinc) up to at least about 2.8 percent silicon. At somewhat above this percentage of silicon a beta phase appears so that from about 2.8 percent silicon up to about 5.2 percent we have mixed alpha and beta phases for 85—15 brass. These are all useful alloys. Further, as intimated above, with an increase in copper silicon forms solid alpha solutions or mixed alpha and beta solutions up to about 6 percent silicon. These are also very useful alloys.

Thus we have discovered that a valuable series of strong, workable, corrosion resistant alloys can be produced with copper ranging from about 80 percent to about 98 percent, silicon from about 0.5 percent to about 6 percent, and the balance zinc, or that is, from about 19 percent to about 1 percent. The higher the percentage of copper in the alloy the greater is the amount of silicon it is

possible to use to secure a solid, homogeneous alloy, and one which may be worked, but as the silicon is increased the zinc should be decreased. However small amounts of tin, aluminum, chromium, manganese, or other metals may also be present.

The silicon increases the usefulness of the copper zinc alloys by giving them a lower melting point, and by making them easier to cast. The castings produced are cleaner and sounder than those produced without the use of silicon, and the alloys formed have greater strength, hardness, toughness, and elasticity than the common brasses, and are much more resistant to the corrosive action of certain corrosive liquids.

The alloys may be prepared by first melting the copper and silicon together in a crucible, and then adding the zinc. Suitable deoxidizers may be used, and a suitable flux cover of such as sodium chloride and borax in about equal amounts.

These alloys may be worked hot or cold, and when worked cold may be softened at certain stages by annealing at suitable temperatures and for the proper length of time. For example they may be annealed by heating from about 650 to 800° C. at from one to twelve hours, with which treatment they become practically homogeneous and attain a condition of equilibrium. After such anneals the cold working may be continued.

Having thus set forth the nature of our invention, what we claim is:

1. A copper base alloy composed of copper, silicon and zinc in substantially the following proportions, from 0.5% to 6% silicon, from 5.5% to 19% zinc, and balance substantially copper and at least 80.5% in amount. 80
2. A copper base alloy comprising from about 10% to about 15% zinc, from about 2% to about 4% silicon, and balance substantially copper. 85
3. A copper base alloy comprising approximately 88% copper, 2% silicon and balance substantially all zinc.
4. A copper base alloy comprising approximately 82% copper, 3% silicon and balance substantially all zinc. 90
5. A copper base alloy comprising approximately 84% copper, 4% silicon and balance substantially all zinc.
6. A copper base alloy composed of copper, silicon and zinc in substantially the following proportions, from 0.5% to 3.5% silicon, from 1% to 19% zinc, and balance substantially copper and at least 80.5% in amount. 95
7. A copper base alloy comprising approximately 0.5% to 2.8% silicon, from 1% to 19% zinc and balance substantially all copper. 100

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