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COPPER ALLOY

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This invention relates to alloys, and particularly to copper base alloys.

An object of this invention is the provision of a copper base alloy which is susceptible to precipitation hardening.

A more specific object of this invention is the provision of a copper base alloy of the bronze classification which has a high hardness and tensile strength in the "as cast" condition and which has precipitation hardening characteristics.

Other objects of this invention will become apparent from the following description when taken in conjunction with the appended claims.

In order to produce the copper base alloy having the desired hardness and physical characteristics, metals which can be precipitated from solution in the copper are added to a copper melt. It has been found that a copper base alloy containing from a small but effective amount up to 5% of cobalt, from a small but effective amount up to 5% of iron and from about .10% up to 20% of tin has the desired characteristics. In a prior application Serial No. 149,146, filed June 19, 1937, and issued as Patent 2,147,844 on February 21, 1939, I have disclosed and claimed the alloy of copper, cobalt and iron and have disclosed a particular relationship for the cobalt and iron contents. In the alloy of this invention, it is desirable to maintain substantially the same relation of the cobalt and iron contents, since it has been found that in the ratio of between .5 and 1.25 to 1, as disclosed in the aforesaid patent, the cobalt and iron contents cooperate with the alloying element tin in the copper base to give the desired characteristics.

As examples of the results obtained with the alloy of this invention, a direct comparison is made in the following table between the copper, cobalt and iron alloy of Patent 2,147,844 and alloys of similar cobalt and iron content but containing tin as an essential alloying element thereof. In the table, the copper content is omitted, it being understood that the balance of the alloying content comprises copper with possible incidental impurities occurring during the alloying process:

Table I

Alloy No.	Per cent of constituents			Hardness Rockwell B	Ultimate strength
	Co	Fe	Sn		
3783	1	1	------	72	64,700
3798	1	1	0.5	88	86,500
3799	1	1	1.0	86	80,000

These results were obtained from the alloys which were precipitation hardened by the preferred treatment consisting of quenching from a temperature of between 750° C. and the melting point of the alloys and ageing them at a temperature of between 400° C. and 550° C. The particular treatment given the alloys in the foregoing table consisted of quenching them from 1000° C. in water and ageing them for 25 hours at 500° C. after which they were swaged about 23% and tensile tests were conducted on samples 12" long by .25" in diameter using a constant strain rate on all specimens.

From the results given, it is apparent that the cobalt, iron and tin cooperate in the copper base to give an alloy having improved characteristics. Although tin because of its high solid solubility in copper is not generally considered to be a precipitation hardening element when added to copper, it is thought that, in combination with the iron and cobalt in the alloy of this invention that it accelerates and intensifies the beneficial effect of these alloying elements.

In the alloys produced, it is found that the tin is very active in restricting columnar crystal growth in the alloy in the "as cast" condition. Thus, the inclusion of tin in this particular alloy is conducive to a fine grain structure producing castings which are stronger mechanically and which are easily reproduced. In addition, it is found that tin in the alloy of this invention improves the elongation characteristics of the alloy giving an alloy in which tensile tests produces a neck down type of fracture instead of a shear type of fracture.

The beneficial effects of the alloying elements cobalt, iron and tin in copper are particularly found in the alloys containing tin in up to 20% as an essential alloying constituent thereof. Such alloys are found to be precipitation hardening as well as having the unusual characteristic of being extremely strong in the "as cast" condition. As representative of the alloys containing the higher tin content, reference may be had to the following table giving the alloying constituents of certain of the alloys examined both as to the results obtained for the particular alloy of this invention and for comparison with the well known standard bronze alloy containing 90% copper and 10% tin.

Table II

Alloy No.	Percent Cu	Percent Sn	Percent Co	Percent Fe
3841	90	10		
3842	89	10		1.0
3843	89	10	1.0	
3844	88	10	1.0	1.0

It is to be noted that alloy 3844 in Table II contains as essential elements thereof, tin, cobalt and iron, whereas alloy 3841 contains only tin, 3842 contains tin and iron and 3843 contains tin and cobalt. By making such a series of alloys and subjecting them to the same conditions of casting and heat treatment, the effect of each of the alloying elements on the copper base is determined and the beneficial effects of the combined alloying constituents in the alloy of this invention are apparent.

Each of the alloys identified in Table II were subjected to the same casting procedure, after which hardness measurements were taken, and then subjected to a heat treatment consisting of quenching them from 800° C. in water, after which hardness measurements were again taken, and then ageing them for different periods of time at 450° C. The results obtained on the alloys identified in Table II when subjected to the hereinbefore decribed heat treatment are given in the following table.

Table III

Alloy No.	As cast	Quenched from 800° C.	Hardness—Rockwell B aged at 450° C. for—			
			2 hrs.	5.5 hrs.	10 hrs.	25 hrs.
3841	46	37	39	41	44	44
3842	48	42	63	67	67	64
3843	71	53	58	56	62	61
3844	83	59	74	80	81	73

From the results given in Table III it is apparent that the combined effect of the alloying elements cobalt, iron and tin in the alloy identified as 3844 provides an alloy having exceedingly high strength not only as precipitation hardened but also in the "as cast" condition. Further, from the results given with respect to the alloys 3841–2–3, it is quite apparent that the alloying elements, tin, cobalt and iron, are not effective as of themselves to impart desired characteristics to copper. Nor is the combined effect of tin and iron, or tin and cobalt, in the copper base satisfactory for producing the desired characteristics. This is especially noted in alloy 3843 which has the highest hardness in the "as cast" condition but which upon precipitation hardening loses a large part of its hardness. Other alloys containing tin in quantities up to 20% in combination with cobalt and iron in up to 5% of each have similar characteristics of being extremely hard in the "as cast" condition and of being susceptible to precipitation hardening.

In examining the alloys of this invention, it is noted that for all the contents of tin in combination with the cobalt and iron in the copper base, as hereinbefore described, the alloys have extremely fine grain size. In order to illustrate a representative grain size occasioned by the cooperation of the tin, cobalt and iron in this alloy, reference may be had to the following table in which a direct comparison is made on the grain size of the alloys identified in Table II the results of which are given in Table III.

Table IV

Alloy No.	Average diameter of grains in millimeters at 80x
3841	.200
3842	.120
3843	.120
3844	.045

From this table it is quite apparent that the particular combination of the alloying elements in the alloy of this invention is a finer grain structure than is obtained with the simpler ternary alloys.

In practice, it is found that the higher additions of tin of from about 15% up to 20% with the cobalt and iron within the range and ratio given, lowers the melting point of the resulting alloy to around 975° C. producing an alloy suitable as a brazing alloy. The resulting alloy has exceptional strength and good ductility and is quite suitable for brazing joints where it is desired to later heat treat the brazed joint. In certain applications of the alloy of this invention as a brazing alloy, it has been found desirable to add from .05% up to 2% of phosphorus as an essential alloying element thereof thereby further improving the wetting action of the alloy and also lowering its melting point. This addition of phosphorus, however, is not always essential as for certain applications the copper, cobalt, iron and tin alloy described hereinbefore is entirely satisfactory for the making of brazed joints.

Where desired, other alloying elements such as titanium, vanadium, lead, zinc, silver, zirconium, beryllium, silicon, aluminum and cadmium may be added to the copper, cobalt, iron and tin alloy of this invention in an amount up to 25% of the iron plus cobalt content. These different alloying elements may be added to the copper, cobalt, iron and tin alloy depending upon the characteristic which it is desired to improve. For example, small additions of beryllium, titanium, zirconium, vanadium, silicon, alluminum and cadmium all improve the hardness of the basic alloy while lead improves its machineability, rendering the alloy substantially free cutting, and the silver renders the alloy thermally stable while the cadmium improves the electrical characteristics of the alloy. With any of these additions in an amount up to 25% of the iron plus cobalt content of the alloy, the resulting alloy is susceptible to precipitation hardening rendering it quite suitable for casting purposes and for other applications.

In addition to the advantages pointed out

hereinbefore for the alloy containing tin, it has been found that the tin additions in combination with the cobalt and iron in the copper base, gives an alloy very resistant to wear having desirable machining characteristics. These alloys are also resistant to corrosion particularly in applications that involve salt water stability. These alloys are quite satisfactory for other applications such as pipe fittings, gears, bolts, bushings and bearings and are particularly applicable for use in the industry since castings and forgings of the alloy can be hardened and softened at will.

Although this invention has been described with reference to particular embodiments thereof, it is, of course, not to be limited thereto except insofar as is necessitated by the prior art and the scope of the appended claims.

I claim as my invention:

1. An age-hardened alloy composed of from a small but effective amount up to 5% of cobalt, from a small but effective amount up to 5% of iron, from .10% up to about 20% of tin, and the balance substantially all copper which has been quenched from a temperature of between 750° C. and the melting point of the alloy and aged at a temperature of between 400° C. and 550° C.

2. An alloy composed of from a small but effective amount up to 5% of cobalt, from a small but effective amount up to 5% of iron, from .10% up to about 20% of tin, and the balance substantially all copper, the ratio of the cobalt to the iron in the alloy being between .5 and 1.25 to 1.

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