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ZINC BASE ALLOYS

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My invention, which will be best understood from the following description, relates to zinc base alloys, and has among its objects the production of zinc base alloys of improved characteristics particularly in respect to combining excellent mechanical working properties with high tensile strength, ductility and stability.

As will be understood by those skilled in the art, commercially pure zinc has a high degree of plasticity both when hot and when cold. The tensile strength of the worked metal however is relatively low, and it has the most serious defect of not retaining that strength and its ductility as it ages, the tensile strength and particularly the ductility gradually decreasing with age at room temperatures until articles made of the metal become seriously defective. Further, zinc when cold worked "self anneals," and for that reason cannot be hardened or otherwise tempered, like brass for example can, by cold working it.

The standard accepted test for determining the effect of age on zinc and its alloys is to subject articles made of the metal to moist steam at 95° C. for 10 days. As an example of the effect of age on zinc, it is mentioned that hot rolled zinc having a tensile strength of about 17,000 pounds per square inch and the excellent elongation in 2 inches of about 45% will, after being subjected to this test, have a tensile strength of about 11,000 pounds per square inch and an elongation in 2 inches of only about 2%. In other words, aging the zinc will reduce its tensile strength about 35% and its ductility and malleability about 95%.

The attempt to render zinc stable in respect to tensile strength and ductility by adding small amounts of other metals heretofore commonly has been done at a sacrifice of, among other things hereinafter pointed out, its hot plasticity, that is to say, the facility with which it may be hot worked. Applicant however has found that by adding to zinc small amounts of copper and antimony within definite ranges and proportions a stable alloy in the respects mentioned will be produced, not only without deleteriously affecting the hot plasticity of the zinc, but in fact markedly improving it. At the same time the zinc by these additions will be given a very much higher tensile strength combined with satisfactory ductility.

The improved results applicant has found will be secured with, approximately, 2.4 to 7.5% copper and 0.05 to 1% antimony, provided the maximum percentage amount of antimony present within the range thereof specified is not more than approximately 0.2% with 7.5% copper and with amounts of copper less than 7.5% does not exceed a value which varies approximately from 0.2 to 1% linearly and inversely with the percentage amount of copper within the range of copper specified, that is to say, the range of antimony is approximately 0.05 to 1% when 2.4% copper is present and the range of antimony is approximately 0.05 to 0.2% when 7.5% copper is present, while with amounts of copper between 2.4 and 7.5% the maximum amount of antimony that can be present decreases approximately linearly from 1 to 0.2% as the amount of copper present increases from 2.4 to 7.5%. The improved alloys having up to about 7.5% copper have such extreme hot plasticity as enables them in some instances to be reduced as much as approximately 95% by commercial hot rolling when presented to the rolls at a temperature of about 650° F. without the necessity of reheating them during the course of such reduction. Further, the improved alloys with amounts of copper up to about 4% have a markedly high cold plasticity, enabling them readily to be cold rolled into sheets by commercial practices with great facility, it being possible commercially to form sheets of these alloys by reducing them by cold rolling as much as about 85% without the necessity of annealing the metal during the course of such reduction.

The preferred alloys, in respect to securing best all around properties, contain, approximately, 2.5 to 3.5% copper and 0.25 to 0.7% antimony. All these may be rolled, forged and extruded while hot within a temperature range of from about 300 to 650° F., and may be rolled, spun, stamped and drawn while cold, in all cases by commercial operations with great facility.

Other alloys however within the preferred range just specified and outside it have marked characteristics making them particularly suitable for special commercial applications. For example, the alloys having from about 2.4 to 2.7% copper with the antimony within the range of about 0.1 to 0.4% have extreme cold plasticity and ductility in respect to making them eminently suitable for the commercial fabrication of certain types of articles, such as ferrules having say the dimensions of cartridge cases, by deep drawing operations. For example, an alloy of this last mentioned group having 2.55% copper and 0.25% antimony has a tensile strength of about 35,000 pounds per square inch and the very high elongation in 2 inches of about 70%, in other words, about the same tensile strength

and ductility as brass containing 90% and upward of copper. Again, when the copper in the improved alloys is increased above about 5% a very high tensile strength is obtained at some expense of the otherwise high ductility, making such alloys eminently suitable for articles fabricated by hot forging. For example, an alloy suitable for hot forging containing 6% copper and 0.1% antimony has a tensile strength of about 49,000 pounds per square inch and an elongation in 2 inches of about 20%. In other words, the properties of this last mentioned alloy in the respects mentioned are comparably the same as those of ordinary forging brass.

The alloys with 5% copper and upward to 7.5% however, like those with less than 5% copper, still have extreme hot plasticity and can be commercially hot rolled and hot extruded with great facility within the same wide temperature range of 300 to 650° F. Still these last mentioned alloys have a fair degree of cold plasticity, and commercially fabricating them into articles by cold rolling, spinning and stamping is not precluded, although these operations cannot be performed with the same facility as with the alloys having not more than 5% copper and particularly with the same facility as with those having about 4% or less copper.

In respect to securing an alloy the ductility of which is stable in respect to age, the amount of copper present is rather critical. Reducing the amount of copper to below 2.4% it has been found causes the ductility to decrease as the alloy ages. For example, the above mentioned alloy having 2.55% copper and 0.25% antimony exhibits no tendency to decrease in ductility with age as determined by subjecting the alloy to the above mentioned steam test. When the amount of copper in this alloy is reduced to 2% however its ductility measured by its elongation in 2 inches decreases about 11% when subjected to this steam test, while with 2.4% copper no particular decrease in its elongation can be observed as a result of subjecting it to the steam test.

The improved alloys may be substituted for various brasses, the importance of which will be appreciated when it is observed that, as compared to brass, they contain less of the more expensive and more strategic metal copper and more of the less expensive and less strategic metal zinc.

The excellent mechanical properties of the improved alloys, in respect to their equivalency to various brasses, and their stability in respect to tensile strength and ductility, will be clear from the following table of the properties of the hot rolled alloys, in which table the steam test referred to is that above described.

Percent Cu	Percent Sb	Tensile strength, p. s. i.	Elongation in 2 inches, percent	Tensile strength after steam test, p. s. i.	Elongation in 2 inches after steam test, percent	Brass equivalent
0	0	17,000	45	11,000	2	
2.5	0.25	35,000	70	32,000	70	90 Cu—10 Zn.
3	0.63	42,000	35	39,000	40	75 Cu—25 Zn.
6	0.1	49,000	20	46,000	22	Forging brass.

The attempt to cure the instability of zinc in respect to tensile strength and ductility by adding small amounts of other metals, besides commonly resulting in a sacrifice of hot working properties of the metal, heretofore has commonly also resulted in a sacrifice of the dimensional stability of the metal. Commonly zinc base alloys as they age at room temperature are subject to gradual intercrystalline corrosion and the gradual formation of an additional alloy phase, either of which occurrences causes a gradual increase in the volume of the zinc and hence a gradual increase in its linear dimensions, making the alloys unsuitable for many industrial uses. In these respects prior zinc base alloys commonly have shown, when subjected to the above mentioned steam test, an increase in linear dimensions greater than 0.002 inch per linear inch, and rates of increase as great as 0.001 inch per linear inch heretofore have been deemed satisfactory considering what could be expected of such alloys. Applicant's improved alloys however when subjected to this test show an increase in linear dimensions in the order of but 15% of that which occurs in these alloys heretofore deemed satisfactory, rendering the improved alloys from a commercial standpoint entirely stable in respect to dimensions in so far as most uses are concerned.

It has been found that the slight amount of dimensional instability exhibited by the improved alloys may be decreased or entirely eliminated, when desired, by adding to them relatively minute amounts of vanadium. As little as about 0.005% vanadium will produce marked effects in this respect, and an amount of vanadium as small as about 0.03% will cause the alloys to exhibit substantially a zero rate of increase in dimensions when subjected to the above mentioned test. As much as 0.5% vanadium may be added without deleteriously affecting the other above mentioned valuable properties of the alloys.

Vanadium within the range of 0.005 to 0.5% thereof, it has been found, also markedly increases the impact strength of the improved alloy and its stability with age in that respect, and, therefore, vanadium advantageously may be added to the alloy when high shock resistance is a consideration. For example, a ternary copper-antimony-zinc alloy containing about 2.4% copper and 0.25% antimony and having a Charpy impact strength of 256 foot pounds per square inch before being subjected to the above mentioned steam test and a corresponding impact strength of 208 after being subjected to it will, upon the addition of about 0.05% vanadium, have a Charpy impact strength of 480 both before and after being subjected to that test.

According to the preferred method of making the alloys the zinc is melted under a layer of charcoal to protect it against oxidization, and a molten mixture of the copper and antimony, containing also the vanadium when the latter is employed, is formed separately from the molten zinc. When the zinc reaches the molten state this molten mixture, which is of much higher temperature than the zinc, is poured into the latter, preferably slowly. Pouring the high temperature molten mixture into the relatively low temperature molten zinc causes a pronounced

agitation and rise in temperature of the zinc, which act thoroughly to incorporate the mixture into the latter. Preferably, the molten alloy thus formed is poured without delay into a mold to form a casting of suitable shape for the subsequent hot or cold working operations. To insure satisfactory results, deoxidized copper may be employed, or, if ordinary electrolytic copper is employed, a small amount of phosphorus or other deoxidant may be added, to the melt containing the copper, in sufficient amount to deoxidize it, any residual phosphorus burning off. Also, to insure satisfactory results, the high temperature mixture likewise may be melted under a layer of charcoal, and preferably that mixture is poured into the molten zinc and the resulting alloy poured into the mold not longer than about 5 minutes after the zinc reaches the molten state. In making the high temperature mixture the bulk of the copper may be melted in a crucible, and the antimony may be added to the molten copper by throwing it into small pieces of copper-antimony alloy rich in antimony. The vanadium, when employed, may be similarly added to the copper.

It will be understood that, within the scope of the appended claims, wide deviations may be made from the compositions herein described without departing from the spirit of the invention.

I claim:

1. Workable alloys having, approximately, 2.4 to 7.5% copper and 0.05 to 1% antimony, the balance being substantially zinc, the percentage amount of antimony present not exceeding a value which varies approximately from 0.2 to 1% linearly and inversely with the percentage amount of copper present within the range of copper specified.

2. Workable alloys according to claim 1 having 2.5 to 4% copper, said alloys having a maximum of approximately 1% antimony with 2.5% copper and a maximum of approximately 0.75% antimony with 4% copper.

3. Workable alloys according to claim 1 having 5 to 7.5% copper, said alloys having a maximum of approximately 0.6% antimony with 5% copper and a maximum of approximately 0.2% antimony with 7.5% copper.

4. Workable alloys according to claim 1 containing approximately 0.005 to 0.5% vanadium substituted for an equal amount of the zinc.

5. Workable alloys according to claim 1 having 2.5 to 4% copper and containing approximately 0.005 to 0.5% vanadium substituted for an equal amount of the zinc, said alloys having a maximum of approximately 1% antimony with 2.5% copper and a maximum of approximately 0.75% antimony with 4% copper.

6. Workable alloys according to claim 1 having 5 to 7.5% copper and containing approximately 0.005 to 0.5% vanadium substituted for an equal amount of the zinc, said alloys having a maximum of approximately 0.6% antimony with 5% copper and a maximum of approximately 0.2% antimony with 7.5% copper.

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