

Feb. 8, 1966

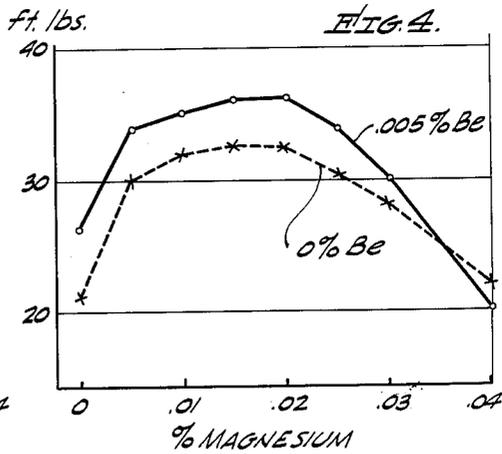
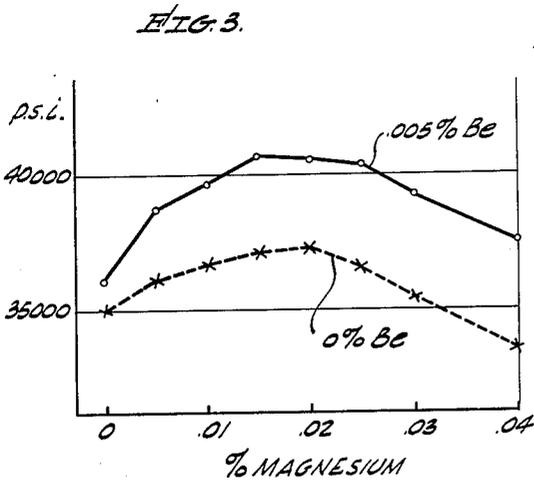
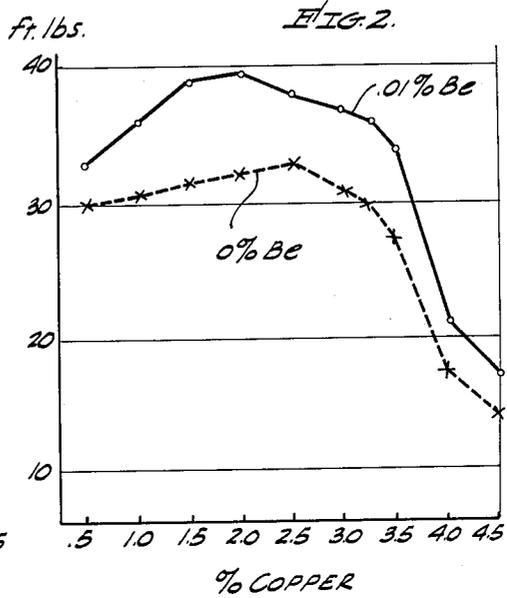
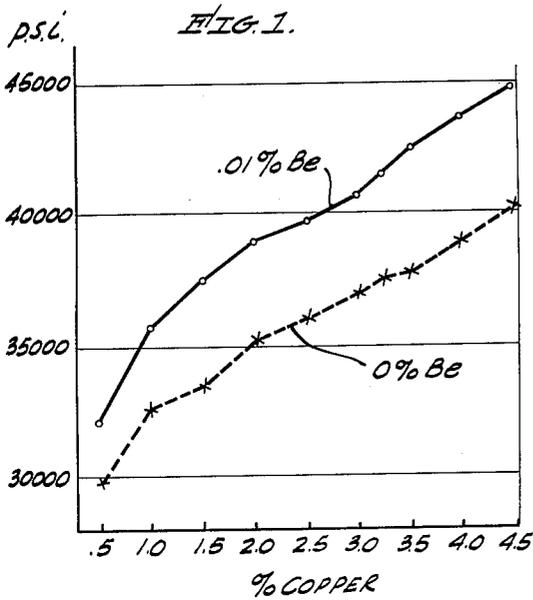
L. J. LARRIEU

3,234,016

ZINC BASE ALLOY

Filed April 30, 1963

2 Sheets-Sheet 1



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Feb. 8, 1966

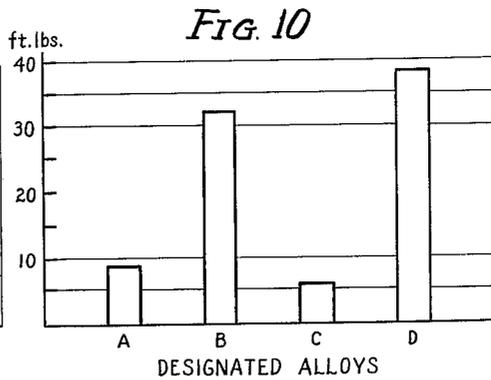
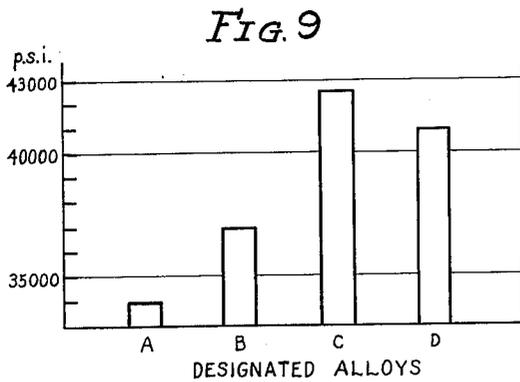
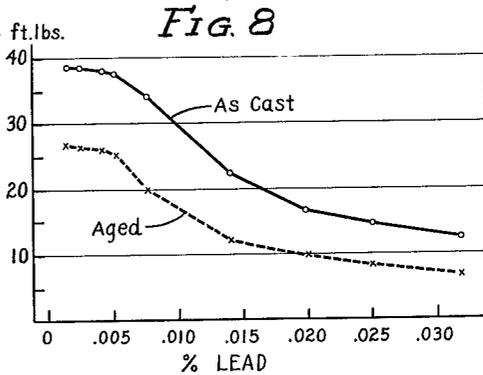
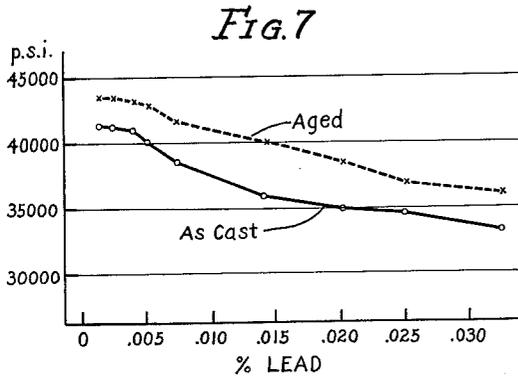
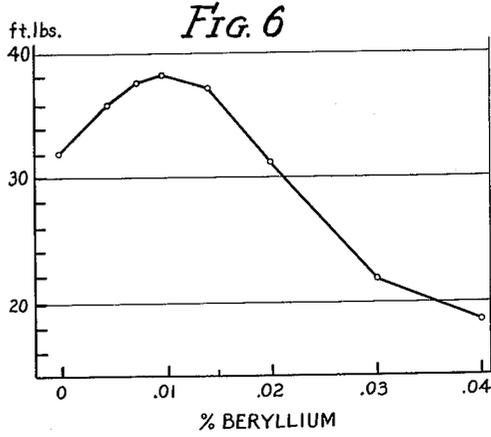
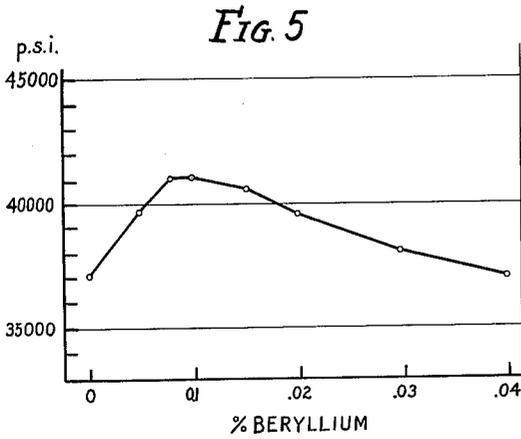
L. J. LARRIEU

3,234,016

ZINC BASE ALLOY

Filed April 30, 1963

2 Sheets-Sheet 2



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3,234,016

ZINC BASE ALLOY

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Filed Apr. 30, 1963, Ser. No. 285,169

4 Claims. (Cl. 75-178)

This is a continuation-in-part of copending application S.N. 211,376 filed July 20, 1962 and now abandoned, which, in turn, is a continuation-in-part of application S.N. 68,674, filed November 14, 1960, now Patent No. 3,083,096, granted March 26, 1963.

This invention relates to a high purity alloy of zinc base with improved mechanical and physical properties containing aluminum and copper as major alloy constituents and beryllium and/or magnesium as a minor alloy constituent present in small but highly critical amounts that are extremely determinative of the improved properties.

The most important mechanical properties that are essential for the best performance of a forming die are, tensile strength and impact strength. Brinell hardness also is important, as are the physical properties of grain refinement, dimensional stability upon ageing and castability. Adequate tensile strength insures commensurate adequacy of compressive strength because of the mutual proportional relations of these two strength properties.

Since the introduction of the basic 4% aluminum, 3% copper, .05% magnesium, balance zinc, sand casting alloy, in 1939, there has existed a need to improve the impact strength and tensile strength of this alloy. Today this need is even more urgent because of the expanding technologies of the aero-space industries, which pose even more exacting and more severe mental forming tasks. Research work directed toward such alloy improvement resulted in the alloy disclosed in Patent No. 2,940,846, granted to me on June 14, 1960. The patent discloses that a radical reduction in the nominal .05% magnesium content of the prior art alloy to an amount less than .03%, and preferably less than .02%, refines grain size, increases tensile strength and impact strength and generally improves the basic 4% aluminum, 3% copper, balance zinc, alloy in all mechanical and physical properties.

Additional research directed toward the improvement of this basic alloy type has resulted in the discovery that the addition of small, but highly critical amounts of beryllium to an alloy containing 4% aluminum, 3.25% copper, .01% magnesium, balance zinc, very substantially increases the tensile strength and impact strength of the alloy. Other improvements include a slight increase in Brinell hardness, a most substantial improvement in castability and a marked additional refinement of grain size. This discovery was unexpected in that it represents complete departure from previous attempts to refine grain, and obtain additional mechanical and physical property improvements, by the addition of potentially helpful agents, including the addition of beryllium in amounts approximating .05%. The .05% beryllium addition, as will be revealed hereinbelow, detracts rather than helps in the attainment of the desired improvements.

The use of beryllium as a minor alloy constituent in alloys of zinc base is known. Patent No. 3,037,859 granted to me on June 5, 1962, discloses the use of .05 to .10% beryllium in an alloy of zinc base containing substantial amounts of copper, such as 8%, lesser amounts of aluminum, such as 3%, and minor amounts of magnesium, such as .05%. This alloy possesses a very good tensile strength, compressive strength and Brinell hardness and retains these properties in substantial amounts when sub-

jected to operating temperatures up to 400° F. The impact strength of the alloy is about equivalent to that possessed by the 4% aluminum, 3% copper, .05% magnesium, balance zinc alloy, or about 8 ft. lbs. Melting and casting temperatures are somewhat in excess of those required for the alloys containing 3% copper.

Accordingly, it is an important object of this invention to provide a zinc base alloy which, upon being sand cast, possesses maximized mechanical and physical properties.

Another object of this invention is to provide an improved zinc base alloy which readily can be melted in conventional melting equipment and which readily can be cast in sand, permanent molds and pressure die casting methods for producing sound forming dies, heavy duty tooling plate, exceptionally strong die castings having maximum high tensile strength, impact strength, and dimensional stability.

Additional objects and advantages of the invention will become apparent from the following description.

Briefly stated, in general terms, the objects of this invention are attained by providing a zinc base alloy of high purity containing from about 3.5% to about 4.5% aluminum, from about .5% to about 3.5% copper, from a trace to about .03% magnesium, from about .0002% to about .02% beryllium, and the remainder zinc. A preferred alloy contains from about 3.8% to about 4.2% aluminum, from about 1.5% to about 3.25% copper, from about .005% to about .025% magnesium, from about .005% to about .012% beryllium and the remainder zinc. An especially preferred alloy contains about 4% aluminum, about 3.25% copper, about .01% magnesium, about .01% beryllium, and the balance zinc.

All of the above metals are substantially pure that is the aluminum, copper, magnesium, beryllium, and zinc are all substantially 100% pure. However, some impurities do creep into the processing of the metals but these are kept to a very low maximum. In fact the soft metal contaminants consisting of lead, tin, cadmium, bismuth, and antimony are held to a collective maximum of .0066% with lead being held to a maximum of .004%. Iron is held to a maximum of .02% while silicon is held to a .003% maximum content. Other contaminants such as manganese, chromium and titanium are held to a collective maximum amount of .005%.

Applicant has used a commercial and available special high grade zinc in which the zinc content is 99.99796% pure. Included in the impurities is lead at .0008%, iron at .0005% and cadmium at .00004%. It does contain .0007% copper which is not considered an impurity because copper is used in this alloy. Applicant has used a commercial and available specially high grade aluminum which contains 99.85% aluminum with .07% silicon and .07% iron and .01% other metals. The copper used by applicant in the manufacture of the present alloy as set forth in the application, has been assayed to include .005% tin, .003% lead, leaving a copper content of 99.992% pure.

The beryllium copper master alloy used by applicant has been found to contain .005% lead, .005% tin, .06% silicon, .005% chromium, .01% nickel, .06% iron and .01% cobalt. This is the 4% beryllium copper master alloy which is used by applicant. However, as will be explained later, applicant takes this beryllium copper master alloy and makes another master alloy with the same before putting this into the other constituents metals of the alloy. This beryllium copper alloy also contains some zinc, some aluminum and the balance copper.

A more detailed description of my invention is given below with reference to the attached drawings, wherein:

FIG. 1 is a graph showing the effect of copper on the

tensile strength of a sand cast zinc base alloy containing 4% aluminum, .008% magnesium, and .01% beryllium solid line, and of the same alloy with 0% beryllium broken line;

FIG. 2 is a similar graph showing the effect of copper on the impact strength of a sand cast zinc base alloy containing 4% aluminum, .008% magnesium, and .01% beryllium solid line, and of the same alloy with 0% beryllium broken line;

FIG. 3 is a graph showing the effect of magnesium on the tensile strength of a sand cast zinc base alloy containing 4% aluminum, 3% copper, and .005% beryllium solid line, and of the same alloy with 0% beryllium broken line;

FIG. 4 is a similar graph showing the effect of magnesium on the impact strength of a sand cast zinc base alloy containing 4% aluminum, 3% copper, and .005% beryllium solid line, and of the same alloy with 0% beryllium broken line;

FIG. 5 is a graph showing the effect of beryllium on the tensile strength of a sand cast zinc base alloy containing 4% aluminum, 3.25% copper, and .01% magnesium;

FIG. 6 is a similar graph showing the effect of beryllium on the impact strength of a sand cast zinc base alloy containing 4% aluminum, 3.25% copper, and .01% magnesium;

FIG. 7 is a graph showing the effect of lead on the tensile strength of a sand cast zinc base alloy containing 4% aluminum, 3.25% copper, .01% magnesium, .01% beryllium;

FIG. 8 is a similar graph showing the effect of lead on the impact strength of a sand cast zinc base alloy containing the same alloy as described in connection with FIG. 7;

FIG. 9 is a bar graph showing the comparative tensile strengths of three sand cast zinc base alloys:

(a) Which contains 4% aluminum, 3% copper and .05% magnesium;

(b) Containing 4% aluminum, 3.25% copper and .005% magnesium;

(c) Containing 3% aluminum, 8% copper and .05% magnesium and .05 beryllium;

(d) The alloy of this application, which contains 4% aluminum, 3.25% copper, .01% magnesium, and .01% beryllium;

FIG. 10 is a similar bar graph showing the comparative impact strengths of the four alloys (a), (b), (c), and (d), defined above in describing FIG. 9;

The basic mechanical property relationships and effects of the alloying elements comprising the alloy of this invention will be better understood after consulting the graphs presented in FIGS. 1 through 10.

FIG. 1 presents the effect of the addition of copper with .01% beryllium in the solid line of the graph, and copper without beryllium, in the broken line, upon the sand cast tensile strength of the 4% aluminum, .008% magnesium, balance zinc, alloy. It is readily evident that increased copper content produces increased tensile strength, and that the inclusion of .01% beryllium results in a gain of approximately 4000 p.s.i. tensile strength for each copper percentage from 1.5% to 4.5%.

FIG. 2 presents the effect of the addition of copper with .01% beryllium, in the solid line of the graph, and copper without beryllium, in the broken line, upon sand cast impact strength of the 4% aluminum, .008% magnesium, balance zinc, alloy of FIG. 1. This relationship is one of inverse proportionality in which the effect of beryllium is indicated to be one of retention of higher increments of impact strength for all levels of copper content from .5% to 4.5%.

Table 1 given below contains the test data used to plot the broken lines of the graphs of FIGS. 1 and 2;

Table 1

Effect of copper on the tensile strength, impact strength and Brinell hardness number of a sand cast zinc base

alloy containing 4% aluminum, .008% magnesium, and balance zinc.

Percent Cu added	Tensile strength (p.s.i.)	Impact strength (ft. lbs.)	Brinell hardness (number)
.5	29,800	30.0	85.7
1.0	32,600	30.5	92.6
1.5	33,300	31.5	92.6
2.0	35,000	32.0	96.3
2.5	35,900	33.0	100
3.0	36,900	31.0	100
3.25	37,200	30.0	104
3.5	37,500	27.5	104
4.0	38,800	17.5	109
4.5	40,000	14.2	109

Table 2

Effect of copper on the tensile strength, impact strength and Brinell hardness number of a sand cast zinc base alloy containing 4% aluminum, .008% magnesium, .01% beryllium and the balance zinc.

Percent Cu added	Tensile strength (p.s.i.)	Impact strength (ft. lbs.)	Brinell hardness (number)
.5	32,000	33.0	85.7
1.0	35,500	35.0	96.3
1.5	37,200	38.0	96.3
2.0	38,800	39.6	100
2.5	39,600	38.0	100
3.0	40,600	37.0	104
3.25	41,200	36.0	109
3.5	42,290	34.0	109
4.0	43,800	21.0	114
4.5	44,700	17.0	114

Substantial improvement in melting characteristics and castability as well as marked refinement of grain size are obtained by the addition of small but critical amounts of beryllium alone to the alloy of this invention. Beryllium addition alone in critical amounts to the alloy, also improves tensile strength and impact strength. However, maximum improvement is obtained from the addition of two elements namely, beryllium and magnesium in the critical amounts or ranges specified. These additions of small but critical amounts of beryllium and magnesium benefit the alloy with regard to tensile strength and impact strength in substantial manner for all increments of copper over the range from about .5% to about 4.5% as can be seen by examining FIGS. 1 and 2 and Table 2.

However, the copper content of the alloy as set forth in FIGS. 1 and 2 must be limited to a maximum of 3.5%. This limitation on maximum copper must be observed in order to prevent a substantial loss of impact strength. Attention is directed to the graph of FIG. 2 showing a considerable and fast drop off of the impact strength when the copper content is over 3.5%, both with and without beryllium. It has been confirmed by multiple tests that a copper amount of 3.25%, which is within the preferred range previously stated, gives the best combination of mechanical properties when both impact strength and tensile strength are considered.

FIG. 3 presents the effect of the addition of magnesium with .005% beryllium, in the solid line of the graph, and magnesium without beryllium, in the broken line, upon the sand cast tensile strength of the 4% aluminum, 3% copper, balance zinc, alloy. A critical range for magnesium both with and without the .005% beryllium addition is indicated. The optimum is indicated to be about .01% to about .025% magnesium. It is noteworthy that the .005% beryllium addition accounts for an increase of over 3,000 p.s.i. tensile strength for all levels of magnesium contents through the range from .01% to .04%.

FIG. 4 presents the effect of the addition of magnesium with .005% beryllium, in the solid line of the graph, and

5

magnesium without beryllium, in the broken line, upon the sand cast impact strength of the 4% aluminum, 3% copper, balance zinc, alloy of FIG. 3. A critical range for magnesium is presented with an evident improvement from the beryllium addition over the range of from about 0% magnesium to about .03% magnesium. The optimum from the magnesium addition resides within the range from about .005% to about .025% for both the magnesium alone and the magnesium with beryllium.

Table 3 given below contains the test data used to plot the broken lines of the graphs of FIG. 3 and 4:

Table 3

Effect of magnesium on the tensile strength and impact strength of a sand cast zinc base alloy containing 4% aluminum, 3% copper and balance zinc.

Percent Mg added	Tensile strength (p.s.i.)	Impact strength (ft. lbs.)
Zero	35,000	21.0
.005	36,000	30.0
.010	36,700	31.8
.015	37,000	32.0
.020	37,300	32.0
.025	36,600	30.0
.030	35,400	28.0
.040	33,600	22.0

Table 4 given below contains the test data used to plot the solid lines of the graphs of FIGS. 3 and 4:

Table 4

Effect of magnesium on the tensile strength and impact strength of a sand cast zinc base alloy containing 4% aluminum, 3% copper, .055% beryllium and balance zinc.

Percent Mg added	Tensile strength (p.s.i.)	Impact strength (ft. lbs.)
Zero	36,000	26.5
.005	38,700	34.0
.010	39,800	35.0
.015	40,800	36.0
.020	40,600	36.0
.025	40,300	34.0
.030	39,200	30.0
.040	37,500	20.0

It has been discovered that the presence of small amounts of magnesium in the zinc base alloy containing beryllium is not necessary to achieve the results. The small amounts of magnesium however, do improve the impact strength and the tensile strength over that of a beryllium containing alloy without the magnesium addition. The presence of beryllium in the alloy does enhance the dimensional stability thereof, produces refined grain, improves the castability and also improves the impact strength and the tensile strength. This is clearly shown in the graphs of FIGS. 3 and 4. The percentage of magnesium added, with beryllium of course, as shown by the solid line of the two graphs, does increase the impact and tensile strengths. However, it is to be noted from an examination of both FIG. 3 and FIG. 4 that a substantial improvement for tensile strength and a very substantial improvement for impact strength are obtained for the alloy containing 4% aluminum, 3% copper, .005% beryllium and essentially no magnesium over that obtained for the same magnesium free alloy without beryllium. Specifically the improvements are 1000 p.s.i. tensile strength and 5.5 ft. lbs. impact strength.

The presence of magnesium in relatively low amounts and specifically in the preferred range of .005% to .025% produces maximum mechanical properties for the alloy containing 4% aluminum, 3% copper, .005% beryllium,

6

balance zinc of high purity both in the cast condition and after aging 1 year at room temperature.

In the absence of magnesium this same composition yields somewhat lower mechanical properties in the as cast condition, however, these properties improve upon aging and substantially exceed those obtainable from the same alloy composition without beryllium, but containing magnesium over the range .01% to .05% and higher, after aging 1 year at room temperature.

This property of beryllium that improves the magnesium free alloys in mechanical properties after aging at room temperature has been found to be maximum in amount for the desired alloy of 4% aluminum, 3.25% copper, .01% beryllium balance zinc and with the soft metal impurities present in a collective amount of less than .0066%.

FIG. 5 presents the effect of the addition of beryllium, over the range of 0% to .04%, upon the sand cast tensile strength of the 4% aluminum, 3.25% copper, .01% magnesium, balance zinc, alloy. The critical amount of beryllium for maximum tensile strength is from about .008% to about .012%. It is to be noted that the .04% beryllium alloy has a tensile strength which is substantially equivalent to that possessed by the alloy without the beryllium addition inasmuch as both .0% and .04% are approximately at the 37,000 lb. level. It has been found from multiple test evaluation that additions of beryllium in excess of .04% to this alloy reduces both the tensile strength and the impact strength of the resulting alloy below that possessed by the beryllium free alloy.

FIG. 6 presents the effect of the addition of beryllium upon the sand cast impact strength of the 4% aluminum, 3.25% copper, .01% magnesium, balance zinc alloy of FIG. 5, over the range of 0% to .04% beryllium. It is evident that a high degree of criticality of the amount of added beryllium also applies to the property of impact strength. Beryllium in the amount of about .02% is the indicated absolute maximum addition. The desired optimum amount is indicated to be from about .008% to about .012% beryllium.

Although in the broad range the lower limit of beryllium has been placed at .0002% and that this amount has been found to have beneficial results as shown by the graphs of FIGS. 5 and 6, it has been found that the lower limit of beryllium may be placed at .0005%. With this increased amount of properties of the alloy are likewise increased as shown by the graphs.

Table 5 given below contains the test data used to plot the graphs of FIGS. 5 and 6:

Table 5

Effect of beryllium on the tensile strength and impact strength of a sand cast zinc base alloy containing 4% aluminum, 3.25% copper, .01% magnesium, and balance zinc.

Percent Be added	Tensile strength (p.s.i.)	Impact strength (ft. lbs.)
zero	27,000	32.0
.005	29,800	36.0
.008	41,000	37.8
.010	41,000	38.0
.015	40,600	37.0
.020	39,300	31.2
.030	35,000	22.2
.040	37,000	18.0

It is well known that the presence of lead in zinc base alloys lowers the mechanical properties of such alloys, particularly the impact strength, and can if present in sufficient amount cause outright destruction to the alloy by the processes of intergranular corrosion.

In consequence of these considerations, and in order to maintain maximum properties, particularly impact strength, it is essential that the lead content of the alloy

of this invention be maintained at a level no greater than about .004%.

This retention of maximum mechanical properties, particularly impact strength, becomes very important when sand cast forming dies, permanent mold cast tooling plate and pressure die cast shapes are subjected to maximum stresses.

FIG. 7 shows the effect of lead on tensile strength in a zinc base alloy containing 4% aluminum, 3.25% copper, .01% magnesium, .01% beryllium, balance zinc, as cast in the solid line, and the broken line shows the effect of lead on the tensile strength of the same alloy when cast and after aging for 1 year. It will be noted that in the "as cast" line, the tensile strength of the alloy drops off considerably after .004% lead and also drops off in the line denoted for the aged alloy.

FIG. 8 is a chart showing the effect of lead on impact strength of an alloy containing 4% aluminum, 3.25% copper, .01% magnesium, and .01% beryllium, balance zinc as cast by the solid line, and after aging for 1 year in the broken line. Also in this chart it is noted that both lines drop off after .004% lead.

Therefore, it is to be noted that when the lead content of an alloy is more than .004%, such percentage is detrimental to the alloy, and that, therefore, the lead content of the alloy must be kept below .004%.

Table 6 given below contains the test data used to plot the graph of FIG. 7.

Table 6

Effect of lead on the tensile strength and impact strength of a sand cast zinc base alloy containing 4% aluminum, 3.25% copper, .01% magnesium, .01% beryllium, balance zinc as cast.

Percent Pb	Tensile strength (p.s.i.)	Impact strength (ft. lbs.)
.0015	41,500	38
.0025	41,200	38
.004	41,000	37.8
.005	40,000	37
.0075	38,000	34
.014	36,000	22
.02	35,000	16
.025	24,800	14
.033	33,000	12

Table 7 given below contains the test data used to plot the graph of FIG. 8;

Table 7

Effect of lead on the tensile strength and impact strength of a sand cast zinc base alloy containing 4% aluminum, 3.25% copper, .01% magnesium, .01% beryllium, balance zinc when aged 1 year, at room temperature.

AGED		
Percent Pb	Tensile strength (p.s.i.)	Impact strength (ft. lbs.)
.0015	43,500	27
.0025	43,500	26.3
.004	43,300	26.2
.005	43,000	25
.0075	42,000	20
.014	40,000	12
.02	38,000	10
.025	37,000	8
.033	36,000	7

As explained above, other contaminants may enter into the alloy such as tin, cadmium, bismuth, and antimony which, together with lead, form the soft metal contaminants. As explained above, lead is the most important contaminant and must not be over .004%.

Tin must have a maximum of .001%, cadmium must have a maximum of .001%, bismuth must have a maximum of .0005% and antimony must have a maximum of .0001%. Thus the soft metal contaminants must not have a collective maximum of more than .0066%.

Iron can have a maximum of .02% and silicon can have a maximum of .003%. Other metals which include manganese, chromium and titanium cannot have a maximum of over .005%. Therefore all of the contaminants in the alloy must not be over .0346%.

Thus it can be seen that the alloy of the present invention is substantially pure and in fact is very close to 100% pure.

FIGS. 9 and 10 present, in bar graph form, the comparative sand cast tensile strength and comparative sand cast impact strength obtained from four alloys designated A, B, C, and D. Alloy A is the equivalent of the A.S.T.M. Alloy XXI comprising 4% aluminum, 3% copper, .05% magnesium and balance zinc of high purity; Alloy B is a preferred composition of Patent No. 2,940,846 and contains 4% aluminum; 3.25% copper, .005% magnesium and balance zinc of high purity; Alloy C is a preferred composition of Patent No. 3,037,859 and contains 3% aluminum, 8% copper, .05% magnesium, .05% beryllium and balance zinc of high purity, and Alloy D is the alloy of this invention having about the optimum composition of 4% aluminum, 3.25% copper, .01% magnesium, .01% beryllium and balance zinc of high purity.

Table 8 given below contains the test data used to plot the bar graphs of FIGS. 9 and 10;

Alloy	Tensile strength (p.s.i.)	Impact strength (ft. lbs.)
A-----	34,000	8.5
B-----	37,000	32.0
C-----	42,400	6.0
D-----	41,000	38.0

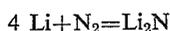
An additional evaluation of the alloy of this invention is obtained by consulting FIGS. 11, 12, 13 and 14. These figures are photo micrographs of alloys designated A, B, C, and D respectively.

It will be seen that the alloy of this invention represents an extension of the art with this class of alloy. The addition of a small, but highly critical amount of beryllium in the range of .005% to .012% to an alloy of zinc base containing 4% aluminum, .01% magnesium and copper in the range from about .5% to about 3.5%, imparts a remarkable improvement in the tensile strength and a substantial improvement in the impact strength; this is particularly the case with the preferred alloy of this invention containing about 4% aluminum, about 3.25% copper and about .01% magnesium.

An example of a specific manufacturing procedure for producing the alloy of my invention is given below.

High purity copper in the form of wire or ingot is added to the correct amount of molten high purity zinc at 900° F. When all of the copper is in solution, the correct amount of high purity aluminum is added to the molten alloy. After solution and agitation, the molten alloy is skimmed. After skimming, a sufficient amount of copper-aluminum-beryllium Master Alloy is added in order to introduce beryllium into the alloy. The Master Alloy is prepared by melting a sufficient amount of pure aluminum in a graphite crucible at about 1300° F. after which a predetermined amount of 96% copper-4% beryllium alloy is added. A Master Alloy of the following composition is obtained: Copper 57.8%, aluminum 39.75%, beryllium 2.41%. Intermittent slow agitation at 900° F. readily introduces this master alloy into the melt. Finally, the stick magnesium of high purity is then added in sufficient amount to introduce .01%.

Before adding the beryllium master alloy and the magnesium, it may be desirable to deoxidize the zinc-aluminum-copper melt. This is done while maintaining the temperature at approximately 900° F. by adding about .0005% of pure elemental lithium metal. After this addition of lithium, the resulting mixture is strongly agitated mechanically for about 45 minutes. Very thorough hand skimming of all dross and other non-metallic residues concludes this deoxidation, desulphurization and oxide reduction operation. When excessive oxide, sulphur, or both are suspected in the metal, amounts of lithium greater than .0005% may be added. This excess lithium is removed preferentially by gassing the molten metal with nitrogen at from about 900° to about 950° F. The reaction is symbolized by the following chemical equation:



The desirability of removing excess lithium is based upon the adverse effect of lithium upon impact strength and an undesirable coloration imparted to sand cast shapes after aging.

It is to be understood that the foregoing description has been given only by way of illustration and example, and that changes and modifications in the present disclosure, which will be apparent to a person skilled in the art, are contemplated as being within the scope of the present invention, which is limited only by the claims which follow.

I claim:

1. A zinc base alloy of high purity consisting essentially of, by weight, aluminum 3.8% to 4.2%, copper 1.5% to 3.25%, magnesium .005% to .025%, beryllium .005% to .012%, and having as impurities soft metal contaminants not greater in collective amount than .0066%, iron not more than .02%, the balance zinc.

2. A zinc base alloy of high purity consisting essentially of, by weight, aluminum 4%, copper 3.25%, magnesium .01%, beryllium .01% with soft metal contaminants not

greater in collective amount than .0066%, iron not more than .02%, and the balance zinc.

3. A zinc base alloy of high purity consisting essentially of, by weight, about 3.5% to about 4.5% aluminum, about .5% to about 3.5% copper, about .005% to about .025% magnesium, from about .0002% to about .02% beryllium, and impurities consisting of soft metal contaminants and iron, the soft metal contaminants being not greater in collective amount than .0066%, iron being not greater than .02% and the balance zinc.

4. A zinc base alloy of high purity consisting essentially of, by weight, about 3.5% to about 4.5% aluminum, about .5% to about 3.5% copper, about .005% to about .025% magnesium, about .0002% to about .02% beryllium, and impurities consisting of soft metal contaminants and iron, the soft metal contaminants being tin not more than .001%, cadmium not more than .001%, lead not more than .004%, antimony not more than .0001% and bismuth not more than .0005% and iron not more than .02% and the balance zinc.

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