

June 5, 1962

L. J. LARRIEU
ZINC BASE ALLOY

3,037,859

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2 Sheets-Sheet 1

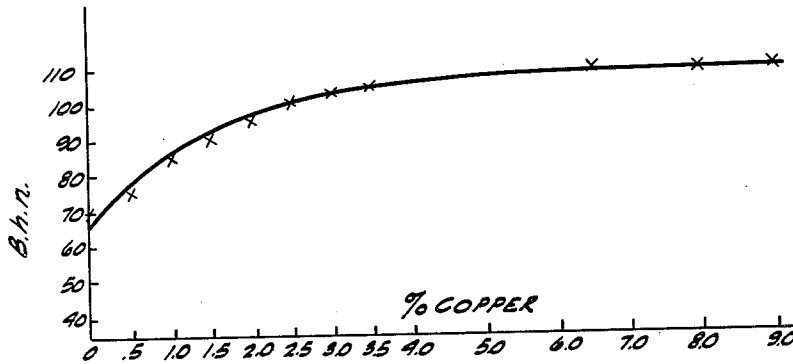


FIG. 1.

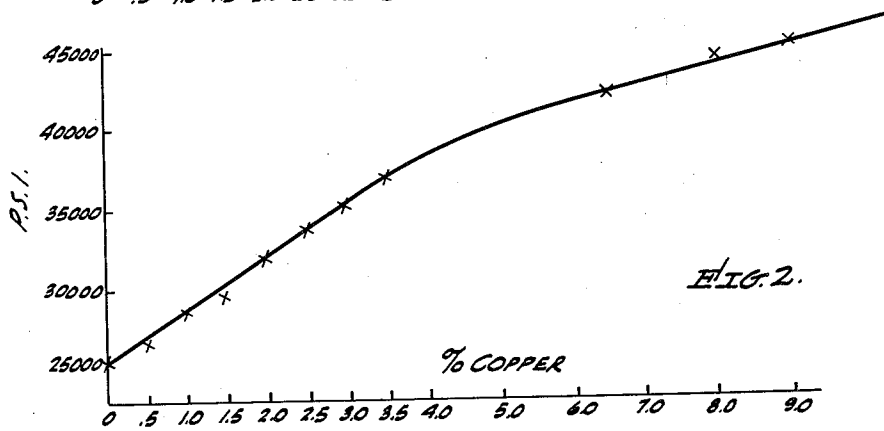


FIG. 2.

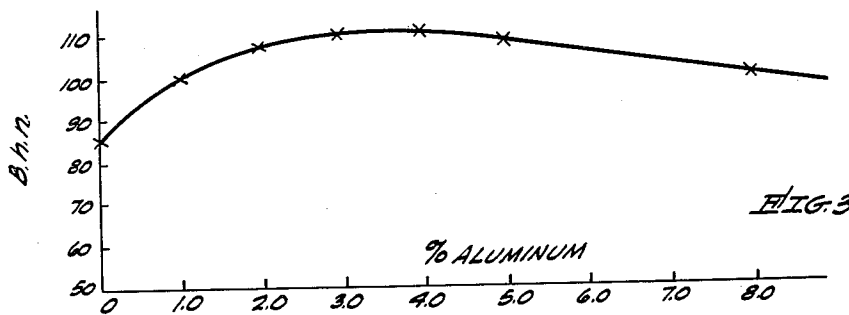


FIG. 3.

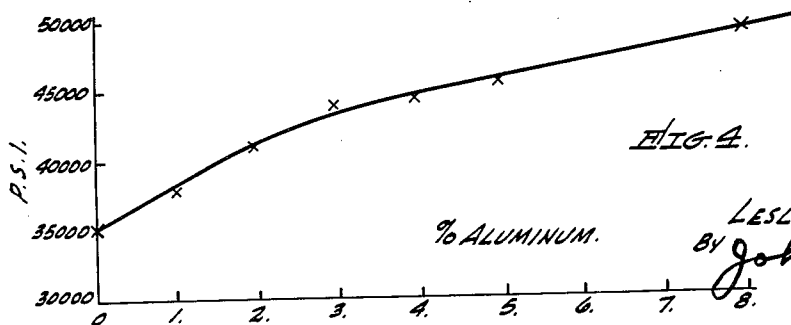


FIG. 4.

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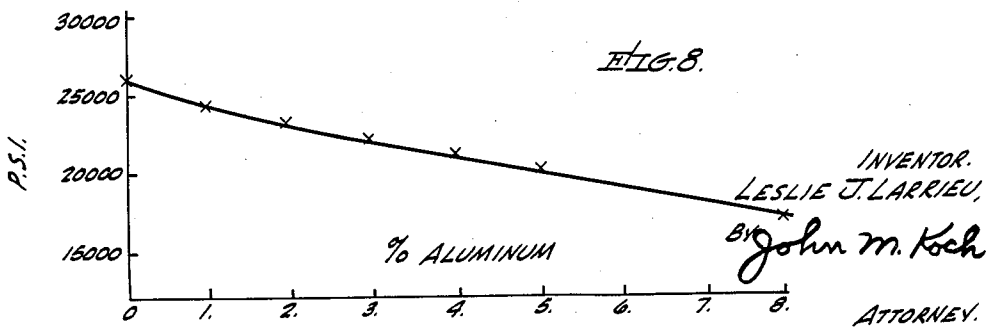
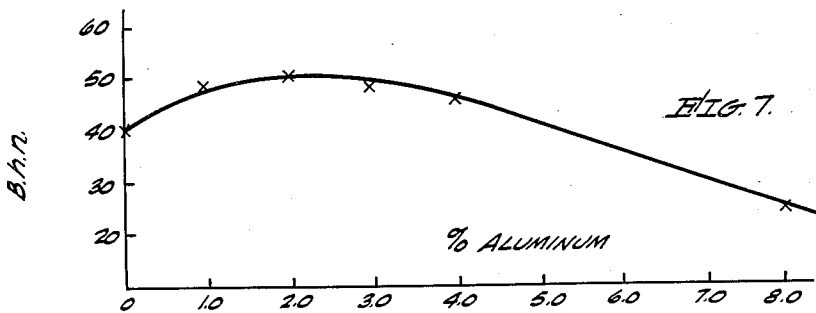
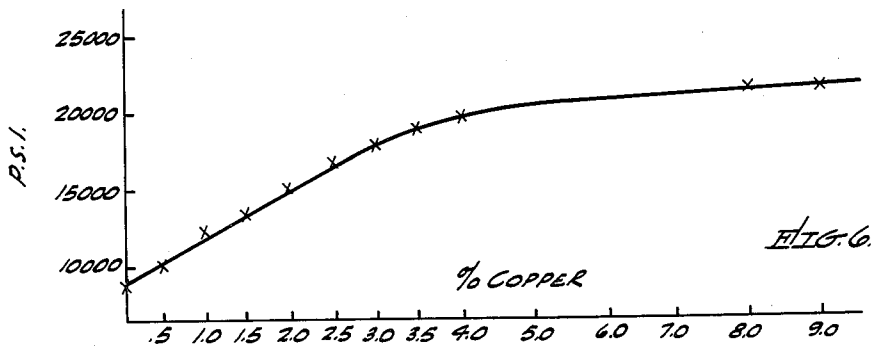
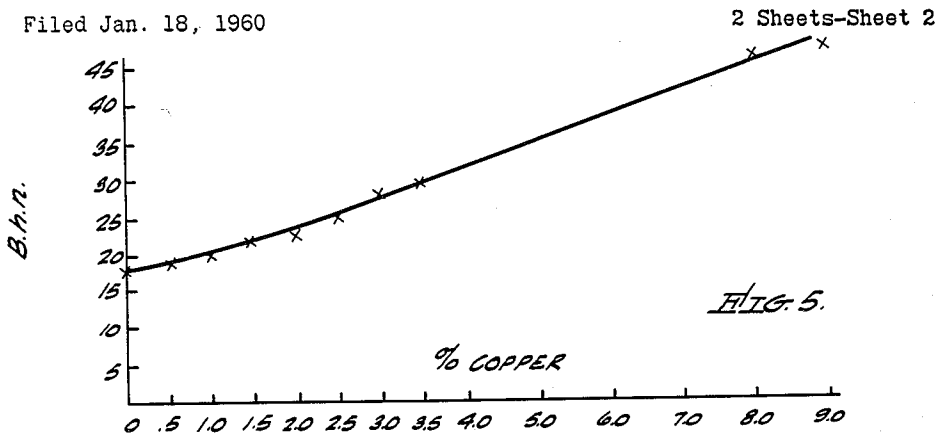
ATTORNEY.

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ZINC BASE ALLOY

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15 Claims. (Cl. 75-178)

The present invention relates generally to the nonferrous metal art, and more particularly to a novel zinc base alloy and sand-cast forming dies and cast tooling plate produced therefrom.

In the forming of metal parts and plastic laminates by pressure in preformed dies, as by using drop hammers, hydro presses and the like, the shape and thickness of the formed part and the speed at which the parts can be produced are limited by the physical characteristics of the zinc base alloy used in making the forming die or the tooling plate. This is especially true in the airplane, automobile, and missile vehicle manufacturing fields where the engineers are constantly faced with the problem of producing high strength parts of unusual shapes in large quantities in a minimum amount of time.

Also, there has long been a need for stronger and more wear-resistant nonferrous forming dies of zinc base which will retain sufficient mechanical properties at elevated temperatures up to 400° F. to permit the use of such dies in the hot forming of metal sheet plastic plate and plastic laminates. This is especially pertinent to such an alloy which can be melted in conventional cast iron melting equipment and cast into sand molds, open metal molds and closed permanent molds for the production of dies and tooling plate capable of performing heavy duty metal-forming assignments. Dies presently used for such operations must be fabricated by cast iron and steel foundries and such procedures subject the aircraft and missile manufacturing industries to added expense and delayed production.

It is an object of the present invention, therefore, to provide a novel zinc base alloy and forming dies made therefrom which possess outstanding mechanical properties at room temperatures, and which retain much of the same properties at 400° F. More particularly, it is an object to provide such an alloy which is especially suitable for producing dies for use in the explosion-forming of metal parts and in the forming of high temperature plastic materials. Specifically, it is an object to provide such an alloy for producing dies which can be used in the explosion-forming of metal parts at room temperatures without pitting or deforming the inner surfaces of the dies, and which can also be used for producing dies which can be used in forming plastic laminates and the like at temperatures up to 500° F.

Another object is to provide a novel zinc base alloy which can be melted in conventional melting equipment (i.e., below about 1100° F.) and which can be readily cast in sand and permanent molds for producing sound forming dies and heavy duty tooling plate having exceptionally high tensile strength and a substantially increased hardness.

A further object is to provide a novel zinc base alloy which will enable aircraft, automobile and other metal forming industries and missile manufacturing plants to retain the die manufacturing activities under their own

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supervision and thereby obtain advantages of speed of production and continuity of production.

Another object is to provide a novel zinc base alloy and forming dies made therefrom which have increased life due to superior wear resistance.

Further objects and advantages of the present invention will be readily apparent from the following detailed description.

Briefly stated, the invention comprises a zinc base alloy containing from about .50 percent to about 5.0 percent aluminum, from about 5 percent to about 10 percent copper, preferably from about 6.5 percent to about 10.0 percent copper, from about .005 percent to about .30 percent magnesium, and from about .001 percent to about .30 percent beryllium, and the remainder pure zinc.

As is well known in the art, the zinc base alloy which has been used most universally for many years contains 4 percent aluminum, 3 percent copper, and the remainder substantially pure zinc. I have discovered that a much improved zinc base alloy for use in making forming dies and tooling plate, both from the standpoint of increased hardness and improved tensile strength, can be produced by making full use of the aluminum range of .5 percent to 5.0 percent and increasing the copper content beyond the percentages now known or used. The improved characteristics are present when the alloy is at room temperatures in the neighborhood of 75° F. as well as at elevated temperatures up to about 500° F. For a zinc base alloy for use in producing forming dies for general high strength use at normal temperatures, it is desirable to have the aluminum content in the range of about 2.5 percent to about 5.0 percent, with the preferred amount at 3.5 percent, and the copper content in the range of about 5 percent to about 9 percent, especially from about 6.5 percent to about 9 percent with the preferred amount at 8.0 percent. For a zinc base alloy which is to be used in producing forming dies for operation at elevated temperatures in the neighborhood of 400° to 500° F., it is desirable to have the aluminum content in the range of about .50 percent to about 2.5 percent, with the preferred amount at 1.50 percent, and the copper content at about 9.0 percent to about 10.0 percent, with the preferred amount at 9.0 percent. Thus, the over-all operating range of aluminum content is from about .50 percent to about 5.0 percent and the operating range of copper is from about 5 or about 6.5 percent to about 10 percent, the remainder being pure zinc.

I have also discovered that the hardness and tensile strength of such a zinc base alloy can be further improved, and the smoothness of a casting produced therefrom increased by the use of from about .001 percent to about .30 percent beryllium. For the high strength general purpose alloy the beryllium content can be from about .001 percent to about .10 percent with a preferred content of about .05 percent. On the other hand, for high-temperature use, the beryllium content should be from about .01 percent to about .30 percent with a preferred content of about .10 percent.

A further discovery was that the hardness and tensile strength of a zinc base alloy casting are also increased (particularly at elevated temperatures) by the use of relatively small amounts of magnesium. Thus, for a zinc base alloy which is to be used in producing high strength forming dies for use at room temperatures, the magnesium

content is preferably in the range of from about .005 percent to about .10 percent, with an optimum amount of about .05 percent and for an alloy for use in producing dies for use at high temperatures in the neighborhood of 400° F., the preferred range of magnesium is from about .01 percent to about .30 percent with an optimum content at about .10 percent. Consequently, the operating range for magnesium is from about .005 percent to about .30 percent.

A zinc base alloy produced in accordance with the teachings of the present invention has the following listed physical properties:

Solidus-----	795° F. to 800° F.
Liquidus (complete liquidity)-----	900° F. to 980° F.
Casting temperature-----	1000° F. to 1100° F.
Solidification shrink (pattern to die)-----	.12 inch per foot.
Coefficient of expansion-----	.000016 inch per inch per degree Fahrenheit.
Density-----	6.82.
Weight per cubic inch-----	0.255 pound.
Weight per cubic foot-----	440.6 pounds.

Thus, it is apparent that there has been produced a novel zinc base alloy for use in producing forming dies and the like therefrom which fulfills all of the objects and advantages sought therefor. The increase of copper content from the usual 3 percent to the preferred range of 5 to 10 percent, especially 6.5 to 10 percent results in a general hardening and strengthening effect, and these effects are retained by the increased copper alloy in greater amounts at higher temperatures in the neighborhood of 400° F. than are retained at such temperatures by alloys containing the conventional 3 percent copper. Reducing the aluminum content down to a range of about .50 percent to about 2.5 percent has a further beneficial effect on tensile strength and hardness, when the alloy is used in the higher temperature ranges, and it also decreases the susceptibility to intergranular corrosion and brittleness. The addition of magnesium in amounts of from about .005 percent to about .30 percent and the addition of beryllium in amounts from about .001 percent to about .30 percent improves the alloy as to tensile strength, hardness, and resistance to compressive failure both at room temperatures and elevated temperatures as high as 400° F. Beryllium in the aforementioned amounts also helps to restore the lost increment of impact strength to the relatively low aluminum and relatively high copper alloy, and also benefits it in such physical properties as improved castability, controllable shrinkage, freedom from excessive drossing, refinement of grain, and improved resistance to corrosive attack.

A zinc base alloy containing aluminum and copper in the aforementioned preferred ranges achieves a substantial gain in tensile strength both at room temperatures and at 200° F. because of the amenability of the alloy to precipitation harden by being subjected to a temperature of 200° F. for twelve or more hours, and this gain is appreciably increased by the presence of magnesium and beryllium in the stated amounts.

Furthermore, a zinc base alloy containing aluminum and copper in the aforementioned ranges achieves a stabilizing anneal at 400° F. which imparts a maximum positive linear dimensional change of .002 inch per inch to the cast shape, which is not substantially altered by repeated reheatings. The presence of magnesium and beryllium accelerates this positive linear stabilizing change.

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 Brinell hardness number of an alloy containing 4 percent aluminum and the balance zinc, when tested at 75° F.;

FIG. 2 is a graph showing the effect of copper on the

tensile strength of the 4 percent aluminum balance zinc, alloy when tested at 75° F.;

FIG. 3 is a graph showing the effect of aluminum on the Brinell hardness number of an alloy containing 8 percent copper and the balance zinc, when tested at 75° F.;

FIG. 4 is a graph showing the effect of aluminum on the tensile strength of the 8 percent copper, balance zinc, alloy when tested at 75° F.;

FIG. 5 is a graph showing the effect of copper on the Brinell hardness number of an alloy containing 4 percent aluminum and the balance zinc, when tested at 400° F.;

FIG. 6 is a graph showing the effect of copper on the tensile strength of the 4 percent aluminum, balance zinc, alloy when tested at 400° F.;

FIG. 7 is a graph showing the effect of aluminum on the Brinell hardness number of the 8 percent copper, balance zinc, alloy when tested at 400° F.; and

FIG. 8 is a graph showing the effect of aluminum on the tensile strength of the 8 percent copper, balance zinc, alloy when tested at 400° F.

It is known that zinc in the unalloyed state is a relatively weak metal but when alloyed with copper or aluminum or a combination of both metallic elements, it forms with these elements alloys that possess improved mechanical properties. Examples are the zinc base die casting alloys known in the art as Zamak No. 3 and Zamak No. 5 and the zinc base sand casting alloys sold under the trademarks "Kirksite" A and "Hi-Phy Kirksite."

The effect of additions of copper on the mechanical properties of zinc can be illustrated as follows. An alloy comprising 4.6 percent copper, balance special high grade zinc in the sand cast state, possesses a tensile strength of 25,450 p.s.i., an impact resistance of 5 ft. lbs. ($\frac{1}{4}$ " x $\frac{1}{4}$ " bar) and a Brinell hardness number (B.H.N.) of 71. If the copper content of this alloy is increased to 9.0 percent, the tensile strength increases to 35,000 p.s.i., impact resistance decreases to 3.0 ft. lbs., and the B.H.N. increases to 86. Accordingly, there is a general hardening and strengthening effect produced by the addition of copper to zinc, and these effects are retained at 400° F. by the 9 percent alloy to a greater extent than by the 4.6 percent alloy.

Similarly, the addition of increasing amounts of aluminum improves the mechanical properties of zinc. An alloy comprising 4 percent aluminum, balance special high grade zinc, in the sand cast state possesses a tensile strength of 24,800 p.s.i., an impact resistance of 11.0 ft. lbs. ($\frac{1}{4}$ " x $\frac{1}{4}$ " bar), and a B.H.N. of 70, all under room temperature conditions of test. Increasing the aluminum content substantially above 4 percent imparts higher tensile strength and increases hardness. However, the increased susceptibility to intergranular corrosion and brittleness of the resulting alloys does not make such alloys attractive for use in sand cast forming dies. Such alloys yield very poor properties when tested at the elevated temperatures of 300° F. and 400° F. In fact, the retention of mechanical properties for an alloy comprising 8 percent aluminum balance zinc is very poor at 400° F.

The addition of both copper and aluminum to zinc will, of course, produce a combined improvement in the mechanical properties of zinc. Copper is an effective hardening and strengthening alloy addition, both at room temperature and at the elevated temperatures of 300° F. and 400° F., and in combination with aluminum and small additions of other elements it is possible to obtain very worthwhile and superior properties both at room temperature and at 300° F. and 400° F.

Pure zinc has a melting point of 786.2° F., and the zinc-aluminum eutectic (5 percent aluminum, balance zinc) has a melting point of 719.6° F. The zinc-copper pseudoeutectic, consisting of 1.8 percent copper, balance zinc, has a melting point approximately that of pure zinc, or 780° F. The various liquidus-solidus relationships of

the zinc-aluminum and zinc-copper combinations of interest may be listed as follows.

	° F.
Pure zinc-----M.P.	786.2
95% Zn-5% Al (eutectic)-----M.P.	719.6
97.5% Zn-2.5% Al:	
Liquid -----	752
Solid -----	719.6
98.2% Zn-1.8% Cu (pseudo-eutectic)-----M.P.	786.2
95% Zn-5% Cu:	
Liquid -----	932
Solid -----	795
90% Zn-10% Cu:	
Liquid -----	1080
Solid -----	795

From an examination of the preceding data it will be seen that a solidus of 975° F. is preferable to a solidus of 719.6° F., if elevated temperature properties are a prime concern. Also it will be seen that it is better to accept a lesser amount of the zinc-aluminum constituent, such as 1.5% or 2.0%, in lieu of 5% for reasons of liquidity and temperature. A very compelling consideration in the research and development of "high temperature" alloys of zinc base concerns meltability, castability and soundness of the cast part. Meltability is chiefly concerned with the ability to melt such alloys in existing foundry equipment. A top temperature consideration in this respect lies very close to 1100° F. Castability is a most important property of a new alloy and quite often such alloys suffer commensurately with increasing melting points. Soundness of the cast part is, of course, the ultimate goal and every consideration in the adjustment of composition is directed to the attainment of this property in fullest measure. Accordingly, therefore, with this metallurgical background, my invention, which is related to an alloy of zinc base and containing as major alloy constituents copper and aluminum and as minor alloy additions magnesium and beryllium separately, and as dual additions, will be more particularly described below.

As illustrated in FIG. 1, an alloy of zinc base and containing aluminum in the range of 1 to 4 percent is progressively hardened and strengthened by additions of copper to the composition with maximum hardness being achieved by additions in the 5 percent to 10 percent range, especially in the 6 percent to 10 percent range as determined by tests conducted at room temperature on sand cast test specimens.

FIG. 2 shows that an alloy of zinc base and containing aluminum in the range of 1 to 5 percent is progressively improved in tensile strength by each increment of copper addition up to and including 9 percent copper as determined by tests conducted at room temperature on sand cast test specimens.

FIG. 3 illustrates that an alloy of zinc base and containing copper in the range of 6 percent to 10 percent possesses highest hardness properties when aluminum is present in the range 2 percent to 5 percent, as determined by tests conducted at room temperature on sand cast test specimens.

Reference to FIG. 4 shows that an alloy of zinc base and containing copper in the range of 6 percent to 10 percent is progressively improved in tensile strength by each increment of aluminum addition up to and including 8 percent aluminum, as determined by tests conducted at room temperature on said cast specimens.

Similarly, FIG. 5 shows that an alloy of zinc base and containing aluminum in the range of 1 percent to 5 percent retains maximum hardness when copper is present at the maximum of 9 percent under conditions of test at 400° F. on sand cast test specimens.

FIG. 6 shows that an alloy of zinc base and containing aluminum in the range of 1 percent to 5 percent retains maximum tensile strength when copper is present in the

range 7 percent to 9 percent under conditions of test at 400° F. conducted on sand cast test specimens.

As illustrated in FIG. 7, an alloy of zinc base and containing copper in the range of 6 percent to 10 percent retains maximum hardness when aluminum is present in the range 1 percent to 4 percent, but with best retention at the 2 percent level under conditions of test at 400° F. conducted on sand cast test specimens.

In addition, FIG. 8 shows that an alloy of zinc base and containing copper in the range 6 percent to 10 percent retains the highest degree of tensile strength when aluminum is at zero percent and with better retention for the 1 percent aluminum addition than the 2 percent addition and better retention for the 2 percent addition than the 3 percent addition, etc., all under conditions of test at 400° F. and conducted on sand cast test specimens.

It was also discovered that an alloy of zinc base and containing aluminum in the range of 1 percent to 5 percent and copper in the range of 6.5 percent to 10 percent is improved in tensile strength, hardness and resistance to compressive failure by the addition of .01 percent to .20 percent magnesium as determined by conditions of test at room temperatures, 200° F. and 400° F.

TABLE 1

Comparative Mechanical Test Results (Obtained From Sand Cast Test Specimens)

[7% copper—2% aluminum—balance zinc (with additions as indicated)]

	75° F.		200° F.		400° F.	
	0% Mg	.10% Mg	0% Mg	.10% Mg	0% Mg	.10% Mg
Tensile (p.s.i.)-----	38,475	40,900	39,900	41,500	19,000	23,400
B.h.n.-----	104	109	89	96	40	48
Compressive, inches-----	.23	.13	.034	.018	.033	.021
Impact (ft. lbs.) ($\frac{1}{4}$ " x $\frac{1}{4}$ " bar)-----	6.5	3.5	7.6	6.0	10.2	6.6

NOTE.—Compressive specimens—machined cylinders 1" diam. and 2" high 75,000 p.s.i., 38,000 p.s.i. and 15,000 p.s.i. used.

As shown in Table 2 below, it also was discovered that the zinc base alloy containing aluminum in the range of 1 percent to 5 percent and copper in the range of 5 percent to 10 percent, especially 6.5 percent to 10 percent is improved in tensile strength, hardness and resistance to compressive failure by the addition of .001 percent to .28 percent beryllium, as determined by conditions of test at room temperature, 200° F. and 400° F.

TABLE 2

Comparative Mechanical Test Results (Obtained From Sand Cast Test Specimens)

[7% copper—2% aluminum—balance zinc (with additions as indicated)]

	75° F.		200° F.		400° F.	
	0% Mg	.05% Be	0% Mg	.05% Be	0% Mg	.05% Be
Tensile (p.s.i.)-----	38,475	41,500	39,900	44,000	19,000	24,050
B.h.n.-----	104	109	89	93	40	46
Compressive, inches-----	.23	.21	.034	.020	.033	.023
Impact (ft. lbs.) ($\frac{1}{4}$ " x $\frac{1}{4}$ " bar)-----	6.5	7.2	7.6	6.9	10.2	8.6

NOTE.—Compressive specimens—machined cylinders 1" diam. and 2" high 75,000 p.s.i., 38,000 p.s.i. and 15,000 p.s.i. used.

Table 3 below further shows that the zinc base alloy containing aluminum in the range of 1 percent to 5 percent and copper in the range of 5 percent to 10 percent, especially 6.5 percent to 10 percent is even more improved in tensile strength, hardness and resistance to compressive failure by the addition of both .01 percent to .20 percent magnesium and .001 to .28 percent beryllium, as

determined by conditions of test at room temperature, 200° F. and 400° F.

TABLE 3

Comparative Mechanical Test Results (Obtained From Sand Cast Test Specimens)

[7% copper—2% aluminum—balance zinc (with additions as indicated)]

	75° F.		200° F.		400° F.	
	0% Mg 0% Be	.10% Mg .05% Be	0% Mg 0% Be	.10% Mg .05% Be	0% Mg 0% Be	.10% Mg .05% Be
Tensile (p.s.i.).....	38,475	42,225	39,900	44,400	19,000	25,000
B.h.n.....	104	114	89	100	40	50
Compressive, inches.....	.23	.117	.034	.016	.033	.019
Impact (ft. lbs.) ($\frac{3}{4}$ " x $\frac{1}{4}$ " bar).....	6.5	6.4	7.6	7.6	10.2	7.7

NOTE.—Compressive specimens—machined cylinders 1" diam. and 2" high 75,000 p.s.i., 38,000 p.s.i. and 15,000 p.s.i. used.

As can be seen with reference to Tables 1, 2 and 3 above, beryllium in amounts of about .01 percent to about .28 percent helps to restore the lost increment of impact strength to the zinc base alloy containing aluminum in the range of 1 percent to 5 percent and copper in the range 5 percent to 10 percent, especially 6.5 percent to 10 percent when magnesium, in the range of about .01 percent to about .20 percent, has been included in the composition of the alloy for the purpose of improving its hardness, tensile strength and resistance to compressive deformation.

In addition, the zinc base alloy containing aluminum in the range of 1 percent to 5 percent and copper in the range of 5 percent to 10 percent, especially 6.5 percent to 10 percent and both with and without the addition of the magnesium in the range of .01 percent to .20 percent is materially benefited in such physical properties as improved castability, controllable shrink, freedom from excessive drossing, refinement of grain and improved resistance to corrosive attack by the addition of .001 percent to .28 percent beryllium. Furthermore, an alloy of zinc base and containing aluminum in the range of .5 percent to 2.5 percent, preferably 1.5 percent or 2.0 percent, and copper in the range of 6.5 percent to 10 percent, preferably 8 percent or 9 percent, and containing as additive strengthening agents, magnesium in the range .01 percent to .20 percent, preferably .10 percent, and beryllium in the range .001 percent to .28 percent, preferably .05 percent or .10 percent, has been found to be stronger, harder and more resistant to compressive deformation under service conditions of 300° to 400° F. than any zinc base alloy ever developed, introduced or used for sand cast forming dies and cast tooling plate. In this connection reference should be made to Table 4 given below:

TABLE 4

Comparative Mechanical Test Results (Obtained From Sand Cast Test Specimens)

	75° F.		200° F.		400° F.	
	Prior Art Die Metal	Invent-ed Hi Temp. Alloy	Prior Art Die Metal	Invent-ed Hi Temp. Alloy	Prior Art Die Metal	Invent-ed Hi Temp. Alloy
Tensile, p.s.i.....	35,000	42,225	34,800	44,400	18,000	25,000
B.h.n.....	100	114	75	100	26	50
Compressive, inches.....	.24	1.17	.11	.016	.06	.019
Impact (ft. lbs.).....	4.6	6.4	10.0	7.6	10.0	7.7

NOTE.—Compressive specimens—machined cylinders 1" diam. and 2" high, loads of 75,000 p.s.i., 38,000 p.s.i. and 15,000 p.s.i. used. Values listed are amounts of permanent deformation.

The superior wear resistance of the alloys of my inven-

tion are clearly illustrated by the high strength general purpose alloy when used for drop hammer dies. Such dies were used in regularly scheduled parts production by a major aircraft manufacturer. These dies produced a very substantially increased number of stamped parts without failure as compared with dies constructed out of conventional alloys and used to the point of failure of the dies. Table 5 given below presents the comparison:

TABLE 5

	High Strength Alloy Die	Conventional Alloy Die
Alloy Formed.....	19-9 D.L. Uniloy.....	19-9 D.L. Uniloy.
Metal Thickness.....	.069"—.072"	.069"—.072"
Number of Parts.....	400 ¹	150. ²
Planishing and Sizing.....	None required.....	50% required.

¹ Dies still serviceable.

² Dies retired to remelt due to wear.

In addition, the zinc base alloy containing aluminum in the range 1 percent to 5 percent and copper in the range of 5 percent to 10 percent, especially 6.5 percent to 10 percent, shows a substantial increase in tensile strength both at room temperature and at 200° F. due to the amenability of the alloy to precipitation hardening when placed in an atmosphere of 200° F. for 12 or more hours. It has been found that the total net amount of increased tensile strength due to the process of precipitation hardening is further increased by the presence of .01 percent to .20 percent magnesium, or .01 percent to .28 percent beryllium, or combinations of both additive elements in the ranges indicated. Furthermore, it was discovered that the zinc base alloy containing aluminum in the range 1 percent to 5 percent and copper in the range of 5 percent to 10 percent, especially 6.5 percent to 10 percent is subject to a stabilizing anneal at 400° F. which imparts a positive linear dimensional change of .005 inch per inch to the cast shape which is not altered by repeated reheatings. The coefficient of expansion of .0000076 inch per inch may then be used on the new dimension for the temperature range 75° F. to 400° F. The presence of magnesium or beryllium, or both, in the above prescribed ranges has been observed to accelerate this positive linear stabilizing change.

A preferred method of manufacturing an alloy of my invention is as follows. The alloy is manufactured in 3000 lb. capacity cast iron kettles that are protectively coated and it is advisable to pre-alloy the 4 percent beryllium master alloy with an equal amount of pure 2S aluminum in order to produce a readily dissolvable 50-50 hardener alloy.

This hardener alloy may be manufactured in 70 lb. quantities in a No. 50 graphite crucible which will render the beryllium in a dissolvable state for melting into the required amount of zinc.

MANUFACTURING SEQUENCE

Raw Materials for Manufacturing 3000 lbs. of Alloy

	Lbs.
Special high grade zinc 99.99+ %.....	2668
4% master alloy ¹	35
2S aluminum (99.8% Al).....	90
Copper (electrolytic).....	206
65 Magnesium (pure).....	1.5

¹ 4% beryllium, 96% copper.

The special high grade zinc is first melted and then 70 lbs. of prealloyed 50-50 hardener (35 lbs. 4% master alloy+35 lbs. 2S aluminum), 55 lbs. 2S aluminum and 206 lbs. of pure copper, are added to the molten zinc. The alloying is conducted at 1000° F. to 1100° F. in a 3000 lb. capacity protectively coated cast iron pot. When solution is complete, 1.5 lbs. of pure magnesium are 75 added to the melt. The contents of the pot are thor-

oughly mixed, skimmed and cast into water-cooled ingot molds. This will yield an alloy of the following composition:

	Percent
Aluminum -----	3.00
Copper -----	8.00
Beryllium -----	.05
Magnesium -----	.05
Zinc -----	Balance

NOTE.—Only special high grade zinc, pure 2S aluminum, pure copper and pure magnesium are used. This enables control of impurities to the following maximum amounts:

	Percent
Lead -----	.005
Tin -----	.003
Cadmium -----	.003
Iron -----	.03
Others, each -----	.005

My invention comprises two zinc base alloys with the following compositional ranges.

(1) For high temperature use:

	Percent
Aluminum -----	.50 to 2.5
Copper -----	9.0 to 10
Magnesium -----	.01 to .30
Beryllium -----	.01 to .30

(2) For general high strength use:

Aluminum -----	2.5 to 5.0
Copper -----	5.0 to 9.0
Magnesium -----	.005 to .10
Beryllium -----	.001 to .10

My invention also comprises two zinc base alloys with the following preferred compositions.

(1) For high temperature use (high retention of mech. properties at 400° F.):

	Percent
Aluminum -----	1.50
Copper -----	9.0
Magnesium -----	.10
Beryllium -----	.10

(2) For room temp. use (high strength, general purpose):

Aluminum -----	3.5
Copper -----	8.0
Magnesium -----	.05
Beryllium -----	.05

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

What is claimed is:

1. A zinc base alloy consisting essentially of from about .50 percent to about 5.0 percent aluminum, from about 6.5 percent to about 10.0 percent copper, from about .001 percent to about .30 percent beryllium, and the remainder zinc.

2. A zinc base alloy consisting essentially of from about 2.5 percent to about 5.0 percent aluminum, from about 6.5 percent to about 9.0 percent copper, from about .001 percent to about .10 percent beryllium, and the remainder zinc.

3. A zinc base alloy consisting essentially of from about .50 percent to about 2.5 percent aluminum, from about 9.0 percent to about 10.0 percent copper, from about .01 percent to about .30 percent beryllium, and the remainder zinc.

4. A zinc base alloy consisting essentially of about 3.5 percent aluminum, about 8.0 percent copper, about .05 percent beryllium, and the remainder zinc.

5. A zinc base alloy consisting essentially of about

1.50 percent aluminum, about 9.0 percent copper, about .10 percent beryllium, and the remainder zinc.

6. A zinc base alloy consisting essentially of from about 2.5 percent to about 5.0 percent aluminum, from about 6.5 percent to about 9.0 percent copper, from about .005 percent to about .10 percent magnesium, from about .001 percent to about .10 percent beryllium, and the remainder zinc.

7. A zinc base alloy consisting essentially of about 3.5 percent aluminum, about 8.0 percent copper, about .05 percent magnesium, about .05 percent beryllium, and the remainder zinc.

8. A zinc base alloy consisting essentially of about 1.50 percent aluminum, about 9.0 percent copper, about .10 percent magnesium, about .10 percent beryllium, and the remainder zinc.

9. A zinc base alloy for the construction of sand cast forming dies and permanent mold cast tooling plate for room temperature use, consisting essentially of from about 2.5 percent to about 5 percent aluminum, from 5 percent to about 9 percent copper, from about .005 percent to about .10 percent magnesium, and the remainder zinc.

10. A zinc base alloy for the construction of sand cast forming dies and permanent mold cast tooling plate for room temperature use, consisting essentially of about 3.5 percent aluminum, 5 percent copper, about .05 percent magnesium, and the remainder zinc.

11. A zinc base alloy for the construction of sand cast forming dies and permanent mold cast tooling plate for room temperature use, consisting essentially of from about 2.5 percent to about 5 percent aluminum, from 5 percent to about 9 percent copper, from about .001 percent to about .10 percent beryllium, and the remainder zinc.

12. A zinc base alloy for the construction of sand cast forming dies and permanent mold cast tooling plate for room temperature use, consisting essentially of about 3.5 percent aluminum, about 5 percent copper, about .05 percent beryllium, and the remainder zinc.

13. A zinc base alloy for the construction of sand cast forming dies and permanent mold cast tooling plate for room temperature use, consisting essentially of from about 2.5 percent to about 5 percent aluminum, from about 5 percent to about 9 percent copper, from about .005 percent to about .10 percent magnesium, from about .001 percent to about .10 percent beryllium, and the remainder zinc.

14. A zinc base alloy for the construction of sand cast forming dies and permanent mold cast tooling plate for room temperature use, consisting essentially of about 3.5 percent aluminum, about 5 percent copper, about .05 percent magnesium, about .05 percent beryllium, and the remainder zinc.

15. A zinc base alloy consisting essentially of from about .50 percent to about 5.0 percent aluminum, from about 6.5 percent to about 10.0 percent copper, from about .005 percent to about .30 percent magnesium, from about .001 percent to about .30 percent beryllium, and the remainder zinc.

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