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ALLOY

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My invention relates to anti-friction alloys and more particularly to a lead base alloy that is suitable for bearing or type metals.

An object of my invention is to provide a lead base alloy containing alloying ingredients in such proportions that it will have high strength and anti-frictional properties.

Another object of my invention is to provide as a base for bearings or type metals an alloy of lead and a metal which forms a solid solution with the lead, thereby producing a basic alloy which has a higher melting point, greater strength and resistance to corrosion than lead and to which other ingredients may be added to produce a final alloy having high strength and anti-frictional properties.

A further object of my invention is to provide an anti-frictional alloy having as a base an alloy of lead and an element which forms a solid solution with lead, to which has been added one or more elements to give the basic alloy anti-frictional properties and to render it suitable for use in the manufacture of high grade bearings.

It has heretofore been the practice to utilize tin as a base metal for alloys employed in the manufacture of high grade bearings. Bearings made of such alloys have proven satisfactory in service, but the price of tin has been rapidly increasing during recent years because of its broader application in the industry and because of the failure to discover any deposits of considerable quantity. At the present time, tin base alloys are, therefore, relatively expensive and attempts have been made to reduce the cost by the substitution of lead base alloys. Lead, however, is a comparatively soft metal and its low limit of proportionality and ultimate strength renders it unadaptable for the purpose desired.

Attempts have been made to harden lead by working it or by adding alloying ingredients. Lead, however, cannot be hardened by cold working because its temperature of recrystallization is about 20° C., and while the grain structure of coarsely crystalline lead can be refined somewhat by plastic deformation at room temperature, the increase in hardness is not sufficient to render the metal desirable in the manufacture of bearing alloys which are subjected to severe strains in service.

The alkali or alkaline earth metals such as sodium, magnesium, barium or calcium have been utilized for hardening lead, and lead base alloys containing such metals have been employed in the manufacture of bearings. Certain difficulties, however, are encountered in remelting these alloys because of drossing and oxidation. A hydrate "bloom" also forms upon such alloys when they are exposed to moisture which, under certain conditions, is objectionable.

Binary alloys, composed of lead and antimony and ternary alloys composed of lead, antimony and tin, have been utilized for bearing metals, but the lead-antimony alloys do not have sufficient strength to meet the increasing loads to which such bearings are being subjected and the lead-antimony-tin alloys, while possessing greater hardness and compressive strength, are more brittle and less able to withstand shock.

I have made the discovery that if in place of utilizing lead alone as the base for bearing alloys, an ingredient is added to the lead which will form a solid solution therewith, a basic metal will be formed that has a higher melting point and greater strength and resistance to corrosion than lead. The only known metals which form a solid solution with lead in sufficient proportions to effect a material hardening action are thallium, gallium and indium. For economical reasons, I prefer to utilize thallium. These metals are members of the aluminum family and constitute the group of elements occurring in the second column of Group 3 of the periodic series of elements.

In preparing bearing alloys having as a basis the solid solutions of thallium, gallium, indium or two or more of these metals, in lead, the usual anti-frictional ingredients are added as when lead alone is employed. The preferable alloying ingredients having the property of reducing friction are antimony, tin antimonide or the alkali or alkaline earth metals, such as sodium, calcium, barium or magnesium.

I prefer to utilize antimony or a mixture of antimony and tin, although it will be understood that one or more of the alkali or alkaline earth metals may be utilized when the hydrate "bloom" is not objectionable. It is well known that these ingredients have the property of hardening lead as well as increasing its anti-frictional properties. My researches show that these ingredients will produce a like effect when added to a basic metal composed of a solid solution of thallium, gallium or indium in lead, and a final alloy will thus be produced that is greatly superior in hardness and strength to lead base alloys; in fact, the properties of my improved alloy are at least equal, if not superior, to bearing alloys having a tin base.

The proportions in which the elements may be utilized in making up the alloy may be widely varied. In the manufacture of lead-thallium-antimony alloys, the antimony is maintained in the proportion of about 5% to 20% of the alloy and the proportion of thallium to lead is maintained in the ratio of about 1 to 9, the amount of thallium in the alloy, however, being greater than 5%.

The following table shows the stress required to compress a sample of an alloy containing lead, thallium and antimony, in which the proportion of thallium to lead was in the ratio of 1 to 9 and the amount of antimony varied from 5 to 20%.

Lead	Thallium	Antimony	Stress in pounds per square inch
Per cent	*Per cent*	*Per cent*	
85.5	9.5	5	13,500
81.0	9.0	10	15,200
76.5	8.5	15	16,900
72.0	8.0	20	15,800

The stress required to compress similar samples containing 90% lead and 10% antimony and 85% lead and 15% antimony was 12,880 and 12,820 lbs. per square inch, respectively, which shows that the substitution of thallium for part of the lead increases the strength of the alloy about 20%. The strength of alloys having the above composition compares favorably with the tin-base alloys now utilized in bearing metals.

A series of alloys was next prepared in which 5% of tin was added, the total amount of antimony and tin being not more than 25%. The thallium and lead were maintained in the ratio of 1 to 9 and the stress required to compress a sample to .75 of its original length was determined. It was found that the stress varied somewhat, depending upon the size of the sample.

The following results were obtained:

Antimony	Tin	Thallium	Lead	Stress in pounds per square inch
Per cent	*Per cent*	*Per cent*	*Per cent*	
5	5	9	81	15,400 to 16,200
10	5	8.5	76.5	17,900 to 19,500
15	5	8	72	20,100 to 21,200
20	5	7.5	67.5	17,000 to 19,300

The proportional limit and the maximum unit stress to which the alloy may be subjected without permanent deformation is definitely raised by the addition of thallium. While the limit of proportionality of lead is as low as 200 lbs, per square inch, the proportional limit of my improved alloy may be as high as 5650 lbs. per square inch.

My improved alloy is similar in structure to the tin-base alloys now employed in high grade bearings. As compared with a tin-base alloy containing up to 8% antimony and 8% copper, cast under the same conditions, tests show that the lead-thallium base alloys are superior to a majority of the tin-base alloys.

While I have described my invention in considerable detail and have given numerous examples, it will be understood that I do not desire to limit my invention to the exact proportions given. In order to obtain the best results, however, when a lead-thallium-antimony alloy is utilized, the thallium should be maintained above 5% and while the upper limit may be varied, no mechanical advantage is to be gained in maintaining the proportions of thallium to lead at a greater ratio than 3 to 7 and because thallium is considerably more expensive than lead, I prefer to maintain the relations of these elements in the ratio of approximately 1 to 9.

When gallium and indium are utilized, they may be maintained in a somewhat higher proportion with respect to the lead, say up to about equal proportions. The amount of antimony and tin in the alloy should not be in excess of 15% of each of these elements. When the alkali or alkaline earth metals are added to the solid solutions of thallium, gallium or indium in lead, the amount added may range up to 5%. I preferably utilize from 1/4 to 1%.

In recapitulation, the preferred ranges of this bearing metal composition comprise about 5 to 20 percent antimony, or from 5 to 15 percent each of antimony and tin, with the balance essentially a matrix of lead containing dissolved gallium, indium, or thallium. This dissolved metal strengthens the matrix. It may also contain about 0.25 to 5 percent alkali or alkali-earth mixture,

which hardens the solid solution of lead-thallium, etc. The matrix thus constitutes about 65 to 95 per cent with lead ranging from about 45 to 90 percent and thallium etc., from about 5 to 30 percent of the bearing metal. In this the antimony acts as anti-friction metal, which because of the physical chemical nature of this alloy system is suspended throughout this lead solution. The antifriction metal of antimony when united with tin is distributed as relatively hard cubes in a particularly strong matrix. Thus, this invention presents a bearing metal that contains no tin or but a low proportion of tin and yet compares favorably in its engineering utility, with types of bearing metal that are high in tin.

Other modifications of my invention will be apparent to those skilled in the art. I desire, therefore, that only such limitations shall be imposed upon my invention as are required by the prior art and the appended claims.

I claim as my invention:

1. A bearing metal containing about 65 to 85 percent lead and 7 to 10 percent thallium as matrix alloy, with the balance suspended as antifriction metal composed essentially of about 5 to 20 per cent antimony.

2. A bearing metal containing about 70 to 80 percent lead and about 7 to 10 percent thallium as matrix alloy, with the balance suspended as antifriction metal composed essentially of about 5 to 10 percent tin and 5 to 10 percent antimony.

3. A bearing metal having as matrix alloy lead solution in which lead constitutes about 70 percent and thallium about 8 percent of the bearing metal, with about 15 per cent antimony and 5 percent tin as antifriction metal.

4. A bearing metal containing about 70 percent lead, 8 percent thallium, 15 percent antimony, 5 percent tin, and 0.25 to 1 percent alkali or alkali-earth metal.

In testimony whereof, I have hereunto subscribed my name this 22nd day of August, 1929.

OWEN W. ELLIS.