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2,807,540

ALUMINUM BASE BEARING

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This invention relates to an aluminum base alloy and particularly to an improved alloy of this type having properties rendering it especially suitable for use as a bearing material.

Many aluminum base bearing alloys, such as the type disclosed in Patent No. 2,238,399, which issued April 15, 1941, in the name of Alfred W. Schluchter, are satisfactory bearing materials in most respects. However, such alloys cannot be satisfactorily heat treated so as to provide sufficient hardness for many purposes. Accordingly, a principal object of my invention is to provide an aluminum base bearing alloy which can be heat treated so that it possesses a hardness comparable to that of any conventional hardenable aluminum alloy and which, at the same time, can be rolled into strip form by conventional commercial methods.

A further object of this invention is to provide such a heat treatable aluminum alloy which has good score resistance when used as a bearing. Aluminum and most of its alloys are generally quite unsuitable for use in bearings for machine parts of iron for the additional reason that aluminum tends to adhere to, or combine with, the ferrous metal, thereby causing scoring or seizing. I have found, however, that by a suitable combination of alloying constituents this difficulty can be overcome and an alloy produced having not only excellent anti-friction properties but other characteristics especially desirable in a bearing material.

In accordance with my invention, therefore, the foregoing and other objects and advantages are attained to a particularly high degree in an aluminum base alloy containing copper, magnesium, cadmium and silicon. Inasmuch as the alloy thus produced is a much stronger metal than the aluminum alloys generally heretofore used for bearing purposes, solid bearings may be made from it, no backing of steel or similar metals being necessary for many applications. Of course, this alloy can also be readily bonded to steel and many other metals and can be used on a backing of such metals. Moreover, if desired, a bearing formed from my alloy may be advantageously provided with a thin overlay of lead or a lead base alloy. Examples of these overlays include the lead-tin and lead-indium alloys which are used for this purpose and in which the lead is the major constituent. Hence it is obvious that, as well recognized by the trade, the term "bearing" is used herein as meaning an element which performs a bearing function regardless of the presence or absence of such an overlay.

Furthermore, the above-described alloy is characterized by much greater hardness than related aluminum base alloys heretofore generally used, heat treatment of this alloy resulting in increasing its hardness as much as several hundred percent. Such a high degree of hardness is desirable because recently developed high compression engines impose exceptionally heavy loads on bearings, thus creating an increased need in recent years for greater hardness in such bearings. Similarly, the greater hardness of my alloy permits it to be formed into a bearing

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having a correspondingly longer fatigue life. As a result of this hardness, solid bearings made from this alloy also retain their original shapes much better than many of the bearings which heretofore have been made of softer alloys. The former do not take a set at temperatures to which they are normally subjected, and they undergo a negligible amount of shrinkage when removed from engines after extensive use. Despite these aforementioned properties, the alloy can be easily rolled down by conventional methods.

In accordance with my invention, highly satisfactory bearing properties are obtained with an alloy having the following composition by weight: 0.05% to 3.0% magnesium, 0.05% to 5.0% cadmium, 0.3% to 11.0% silicon, 0.1% to 3.0% copper and the balance substantially all aluminum. Various incidental impurities may be included in this alloy in the usual small amounts without any substantial detrimental effects. For example, iron, which together with silicon is present in commercial aluminum, may be present in amounts up to 0.5% without causing any harmful results. Under severe test conditions, alloys having the above composition show excellent anti-friction properties so that bearings formed of this alloy not only do not score or gall when in contact with a rotating steel shaft, but neither the shaft nor the bearings show an appreciable amount of wear after long and severe use. I have also found that the resistance of this alloy to cracking or crumbling is extraordinarily high.

The magnesium is added to increase the hardness of the bearing alloy, a magnesium content of only 0.05% being sufficient to provide a sufficient degree of hardness for many applications. Inasmuch as the molten magnesium tends to oxidize during the alloying procedure, however, for best results it is preferable that the magnesium be added in amounts equal to at least 0.2% of the weight of the alloy. Magnesium has an adverse effect on score resistance and friction properties, however, and as a result the magnesium content should not be higher than approximately 3.0%.

With additions of magnesium in amounts greater than approximately 0.5%, the increase in hardness is relatively slight. Moreover, if the magnesium content is not higher than this amount, the addition of copper tends to offset the adverse effect of magnesium on the score properties of the alloy. Accordingly, a magnesium content ranging from 0.2% to 0.5% is preferred, approximately 0.5% magnesium generally being the optimum amount to be added.

The addition of cadmium greatly improves the score resistance of the alloy. Despite the fact that it has been generally recognized that the addition of cadmium to aluminum causes slight loss of strength, I have found that cadmium, in the presence of silicon, may be beneficially introduced in amounts as large as 5.0% without causing a measurable loss of strength. In fact, the resultant alloy is remarkably resistant to disintegration under impact or "pounding" such as occurs in severe bearing service. Moreover, the presence of cadmium does not affect the hardness if the alloy is subsequently heat treated. Although the effect of cadmium on both strength and hardness is negligible in any event if added in quantities no greater than 5.0%, cadmium is a relatively soft metal and hence the cadmium content should not be higher than this amount.

I have also found that a cadmium content greater than 5.0% tends to cause this element to segregate out and settle to the bottom of the casting during the solidification thereof in the form of the apparently nearly pure metal. Thus, too high a cadmium content raises the cost of the alloy by increasing personnel expenses because of increased handling costs and the necessity of more detailed and careful supervision. Moreover, inasmuch

as cadmium is also a relatively expensive and somewhat rare metal, it is desirable to add only as much of this metal as is necessary to produce the desired results.

There is a marked improvement in score properties if cadmium is added in quantities up to 2.5%, but increasing the cadmium content beyond this amount does not appreciably increase the score resistance of the alloy. Hence, cadmium preferably should be present in an amount ranging from approximately 0.2% to 2.5% in order to provide the most desirable anti-friction properties. Inasmuch as cadmium also tends to volatilize at the temperature of molten aluminum, however, it often may be desirable to add slightly greater amounts of cadmium to offset any losses due to this tendency for volatilization. A cadmium content of at least 0.5% is necessary in all instances to provide adequate score resistance.

The inclusion of silicon in my aluminum base bearing alloy also enhances its score resistance. This property of silicon, plus the manner in which it influences the effects of the cadmium present in the alloy and the fact that solidification shrinkage is lower as the silicon content is raised, dictates that the alloy contain at least 0.3% silicon. Inasmuch as a high silicon content interferes with rolling processes, however, the maximum amount of silicon to be added necessarily is governed by the method in which the article, such as a bearing, is formed. Accordingly, silicon should not be present in amounts greater than 5.0% in the wrought alloy because such an alloy needs to be rolled, while it may be added in amounts as high as 11.0% in the cast alloy. While an increased silicon content improves score resistance, the addition of silicon in amounts greater than 5.0% provides only slight additional beneficial properties in this respect. Accordingly, best results are obtained for most purposes when the silicon content is kept within a preferred range of 2.0% to 5.0%.

The addition of copper, in conjunction with the magnesium present in the aluminum base alloy, contributes to the hardenability of the resultant alloy. The hardness of the alloy will be reduced to too great an extent if the copper content is below 0.1%, and the addition of at least 0.3% copper is preferable in order to obtain a satisfactory degree of hardness in those applications where this property is of prime importance. Where even greater hardness is desired, amounts of copper as high as 3% may be added and, in the case of the cast alloy, the copper content may be as high as 5% in some instances. Copper should not be present in amounts greater than about 3% in the wrought alloy, however, because of the difficulties which would otherwise be encountered in rolling operations due to the reduction in ductility of this alloy. In general, the increase in the hardness of the alloy resulting from the addition of copper in quantities above approximately 1% is not substantial if this alloy is subsequently subjected to a suitable form of heat treatment, such as the preferred one hereinafter described. In the absence of such a heat treatment, however, the hardness of the alloy continues to increase with the use of the larger amounts of copper. It is usually not feasible to add more than 3% copper because increasing the copper content above this amount raises alloy costs by greatly increasing the difficulty in casting and fabrication of the cast parts.

As a result of the above considerations, I have found that a copper content within a preferred range of 0.3% to 1% provides excellent results in all respects.

In the alloy hereinbefore described, it is necessary that both magnesium and copper be used in conjunction to obtain the desired hardness. The use of either one of these metals alone in a quantity equal to the combined amounts of the two metals will not provide the same degree of hardness as the use of the two metals in combination.

The above alloy possesses the aforementioned desirable characteristics to an outstanding degree when it consists

of the following preferred composition: 0.5% magnesium, 2.0% cadmium, 4.0% silicon, 0.7% copper, and the balance substantially all aluminum. As hereinbefore stated, other incidental impurities may be present in the above alloy, but for best results the amounts of these other elements should be confined to relatively low proportions. Accordingly, it is desirable that iron, for example, be present in amounts not greater than 0.5%.

In order to obtain the high degree of resistance to pounding, such as is encountered in a bearing, it is preferable that the alloy have a physical structure typified by the absence of continuous networks of relatively brittle eutectic mixtures. Conventional alloying procedures may be employed with intermediate alloys, such as aluminum-silicon and aluminum-copper alloys, being used to introduce the silicon and copper. It is desirable that the more volatile elements, such as cadmium, be the last to be added to the melt in order to prevent their vaporization. In general, it is advisable to use the lowest temperature possible to keep the cadmium from vaporizing. For example, I have found that the aluminum, silicon and copper may advantageously be fused at a temperature in the order of approximately 1200° F., the melt then preferably being removed from the furnace. The magnesium and cadmium may next be successively added to the melt, which is subsequently stirred and cast, usually in metal or graphite molds. The highest temperature suitable for casting is that point at which the cadmium just begins to vaporize or "smoke" and, in order to avoid loss of metal, it is desirable not to raise the temperature of the melt above this point. Accordingly, care should be taken to prevent the temperature from exceeding approximately 1400° F. The alloy may be either cast in the desired form for use in bearings or it may be cast in ingots, rolled down to strip material of the desired thickness, and bearing liners or other bearing elements formed from the stock.

Cast articles having a metallographic structure showing a continuous network of segregated metal compounds may be improved as to strength and fatigue resistance by suitable heat treatment. For example, I have found that a solution treatment at a temperature between approximately 900° F. and 1050° F. for a period of eight to fifteen hours is particularly effective to more completely dissolve the constituent elements and form a solid solution. Upon removing the alloy from the furnace following the solution treatment, it is preferable to cool it immediately by quenching in water. This treatment provides the alloy with the high degree of ductility, such as is desirable for rolling operations; and it may then be easily rolled down to strip material of the desired thickness.

A precipitation treatment may thereafter be employed to substantially increase the hardness of the alloy. This process is preferably carried out by heating the article for five to ten hours at a temperature in the range between approximately 300° F. and 400° F., a precipitation treatment at 370° F. for eight hours being particularly satisfactory. The alloy then may be again cooled, preferably in water, and suitably machined. Such a heat treating process results in an article which is three or four times as hard as it was in the as-cast condition and whose fatigue strength is proportionally improved.

The specific gravity of the above-described alloy is about one-third that of a tin-bronze bearing alloy, and has much greater resistance to fatigue or to cracking under the pounding action to which bearings, such as connecting rod bearings, are subjected. This property renders such an alloy particularly suitable as a bearing for use under extreme conditions, tests on such bearings indicating the remarkable absence of wear, either of the bearing or the shaft. In addition, the alloy appears to be resistant to corrosion by acid constituents of lubricating oils which attack many other bearing compositions.

It is to be understood that, while the invention has been

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described in conjunction with certain specific examples, the scope of the invention is not to be limited thereby except as defined in the appended claims.

I claim:

1. A bearing formed from a heat-treatable wrought alloy consisting of 0.05% to 3% magnesium, 0.05% to 5% cadmium, 0.3% to 5% silicon, 0.1% to 1% copper, and the balance aluminum plus incidental impurities.

2. A bearing formed of an alloy consisting essentially of 0.05% to 3% magnesium, 0.05% to 5% cadmium, 0.3% to 11% silicon, 0.1% to 5% copper, 0% to 0.5% iron, and the balance aluminum.

3. A bearing characterized by high anti-friction properties and resistance to disintegration under impact and to attack by acids developed in lubricating oils, said bearing being formed of an alloy consisting of 0.05% to 3% magnesium, 0.05% to 5% cadmium, 0.3% to 5% silicon, 0.1% to 3% copper, and the balance aluminum plus incidental impurities.

4. A bearing formed of an alloy capable of being rolled into sheet form from cast ingots and having high anti-friction properties and fatigue resistance, said alloy consisting essential of 0.2% to 0.5% magnesium, 0.2% to 2.5% cadmium, 2% to 5% silicon, 0.3% to 1% copper, iron not in excess of 0.5%, and the balance aluminum.

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