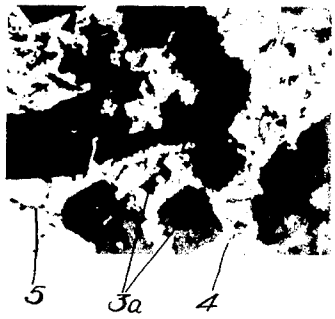
May 26, 1970 YATARO UNAI ET AL 3,514,286
WEAR-RESISTING ALUMINUM ALLOYS
Filed June 23, 1969

FIG. 1



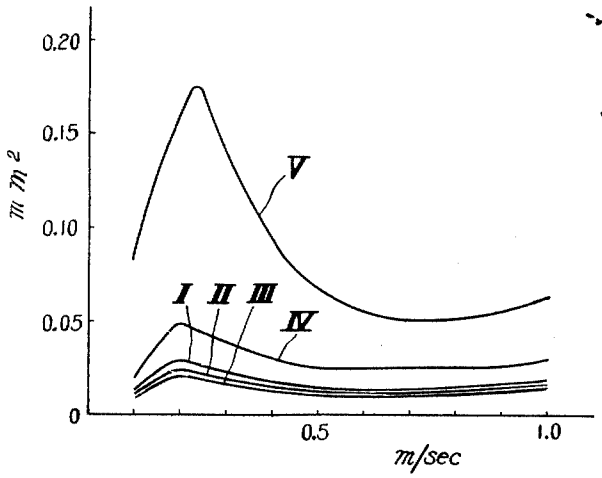


FIG. 2

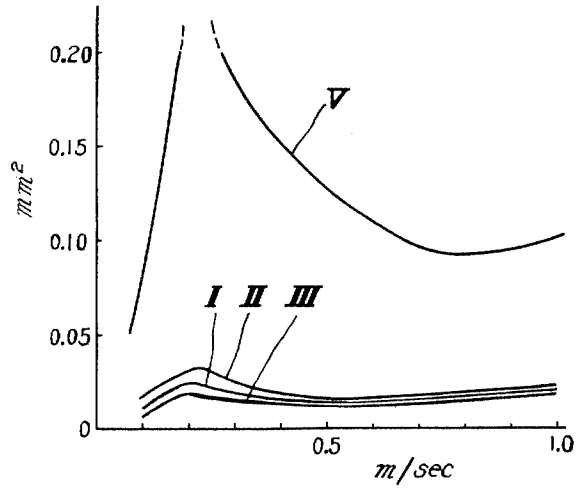


FIG. 3

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3,514,286

WEAR-RESISTING ALUMINUM ALLOYS

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Continuation-in-part of application Ser. No. 495,109, Oct. 12, 1965. This application June 23, 1969, Ser. No. 835,416

Int. Cl. C22c 21/02

U.S. Cl. 75—148 2 Claims

ABSTRACT OF THE DISCLOSURE

A wear-resisting aluminum alloy containing silicon from about 12% to about 25%, lead from about 3% to about 10%, tin from about 3% to about 20% and the balance consisting essentially of aluminum.

This is a continuation-in-part of my prior application Ser. No. 495,109, filed Oct. 12, 1965 now abandoned.

This invention pertains to improvements in hyper-eutectic aluminum-silicon alloys containing optionally copper, magnesium, nickel and other ordinary contents, to which are added lead and tin, which alloys are adapted primarily for use in cylinders and cylinder liners of internal combustion engines assembled with aluminum pistons.

In conventional internal combustion engines, pistons, cylinders and cylinder liners have been made of cast iron, and in part pistons made of aluminum alloys have been used.

Recently hyper-eutectic aluminum alloys containing over 12% silicon are also adapted for improving wear-resistance. Today, the developments and studies on substitution by aluminum alloys not only for pistons, but for cylinders and cylinder liners are being carried out in order to make less in weight the engine as a whole.

α-Phase aluminum is precipitated (primary or eutectic) in aluminum alloys particularly aluminum-silicon alloys. This α-phase aluminum is low in wear-resistance, especially when two materials containing α-phase aluminum are mated, an abnormal wear of "galling or scuffing" will occur. That is why aluminum cylinders and cylinder liners are not used together with aluminum pistons.

The alloys of the present invention contain 3 to 10% lead and 3 to 20% tin, added to 12% to 25% silicon hyper-eutectic aluminum-silicon alloys comprising optionally small quantities of copper, magnesium, nickel and other ordinary contents. And these alloys are dotted with well lubricated lead particles and hard primary silicon, or formed with aluminum-eutectic matrix abundant in tin, or mixed with a combination of these lead and tin particles or materials providing thereby a high wear-resistance not only to conventional cast iron or chrome plated materials, but also even to aluminum-alloys.

The invention will become apparent from the following detailed description with reference to the accompanying drawings, wherein:

FIG. 1 is a microscopic section of a hyper-eutectic aluminum-silicon alloy containing lead and tin;

FIG. 2 represents the results of the metal-to-metal sliding wear test using an ordinary aluminum-alloy, a cast iron and an aluminum alloy of the present invention as one specimen and chrome-plated materials as the other mating specimens; and

FIG. 3 shows the results of the metal-to-metal sliding wear test using an ordinary aluminum alloy and an aluminum alloy of the present invention as one specimen and an ordinary aluminum as the other mating specimens.

FIG. 1 shows the micro structure of aluminum-alloy containing 25% silicon, 2% copper, 1% magnesium, 3% tin, 10% lead and the balance substantially all aluminum. In aluminum-tin-eutectic matrix **4** big eutectic silicon as crystal **2**, tiny fine eutectic silicon **5**, and minute particles of lead or lead and tin-eutectic **3***a* come out as a number of black dots.

FIGS. 2 and 3 respresent the results of comparative wear tests using aluminum-alloys of the present invention or cast iron as one specimen and chrome-plated material as its other mating specimen and aluminum castings containing 12% silicon, 1% magnesium, 1.2% nickel and the balance all aluminum as its other mating specimen, respectively. The results of wear tests using specimens as follows: the aluminum-alloy containing 20% silicon, 2% copper, 1% magnesium, 5% lead and the balance substantially all aluminum; the aluminum-alloy containing 20% silicon, 2% copper, 1% magnesium, 20% tin, and the balance substantially all aluminum; the aluminum-alloy containing 25% silicon, 2% copper, 1% magnesium, 3% tin, 10% lead and the balance substantially all aluminum; cast iron; and one of conventional aluminum-alloys—that is—aluminum-alloy containing 7% silicon, 0.2% copper, 3% magnesium, and the balance substantially all aluminum as each one specimen, are shown in the respective curves I, II, III, IV, and V, drawn as co-ordinates of the longitudinal lines showing quantity of wear ($mm.^3$) and the lateral lines showing friction velocity (m./s.). As shown in curve V, a conventional aluminum-alloy is most remarkably poor in wear-resistance to chrome plated metal and aluminum-alloy containing neither lead nor tin, particularly in the case of the latter, "scuffing or galling" occurs at the point of about 0.2 m./sec. of wear-friction. Although the curves I and II which contain lead or tin alone show high resistance to wear, the curve III containing both lead and tin show the highest resistance to wear in use in association with chrome-plated metal. Conventional aluminum-alloy has very poor wear-resistance, and the new alloys show better results of wear-resistance than the conventional cast iron (curve IV) which has fairly high wear-resistance.

The aforesaid improvement in wear-resistance of the alloy results from the good lubrication of the lead and tin materials in the alloys. Consequently, the aforesaid high resistance is not achieved by minor additions of lead or tin. And best results cannot be secured by the major additions, which will lead only to the increase of weight of its products. For preferred contents of lead and tin, the former ranges from 3 to 10% and the latter from 3 to 20%.

Hence, the new alloys require both lead and tin therein in the ranges stated. Small amounts of copper, magnesium and/or nickel may be present in the alloy up to a total of about 7% so that one or more of these materials may be present within such range and excellent wear-resistance is still obtained. In all alloys, the remainder is all alu-

minum subject to the presence of normal incidental impurities therein in very small quantities.

The lubricating qualities of the alloys and wear resistance are believed to come from the characteristic of the tin and lead particles and the silicon crystals in the aluminum-eutectic matrix **4** which is abundant in tin.

Thus, it is believed that the objects of the invention have been achieved.

What is claimed is:

1. A wear-resisting aluminum alloy which consists of from 12 to 25% silicon, from 3 to 10% lead, from 3 to 20% tin, and the balance essentially aluminum.

2. A modification of an alloy as claimed in claim **1** which contains small quantities of at least one element of the group consisting of magnesium, copper and nickel, and the total amount of additional elements does not exceed 7%.

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RICHARD O. DEAN, Primary Examiner

U.S. Cl. X.R.

75—142, 143, 147