

UNITED STATES PATENT OFFICE

2,293,864

ALUMINUM BASE ALLOY

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No Drawing. Application September 19, 1939,
Serial No. 295,644

5 Claims. (Cl. 75-142)

This invention relates to aluminum base alloys which contain a substantial amount of magnesium, and has particular reference to the prevention of dross and skim formations which usually occur when such alloys are in a molten condition.

Aluminum base alloys containing substantial amounts of magnesium have recently enjoyed wide use because of their desirable fabricating characteristics, high mechanical properties, and excellent resistance to corrosion. These alloys, however, have the disadvantage that when they are in a molten state, some of the magnesium alloying constituent tends to burn out of the alloy by combining with oxygen, nitrogen, and atmospheric moisture, especially when the alloy is maintained for a considerable period of time in the molten condition. Under ordinary circumstances, a black nodular dross formation appears upon the molten alloy which, upon continued heating, changes to a white porous crust containing a considerable amount of entrapped metal. For the purpose of convenience, this formation of dross is considered to be the result of oxidation. In addition to the magnesium which is lost by oxidation and inclusion in this crust of dross, added amounts of magnesium are lost from the molten alloy when the dross is skimmed or otherwise removed from the metal. Further, the presence of any substantial amount of dross in the molten alloy tends to make the metal sluggish and less fluid, rendering casting of the alloy more difficult since the metal does not properly fill the molds and since non-metallic inclusions may be introduced into the casting during the pouring operation.

One of the principal objects, then, of this invention is to minimize the loss of magnesium from molten aluminum base alloys containing this element. A further object is to prevent the formation of the crust of dross which ordinarily forms upon the surfaces of aluminum base alloys containing magnesium. An additional object of the invention is to provide a means for dispensing with protective fluxes and inert atmospheres heretofore considered necessary in melting aluminum base alloys containing magnesium. Another object is to provide an aluminum base alloy containing magnesium which is resistant to oxidation while in the molten condition. Still another object of my invention is to achieve the foregoing purposes by an economical and convenient means readily adaptable to prevailing plant practices. Other objects will appear in the following description of the invention.

I have found that the formation of the above described crust of dross upon the surfaces of molten aluminum base alloys containing appreciable amounts of magnesium may substantially be prevented by the addition of a very small amount of beryllium and lithium to such alloys. These alloys containing beryllium and lithium may be handled in the manner usually followed in foundries, it being unnecessary to use a protective atmosphere or a covering flux to prevent their oxidation. My invention, accordingly, consists in the utilization of this discovery to prevent formation of dross and the attendant loss of metal from molten aluminum base alloys containing magnesium.

For the purposes of my invention, only very small amounts of beryllium and lithium need be added to the alloy, from about 0.001 per cent to about 0.02 per cent of each of these elements being sufficient. The total amount of beryllium and lithium, however, should not exceed about 0.03 per cent of the alloy. I generally prefer to use equal parts of each of these elements in the alloy, but it may be desirable to increase the amounts of lithium and to decrease the amounts of beryllium, which is the more expensive of the two elements, while, of course, maintaining the total amount of these elements used in the alloy within the ranges indicated above. These amounts of beryllium and lithium, while small, serve to render the alloys resistant to oxidation and thus substantially prevent dross formation and loss of magnesium content from aluminum base alloys containing from 1 per cent to 50 per cent magnesium. Additions of these elements are particularly beneficial in commercial alloys which contain magnesium in amounts from about 1 per cent to about 15 per cent, and especially in alloys which comprise from about 4 per cent to about 12 per cent of magnesium. Since formation of dross does not present a serious problem in the melting of aluminum base alloys containing less than 1 per cent of magnesium, there is little need for application of my invention to these alloys. As for the amounts of beryllium and lithium which may be added to these alloys, I have found that at least a total of 0.0005 per cent of these elements should be present in order to impart the desired beneficial effect to the molten alloys, and in the preferred practice of my invention I recommend the use of 0.001 per cent to 0.02 per cent each of beryllium and lithium. I do not find it advisable to add a total of more than 0.03 per cent of these elements since larger amounts show no greater benefit to these

alloys in their molten state and may even cause an increase in the amount of dross formation and greater loss of magnesium.

My invention has been found to be particularly adapted to aluminum base alloys containing substantial amounts of magnesium which are employed in die casting operations since these alloys, containing beryllium and lithium, resist oxidation while in the molten state, even when held at elevated temperatures for extended periods of time. Also, because the molten metal containing these elements does not acquire the usual dross or skin, it is relatively fluid and effectively fills the mold without introducing non-metallic inclusions into the casting.

The desired amount of beryllium and lithium may be added to the alloy in any convenient manner. For example, it may be added in the form of metallic beryllium and lithium, or as a rich aluminum-beryllium-lithium alloy. However, I prefer to add the beryllium and lithium to the alloy by the decomposition of compounds of these metals.

While the presence of beryllium and lithium has beneficial effects upon binary aluminum base alloys containing various amounts of magnesium, I have found that it is also advantageous to use these elements in alloys containing magnesium with additional ingredients. For example, from 0.1 to 5 per cent copper, or from 2 to 14 per cent zinc, or from 0.3 to 5 per cent silicon, or combinations of these elements may be present in the alloy along with the magnesium. In addition, the alloy may contain small amounts of one or more of a group of insoluble metals which serve to increase the hardness of the alloy. These include manganese, chromium, titanium, vanadium, molybdenum, tungsten, zirconium, uranium, nickel, boron, and cobalt. These elements may be employed individually in the following amounts: manganese 0.1 to 2 per cent; chromium 0.1 to 0.5 per cent; titanium 0.01 to 0.5 per cent; vanadium 0.1 to 1 per cent; molybdenum 0.1 to 1 per cent; tungsten 0.1 to 1 per cent; uranium 0.1 to 1 per cent; zirconium 0.05 to 1 per cent; nickel 0.1 to 2 per cent; boron 0.01 to 0.1 per cent; and cobalt 0.1 to 2 per cent. The total amount of these hardening elements should in no case exceed about 2 per cent of the composition of the alloy. Since magnesium is susceptible to oxidation regardless of the presence of the above elements in the molten alloy, the addition of beryllium and lithium effectively prevents dross formation and magnesium losses in any of these magnesium-containing aluminum base alloys.

The presence of beryllium and lithium in these alloys in the small amounts above indicated has no noticeable effect upon the physical or mechanical properties of the alloys. It appears that these alloys have substantially the same tensile and yield strengths, elongation hardness, and resistance to corrosion whether or not beryllium and lithium are present. Moreover, the presence of beryllium and lithium seems to have no appreciable effect upon the properties developed by these alloys following various heat treatments and aging operations.

The effect of small beryllium and lithium additions to aluminum base alloys containing substantial amounts of magnesium may be illustrated by the following observations. An aluminum base alloy nominally containing 8 per cent magnesium was melted and divided into three portions, one portion being used as a standard of comparison and various amounts of beryllium

and lithium being added to the other portions as indicated in the table below. Samples were taken from each alloy prior to the soaking period to determine the exact magnesium content. These melts then were held, or soaked, at a temperature between 1400 and 1500° F. for a period of about 6 hours in order to simulate the most severe conditions sometimes encountered in foundry practice and to promote the formation of dross. While the melts were held at this temperature, substantial amounts of dross only appeared upon the surface of the alloy which contained no beryllium and lithium. After the soaking period, all of the melts were cast in molds and subsequently analyzed to determine the magnesium content of the alloys after soaking at the elevated temperature as compared to the amount of magnesium which they had contained prior to this soaking treatment. The following table summarizes the results of the tests.

Per cent of beryllium added to alloy	Per cent of lithium added to alloy	Per cent of magnesium in alloy before soaking	Per cent of magnesium in alloy after soaking
None	None	8.00	5.27
0.002	0.002	8.12	7.95
0.002	0.004	7.91	7.66
0.03	0.02	8.28	7.37

The above table indicates that a considerable amount of the magnesium content was lost from the alloy which contained no beryllium and lithium, whereas but slight losses occurred during the soaking period in the alloys containing those elements. Under less severe conditions than usually obtain in commercial operations, the losses are smaller; however, even losses of the magnitude shown above in the beryllium-lithium-containing alloys would be permitted in practice. Moreover, the alloys which contained beryllium and lithium did not acquire a black nodular crust such as formed upon the beryllium and lithium-free alloy during the soaking period, and the surfaces of the castings of the beryllium and lithium-containing alloys were clean and attractive as compared with the dull appearance of the alloys which had not been treated with beryllium and lithium.

The term "aluminum" as herein employed refers to aluminum as commercially produced, and the term "aluminum base alloy" refers to those alloys containing at least 50 per cent aluminum regardless of whether the alloy is binary, ternary or of a more complex character.

I claim:

1. An aluminum base alloy containing from 1 to 15 per cent magnesium and from 0.001 to 0.02 per cent beryllium and from 0.001 to 0.02 per cent lithium, the total amount of said beryllium and lithium not exceeding about 0.03 per cent, and from 0.1 to 5.0 per cent copper, the balance being aluminum.

2. An aluminum base alloy containing from 1 to 15 per cent magnesium and from 0.001 to 0.02 per cent beryllium and from 0.001 to 0.02 per cent lithium, the total amount of said beryllium and lithium not exceeding about 0.03 per cent, and from 2.0 to 14.0 per cent zinc, the balance being aluminum.

3. An aluminum base alloy containing from 1 to 15 per cent magnesium and from 0.001 to 0.02 per cent beryllium and from 0.001 to 0.02 per cent lithium, the total amount of said beryllium and lithium not exceeding about 0.03 per cent, and

from 0.3 to 5.0 per cent silicon, the balance being aluminum.

4. An aluminum base alloy containing from 1 to about 15 per cent magnesium and from about 0.001 to 0.02 per cent beryllium and from 0.001 to 0.02 per cent lithium, the total amount of said beryllium and lithium not exceeding about 0.03 per cent, said alloy being characterized by a higher resistance to oxidation in the molten condition than characterizes an alloy of the same composition but devoid of said amounts of beryllium and lithium, said higher resistance being attributable substantially to said beryllium and lithium content and said alloy being devoid

of elements materially subversive to the aforesaid effect of the beryllium and lithium content.

5. The method of preparing aluminum base alloys for casting, said alloys containing from 1 to about 15 per cent of magnesium, which method comprises melting said aluminum base alloys, and inhibiting oxidation of the melt and formation of surface skim thereon by providing a beryllium and lithium content in the molten metal of between about 0.001 and 0.02 per cent of each, the total amount of beryllium and lithium not exceeding about 0.03 per cent.

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