

UNITED STATES PATENT OFFICE

2,336,512

ALUMINUM BASE ALLOY

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No Drawing. Application September 19, 1939,
Serial No. 295,642

5 Claims. (Cl. 75-147)

This invention relates to aluminum base alloys which contain a substantial amount of magnesium, and it 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. Besides the magnesium which is lost by oxidation and inclusion in this crust of dross, additional 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.

This invention is predicated upon the discovery that the addition of a very small amount of beryllium to aluminum base alloys containing magnesium will prevent the formation of a crust of dross or skim upon the surface of the molten alloy. These alloys containing beryllium 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 the formation of dross and the attendant loss of metal from molten aluminum base alloys containing magnesium.

Only a very small amount of beryllium is needed to accomplish my purpose, amounts of 0.02 per cent or less being required. I have discovered that this amount of beryllium is effective in rendering the alloy resistant to oxidation in the molten state, with a consequent reduction in the formation of dross and loss of magnesium. While the use of beryllium for this purpose is beneficial in alloys containing from 1 to 50 per cent magnesium, I have found that it is particularly helpful in commercial casting alloys containing from 1 to 15 per cent magnesium, and especially those containing from 4 to 12 per cent magnesium. Since the formation of dross does not present a serious problem in the melting of aluminum base alloys containing less than 1 per cent magnesium, there is little need for the use of beryllium in such alloys. Also, since beryllium is an expensive alloying constituent, I prefer to add only a sufficient amount to accomplish the elimination of dross, this amount not being over 0.02 per cent. Larger amounts of this element do not provide any better protection for molten alloys. On the other hand, at least 0.0005 per cent beryllium should be present to have a beneficial effect. In my preferred practice, I recommend the use of from 0.003 to 0.01 per cent of this element.

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 they are often exposed to elevated temperatures for a considerable length of time. The addition of beryllium to alloys used in making die castings renders the liquid metal relatively fluid and capable of filling the molds without introducing non-metallic inclusions into the casting.

The desired amount of beryllium may be added to the alloy in any convenient manner. For example, it may be added in the form of metallic

beryllium, or as a rich alloy, or by the decomposition of a suitable compound.

While the benefits of adding beryllium to binary aluminum-magnesium alloys have been discussed hereinabove, I have found that it is advantageous to employ this element in alloys containing other alloying ingredients. For example, alloys containing from 1 to 15 per cent magnesium may also contain 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 any combination of these elements. 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, such, for example, as 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 effectively prevents dross formation and magnesium losses in any of these magnesium-containing aluminum base alloys.

The effect of a small amount of beryllium in aluminum base alloys containing substantial amounts of magnesium is illustrated by the following examples. An aluminum base alloy nominally containing 10 per cent magnesium as the only added alloying constituent was melted and divided into three portions, one portion being used as a standard of comparison and various amounts of beryllium 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 were soaked for 6 hours at a temperature of 1400 to 1500° F. 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 the elevated temperature, substantial amounts of dross only appeared upon the surface of the alloy which contained no beryllium, the other alloys being substantially free from the dross formation. 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 contained prior to this soaking treatment. The following table summarizes the results of the tests.

Beryllium added to alloy	Magnesium in alloy before soaking	Magnesium in alloy after soaking
Percent	Percent	Percent
0.005	10.40	7.27
0.10	10.13	9.56
	10.29	9.86

The above table indicates that a considerable amount of magnesium was lost in the alloy which

contained no beryllium, whereas but slight losses occurred during the soaking period in the alloys which contained beryllium. Under less severe conditions that usually obtain in commercial operations, the losses are smaller; however, even losses of the magnitude shown above in the beryllium-containing alloys would be permitted in practice. Moreover, the alloys which contained beryllium produced castings which had clean and attractive surfaces as compared to the dull appearance of the casting made from the alloy which contained no beryllium.

I have found that the addition of from 0.0005 to 0.02 per cent beryllium to aluminum base alloys containing substantial amounts of magnesium has no effect on their age-hardening properties. For example, die cast test bars 0.5 inch in diameter were made from two aluminum base alloys having the following nominal compositions: 10 per cent magnesium, and 10 per cent magnesium plus 0.01 per cent beryllium, the balance being aluminum in both cases. The test bars were heated at 810° F. for 4 hours and quenched in water at 150° F. Additional samples which received the same heat treatment were artificially aged for 12 hours at 350° F. to determine the effect of any aging. The average tensile properties for the test bars of the two alloys in both the as-quenched and in the aged conditions are given in the tables below.

Heat treated 4 hours at 810° F. quenched in water 150° F.

Alloy	Tensile strength, pounds per sq. in.	Yield strength, pounds per sq. in.	Per cent elongation in 2"	Brinell hardness No.
10% Mg.....	43,425	27,250	9.7	80
10% Mg+0.01% Be..	41,305	27,950	8	80

Heat treated 4 hours at 810° F. quenched in water 150° F. aged 12 hours at 350° F.

Alloy	Tensile strength, pounds per sq. in.	Yield strength, pounds per sq. in.	Per cent elongation in 2"	Brinell hardness No.
10% Mg.....	40,555	30,150	2.3	109
10% Mg+0.01% Be..	39,555	31,450	2.5	109

The foregoing results show that initially the alloys in the as-quenched condition had about the same strength, hardness and elongation, and that when subjected to an artificial aging treatment there is some age-hardening due to the presence of the magnesium without the addition of beryllium. However, it should be noted that there is no significant difference in the properties of the aged alloys, thus showing that the addition of such small amounts of beryllium has had no significant effect upon the age-hardening properties of this aluminum alloy.

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 a binary, ternary, or a more complex combination.

I claim:

1. An aluminum base alloy containing from 1 to 15 per cent magnesium, from 0.0005 to 0.02 per cent beryllium, and from 0.1 to 5 per cent copper, the balance being aluminum.

2. An aluminum base alloy containing from

1 to 15 per cent magnesium, from 0.0005 to 0.02 per cent beryllium, and from 2 to 14 per cent zinc, the balance being aluminum.

3. An aluminum base alloy containing from 1 to 15 per cent magnesium, from 0.0005 to 0.02 per cent beryllium, and from 0.3 to 5 per cent silicon, the balance being aluminum.

4. An aluminum base alloy containing from 1 to about 15 per cent magnesium and from about 0.0005 to about 0.02 per cent beryllium, 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 amount of beryllium, said higher

resistance being attributable substantially to said beryllium content and said alloy being devoid of elements materially subversive to the aforesaid effect of the beryllium 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 content in the molten metal of between about 0.0005 and about 0.02 per cent.

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