

UNITED STATES PATENT OFFICE.

JUNIOUS D. EDWARDS, OF OAKMONT, PENNSYLVANIA, ASSIGNOR TO ALUMINUM COMPANY OF AMERICA, OF PITTSBURGH, PENNSYLVANIA, A CORPORATION OF PENNSYLVANIA.

ALUMINUM-SILICON ALLOY AND METHOD OF MAKING IT.

No Drawing.

Application filed March 18, 1922. Serial No. 544,950.

To all whom it may concern:

Be it known that I, JUNIOUS D. EDWARDS, a citizen of the United States, and a resident of Oakmont, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Aluminum-Silicon Alloys and Methods of Making Them, of which the following is a specification.

The invention relates to aluminum alloys containing substantial amounts of silicon. One object is to provide an alloy of this type having improved physical properties, especially tensile strength and ductility, and a further object is to provide a method of producing such alloys.

The invention is based primarily upon my discovery that the addition to silicon-aluminum alloys of certain metalloids, such as antimony or bismuth, has a marked beneficial effect upon their properties, particularly when the alloy is rapidly cooled to complete solidification.

U. S. Patent No. 1,410,461 to Junius D. Edwards, Francis C. Frary and Harry V. Churchill, discloses the fact that the tensile strength and ductility of silicon-aluminum alloys can be increased, and the grain structure refined, by the addition of the alkali metals, sodium or potassium, to the alloys before casting them. It is characteristic of such use of these alkali metals that they are readily lost from the molten metal by volatilization and oxidation, so that the molten metal must be cast promptly after their addition in order to effect the maximum improvement in the properties of the resultant alloys arising from the introduction of these alkali metals. I have found, however, that if a metalloid of relatively low volatility and relatively low affinity for oxygen, such as antimony or bismuth, be incorporated in a silicon-aluminum alloy, this requirement of prompt casting no longer holds, and a marked improvement in the tensile strength and ductility of the casting results, particularly if the alloy is caused to solidify rapidly in a chill mold according to the invention fully disclosed in the co-pending patent application of Robert S. Archer and Junius D. Edwards, Serial No. 426,839. As described in said application, the rapid solidification of the alloy causes the precipi-

tating silicon to take the form of minute particles with a concomitant improvement in the physical properties of the alloy.

In the preferred practice of the present invention, a silicon-aluminum alloy is first prepared in which a substantial amount of silicon is present. Silicon in small amounts, usually less than 1.0%, appears in most commercial aluminum as an impurity. The desirable properties of silicon-aluminum alloys, such for example as their low casting shrinkage, become usefully apparent only when the silicon is present in substantial amounts, say above about 3.0%, and it is alloys containing above about this percentage of silicon that are contemplated in this specification and claims as alloys containing a substantial amount of silicon. The amount of silicon present may vary from about 3.0 to 15.0%, although the best results are usually obtained when the silicon content is from about 8.0 to 13.0%. The silicon-aluminum alloy may be prepared, for example by stirring metallic silicon in molten aluminum at a temperature of about 750° to 800° C.

To the molten silicon-aluminum alloy, bismuth or antimony are added, preferably in a finely divided form, and thoroughly incorporated by stirring. It is advantageous to pulverize the antimony or bismuth to about 20 mesh, and to introduce them into the molten silicon-aluminum alloy by sifting over the clean surface of the alloy. The reason for this is that the density of these metalloids is so high that they tend to sink rapidly to the bottom of the crucible, and thereafter it is difficult to thoroughly incorporate them into the specifically lighter silicon-aluminum alloy. If, however, they are reduced to small particles before introduction, thorough mixing is much more readily accomplished, particularly in the case of bismuth which has a limited solubility in aluminum.

The antimony or bismuth may be added up to a content of about 1.5% or more but the best results are secured with 0.5 to 1.0% of either. These elements remain in the alloy so that the alloy may be cast at any convenient time after the incorporation of bismuth or antimony. For the reasons fully explained in said co-pending application

Serial No. 426,839, the completed alloy is preferably cast in a chill mold.

The invention is not limited to silicon-aluminum alloys containing bismuth or antimony alone, but includes alloys having additional elements, such for example as copper or zinc which, in connection with silicon, form a series of useful aluminum alloys. It is desirable that the iron content be kept low, preferably less than 0.6%, although in some cases as much as 1.5% or more of iron might be permissible when high ductility is not essential.

While the chilled casting alone produces a marked improvement in the properties of silicon-aluminum alloys, the addition of bismuth or antimony produces an improvement in tensile strength and ductility over and above that obtained in a similarly cast alloy without bismuth or antimony. For example, a silicon-aluminum alloy containing 10.0% silicon, when cast with a certain degree of chill, had a tensile strength of 25,000 lbs. per square inch and an elongation of 4.0%. The same alloy cast under the same conditions after the addition of 1.0% of bismuth had a tensile strength of 30,040 lbs. per square inch and an elongation of 9.5%. A similar 10.0% chill cast silicon-aluminum alloy showed an increase in tensile strength of 5,000 lbs. per square inch, and a doubling of the elongation after the addition of 1.0% antimony.

In sand castings of silicon-aluminum alloys containing antimony or bismuth, the rate of solidification is in general too slow to permit the antimony or bismuth to effect very substantial improvements in the physical properties of the alloy. However, an increase in tensile strength of 1,400 lbs. per square inch and several percent in elongation has been obtained when silicon-aluminum alloys containing about 1.0% bismuth or antimony were cast in sand.

In the periodic system of the elements, antimony and bismuth, together with phosphorus and arsenic, form sub-group *b* of the fifth group (Roscoe and Schorlemmer, 1913 edition, volume 2, page 910), and are usually spoken of as metalloids, while the elements of sub-group *a*, with the exception of nitrogen, are more metallic in character and are classed with the metals. Antimony and bismuth, which are the metalloids of the fifth group of the periodic system of the elements having an atomic weight over 100, both act advantageously and similarly as fully explained in this specification, and therefore are classed together and defined in the appended claims as metalloids of the fifth group of the periodic system of the elements having an atomic weight greater than 100.

I claim as my invention:

1. In the art of making articles of an aluminum alloy containing a substantial

amount of silicon, the improvement comprising incorporating in a finely divided state in the molten alloy a metalloid of the fifth group of the periodic system of the elements, having an atomic weight greater than 100, and thereby favorably affecting the strength and ductility of the resulting alloy.

2. In the art of making articles of an aluminum alloy containing a substantial amount of silicon, the improvement comprising incorporating antimony in a finely divided state in the molten alloy, thereby favorably affecting the strength and ductility of the resulting alloy.

3. In the art of making chill castings of an aluminum alloy containing a substantial amount of silicon, the improvement comprising incorporating in the molten silicon-aluminum alloy a metalloid of the fifth group of the periodic system of the elements, having an atomic weight greater than 100, and causing rapid solidification of the molten alloy in a suitable mold.

4. In the art of making chill castings of an aluminum alloy containing a substantial amount of silicon, the improvement comprising incorporating antimony in the molten silicon-aluminum alloy, and causing rapid solidification of the molten alloy in a suitable mold.

5. In the art of making castings of an aluminum alloy containing a substantial amount of silicon, the improvement comprising incorporating not more than about 1.5% antimony in the molten silicon-aluminum alloy, and casting the resultant molten alloy in a chill mold.

6. In the art of making articles of an aluminum base alloy containing from about 8.0 to 13.0% silicon, the improvement comprising incorporating in a finely divided state in the molten alloy a metalloid of the fifth group of the periodic system of the elements, having an atomic weight greater than 100, thereby favorably affecting the strength and ductility of the resulting alloy.

7. In the art of making chill castings of an aluminum base alloy containing from about 8.0 to 13.0% silicon, the improvement comprising incorporating not more than about 1.5% antimony, and casting the resulting alloy in a chill mold.

8. An aluminum base alloy containing not less than about 3.0% silicon, and not more than about 1.5% of a metalloid of the fifth group of the periodic system of the elements, having an atomic weight greater than 100.

9. An aluminum base alloy containing a substantial amount of silicon, and also containing antimony.

10. An aluminum base alloy containing a substantial amount of silicon, and an effective amount but not more than about 1.5% antimony.

11. An aluminum base alloy containing

from about 8.0 to 13.0% silicon, and an effective amount but not more than about 1.5% antimony.

5 12. A chill casting formed of an aluminum base alloy containing from about 3.0 to 15.0% silicon, and a metalloid of the fifth group of the periodic system of the elements, having an atomic weight greater than 100.

10 13. A chill casting formed of an aluminum base alloy containing from about 3.0 to

15.0% silicon, and also containing antimony.

14. A chill casting formed of an aluminum base alloy containing from about 3.0 to 15.0% silicon, and an effective amount but not more than about 1.5% antimony.

In testimony whereof, I sign my name.

JUNIUS D. EDWARDS.

Witnesses:

PAUL N. CRITCHLOW,
EDWIN O. JOHNS.