

UNITED STATES PATENT OFFICE.

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ALUMINUM-BASE ALLOY.

No Drawing.

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The invention relates to aluminum alloys containing substantial amounts of silicon, and has chiefly to do with such alloys which also contain iron.

5 The disadvantages of the presence of iron in more than minimal amounts in aluminum alloys containing substantial amounts of silicon have long been known. Not only does it impair the physical properties of these al-
10 loys, but it makes machining difficult, and tends to make the molten alloy sluggish so that permanent mold or pressure die casting is rendered difficult.

15 In some cases it is difficult, if not impossible, to keep the iron content low. In the first place, iron may be present in aluminum by reason of its presence in the bauxite or other earths or materials from which aluminum is derived. Also, iron may be present
20 as a result of manufacturing conditions. For example, aluminum silicon alloys have been found to be particularly adapted for making castings in iron molds and dies, and it is quite difficult with present methods to
25 keep the iron content of the alloy as low as is desired. It is necessary to keep the aluminum silicon alloy molten for considerable periods of time in the iron melting pots attached to die casting apparatus, and ap-
30 preciable quantities of iron are therefore continuously introduced in this way. Even in ordinary foundry work, the use of iron melting pots is common practice, and the introduction of iron from the melting pots
35 has always to be reckoned with.

Aluminum silicon alloys containing up to about 12% silicon are normally composed of primary aluminum dendrites with an aluminum silicon eutectic containing relatively
40 large plates and needles of silicon. Hyper-eutectic alloys containing more than about 12% silicon may contain, in addition to the eutectic, large crystals of excess silicon. In United States Patent No. 1,410,461 to Junius
45 D. Edwards, Francis C. Frary and Harry V. Churchill, there is disclosed a process, known as a "modification" process, whereby the strength and ductility of these aluminum silicon alloys can be greatly increased and
50 the grain structure refined by the addition of alkali metals, sodium or potassium, to the alloys before casting. By this process the

normally coarse particles of eutectic, and particularly of the excess silicon, are very finely dispersed, with consequent increase in
55 the strength and ductility of the alloy. If high ductility is desired in the resulting casting, it is very desirable to keep the iron content low, say below about 0.8%, because the iron seems to form a separate constituent
60 in aluminum silicon alloys, taking the form of long, brittle plates or needles upon which said modification process has less eliminat-
ing effect or dispersing effect than upon the coarse particles of eutectic and of excess
65 silicon. That the iron constituent in this form impairs strength and ductility has been shown by physical tests, as well as by observing the very coarse fractures which it produces when present in large amounts.
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The objects of this invention are to provide an aluminum silicon alloy in which the deleterious effects of the presence of iron are minimized or neutralized, and an alloy of the type stated which has improved physical
75 properties, such as tensile strength and ductility.

The invention is based on my discovery that the addition of certain metals to aluminum silicon alloys containing iron has a
80 marked beneficial effect upon the physical properties of the alloy, and has the effect of minimizing or neutralizing the deleterious effect of iron particularly when the alloys contain relatively large amounts of it, say
85 above about 0.8%. The metals, one or more of which may be added to aluminum silicon alloys containing iron to produce these advantages, are chromium, tungsten and molybdenum. They are metals of the sixth
90 group of the periodic system having atomic weights below 190, and are so defined throughout this specification and in the appended claims. Of these metals it is preferred to use chromium.
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In producing an alloy embodying the invention, an alloy of aluminum and silicon may be first prepared containing from about 3 to 15% silicon, which can be done by stirring silicon into molten aluminum at a tem-
100 perature of about 750° to 900° C. until dissolved. The necessary amount of one or more of the metals of the sixth group of the periodic system having atomic weights be-

low 190 may then be introduced into the aluminum silicon alloy in the form of an aluminum alloy containing about 4% of the metal. While the alloy may, as stated, contain as little as 3% silicon, its preferred silicon content is from 8 to 15%.

As examples of the effect of the addition of chromium to aluminum silicon alloys, such an alloy containing approximately 10% silicon and approximately 0.4% iron, when poured at 700° C. in sand molds to form half-inch test bars, had a tensile strength of 20,540 pounds per square inch and an elongation of 4% in two inches. When the iron content of this alloy was increased to 1.07%, its tensile strength decreased to 20,250 pounds per square inch, and its elongation to 2% in two inches. When the iron content was further increased to 2.42%, the tensile strength was only 6,820 pounds per square inch and the elongation 0.5% in two inches. However, by the addition of chromium to these alloys, a substantial increase in strength was produced. For example, in the case of the last-mentioned alloy which contained 10% silicon and 2.42% iron, the tensile strength was increased from 6,820 to 10,830 pounds per square inch by the addition of 0.25% chromium. The addition of 0.44% chromium further increased the tensile strength to 14,930 pounds per square inch, and the still further addition of chromium to 0.83% raised the tensile strength to 18,175 pounds per square inch, the elongation remaining about 0.5% in two inches. A 10% silicon alloy containing approximately 4% iron had a tensile strength of only 3,025 pounds per square inch and an elongation of 0.5% in two inches. The addition of 0.45% chromium increased the tensile strength to 7,955 pounds per square inch; the addition of 0.86% chromium increased the tensile strength to 13,640 pounds per square inch; and 0.91% chromium increased the tensile strength to 15,950 pounds per square inch.

The foregoing examples of the advantage of the addition of chromium to aluminum silicon alloys are all of alloys cast in sand molds. As showing the advantage of the addition of chromium to aluminum silicon alloys cast in iron molds, such an alloy containing 13.65% silicon and 1.25% iron, when cast in an iron mold in the form of half-inch test bars showed an average tensile strength of 28,625 pounds per square inch and an average elongation of 2.3% in two inches for four test bars. By adding 0.4% chromium to this alloy, the average tensile strength of four test bars was increased to 30,915 pounds per square inch, and the elongation to 2.5% in two inches.

As an example of the advantage of the invention in die cast aluminum silicon alloys, such an alloy containing approximately 13% silicon and about 2.5% iron showed,

when die cast in the form of test bars 0.252 inch in diameter, an average tensile strength of 30,246 pounds per square inch and an elongation of 0.8% in two inches. By adding 0.125% chromium to this alloy and forming similar die cast test bars from it, it was found to have an average tensile strength of 33,504 pounds per square inch and an elongation of 1.9% in two inches.

That the advantages of the invention are realized in alloys containing smaller amounts of silicon than those given in the specific examples to which reference has thus far been made, is shown by the following: An aluminum alloy containing approximately 5% silicon and 3% iron had an average tensile strength of 16,015 pounds per square inch and an elongation of 1.9% in two inches when cast in sand in the form of half-inch test bars. The addition of 0.125% chromium raised the average tensile strength to 17,150 pounds per square inch and the elongation to 3.1% in two inches. Further increasing the chromium to 0.25% increased the tensile strength to 17,730 pounds per square inch and the elongation to 3.8% in two inches.

It is well known that the production of homogeneous alloys of aluminum with high melting metals, such as chromium, tungsten, iron, etc., is often attended with some difficulty. It is known that this can be overcome in part by casting, remelting and again casting the alloys. By using this procedure, the physical properties of the aluminum alloys containing 5% silicon to which reference was last made, were still further increased. The alloy with 0.125% chromium, when subjected to this procedure, possessed after remelting an average tensile strength of 18,140 pounds per square inch, and the alloy with 0.25% chromium possessed a tensile strength of 18,860 pounds per square inch.

As an example of the advantage of incorporating tungsten in an aluminum silicon alloy, such an alloy containing about 10% silicon and about 3% iron when cast in sand in the form of half-inch test bars, showed an average tensile strength of 6,670 pounds per square inch. After adding 1% of tungsten to this alloy, tensile strengths as high as 13,600 pounds per square inch were obtained.

As an example of the advantage of incorporating molybdenum in aluminum silicon alloys, the addition of about 1% molybdenum to an aluminum alloy containing about 10% silicon and about 4% iron, increased the tensile strength of sand cast test bars from 3,850 to 13,625 pounds per square inch. The addition of smaller amounts of molybdenum produced tensile strengths between these.

Reference has heretofore been made to the fact that the modification process of alumi-

num silicon alloys does not eliminate the deleterious effects of the presence of iron in such alloys. As an example of the advantage of this invention in alloys which have been subjected to the modification process, an aluminum silicon alloy containing about 10% silicon and about 3% iron was cast in sand molds in the form of half-inch test bars, and showed an average tensile strength of 6,670 pounds per square inch. The same alloy was treated at 927° C. with 2% of the refining flux described in United States Patent No. 1,387,900 to A. Pacz, and after being cast in sand molds in the form of half-inch test bars showed a tensile strength of 6,615 pounds per square inch. This shows that the modification treatment did not effect the usual improvement incident to it because of the presence of too large an amount of iron. By the addition of about 1% of tungsten to this alloy, and subjecting it to the modification treatment of said Pacz patent, the alloy showed an average tensile strength of 12,000 pounds per square inch.

A microscopic examination of the various alloys described in the foregoing examples, and other iron-containing aluminum silicon alloys, shows that the addition to aluminum silicon alloys of a metal of the sixth group of the periodic system having an atomic weight below about 190 produces a marked effect. With chromium, for example, a new constituent, which usually takes the form of equiaxed particles appears, and the coarse, needle-like structure of the iron particles almost entirely disappears. The iron content appears to be largely associated with the constituent of the added metal, but some of it may be present in finely dispersed form. The coarse fracture usually associated with high iron in aluminum silicon alloys becomes finer and finer with increasing additions of the added metal.

Referring particularly to the addition of chromium, its effect in eliminating the brittle, needle-like iron crystals ordinarily present in aluminum silicon alloys is most marked in the alloys of high silicon content, say from 10 to 15%, which also contain relatively large amounts of iron. However, the use of chromium is advantageous under some conditions in alloys containing less amounts of silicon, say as low as about 3%. The preferred chromium content varies somewhat with the content of iron and silicon. When silicon is present within the limit stated, from about 3 to 15%, and the iron does not exceed about 3%, the preferred chromium content is from about 0.25 to 2%, depending upon the properties desired. Under some circumstances, chromium contents as low as 0.05% may be beneficial.

When the iron content does not exceed about 1.5% the use of the modification processes to which reference has been made pro-

duces a beneficial effect upon the physical properties largely by refining the grain and increasing the dispersion of the silicon. Chromium may also be added to aluminum silicon alloys with the advantages previously explained, although when the iron content exceeds about 1.5% the simultaneous use of the modification process and the addition of chromium has little, if any, advantage, and when the iron content exceeds about 1.5%, I usually prefer to add chromium to the alloy without subjecting it to the modification process.

In addition to refining the grain and eliminating the needle form of the iron constituent of an aluminum silicon alloy, the addition of a metal of the sixth group of the periodic system having an atomic weight below 190, and particularly the addition of chromium, apparently increases the fluidity of the alloy. This is of marked advantage in the use of the alloy in die casting and in iron molds where a very fluid alloy is necessary in order to completely fill the molds before solidification takes place. By eliminating, or reducing the brittle, needle-like form of the iron constituent, these metals, and particularly chromium, also act to make the resulting casting more easily machinable, which is an additional great advantage.

According to the provisions of the patent statutes, I have explained the principle and operation of my invention, and have given numerous specific examples of various embodiments of it. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as herein specifically described.

I claim as my invention:

1. An aluminum base alloy containing from about 3 to 15 per cent silicon with more than about 0.8 per cent iron, and more than about 0.05 per cent of a metal of the sixth group of the periodic system having an atomic weight less than 190.

2. An aluminum base alloy containing from about 3 to 15 per cent silicon with more than about 0.8 per cent iron, and also containing from 0.05 per cent to about 2.0 per cent of a metal of the sixth group of the periodic system having an atomic weight less than 190.

3. An aluminum base alloy containing from about 3 to 15 per cent silicon with more than about 0.8 per cent iron, and also containing in amounts sufficient to substantially reduce the plate and needle-like iron constituent, a metal of the sixth group of the periodic system having an atomic weight less than 190.

4. An aluminum base alloy containing from about 3 to 15 per cent silicon with more than about 0.8 per cent iron, and also containing chromium in amounts sufficient to

substantially reduce the plate and needle-like iron constituent.

5 5. An aluminum base alloy containing from about 3 to 15 per cent silicon with more than about 0.8 per cent iron, and also containing more than about 0.05 per cent of chromium.

10 6. An aluminum base alloy containing from about 3 to 15 per cent silicon with more than about 0.8 per cent iron, and also

containing from 0.05 to about 2.0 per cent of chromium.

7. An aluminum base alloy containing from about 3 to 15 per cent silicon, iron in amount less than the silicon, but at least 15 about 0.8 per cent, and more than about 0.05 per cent of chromium.

In testimony whereof, I sign my name.

ROBERT S. ARCHER.