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ALUMINUM-BASE ALLOY.

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To all whom it may concern:

Be it known that we, ROBERT S. ARCHER and ZAY JEFFRIES, citizens of the United States, and residents of Cleveland, in the county of Cuyahoga and State of Ohio, have invented a new and useful Improvement in Aluminum-Base Alloys, of which the following is a specification.

The object of our invention is to provide an aluminum base alloy having a low specific gravity, and which when quenched is relatively soft and workable and ages slowly at room temperature, and which when subsequently artificially aged has very high strength and hardness.

Aluminum base alloys containing various constituents in different percentages are known and some of them have been commercially used for some time. Also it is old in the art to quench some of these alloys from certain temperatures and to subsequently age them either naturally at room temperature or artificially at an elevated temperature for the purpose of increasing their physical properties. Such alloys often contain copper and magnesium, and include as an impurity various amounts of silicon, usually not more than about 0.4%, the silicon being derived both from the material entering into the manufacture of the alloys and from the receptacles in which they are produced.

Our invention is predicated upon our discovery that an aluminum base alloy containing silicon purposely added, either by the selection of raw material or by silicon as such, so as to be present to the extent of not less than about 0.5% and also containing copper and magnesium is readily workable; that after quenching it ages at a normal rate at room temperature; and that when subsequently artificially aged at elevated temperature it possesses, due to the increased silicon content, greater strength and hardness than any aluminum base alloy of which we have knowledge except those containing large percentages of zinc.

The alloy which we provide may contain, in addition to copper, magnesium and the minimum of silicon stated, other elements such as manganese, chromium, nickel and molybdenum. We have found that the addition of manganese assists in producing a fibrous structure in the alloy when in the heat treated condition, and in producing higher elongation when the alloy has been aged at about 150° C. We have also found that chromium has a similar effect. The preferred alloy contains about 4.5% copper, 0.5% magnesium, 0.75% silicon and 0.5% manganese.

The quenching temperature of the alloy may be between about 500 and 550° C., but we have found that it is preferable to quench the hardest alloys from a temperature of about 500 to 515° C.

After it is quenched the alloy ages normally at room temperature, but does not attain its maximum physical properties unless artificially aged at an elevated temperature. The alloy may be given different physical properties by varying artificial aging temperatures. Aging below about 130° C. produces an increase in strength over natural aging without unduly affecting the elongation or ductility, while aging at a temperature of from about 130° C. to 175° C. produces a greater increase in strength and hardness but lowers the ductility. In general the preferred aging temperature is above about 100° C. When it is not desired to subject the alloy to cold working after quenching, it may be quenched to the desired artificial aging temperature rather than to room temperature.

The invention is applicable to both worked and unworked or cast alloys. It may be further explained and more fully understood by reference to a few examples of the alloys we have produced and tested. Having reference first to worked alloys, a forged alloy containing 4.32% copper, 0.78% silicon, 0.50% magnesium and 0.49% manganese, the remainder being aluminum except for impurities, when quenched from a temperature of between 500 and 515° C. and aged naturally for three days at room temperature had a tensile strength of 59,300 lbs. per square inch, an elongation of 25% in two inches, and a Brinell hardness number of 127. This alloy is, except for its higher silicon content, similar to commercial heat-treated alloys. After it had been artificially aged for seventy hours at 120° C., its tensile strength had increased to 66,900 lbs. per square inch, its elongation was 20.5% in two inches, and its Brinell hardness number was 143. After being artificially aged

for twenty hours at 150° C. its tensile strength was 75,300 lbs. per square inch, its elongation 13% in two inches and its Brinell hardness was from 160 to 172. The specific gravity of the alloy was 2.8. This tensile strength and hardness are higher than those in any aluminum base alloy heretofore produced of which we have knowledge, except aluminum zinc alloys which have a specific gravity of about 3.13, and which have well known undesirable characteristics which render them unsuitable for most purposes.

The following example shows the applicability of the invention to alloys containing relatively small amounts of copper. A worked alloy containing 0.75% silicon, 0.5% magnesium, 1.5% copper and the remainder aluminum except for impurities, after being quenched from 500° C. and aged for forty-eight hours at 145° C. had a tensile strength of 56,300 lbs. per square inch, an elongation of 16.5% in two inches, and a Brinell hardness of 130. When aged at 100° C. its tensile strength was about 50,000 lbs. per square inch and its elongation about 30% in two inches.

That the high silicon content is chiefly responsible for the improved physical properties obtained by artificially aging the alloy we provide, may be seen from tests made upon an alloy containing a low percentage of silicon. A worked alloy the same as the first example given, with the exception that it contained .11% instead of .78% silicon, after being quenched from 500° C. and aged naturally for three days at room temperature, had a tensile strength of 60,700 lbs. per square inch and an elongation of 22.5% in two inches. After being artificially aged for seventy hours at 120° C. the tensile strength of the alloy was 59,200 lbs. per square inch and its elongation 22% in two inches, and after aging for thirty-five hours at 150° C. its tensile strength was 59,300 lbs. per square inch and its elongation 21.5% in two inches. Thus one effect of the increased silicon is to render the alloy capable of attaining much higher tensile strength and hardness as a result of artificial aging than are attainable by either natural or artificial aging of alloys having a silicon content such as may be found as an impurity in commercial alloys.

As illustrative of the applicability of the invention to unworked alloys, an alloy containing 4.5% copper, 0.5% manganese, 0.75% silicon and 0.5% mangnesium, when cast in a chill mold, had a Brinell hardness number of about 90. When quenched from a temperature of 500° C. maintained for sixteen hours and then aged for forty-eight hours at 140° C. had a Brinell hardness number of from 145 to 155 and a tensile strength of over 50,000 lbs. per square inch.

We claim as our invention:

1. An aluminum base alloy containing about 4.5% copper, 0.5% magnesium, 0.75% silicon, the alloy having been quenched from a temperature above about 500° C. and artificially aged at a temperature above about 100° C.

2. An aluminum base alloy containing copper, magnesium, manganese, and not less than about 0.5% silicon, the alloy having been quenched from a temperature above about 500° C. and artificially aged at a temperature above about 100° C.

3. A quenched and artificially aged aluminum base alloy containing copper, magnesium, and not less than about 0.5% silicon, the alloy being exceptionally hard and having high tensile strength.

4. An aluminum base alloy containing copper, magnesium, and not less than about 0.5% silicon, the alloy having been quenched from a temperature above about 500° C. and artificially aged and having high tensile strength and hardness.

5. An aluminum base alloy containing about 4.5% copper, 0.5% magnesium, 0.75% silicon, 0.5% manganese, the alloy having been quenched and artificially aged and having high tensile strength and hardness.

6. A quenched and artificially aged aluminum base alloy substantially free from zinc and containing copper and magnesium, having silicon as an added element, and having a tensile strength not less than 70,000 lbs. per square inch.

7. A quenched and artificially aged aluminum base alloy containing copper and magnesium, having silicon as an added element, and having a specific gravity not over 2.9, a tensile strength of not less than 70,000 lbs. per square inch and an elongation of not less than 10% in two inches.

8. A quenched and artificially aged aluminum base alloy substantially free from zinc and containing copper, magnesium and manganese, having silicon as an added element, and having a tensile strength of not less than about 70,000 lbs. per square inch.

In testimony whereof we hereunto sign our names.

ROBERT S. ARCHER.
ZAY JEFFRIES.

Witnesses:
MERLE B. PRICE,
ADA HARPER.