

UNITED STATES PATENT OFFICE

1,999,042

ALUMINUM REFLECTOR SURFACE AND
METHOD OF PRODUCING THE SAME

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No Drawing. Application January 25, 1932,
Serial No. 588,843

10 Claims. (Cl. 88—1)

5 This invention relates to improvements in the metal used for the production of aluminum reflecting surfaces and it is particularly concerned with the production of etched aluminum reflecting surfaces of maximum brightness and uniform reflecting qualities.

10 Etched aluminum surfaces have found a wide application in the production of articles having good light reflecting surfaces, particularly where a more or less diffuse reflection is desired. For example, aluminum and its alloys have been used widely in the production of such articles as engraved name plates, electric light reflectors, and more recently for reflectors used in connection with ultra-violet light reflection. The type of surface generally desired for these uses is obtained by treating the aluminum with one or more solutions having a solvent action on the aluminum surface, whereby a matte or satin finish is produced. Undesirable results are sometimes obtained, however, because of an irregular action of the etching solution on the metal so that a surface having a streaked or spotted appearance is obtained. The brightness of the reflecting surface is also impaired at times by the presence of a gray film left thereon after the etching action. While this film can, under some conditions, be readily rubbed off, the rubbing tends to reduce the brightness of the etched surface and is objectionable in that it requires an additional step in the preparation of suitable light reflecting surfaces.

25 It is an object of this invention to overcome the difficulties in the preparation of etched aluminum reflecting surfaces and to produce an aluminum or aluminum alloy reflector metal of improved etching qualities.

30 It is a further object of this invention to produce an aluminum or aluminum alloy reflector sheet upon which etched reflecting surfaces of uniform reflectivity and maximum brightness may be produced.

35 It is more particularly an object of this invention to produce etched aluminum reflecting surfaces of uniform reflectivity and maximum brightness.

40 In the production of etched light reflecting surfaces, a commercial grade of aluminum containing not more than about 1 per cent of total impurities or a simple alloy thereof containing at least about 98 per cent of aluminum and a small percentage of other elements such as manganese or titanium may be used. The term "aluminum" is therefore used herein and in the appended claims in a generic sense to include both a com-

mercial grade of aluminum suitable for this purpose and simple alloys thereof containing at least about 98 per cent of aluminum.

45 We have found that the etching characteristics of aluminum are affected by the composition of the metal used with respect to certain constituents present among the impurities, heretofore regarded as unimportant and immaterial in determining the properties of the metal. We have also found that by controlling the composition of the aluminum with respect to these constituents the etching characteristics may be so improved that reflecting surfaces of maximum brightness and uniform reflectivity may be obtained directly by the action of the usual etching solutions on the metal. Among the impurities present in the aluminum is generally included a very small percentage of copper and a relatively large percentage of silicon. We have found that the property of the aluminum of taking a uniform etch varies with the percentage of copper present and that aluminum containing more than a minimum percentage of copper, which is definite though very small, is characterized by the property of being uniformly etched with the usual etching solutions. The gray film left on the aluminum surface by the action of the etching solutions we have found to be due to the presence in the metal of free or elementary undissolved silicon known in the art as graphitic silicon.

50 The copper present as an impurity in the aluminum varies in amount between about 0.01 per cent and 0.08 per cent but it generally occurs in amounts less than 0.05 per cent. We have found that in order to obtain a uniformly etched surface on aluminum or its alloys it is necessary that the aluminum contain at least about 0.06 per cent and preferably less than 0.3 per cent copper, and we have been able to produce the best results with aluminum containing between 0.1 per cent and 0.2 per cent copper. With a copper content lying within these limits the etched surface produced on the aluminum by means of ordinary etching procedure has a regular matte finish entirely free from streaks and spots due to the presence of unetched or poorly etched areas. The reflection characteristics of this surface are consequently more uniform and a better appearance and distribution of light are obtainable with it.

55 The silicon present as an impurity in the aluminum of the grade used for this purpose is generally less than about half of the total impurities present and in most cases varies between about 0.1 per cent and 0.4 per cent. This silicon may be present either in solution in the aluminum or in

combination with one of the other impurities, such as iron, or as undissolved uncombined graphitic silicon. Silicon present in the dissolved or in the combined state does not materially affect the adaptability of the aluminum to the production of etched light reflecting surfaces. Graphitic silicon, however, leaves the gray film heretofore referred to and its presence in the metal tends to reduce the brightness of the etched surface obtainable on the metal. Graphitic silicon may be caused to dissolve in the aluminum by annealing the metal at suitable temperatures. The annealing of aluminum used for the production of etched light reflecting surfaces is customarily carried out at temperatures of about 600 to 650° Fahrenheit. We have found, however, that annealing at this temperature, even when carried on for relatively long periods, does not eliminate this gray film produced by etching, but that if the annealing be carried on at temperatures between 800° Fahrenheit and 900° Fahrenheit, preferably at about 850° Fahrenheit, the silicon may be caused to dissolve with elimination of the gray film attributed to the silicon. The annealing may be followed, of course, by further cold working to change the gage or shape of the aluminum or to increase its hardness. There is thus obtained aluminum free from graphitic silicon which may be etched with the usual solutions without the production of a gray film on the etched surface.

Consequently, we are able, by controlling the copper content of the aluminum so that at least 0.06 per cent and preferably less than 0.3 per cent is present and annealing the metal at a temperature preferably about 850° Fahrenheit, to produce a metal which etches uniformly and which acquires a surface free from any dark film. Thus we are able to produce etched aluminum light reflecting surfaces of uniform reflectivity and maximum brightness directly from the etching bath.

The etching of our improved aluminum light reflecting material may be carried out with most of the ordinary etching solutions. We prefer, however, to use certain solutions in order to obtain the maximum reflectivity. For this purpose we have found two types of etching treatment to be particularly satisfactory; that is, etching with hydrofluoric acid and nitric acid or etching with a solution of sodium hydroxide and sodium fluoride followed by nitric acid. When the etching is carried out using hydrofluoric acid and nitric acid the aluminum is first dipped into a solution of one part concentrated hydrofluoric acid in 19 parts of water at a temperature of 50 to 60° centigrade, until an etch of the desired depth is obtained. The surface is washed and the article is immersed for several seconds in a solution of nitric acid containing one volume of acid to one volume of water and held at room temperature. The aluminum is washed and dried and a clean, bright and uniformly etched surface is obtained. In the sodium hydroxide-sodium fluoride etching procedure a 5 per cent sodium hydroxide solution in water containing about 4 per cent sodium fluoride is used. The aluminum is immersed in this solution at a temperature of about 90° centigrade until the desired etch is obtained. It is then removed, washed, and treated with a 1:1 nitric acid solution, washed and dried as before. Again a very satisfactory clean, bright, and uniformly etched surface is obtained. It should be noted that the presence of copper in the aluminum causes the metal to turn gray to black on immersion in the hydrofluoric acid or the sodium hydroxide solutions. This

black coloration, due to copper, is removed by immersion in the nitric acid. However, the nitric acid does not remove the gray film due to graphitic silicon, if it is present, and this must either be removed by rubbing or prevented from forming.

The effect of the presence of a sufficient amount of copper in aluminum on its etching properties is pointed out specifically by the following examples: A sample of a commercial grade of aluminum containing about 1.0 per cent of impurities, including 0.6 per cent iron, 0.3 per cent silicon, and 0.01 per cent copper, when etched with hydrofluoric and nitric acids as above described, produced a surface which was irregularly etched, having a streaked appearance. On the other hand, a sample of aluminum containing 0.6 per cent iron, 0.08 per cent copper, and 0.18 per cent silicon as impurities, when etched in a similar manner, produced a very satisfactory uniform reflecting surface.

The following examples further point out the beneficial effects of copper in the aluminum and at the same time show the results obtainable by annealing the aluminum at 850° Fahrenheit. Samples of commercially pure aluminum containing about 0.44 per cent iron and 0.29 per cent silicon, to which copper had been added to an amount of about 0.1 per cent, were prepared. One sample of this metal was annealed at 650° Fahrenheit according to the usual practice and subsequently etched by the hydrofluoric acid-nitric acid method. An etched surface was produced which was lightly coated with a gray film. When this film was removed the etched surface was found to be regular and uniform. A portion of the silicon was present as graphitic silicon as shown by qualitative tests. The other sample of this metal was annealed at 850° Fahrenheit and etched with hydrofluoric and nitric acids. This treatment produced a bright uniformly etched surface, free from any film.

We claim:

1. A method of producing an aluminum article having a uniformly etched light-reflecting surface comprising forming the article of aluminum containing 0.06 to 0.3 per cent of copper and a substantial amount of silicon, annealing the aluminum at a temperature of 800° to 900° F. until all elementary silicon contained therein is dissolved and subsequently treating the surface of said article with a solvent for aluminum and non-graphitic silicon and a solvent for copper.
2. A method of producing an aluminum article having a uniformly etched light-reflecting surface of maximum brightness comprising treating the surface of an article formed of aluminum containing 0.06 to 0.3 per cent of copper and free from undissolved elementary silicon with a solvent for aluminum and non-graphitic silicon and a solvent for copper.
3. A method of producing an aluminum article having a uniformly etched light-reflecting surface comprising treating the surface of an article formed of aluminum containing 0.06 to 0.3 per cent of copper with a solvent for aluminum and a solvent for copper.
4. In a method of producing aluminum light-reflecting surfaces of uniform reflectivity and maximum brightness, the steps comprising annealing aluminum containing 0.06 to 0.3 per cent of copper and a substantial amount of silicon at a temperature of 800° to 900° F. until all uncombined silicon contained therein is dissolved and subsequently etching the surface of the alumi-

num to dissolve therefrom aluminum, non-graphitic silicon and copper.

therein is dissolved and subsequently treating the surface of said article with a solvent for aluminum and non-graphitic silicon and a solvent for copper.

5 In a method of producing aluminum light-reflecting surfaces of uniform reflectivity and maximum brightness, the step comprising etching the surface of aluminum containing 0.06 to 0.3 per cent of copper and substantially free from undissolved elementary silicon to dissolve therefrom aluminum, non-graphitic silicon and copper.

8. As an article of manufacture, an aluminum diffuse light-reflecting means formed by etching aluminum containing 0.06 to 0.3 per cent of copper to produce a diffuse light-reflecting surface substantially free from unetched and partially etched areas, which is visibly uniform. 5 10

10 6. A method of producing an aluminum article having a uniformly etched light-reflecting surface comprising forming the article of aluminum containing 0.06 to 0.3 per cent of copper and a substantial amount of silicon, annealing the aluminum at a temperature of 800° to 900° F. until all the elementary silicon contained therein is dissolved and subsequently etching the surface of said article with hydrofluoric and nitric acids.

9. As an article of manufacture, an aluminum diffuse light-reflecting means formed by etching aluminum containing 0.06 to 0.3 per cent copper and free from undissolved silicon to produce a diffuse light-reflecting surface substantially free from unetched and partially etched areas and free from film, which is visibly uniform. 15

20 7. A method of producing an aluminum article having a uniformly etched light-reflecting surface comprising forming the article of aluminum containing 0.06 to 0.3 per cent of copper and a substantial amount of silicon, annealing the aluminum until all elementary silicon contained

10. As an article of manufacture, an aluminum diffuse light-reflecting means formed by etching aluminum containing 0.1 to 0.2 per cent copper to produce a diffuse light-reflecting surface substantially free from unetched and partially etched areas, which is visibly uniform. 20

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