Patented June 9, 1925. 1,540,766

UNITED STATES PATENT OFFICE.

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METAL PROCESS.

No Drawing. Application filed February 23, 1923. Serial No. 620,833.

To all whom it may concern:

Be it known that we, SAMUEL DANIELS and ARTHUR C. ZIMMERMAN, citizens of the United States, residing at Dayton, in the county of Montgomery and State of Ohio, have invented certain new and useful Improvements in Metal Processes, of which the following is a specification.

This invention relates to the treatment of aluminum, of magnesium, or their alloys, to render castings, forgings, rolled sheet, or other forms thereof substantially impervious to fluids, gaseous or liquid, to inhibit corrosion and to improve physical properties. While the process is herein disclosed and referred to with respect to the treatment of aluminum, of magnesium, and their alloys, it will be understood that the invention is not so limited in its broader aspects.

One object of this invention is so to treat a metal of the character above specified that its initial porosity is substantially decreased.

Another object is to provide a treatment which will inhibit corrosion of such metal. In this connection, it is well known that agencies, such as fresh water, salt water, vapors, ordinary weathering, etc., will corrode aluminum, magnesium, and their alloys, to such an extent that the metals are rendered valueless within a short period of time. The metal likewise is so treated that corrosion by gasoline and liquids of like character is inhibited.

It is another object to improve, by appropriate treatment, the physical properties of the metal, as for instance, to increase its ultimate strength and the percentage of elongation to a substantial degree.

It is a further object to reduce the electrolytic action which takes place between welded or otherwise united joints of aluminum, of magnesium, and their alloys or between the joints of dissimilar metals.

It is a further object to treat the metal in such a manner that simultaneously its electrical conductivity is decreased and its heat conductivity is increased.

It is another object to provide a treatment of the metal that will cause the pores thereof to be filled with a material insoluble in water, oil, gasoline, etc.

Another object is to provide a treatment of metals such as those of the class described that will minimize porosity, inhibit corrosion, improve the physical properties and still maintain the original lustre of the metal as cast or otherwise formed.

Another object is to provide a method of treatment which will, in metals originally having the physical properties desired, minimize porosity and inhibit corrosion without impairing the original and desired physical properties.

Other objects will appear from the description as it proceeds and from the claims.

Heretofore, to our knowledge, no process has been devised which substantially inhibits the corrosion of aluminum, of magnesium, and their alloys on exposure to the weather, or by contact with salt water, gasoline, oils, etc; nor has any process been devised which is successful in inhibiting corrosion, which will at the same time substantially decrease porosity and improve the physical properties of the metal.

One of the greatest impediments to the extensive use of aluminum, of magnesium, and their alloys as liquid fuel containers or passages, engine crank cases and sumps, airplane structural elements, cooking utensils, marine propellers, etc., has been corrosion. Experience has incontrovertibly proven that the uses to which aluminum may be put would be almost unlimited but for its peculiar susceptibility to corrosion. We have discovered that by a treatment to be hereinafter more fully described, this susceptibility may be overcome, and inhibited even under the most severe corrosion tests. This processing to be described not only inhibits corrosion but fills the pores of the metal, adapting it for use as containers for liquids, and, in such cases where physical properties are not already improved, or brought up to the desired qualifications, will improve the physical properties of the metal so that its ultimate strength will be improved from 15 to 50% and the percentage of elongation will be improved from 0 to 250%.

We are aware that the porosity of metals, such as aluminum, may be substantially eliminated by a process described in Patent #1,384,033, issued July 5, 1921, but we are unaware of any process that also inhibits corrosion.

Broadly speaking, the process consists in heat treating the metal, regardless of its form, by quenching, by subsequently immersing in a silicate solution and by finally baking the metal so treated at some temperature above atmospheric. The silicate treatment may be applied in any manner desired but in its preferred forms is described more specifically hereinafter. Various specifications may dictate various modifications of treatment and it will thus be apparent that many digressions from the broad principles may be made, although in its preferred forms, the process is applicable for different results as will be pointed out, in the following related process forms:

Method No. 1.—This method may have the most general application and takes care of those cases where the physical properties of light metals or alloys are not required to be better than those of the metal as cast or otherwise formed, or as cast or otherwise formed and heat treated. It has as its sole aims, minimization of porosity, and inhibition of corrosion without substantially affecting the physical properties of such metals inherent before the application of method No. 1. This method consists in immersing the alloys in an aqueous solution of a soluble silicate or of soluble silicates of specific gravity of 1.05 to 1.3 inclusive, (although an aqueous solution of a soluble silicate or of soluble silicates of any specific gravity may be used), for any desirable length of time, the temperature of said solution to be maintained at any temperature or between any temperatures up to and including the boiling point of said solution at any pressure, and subsequently baking said metals with the solution still adhering, at some temperature above atmospheric dependent upon the physical properties inherent before the application of method No. 1: In pursuing this process, the lustre of the alloy, if originally bright before treatment, is preserved. We may heat the metal in such an aqueous solution of soluble silicate for a short period of time, perhaps from one to four hours at a temperature of from 100° to 200° F., remove the metal from the bath and bake it for the same period i. e., one to four hours at a temperature above the boiling point of water, say from 300° to 350° F., but in a preferable form this process consists in the following steps where physical properties of the metal are not required to be improved. The metal is heated in an aqueous solution of sodium silicate of 1.1 specific gravity at a temperature of 150° F. which is maintained for two hours. The metal is then removed from the solution and baked for 20 hours at about 300° F. with a film of the solution thereon. As an example of the effect of this processing, a duralumin cast cup showed no signs of corrosion after subjection to 120 hours of 20% salt spray solution at room temperature, whereas an untreated cup became corroded after three hours. Porosity of the cup after this treatment, was reduced from 14 minutes for a leakage of 1000 cc. of air at 110 pounds per square inch pressure before treatment, to 1200 minutes for the same amount of air leakage at the same pressure.

With a cup made from an alloy composed of 92% by weight of aluminum and 8% by weight of copper, under a pressure of 110 pounds per square inch, the porosity before treatment caused 1000 cc. of air to pass through in 54 seconds, whereas after treatment, 2100 seconds were required. Corrosion in salt spray before treatment took place within 2 hours, whereas after treatment a very slight corrosion was noticeable only after 150 hours.

All porosity tests as herein recorded were measured by the standard test, which determines the time required for 1000 cc. of air leakage through a standard porosity cup at a pressure of 110 pounds per square inch. Corrosion tests were made both in a 20% salt spray solution and in containers of light metal holding a mixture of distilled water and gasoline. In the latter type of test for corrosion, a cup whose analysis was 92 parts of aluminum and 8 parts of copper by weight, and which was treated according to method No. 1 was not corroded after having held a mixture of distilled water and gasoline for over 135 days. Untreated specimens of the same chemical analysis showed corrosion under the same conditions within 24 hours.

As an example of the effect of this process on duralumin previously heat treated to the desired physical properties, specimens lost none of their inherent physical properties and attained diminished porosity and protection from corrosion according to the following table:

	Porosity.	Corrosion.
Untreated specimen---	21 minutes.	Before 7 hours.
Treated specimen-----	8, 500 minutes.	After 150 hours.

Method No. 2.—This method provides for the betterment of physical properties, minimization of porosity and inhibition of corrosion, and consists in heating a light metal of the class described to some temperature not over 1300° F. as, for instance, from 850° to 950° F. for from 2 to 144 hours, in then quenching in an aqueous solution of a soluble silicate or soluble silicates of specific gravity from 1.05 to 1.3, although as stated with reference to Method No. 1, an aqueous

solution of a soluble silicate or of soluble silicates of any specific gravity may be used. These metals are then treated in such manners as to affix the silicate coating thereon and develop the physical properties required, which treatments may consist in baking the metal with the coating thereon for from 4 to 30 hours at temperatures from 200° F. to 400° F., although various fixing and aging processes may be used. As the nature of aging processes is well known and as different requirements for metals dictate different aging processes, they will not be more fully discussed, although we may prefer to age the metal as more fully set forth infra. It may be advisable to treat these alloys in a silicate solution at low temperature before the final aging designed to secure the desired physical properties. By this process, the corrosion and porosity of the metals are minimized and the physical properties, as evidenced in ultimate strength and percentage of elongation are very much improved. The lustre of the alloy, if originally bright before this treatment, is lost, and the appearance of the metal is dull and frosty. In a preferable form this process consists in heating the castings, etc., at 925° F. for 2 hours, quenching in a solution of sodium silicate of 1.1 specific gravity at room temperature, and aging or baking without washing, for not longer than 20 hours at 300° F. This process, in addition to substantially eliminating both porosity and corrosion, increases the physical properties, as noted below.

	Ultimate strength.	Elongation.
As cast duralumin	22,000 lb.	1.25 per cent.
Treated duralumin	32,340 lb.	2.75 " "

As an alternative we may heat the metal for 144 hours at 925° F., quench in sodium silicate of specific gravity 1.1 at room temperature and bake for 20 hours at 300° F. This has given results as follows:

	Ultimate strength.	Elongation.
Treated duralumin	48,160 lb.	1.25 per cent.

As an additional alternative, metal may be heated for 144 hours at 925° F., quenched in sodium silicate of 1.1 specific gravity, at room temperature and baked for 8 hours at 300° F. whereupon the following results may be attained.

	Ultimate strength.	Elongation.
Treated duralumin	38,010 lb.	2.16 per cent.

By each of these methods under method No. 2, porosity is minimized to about the same extent as comes from the use of methods Nos. 1 and 3; but corrosion is inhibited to a somewhat less extent than is effected by the use of Nos. 1 and 3.

Method No. 3.—This method provides for the betterment of physical properties of the metal, minimization of porosity, and inhibition of corrosion and consists in heating the metal to some temperature not over 1300° F. such as 925° F., and in subsequently cooling in air, water, oil or by other methods; thereafter they are heated for some length of time in an aqueous solution of a soluble silicate or soluble silicates of specific gravity from 1.05 to 1.3 (any specific gravity of solution may be used), at some temperature up to and including the boiling point of the solution at any pressure at which the boiling point does not exceed 550° F. The metal is then baked or aged at some temperature above atmospheric until such time when the required physical properties are obtained. In this, as in all other methods herein described, test bars, cups, etc. may be put through the same treatment to determine the physical properties, and the extent of porosity and inhibition to corrosion. This process produces all the results attained in following method No. 2, and in addition, preserves the lustre of the alloy, if originally bright before treatment. It is understood that the treatment in the soluble silicate bath may be carried out under pressures other than atmospheric. In a preferred form, the castings, etc. are heated at 925° F. for 144 hours and quenched in water at room temperature. They are then treated in a sodium silicate solution of 1.1 specific gravity for 2 hours at 150° F. and finally baked for 8 hours at 300° F. The following results may be obtained thereby:

Treated duralumin:

Porosity, reduced from 14 min. for 1000 cc. leakage to 11,000 min. for the same amount of leakage at 110# sq. in. pressure, ultimate strength, 35,200 lb.; elongation, 4.33 per cent; corrosion, none after 150 hrs. in salt spray.

As an alternative method, the material may be heated at 925° F. for 144 hours, cooled in air, treated in sodium silicate solution, specific gravity of 1.1 for 2 hours and baked for 8 hours at 300° F. This evidences physical properties as follows:

Treated duralumin:

Porosity, reduced from 47 minutes to no leakage; ultimate strength, 39,060 lb.; elongation, 1 per cent; corrosion, none in 150 hrs. in salt spray.

The difference in porosity between the specimens treated by these latter two methods was probably due to normal differences in the permeability of the metal as cast.

Methods Nos. 1, 2 and 3 will remove casting strains. Methods Nos. 2 and 3 are not adapted to the treatment of soldered joints whereas method No. 1 may be so adapted, depending upon the composition of the sol-

der used in the joint, and methods Nos. 1, 2 and 3 are all adapted to the treatment of welded joints.

It may be found desirable after having applied one of these three methods to a metal, to treat it again by the same or different method or to re-treat it in the silicate solution and then re-bake it in any suitable manner, dependent upon the properties and qualities desired in the finished product.

What we claim and desire to secure by Letters Patent is:

1. A process for treatment of metals which comprises, coating the metal with a silicate and heating said coating to permanently affix it.

2. A process for treatment of metals comprising coating the metal with a silicate and fixing said coating thereon with the aid of heat at low temperature to render it tenacious and resistant to physical and chemical changes.

3. A process for treatment of metal to form a protective coating thereon comprising, applying a thin coat of a silicate solution to the metal and dehydrating said silicate.

4. A process for the treatment of metals comprising producing a silicate coating thereon and affixing said coating thereto with the aid of heat at low temperatures.

5. A process for the treatment of metals comprising coating and impregnating the metal with a soluble silicate and rendering said coating and impregnation resistant to physical and chemical changes with the aid of heat at low temperatures.

6. A process for the treatment of metals comprising applying a coating of a soluble material thereon and thereafter rendering said material non-hygroscopic with the aid of heat at low temperatures.

7. A process for the treatment of metals comprising coating said metal with a film of a heated soluble silicate solution and drying said film intact on the metal.

8. A process for the treatment of corrodible metals to inhibit their corrosion, comprising heating said metal, applying a coating of a soluble silicate solution and baking at relatively low temperatures to dehydrate and render said coating fixed.

9. A process for the treatment of metals which comprises immersing the metal in a heated solution of a soluble silicate held at a temperature below its boiling point, removing said metal from the said solution with a film of said solution thereon and affixing said film permanently thereto.

10. A process for the treatment of metals comprising treating the metal to form a thin coat of soluble silicate thereon and so treating said metal that said coating is dehydrated and remains intact thereon.

11. A process for treatment of metals comprising heating the metal in a 1.1 specific gravity solution of sodium silicate.

12. A process for treatment of metals comprising heating the metal in a soluble silicate solution and baking.

13. A process for treatment of metals comprising immersing the metal in a solution of sodium silicate, and baking the silicate adhering to the metal.

14. A process for treatment of metals comprising immersing the metal in a solution of soluble silicate of 1.1 specific gravity, and thereafter baking the metal with the silicate adhering thereto.

15. A process for treatment of metals comprising immersing the metal in a 1.1 specific gravity solution of sodium silicate, and baking the silicate adhering to the metal.

16. A process for treatment of metals comprising immersing the metal in a soluble silicate solution and baking at 300° F.

17. A process for treatment of metals comprising heating the metal in a solution of sodium silicate, and baking for 8 hours at 300° F.

18. A process for treatment of metals comprising, heating the metal in a solution of soluble silicate of 1.1 specific gravity, and baking for 20 hours at 300° F.

19. A process for treatment of metals comprising, heating the metal in 1.1 specific gravity solution of sodium silicate, and baking for 20 hours at 300° F.

20. A process for the treatment of the lighter metals comprising heating the metal in an aqueous solution of a soluble silicate of a specific gravity greater than unity at a temperature less than the boiling point of water, removing and baking the metal thus treated for from one to four hours at a temperature greater than the boiling point of water.

21. A process for the treatment of metals which comprises, heating the metal in an aqueous solution of soluble silicate of specific gravity of 1.1 for two hours at 150° F. removing and baking for two hours at 350° F.

22. A process for treating metals of the class described, which comprises, heating the metal and thereafter treating with a silicate.

23. A process for treating metals of the class described, comprising heat treating the metal and thereafter treating in a soluble silicate.

24. A process for treating metals of the class described comprising heat treating the metal and quenching in a solution of a silicate compound.

25. A process for treating metals of the class described, comprising heating the metal and quenching in a soluble silicate.

26. A process for treating metals of the

class described, comprising heat treating the metal, quenching in a solution of sodium silicate and baking.

27. A process for treating metals of the class described comprising heat treating the metal for from two to one hundred and forty-four hours at from 850° F. to 950° F., quenching in a solution of soluble silicate and baking for from four to thirty hours at from 200° F. to 400° F.

28. A process for treating metals comprising heat treating, quenching, treating with a silicate and baking.

29. A process for treating metals of the class described which comprises heat treating, quenching in water, treating with a silicate and aging.

30. A process for treating metals of the class described, which comprises heat treating, quenching in air, treating with a silicate and aging.

31. A process for the treatment of metals of the class described which comprises treating the metal with a silicate, baking, and re-treating with a silicate.

32. A process for the treatment of metals of the class described which comprises treating the metal with a silicate, baking, re-treating with a silicate and baking.

33. As a new material, a metal having an impregnated surface coating of sodium silicate permanently affixed thereto.

34. As an article of manufacture, a metal having a coating of sodium silicate baked thereon.

35. As an article of manufacture, a metal having a coating and impregnation of silicate baked thereon.

In testimony whereof we affix our signatures.

SAMUEL DANIELS.
ARTHUR C. ZIMMERMAN.